



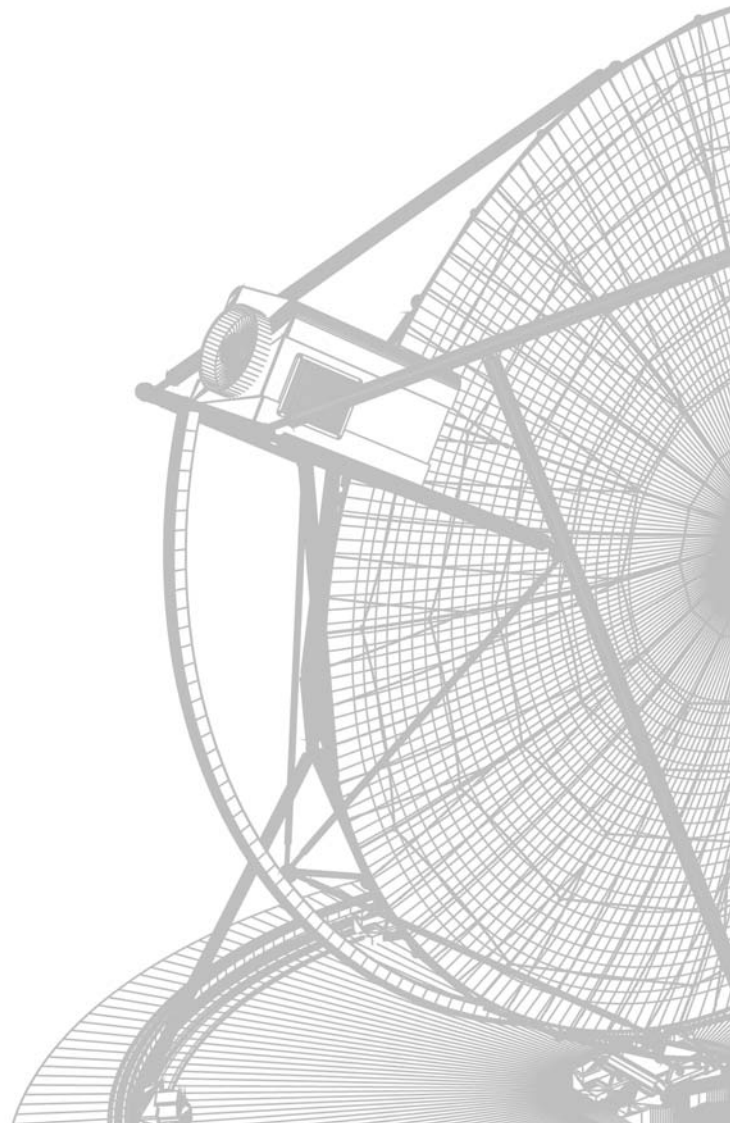
FAG



Always Following the Sun

Bearing solutions for tracking systems

SCHAEFFLER



Photovoltaic and solar thermal systems: Improved performance with tracking systems with high-precision bearing supports

The energy provided by the sun every day is equivalent to the world's entire annual energy requirements. This energy is unlimited, environmentally-friendly and free of charge. Due to the rising pressure caused by climate change, an increasing number of countries are now using the sun as a source of energy for generating electricity with a view to further decreasing damaging CO₂ emissions.

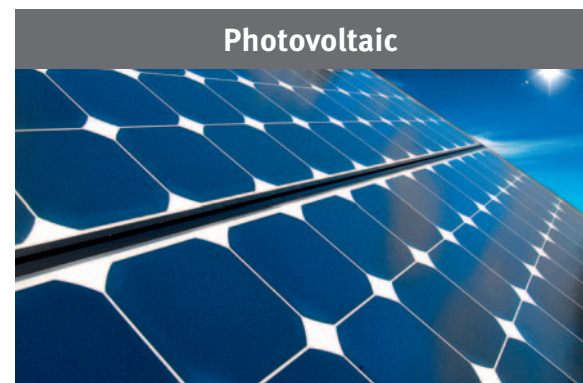
Irrespective of whether plants are photovoltaic or solar thermal plants, they are particularly efficient if the collectors (the moveable mirrors or heliostats) track the course of the sun in the sky. The more precise and trouble-free they operate the better and more profitable the plants are.

This is where rolling and plain bearings from INA, FAG and ELGES come in. They have high rigidity and high load carrying capacity and operate reliably even under extreme operating conditions.

With its large product range and special expertise in materials, coatings and seals, Schaeffler Group Industrial is an important development partner and supplier for a whole series of current projects.

There are two basic principles for converting solar energy. Photovoltaic systems convert solar energy directly into electrical energy. Tracking systems are used in concentrated photovoltaics (CPV) in particular. These use photovoltaics in power plants for the central energy supply in order to generate higher efficiency.

Solar thermal systems have reflectors that concentrate the sun's rays in an absorber to heat a fluid that generates water vapor using a heat exchanger. The water vapor is used to drive turbines and generators as in conventional



thermal power plants. Solar thermal power plants include parabolic trough, Fresnel and solar tower power plants. Dish Stirling power plants operate differently – here concentrated sunlight directly drives a Stirling engine that in turn drives a generator.

One thing all these solar applications have in common is a single-axis or double-axis tracking system that continuously aligns the reflectors with the course of the sun.



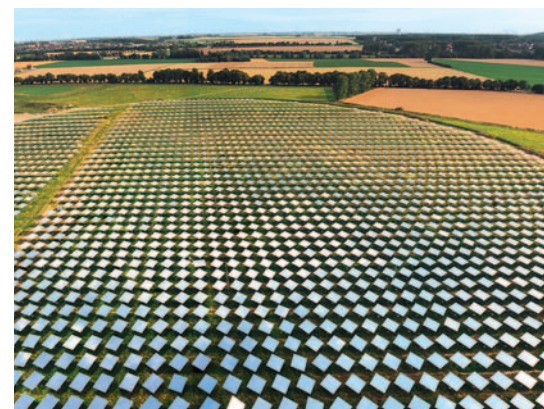
The right bearing support for every application

	Photovoltaics/ Concentrated photovoltaics	Solar thermal systems			
	Photovoltaic power plants	Dish Stirling power plants	Solar tower power plants	Parabolic trough power plants	Fresnel power plants
Slewing rings	A	A	A/E		
Angular contact roller bearings AXS	A/E	A/E	A/E		
Housing units/Radial insert ball bearings	E	E	E		
Track rollers/Yoke type track rollers	A	A		E	
Spherical plain bearings	E	E	E	E	E
Plain bearing bushes/shells (ELGOTEX®, ELGOGLIDE®, metal-polymer composite)	E	E	E	E	E
	Double axis (azimuth and elevation)			Single axis (elevation)	

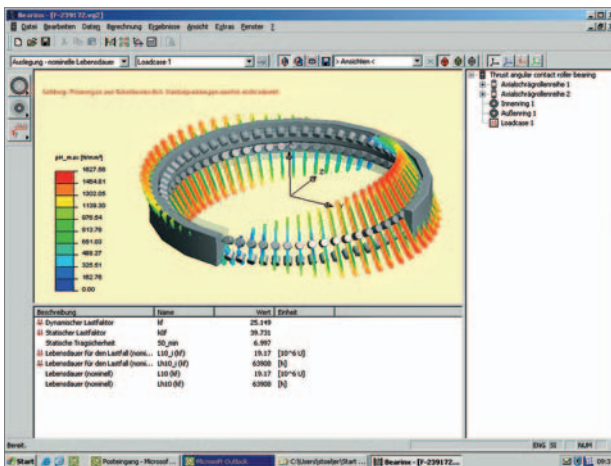
Selection of bearing types that can be used for various power plant types/technologies, categorized according to their suitability for the azimuth and elevation axis (A/E)

The precision and robustness of bearing supports make a decisive contribution to achieving maximum efficiency in a plant. High rigidity is required for the precise alignment of the reflectors and collectors to the sun and, thus, accurate concentration of the sun's rays. These bearings must not only withstand local weather conditions, for example during sudden gusts of wind,

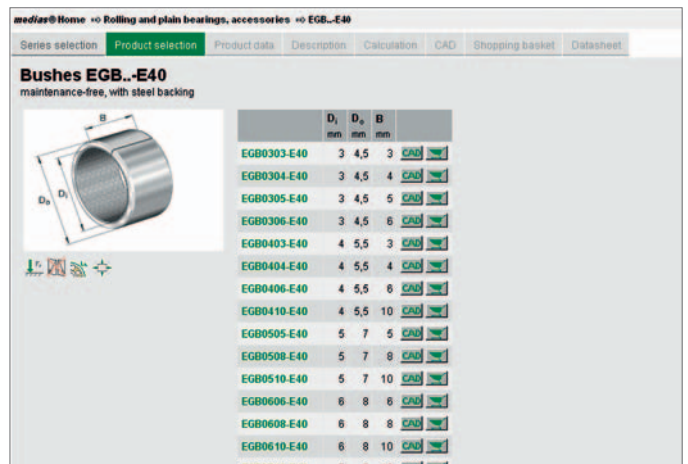
but also high forces and moments. Depending on the type and design of the power plant involved, the following bearing types have proved successful in these applications: slewing rings, angular contact roller bearings, track and yoke type track rollers, radial insert ball bearings, housing units, plain bearing bushes, and spherical plain bearings.



Optimized benefits for customers and the right software for all applications



Bearing design with BEARINX®



Bearing selection with medias®

Optimized benefits for customers

Our services involve much more than simply supplying standard bearings. These services start with expert product selection and bearing design. The specific environmental conditions of the bearing and the user's special requirements are included in this process. Aspects such as seals, lubrication, corrosion protection, fixing and installation are clarified with the customer while always taking high operational safety and long operating life of the bearing support into account. Basic research, calculation programs, fitting aids and training round off the package of services we provide.

Our advisory engineers are in your area and establish what's particularly important to us – personal contact with you, our partners!

BEARINX®

With BEARINX®, we have created one of the leading programs for rolling bearing and plain bearing calculation. The software enables bearing supports to be analyzed in detail – from single bearings to complex shaft or linear guidance systems right up to complex gear systems. All calculations are performed in a consistent calculation model.

Friction calculations are a new feature of BEARINX®. An analytical model was created for this feature, which means it

is possible for the first time to select a bearing concept with optimized friction characteristics early on during the product development phase.

medias® professional

Our electronic support and selection system *medias® professional* provides information on more than 40,000 standard products for approximately 60 industrial sectors.

In contrast to BEARINX®, this system only considers single bearings. All in all, it offers comprehensive help for users to help themselves as it answers several questions about bearing technology quickly, in electronic format and irrespective of the user's location.

Plain bearings for single-axis tracking systems



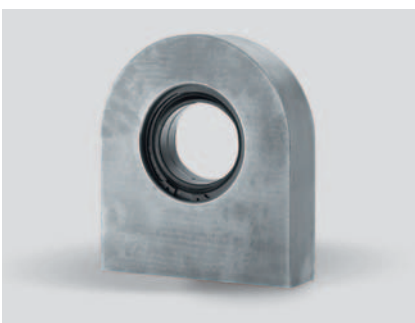
In the Andasol solar power plant in Spain, for example, Schaeffler Group plain bearings facilitate precise swiveling of the parabolic troughs around the elevation axis. Over 1248 rod ends are fitted in the plant. They support the several hundred hydraulically-adjustable para-

bolic troughs, position them and enable them to continuously track the sun. Plain bearings are ideally suited for slow and precise swivel motions. They can support high forces and are suitable for both high unilateral loads and alternating loads, e.g. due to changing wind

directions. The 150-meter collector chains can be aligned with the course of the sun from east to west to an accuracy of a tenth of a millimeter.

The rod ends are equipped with manganese phosphated radial spherical plain bearings with a steel/steel sliding contact surface. This special surface treatment protects the material from wear and reduces friction. The spherical plain bearings' inner rings have a width of 70 millimeters, a cylindrical bore with a diameter of 110 millimeters and a convex outer slideway, while the 160-millimeter outer rings have a cylindrical outside surface and a concave inner slideway with a diameter of 140 millimeters.

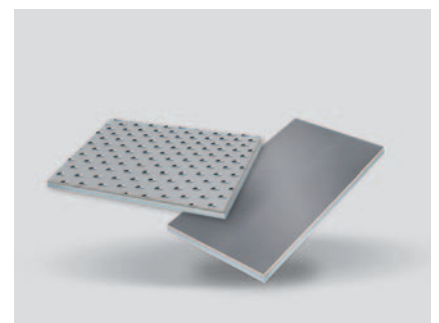
7,488 environmentally-friendly sliding strips from the metal-polymer composite plain bearing range supplement Schaeffler's contribution to Andasol. They ensure nearly friction-free swiveling during tracking in the supports between the individual segments of the 150-meter long collector chains.



Rod end



Metal-polymer composite plain bearing, maintenance free



Strips E50/E40, e.g. for plain bearings

Angular contact roller bearings for double-axis tracking systems...



for example with driven slewing rings with gear teeth and hydraulic cylinders. In axes with separate drives, slewing rings are suitable for use as bearing supports in the azimuth axis and plain bearings can be used in the bearing supports of the elevation axis. Solutions such as two axis gearboxes operated using motors that combine the tracking system of both axes in one housing are also available.

One bearing that is particularly suited to the requirements of tracking systems is the angular contact roller bearing of series AXS. High load carrying capacity and rigidity as well as a small cross section ensure high flexibility in the design and facilitate compact, reliable, and cost-effective gearboxes. The high load carrying capacity of the AXS angular contact roller bearing means the high loads generated by the weight of the mirrors and high winds are securely supported. On the other hand, the

clearance-free setting of the bearings and the high rigidity of the entire system create a particularly smooth bearing support without vibrations. This enables the power plant to track the sun more evenly and also results in higher positioning accuracy. Here too, the precision and robustness of bearing supports make a decisive contribution to achieving maximum efficiency and high cost-effectiveness in a plant.

Angular contact roller bearings AXS can be integrated in existing and new designs. They are very easy to fit securely. The geometry of the bearing rings is identical, which means no errors can occur during fitting. Simple, turned bearing seats are sufficient for supporting the bearing rings manufactured using forming methods. In addition, special lubricants (both grease and oil can be used) mean the bearing supports have particularly low maintenance requirements.

Whereas single-axis tracking systems move the collectors or reflectors in one direction only, double-axis tracking systems track the course of the sun both horizontally and vertically. This can be carried out using two separate drives,



Slewing ring with external gear teeth



Axial angular contact roller bearing



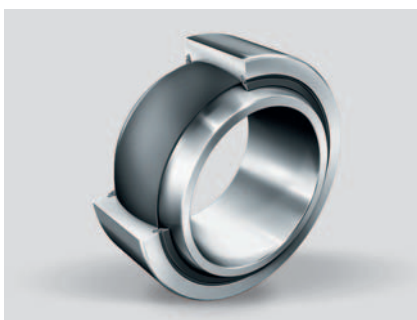
Maintenance-free plain bush with ELGOGLIDE®

... lightweight, high load carrying capacity, compact

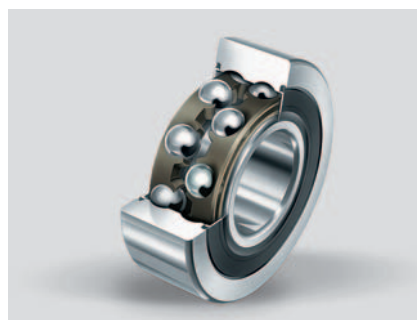
Series AXS angular contact roller bearings have cylindrical rollers as rolling elements and raceways that are arranged at an angle to the bearing axis. The conical bearing rings that are reminiscent of thin disc springs are a special feature of series AXS. These special rolling bearing rings are manufactured using forming methods. These methods require special manufacturing expertise, which the Schaeffler Group has been using for several years on a very wide range of products. Consistent use of forming technology enables designs to be manufactured that are extremely lightweight and have a very high load carrying capacity. Bearing rings one millimeter thick and low radial bearing section heights facilitate especially compact types. The roller and cage assemblies are comprised of cylindrical rollers that are snapped into high-rigidity plastic cages with very close spacing.

Lightweight steel cages formed of strip material are used for bearing dimensions of >250 mm. This means high load

ratings are achieved and, at the same time, the high bearing preload ensures high system rigidity.



Spherical plain bearing with ELGOGLIDE®



Track roller



Yoke type track roller

Seals and coatings are often indispensable

Of course, the development and design of bearing supports for solar power plants must also take environmental conditions into account. The environment – often desert or desert-like regions – is usually characterized by aridness, sand, high temperatures and significant temperature fluctuations. Such conditions require the use of reliable seals that prevent particles from entering the bearing and keep the high-quality bearing grease inside the bearing, and special materials and coatings that protect the bearing from corrosion.

The Schaeffler Group offers a modular seal system comprising a variety of sealing principles, sealing systems, sealing element arrangements and combinations. The Schaeffler Group has been a leader in the area of innovative surface and coating technology for many years and has optimized the functionality of surfaces of rolling bearings and precision components

that are subjected to high loads. The Schaeffler Group's Surface Technology Center performs development work on laboratory scale and reliably transfers developments to volume production processes.

Zinc and zinc alloys are predominantly used for anti-corrosion protection. Under the Corrotect® name, the Schaeffler Group has brought various coatings onto the market, such as zinc (Corrotect® ZK), zinc iron (Corrotect® ZI) or zinc nickel (Corrotect® ZN).

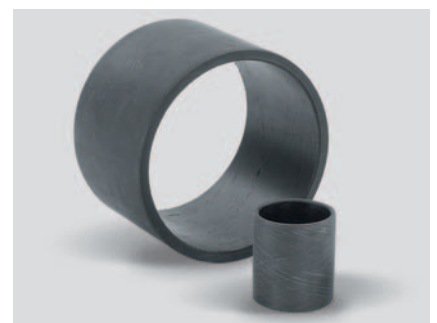
The sliding partner (shaft/pin) of plain and spherical plain bearings can be coated with chromium mixed oxide (LC layer) on a columnar chromium layer (Durotect® CK+) to provide anti-corrosion protection and to improve the sliding function. Combining the basic layer with a soft sliding layer improves not only the running-in behavior but also the friction and wear behavior.



Flanged and plummer block housing units, coated with Corrotect®



Maintenance-free plain bearing shell with ELGOTEX®



Maintenance-free plain bearing bushes with ELGOTEX®

Lubrication and fitting



ARCANOL rolling bearing greases – standard and special greases



Mounting tool set for fitting/dismantling

Lubrication – decisive for bearing performance and operating life

Incorrect lubrication is the most common cause of rolling bearing failure. This is why we place great emphasis on lubrication in our range of services. By using ARCANOL products for initial greasing that are tested in our in-house laboratories, we lay the foundation for long bearing life with low maintenance requirements. The ARCANOL range also includes greases for very high loads and environmentally-friendly greases. We offer customized permanent lubrication systems for automatic relubrication.

Expert fitting – the prerequisite for precision and performance

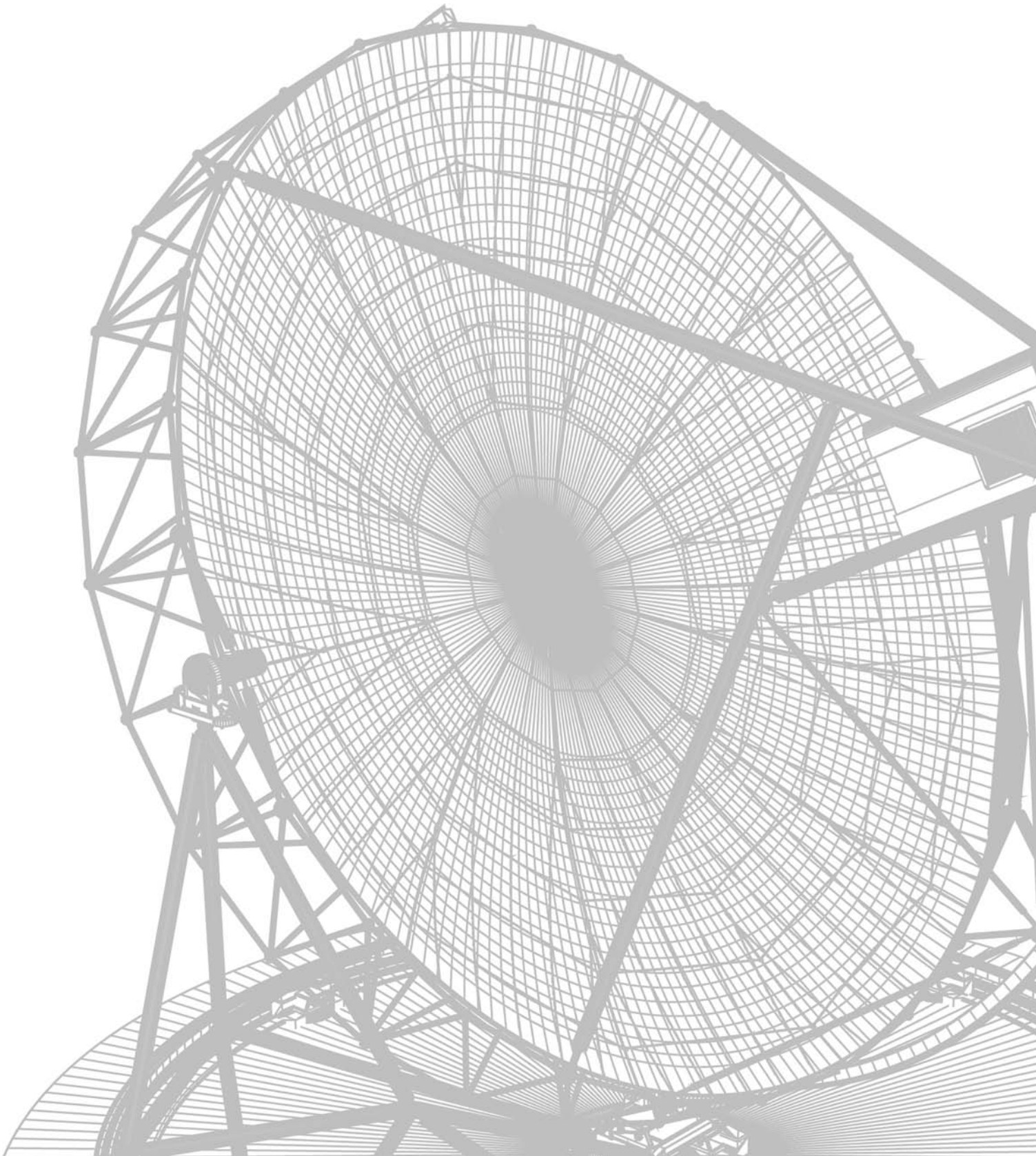
Rolling bearings are high-precision machine elements that are subject to high loads. The use of suitable tools for fitting and dismantling as well as proper care and cleanliness at the fitting location are important prerequisites for ensuring that rolling bearings achieve a long operating life. We offer professional fitting and dismantling tools as well as sector-specific training for fitting rolling bearings. Use our fitting service provided by our experienced, specially-trained team of Schaeffler fitting personnel.



Fitting service – also on site



Customer-specific training for fitting rolling bearings



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