SCHAEFFLER

Axlebox Rolling Bearing Arrangements

FAG

Foreword

Today's manufacturers, operators and above all travellers expect extremely high reliability and operational security of railway vehicles, whether they be trams or high-speed trains. Axlebox bearings are an essential element in the bogies and chassis on all railway vehicles as well as being a safety component.

Axlebox bearings include cylindrical roller bearings, tapered roller bearings and spherical roller bearings. Depending on the application, the axlebox bearings are manufactured in a range of sizes for local and regional public transport as well as freight transport in order to guarantee the required load carrying capacity and rating life.

In most cases, the wheelsets are arranged in bogies with an outer bearing arrangement. In order to be able to produce a shorter design for the wheelset – for example to reduce the mass within a restricted outline profile or to provide the vehicle with a particularly low displacement resistance with an all-round cladding– the bearing arrangement is designed as an inner bearing arrangement. Specific installation and loading conditions must be taken into consideration in this case.

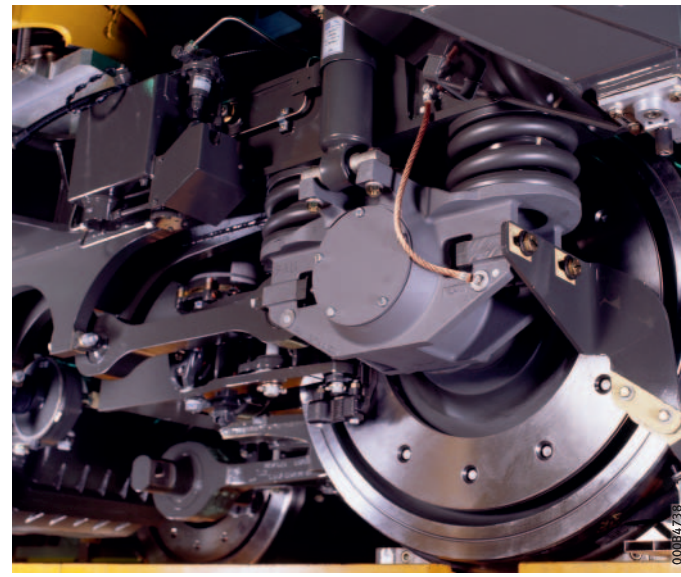

Figure 1
Bogie external bearing arrangement

Vehicles in local public transport and trams frequently have a low-floor design with a low boarding height to provide barrier-free boarding onto the vehicle. To achieve this, the chassis, bogies and their components must have a particularly compact design. The chassis therefore have a non-locating bearing arrangement design. In this design, the wheel is supported directly on the stationary axle journal.

Foreword

In any rail vehicle, the chassis and bogies are particularly important components with respect to safety. Accordingly, the quality of the rolling and plain bearings developed and manufactured by Schaeffler Group Industrial is also very high.

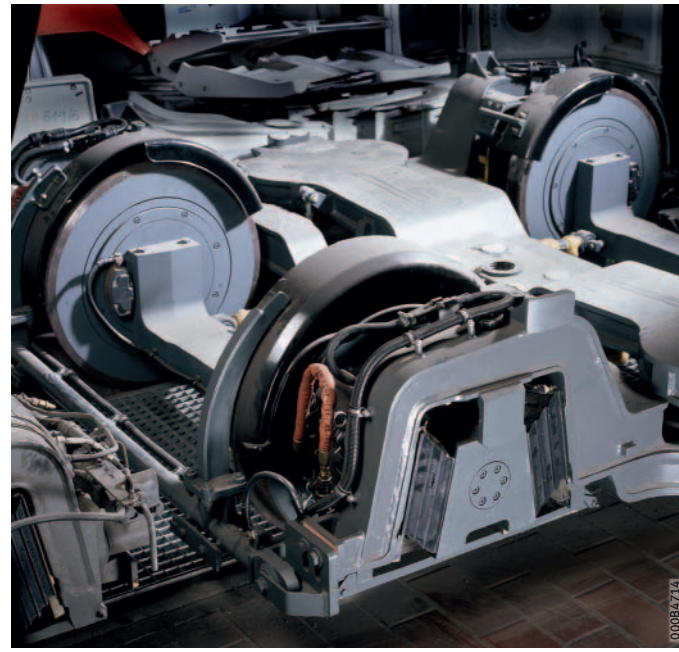

Figure 2
Non-locating bearing arrangement

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Axlebox bearings

Definition

The standard EN 12080 defines an axlebox bearing as a subassembly comprising:

- bearing housing
- rolling bearings
- sealing
- lubricating grease.

No further details are provided on the design or type of bearing housing and rolling bearing. The rolling bearings must meet the requirements to EN 12080 irrespective of the type. The grease must be in accordance with EN 12081. The whole subassembly must be checked in accordance with EN 12082.

Types of rolling bearings

Axlebox bearings comprise the interface between the wheelset and the bogie frame; they are therefore subjected to extreme loads and must fulfil a wide range of technical requirements. If rolling bearing components are subjected to a series of tests in accordance with EN 12080, including, for example, ultrasound testing of the inner and outer rings, they correspond to the highest quality class and are marked with CLASS 1. Compliance with EN 12082 is verified on special axlebox bearing test rigs. Axlebox bearings are developed in close collaboration with manufacturers and operators of railway vehicles to ensure optimum reconciliation with the relevant operating conditions. Cylindrical roller bearings, tapered roller bearings and spherical roller bearings are the bearing types most frequently used in wheelsets, *Figure 1* to *Figure 3*, page 7.

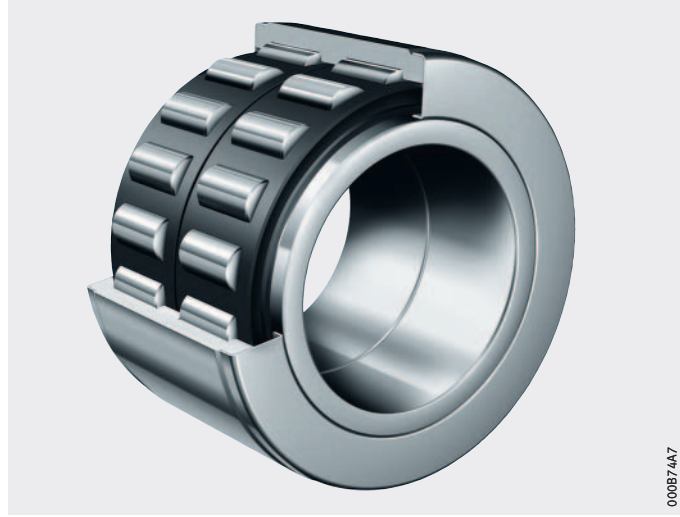


Figure 1
Cylindrical roller bearing unit

Figure 2
Tapered roller bearing unit TAROL

Figure 3
Spherical roller bearing

Vehicles operating within the scope of European standards use TAROL (**Ta**pered **Rol**ler Bearing) tapered roller bearings in metric sizes, or cylindrical roller bearings, or cylindrical roller bearing units. Chassis for special installation conditions, for example, with a non-locating bearing arrangement, use rolling bearings with standard dimensions or insert bearings from the automotive industry. Spherical roller bearings have a high load carrying capacity but display increased slippage due to their internal construction and are less suitable for long grease operating lives. For this reason, spherical roller bearings are no longer used in new designs. However, there is a significant global spares market.

Axlebox bearings

TAROL rolling bearings in inch sizes are used in North America for freight transport. The rolling bearings and the adapters used meet the requirements of the AAR (**A**ssociation of **A**merican **R**ailroads).

Cylindrical roller bearings and tapered roller bearings are used in equal measure for wheelsets. Cylindrical roller bearings have a lower friction when travelling in a straight line, tapered roller bearings have a higher axial load carrying capacity. These benefits balance each other out in actual use.

Axlebox bearings are designed and manufactured in appropriate dimensions with the required load carrying capacity for a range of applications. Available bearing sizes and application examples can be found in TPI 158, Products for Railway Applications. Special sizes, individual parts, replacement parts and housing adapters are available by agreement.

Tapered roller bearing units TAROL

TAROL units of the FAG brand are double row tapered roller bearings that are supplied set for clearance, greased and sealed. TAROL units are thus supplied ready for mounting.

TAROL units are used for the axlebox bearing arrangements on rail vehicles such as locomotives, freight wagons and passenger carriages. They can be quickly and easily fitted: the bearing is pressed onto the shaft journal in a single operation and secured by means of additional parts and screws. Since the unit has a press fit on a shaft journal which has a diameter which is within the specified tolerances, the bearing arrangement achieves the required axial clearance.

TAROL units are filled as standard with greases proven in practical use. The standard grease in the metric size bearing units is certified in accordance with EN 12081. A grease with AAR approval is used as standard for inch size units. We can also supply TAROL units with relubrication holes on request. The relubrication intervals are then set in accordance with the application. Schaeffler supplies TAROL units in inch and metric sizes for all standardised shaft journals on rail vehicles. Special sizes, individual parts, replacement parts and housing adapters are available by agreement.

Tapered roller bearing units
TAROL – inch sizes

TAROL units in inch sizes correspond to the regulations of the AAR. Designs of the classes D, E, F, G and K correspond to the standard AAR M 934. Types B, C and GG are not described in AAR M 934 but are still used in significant quantities on the market.

TAROL units in inch sizes in their normal design are supplied greased at the factory with a grease certified by the AAR. Sealing is provided by contact seals, where a spring preloaded seal lip generally runs against a special seal wear ring. Sheet metal cages are standard for inch size TAROL units, especially for the North American market. Cages made from polyamide are available by agreement.

The scope of delivery of inch size bearing units in accordance with the AAR includes not only the rolling bearing and seals together with the seal wear rings but also the backing ring and the end cap as well as the axle bolts and retainers, *Figure 4*.

Figure 4
TAROL unit in inch sizes

Tapered roller bearing units TAROL – metric sizes

Schaeffler supplies TAROL units with a bore diameter between 90 mm and 160 mm in graduations of 10 mm. Depending on the requisite load carrying capacity, each bore diameter is available with a range of outside diameters and widths. TAROL units are supplied ready for mounting, where the grease selection and seal design are matched to the envisaged application in accordance with the data in the customer specification. The greases used correspond to EN 12081; this is an absolute precondition principally for applications within the EU.

Seals of contact and contact-free design are used. In the selection process, attention must be paid to climatic conditions, the adjacent construction, the available space and the operating conditions, particularly the travel velocity.

TAROL units in metric sizes are generally fitted with cages made from glass fibre reinforced polyamide. Cages made from polyamide have proved themselves in operation for several decades and have largely replaced sheet metal cages, *Figure 5*.

In order to mount a TAROL bearing on the shaft journal, additional components are necessary. In addition to the seals already integrated in the bearing, these are the backing ring, end cap, fasteners and, where necessary, other parts.

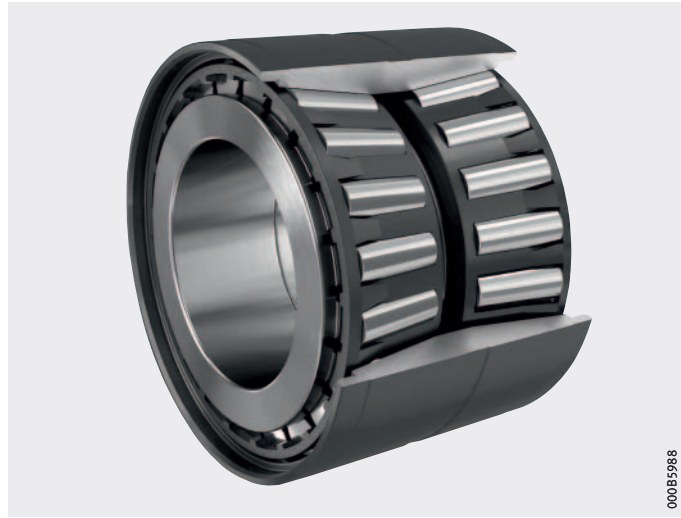


Figure 5
TAROL unit in metric sizes

Designs

For both inch and metric sizes, Schaeffler differentiates between the following variants of TAROL units.

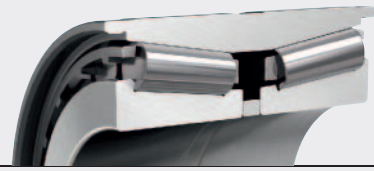
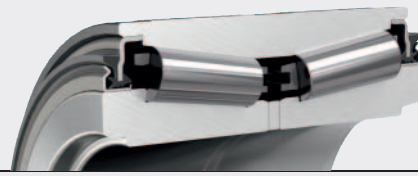
Variants

Designation	Definition
TAROL	Bearing design of standard quality
TAROLX[1)]	Bearing design in X-life quality
TAROLC	Compact bearing design: - greased bearing with integrated seal seats on outer and inner rings for cartridge seals
TAROLS[1)]	Supreme bearing design: - TAROLC in X-life quality

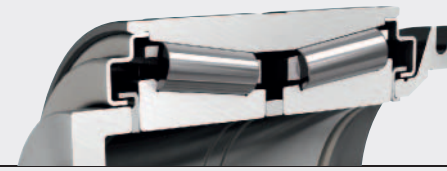
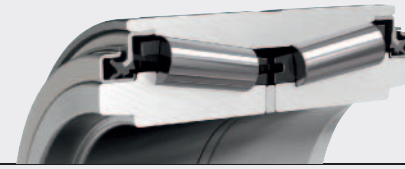
1) The suffixes X and S are not used for new designs.

Axlebox bearings

Identification

Designation	Definition
R	 **Base bearing (R)** (TAROL130/230-R-TVP) Base bearing comprising: - one outer ring - two inner rings - two rows of rollers with cages - one intermediate ring
G	 **Greased base bearing (G)** (F-617304.TAROLC3030A-G) Base bearing: - sealed - greased
B	 **Base unit (B)** (F-587314.TAROL130/230-B) Bearing unit comprising: - base bearing (R) - sealed - greased Further accessory parts can be fitted or a base unit comprising: - base bearing (G) Further accessory parts are definitively fitted

Identification (continued)

Designation	Definition
U[1)]	 **Complete unit (U)** (F-572309.TAROL130/230-U-TVP) Bearing unit comprising: ■ base bearing ■ sealed ■ greased ■ with all necessary accessory parts for complete axle mounting
BC[1)]	 **Base unit in compact design (BC)** (F-568142.02.TAROL-BC-TVP) Bearing unit comprising: ■ base bearing of compact design ■ sealed ■ greased Further accessory parts can be fitted, but not complete as in the case of the bearing unit UC
UC[1)]	 **Complete unit in compact design (UC)** (F-572086.02.TAROL-UC-TVP) Bearing unit comprising: ■ bearing unit of compact design ■ sealed ■ greased ■ with all necessary accessory parts for complete axle mounting

1) Designation no longer used for new designs.

Designation structure

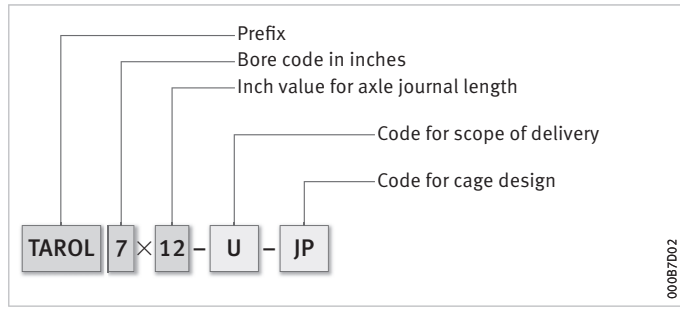


Figure 6
Inch size TAROL with dimensions in whole numbers

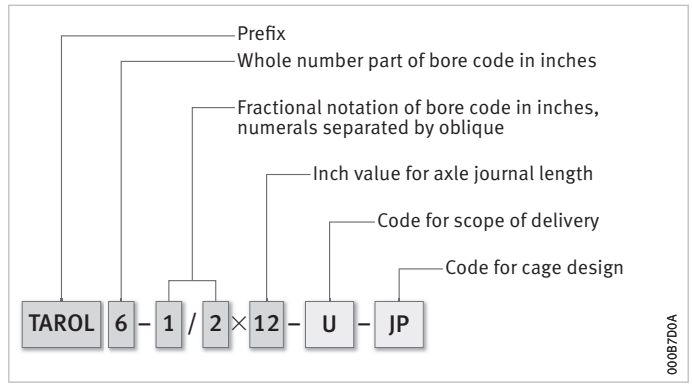


Figure 7
Inch size TAROL with dimensions in fractions

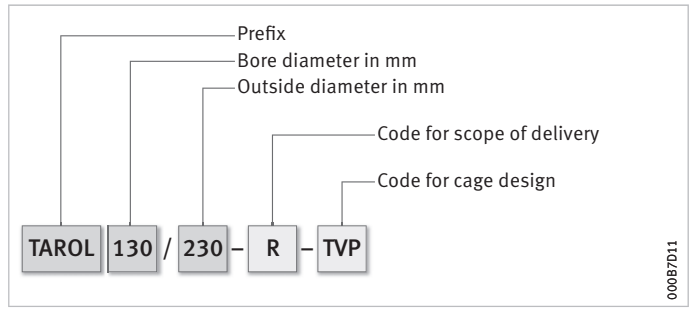


Figure 8
Metric size TAROL

Identification of the cage design is not used in the case of new designs.

Ordering designation

For customer-specific designs, the ordering designation is preceded by a drawing number:

- F-607804.TAROLC7×12-G
- F-604048.01.TAROL130/240.

The scope of delivery is identified from table, page 12.

In the case of metric size TAROL bearings, the bore and outside diameter can be stated in a combined form without an oblique, for example TAROL3040-R corresponding to TAROL130/240-R.

Axlebox bearing arrangement with cylindrical roller bearings

Cylindrical roller bearings and cylindrical roller bearing units

Cylindrical roller bearings have been a proven solution in axlebox bearing arrangements in all types of railway vehicles for decades, *Figure 9*. They have undergone progressive development and their performance capacity has therefore been matched to the requirements of modern rail vehicles. Cylindrical roller bearings are supplied as standard with cages made from glass fibre reinforced polyamide.

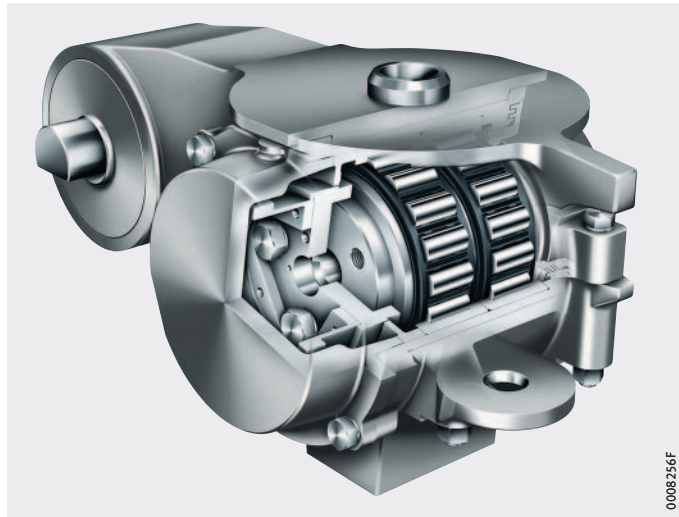


Figure 9
Axlebox bearing for Coradia

Single row cylindrical roller bearings

Compared to other conventional bearing types in wheelsets (such as TAROL units or spherical roller bearings), single row cylindrical roller bearings have the advantage that they can be easily dismounted (without the use of tools) into an inner ring and an outer ring with a roller and cage assembly. This offers the user practical benefits in relation to mounting, dismounting, maintenance and inspection. Single row cylindrical roller bearings are interchangeable. Assembling an outer ring and roller and cage assembly with an inner ring results in the internal clearance marked on the inner ring.

Single row cylindrical roller bearings to DIN 5412-11 with the designation WU, WJ and WJP comprise an inner ring and outer ring with a self-retaining roller and cage assembly, *Figure 10* and *Figure 11*. The rolling bearing for a wheelset usually comprises a pair of WJ and WJP bearings of the same size. The bearings are not supplied greased and sealed and have to be greased during assembly. A suitable sealing arrangement is particularly important for axlebox bearing housings.

Figure 10
Single row cylindrical roller bearing WJ

Figure 11
Single row cylindrical roller bearing WJP

Cylindrical roller bearing units

Cylindrical roller bearing units are double row bearing units with two cylindrical roller and cage assemblies, *Figure 12*. As with the TAROL units, the bearings are supplied greased and sealed. The units are greased using a grease approved in accordance with the standard EN 12081 and are usually sealed with a sheet metal cap seal. The type of grease and sealing design is dependent on the individual application.

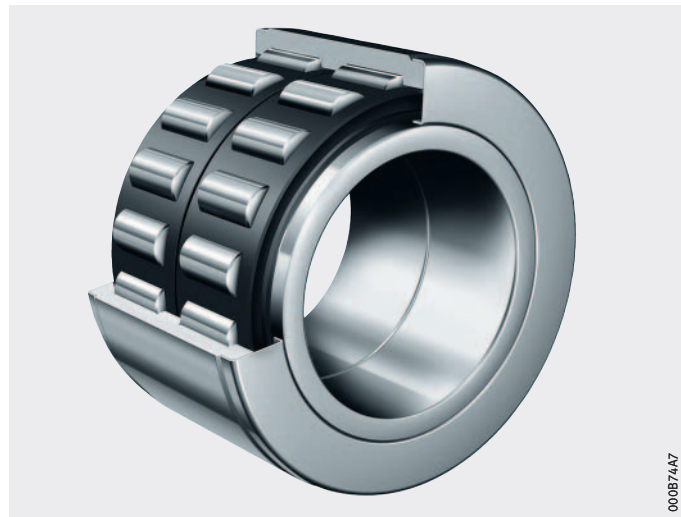


Figure 12
Cylindrical roller bearing unit

The use of cylindrical roller bearing units goes hand in hand with the desire for extended maintenance intervals compared to the classic WJ or WJP arrangements. These units are therefore optimised to a more uniform contact pattern. The bore and outside diameters are manufactured to tight tolerances; the raceway diameters and enveloping circle diameters on the roller and cage assemblies are matched.

As with TAROL bearings, accessory parts such as a backing rings, end caps and fasteners are required for mounting wheelsets comprising single row cylindrical roller bearings or cylindrical roller bearing units onto the shaft journal. Design and dimensioning are in accordance with customer requirements.

Axlebox bearings

Composition of designations

The designation of single row bearings in accordance with the standard DIN 5412-11 comprises the design code, a dimensional block for inside diameter x outside diameter, and a designation for the cage design. An additional P is added for the inner ring design WJP if the rib washer is also supplied.

Single row cylindrical roller bearings in special designs or even bearings in standard sizes (NJ, NJP) in axlebox bearing designs are allocated a drawing number.

Double row bearing units with or without accessory parts are always special bearings and therefore have a drawing number.

Examples of designations:

- WJ130×240-TVP
- WJP130×240-P-TVP
- Z-579021.ZL
  (design NJP, TVP)
- Z-579020.ZL
  (design NJ, TVP)
- F-809100.ZL
  (double row unit, TVP cage, sheet steel metal cap).

Designation

Designation	Description
F, Z	Designation for drawing number
P	Rib washer
TVP	Polyamide cage
WJ, WJP	Cylindrical roller bearings, designation to DIN 5412-11
ZL	Cylindrical roller bearings

Axlebox bearing arrangement with FAG spherical roller bearings

Schaeffler supplies spherical roller bearings for axlebox bearings with a fixed inner ring rib and a solid brass or sheet steel cage.

When a spherical roller bearing is used, axle deflection can be compensated without any additional forces. Spherical roller bearings are used in wheelsets on freight wagons, locomotives and other rail vehicles.

Figure 13
Spherical roller bearing arrangement for freight wagons

Due to their internal design, spherical roller bearings have high internal slippage which leads to increased demands on the grease. We therefore recommend the use of other rolling bearing designs in order to extend the maintenance intervals.

Special non-locating bearing arrangement

Vehicles in local public transport frequently have a low-floor design to provide barrier-free boarding onto the vehicle. Modern low-floor trams offer not only the comfort of low-floor access but also free passage from the front to the rear of the vehicle. The low-floor component means that it is not possible to install continuous wheelset shafts in the chassis. A portal design is used instead in which the wheels are supported in a fixed frame. Unlike in wheelset arrangements, the wheels can move independently of each other at different speeds in chassis with a non-locating bearing arrangement. Insert bearings are used here or a bearing arrangement comprising primarily tapered roller bearings.

FAG insert bearing arrangements

FAG insert bearing arrangements comprise a pair of tapered roller bearings, *Figure 14* and *Figure 15*. The inner rings of both bearings are manufactured to a sufficiently high accuracy that the required preload is achieved once they are mounted in the wheel unit. FAG insert bearings are a derivative of truck trailer bearing arrangements.

FAG insert bearings are sealed and lubricated to the next maintenance interval during assembly. The anticipated maintenance intervals are at least 500 000 km.

The preload in the bearing results in optimum load distribution and therefore significantly higher rating life. The internal bearing geometry also ensures good running characteristics under preload (low friction).

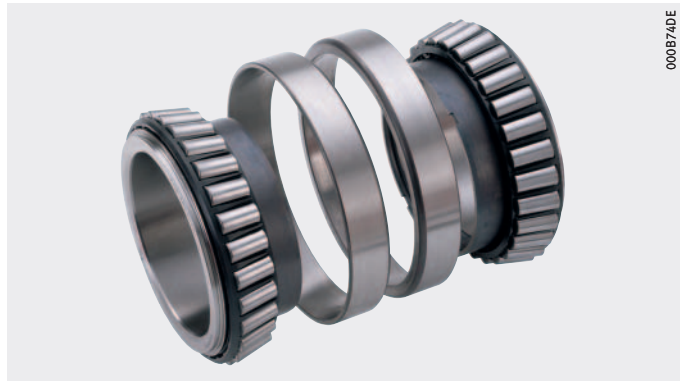


Figure 14
Insert bearing arrangement

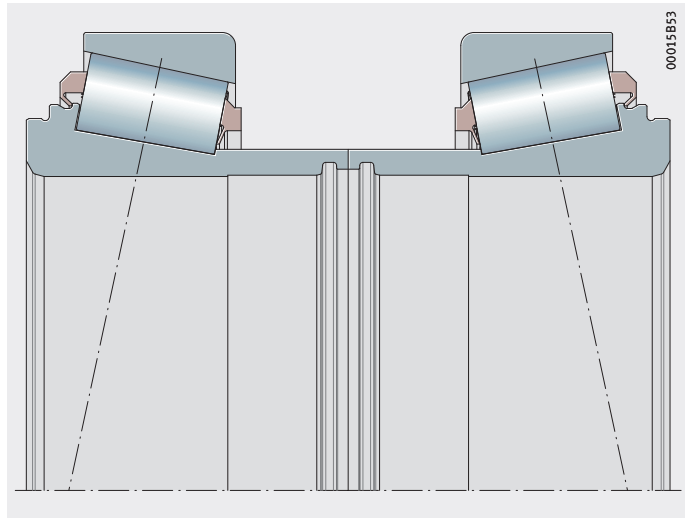


Figure 15
Cross-section
of insert bearing arrangement

FAG insert bearing arrangements make assembly easier and require significantly less space compared to previous solutions, but have a comparable rating life.

FAG insert bearing arrangements are characterised by the following features:

- low space requirement due to compact design
- seals can be integrated
- easy assembly (no adjustment work required which reduces the potential for error)
- use of improved materials/heat treatment
- operation with preloaded bearing unit and optimised internal design (e.g. profiles, rib angles)
- beneficial pressure distribution within the bearing arrangement, primarily when the unit is under moment loading
- increased rigidity due to preloaded unit.

Bearing sets with current insulation

The bearing arrangement can be made up of special bearings if required by the geometry or load carrying capacity. Special bearings can be more flexibly designed and an optimum design can be found for the bearing arrangement to suit the demands of the design brief.

Single row tapered roller bearings are most frequently used.
If there is a risk of current passing through the bearings, an outer ring coated with Insutect A can be used. Insutect A is an aluminium oxide ceramic coating.

Axlebox bearings

Marking

Rolling bearings in wheelsets are permanently marked on a visible surface in accordance with EN 12080. Schaeffler uses laser marking as standard. If required by the specification, for example, for inch size TAROL bearings in accordance with AAR specifications, stamping is also possible. The primary data for TAROL bearings is also identified in a circumferential groove on the outside surface.

Marking metric TAROL bearings and cylindrical roller bearings

The data for rolling bearings are entered consecutively on the identification surface and are separated by spaces.

The marking comprises the following:

- trademark
- country of manufacture
- product designation
- notification of EN 12080 CLASS1
- date of manufacture
- consecutive number.

Marking

Characteristic	Definition
Brand	FAG
Country of origin	Country in which the last significant production steps were carried out. Axlebox rolling bearings are manufactured in the following countries: - GERMANY cylindrical roller bearings, TAROL, spherical roller bearings - ITALY cylindrical roller bearings, TAROL - CHINA cylindrical roller bearings, TAROL - AUSTRIA insert bearings, tapered roller bearings - INDIA cylindrical roller bearings, TAROL, spherical roller bearings - ROMANIA cylindrical roller bearings, TAROL
Product designation	Complete designation of the base bearing
Notification of EN 12080	Bearing corresponds to EN 12080 CLASS1
Date of manufacture	Month and year of manufacture, 2 digits for each separated by a hyphen or dot (MM-YY)
Consecutive number	Bearing (units) of a specific design are given a number from 00001 to 99999. This then starts again at 00001. The consecutive number can be omitted for individual cylindrical roller bearings

Marking inch size TAROL bearings

Markings for inch size TAROL bearings are derived from the AAR Specification Section H (M 934).

Position of the designation

Cylindrical roller bearings and cylindrical roller bearing units are marked on the end face.

Individual cylindrical roller bearings are marked on the outer ring, inner ring and rib washer.

TAROL bearings are marked on the outside surface of the outer ring (in a central circumferential direction) or, if requested by the customer, on the end face. The inner rings are marked with the designation of the base bearing on the large external end faces.

Complete TAROL units comprise a base bearing and special accessory parts. In this instance, the designation for the complete unit is also marked on one of the recessed outer edges of the outside surface.

Figure 16
Marking

The accessory parts on complete units are marked with the component designation. This may differ from the complete designation for the bearing.

Special features:

- To identify the mounting direction for metric TAROL units, one inner ring is marked with an “A” and the other with a “B”. After mounting, the “A” side should be visible on the shaft end.
- On individual cylindrical roller bearings, the outer ring can be marked with a WU, irrespective of the inner ring design.

Material, heat treatment and internal freedom from defects

Cylindrical roller bearings are generally manufactured from through-hardening rolling bearing steel with bainitic heat treatment. Depending on the customer requirements, FAG TAROL units are made from either chromium steel with bainitic heat treatment or case hardening steel with surface hardening.

Schaeffler uses premium quality chromium steel for use in high speed applications to ESR quality. All components are subjected to the inspections required for EN 12080 CLASS 1 in order to ensure they are free from defects.

Required inspections include:

- ultrasound inspection to ensure the rings are free from internal defects
- magnetic particle inspection to check for cracks in the surfaces of the rings
- eddy current testing for rolling surfaces.

FAG TAROL units and cylindrical roller bearings for axlebox bearing applications comply with EN 12080 CLASS1.

TAROL units in inch sizes comply with Association of American Railroads (AAR) specifications or, if required, EN 12080 CLASS 1 as well.

Spherical roller bearings are manufactured from chromium steel with a bainitically hardened inner ring. Insert bearings are manufactured from chromium steel.

X-life

X-life is the premium brand that identifies particularly high performance products within the INA and FAG brands. They are characterised by a longer rating life and operating life, due to higher basic dynamic load ratings compared to the previous standard.

X-life opens up expanded design possibilities:

- X-life bearings have a greater service and rating life under the same load and without altering the design envelope. Maintenance intervals are also extended.
- Conversely, an X-life bearings in the same design envelope and with the same rating life can support higher loads.
- Where the rating life and load remain unchanged, X-life bearings allow higher performance density, facilitating optimisation of the design envelope and reductions in mass.
- X-life bearings therefore make a significant contribution to improving the overall efficiency.

Product characteristics

- Improved raceway surface
- Optimised inner ring rib and raceway geometry
- Improved rolling bearing geometry
- Improved material quality
- Improved heat treatment.

Technical benefits

- Up to 18% higher basic dynamic load ratings C_r
- Up to 70% longer rating life
- Reduced friction
- Lower operating temperatures
- Greater accuracy
- Reduced grease loading.

Customer benefits

- Longer operating time
- Greater reliability and availability
- Greater useful load capacity
- Lower system costs (TCO/LCC)
- Longer maintenance intervals
- Reduced energy consumption.

High Capacity TAROL (HCT)

High Capacity TAROL (HCT), *Figure 17*, are a new development from Schaeffler and a new performance class, specifically for heavy freight traffic. The increased performance capability is achieved by using the new Mancrodur material quality with a special heat treatment process.

Figure 17
High Capacity TAROL (HCT)

Carbon nitrided Mancrodur is a new rolling bearing material for extended operating life under heavy-duty operating conditions.

For years, material technologists have been striving to make rolling bearing steels which are less sensitive to mixed friction conditions or contamination with foreign particles. These conditions also occur in railway technology. Significantly reduced bearing operating life or premature failure can lead to extremely high on-costs in this sector.

With carbon nitrided Mancrodur, Schaeffler has found the answer to a long-standing conflict of interests in the development of rolling bearing materials: the new steel, when combined with carbonitriding heat treatment, i.e. a combination of carburisation and nitriding, offers both a high surface hardness and a high ductility when compared to other steels. Carbon nitrided Mancrodur produces fine, spherical carbides which are uniformly distributed in the material and are less concentrated around the grain boundaries. This reduces the risk of local weak points

which in turn allows bearings to be produced with very hard, wear-resistant raceways with a high load carrying capacity and a sufficient ductility to be able to tolerate well the deformations cased by over-rolling of hard foreign particles. Specifically, when operating under mixed friction conditions or contamination, this results in a significant increase in the operating life for rolling bearings made from Mancrodur.

Bearings made from carbon nitrided Mancrodur offer a basic load rating which is 30% greater than those made from standard materials. Under normal lubrication conditions (full lubrication), this is comparable to doubling the nominal operating life.

Product characteristics	■ Tapered roller bearing unit (TAROL) for applications in heavy freight transport ■ Bearing unit can be retrofitted to existing shaft journals ■ Ring components made from the new Mancrodur case hardening steel ■ Optimised ring and roller raceway profile ■ Reinforced polyamide cage ■ Cartridge seal with optimised friction properties ■ Special retaining ring between inner and support ring for easy and safe bearing assembly.
Technical benefits	■ Up to 30% increase in basic load rating compared to standard TAROL ■ Dimensional stabilisation up to +200 °C ■ Reduced pressure peaks in the load zone ■ Special quality ring steel with increased material purity ■ Carbonitrided bearing rings with increased resistance to fatigue ■ Reduced fretting corrosion.
Customer benefits	■ Increased useful load or double the nominal rating life compared to standard TAROL bearings under the same load ■ Increased reliability when operating under extreme loads ■ Suitable for reconditioning stock ■ Suitable for automated assembly process ■ Increased return and reduced overall costs (TCO) ■ Possible optimisation of design envelope.

Components

The axlebox bearings can be optimally matched to the required operating conditions through appropriate selection and combination of the cage, seal, retaining ring, coating and grease components.

Cages

Schaeffler supplies tapered roller bearings and cylindrical roller bearings with glass fibre reinforced polyamide cages (designation TVP). Polyamide is a construction material with a high load capacity which many industries can no longer do without. For example, plastic cages are used as standard in rolling bearings for the automotive industry. Since the end of the 1980s, polyamide cages have become the standard for TAROL and cylindrical roller bearings in the railway industry.

Polyamide cages have many benefits, from low mass, through increased grease life and very good emergency running characteristics, to longer bearing rating life, lower friction and low-noise running.

Schaeffler obviously also supplies polyamide cages as individual replacement parts.

Figure 18
Polyamide cage

Sheet steel cages for inch size TAROL bearings are required to meet AAR specifications. Solid brass cages are often available as an alternative for cylindrical roller bearings.

Rolling bearing seals

The rolling bearings in axlebox bearings only achieve the target service life if the grease is not allowed to escape from the bearing and the ingress of moisture and contaminants is prevented.

The **compact seal**, also known as a cartridge seal, comprises a sheet steel component with a moulded sealing lip and a second sheet steel element which encloses the sealing lip to form a cartridge arrangement. The elastomer component comprises three sealing lips and an outer seal. The outer seal is located outside the cartridge and is intended to prevent the ingress of spray water and coarse contamination. The main sealing lip and the other sealing lips are located inside the cartridge. The main lip is a gap seal acting as a pressure compensator between the bearing interior and the cartridge and is primarily intended to retain the grease in the bearing. The two other lips are designed to prevent grease escaping and the ingress of moisture and contamination.

As the sealing lips have only a minimal preload, the cartridge seal has a very low frictional torque (low friction seal). The inner surface of the cartridge forms the running surface for the seals.

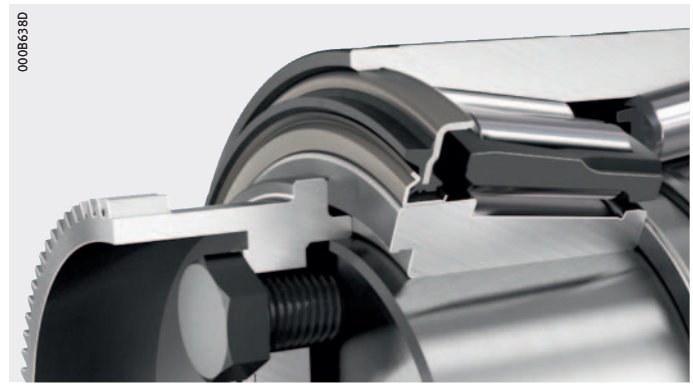


Figure 19
TAROL unit with compact seal

Cartridge seals are primarily fitted to compact TAROL units. The cartridge sits on the extended inner ring rib. An additional support ring for the seal is not required. The cartridge seal is suitable for operating in open adapters.

WJ/WJP cylindrical roller bearings and spherical roller bearings are not sealed. In this case, the housing seal must be designed such that it prevents the ingress of contamination and moisture into the interior of the housing. Design measures must be put in place to retain the grease in the bearing.

Closed housings are usually sealed on the covered side with an O-ring. Suitable seals must be provided on the wheel side to prevent the ingress of water, moisture and contamination, see page 48.

Contact or non-contact sealing elements can be used as bearing seals. Non-contact **sheet steel metal caps** are usually used in closed housings. These are simple sheet steel caps or labyrinths made from interlocking metal elements, *Figure 20*, or systems with **lamellar sealing rings**, *Figure 21*. These seals are not only effective and space-saving but also economical.

Figure 20
TAROL unit
with sheet metal cap seal

Figure 21
TAROL unit
with lamellar sealing rings

Rotary shaft seals and compact seals are used as contact seals. Rotary shaft seals are common when using open adapters where AAR specifications apply. These seals consist of a sheet steel element with a moulded elastomer sealing lip which runs on a seal support ring. Sealing lips are usually spring-preloaded and run under preload on the seal support ring. As the seals are unprotected in open adapters, these seals have a particularly robust design. Spring-preloaded seals exhibit high friction when running at higher speeds.

Figure 22
TAROL unit
with rotary shaft seal

TAROL type axlebox bearings and cylindrical roller bearing units are sealed at the factory. Insert bearings are fitted with two seals during assembly which provide sealing between the outer ring seating and the inner ring rib.

Retaining ring

The retaining ring centres the support ring and the end cap on the inner ring. The retaining ring centres and holds the support ring when mounting the bearing unit with support ring. The retaining ring is load-free after mounting.

The end cap is located in the inner ring by the retaining ring. This ensures that the end cap cannot fall out before the axle bolts are fitted.

The patented sealing ring fitted on the outside diameter of the retaining ring performs a further important function. This sealing ring is positioned such that the joint between the end face of the inner ring and the support ring is sealed once the retaining ring is mounted. The O-ring in the axial face of the support ring is therefore superfluous. A large seating surface is therefore possible which helps prevent the onset of fretting corrosion.

The retaining ring is sized such that it keeps the support ring and inner ring in place during transport and can safely support the mass forces from the support ring or end cap when unpacking and during mounting. This should ensure injuries such as squashing are avoided.

The retaining ring holds the parts together during dismounting. The retaining ring is easy to dismount to refurbish the bearing.

The retaining ring is a special part. If required, if can be used for all common TAROL sizes.

The retaining ring is made from polyamide.

Figure 23
Retaining ring

Figure 24
Retaining ring installation position

Accessory parts

In addition to the rolling elements and housing, a complete axlebox bearing unit also consists of a support ring, the axle cap, the bolts and the bolt retention elements. Depending on the specific application, the axlebox bearing unit may also have other components such as sealing support rings or spacers. These components are designed to customer specification. For inch size TAROL units to AAR specifications, the accessory parts are standardised and interchangeable.

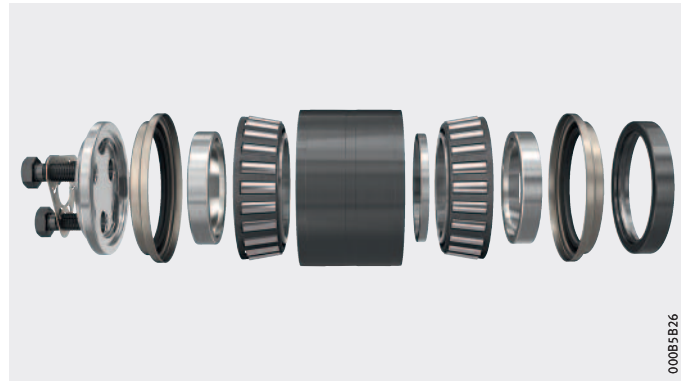


Figure 25
TAROL tapered roller bearing unit

The accessory parts are designed such that they can transmit the assembly forces and operating forces.

The support ring is tasked with transferring the assembly and operating forces safely from the bearing to the step on the wheelset shaft.

Axlebox bearings

Above all, TAROL bearings must be slid onto the shaft journal with a defined axial mounting force so that the inner rings do not move about during operation. Due to their geometry, TAROL bearings also produce a force component which acts in the axial direction when under radial load. The support ring must be firmly seated on the inner ring end face and the shaft step so that it can transmit these forces without any settling phenomena and micromovements. The wheelset shaft is subject to shaft deflection. If there is insufficient contact force, there is a tendency for fretting corrosion to occur at the contact points in the unit.

The axle cap secures the bearing unit axially after mounting and retains the axial preload forces applied during assembly. In order to ensure this remains during operation, the axle cap has to deform when the axle bolts are tightened so that settling phenomena are compensated by a disc spring effect. If other parts are included in the force flow between the axle cap and the support ring, for example, sealing support rings, these must be designed so that they can safely transmit the effective axial preload forces and operating forces.

Hexagon head screws are usually used for tightening and are tightened to the prescribed torque. The bolts are retained to ensure they do not come loose. Retaining plates, locking wire or locking washers are used to retain the bolts.

See publication TPI 156, Tapered Roller Bearing Units TAROL for further information on mounting axlebox bearings.

Coating

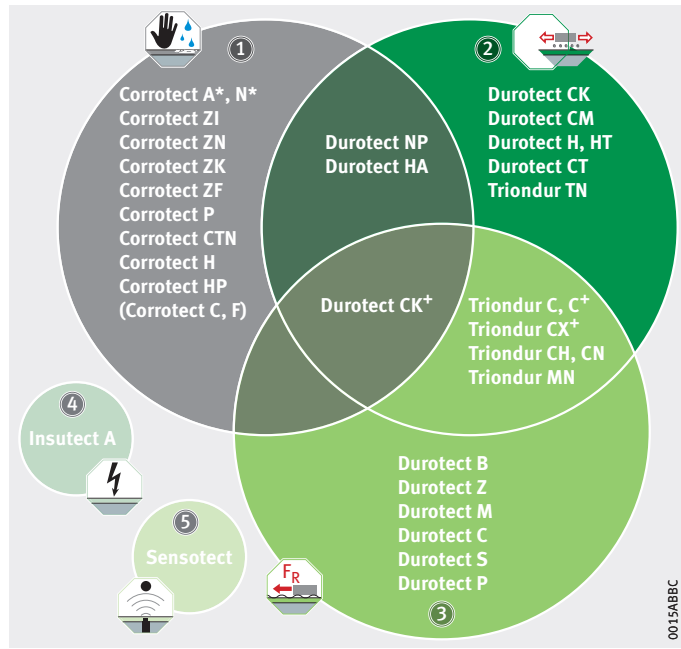
Overview

Bearings and precision components from Schaeffler offer high performance capacity and a long operating life. They provide the user with thoroughly developed and economical solutions for a significant majority of requirements. The characteristics of the components can be expanded by the use of suitable coating systems, thus offering the customer advantages in the application. The Schaeffler modular coating concept provides a specific solution for the customer with the coating as a design element.

Through the prevention of corrosion and wear, Schaeffler coating systems contribute to the conservation of resources, as the operating life of the components is significantly extended. By reducing friction, the coatings contribute to energy efficiency in the form of lower energy consumption.

The coating systems are applied to the surface by a wide variety of methods. They should always be individually matched to the mounting situation. In many cases, it is sufficient to coat only one of the components in rolling contact or only a part thereof.

An overview of the coatings used by Schaeffler arranged by their main areas of use can be found in TPI 186, Higher Performance Capacity Through the Use of Coatings. The properties, features and benefits are given for each type of coating. Specific examples and references are shown.



① Corrosion protection
② Wear protection
③ Friction reduction
④ Current insulation
⑤ Sensor technology

Figure 26
Coating systems and their areas of application

Axlebox bearings

Coating systems in axlebox bearings

The main requirements on the coating in axlebox bearings are:

- friction reduction
- wear protection
- prevention of fretting corrosion.

The most suitable option from the Schaeffler range of coatings for these requirements is Durotect Z (zinc phosphate).

Durotect Z

Features	Benefits
■ Colour: grey/black ■ Coating structure: zinc phosphate thickness 1 µm to 10 µm	■ Anti-corrosion protection in oiled condition (salt spray test to DIN EN ISO 9227 up to 48 hours against red rust formation) ■ Prevention of fretting corrosion in the bearing seat ■ Reduction in friction facilitates the sliding action when mounting and dismounting with a hydraulic unit

In non-locating bearing arrangements, it is possible for the bearings to be damaged by the passage of current. One solution here is to use bearings with an Insutect A coating (aluminium oxide). TAROL axlebox bearings are occasionally damaged by the passage of current. The Isotect A coating is a good remedial solution in these instances.

Insutect A

Features	Benefits
■ Colour: light grey to matt beige ■ Coating structure: ceramic coating comprising aluminium oxide Al_2O_3 with sealant ■ Coating thickness 100 µm to 200 µm, or more on customer request	■ Current insulation according to coating type, resistance to current puncture up to 3 000 V ■ Anti-corrosion protection

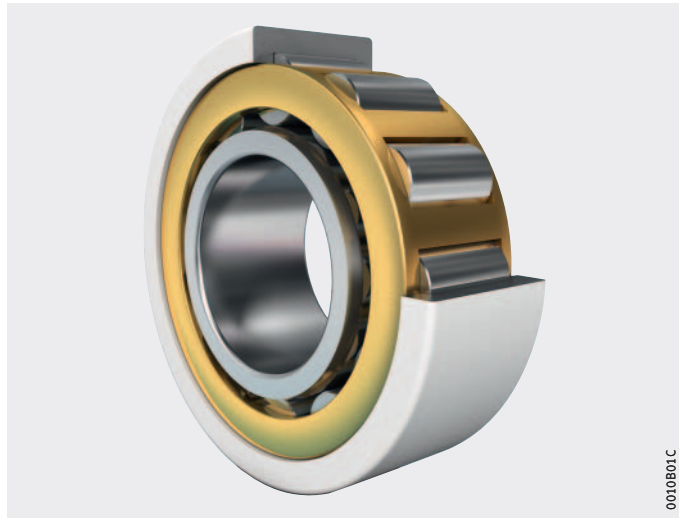


Figure 27
Ceramic-coated cylindrical roller bearing

Depending on the demands on the bearings or components, other options are available from the Schaeffler range of coatings, for example, Corrotect for sheet metal caps. Our specialists are always available to advise.

Further information

- TPI 206, Current-insulating Bearings
- TPI 186, Higher Performance Capacity Through the Use of Coatings.

Lubricating greases

Special rolling bearing greases such as Arcanol offer the best conditions for achieving reliable, durable and cost-effective bearing arrangements. Arcanol gives you certainty, as Schaeffler carries out selection tests, provides quality assurance and gives practice-based lubrication recommendations. Bearings that fail prematurely because they were lubricated with the wrong grease, with all the unpleasant and expensive consequences, are increasingly a thing of the past.

We have been developing lubricants that are particularly suitable for rolling bearings for many years in collaboration with renowned lubricant manufacturers. However, before a new grease can be included in the Arcanol range, it is subjected to a series of tests in the Schaeffler lubricant laboratory where greases are tested in rolling bearings for rating life, friction and wear. Our strict quality controls ensure consistent characteristics. The greases we use take into consideration the requirements of the relevant norms and standards such as UIC, EN, DIN, AAR and others.

The Arcanol range of greases is designed to cover nearly all application areas, from standard greases to high quality special greases, *Figure 28*.

Figure 28
Arcanol rolling bearing grease

Schaeffler uses greases approved to EN 12081 or with AAR approval for the safe operation of axlebox bearings. These greases are also successfully used by the operating companies during travel.

The greases used cover a wide range of application areas such as suitability for load and speed, a wide range of temperatures, water resistance and long operating life. The selection of a suitable grease is determined by the specific details of the particular application.

FAG TAROL axlebox bearings and cylindrical roller bearing units are greased and sealed at the factory. The grease is distributed such that the bearing has as short a running-in time as possible. However, the grease must still be distributed during operation; higher bearing temperatures may occur during the distribution phase.
The running-in time may last several hours.

FAG cylindrical roller bearings WJ/WJP, spherical roller bearings and insert bearings are not greased at the factory. These bearings are greased during mounting with the grease type, quantity and distribution specified in the mounting manual.

Schaeffler does not recommend relubrication during operation as this can lead to contamination and overgreasing. Also, there is no guarantee that the used grease is forced out of the bearing and replaced with new grease.

The type and quantity of grease in FAG axlebox bearings is selected such that the agreed maintenance intervals will definitely be achieved if the specified operating conditions are maintained.

Rolling bearings refurbished in house by Schaeffler have the same grease properties as new bearings.

The length of the maintenance interval is determined by the choice of grease depending on the operating conditions such as the annual distance travelled, the average trip distance between two stops, the frequency of braking and start-up procedures, the average speed of travel and loading, and possible downtimes. Maintenance intervals up to 1.65 million kilometres are possible with favourable operating parameters and corresponding operational experience. The objective for the future in high-speed travel is intervals up to 2.0 million kilometres.

The ingress of contamination and moisture, bearing wear and non-standard operating conditions can have a negative effect on the grease operating life and lead to premature failure of the grease or to a reduction in the operating life.

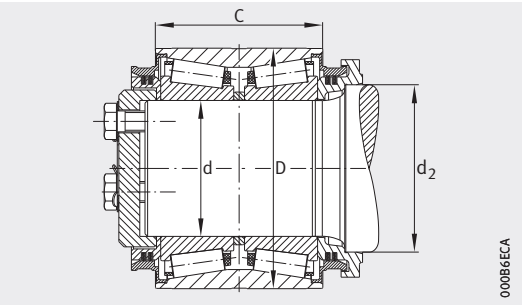
Operating limits and areas of application

Characteristic	Grease designation		
	L218	L222	L224
Specification	GA41	GA40	GA40
Operating limits	Axlebox bearing grease > 200 km/h	Axlebox bearing grease < 200 km/h	Axlebox bearing grease < 200 km/h
Typical areas of application	■ ICE high-speed train	■ Axle bearings in rail vehicles ■ Freight wagons, assenger carriages and powered units ■ Area of application: SNCF/SNCB	■ Axle bearings in rail vehicles ■ Freight wagons, passenger carriages and powered units ■ Area of application: DB
Application criteria	■ High speed applications ■ Extended maintenance intervals ■ Good sealing of labyrinths ■ Good wear protection	■ Mean rolling bearing diameter up to 185 mm ■ Wheel diameter up to 800 mm ■ Excellent water resistance ■ Good corrosion protection ■ Good oxidation resistance	■ Mean rolling bearing diameter up to 185 mm ■ Wheel diameter up to 800 mm ■ Excellent water resistance ■ Good corrosion protection ■ Good oxidation resistance
Approvals	DB	SNCF	DB
Thickener type	Lithium soap	Lithium soap	Lithium soap
Base oil	Mineral oil	Mineral oil	Mineral oil
NLGI grade	2 to 3	2 to 3	2 to 3
Base oil viscosity +40 °C	42	100	100
Base oil viscosity +100 °C	7	11	11
Operating temperature °C	–50 to +140	–20 to +120	–20 to +120
Continuous limit temperature °C	80	75	75
Copper corrosion DIN 51811	1/+120 °C	1/+100 °C	2/+100 °C
Emcor test DIN 51802	0/0	0/0	0/0
Behaviour in the presence of water DIN 51807-1	1 to 90	1 to 90	1 to 90
Speed limit $n \cdot d_m$ Ball bearings Cylindrical roller bearings	800 000 mm/min	400 000 mm/min	400 000 mm/min
Other roller bearings	350 000 mm/min	250 000 mm/min	250 000 mm/min

	L225	L293	L055	VIB3
	GA40	GA40	GA34	–
	Axlebox bearing grease < 200 km/h	Axlebox bearing grease < 200 km/h	Universal axlebox bearing grease	Axlebox bearing grease for strong vibrations
	■ Axle bearings in rail vehicles ■ Freight wagons, passenger carriages and powered units ■ Area of application: Europe, such as SBB	■ Axle bearings in rail vehicles ■ Freight wagons, passenger carriages and powered units ■ AAR 48 hour vibration test	■ Local public transport ■ Tram ■ Axlebox bearings in cold climates ■ Freight wagons	■ Axle bearings in rail vehicles ■ Trams and metro trains
	■ Mean rolling bearing diameter up to 185 mm ■ Wheel diameter up to 800 mm ■ Excellent water resistance ■ Good corrosion protection ■ Good oxidation resistance ■ Tested on Schaeffler test rig AN42	■ Excellent water resistance ■ Good corrosion protection ■ Good oxidation resistance ■ Long grease operating life ■ Tunnel traffic	■ Versatile application ■ Moderate to high load ■ Low starting temperatures ■ Other temperatures possible ■ Very wide range of temperatures possible ■ Good relubrication	■ High pressure absorption under shock loads ■ Low starting temperatures ■ Good starting friction
	For SBB, ÖBB, FS, RENFE and other rail operators	To AAR M-942-98	–	–
	Lithium soap	Lithium soap	Lithium soap	Lithium soap
	Mineral oil	Mineral oil	Mineral oil + PAO	Mineral oil
	2 to 3	1 to 2	2	3
	100	173	82	170
	11	14,5	12,5	14
	–20 to +120	–30 to +120	–50 to +140	–30 to +150
	75	80	80	90
	2/+100 °C	No code	2/+140 °C	–
	0/0	0/0	0/0	–
	1 to 90	1 to 90	1 to 90	–
	400 000 mm/min 250 000 mm/min	500 000 mm/min 350 000 mm/min	800 000 mm/min 350 000 mm/min	350 000 mm/min 200 000 mm/min

Tapered roller bearing units

TAROL
Metric

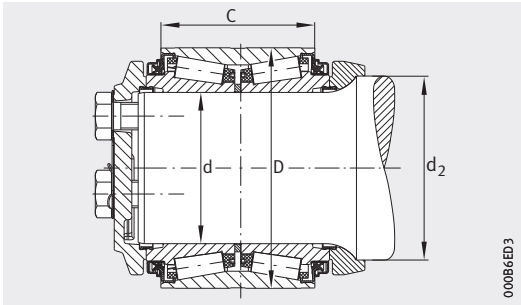


Lamellar seal

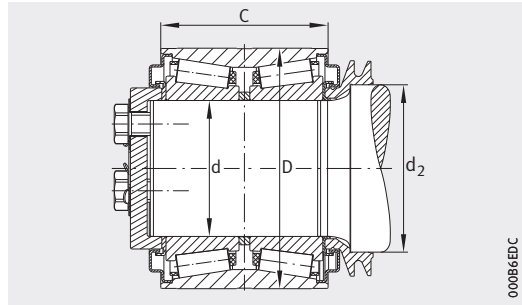
Dimension table · Dimensions in mm

Designation	Typical ordering designation of complete unit	Mass	
		Base bearing	TAROL unit
		≈ kg	≈ kg
TAROL90/154-R-TVP[1]	**F-567684.TAROL90/154-U**	7,5	13
TAROL100/165-R-JP	**Z-517874.TAROL100/165-U**	9,16	14
TAROL100/175-R-TVP	**F-579825.TAROL100/175-U**	10,7	16
TAROL110/180-R-TVP	**F-572314.TAROL100/180-U**	14	17
TAROL120/195-R-TVP[1]	**F-600318.TAROL120/195-U**	14,7	19
TAROL130/210-R-JP	**F-622659.TAROL3010-U**	16,7	24
TAROL130/220-R-TVP[1]	**F-617389.TAROLC3020A-U**	20	31
TAROL130/230-R-TVP[1]	**F-606759.TAROL130/230-U**	27,1	35
TAROL130/240-R-TVP[1]	**F-631814.TAROL3040-U**	28,9	37
TAROL140/220-R-JP	**F-574500.TAROL140/220-U**	18,5	26
TAROL150/250-R-TVP[1]	**F-622119.TAROL5050-U**	28,9	38
TAROL160/270-R-TVP[1]	**F-575890.TAROL160/270-B**	33	40
TAROL160/280-R-TVP	Ordering designation availableby agreement	–	–

[1] Size also available with JP cage.



Compact seal

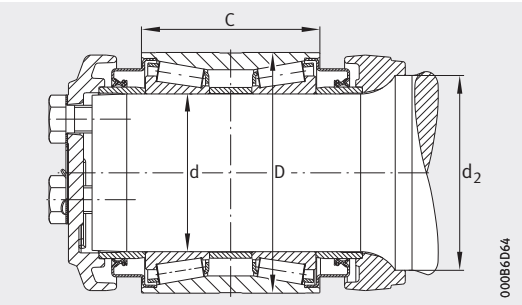


Sheet metal cap seal

Dimensions					Basic load rating
Bearings			Shaft		DIN ISO 281
d	D	C	d	d_2	C
					kN
90	154	115	90 n6	120	390
100	165	114,3	100 n6 (p6)	126 k8	415
100	175	120	100 n6 (p6)	126 k8	510
110	180	142	110 p6	140 t7	520
120	195	131,4	120 p6	138 t7	560
130	210	132	130 p6	150 t7	620
130	220	150	130 p6	160 t7	780
130	230	160	130 p6	160 t7	850
130	240	160	130 p6	160 t7	910
140	220	140	140 p6	160 t7	655
150	250	160	150 p6	170 t7	900
160	270	150	160 p6	190 t7	1 050
160	280	180	160 p6	189 k6	1 270

Tapered roller bearing units

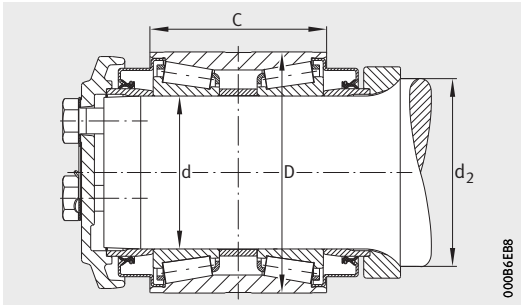
TAROL
Inch size



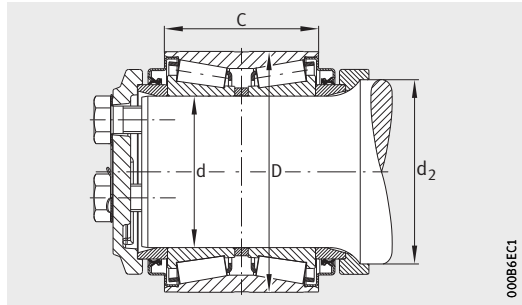
Class E, F, G, GG

Dimension table · Dimensions in mm and inch

Designation	Design	Size	Mass		Dimensions					
					Bearings					
					d		D_{min}		C	
	Class		lbs	≈ kg	inch	mm	inch	mm	inch	mm
TAROL4-1/4×8-U-JP	B	$4^1/_4 \times 8$	32,6	14,8	*4*	101,6	*6,5*	165,1	*4,5*	114,3
TAROL5×9-U-JP	C	5×9	54,7	24,8	*4,6875*	119,063	*7,6875*	195,263	*5,63*	142,9
TAROL5-1/2×10-U-JP	D	$5^1/_2 \times 10$	60,2	27,3	*5,187*	131,75	*8,1875*	207,963	*6*	152,4
TAROL6×11-U-JP	E	6×11	77	34,9	*5,687*	144,45	*8,6875*	220,663	*6,437*	163,5
TAROL6-1/2×12-U-JP	F	$6^1/_2 \times 12$	116,6	52,9	*6,187*	157,15	*9,9375*	252,413	*7,25*	184,15
TAROL6-1/2×9-U-JP	K	$6^1/_2 \times 9$	89,7	40,7	*6,187*	157,15	*9,8375*	249,873	*6,3*	160
TAROL7×12-U-JP	G	7×12	132,5	60,1	*6,9995*	177,787	*10,875*	276,225	*7,31*	185,74
TAROLGG6-1/2-U-JP	GG	$6^1/_2$	179,5	81,4	*6,4995*	165,087	*11,882*	301,803	*7,75*	196,85
TAROLGG6-7/8-U-JP	GG	$6^7/_8$	170,4	77,3	*6,8745*	174,612	*11,882*	301,803	*7,75*	196,85



Class B, C, D



Class K

Shaft						Basic load ratings		
						ABEC/RBEC		DIN ISO 281
d_{min}		d_{max}		d_2		C_1		C
inch	mm	inch	mm	inch	mm	lbs	kN	kN
4,003	101,676	*4,004*	101,702	*5*	127	106 000	475	415
4,6905	119,139	*4,6915*	119,164	*5,875*	149,225	146 000	655	560
5,1905	131,839	*5,1915*	131,864	*6,375*	161,925	160 000	720	620
5,6905	144,539	*5,6915*	144,564	*7,030 – 7,032*	178,562 – 178,613	170 000	750	655
6,1905	157,239	*6,1915*	157,264	*7,530 – 7,532*	191,262 – 191,313	232 000	1 040	900
6,1905	157,239	*6,1915*	157,264	*7,530 – 7,532*	191,262 – 191,313	232 000	1 040	900
7,003	177,876	*7,004*	177,902	*8,000 – 8,002*	203,200 – 203,251	265 000	1 180	1 020
6,503	165,176	*6,504*	165,202	*7,905 – 7,906*	200,79 – 200,81	300 000	1 530	1 320
6,878	174,701	*6,879*	174,727	*7,870 – 7,873*	199,898 – 199,974	300 000	1 530	1 320

Housings and seals

Housings for axlebox bearing arrangements
Materials
Anti-corrosion protection
Seals for axlebox bearing housings

Housings for axlebox bearing arrangements

As a connecting part between the vehicle bogie frame and the wheelset, the housing must reliably transmit the forces present. Axlebox bearing housings in locomotives, freight wagons and passenger trains in local public transport (trams, underground), regional and high-speed trains are subjected to many different demands.
In terms of the design, it is important to know how the forces are introduced into the housing. A housing of a suitable geometry will give a favourable pressure distribution in the rolling bearing, thus reducing the specific load and preventing the occurrence of stress peaks in the contact surfaces transmitting load. The considerations for the housing are therefore minimum mass and optimum feasibility.

Housing for freight transport with axles up to 25 t

- Approval for all spring systems
- Welded construction for the sliding plates and sleeve
- Spring support on both sides
- Single-piece housing.

Figure 1
Housing for freight transport with axles up to 25 t

Housing for passenger transport (double-decker carriages)

- Guide bushes to be pressed in
- Spring support on one side
- Rubber buffer on one side
- Split housing.

Figure 2
Housing for passenger transport (double-decker carriages)

Housing for locomotives

- Complex cast form with cast-on cover
- Spring support on both sides
- Single-piece housing.

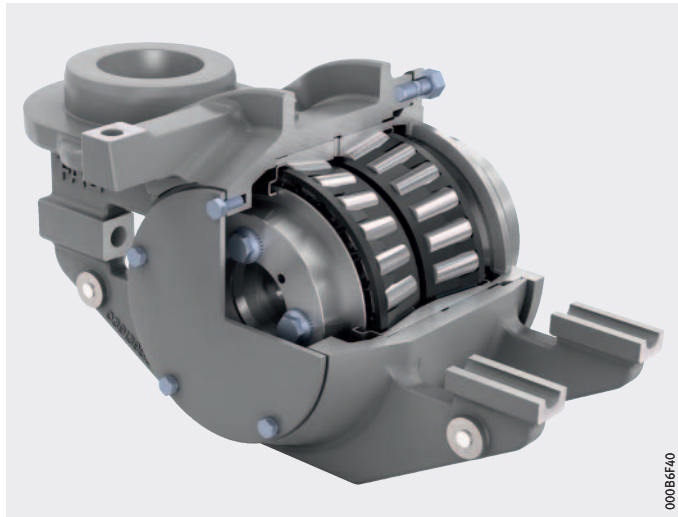


Figure 3
Housing for locomotives

Housing for trams

- Material: aluminium
- Spring support on both sides
- Compact design
- Single-piece and split housing designs possible.

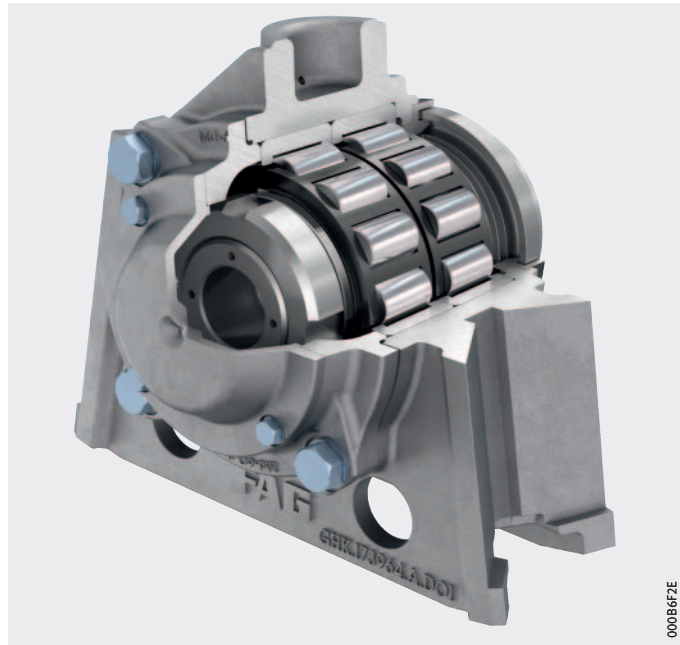


Figure 4
Housing for trams

High safety requirements are placed on the axlebox bearing housings. The design must be appropriate to the load arising from the operating conditions over long periods of several decades. In order to achieve this, a precise analysis of the loads occurring is necessary. For further information on calculation and inspection, see page 60.

Materials

The standard material for axlebox bearing housings is spheroidal graphite cast iron EN-GJS-400-18-LT. Depending on customer requirements in terms of characteristics such as mass, strength or weldability, other materials such as cast aluminium alloys or cast steel may be used.

Anti-corrosion protection

All outer surfaces of housings machined by methods that are not chip-forming are provided with a coating system. Inner surfaces and outer surfaces machined by chip-forming methods are provided with anti-corrosion protection. The paint systems used by large train operators are registered with Schaeffler and can be implemented without any problems. If there are particular requirements relating to paint coating and corrosion protection, special solutions are possible. If the customer has particular specifications, we check their feasibility and these can be implemented if the result is positive.

Seals for axlebox bearing housings

In order for a wheelset to retain its functionality, it is necessary to prevent the ingress of contaminant particles or liquids and the escape of lubricant. Sealing makes a very important contribution to maintaining the function of the wheelset. The fact that TAROL units and cylindrical roller bearing units are already sealed must be borne in mind. When using individual bearings such as WJ and WJP cylindrical roller bearings, particular emphasis must be placed on sealing against the ingress of contamination and moisture as well as the retention of the grease in the rolling bearing.

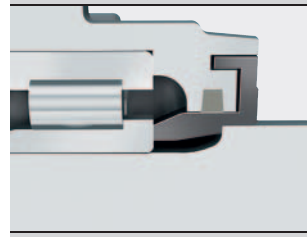
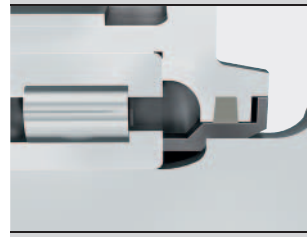
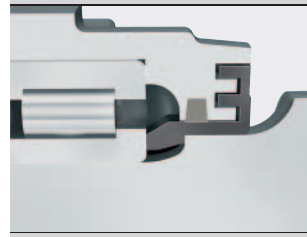
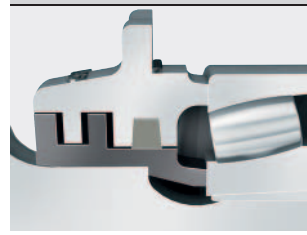
The seal types are differentiated into contact seals and non-contact seals. Based on the operating conditions present, the seal type most suitable for the application is then determined.

For example, contact seals cannot be used in the high speed sector in very many cases due to the high circumferential velocities and the resulting generation of heat. In contrast, contact seals are necessary in the tram sector where circumferential velocities are lower and the tracks may become flooded.

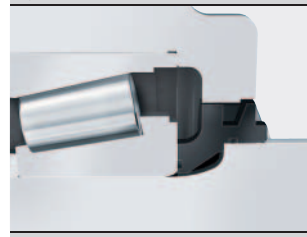
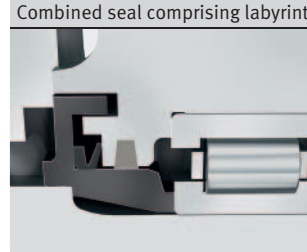
In order to cover the whole spectrum of operating conditions, there is a wide range of seal variants, see table, page 52. The seals used in axlebox bearing housings are designed for grease lubrication.

Other seal types such as labyrinth, lamellar rings or felt ring seals require more space and are more expensive to procure. The use of these types of seal is determined by the design brief.

Axlebox bearing housing seals

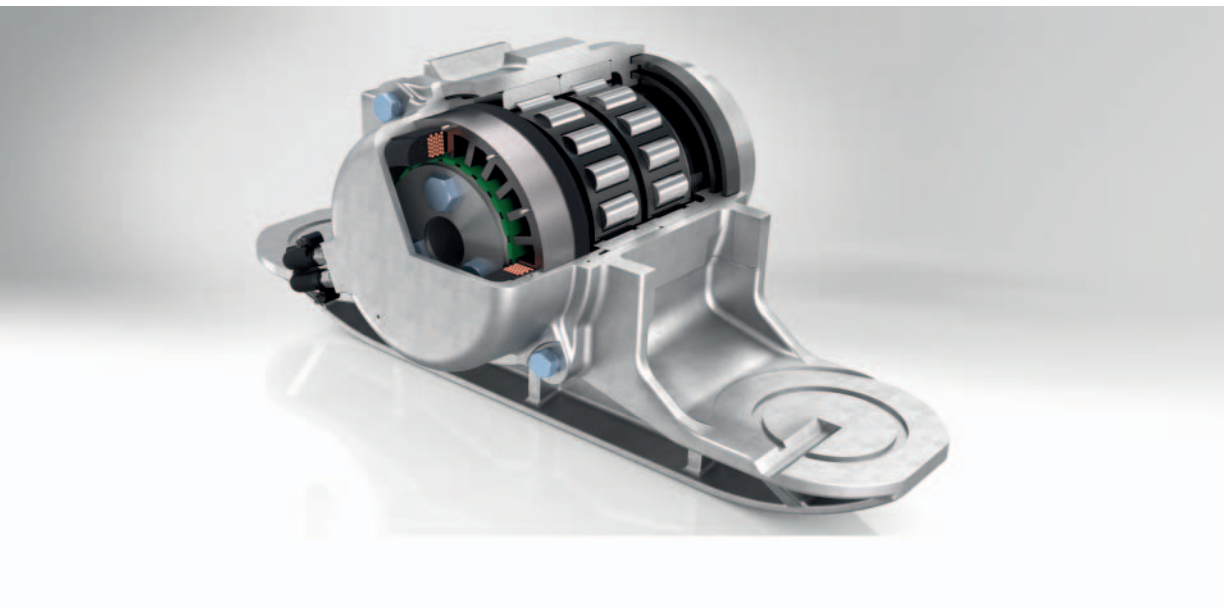
Seal	Properties
Single axial labyrinth seal	
	■ low space requirement ■ non-contact ■ improved sealing when combined with a felt seal, but then no longer a non-contact type
Single radial labyrinth seal	
	■ low space requirement ■ also possible with split housings ■ non-contact ■ improved sealing when combined with a felt seal, but then no longer a non-contact type
Double axial labyrinth seal	
	■ greater space requirement ■ better labyrinth sealing action ■ non-contact ■ improved sealing when combined with a felt seal, but then no longer a non-contact type
Double radial labyrinth seal	
	■ greater space requirement ■ better labyrinth sealing action ■ also possible with split housings ■ non-contact ■ improved sealing when combined with a felt seal, but then no longer a non-contact type

Axlebox bearing housing seals (continued)

Seal	Properties
Splash ring seal	
	■ simple design ■ for use only in conjunction with sealed bearing ■ suitable for use with split and unsplit housings ■ non-contact
Labyrinth seal with stuffing box packing	
	■ also suitable for high circumferential speeds ■ low space requirement ■ contact
Combined seal comprising labyrinth seal, felt seal and V ring seal	
	■ very good sealing action against ingress of foreign matter from outside ■ contact

Schaeffler has many years of experience in the development of axlebox bearing housings. In order to achieve the best possible solution for the relevant application, development is carried out in close partnership and consultation with the customer. In addition to volume housings for standard applications, such as Y25 housings for freight transport, Schaeffler also develops specially adapted designs in many projects for the specific loads and the available space. In order to improve customer proximity and availability, Schaeffler manufactures in many locations throughout the world.

FAG



Mechatronics

Sensor kit for TAROL and bearing units
Condition monitoring (CM) for railway applications
Axlebox generator

Wheelsets are mechanical machine components. By combining them with suitable mechatronic modules, it is possible to capture condition monitoring information on the bearing or the vehicle.

Sensor kit for TAROL and bearing units

The sensor kit allows the speed, direction of rotation and temperature to be measured on TAROL axlebox bearings, *Figure 1*. The unit is fixed axially to a special sheet steel cap with a recess and screw fixing. The speed signal is produced by an impulse disc. This is located between the axle cap and the bearing inner ring and runs at the rotational frequency of the wheelset shaft. The product can be adapted to the customer's specific technical requirements.

Figure 1
Sensor kit

Condition monitoring (CM) for railway applications

Schaeffler has developed a concept for a modular, open condition monitoring system specifically for locomotives, multiple units and passenger vehicles, *Figure 2*. The concept is intended to form the basis of a series of individual solutions to secure the functional capability of a range of vehicle components in the bogie such as axlebox bearings, wheels, traction motors and gearboxes. The base module offers scalability for up to three axles per bogie. Other modules can be integrated as required. The system increases availability, optimises maintenance and thus contributes to economical operation of the vehicles.

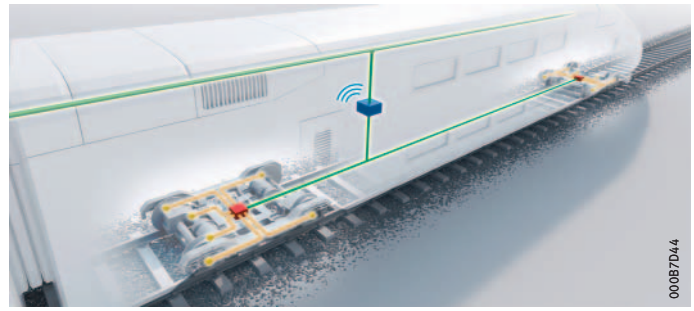


Figure 2
Condition monitoring system

A module can also be connected as an add-on for monitoring hot boxes on a vehicle.

Axlebox generator

Axlebox generators, *Figure 3*, are fitted to provide an independent power supply for electrical consumer units in freight wagons as there is no permanently installed electrical supply. An axlebox generator is a suitable on-vehicle source of electrical energy.

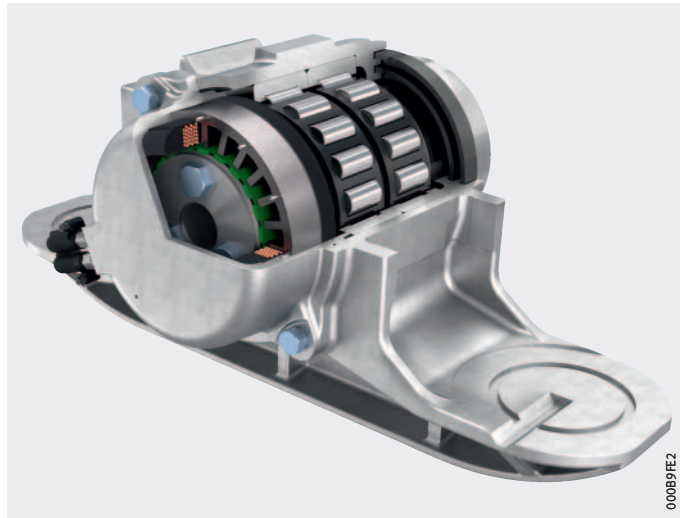


Figure 3
Axlebox generator

Axlebox generators are subdivided into various performance classes:

- low power = 5 W at n = 240 min^{-1}
- high power = 100 W at n = 240 min^{-1}.

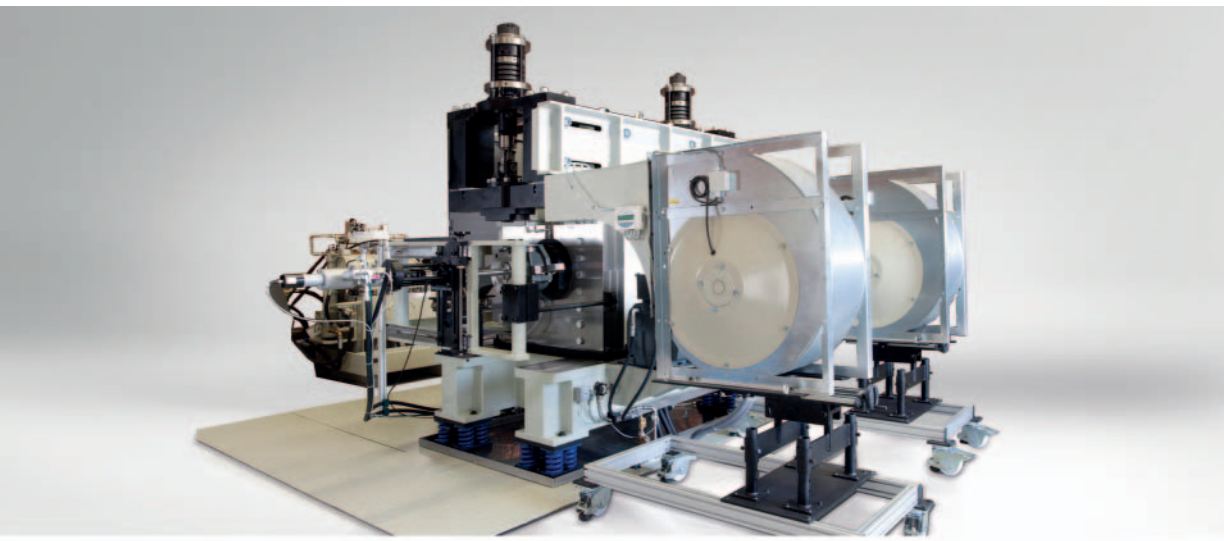
The generators were designed for mounting on closed housings of type UIC or Y25. Only the end cap and housing cover are replaced in replacement solutions. They are completely maintenance-free during operation.

Other modules can be connected as add-ons:

- energy management with supply when stationary
- GSM telemetry unit for location tracking
- anti-theft protection
- mass measurement.

Axlebox generators are special units. All types of wheelset can be adapted to suit customer requirements, including AAR for truck or bogie adapter for lower-power generators.

FAG



Calculations and inspections

Rating life
Maintenance intervals
RAMS-LCC
Housing calculations and inspections
Performance checks and test rigs
Accreditation

Rating life

Methods for determining the nominal rating life are laid down in ISO 281. This is the rating life that is reached or exceeded by at least 90% of a sufficiently large number of apparently identical bearings before the first evidence of material fatigue develops. The equation used to calculate the fatigue limit life assumes a constant load of constant magnitude which is purely radial for radial bearings. This is not usually the case in axlebox bearings. The forces change direction and magnitude. In these instances, a constant force must be determined for the rating life calculation which is equivalent to the loading. This force is described as the equivalent dynamic load. Schaeffler has developed a calculation program BEARINX which is used to calculate this equivalent load. This program calculates the fatigue life and includes in the calculation not only the external forces but also the internal geometry of the bearings, for example, the profile of the rings and rolling elements as well as the radial and axial internal clearance. The program can also be used to calculate the extended rating life to ISO/TS 16281 as well as the nominal rating life. The operating conditions, for example, the type of lubrication or cleanliness can also be taken into consideration for this rating life.

In standard-gauge railways (freight and passenger carriages, multiple units, locomotives), experience has shown that bearings which are calculated to achieve a nominal rating life of more than 3 million kilometres can be classified as fatigue-resistant, i.e. they do not fail due to fatigue.

The axle force is converted to a bearing load using the following formula:

$$F_r = \frac{(m_A - m_R) \cdot g \cdot f_z}{i_R}$$

F_r kN
Radial load per axlebox roller bearing

m_A t
Axle load (proportion of vehicle mass acting on the axlebox bearing) according to design brief

m_R t
Mass of wheelset (wheelset mass) according to design brief

g m/s^2
Acceleration due to gravity; $g = 9{,}81\ m/s^2$

f_z –
Factor for additional dynamic loads, see table, page 61

i_R –
Number of rolling bearings per axle according to design brief.

When calculating the rating life, there is a standard assumption that the application is appropriately and regularly maintained and regreased.

Factor f_z for axlebox bearings

Vehicle type	Factor f_z	
	from	to
Tipper wagons, freight wagons, mine cars	1,2	1,4
Goods wagons, railway carriages, powered units, tram applications	1,2	1,5
Locomotives	1,3	1,8

Rail vehicles

Bearing arrangement	Load configuration
Axlebox bearing[1)]	Static axle pressure with safety factor f_z (as a function of maximum velocity, vehicle type and track superstructure)

1) Factor f_z; see table.

Maintenance intervals

The maintenance intervals are determined by the grease operating life. Due to the influencing factors from operation in the field, such as vibrations, temperature difference, frequency of starting and braking procedures, carriage downtimes, annual running times, reconditioning and bogie cleaning practices, a well-founded, meaningful assessment of the grease operating life is, in practice, only possible through regular examination of the lubricant during operation.

Suitable inspection intervals are established in agreement with the operators and provide a verifiable statement on the optimum maintenance interval for a specific vehicle.

The following can be taken as guide values.

Guide values

Design	Mounting location		Distance travelled km
Non-locating bearing arrangement	in trams with	almost standard bearings	250 000
		insert bearings	500 000
Inner and outer ring bearing arrangement	in local trains		600 000 up to 1 000 000
Axlebox bearings	in freight wagons		600 000
	in passenger carriages		1 000 000
	in high-speed applications		1 600 000

RAMS-LCC

RAMS Engineering is an acronym for Reliability, Availability, Maintainability, Safety. Some useful tools are available to detect potential defects at the early stages of development such as FMEA and Hazard Analysis and these make a significant contribution to quality.

For this reason, Schaeffler has integrated the RAMS process into its product development process and is therefore now compliant with the requirements of Paragraph 7.1 of the IRIS (International Railway Industry Standard) rulebook and EN 50126.

This all contributes to reducing the Life Cycle Costs (LCC). Schaeffler can support customers when considering the life cycle costs. Schaeffler can estimate the costs of scheduled and corrective maintenance work both in terms of working hours and material costs (wear parts and statistically determined number of defective bearings thanks to FPMK calculations).

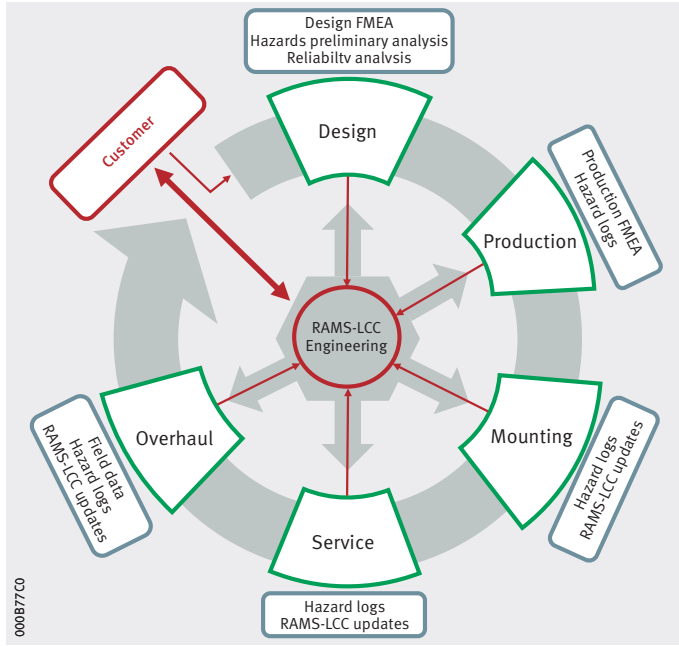


Figure 1
RAMS-LCC

Housing calculations and inspections

Calculation

Schaeffler uses state-of-the-art methods such as FEM calculation and topological optimisation, which give a description close to reality of not only difficult geometries but also the complex pattern of force flow in the housing. For the latter, a precise description of the interaction between the components is required, for example by means of a contact analysis. Valid design guidelines and a design brief prepared by the customer are required. A calculation-based strength analysis can be used as early as the design and development phase to identify weak points and optimise the geometry. In addition, this means that experimental investigations can be reduced to a minimum, *Figure 2*.

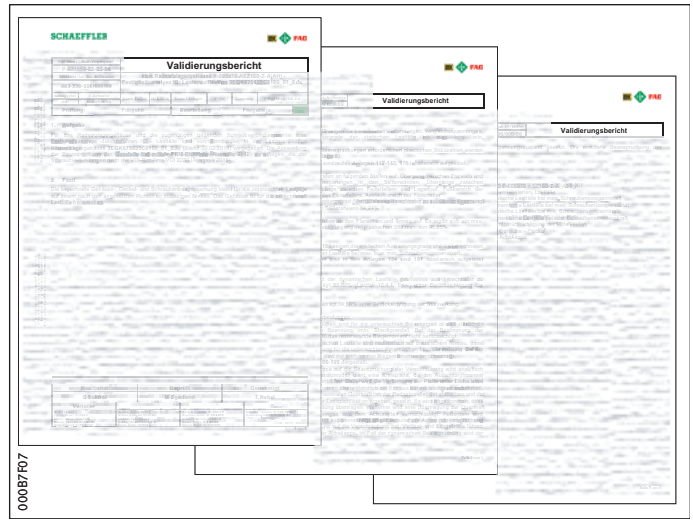


Figure 2
Validation report

Experimental investigations

A range of experimental investigations can be carried out if requested by the customer:

- static load tests
- vibration tests
- salt spray mist tests
- sealing inspections.

Furthermore, the performance tests for the axlebox bearings to EN 12082 are carried out in the original housings.

Performance checks and test rigs

Schaeffler has decades of experience in the field of axlebox bearing inspection. The initial inspections were carried out in Schweinfurt around 50 years ago. The axlebox bearing test rigs AN77 and AN55 are test equipment developed specifically for this sector, *Figure 3* and *Figure 4*.

Figure 3
Performance test rig AN77-1_DE

Figure 4
Performance test rig AN55D

The loads acting on the bearings during the check represent the actual axle load (radial load) and the lateral guidance forces (axial load). The possible speeds for the test bearing on the AN77-1_DE test rig correspond to the typical wheel size on an ICE travelling at a velocity of up to 550 km/h. Both AN77_CN test rigs are used for axlebox bearings running under high axle loads in freight transport, i.e. with up to 40 tonnes of freight volume per axle (heavy haul).

Each test rig is controlled by a computer program. This allows travel cycles to be simulated (acceleration, deceleration, and stop conditions). As airflow cooling on the axlebox bearing housings – and thus the bearings – has a considerable influence on the grease operating life, wind speeds of up to 40 km/h are also simulated on the test rigs.

Most tests carried out are on double row tapered or cylindrical roller bearings in their original housings. For a typical track test, the maximum mass of the vehicle when ready for operation is required as well as the number and mass of the individual wheel sets. The wheel diameter, the permissible speed of travel for the vehicle and the required distance are also included in the calculation of the test conditions.

The three most important test parameters are determined from this information:

- radial load F_r
- axial load F_a
- speed n.

The tests are carried out in accordance with EN 12082 or in agreement with the customer.

The bearing temperatures a various points are taken as measurement data:

- on the outer ring in the load zone
- on the housing in the area of the HOA, the hot box location device, a measuring system built into the rail network which measures the temperatures of the axlebox bearing housing as the train passes over it.

The vibrations are also recorded by an accelerometer.

The measurement results are evaluated on a day-by-day or long-term basis, *Figure 5*.

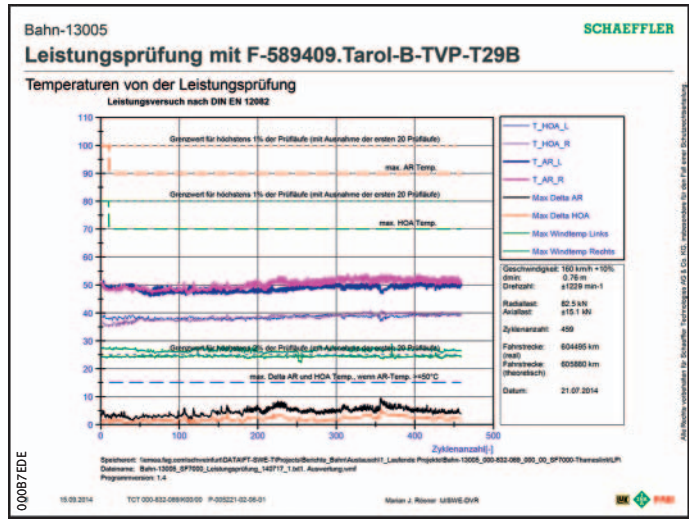


Figure 5
Evaluation of performance test

The tests are regarded as being successfully completed if the following criteria are met:

- the measured temperatures and the temperature differences between the two axlebox bearings and the two consecutive cycles are within the limits laid down by the standard
- no mechanical damage has occurred, such as smearing, spalling, fracture or similar
- the grease samples removed are within permissible limits as far as their physical and chemical properties are concerned.

Accreditation

The rail test facility in Schweinfurt was given its first accreditation in 2004 by DAP Deutsches Akkreditierungssystem Prüfwesen GmbH. Following the merger of various accreditation bodies, accreditation continued to be carried out by DAkkS (**D**eutsche **Akk**reditierungs-**s**telle GmbH) following a seamless transfer. According to DIN EN ISO/IEC 17025, the rail test facility may be used for testing the performance capacity of axlebox bearings in railway applications in accordance with EN 12082, *Figure 6*. The functional tests carried out in accordance with this standard provide evidence for the usability of axlebox bearings during actual travel. The accreditation is recognised in Europe, Australia, New Zealand, South Africa, Brazil, Canada, the USA and most Asian countries such as China, India, Indonesia, Japan and Korea. The Test Field Railway – Anting (China) was also successfully accredited by DAkkS.

DAkkS
Deutsche
Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Beliehene gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV
Unterzeichnerin der Multilateralen Abkommen
von EA, ILAC und IAF zur gegenseitigen Anerkennung

Akkreditierung

Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium

Schaeffler Technologies AG & Co. KG
Prüffeld Bahn
Georg-Schäfer-Straße 30, 97421 Schweinfurt

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

Leistungsvermögen von Radsatzlagern - Bahnanwendungen

Berlin, 31.07.2015

Im Auftrag Dr. Heike Manke
Abteilungsleiterin

00087EC3

Figure 6
DAkkS accreditation

Quality system and certificates

Quality system and certificates

Quality system

Today's railway system is subject to a vast range of challenges in terms of quality in different economic and legal jurisdictions throughout the world.

Schaeffler is developing appropriate solutions and procedures to be able to implement the relevant demands arising from legal and regulatory requirements and, above all, customer-specific requirements.

The new standard ISO/TS 22163 is a lucrative addition to the Schaeffler Group management system which has already been shaped by IATF 16949 and ISO 9001:2015, particularly in the railway industry sector. Stakeholder needs and customer expectations are considered in detail, decisive process capabilities are effectively enhanced and their performance capacity regularly monitored and updated. We can trace our stable processes in the railway sector back to over ten years of experience in applying IRIS requirements.

Many of our international locations are certified to ISO/TS 22163; we are now also certified to AAR, RSFGT and CRCC. In this way, we ensure we are engaged in a broad spectrum of potential markets as well as the safe use of appropriate methods and concepts. This allows us to make a significant contribution to efficient development and production as well to the quality of our products and processes.

Certificates

Sample certificates from AAR, RSFGT, CRCC and IRIS are shown in *Figure 1*.

Figure 1
Certificates

Packaging and storage

Packaging and storage

Packaging

Ungreased axlebox bearings such as WJ and WJP cylindrical roller bearings, spherical roller bearings or insert bearings are pre-packed in a polyethylene film after preservation and individually packaged in a cardboard box.

TAROL and cylindrical roller bearing units are greased and assembled with seals, preserved and wrapped in a polyethylene film and, depending on their weight, individually packed in either cardboard boxes (up to 30 kg) or wooden crates (over 30 kg). If the bearing set includes accessory parts, these are packaged with the rolling bearing.

Bearing units with protruding seals have protective caps on both sides to protect the seals from impacts.

Storage

In general, bearings should be stored in dry, clean areas at as constant a temperature as possible. The effect of aggressive media and direct sunlight is to be avoided.

In order to avoid condensation, the following conditions are permissible:

- a temperature between +6 °C and +25 °C, up to +30 °C for short periods
- maximum temperature differences between day and night 8 K
- maximum relative humidity of 65%.

Preserved bearings in their original packaging can be stored for up to 5 years under these conditions. If bearings are to be stored for longer than this, we recommend the condition of the preservative is checked and the bearings are inspected for corrosion. Further information on storing rolling bearings is available in the catalogue HR 1, Rolling Bearings.

For axlebox bearings, the following applies in accordance with EN 12080:

- the packaging must ensure a minimum storage period of two years under standard storage conditions. Precondition for this is that the original packaging remains unopened
- for rolling bearings that are supplied greased, the storage period from manufacture to commissioning is limited to 24 months in a closed room at temperatures between –5 °C and +40 °C in accordance with EN 12080. During this period of 24 months, the product may not be stored with the manufacturer for more than 12 months.

FAG

Mounting, dismounting and bearing reconditioning

Cylindrical roller bearings with rib washer WJ, WJP
TAROL tapered roller bearing units and
cylindrical roller bearing units
Bearing reconditioning

Mounting, dismounting and bearing reconditioning

Axlebox bearings are sometimes subjected to extremely harsh operating conditions. They have to support operational forces and are subjected to vibrations and harsh climatic conditions.

The inner rings on the axle journals are subjected to reverse bending loads. In order to prevent fretting corrosion and bearings and components running against each other, the bearing has a tight fit on the axle journal. To avoid the end faces of components running against each other and on the rolling bearing end face, the bearings must also have a tight axial fit. TAROL tapered roller bearing units must have minimum axial bracing across the inner rings so that the inner rings do not move during operation. The mounting process is extremely important. Correct mounting ensures that the bearings and the shaft are not damaged during mounting and that the bearings sit securely on the axle journal.

Cylindrical roller bearings with rib washer WJ, WJP

Cylindrical roller bearings WJ, WJP can be disassembled and the inner rings are mounted individually on the axle journal. We recommend cylindrical roller bearings are thermally mounted to overcome the interference between the axle journal and the inner ring bore. The inner rings are heated to the correct temperature of approximately +120 °C using suitable heating devices, *Figure 1*, or heated in accordance with available mounting and maintenance instructions and pushed onto the axle journal.

Figure 1
Induction heating device HEATER 200

To ensure the bearings are in the correct axial position, the inner rings are tapped in place with a mounting sleeve. The outer rings with roller and cage assembly are greased and inserted into the housing bore. The axlebox bearing housing and any other accessory parts are mounted. Tightening the end cap bolts in accordance with the mounting instructions ensures the inner rings are axially preloaded and secured.

Cylindrical roller bearings are dismounted in a similar way. After loosening the end cap bolts, the end cap and accessory parts are dismounted. The axlebox bearing housing is withdrawn from the wheelset together with the outer rings and roller and cage assembly. The outer rings can then be easily removed from the housing bore.

The inner rings initially remain on the axle journal and can be inspected for damage after having been cleaned. To dismount the inner rings from the axle journal, the rings are heated to +120 °C so that they can be easily withdrawn from the axle journal. The rings must be heated quickly and in a controlled manner without heating the axle journal. The use of induction heating devices is recommend for batch dismounting.

Further information

- TPI 200, Induction Heating Devices HEATER
- TPI 217, Induction Units with Medium Frequency Technology (MFT).

Mounting, dismounting and bearing reconditioning

Batch dismounting of labyrinth rings and inner rings

Due to defined maintenance intervals, axlebox bearings on rail vehicles must be inspected and maintained regularly. Dismounting of the axlebox bearings is thus necessary. FAG cylindrical roller bearings WJ/WJP120×240 and WJ/WJP130×240 are used in this application example. The bearings are separable, which means that the inner rings and the associated labyrinth rings can be dismounted using induction heating methods.

Requirements

The requirements are as follows:

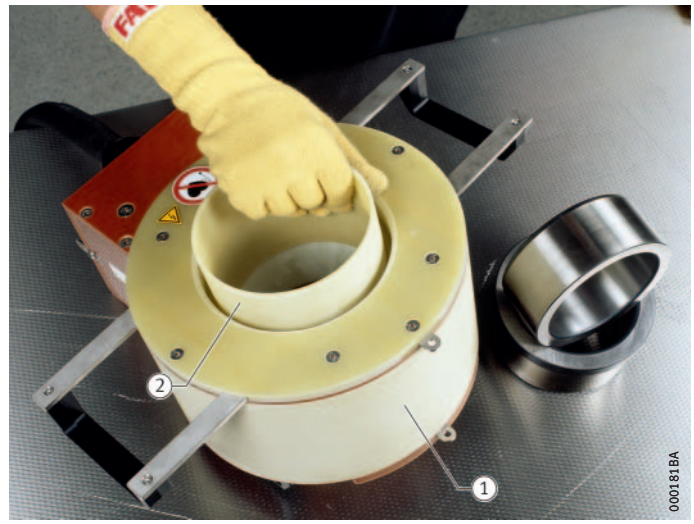
- removal of normally large quantities, in some cases in shift operation
- rapid, safe, energy-efficient and environmentally compatible dismounting
- reuse of the bearings where suitable
- controlled and uniform heating including demagnetisation. This is important for process security.

Solution

For dismounting of the wheelset bearings described, an induction unit with medium frequency technology of the following configuration is used:

- HEAT-GENERATOR20-RAIL, *Figure 2*
- HEAT-INDUCTOR-IN157×145, *Figure 3*, page 77
- HEAT-INDUCTOR-LAB176×50, *Figure 4*, page 77.

Figure 2
HEAT-GENERATOR20-RAIL



① HEAT-INDUCTOR-IN157×145
② Spacer ring

Figure 3
HEAT-INDUCTOR-IN157×145
with spacer ring

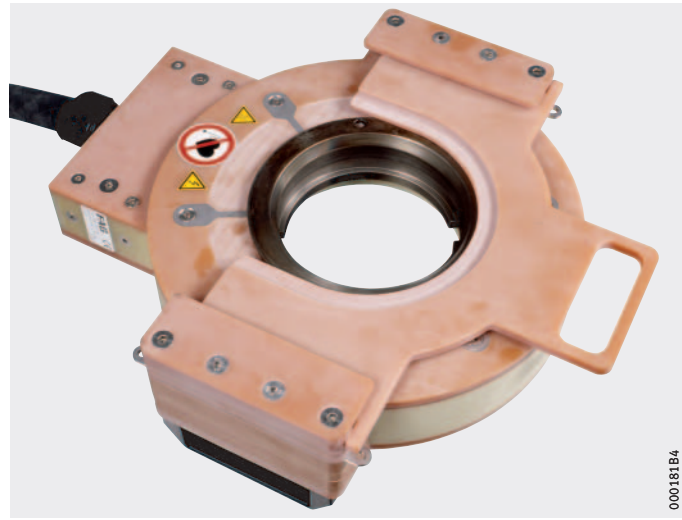


Figure 4
HEAT-INDUCTOR-LAB176×50
for dismounting labyrinth rings

Mounting, dismounting and bearing reconditioning

The induction unit can be operated by open or closed loop control. This gives temperature-dependent shutdown of the coils.

The temperature of the workpiece is measured by means of a type K thermocouple with a magnetic clamp. In order to prevent overheating of the coils, the temperature of the winding in the inductors is also monitored by means of a thermistor.

A coded push-fit connector signals to the generator whether the connected inductor is for bearing inner rings or for labyrinth rings.

The generator detects the inductor via the coded push-fit connector and automatically selects the operating mode specified for the relevant inductor.

Dismounting bearing inner rings

Operations for dismounting bearing inner rings:

- the bearing inner rings and adjacent parts are cleaned
- for dismounting of the bearing WJ/WJP120×240, the spacer ring supplied must be used, *Figure 5*, ①
- the inductor is slid onto the inner ring and the slider on the rear face is closed
- the magnetic temperature sensor is applied to the end face of the bearing inner ring, *Figure 5*, ②
- once the requisite heating temperature has been reached, the generator shuts down automatically. The inner ring is removed together with the inductor
- finally, the inner ring is removed promptly from the inductor.

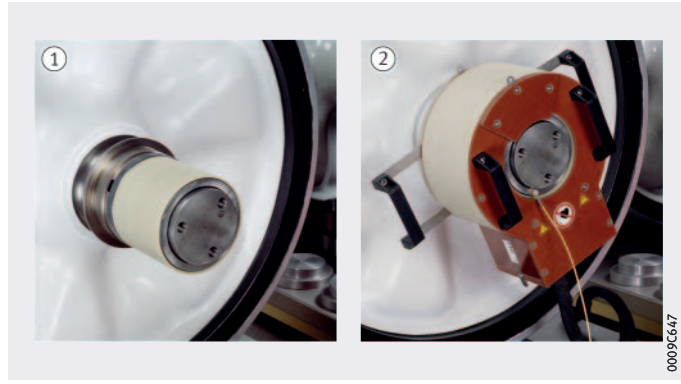


Figure 5
Dismounting bearing inner rings

Dismounting labyrinth rings

Operations for dismounting labyrinth rings:

- depending on the labyrinth ring design, a spacer ring is used
- the inductor is slid into place and the appropriate slider for gripping behind the labyrinth rings is selected and closed, *Figure 6*, ①
- the magnetic temperature sensor is applied to the end face of the labyrinth ring, *Figure 6*, ②
- once the requisite heating temperature has been reached, the generator shuts down automatically. The labyrinth ring is removed together with the inductor
- finally, the slider is removed and the inner ring is removed from the inductor.

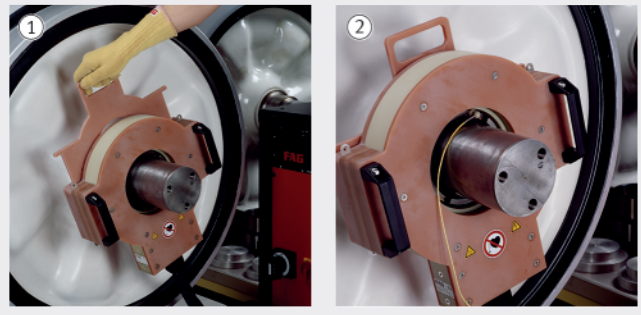


Figure 6
Dismounting labyrinth rings

TAROL tapered roller bearing units and cylindrical roller bearing units

TAROL tapered roller bearing units and cylindrical roller bearing units are compact, ready to fit, greased, sealed and axially adjusted rolling bearings that are pressed onto the shaft journal in a single operation. If the shaft journal diameter is within the specified tolerance, the press fit of the bearing will give the required axial internal clearance. Schaeffler recommends the use of a mobile hydraulic unit, *Figure 7*, and appropriate tool sets, *Figure 8*, page 81, when mounting and dismounting these bearings. A variant with force/distance measurement with a touchscreen is available as an option in order to record the mounting procedure and pressing on up to the shaft shoulder.

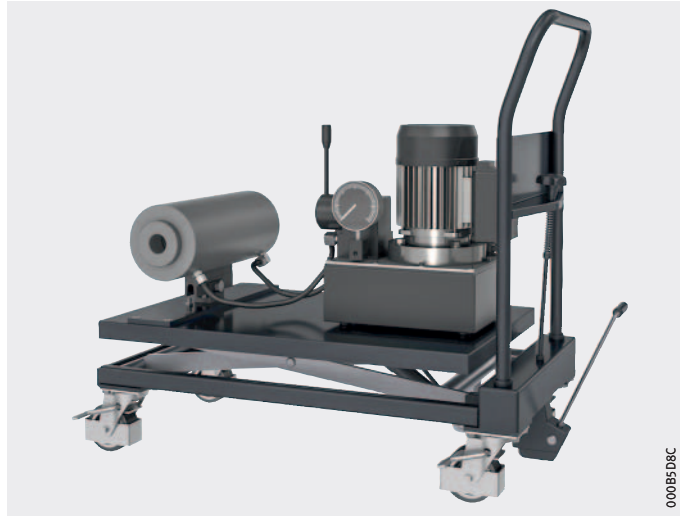


Figure 7
Mobile hydraulic unit
TOOL-RAILWAY-AGGREGATE-2

① Yoke
② Tie rods
③ Withdrawal shoe
④ Centring ring
⑤ Locknut
⑥ Guide bush (2×)
⑦ Mounting sleeve
⑧ Spindle
⑨ Crank arm
⑩ Socket head screws for guide bush

Figure 8
Tool set

Depending on their design (with or without rib washer), cylindrical roller bearing units are treated as individual bearings or in the same way as TAROL units.

Further information

Detailed information on mounting and dismounting:

- TPI 156, Tapered Roller Bearing Units TAROL – Mounting, Maintenance, Repair
- MH 1, Mounting Handbook
- IS 1, Mounting and Maintenance of Rolling Bearings.

Mounting, dismounting and bearing reconditioning

Bearing reconditioning

When axlebox bearings reach their first maintenance interval, they have generally not reached their calculated rating life. The length of the maintenance interval is a result of the rating life or the service life of other components fitted in the bogie or the service life of the bearing grease. The bearings can usually be reused once they have been reconditioned.

Schaeffler offers an axlebox bearing repair service at several locations worldwide, *Figure 9*.

On TAROL cylindrical roller bearing units, the seals are dismounted after delivery. To remove the grease, the inner rings and roller and cage assembly are washed with the outer ring and the intermediate ring in a special washing machine. The components are inspected for damage, fretting corrosion points are polished, and the units are reassembled. After quality control, the bearings are greased and the seals refitted or replaced. The units are marked as a reconditioned bearing and then repackaged and delivered. Reconditioned bearings can be used in the same way as new bearings.

① Before reconditioning
② After reconditioning

Figure 9
TAROL units

Further information

- TPI 156, Tapered Roller Bearing Units TAROL – Mounting, Maintenance, Repair
- TPI 207, Reconditioning and Repair of Rolling Bearings.

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