FAG

Wheel bearings for commercial vehicles

Technology
Failure Diagnosis

LUK INA FAG RUVILLE

SCHAEFFLER
AUTOMOTIVE AFTERMARKET

Content

1 Introduction

In the commercial vehicle sector, wheel bearings have undergone constant development in recent years. With increasing transport volumes, higher performance, as well as modified driving behaviour, the high requirements placed on a wheel bearing are rising. Long life, high reliability and maintenance-free use are essential in this, because not only is it used as a link between the wheel and chassis; it is still also subjected to all driving-dynamic forces.

A wheel bearing is thus an essential safety component. The development from simple standard tapered roller bearings up to today's maintenance-free, lubricated-for-life units has more than proved its worth. Wheel bearing units reduce the number of possible installation errors to a minimum.

As such, the adjustment of the bearing clearance, which was formerly a standard element of maintenance, is now a thing of the past.

Market demands for commercial vehicles (CVs) have progressed from a mileage of 300,000 km with standard bearings to more than a million km with wheel bearing units. There is a clear trend moving from standard tapered roller bearings towards a tapered roller bearing unit. In addition to the lifetime lubrication, this unit is also pre-set and sealed. FAG is the technological leader in mass production of tapered roller bearing units and also develops special repair solutions for the spare parts market.

2 Designs

When someone in the CV sector refers to a wheel bearing, this is always associated with tapered rollers as the rolling elements. Tapered rollers allow the axle load (radial force) as well as axial forces induced by cornering to be absorbed.

Since a single tapered roller bearing can only absorb axial forces in one direction, a second tapered roller bearing must be arranged in mirror position for the opposing forces.

As the rolling elements have a wider supporting surface on the raceways, greater amounts of force can be absorbed in comparison with ball bearings.

2.1 Product overview

1 Tapered Roller Bearing (TRB)

2 Insert Unit (IU)

3 Repair Insert Unit (RIU)

4 Truck Hub Unit (THU)

5 Truck Axle Module (TAM)

2.2 Tapered roller bearing (TRB)

Design:
Standard tapered roller bearings (TRBs) consist of an outer race, an inner race with rolling elements and a cage. The outer race and the inner race are removed and installed separately.

Single-row tapered roller bearings are supplied neither greased nor sealed. Before installing, the bearings must be lubricated with grease specifically approved for the application (see chapter 3.3).

Function:
Tapered roller bearings support high loads with a small mounting space, and demonstrate good cornering behaviour. They have established themselves as being conventional wheel bearings for commercial vehicles for over 100 years.

Nevertheless, the regular removal of the wheel hub due to maintenance on e.g. the brake system has the following negative effects on the life of the taper roller bearing:

- Ingress of dirt
- Improper relubrication
- Destruction of the seals
- Complicated resetting of the pair of bearings

Note:
For safety reasons and to prevent any consequential damage, the inner and outer tapered roller bearings must always be changed when replacing the wheel bearing!

In addition, the wheel must be turned in the opposite direction to the tightening during the adjustment process or when bracing.

Installation

1. Clean the wheel hub and check for ovality - see chapter 5.2
2. Lubricate the bearing inner race, rolling element and cage with a suitable grease (see chapter 3.3)
3. Press fit the outer bearing races into the wheel hub
4. Place the greased inner races with rollers and cage into the wheel hub
5. Insert the rotary shaft seals to seal the wheel hub with a suitable tool
6. Place the wheel hub on the axle shaft
7. Secure the axle nut and set the bearing clearance according to manufacturer‘s specifications

2.3 Insert Unit (IU)

Design:
The insert unit is a further development of the standard tapered roller bearing. It is supplied in pairs, one inner bearing and one outer bearing including two rotary shaft seals. The dismantling procedure is the same as that of the standard tapered roller bearing. It is neither greased nor sealed. Before installing, the bearings must be lubricated with grease specifically approved by FAG for the application (see chapter 3.3). Both bearings are connected after installation by means of a snap ring (included in the kit contents).

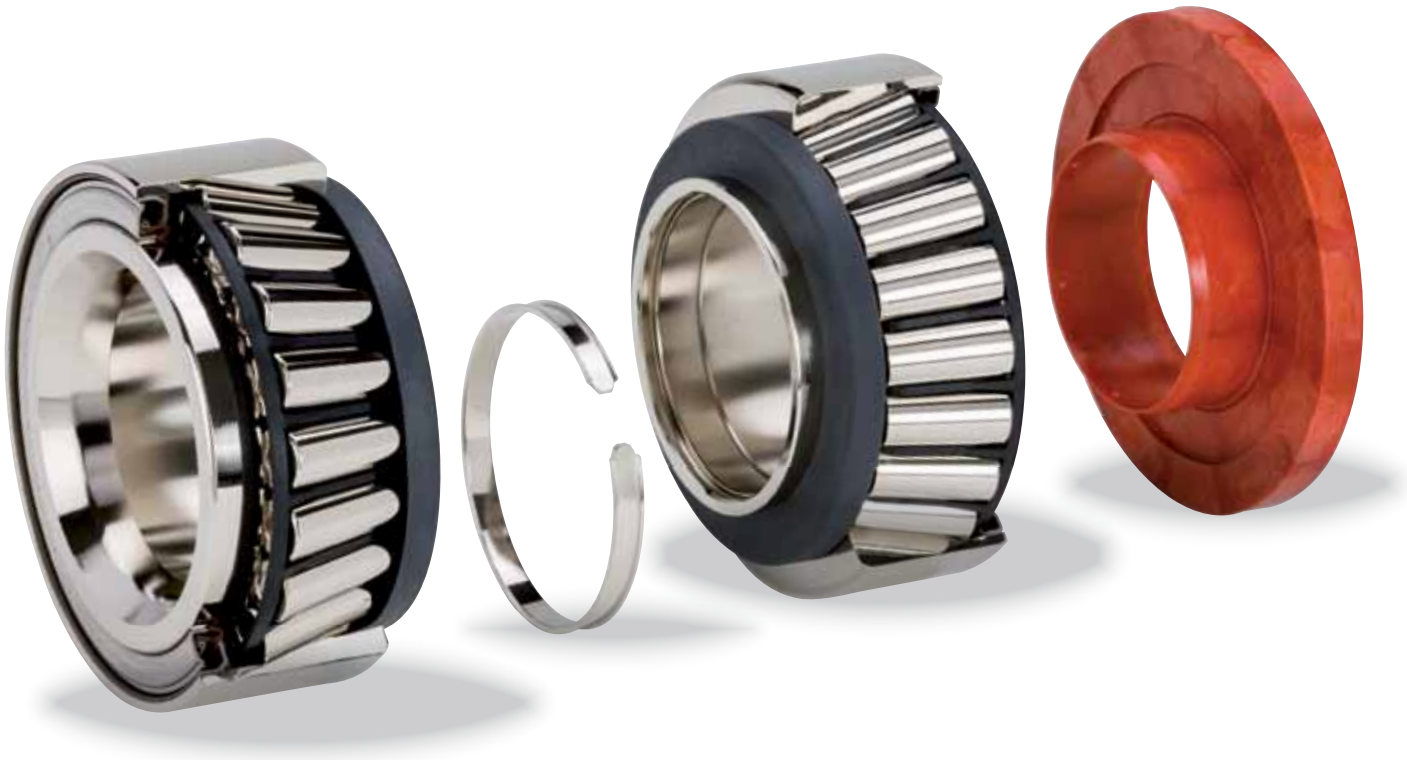
Function:
The insert unit has a factory-set preload and has the same maintenance requirements as the tapered roller bearing. It has no pre-defined bearing clearance and must therefore be adjusted in accordance with the manufacturer‘s specifications after installation.

Note:
The wheel must be turned in the opposite direction to the tightening during the adjustment process or when bracing.

Installation

1. Clean the wheel hub and check for ovality - see chapter 5.2
2. Lubricate both bearing inner races, the rolling elements and cage with a suitable grease
3. Press fit the two outer bearing races into the wheel hub
4. Insert the lubricated inner races with rollers and cage into the wheel hub
5. Insert the snap ring
6. Press fit the rotary shaft seal in order to seal the wheel hub with a suitable tool
7. Place the wheel hub on the axle shaft
8. Secure the axle nut and adjust the bearing clearance according to manufacturer‘s specifications

2.4 Repair Insert Unit (RIU)



Design:
The repair insert unit is a pre-assembled, sealed and lubricated-for-life wheel bearing unit. It consists of two tapered roller bearings, which are connected after installation by means of a snap ring. The snap ring ensures that the bearings are not damaged and are held in position during installation on the axle shaft. In addition, the repair insert unit is supplied with a special tool for easy and convenient installation.

Function:
The repair insert unit is a further technical development of the insert unit. The aforementioned properties ensure reduced installation costs for the workshop. The use of incorrect or contaminated grease can also be ruled out. Three FAG repair insert units enable around 43 hubs for over 2100 different vehicle types to be repaired. This multiple application also enables significant reduction of effort in the ordering process and in storage space.

Note:
The wheel must be turned in the opposite direction to the tightening during the adjustment process or when bracing.

Installation

1. Clean the wheel hub and check for ovality - see chapter 5.2
2. Install the inner bearing and outer bearing in the hub (the bearings are marked Inboard and Outboard)
3. Install the snap ring, taking care to seat it correctly after installation, the snap ring must turn easily in its seat
4. Before fitting the wheel hub, make sure that the supplied o-ring is positioned correctly on the inner bearing. The o-ring offers protection against the ingress of dirt and water
5. Place the wheel hub on the axle shaft
6. Secure or tighten the axle nut to the torque specified by the manufacturer

2.5 Truck Hub Unit (THU)

Design:
In contrast to the standard tapered roller bearing and the insert unit, the THU consists of an outer race, two inner races with a row of tapered rollers each. It is fully assembled and delivered ready for installation, including seals and lifetime lubrication.

Function:
The truck hub unit is a sealed bearing unit with integrated rotary shaft seals. It has a factory-set preload, is maintenance-free and is equipped with a predefined bearing clearance. This solution ensures an increased life. The THU also enables the workshops to perform faster and easier replacements.

Note:
The wheel must be turned in the opposite direction to the tightening during the adjustment process or when bracing.

Installation

1. Clean the wheel hub and check for ovality - see chapter 5.2
2. Press fit the bearing unit with a suitable tool. Press fitting into a hub must only be performed via the outer race; otherwise, the bearing will be damaged
3. Install the snap ring, if present. Depending on the manufacturer, the THU can be fixed with an additional snap ring
4. Place the wheel hub on the axle shaft
5. Secure or tighten the axle nut to the torque specified by the manufacturer

2.6 Truck Axle Module (TAM)

Design:
The truck axle module (TAM) is based on the insert unit (IU) and is installed in the hub by FAG. The TAM is also pre-greased, completed with seals and equipped with an ABS encoder ring.

Depending on the application, the hub material is composed of cast iron, aluminium or ADI (austempered ductile iron). The TAM is developed according to the requirements and/or customer specifications in terms of wheel and brake.

Function:
The truck axle module is a closed and minimised-friction bearing unit that can accommodate the brake disc and wheel carrier, as well as an integrated ABS encoder. It is sealed, adjustment/maintenance free and thus a ready-to-install wheel bearing unit.

Note:
The wheel must be turned in the opposite direction to the tightening during the adjustment process or when bracing.

Installation

1. Install the wheel carrier/brake disc on the truck axle module (TAM)
2. Place the unit on the axle shaft
3. Secure or tighten the axle nut to the torque specified by the manufacturer

3 Lubrication

3.1 Why is a lubricant required?

When it comes to rolling bearings, the main task of lubrication is to keep friction and wear low by preventing or reducing metallic contact of the rolling and sliding contact surfaces.

Grease lubrication is applied with approximately 90 percent of rolling bearings. For secure, long-lasting and economical bearings, special, rolling bearing greases such as FAG Arcanol provide the best conditions. The current requirements for CV wheel bearings and the peak temperatures of around 200°C and beyond that occur during braking make the use of approved lubricants essential.

The main advantages of suitable grease lubrication are:

- Long service life with maintenance-free lubrication
- Good sealing support offered by the grease
- Dissipation of heat
- Protection of the bearing against corrosion
- Very low design project costs

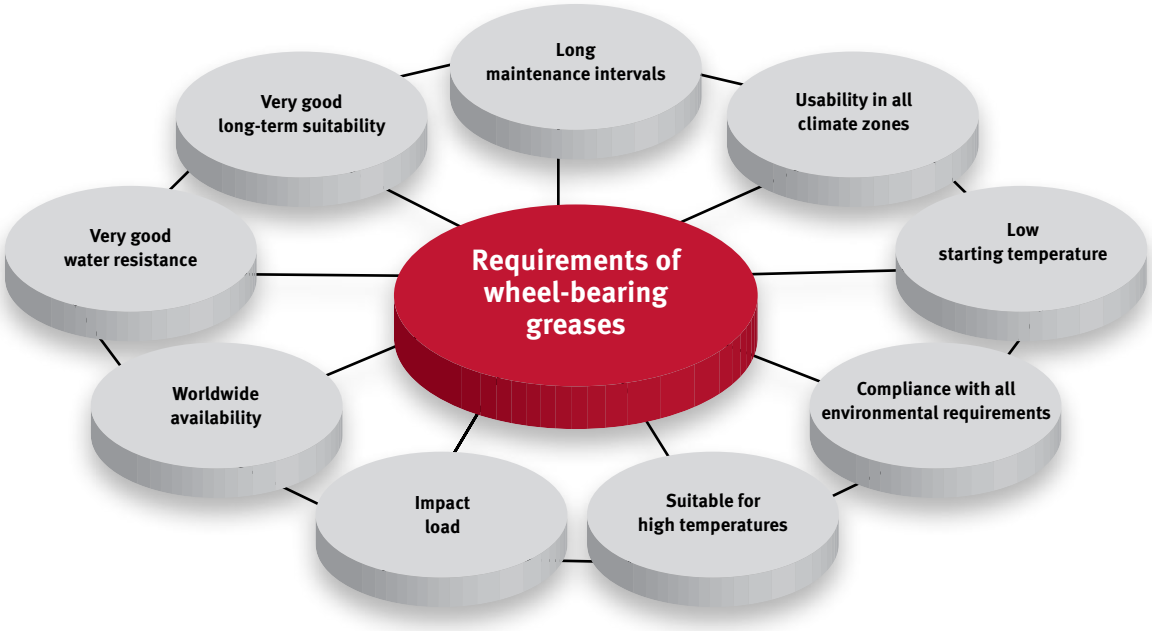
3.2 Composition of and differences in greases

Different types of rolling bearing have different requirements in terms of the lubricant and its additives. The suitability of greases for the respective application cannot be assessed solely on the basis of fact sheets.

The performance of greases of the same type can vary greatly! Lubricating greases can be primarily distinguished according to their main components: thickener and base oil. Normal metallic soaps are usually used as a thickener, but complex soaps and bentonites, polycarbamides, FEP (perfluoro/plastic), PTFE (polytetrafluor ethylene/plastic: Teflon, Turcon) are also used. Mineral oil or synthetic oil is used as a base oil.

The viscosity of the base oil determines, in conjunction with the proportion of thickener, the consistency of the lubricating grease and the structure of the lubricating film. Lubricating greases also contain additional additives to improve the chemical or physical properties, e.g. corrosion protection, oxidation stability.

3.3 Requirements of wheel-bearing greases



3.3 Requirements of wheel-bearing greases

The Schaeffler Group has been developing high-quality rolling bearing lubricants in co-operation with renowned lubricant manufacturers for a long time. At first glance, special rolling bearing greases cost a bit more. However, if you want to accommodate the high requirements placed on a rolling bearing, you need to use special greases.

FAG not only conducts numerous selection tests, but also handles quality assurance and then provides practical lubrication recommendations. If these recommendations are heeded, bearings failing prematurely due to the incorrect choice of grease will increasingly become a thing of the past.

FAG Arcanol Load 150, Shell Retinax LX II and Renolit LX-NHU 2 are specifically recommended for use in wheel bearings under the high temperature conditions that occur in modern commercial vehicles. These are lithium complex greases designed for a temperature range of -30°C to 160°C with short-term peak temperatures of up to 200°C.

In order to qualify as a KP grease, special high-pressure additives must be used (KP grease = designation according to DIN 51502). The high mechanical stability combined with low oil separation enables use at high-stress lubrication points.

3.4 How do I grease a wheel bearing?

Standard tapered roller bearings and insert units must be filled with grease before installation. In these cases, it is not only the quantity that matters; in fact the correct procedure when greasing a wheel bearing is more important.

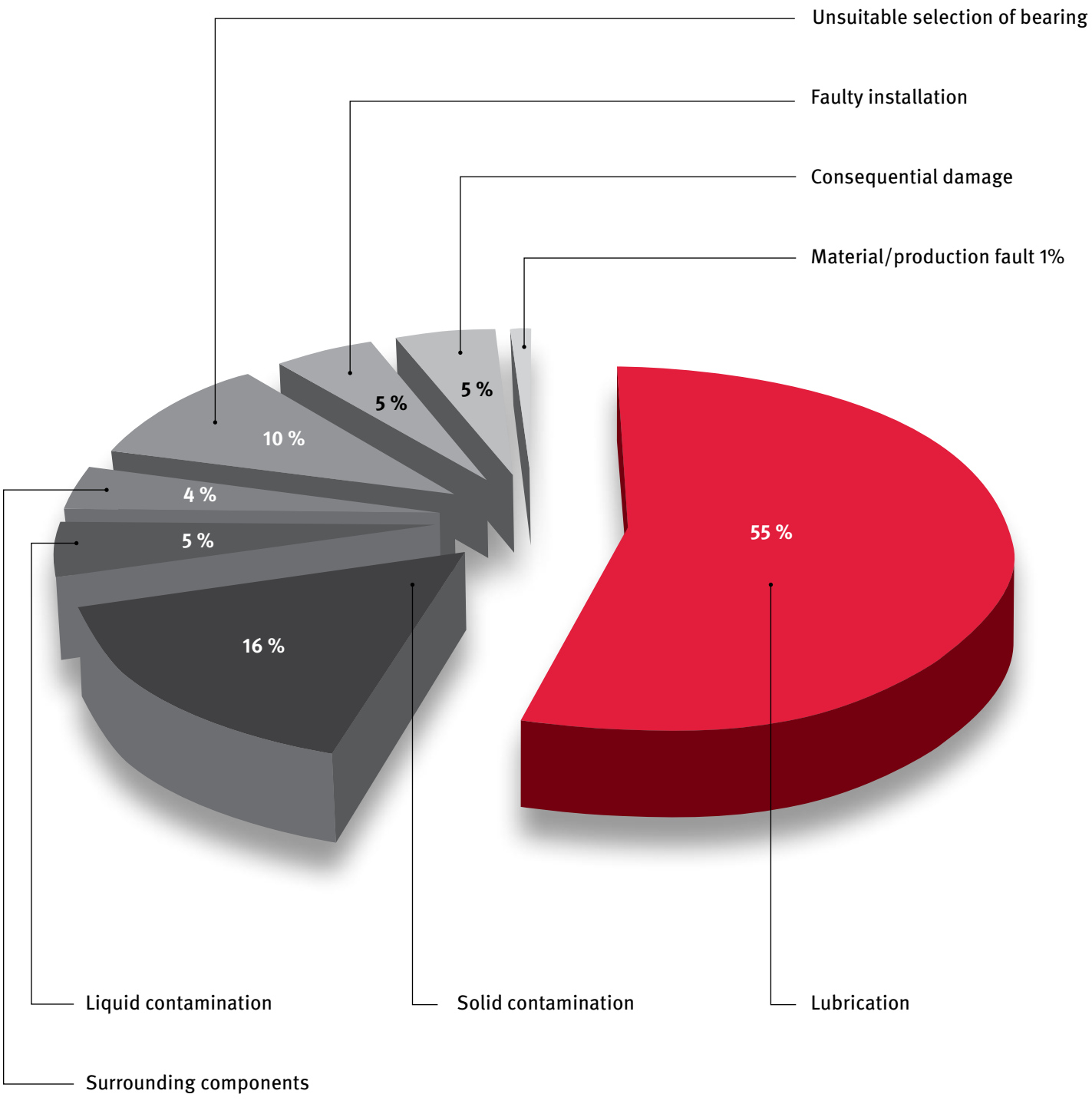
The grease must be completely pushed from one side of the bearing through to the other side and all around (see images on the right). The excess grease is then removed and the outside of the bearing is coated with a thin film.

Note:
To avoid damage, the prescribed quantity of grease (see manufacturer's specifications) must be within the wheel hub after installation. Insufficient grease can lead to hot-running wheel bearings. If the quantity of grease is exceeded, the excess grease can escape from the wheel hub and get onto the brake pads.

3.5 Improper lubrication and its causes

Over 50 percent of all rolling-bearing defects are due to improper lubrication (see diagram). A lot of other damage that cannot be directly attributed to a lubrication issue still involves a lubrication issue. Unsuitable or contaminated lubricant, as well as an incorrect amount of grease, leads to premature malfunction of the wheel bearing. A lack of lubrication in the contact points can lead to fatigue damage or the bearings running hot. This causes increased wear and thus premature malfunction.

Possible causes of rolling bearing malfunction at a glance



3.6 Effects and consequences of solid and liquid contamination

Solid contamination:
Solid contaminants in the lubricant cause wear and premature fatigue. The harder the ingressed contaminant and the smaller the bearing, the more the life is reduced.

Hard contaminants cause friction wear in rolling bearings, particularly at points with a high amount of sliding friction. This occurs, for example, in the contact area of the front side of the rollers in tapered roller bearings.

The wear increases along with the hardness of the foreign material. It also increases approximately in proportion to the concentration of the contaminants in the lubricant and the size of the particles.

Premature malfunction can be minimised through:
- Clean lubricants
- Effective sealing
- Thorough cleaning of the parts surrounding the bearing
- Cleanliness during installation

Liquid contamination:
The harmful effect of liquid contaminants in lubricant is often greatly underestimated. Even pure water without additional aggressive media has a very high potential for damage in rolling bearings.

The damage potential is divided into the following categories:
- Reduction of running time until fatigue
- Cause of wear
- Acceleration of lubricant ageing and residue formation
- Corrosion

The types of damage occur either individually or in combination and are dependent on the lubricant type, the bearing material and the amount of free water introduced to the lubricant. They can lead to an inability to function or completely destroy the bearing.

Selecting the correct lubricant and the proper lubrication is therefore crucial for the reliable assurance of the life of each bearing. To ensure that a viable lubricating film can form in the contact surfaces between the rolling elements and raceways, the lubricating oil must be of a suitable viscosity. The viscosity of a lubricating oil decreases as the temperature increases. It is important, therefore, that the necessary viscosity is present at operating temperature.

3.7 Storage conditions for wheel-bearing greases

A basic prerequisite for storage is a closed storage room in which no penetration of aggressive media is possible, for example, exhaust gases from vehicles. Direct sunlight must also be avoided.

The storage temperature should be kept as constant as possible and the humidity as low as possible. Sudden temperature changes and increased humidity lead to water condensation.

The following conditions must be met:
- Frost-free storage at a minimum temperature of +5°C (reliable avoidance of frost formation, down to +2°C allowed for up to 12 hours a day)
- Maximum temperature +40°C
- Relative humidity less than 65 percent (with temperature changes up to 70 percent allowed for a maximum of 12 hours a day).

4 Failure Diagnosis

Rolling bearings are machine elements with a wide scope of application. They prove themselves to be reliable even in tough conditions, so the reasons for a premature malfunction is usually to be found in the product environment or in defective installation. Rolling bearing damage is primarily noticeable through the noises that occur, though depending on the operating conditions the beginning of the damage will progress to actual malfunction within months in some circumstances.

A wide range of characteristics can be discerned when investigating damaged bearings. In order to find the cause of the damage, examination of the bearing alone is usually insufficient. More often than not, the surrounding components, lubrication and sealing as well as the operating and environmental conditions must also be taken into consideration. A planned approach to the investigation makes it easier to find the causes.

4.1 Causes of bearing damage and actions

Modern wheel bearings from the FAG range are designed to offer maximum life. Wheel bearings can achieve very high mileage when used in optimum conditions. However, there are various disruptive influences that significantly affect the life of wheel bearings.

They include:
- Road/operating conditions
- Incorrect installation
- Corrosion
- Allocation error/incorrect selection
- Incorrect or unsuitable grease
- Product environment/surrounding components

To ensure correct installation, as well as proper and reliable functionality of wheel bearings, factors such as the condition of the vehicle, component environment, cleanliness and the use of special tools must be taken into account. To ensure that these conditions are met, access to the current technical data from the vehicle manufacturer must be guaranteed. Schaeffler Automotive Aftermarket provides all customers with information such as tightening torques via the Internet portal: www.RepXpert.com.
The risk of premature wheel-bearing malfunction is minimised if installation is correct and the above information is taken into account. Sound technical knowledge, vehicle-specific knowledge and a structured approach are basic prerequisites for the diagnosis and assessment of rolling bearing damage.

Information on rolling bearing damage and its causes

Characteristic	Typical causes of rolling bearing damage									
	Incorrect installation	Incorrect tool	Uncleanliness	Excessive preload	Insufficient preload	Excessively tight fit	Excessively loose fit	Incorrect grease	Not enough grease	Too much grease
Rough running	•	•	•							
Noise	•	•	•	•	•	•	•	•	•	
Temperature				•		•		•	•	•
Fatigue damage	•	•	•	•		•	•	•	•	
Damage from running hot				•		•	•	•	•	•
Breaks	•	•		•		•				
Fretting corrosion damage	•				•					
Traces of scuffing								•	•	
Wear damage		•						•	•	
Corrosion damage	•	•						•		

4.2 Damage symptoms

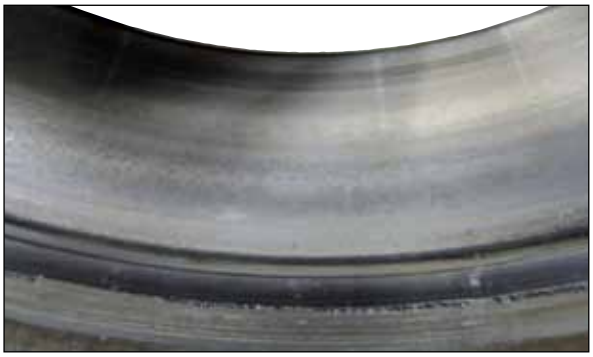
Improper installation can result in premature malfunction of the wheel bearing. Therefore, the use of special tools and compliance with the installation instructions, or more precisely vehicle manufacturer specifications, are essential.

Bearing makes noises

Cause:
- Improper installation/setting
- Incorrect and/or excessively rigid/excessively tight setting of the rolling elements

Impact:
- Temperature rise/hot runner
- Rolling-bearing grease completely consumed

Remedy:
- Perform installation according to manufacturer specifications
- Observe the correct setting
- Replace the hub including the bearing



Oil leakage at the wheel hub

Cause:
- The sealing (rotary shaft seal) is damaged due to improper installation

Impact:
- Damage to the shaft seal ring allows oil into the bearing
- All the grease is washed out, thus lubrication is no longer ensured
- The running surfaces of the bearing are exposed to increased wear

Remedy:
- Observe the manufacturer‘s installation instructions
- Use of special tools is absolutely essential
- Replace the bearing

Leakage at the wheel hub

Cause:
- Bearing was disassembled before installation (pre-assembled unit)
- Bearing has been installed and removed again

Impact:
- Function of the seal (rotary shaft seal) is no longer guaranteed
- Oil gets into the bearing – grease washed out

Remedy:
- Replace the bearing
- Do not disassemble pre-assembled units

Bearing makes noises

Cause:
- Setting too low

Impact:
- Bearing area/bearing width of rolling elements
- incorrect or too narrow
- Incorrect load on the inner race (fretting corrosion)

Remedy:
- Use of the specified tightening torque – see RepXpert etc.
- The condition of the hub must be checked prior
- to installation
- Replace the hub and bearing

4.2 Damage symptoms

Premature malfunction of the wheel bearing

Cause:
- Incorrect or excessively tight setting

Impact:
- Beginning to run hot
- Starved lubrication

Remedy:
- Use of the specified tightening torque – see RepXpert etc.
- Replace the bearing, check the condition of the hub

Wheel hub worn

Cause:
- Bearing and/or outer race has turned in the hub

Impact:
- Incorrect fit
- Visibly incorrect load on the inner race (fretting corrosion)

Remedy:
- Check the condition of the hub before installation
- Check all surrounding components
- Replace the hub and bearing

Wheel-bearing malfunction

Cause:
- Increased axial clearance
- Insufficient bracing of the bearing

Impact:
- High torque load and axial load of the inner bearing with the result that the tapered rollers on the lip rise and set
- As the damage progresses, it can lead to elevated temperatures, as well as the lubricating grease leaking out and the simultaneous evaporation of the base oil

Remedy:
- Replace the bearing
- Check the condition of the wheel hub and replace if necessary

5 Technical information

5.1 Bearing clearance, preload/setting of tapered roller bearings

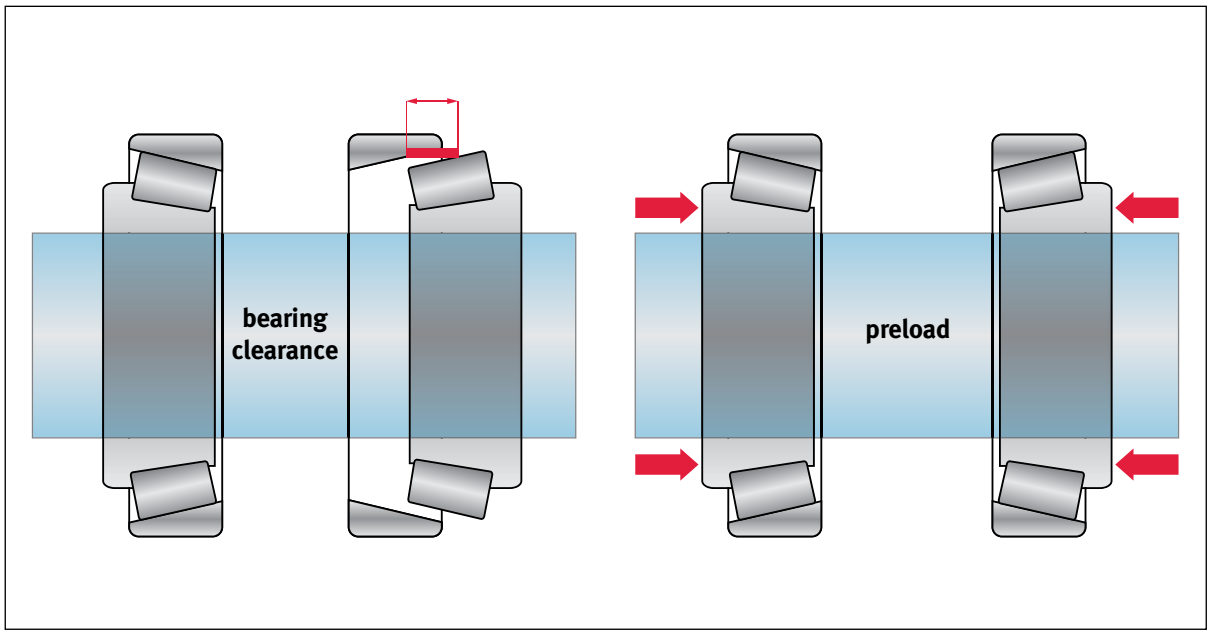
Bearing clearance

Bearing clearance is defined as the total distance by which a bearing race can be moved relative to another bearing race in a radial direction (radial bearing clearance) or in an axial direction (axial bearing clearance).

In addition, a distinction is made between the bearing clearance (by design) prior to installation and the bearing clearance under actual operating conditions once installed (operating clearance).

The bearing clearance prior to installation is therefore greater than the operating clearance, since the different press-fits and heat expansions of the bearing races and associated components lead to expansion or contraction of the races.

Depending on the area of application, it may be necessary to set a positive or negative bearing clearance. In most applications, the operating bearing clearance should be positive, i.e., a slight residual bearing clearance should still be present in the bearing during operation.



Preload

A negative bearing clearance, also called preload, is to be used when the stiffness of the bearing arrangement is to be improved or the running accuracy is to be increased. All pre-assembled units at FAG are designed such that they are installed with a preload.

The main reasons for a preload are as follows:

- Increase in stiffness
- Reduction in running noise
- Long life

In single-row tapered roller bearings, the bearing clearance is only achieved after installation and is dependent on the setting against the bearing, which provides a counter guidance.

Setting

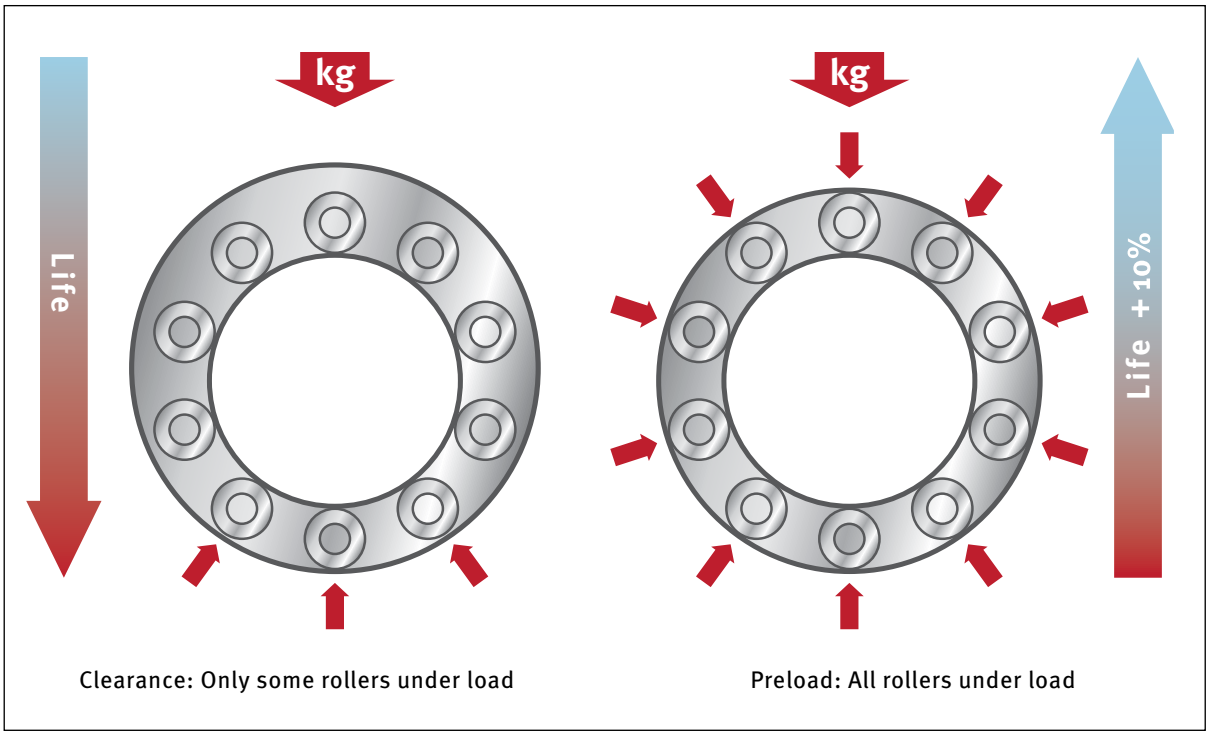
The setting of bearings is a defined clamping of the two bearings against each other.

This involves moving a bearing race of two opposing tapered roller bearings on its seat until the bearing arrangement has the required clearance or preload. This changes the radial bearing clearance and axial bearing clearance simultaneously to a certain ratio.

This ratio depends on the contact angle of the bearing.

In the reciprocal setting of tapered roller bearings, the wheel must be turned such that the rollers assume their correct position, i.e. the large front side of the rollers must be at the guide lip.

Why preload?



Clearance: Only some rollers under load

Preload: All rollers under load

5.2 Checking the condition of the hub (ovality)

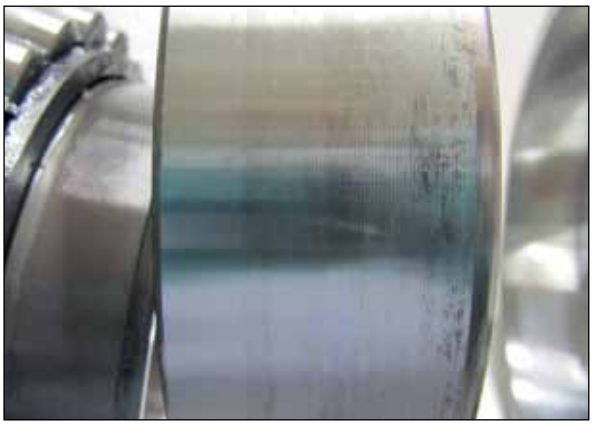
The surrounding components as well as the wheel hub must always be checked for functionality and wear.
The inspection of the condition of the wheel hub (ovality) can be performed in a number of different ways:

Version 1

- Knock out both inner races with cage and rolling elements from the hub. Only the outer races remain in the hub
- Apply a suitable tool for pressing out the outer races (tool is available from specialist shops)
- Clean the hub and place under a press
- Slowly press out the outer race. The pressure on the press must remain at least 0.5 t. If the value falls below this threshold, the hub must be replaced

Version 2

- Knock out both inner races with cage and rolling elements from the hub. Only the outer races remain in the hub
- Clean the hub
- Drive out the outer races with a suitable brass drift
- Check whether the outer race surface has a dark spot on two opposing sides. Check that the two surfaces that are at an angle of 90 degrees to the dark spots are not damaged. If this is the case, the mounting hole is deformed and the wheel hub must be replaced (see pictures)



Wheel hub OK

Ovality - wheel hub not OK

5.3 Installation comparison

Installation benefits of wheel bearing units vs. standard tapered roller bearings									
Wheel Bearing Designs	Installation steps								
		Required tools for fitting and dismantling	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**	**Step 6**	**Step 7**
	Tapered Roller Bearing (TRB)	• Suitable brass drift • Fitting tool for rotary shaft seals • Dial gauge • Torque wrench	• Check wheel hub for ovality • Also see chapter 5.2 of the wheel-bearing brochure	• Install outer races	• Grease wheel bearing prior to installation	• Insert inner races with rollers and cage • Install rotary shaft seals	• Install wheel hub • Make sure that the rotary shaft seals are not damaged	• Tighten the axle nut according to manufacturer's specifications	• Adjust the bearing clearance/ preload
	Insert Unit (IU)	• Suitable brass drift • Fitting tool for rotary shaft seals • Dial gauge • Torque wrench	• Check wheel hub for ovality • Also see chapter 5.2 of the wheel-bearing brochure	• Install outer races	• Grease wheel bearing prior to installation	• Insert inner races with rollers and cage • Install rotary shaft seals	• Install wheel hub • Make sure that the rotary shaft seals are not damaged	• Tighten the axle nut according to manufacturer's specifications	• Adjust the bearing clearance/ preload
	Repair Insert Unit (RIU)	• Metal plate the same size as the special tool • Torque wrench	• Check wheel hub for ovality • Also see chapter 5.2 of the wheel-bearing brochure	• Install wheel hub • Make sure that the o-rings are not damaged	• Tighten the axle nut according to manufacturer's specifications				
	Truck Hub Unit (THU)	• Metal plate the same size as the outside diameter of the bearing • Torque wrench	• Check wheel hub for ovality • Also see chapter 5.2 of the wheel-bearing brochure	• Install wheel hub • Make sure that the o-rings are not damaged	• Tighten the axle nut according to manufacturer's specifications				
	Truck Axle Modul (TAM)	• Torque wrench	• Installation of the wheel hub on the brake disc	• Place the brake disc incl. the wheel hub on the axle shaft	• Tighten the axle nut according to manufacturer's specifications				

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	FAG	●	●	●	●	

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