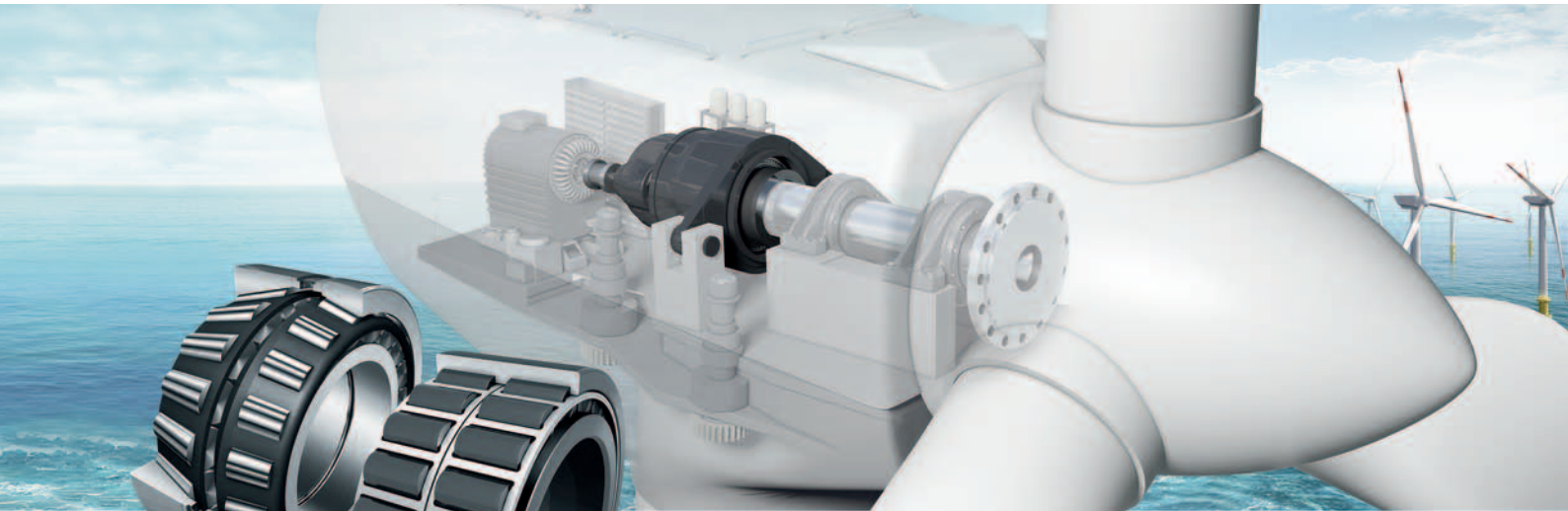


SCHAEFFLER



Bearing Solutions and Services for Wind Turbine Gearboxes





The perfect solution for every bearing position!

You need

Bearing technology for highly-dynamic forces with extreme peaks and minimum loads, sudden alternating loads and varying operating temperatures.

We offer

Bearings with high static safety and reliable dynamic design according to international standards (Germanischer Lloyd GL 2010, ISO 81400-4).

Reliability – Made by Schaeffler

Schaeffler is one of the world's leading manufacturers of rolling bearings. As a development partner to the wind turbine industry, we have been supplying bearing supports to this sector for over 30 years. With our INA and FAG brands, we always offer the best technical and most cost-effective solution for every bearing position – from the rotor shaft, gearbox and generator to the nacelle and blade angle adjustment systems. Our product range is rounded out by rotor bearing housings, special rolling bearing greases and a wide spectrum of services and products for maintenance and condition monitoring.

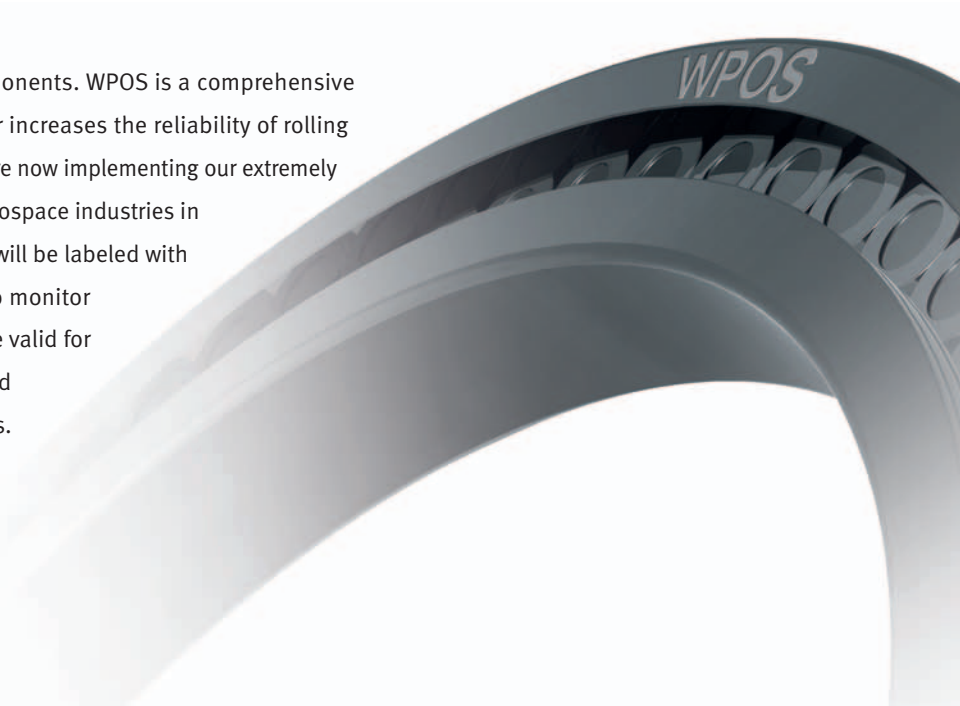
The Schaeffler Wind Power Standard (WPOS)

Cost-effective wind turbines require reliable components. WPOS is a comprehensive concept developed by the company, which further increases the reliability of rolling bearings in wind turbines. The standard means we are now implementing our extremely high quality standards from the automotive and aerospace industries in the wind power industry. In future, these products will be labeled with the WPOS designation. Internal audits are used to monitor compliance with strict quality requirements that are valid for all locations worldwide involved in developing and manufacturing products for wind power applications.

We are your development partners.

Use our engineering expertise!

www.schaeffler.de/windpower



From the first BEARINX® calculation ...



Designing gearbox bearing supports using BEARINX®

Our specialists have been working in close cooperation with wind turbine developers, manufacturers, and operators for many years. Detailed attention is paid to all customer requirements as early as the project planning phase. We use state-of-the-art calculation and simulation pro-

grams such as BEARINX® to ensure optimum designs are produced for wind power bearings. During this process, we always consider the entire system starting from a single rolling bearing and its components and the adjacent construction up to the entire power transmission system, which can be displayed and optimized using multi-body simulation programs developed in-house.

Precision right down to the last detail

For example: In wind turbine gearboxes, the elastic deformation of the gearbox housing can have a considerable impact on the operating life of the bearings. Our calculations for the housing in BEARINX® and the FEM calculation are linked enabling us to incorporate the housing rigidity into the analysis. This means you always receive the product best suited to your particular application. Reliability made by Schaeffler.

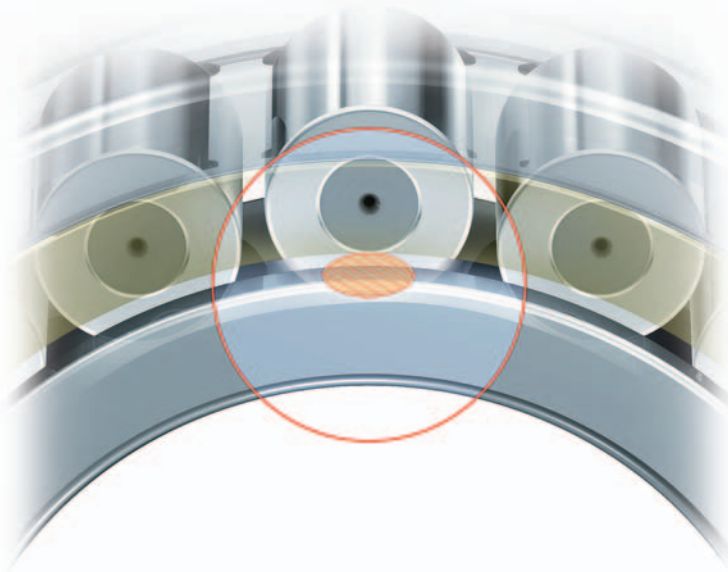
... to a specific gearbox bearing according to WPOS

Developed for wind power

Cylindrical roller bearings with optimized rib contact (TB rollers) are low friction and can support much higher axial loads than other bearings available on the market. They are certainly an interesting design alternative if you are considering down-sizing and increasing energy efficiency in gearboxes.

Tube roller bearings are low-wear cylindrical roller bearings with three slightly enlarged tube rollers that drive the rolling element set at low loads. This prevents slippage. When the load increases, the tube rollers undergo elastic deflection and the load is supported by all the rolling elements.

Our high-capacity cylindrical roller bearings beat the competition due to the innovative cage geometry with high load ratings and low friction. This means they have a considerably longer rating life compared with standard bearings.



The optimized end face profile of the TB roller prevents wear to the ribs and the roller end faces

Schaeffler's standard for black oxide finishing for bearings for wind turbines is called Durotect® B. This layer, which measures only between 0.4 and 2 μm in thickness, reduces the risk of white etching cracks and the damage caused by slippage, improves run-in behavior, and offers protection against corrosion.



Planet Carriers

Planet carrier bearings are the largest and therefore most valuable bearings in a wind turbine gearbox. The loads they have to support depend on the main bearing concept selected. These bearings are usually subjected to relatively low loads due to their size.

The following bearings are suitable for this application:

- INA full-complement cylindrical roller bearings
- FAG cylindrical roller bearings
- FAG tapered roller bearings

Planetary Gears

Planetary gear bearing supports are extremely challenging bearing positions because of the high radial loads that occur. Only a limited amount of space is available for this bearing support, and the planetary gears, which have comparably thin walls, tend to distort leading to unintentional rotation of the bearing outer ring in the planetary gear.

The following bearings are suitable for this application:

- INA full-complement cylindrical roller bearings
- FAG cylindrical roller bearings
- FAG tapered roller bearings

We also offer all these products as direct bearing supports.



Intermediate/Output Shafts

Intermediate shafts are used in single-stage planetary gearboxes in particular. A comparably small amount of space is available for the bearing support for the high radial loads and moderate axial loads that occur here. The output shaft rotates at high speeds.

The following bearings are suitable for this application:

- FAG tapered roller bearings
- FAG cylindrical roller bearings
- FAG four-point contact bearings
- FAG tube roller bearings

Hollow Shafts

Bearing supports for hollow shafts support high radial loads as well as high axial loads in the case of planetary gears with helical gear teeth. Combinations of locating/non-locating bearing arrangements with two tapered roller bearings and one cylindrical roller bearing or two cylindrical roller bearings with one four point contact bearing with radial release have proven themselves in this application.

The following bearings are suitable for this application:

- FAG tapered roller bearings
- FAG cylindrical roller bearings
- FAG four-point contact bearings

Cost-effective and compact

**Planet stage 1:****INA full-complement cylindrical roller bearings with Durotect® B coating**

Full-complement cylindrical roller bearings from the INA brand are a proven and economical solution for the bearing positions in planet carriers that are subject to low loads. These bearings are black oxide coated to minimize the risk of damage caused by smearing between the rolling elements.

- Compact solution with high rigidity
- Increased guidance accuracy due to limited tolerances

Planet stage 2: Adjusted FAG tapered roller bearings

Additional axial loads from the helical tooth gears usually have to be supported around the second planet stage. In this case, using a tapered roller bearing as the bearing support of the planet carrier is a proven solution.

- Precise guidance of shafts
- Internal clearance can be precisely set
- No additional axial bearing necessary
- High axial forces can be supported due to the large contact angle



Reliably ruling out slippage

A combination of locating/non-locating bearings is advisable for the intermediate and output shafts. This combination comprises either two tapered roller bearings in X arrangement and one cylindrical roller bearing or one four-point bearing and two cylindrical roller bearings.

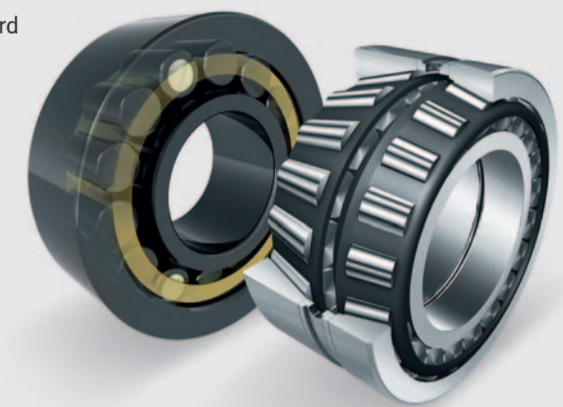
Locating bearings: Double-row FAG tapered roller bearings

- Long life
- High operational safety and short mounting time due to preset internal clearance
- Effective support of radial and axial loads
- Compact bearing design

Non-locating bearings: FAG tube roller bearings with Durotect® B coating

Slippage? No problem! Thanks to its three tube rollers, this bearing rotates in all load conditions without harmful sliding of the rolling elements on the raceways. At the same time, the load rating and rating life are not affected.

- Interchangeable with standard bearings since it has the same mounting dimensions
- Simplified design and assembly compared with axially-preloaded solutions
- Improved run-in behavior due to Durotect® B coating



Two strong alternatives

As direct bearing supports: FAG cylindrical roller bearings X-life without outer rings

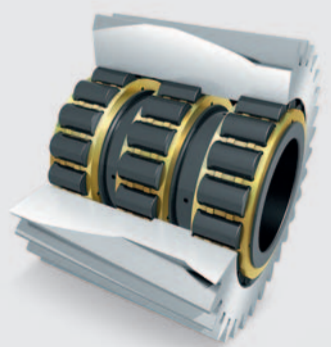
The raceway of this bearing is integrated in the planetary gear, the inner rings and rolling elements are black oxide coated.

- High load carrying capacity
- High operational safety
- Low radial section height
- Optimum load distribution on the bearings due to limited internal clearance

Alternative solution: High-capacity cylindrical roller bearings from the FAG brand

Our high-capacity cylindrical roller bearings combine the advantages of full-complement bearings and cage-type bearings due to the particularly streamlined design of the cage. These bearings can facilitate a significant increase in load ratings compared with bearings with standard cages.

- Low friction
- Higher load ratings due to a greater number of rollers
- Simple bearing mounting due to the self-retaining cage
- High stability, lightweight design
- Optimized lubricant flow
- Improved run-in behavior due to Durotect® B coating



Proven locating/non-locating bearing solutions

Cylindrical roller bearings with cages are usually used as non-locating bearings to achieve smooth kinematic movement conditions on this bearing position by means of a separation of functions using a locating/non-locating bearing support. This is an effective means of preventing smearing in the contact

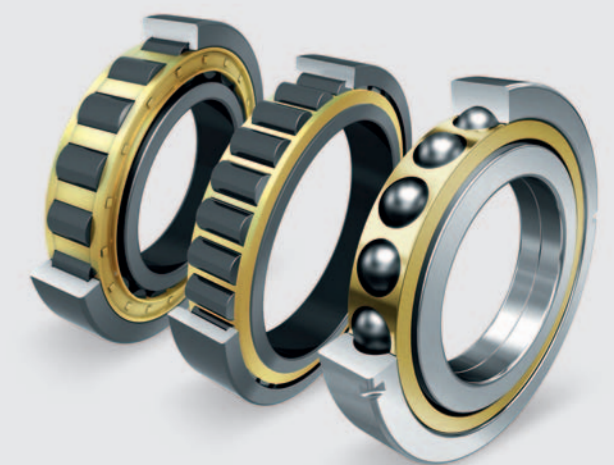
between the rolling elements. Four-point contact ball bearings are a proven low-friction locating bearing solution in gearboxes. They have radial release and therefore only support axial loads.

Non-locating bearing: FAG cylindrical roller bearings with Durotect® B coating

- Effective support of radial loads
- Low frictional torques
- Improved run-in behavior due to Durotect® B coating
- Suitable for high speeds
- Simple to mount as they can be dismantled

Locating bearings: FAG four point bearings with retaining slot in the outer ring for secure location

- Effective support of axial loads
- Favorable kinematics under axial loads in both directions
- Suitable for high speeds
- Low lubricant requirement



Increase operational safety with condition monitoring services and products



Remote monitoring and diagnosis, offline measurements, endoscopy, thermography and torque measurements are just some of the services we can offer you for monitoring the condition of wind turbines. FAG vibration measuring devices help prevent unplanned downtimes, increase the availability of systems and prevent subsequent damage, enabling maintenance work to be planned more easily.

FAG WiPro 8 enables wind farms to be monitored online. This 8 channel system reliably detects potential machine damage at an early stage. Its compact size means it can easily fit in small spaces such as the nacelle of a wind turbine. FAG WiPro 8 is certified by Germanischer Lloyd.

FAG ProCheck is “big brother” to FAG WiPro 8 and is used to monitor multi-megawatt and offshore wind turbines. This 16 channel online system has a more powerful computer module and additional functions such as order analysis. The ability to plan repairs is even more important in the case of offshore turbines, since access to these turbines is considerably more difficult and is associated with higher risks than with those on land.

FAG Wear Debris Check is an oil sensor that monitors the quantity of metallic particles in oil and classifies them according to size and material. This oil sensor can be integrated into an online monitoring system, enabling damage to gearboxes lubricated with oil recirculation to be detected and localized at an early stage.

Cut costs – from expert fitting services to bearing reconditioning

Mounting and dismounting

Expert use of suitable tools when fitting and removing our bearings is an important prerequisite for long bearing operating life. We can offer you support here with professional tools, measuring devices and other equipment. We are also happy to fit bearings for you with our expert team of specially-trained Schaeffler fitting personnel who can work with you on site.

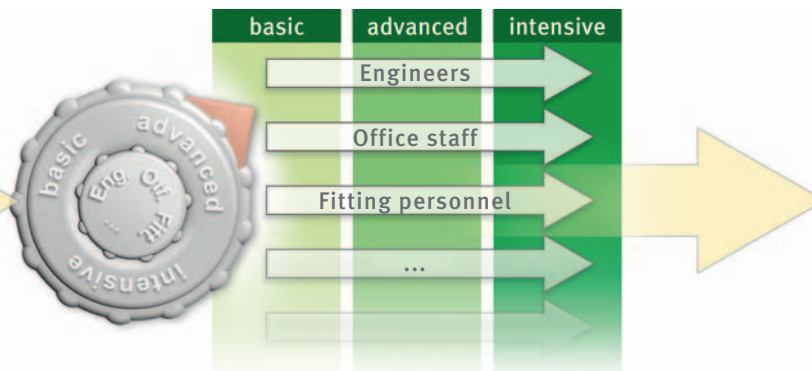
The FAG medium frequency heating device heats large rolling bearings and other ring-shaped steel components quickly and easily during fitting and removal. The device is also ideal for removing bearing rings and labyrinth rings in volume production. The outlay and costs involved are reduced; productivity increases. The device's compact size means it is suitable for mobile use, enabling it to be taken to the workpiece. It is therefore very well suited to the construction sites of wind turbines.

Cutting costs with reconditioning

Schaeffler can recondition bearings with an outside diameter of up to 4250 mm. This often costs considerably less than investing in a new bearing and the delivery times are usually shorter.



Benefit from Schaeffler's expertise with our comprehensive program of wind power training



Do you require training for your engineers for products and services or on the principles of rolling bearings? Do your purchasing staff need to broaden their knowledge of bearings in wind turbines?

Do your fitting personnel want to know more about how to fit rolling bearings in wind turbine gearboxes correctly?

Schaeffler has THE answer to all three questions, namely our comprehensive training program. We offer a wide variety of training in wind power applications for engineers, office staff, and fitting personnel, for example, for products, calculation, fitting, and condition monitoring. Our courses can be taken in one of our Schaeffler training centers or at your premises. Our training program is also certified according to DIN EN ISO 9001:2008.

Please contact us if you require special training courses for your employees that are not included in our program. We can put together a customized training concept for you or even devise new courses should you require them.



Replacement bearings from Schaeffler

State of the art

As one of the most innovative companies in the rolling bearing market, Schaeffler offers state of the art as far as the development status of our replacement bearings is concerned.

These state-of-the-art products enable optimum operating life with minimum maintenance work to be achieved. Our experts constantly work on new and innovative solutions for critical bearing positions to improve the availability of wind turbines.



<http://www.schaeffler.de/windpower>

For more information about Schaeffler's activities in the wind power sector, including all products, applications, and services, simply follow the link.

**Schaeffler Technologies
AG & Co. KG**

Georg-Schäfer-Strasse 30
97421 Schweinfurt
Germany
Internet www.schaeffler.de/windpower
E-Mail FAGinfo@schaeffler.com

In Germany:

Phone 0180 5003872

Fax 0180 5003873

From other countries:

Phone +49 9721 91-0

Fax +49 9721 91-3435

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