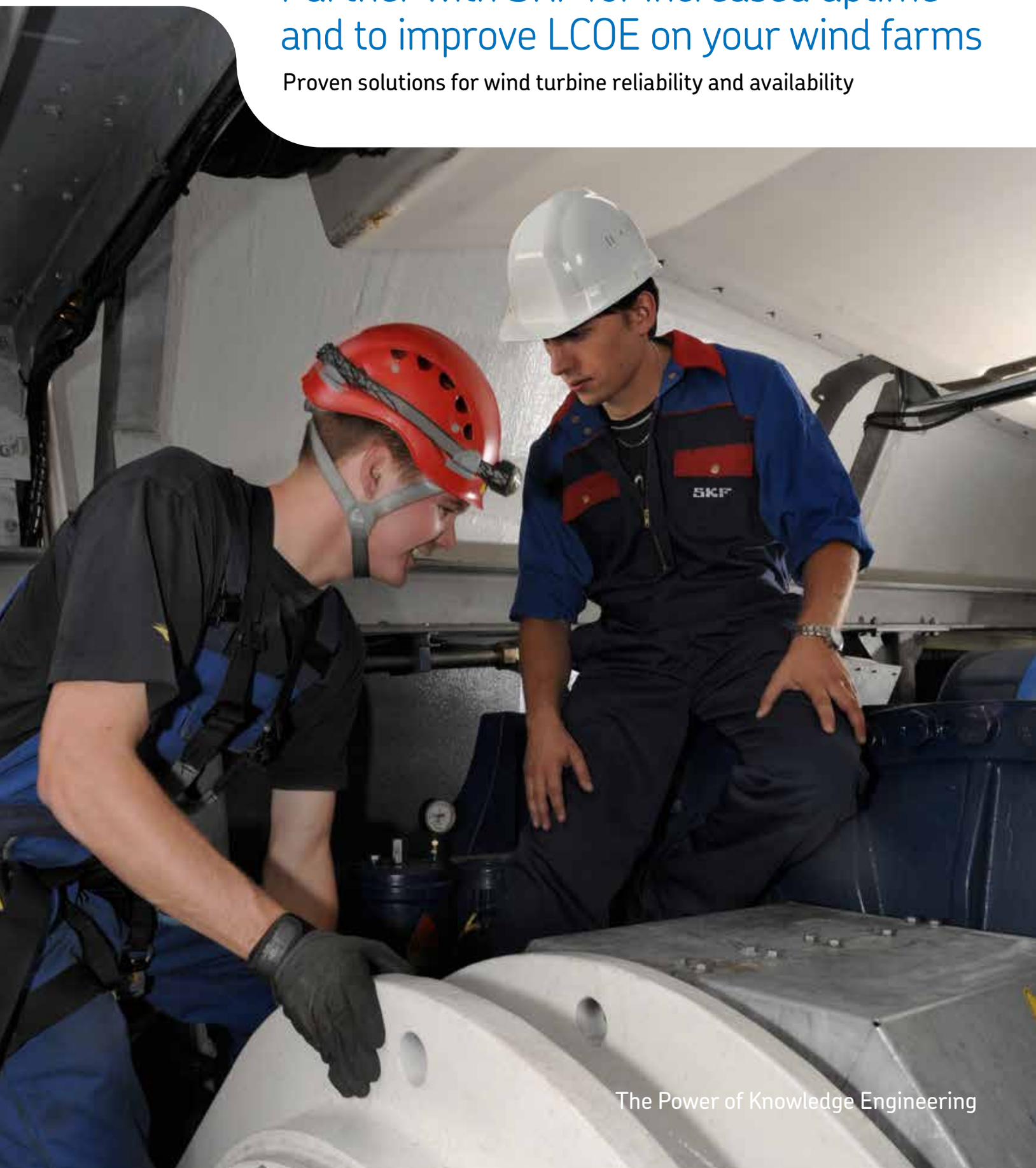
Partner with SKF for increased uptime and to improve LCOE on your wind farms

Proven solutions for wind turbine reliability and availability



The Power of Knowledge Engineering

SKF Life Cycle Management solutions for wind farms

Are your turbines generating power but not enough ROI?

High winds and harsh elements. Rough storms and remote locations. These conditions and more can limit turbine performance and reliability. When turbines go down due to maintenance issues or equipment failure, the high cost of repair crews and crane day rates can send costs per kilowatt hour soaring. Long wait times for spare parts can send them even higher.

Onshore and particularly offshore, anything that can prevent a service trip will help boost wind turbine ROI and reduce its levelized cost of energy (LCOE). As turbines grow increasingly large and move into more remote locations, finding the most reliable components and applying the smartest operations and maintenance processes will be even more critical to the bottom line. Proven SKF Life Cycle Management solutions can help.

Boost your capacity with SKF

SKF has been working with leading OEMs to optimize turbine performance, reliability and energy output since the industry began. Today, we're helping wind farm owners, operators and maintenance providers do the same with a range of wind maintenance solutions that can help drive uptime, add value and increase performance at every turbine life cycle stage.

Backed by our extensive global engineering, manufacturing and service footprint, we can provide you with original or upgraded products with quick deliveries, anywhere in the world. SKF can help to predict the remaining service life of your components with vibration measurement and analysis via remote monitoring, enabling greater machine uptime and much more cost-effective planned maintenance. Together, these SKF Life Cycle Management solutions will help you optimize turbine power output and improve LCOE.

The wind industry quality standard by SKF

In order for wind farms to maximize energy output and minimize total cost of operation, turbine reliability and availability must keep improving. To help make sure it does, SKF developed guidelines to help the industry standardize engineering, manufacturing and quality assurance processes for wind turbines, sub-systems and components. The development and implementation of this standard is helping wind farms meet the industry's goal of optimized life cycle cost efficiency.

Reduced total cost of ownership through

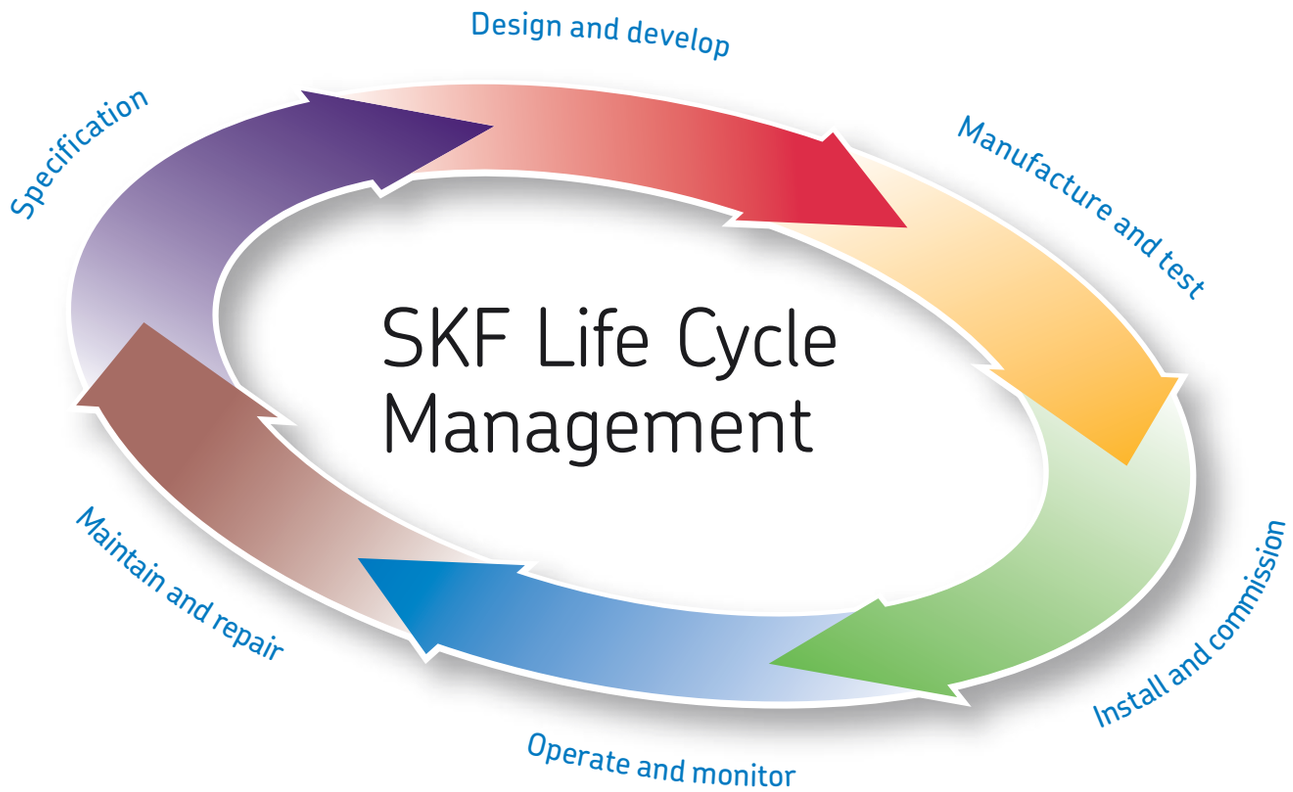
Industrial operations everywhere understand that effective management of assets throughout their life cycle can deliver significant value and reduce ownership costs. SKF Life Cycle Management is making it possible for a range of challenging applications, including wind turbines.

Thanks to more than a century of bearing manufacturing, plus hands-on experience in every major industrial application area, SKF has developed a unique understanding of rotating machinery. By applying a life cycle management approach, we combine our technology platforms and our industry knowledge to help end-user customers meet their challenges. Having a better understanding of end-user requirements, we bring that knowledge to bear on our product offerings to original equipment manufacturers, in turn helping them meet business challenges of their own.

More value at every stage

SKF Life Cycle Management is our proven approach for maximizing productivity while minimizing the total cost of machine ownership over every life cycle stage, from specification, design and manufacturing to operation, maintenance and repairs. With SKF Life Cycle Management, we can add value throughout the turbine life cycle to help you:

- **Maximize productivity and profitability**
- **Reduce total cost of ownership**
- **Minimize maintenance**
- **Improve reliability and safety**
- **Improve energy and resource efficiency**
- **Reduce the cost of energy produced**
- **Extend turbine service life**







out the turbine life cycle

Specification

Like all equipment assets, wind turbine service life cycles begin with a specification. SKF has worked with most leading wind energy original equipment manufacturers (OEM) to specify the right solutions for the application, right from the start. SKF Engineering Consultancy Services can also apply similar approaches to help operators and maintenance providers upgrade originally specified equipment or components.

Design and develop

During product development, SKF helps OEMs look at their turbine designs from a systems perspective to solve application challenges. SKF's proprietary 3-D modelling software simulates the interaction of machine components so that designers can explore alternative materials and geometries virtually, before actual prototyping. By applying the same tools and technologies, we can also help operators optimize existing turbine designs by utilizing additional farm-specific data.

Manufacture and test

SKF also supports wind turbine OEMs with world-class manufacturing and validation services anywhere worldwide, ranging from manufacture quality checks through end of line acceptance testing. These same resources can be used to help wind farms rebuild and test key turbine components in accelerated timetables.

Install and commission

Poor installation will reduce machine service life, lessen product quality and drive up maintenance costs. SKF's Industrial Services feature a range of expert services, training and products to provide fast, accurate installation and commissioning of new and replacement machinery. We can assist with proper mechanical setup and validate machine condition, which gives operators a valuable baseline to reference throughout the turbine life cycle.

Operate and monitor

During turbine operation, SKF can deploy a range of condition monitoring tools and maintenance strategies to increase uptime. Using our proven Asset Efficiency Optimization (AEO) process, we can help you identify and implement the best maintenance approach to reduce your total cost of ownership. By collecting and analyzing the right operating data, SKF can help wind farm operators identify the need for turbine maintenance activities and provide learning about optimum operating conditions.

Maintain and repair

When it's time for turbine maintenance, SKF can support your farm with an array of specialized tools, mechanical maintenance and repair services, plus a wide range of replacement products.

Turbine optimization solutions

A **SKF high-capacity cylindrical roller bearings and SKF high-capacity separable cylindrical roller bearings** for increased carrying capacity leading to improved gearbox reliability

B **SKF WindCon** for early detection of mechanical problems

C **SKF XL Hybrid bearings** with ceramic balls for superior insulation of wind generator bearings and **SKF INSOCOAT bearings** to protect against generator stray currents

D **Black oxide-coated bearings** for improved run-in performance in gearboxes

E **Automatic centralized lubrication kits** for reduced maintenance costs

F **SKF Remote Diagnostic Services** for wind farm remote monitoring and failure analysis

G **SKF Wind Gearbox Bearing Kits** with all needed bearings included for faster repairs, replacements and refurbishments

H **Axial excluder seal HRC1** with increased sealing performance for turbine main shafts and **Reinforced all-rubber HSS radial shaft seals** for turbine drive trains

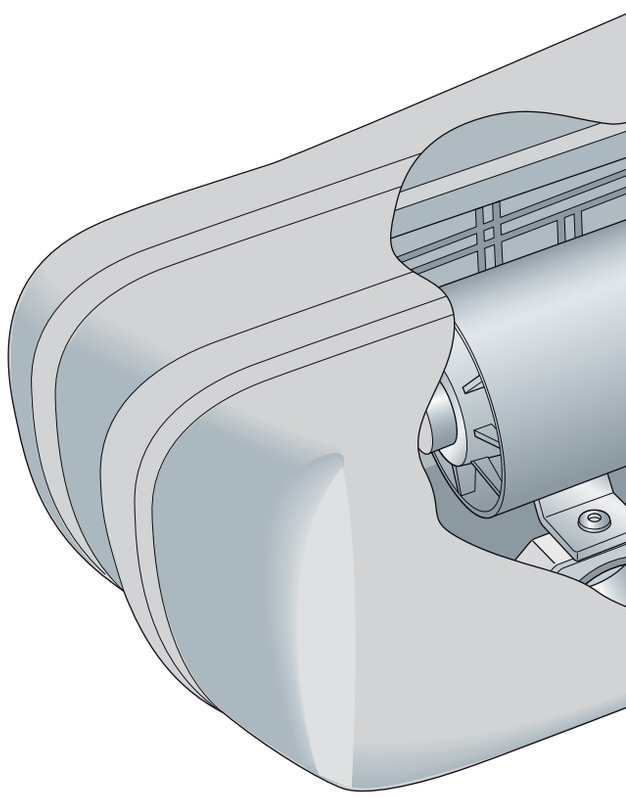
I **SKF High Endurance Slewing Bearings** for turbine pitch and yaw applications

J **SKF self-aligning bearing solutions** with outstanding performance based on state-of-the-art technology

SKF Nautilus bearings, a stiff bearing arrangement that provides high carrying capacity with minimum friction on turbine drive trains

K **Customized housings** optimized by SKF for main shaft bearings

L **Couplings** for faster, easier shaft mounting and dismounting



One goal of SKF BeyondZero is to reduce negative environmental impact from our operations and at the same time increase the positive contribution through the products and solutions we supply to our customers. All SKF solutions for the renewable energy sector have been selected for inclusion in the SKF BeyondZero portfolio, which features products and solutions with significant environmental benefits, including improved energy efficiency and increased renewable energy generation. www.beyondzero.com

SKF Remote Diagnostic Services

Using cloud-based technology, SKF performs remote diagnostic services from locations around the world. SKF experts use advanced signal analysis techniques to analyze turbine data, and then generate reports and make recommendations for customers. Data is always accessible to you via the cloud, and timely changes can be made to avoid bearing damage and extend bearing life.

Dedicated, around-the-clock surveillance and support

With SKF hosted software and diagnostic services, implementing a world-class predictive maintenance program for periodic or continuous monitoring of critical turbine machinery is just an Internet connection away. So many wind farm operators choose to have SKF monitor and manage the system for them.

SKF Remote Diagnostic Services supports informed decision-making for machine health by combining SKF condition monitoring technologies to collect data, SKF experts to analyze data, and the Internet to transfer data.

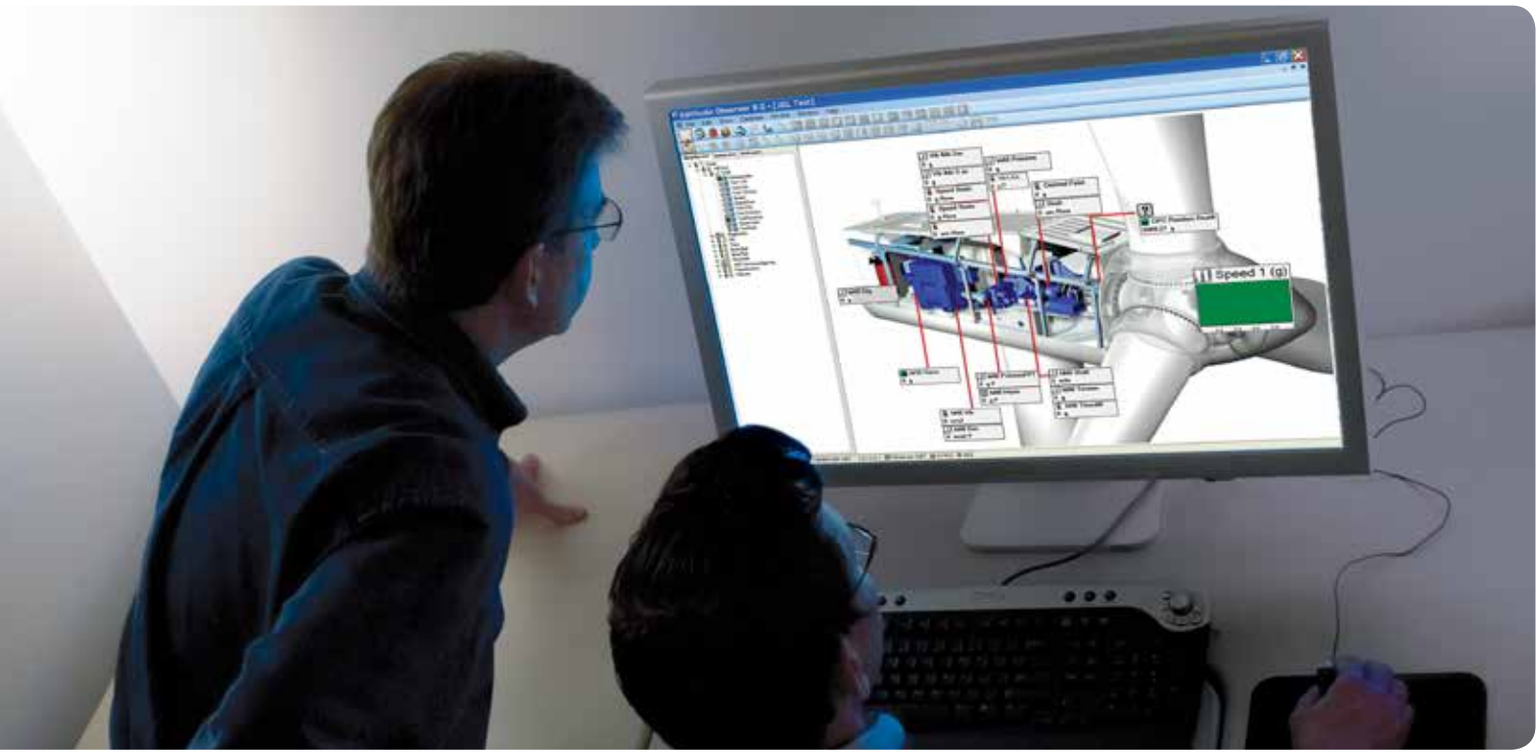
These services are ideal for farms with limited staff trained in predictive maintenance techniques and operations with sites located remotely from a central facility. They are also a proven way for original equipment manufacturers to provide a value-added service to their customers.

Choose your level of service

A flexible offering enables you to tailor SKF Remote Diagnostic Services to your operation's needs. You can choose to either benefit from our complete service offerings, or buy the unique SKF condition monitoring tools to perform your own remote monitoring. SKF Remote Diagnostic Services are available via dedicated centres in the Americas, Europe and Asia. SKF monitors today more than 1 700 wind turbines worldwide.

Benefits

- **Reduced risk of unplanned shutdowns**
- **Preventing lost energy production due to breakdowns**
- **Reduced wind turbine operating costs and cost per kWh produced**
- **Lower investments**
- **Increased data integrity**
- **Expert SKF analysis and recommendations**
- **Global, 24/7 access to reports and data**
- **GL-certified Remote Diagnostic Centre**



SKF WindCon and other condition monitoring tools

Controlling maintenance costs through condition monitoring

When maintenance problems occur at a wind farm, operators are faced with the prospect of expensive crane mobilization costs, lost energy production, and soaring costs per kilowatt-hour. For many farms, the number of maintenance technicians is limited, and determining how best to deploy them is a challenge. Additionally, spare parts for wind turbines are sometimes difficult to source in a timely manner. A well-established condition monitoring program together with appropriate tools can help.

SKF WindCon

Based on actual machine conditions, rather than arbitrary maintenance schedules, SKF WindCon is an easy-to-manage, proactive maintenance system that helps wind farm owners reduce operating and per-kWh costs. Easily installed on all turbine sizes and types, on land or at sea, the system continuously monitors single units or entire farms to reliably predict when maintenance activities will be necessary.

Using vibration sensors mounted on a turbine's main shaft bearings, gearbox and generator, as well as access to the turbine control system, the system collects, analyzes and compiles a range of operating data.

The system provides a reliable performance overview that identifies faults and predicts failures before they occur, enabling operators to consolidate maintenance activities and perform necessary inspection and repair work during planned turbine stops. This also means a possibility of extended maintenance intervals, less unexpected downtime, fewer unexpected costs and longer turbine uptime. The collected data also can be used to perform a root cause failure analysis, which can eliminate recurring failures.

Monitor a range of operating conditions

Through on-line condition monitoring, operators can monitor and track deteriorating component conditions in real time for almost an unlimited number of turbines and turbine data points. Sensors and software combine to continuously monitor and track a range of operating conditions:

- **Unbalanced propeller blades**
- **Misalignment**
- **Shaft deflections**
- **Mechanical looseness**
- **Foundation weakness**
- **Bearing condition**
- **Gear damage**
- **Generator rotor/stator problems**
- **Resonance problems**
- **Tower vibrations**
- **Blade vibrations**
- **Electrical problems**
- **Inadequate lubrication condition**

Access data from anywhere via WebCon

SKF WindCon uses WebCon data analysis, warehousing and web hosting services to make it even easier to access and act on collected data. Utilizing wireless communication, WebCon helps shorten lead-time from alarm to solution, as operators can review data from any location with a computer or hand-held device with Internet access. And with WebCon, operators don't have to develop or maintain any databases – SKF manages and stores all data remotely.

SKF Multilog On-line System

SKF WindCon is also available as a portable version to allow more flexibility, as the system can remain up-tower. The system is powered with a battery that can last up to four hours of continuous operation when fully charged. The analog signal inputs are configurable for a wide variety of sensors, providing valuable input for recording and documenting the turbine condition, especially for commissioning or end of warranty purposes.

SKF Microlog data collectors

The SKF Microlog Analyzer GX series is a family of high performance, one-to-four channel, route-based data collectors/analyzers. Three-channel, simultaneous triaxial input with separate tachometer input enables faster and more comprehensive data collection, without adding more collection time. This handheld device provides a quick vibration snapshot, especially for generators as well as high and intermediate speed shafts of the gearbox.

Technical support

SKF offers several product support plans to help you protect your technology investments, extend product service life and achieve better reliability. From software upgrades and equipment calibrations to annual preventive maintenance and unlimited technical support, SKF product support includes many exclusive benefits and options. SKF customers also enjoy access to a range of resources to help answer questions and resolve challenges. Our expertly trained technical support team is ready to assist you on everything from problems during start-up, to single-incident issues.

Equipment calibration

To help ensure that your equipment provides reliable data, we offer calibration services for most SKF condition monitoring products. All calibrations are traceable to either NIST standards or to UK National Standards; calibrations to ISO10012-1 (Mil Spec) are also available.

SKF WindCon has earned the official certification of Germanischer Lloyd.

No: DAA-GL026-2010

Lubrication solutions for a better bottom line

More availability with less expense

Studies show that 36% of all premature bearing damage is due to improper lubrication. Combine that with the percentage of bearing damage that results from the use of contaminated lubricants and the number rises to around 50%. Given their harsh operating conditions and locations, the answer for wind turbines is an automatic lubrication system.

Lubrication systems from SKF and Lincoln

SKF WindLub, featuring SKF and Lincoln branded lubrication systems can help wind farms benefit from precise automatic lubrication of critical turbine components. In addition to helping increase reliability and availability, SKF and Lincoln lubrication systems can help to prevent bearing damage and unscheduled turbine downtime while reducing operational and lubricant costs.

SKF WindLub

This automatic lubrication system delivers the exact quantity of the right lubricant to the right place at the right time. SKF WindLub offers proven solutions to cover the lubrication of all components and units in a wind energy system. Stationary systems can ensure that grease is continually supplied to main shaft, generator, blade and yaw bearings. For the rotating blade bearings, the lubrication systems are also equipped with a follower plate. The lubrication of the blade and yaw gears are covered by lubrication pinions, which apply the grease precisely to the area of contact on the drive pinion or blade drive gear and evenly lubricate the entire cog width.
SKF WindLub also easily integrates with SKF WindCon to remotely monitor the lubrication system health and the amount of grease applied to the bearing.

Benefits

- **Increases turbine availability and operational safety by avoiding manual lubrication**
- **Extends turbine service life and maintenance intervals**
- **Cuts operating and lubricant costs**
- **Reduces the risk of lubrication-related breakdowns**
- **Quickly detects torn feed lines or short circuits**
- **Monitors lubrication conditions via the Web**

SKF MonoFlex and Lincoln Centro-Matic single-line lubrication systems

- **High-pressure technology with optional grease-follower plate**
- **Suitable for fast bleeding greases**
- **Available as a pre-assembled kit to simplify mounting**
- **High lubrication accuracy on all lubrication points**
- **Electronic fill level control allows centralized monitoring**
- **Quick connector technology on distributors cuts mounting time and expense**
- **Components available in corrosion-resistant design for offshore applications**
- **Available with CAN bus control**

SKF ProFlex and Lincoln Quicklub progressive lubrication systems

- **Easy system monitoring via piston detector on metering device**
- **Continuous delivery of lubricant**
- **Simple system blockage control**
- **Pump units can be designed with integrated controls and CAN bus connection**
- **Manual lubrication aid with progressive feeders for small wind energy system available**

Upgrades

SKF offers lubrication system solutions for every wind turbine. Benefit from SKF's competence and upgrade your wind turbine with our solution. Upgrade kits – optionally preassembled – are available in OEM quality.

Single point automatic lubricators

As an alternative to fully automatic lubrication systems, installing single point automatic lubricators is probably the easiest way to change from manual lubrication to automatic relubrication.

The SKF SYSTEM 24 gas-driven single point automatic lubricator can be used for the relubrication of pitch bearings. Its low weight makes it particularly suitable for the relubrication of bearings in moving parts, such as the pitch. Moreover, it can be used for the relubrication of bearings in small generators.

The SKF Automatic Lubricant Dispenser TLMR can be used for the relubrication of the yaw, main shaft and generator bearings. Its larger cartridge size makes the TLMR suitable for bearings like these that require larger relubrication volumes.

SKF SYSTEM 24 Gas-driven lubricator LAGD

Pumps and grease guns

SKF pumps and grease guns make manual lubrication in the nacelle easier and more ergonomic. Featuring a slim and compact carrying case, the PowerLuber grease gun is an ergonomic tool for virtually any lubrication and preventative maintenance task.

Quick-filling, manual grease filler pumps feature a pump adapter that allows them to fill pump reservoirs in just a fraction of the time that conventional manual grease guns require. Please contact your local sales representative to find out which option is available for you.

Boost reliability with SKF WindCon Lubrication Interface

Remotely activated lubrication for turbine bearings

At preset intervals, SKF WindLub delivers preset lubricant amounts to key wind turbine bearing systems, while SKF WindCon monitors bearing irregularities as they occur.

Linking these two systems, the SKF WindCon Lubrication Interface enables monitoring of the lubrication system's health via alerts. In addition, the unit can be used to remotely trigger a lubrication cycle.

For turbine operators, the added lubrication functionality keeps maintenance crews on the ground instead of traveling to remote locations to manually lubricate the bearings. Bearing life is enhanced while life cycle energy costs are reduced, since poorly functioning bearings can increase energy consumption. The SKF WindCon Lubrication Interface also allows operators to plan repairs and prevent cascading bearing failures, thereby extending maintenance intervals.

Benefits

- **Remotely trigger additional lubrication cycles**
- **Extend wind turbine life cycle**
- **Increase wind turbine availability**
- **Reduce risk of unplanned shutdowns**
- **Remotely monitor lubrication pump and system health via alerts**
- **Incorporate GL-certified solutions**
- **Cut operating costs and costs per kWh produced**
- **Extend maintenance intervals**
- **Reduce up-tower costs**

1 SKF WindLub lubrication systems

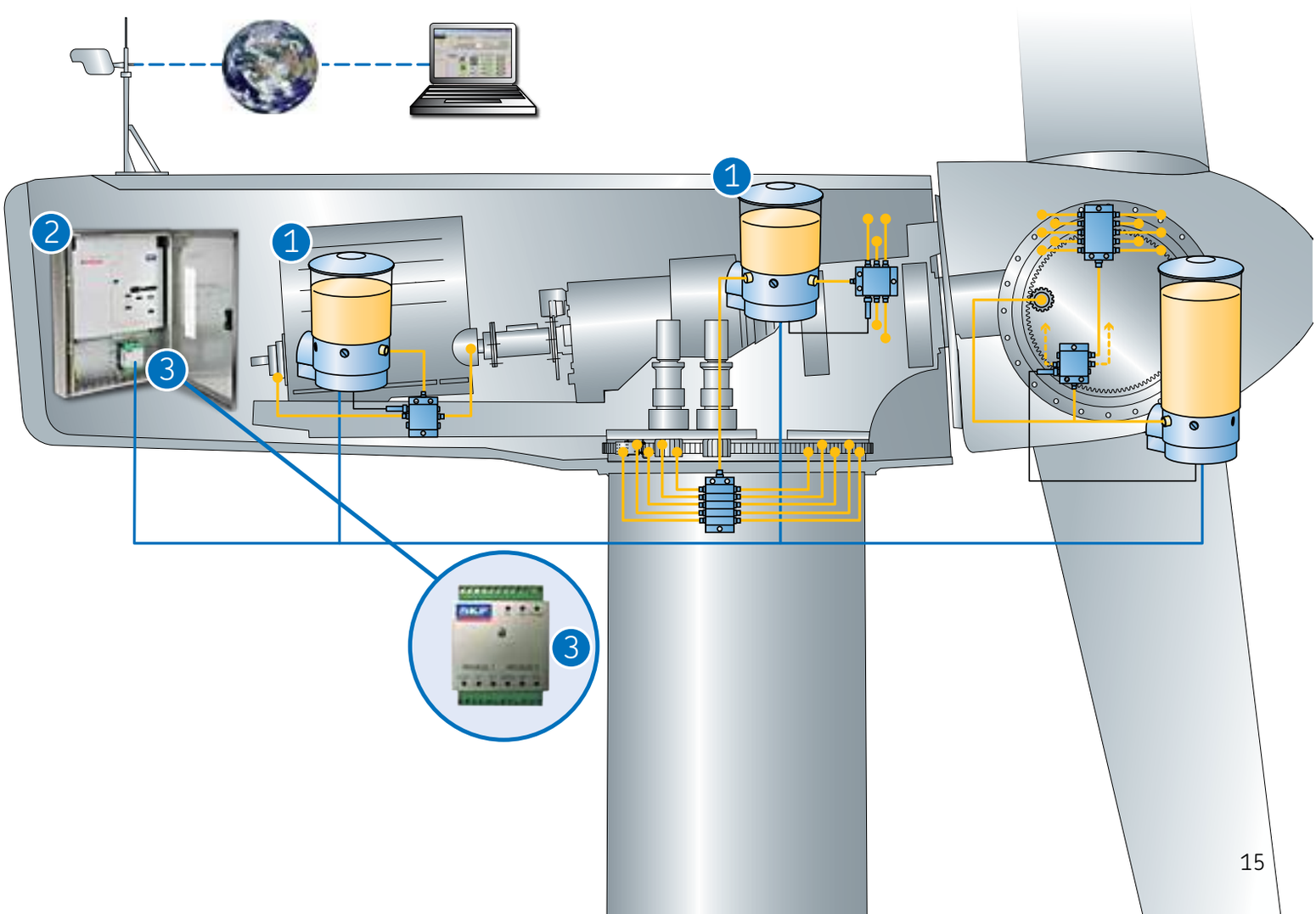
A lack of proper lubrication can bring your turbine to a standstill. Vibration, high mechanical loads, contamination and moisture are all threats to turbine bearings. With an SKF or Lincoln automatic lubrication system, you can lengthen bearing life by delivering frequent, small amounts of grease to each bearing while the machine is running. Precisely controlled amounts of lubricant, delivered at preset intervals, keeps bearings coated, enabling them to perform to their rated capacity.

2 SKF WindCon on-line condition monitoring system

By allowing operators to monitor and track deteriorating component conditions in real time, SKF WindCon enables maintenance decisions to be based on actual machine conditions, rather than arbitrary maintenance schedules. Along with potentially extending maintenance intervals, the system provides a powerful tool for managing day-to-day maintenance routines and consolidating risky, costly maintenance activities.

3 SKF WindCon Lubrication Interface

Utilizing the SKF WindCon Lubrication Interface as a link between SKF WindCon and SKF Windlub systems provides the ability to monitor lubrication system health. In addition, the unit can be used to remotely trigger a lubrication cycle.



The right lubricant for every lubrication point

A reliable lubrication system isn't enough

For turbine nacelles, particularly those operating in extreme environments, an automatic lubrication system that delivers the right quantity of lubricant at the right time is essential. But if it's not dispensing the right lubricant for the right lubrication point, it's not fully minimizing friction and wear.

Trust tribology and SKF

Without the science of tribology, developing lubricants that support longer asset life, bigger load capacity and lower energy consumption would be impossible. This is why SKF established a specialized research centre where we study lubrication and lubricants in detail. Continuous research and development, along with close cooperation with wind turbine manufacturers and operators, has allowed SKF to develop greases optimized for different bearing applications in wind turbines.

A robust range of greases

The following SKF greases are developed, analyzed and tested before reaching your machines, making sure that you receive the proper lubricant for the turbine main shaft, yaw and blades. These greases provide proper lubrication whether the turbine is operating or in standstill mode, installed onshore or offshore, or located in extreme temperatures or conditions.

LGEP 2
Main shaft grease

- Mineral oil/Lithium-based
- High load, extreme pressure bearing grease
- Good lubrication in operating conditions from –20 to 110 °C
- Good mechanical stability
- Excellent water resistance with rust and corrosion-inhibiting properties
- Excellent extreme pressure performance

LGWM 1
Main shaft grease

- Mineral oil/Lithium-based
- Extreme pressure low-temperature bearing grease
- Extremely suitable for lubrication of bearings operating under both radial and axial loads
- Temperature range from –30 to 110 °C
- Good oil film formation at low temperatures down to –30 °C
- Good pumpability at low temperatures
- Good corrosion protection
- Good water stability

LGWM 2
Main shaft grease

- High-load, wide-temperature bearing grease
- Semi-synthetic base oil, based on complex calcium sulphonate thickener technology
- Temperature range from –40 to 110 °C
- Excellent corrosion protection
- Excellent mechanical stability
- Excellent high load lubricating capacity
- Good false brinelling protection
- Good pumpability down to low temperatures

LGBB 2*
Pitch and Yaw grease

- High-load, low-speed bearing grease
- Synthetic oil (PAO) / Lithium complex-based
- Wide temperature range from –40 to 120 °C
- Excellent performance under oscillating or standstill conditions
- Highly suitable for frequent start-ups
- Very low friction and start-up torque at temperatures as low as –40 °C
- Outstanding corrosion protection for offshore applications

** Under arduous test conditions, the patented SKF LGBB 2 grease outperformed other commercial greases in pitch and yaw bearing applications.*

Spare parts management

In the wind aftermarket, it is essential to have the required replacement parts on hand and a reliable logistics set-up tailored to potential needs for all wind turbine applications. With SKF spare parts management capabilities, you can get the right items, at the right place, at the right time.

By analyzing the installation base and accumulating customer demands to optimize availability, SKF is able to offer an installed spare parts management programme that can result in significant costs savings and productivity increases. SKF spare parts management encompasses every critical aspect of wind farm part procurement, from strategic inventorying and engineering upgrades to all-inclusive kits, time-saving logistics and wide-ranging partnership agreements.

Strategic inventory management

SKF has generated a strategic stock that increases the availability of many items and reduces lead times dramatically. Automatic replenishment routines can save time and reduce costs for our customers, while enabling them to get their turbines back into operation sooner. Strategic stocking also helps customers reduce their local stock, reducing the overall cost of capital employed.

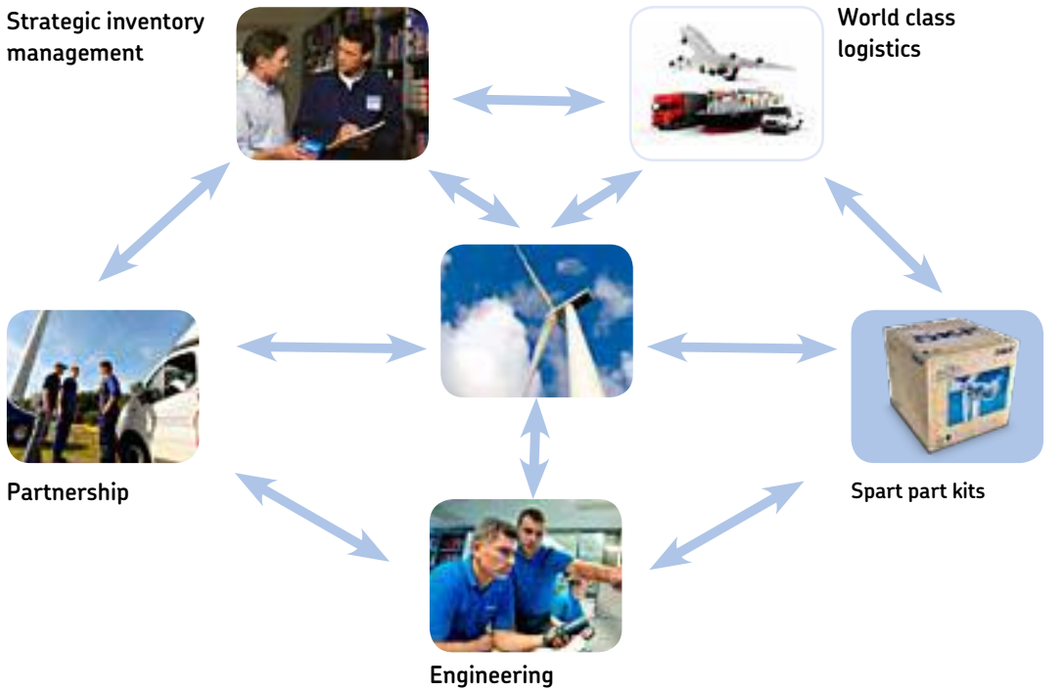
World class logistics

Logistics can play an important role in the efficiency and cost of maintenance in wind turbines, influencing availability as well as punctual and correct arrival of spare parts and other necessary equipment.

SKF Logistics Services has vast experience in industrial logistics and knows the challenges of operator and maintenance assets. By creating efficient processes that keep stock levels low while avoiding errors and costs, we support the profitability of your company. Our logistics set-up is tailored to the requirements of the wind business and can be applied at any of our global locations, including in response to emergencies.

“Average industry savings through spare parts management optimization: 3%”

Source: MAKE Consulting A/S



Engineering

With extensive engineering capabilities and a deep knowledge of the wind industry, SKF is always at the leading edge of component development. We support turbine reliability by supplying the latest products.

Spare part kits

Available for rapid delivery for a wide range of applications, SKF spare part kits simplify the process of identifying and ordering components. Through our knowledge of turbine equipment, we are able to provide you the right spare parts (bearings, seals and lubricant), delivered in one package that contains all the parts necessary for a complete repair, refurbishment or upgrade.

Partnership

Through partnership agreements, SKF can offer other types of spare parts our customers may require. In some cases, this can involve taking responsibility for inventory, supply chain and logistics. SKF can set up procedures to identify critical items based on the customer's forecasts or business processes, then set up safety stock with automatic replenishment routines to ensure availability and short lead times.

Unique kits for unique applications

For wind farm operators and utilities, even routine gearbox maintenance is a challenge. When repairs are required on short notice, the challenge is even greater, as replacement parts must be sourced and delivered as quickly as possible.

SKF Wind Gearbox Bearing Kits feature replacement components for specific applications and equipment brands. These customized kits help ensure availability of bearings when you need them most – reducing downtime for repairs as well as inventory costs. In addition, the kits can support proactive maintenance by interchanging bearings according to the latest technological standards.

SKF offers kits for most gearbox manufacturers, including Moventas, Echesa, Hansen/ZF, Winergy, Bosch Rexroth, and more.

Benefits

- **Easy identification and sourcing of correct bearings**
- **Quick access to bearings when needed**
- **Reduced inventory costs**
- **Reduced downtime and lost productivity**
- **Access to one trusted source for quality bearings**
- **Access to SKF wind industry application**
- **Knowledge and experience**

Range

We maintain a comprehensive inventory of gearbox bearings and will package and deliver them as a complete kit for each gearbox type. Optionally, SKF can customize kits to your requirements. Kits are available for up-tower repairs as well as for complete gearbox refurbishments done in workshops.

Solutions for virtually any rotor bearing arrangement

Depending on the individual requirements of turbine design, SKF can provide solutions for both flexible and rigid main shaft bearing arrangements.

For flexible arrangements, SKF provides different self-aligning bearings together with the appropriate housing and sealing system. For rigid arrangements, there are several solutions. For example, the SKF Nautilus bearing eliminates the need for almost the entire shaft, which leads to a very compact machine design.

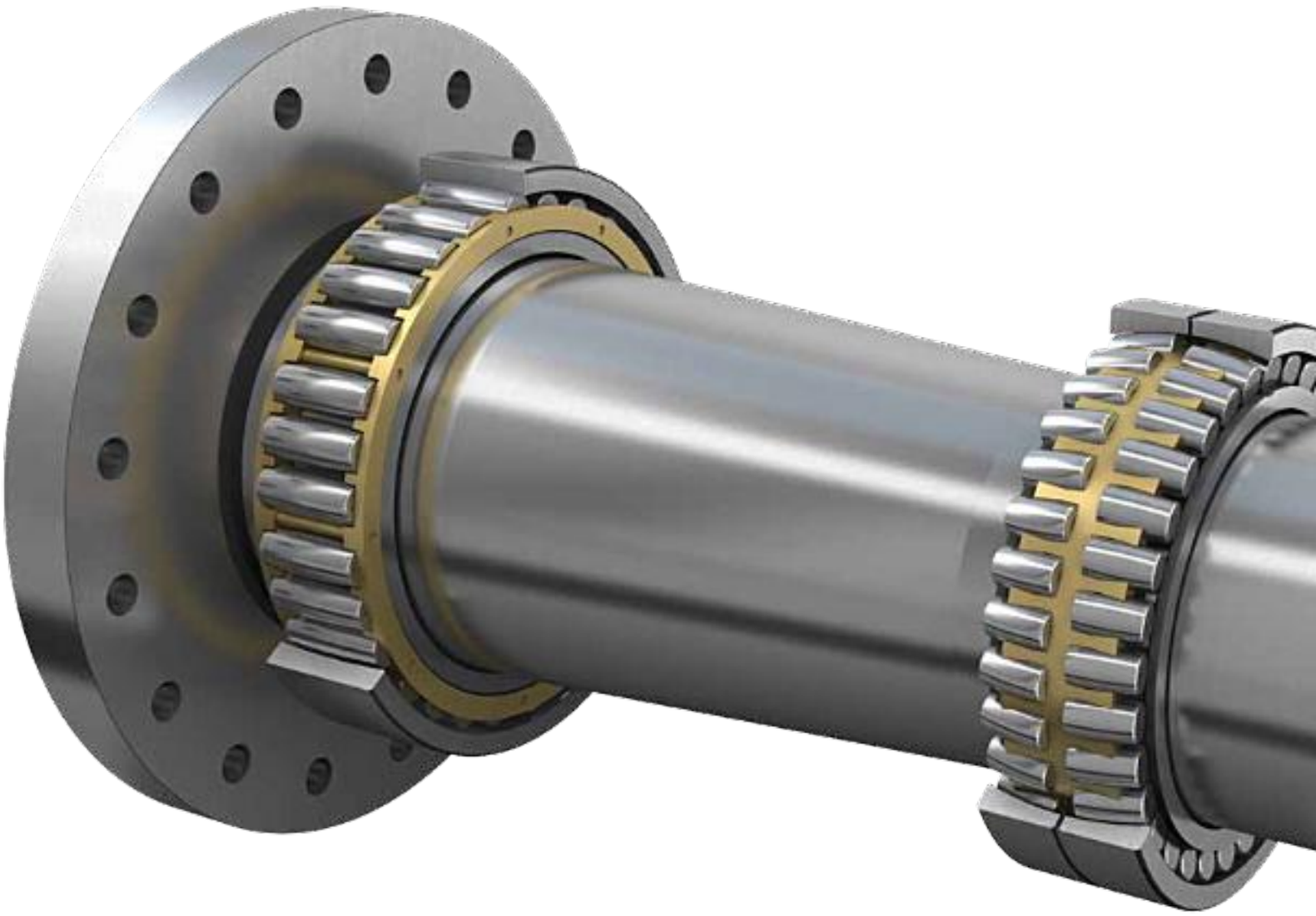
For more traditional concepts, SKF can provide a wide range of bearing sizes and types, such as spherical roller bearings, tapered roller bearings and cylindrical roller bearings.

SKF self-aligning bearing solutions

Improving the performance of wind turbines has typically required design decisions that add weight – and cost – to the nacelle. The SKF self-aligning bearing system for wind turbine main shafts gives turbine designers an effective alternative that reduces nacelle weight and production costs while at the same time increasing turbine reliability.

Upgraded SKF Explorer spherical roller bearings

Self-aligning roller bearings are typically used in demanding equipment, including wind turbines, that requires a high degree of reliability even where there are high levels of contamination and poor lubrication conditions.



By design, SKF spherical roller bearings can accommodate very heavy radial and heavy axial loads in applications prone to misalignment or shaft deflections. All SKF self-aligning roller bearings have been upgraded to a new level of performance with upgraded bearing steel. These heavy-duty self-aligning roller bearings provide even greater wear resistance to further improve turbine reliability and uptime.

The upgraded SKF steel increases hardness while maintaining or improving toughness. Tests have shown that the upgraded steel extends the time from initial spall through fracture. This means that once bearing damage has been detected, the bearing can continue to operate longer, providing more time to plan, order parts and prepare for a shutdown, thereby reducing turbine downtime and its related costs.

In wind turbines, bearing arrangements with two spherical roller bearings on the main shaft are a well-proven solution. With a wide range of standard housings available to simplify mounting and maintenance in turbine applications, SKF spherical roller bearings are a proven solution for higher wind energy equipment availability.

Benefits

- **Proven solution in wind turbines**
- **High product availability**
- **Standard housings available**

SKF self-aligning bearing system, with a locating spherical roller bearing on the left hand side, and a non-locating CARB toroidal roller bearing on the right hand side.

CARB toroidal roller bearings

An alternative to a shaft configuration with two spherical roller bearings, the SKF self-aligning bearing system for wind turbine main shafts features a spherical roller bearing in the locating position and a CARB bearing in the non-locating position. This combination offers a very high load rating in a smaller, lighter housing. Unlike in a conventional bearing arrangement in which friction between the outer ring and housing must be overcome in order to accommodate axial motion, the CARB bearing is able to accommodate both misalignment and axial displacement of the shaft inside the bearing at the same time.

This eliminates the problem of induced axial loads, improving turbine reliability while enabling the cross-section of the bearing to be smaller than would be possible with conventional arrangements. As a result, wind farm owners and operators benefit from reduced tower and foundation weight and improved reliability that translates into reduced maintenance and operating costs.

Benefits

- **Reduced nacelle weight and total weight on tower and foundation**
- **Longer bearing service life**
- **Improved turbine reliability**
- **Reduced maintenance needs during operation**

Solutions for virtually any rotor bearing arrangement (cont.)

SKF Nautilus bearing solutions

The original SKF Nautilus solution

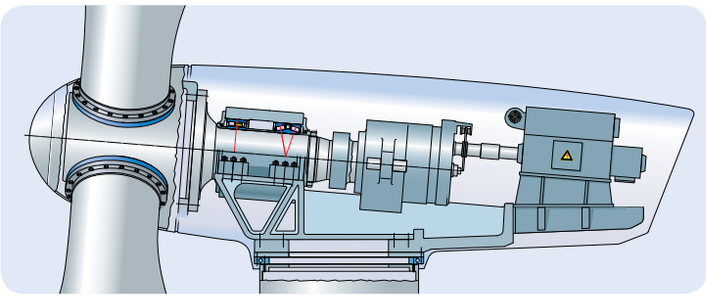
The original SKF Nautilus double row tapered roller bearing is well-known for successfully extending drivetrain service life and increasing turbine reliability. All rotor loads are carried by a single bearing, rather than on a traditional two-bearing arrangement that handles radial and axial loads separately.

By doing the work of two bearings, the Nautilus bearing enables the bearing to be integrated directly into the machine frame and the hub, thus increasing the compactness and stiffness of the whole drivetrain design. As a result, only the rotor torque is transmitted to the drive train.

Expanded range of Nautilus solutions

SKF has created the next generation of SKF Nautilus bearing solutions. Expanded and improved using knowledge gained from many SKF Nautilus-equipped designs developed in cooperation with turbine manufacturers and design consultants, these new solutions offer updated, versatile and integrated features to meet the industry's demands. SKF Nautilus solutions now include integrated sealing carriers, optimized pre-greasing and the option of a bolt-mounted inner ring in addition to the bolted outer ring. These give manufacturers and end-users more options than ever before to:

- **Reduce the cost of energy**
- **Increase reliability and operational safety**
- **Simplify mounting, dismounting and replacement**
- **Extend maintenance intervals**
- **Improve serviceability**
- **Decrease nacelle weight**



Traditional rigid main shaft bearing solution

This main shaft bearing solution is a combination of a double row tapered roller bearing in the locating position and a cylindrical roller bearing in the non-locating position.

Turbines equipped with a gearbox often suffer from parasitic loads induced by the rotor. This can significantly be reduced by using a “clearance free” bearing solution, leading to fewer bearing failures in gearboxes and higher reliability, as well as enhanced operational safety of wind turbines.

Benefits

- **Improved turbine reliability and operational safety**
- **Increased turbine efficiency**
- **Reduced operating and maintenance cost**

Housings customized to your specifications

SKF main bearing housings are tailor-made to suit the specific request of each wind energy customer. These housings have an efficient sealing solution and are grease lubricated. SKF can offer a range of main bearing housings for several sizes, and can also provide support to optimize housing design. The housings are equipped with a high quality labyrinth seal, providing:

- **Long service life**
- **Reliable operation**
- **Limited need for maintenance**

Gearbox solutions for increased safety, extended equipment life cycles and reduced operating costs

Drawing on decades of knowledge of rotating equipment, SKF offers wind farms a range of easy-to-implement solutions for upgrading gearbox performance. SKF gearbox solutions can help to extend equipment life cycles, increase uptime, reduce maintenance and cut total operating costs.

SKF Explorer bearings

Developed in response to increasing performance demands on modern machinery, SKF developed the SKF Explorer performance class of rolling bearings. A significant advance over conventional designs, SKF Explorer bearings can reduce the need for maintenance and contribute to increased productivity. In addition, they can reduce the environmental impact by enabling downsizing and reducing both lubricant and energy consumption. Since their introduction, SKF Explorer bearings have been proven around the world to extend bearing service life by up to 3 times in the most demanding industrial applications.

Upgraded SKF spherical roller bearings exhibit an even higher level of performance. Combining the clean and homogenous high-quality steel used in the original SKF Explorer bearings with an improved heat treatment process, these superior bearings provide longer service life, particularly under difficult operating conditions characterized by high contamination and challenging lubrication conditions.

SKF high-capacity cylindrical roller bearings

Applications such as gearboxes in wind turbines require components that can provide high operational reliability and long service life. To achieve the maximum load carrying capacity of a full complement bearing and the robust performance of a bearing with a cage, SKF developed high-capacity cylindrical roller bearings. These bearings combine the advantages of both bearing types.

In contrast to full complement cylindrical roller bearings, SKF high-capacity cylindrical roller bearings are also available in the SKF Explorer performance class. SKF Explorer high-capacity cylindrical roller bearings, with an optimized surface finish, are recommended for the typical conditions in wind energy applications.

Conventional bearings used in wind applications can suffer from frequent starts and stops because after each start, it takes a certain time to build up the lubricant film. SKF Explorer high-capacity cylindrical roller bearings have a surface finish that quickly promotes the formation of a lubricant film.

Benefits

- **Lower energy consumption**
- **Increased load carrying capacity vs. standard caged bearings**
- **Extended maintenance intervals**
- **Lower noise and vibration levels**

Wind turbine gearboxes transform low speeds and high torques at the input on the rotor side into high speeds and low torques at the output on the generator side. SKF solutions can help you to withstand these challenges.

SKF separable high-capacity cylindrical roller bearings

Over the last decade, wind power generation has increased dramatically, at the same time creating challenging new demands for greater reliability and more efficient turbine maintenance and repair. With offshore farms and larger turbines on the horizon, that demand will only increase, as will calls for increased safety, improved availability and reduced operating costs. SKF separable high-capacity cylindrical roller bearings can help.

Combining the advantages of conventional and SKF high-capacity cylindrical roller bearings, the SKF separable version can help take gearbox reliability and safety to the next level, as it is less sensitive under light loads. Unlike conventional bearings, their unique design reduces the risk of smearing, adhesive wear and bearing failures on high-speed shafts, while allowing high-speed intermediate shafts to withstand higher loads.

Quick and easy maintenance

When maintenance is required, especially top-of-turbine, SKF separable high-capacity cylindrical roller bearings enable it to be accomplished quickly and easily, helping to reduce operating, maintenance and lifetime costs per kW hour. Due to the reduced roller drop, these bearings can be easily mounted like standard cylindrical roller bearings.

Benefits

- **Improved gearbox reliability**
- **Increased load carrying capacity**
- **Minimized smearing and wear**
- **Fewer bearing failures**
- **Quick and easy mount/dismount**
- **Reduced maintenance**
- **Increased operational safety**

Less maintenance and more uptime with gearbox solutions f

High-performance tapered roller bearings

To improve the performance of high-, intermediate- and low-speed shaft bearing arrangements in wind turbines, SKF offers tapered roller bearings in a wide range of bearing sizes and cross sections. These bearings feature optimized raceway geometries, improved surface topographies and higher running accuracy, all of which results in reduced operating temperature and increased gearbox reliability. Available in single and paired executions, in SKF Explorer-class quality, and with black oxidized rollers and rings, these high-performance bearings are ideally suited for turbine gearbox applications.

Benefits

- **Increased gearbox reliability**
- **Reduced friction**
- **Better lubrication conditions**
- **Reduced vibration**
- **Lower operating temperature**
- **Reduced noise level**

rom SKF

Black oxide bearings

Wind turbine bearings must endure widely varying temperatures, speeds and loads, plus exposure to contaminants including moisture and chemicals. These conditions can limit bearing service life and increase already high operation and maintenance expenses.

Featuring an enhanced black oxidation surface treatment applied to the rings and rollers, black oxide coated bearings from SKF help cut turbine operation and maintenance costs. They can offer better performance in poor lubrication situations – particularly under mixed friction – because their treatment delivers improved lubricant adhesion and enhanced smearing resistance. The risks of fretting, micro-pitting and cracks can be minimized. Black oxide bearings can reduce the effects of moisture and aggressive oil ingredients due to their improved corrosion and chemical resistance when compared to conventional bearings. They also help to improve running in and friction behaviour.

Suitable for new installations or as a replacement for conventional bearings of many types during maintenance routines, black oxide coated bearings from SKF offer wind farm operators and maintenance providers significant performance improvements in turbine uptime at an acceptable cost.

Separable high-capacity cylindrical roller bearing

Coupling solutions for wind turbines

The SKF hydraulic coupling for wind turbines (OKCK) is designed to fit within a limited space, offering quick and easy mounting and dismounting. In addition, the design creates controlled high pressure against the shafts, eliminating the need to check preload conditions of screws.

The coupling can be mounted by just one person, using oil power – no loud, vibrating pneumatic wrenches. Factory mounting and dismounting time is less than half an hour for each operation, with similar times when the coupling needs to be mounted and dismounted on-site. Practical testing has shown that the SKF OKCK coupling reduces mounting time by up to four times compared with mechanical couplings.

The slimmer SKF coupling for wind turbines (OKCK) offers even greater weight, time and cost saving possibilities in the connection of shafts in all types of wind turbines. Mounting and dismounting times are less than 15 minutes, in factory or on-site.

SKF Wind Gearbox Bearing Kits

See spare part management → page 18–19

Reduce life cycle costs with SKF innovations for generators

To overcome the damaging effects of stray electric currents, SKF has developed two electrically insulating rolling bearing solutions: SKF XL hybrid bearings and INSOCOAT bearings. These high performance solutions help reduce total life cycle costs, while lowering the risk of costly generator repairs and lost production, ultimately reducing the cost of each kWh produced. The best solution depends on the potential severity and cause of any possible stray electric current and the size of the bearing.

SKF XL hybrid deep groove ball bearings and cylindrical roller bearings

Designed and developed for generators in wind turbines, including the multi-Megawatt class, SKF XL hybrid bearings can insulate against any electric current, while providing high reliability and excellent performance. These bearings feature a unique design with rings of bearing steel and rolling elements of bearing grade silicon nitride (Si_3N_4) with high hardness and low density.

SKF XL hybrid bearings are the most technically reliable and cost-effective solution for avoiding premature bearing failures due to electrical erosion. These bearings combine a unique design, superior material properties and top-class SKF quality control for exceptional long-term reliability. Extended grease life helps reduce life cycle costs even more.

Consistent behavior, stable operation

SKF XL hybrid bearings maximize the effects of the lubricant to enhance long-term performance when compared with all-steel bearings. In fact, you can count on operational reliability, even under poor lubrication conditions, because these bearings are more likely to maintain consistent behavior and operational stability.

An excellent fit

Upgrading turbine generators with SKF XL hybrid bearings is simple. The bearings feature standard bearing dimensions, so there is no need for redesign, additional components or special tools during installation. SKF technical support is available if needed.

Benefits

- **High reliability and increased sustainability**
- **Reduced life cycle cost and total cost of operation**
- **Superior electrical insulation properties even at very high frequencies**
- **Extended maintenance intervals due to longer grease life compared to all steel bearings**
- **Reliable operation even under poor lubrication and contamination conditions**
- **Standard bearing boundary dimensions**
- **Easy upgrade of already installed turbines**

Customized solutions

SKF manufactures and stocks a wide selection of XL hybrid bearings covering the most commonly used sizes in generators for mainstream wind turbines. For multi-megawatt wind turbine generators which require other bearing sizes or other bearing arrangements, SKF can supply customized solutions.

INSOCOAT bearings

With an electric insulation function designed into the bearing, an INSOCOAT bearing is an economical solution for providing a level of protection from the damaging effects of stray electric currents. Whether an INSOCOAT bearing is the right solution will depend on the potential severity of stray electric currents.

INSOCOAT bearings are sealed with a resin to protect against the conductive effects of water and moisture and typically can withstand static voltages up to 1 000 V DC. In addition, coating variants to withstand static voltages up to 2 000, or even 3 000 V DC can be supplied on request.

INSOCOAT bearings that have the bore and side faces of the inner ring coated provide enhanced protection due to the smaller surface area of the inner ring compared to the outer ring surface.

Benefits

- **High reliability, lower life cycle costs**
- **Virtually eliminates premature failures caused by stray electric currents**
- **Economical solution compared to other insulating options**

SKF Quiet Running deep groove ball bearings

Designed and developed based on the operating conditions of wind turbine generators, SKF Quiet Running bearings help prevent resonance that can occur between the rotor, stator and bearings. Less sensitive to variable wind turbine operating conditions such as changing wind speeds, SKF Quiet Running bearings can increase bearing service life and extend relubrication intervals.

These benefits are possible thanks to a specific design and manufacturing process which provides a very low level of vibration. Reduced vibration has a direct impact on the fatigue of the whole system and can lead to increased system reliability and life. Additionally, they are equipped with a new set of cages that have a significant positive impact on grease life.

Because they are fully interchangeable with existing deep groove ball bearings, SKF Quiet Running bearings can be used without modifying the rotor shaft or end shield.

Benefits

- **Minimizes structural resonance and vibration levels**
- **Quiet running under variable operating conditions**
- **Increases service life thanks to better grease utilization**
- **Improves overall system reliability**
- **100% interchangeable with conventional bearings**
- **Available with pressed steel or machined brass cages**
- **Dedicated specification: suffix VQ658**
- **Also available for SKF XL hybrid and INSOCOAT**

Extend generator working life with Baker instruments

As a global leader in wind generator preventive maintenance analysis, SKF designs and manufactures a full line of static (offline) electrical test instruments that evaluate the condition of generators used in wind-powered electrical generation applications.

SKF's acquisition of Baker Instrument Company (an SKF Condition Monitoring Centre) made SKF an instant leader in generator circuit analysis solutions. The SKF portfolio of Baker-engineered analyzers are used to evaluate generator circuits and insulation. This testing helps generator manufacturers and users identify faults or potential problems, avert costly downtime, and extend the working life of their generation equipment.

Generator Inspection

Studies show that electrical faults are one of the most common failures in generators. So in addition to a condition monitoring regime that may include vibration analysis, thermography, laser alignment and oil analysis, a structured electrical testing regime is vital to plant reliability.

The long-standing tool of choice for engineers, the meg-ohm test, is often the only electrical test performed. While this simple test has its place, it is not capable of detecting all the likely faults within a generator's winding. Surge testing should be used to analyze the turn to turn insulation, as this is typically the weakest insulation. Using PC control to provide automatic testing and fault diagnosis, modern test equipment is able to detect micro arcs, and stop the test automatically. Database software allows assets to be saved with all test results, so that a trend can be observed over time, ideally starting when equipment is first commissioned. Even a one-time investigation provides valuable input for end of warranty inspections, since slowly occurring failures can typically be detected at an early stage.

Why high voltage testing?

Why should a 690 volt winding be subjected to a 2 500 volt test? Windings are subject to high voltage spikes on start-up, shut-down and during operation. To provide motor and generator reliability, insulation testing needs to be carried out at similar levels. This will allow early detection of developing faults.

Baker AWA generator winding analyzer

Portable and computer-driven, Baker AWA-IV series motor/generator circuit test equipment is ideal for testing generators used in wind applications.

Comprehensive analysis – The Baker AWA comes in models from 4-12 kV but can be used with a power pack to boost voltages up to 30 kV. The AWA performs tests on all insulation and circuits in AC and DC motors, generators and coils. It has detailed analysis reporting capabilities.

Predictive maintenance – The Baker AWA provides automatic, consistent testing. Trends are gleaned from test results for each generator winding over time, helping to highlight issues such as a connection working loose, build-up of contamination, or damaged insulation, both winding to earth, and winding to winding.

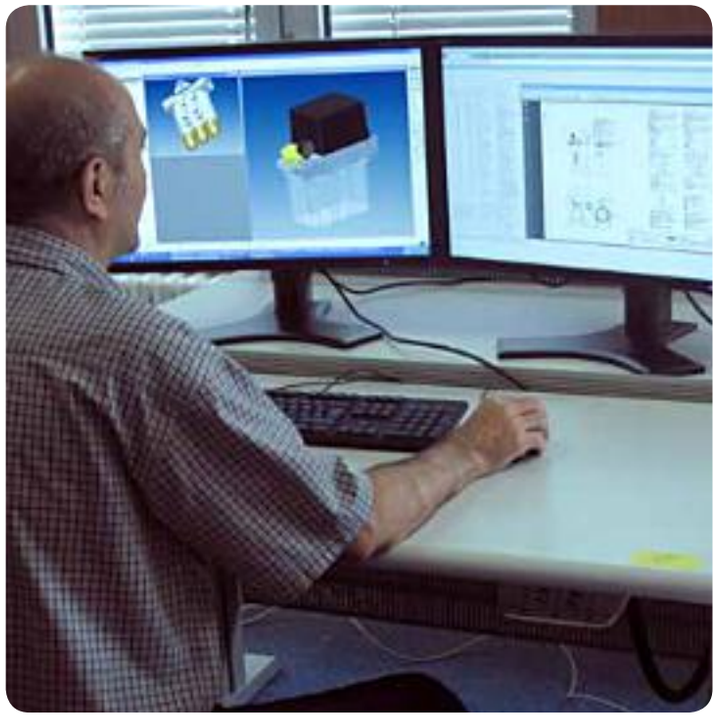
Possible tests

To withstand the high voltage spikes often seen during generator operation, the ability of the insulation needs to be assessed. This can be verified with the Baker AWA in one portable test unit by using various test methods: Winding resistance, Meg-ohm, Polarization Index (PI), DC step voltage and surge tests. These tests will allow you to detect the following faults:

- **Short circuits, open circuits and loose connections**
- **Wet or contaminated windings**
- **Damage to groundwall insulation**
- **Coil-to-coil and phase-to-phase insulation weakness**

Additionally, the surge test is the only method of detecting weak turn insulation. Studies have shown that 80% of electrical failures originate as a turn-to-turn weakness. In order to detect such faults prior to motor failure, surge testing must be performed.

All tests apply international standards, including IEC, IEEE, NEMA and EASA. The described functions and tests can also be used to check for the proper functionality of all small electrical motors for pitch and yaw inside the nacelle.



Driveline services – improving performance and overcoming obs

The needs of the wind operations and maintenance (O&M) market require a holistic programme that combines deep knowledge of wind applications with wind energy-centric products and services. Driveline services deliver this unique combination of expertise, experience and technologies.

SKF's success in helping wind customers achieve their goals is highest when working in partnership, rather than within a traditional customer-supplier relationship. To make renewable energy more competitive with the traditional energy sector, these challenges have to be approached together. The goal is to lower your levelized cost of energy.

SKF application engineering

Driveline service develops upgrades for existing solutions in order to overcome current obstacles, including those our customers face today and those they will face tomorrow. With a goal of lowering lifetime costs and raising turbine availability levels, we draw on SKF's extensive application engineering resources to help ensure that a new upgraded design will be "right" from the start. The selection of the right products, as well as the environmental surroundings where these products need to perform, are essential considerations in our approach to problem solving.

stacles through collaboration

SKF Engineering Consultancy Services

SKF's extensive experience in wind turbine development can be a powerful asset. For deeper analysis, we involve our SKF Engineering Consultancy Services. Using proprietary software tools that can act as a "virtual test bench," SKF engineers are able to analyze the performance of products in your application virtually and develop test strategies to validate designs and evaluate performance of components in prototypes. This enables design refinements to be made prior to commissioning, saving both time and money.

SKF Engineering Consultancy Services are supported by years of in-house wind turbine knowledge, a Design for Six Sigma methodology and world-class testing facilities.

Troubleshooting and special services

Employing our engineering capabilities, SKF's driveline services frequently work with customers to troubleshoot field problems. SKF's approach combines theoretical analysis, material science and the experience gained from overcoming similar challenges in your industry as well as others.

We also provide a broad array of specialized services geared toward the needs of our customers. These range from analyzing vibration data taken from a wind turbine, to up-tower service and remanufacturing of complete applications. For more information of how SKF can be of value to you and your specific challenge, please contact us.

Extend bearing service life and reduce life cycle cost with be

aring remanufacturing

While much can be done to optimize the life of a wind turbine's bearings, eventually they will need to be replaced due to application conditions which can cause all sorts of bearing damage. The alternative is to apply a controlled remanufacturing process before any major damage or bearing failure occurs. This can substantially prolong the service life of the bearing in question, reducing costs and avoiding long lead times that can bring your turbines to a standstill. And since it requires less energy than manufacturing a new bearing, it is better for the environment as well.

A global network of state-of-the-art service centres

SKF is using its new bearing manufacturing standard, processes, equipment, quality assurance, knowledge and competences as the basis for its bearing remanufacturing service. This includes acceptance criteria that deliver high quality results, even when extensive remanufacturing is needed.

SKF's bearing remanufacturing network is present in most parts of the world and is continuously expanding with new service centres. All centres for remanufacturing have highly trained teams with special competencies. Operating as a global network, we share knowledge, specific spare parts procurement, and capabilities development.

As a result, SKF's bearing remanufacturing can offer the agility and flexibility of a small company, but with the capacity, core competencies, and security that only a large industry leader can deliver.

Bearing before and after remanufacturing

Applications experts

Our experienced bearing analysts evaluate your bearing and define which remanufacturing process will be the most efficient for restoring your bearing so that it is compatible with application requirements. During SKF's remanufacturing processes, relevant functional surfaces are repaired and bearing components replaced if necessary. As a consequence, the potential service life of the bearing can be fully exploited.

In addition to standard remanufacturing, we can also remanufacture your bearings to a new or higher specification. This can include mounting sensors and the provision of other enhancements such as integrated lubrication, sealing solutions and rework to other specifications.

Full traceability

To provide full traceability, SKF has developed and uses an advanced management system. By uniquely marking each asset during the remanufacturing process, you will be able to trace your bearing through its future life cycle.

Benefits

- **Reduced total life cycle costs**
- **Extended bearing service life**
- **Reduced turbine downtime**
- **Reduced environmental impact**
- **Maintained stock of replacement bearings**
- **Potential for bearing upgrades**

Protect uptime and performance with SKF seals

Optimized for your requirements

Seals can have a crucial impact on turbine performance. When seal design and materials are optimized for a specific turbine application, they can help boost turbine reliability, productivity and energy efficiency. Sealing solutions from SKF can make it happen.

Easy installation and up-tower replacement

SKF sealing solutions for wind applications are designed to facilitate up-tower installation. They have a high form stability and are available in split designs for easier handling and reduced downtime during planned up-tower replacement.

Proven designs and high performance materials

SKF radial shaft seals for wind applications are manufactured from the SKF-developed materials SKF Duratemp, G-ECOPUR and H-ECOPUR, which have been successfully used in demanding applications for decades, thanks to their excellent ozone, wear and ageing resistance.

With proven designs, high-performance materials and flexible manufacturing processes, combining moulding and machining technologies, SKF can deliver the seals you need, wherever you need them.

Radial shaft seals

SKF polyurethane and reinforced all-rubber seals combine high performance and reliability with easy up-tower replacement. Their high form stability simplifies installation procedures, and they are available in solid and split versions to minimize downtime and lost productivity.

HSS reinforced all-rubber seals are made of SKF Duratemp, an SKF-developed hydrogenated nitrile rubber. A standard grade of the material is used for the sealing lip, while the part of the seal body contacting the housing bore is made from a harder grade for improved stability in operation and during installation.

SKF radial shaft seals machined from the proprietary polyurethane compound G-ECOPUR offer outstanding wear resistance and tear strength. SKF has also developed a procedure that allows optional welding of split large diameter polyurethane seals on site, maintaining the full sealing capacity.

Both of these radial shaft seals feature a well-proven, spring-loaded sealing lip design with a defined radial load for reliable performance. They provide excellent static sealing performance by their ability to accommodate small imperfections in the housing bore surface owing to their smooth outside diameter surfaces.

Protect uptime and performance with SKF seals

Excluder seals

SKF recommends the use of excluder seals as the first line of defense for robust contaminant protection.

Stretchable and easy to install, SKF V-ring seals are available in a range of designs and sizes to fit virtually any turbine application. The seals are available in hydrogenated nitrile rubber or polyurethane materials for excellent resistance to ozone and UV light.

Offering significantly longer service life than the rubber excluder seals typically used in main shaft applications, SKF's axial excluder seal HRC1 delivers robust contaminant protection for main shaft bearings.

The HRC1 seal is made of a special H-ECOPUR, an SKF-developed polyurethane material with excellent abrasion resistance and tear strength. The seal is available in solid and split versions and features a highly engineered design that helps keep the sealing lip lubricated while minimizing friction and wear. The result: an axial excluder seal that lasts long enough to meet standard wind farm maintenance inspection schedules.

V-ring made of HNBR

The HRC1 high-performance profile

Wear sleeves

Once wear grooves have formed on a shaft, sealing effectiveness suffers. Repairs usually involve dismantling and re-machining the shaft, and installing a new seal size. SKF Speedi-Sleeve and large diameter wear sleeves offer a much faster, more cost-effective alternative.

SKF Speedi-Sleeve is a thin-walled shaft sleeve that users simply press into position over the damaged shaft surface to provide a new sealing surface – without power tools, heating, or the need to change seal sizes. For highly contaminated operating conditions, SKF Speedi-Sleeve Gold features a special metallic coating that reduces abrasive wear. SKF large diameter wear sleeves accommodate shaft dimensions up to 1 143 mm (*45 in.*).

Hydraulic seals

SKF offers a full range of hydraulic seals to meet the high power density demands of pitch and yaw drives and hydraulic brakes. To help wind farms improve fluid power system performance, SKF can optimize underperforming sealing arrangements by developing customized seal designs and/or upgrading seal materials with an SKF formulation compatible with a wide range of hydraulic fluids.

Maximize service life with SKF Maintenance Products

All bearings have a pre-calculated service life, but not all of them reach it. Often, poor maintenance practices and/or the use of improper tools are to blame. SKF can help wind farms avoid problems with a wide range of maintenance products that reduce premature bearing failures and extend turbine service life.

SKF Shaft Alignment Tools

Shaft misalignment can limit wind turbine energy efficiency and cause bearings and associated components to fail, particularly shaft misalignment of shafts with high speeds, such as the shaft between the generator and the gearbox. Performing an accurate shaft alignment used to be a difficult, time-consuming process. SKF's TKSA series of laser shaft alignment tools make it faster and easier than ever.

The TKSA series includes solutions for turbine maintenance staff at every level. Beginners will appreciate the TKSA entry level instrument for its simplicity. The intermediate TKSA instrument, with its intuitive interface and advanced functionality, also allows alignment results to be stored and shared. For advanced users, the high-end TKSA instruments feature wireless connectivity and simplify even the most complex alignment jobs.

SKF Induction Heaters

SKF Induction Heaters are energy efficient and can heat bearings faster and in a more controlled way.

The units only heat up the bearing – and not the unit itself – so mounting procedures are safer than traditional methods. SKF Induction Heaters are suitable for use with virtually all bearings used for wind turbine applications.

SKF Thermal Imagers and Endoscopes

SKF Thermal Imagers allow you to “see” troublesome equipment hot spots on electrical cabinets, cables, mechanical transmissions and more. Operators simply point the imager at the area in question, and a thermal camera converts the infrared radiation into an image on the display screen. Similarly, SKF Endoscopes allow users to peer inside gearboxes and bearing housings without disassembly, saving valuable time and effort.

SKF Grease Test Kit TKGT 1

Lubricant analysis can play a key role in predictive maintenance. With the portable SKF Grease Test Kit TKGT 1, turbine maintenance teams can now perform this vital testing in the field. The TKGT tests for grease consistency, bleeding properties and contamination.

For fresh greases, the TKGT 1 can help to establish remaining shelf life and assess the quality consistency of different production batches. Testing used greases can help operators evaluate the effectiveness of the lubrication intervals, and uncover possible sources of contamination when it occurs.

Expand your team's competencies with SKF Training Solutions

Reliability courses for wind energy companies

Reliability training courses for our customers are another way that we're equipping the world with SKF knowledge. Delivered by experienced SKF trainers with a vested interest in their students' success, these programmes are structured for everyone from operations and maintenance personnel to upper management. Individual training is possible as well.

Learning how to lower total cost of ownership

For the wind industry, SKF has developed a range of training courses that focus on managing total cost of ownership by boosting machine reliability and uptime. For wind farm operators, SKF wind energy courses offer a cost-effective way to invest in employee skills and the bottom line.

Why SKF for training?

SKF draws on a century of rotating machinery expertise, plus our experience in working with wind industry OEMs as well as operators and maintenance providers. Our wind energy training platform reflects industry best practices and includes instruction on the latest machine reliability technologies, thus enhancing wind turbine efficiency.

Courses that work for you

SKF will work with your organization to deliver the most relevant and convenient programme for your employees. Course content can range from basic maintenance skills to asset management – whatever your reliability requirements, we can develop a solution for your team.

SKF Training Solutions offer a choice of course types and venues. Basic courses are available via e-learning 24/7. On-site training is available at your location, and many classes are held at SKF Solution Factory training facilities and other regional locations. These include dedicated training sessions in wind energy. For more information about SKF Training Solutions for wind energy, contact your local SKF representative.

Benefits

- **Improved personnel and machine efficiency levels**
- **Reduction of machinery problems**
- **Increase machine uptime and productivity**
- **Helps identify root cause associated with equipment problems**
- **Reduces equipment damage or underutilization**
- **Enhances worker safety**

SKF's most popular core training courses

WE201: Bearing Maintenance and Technology

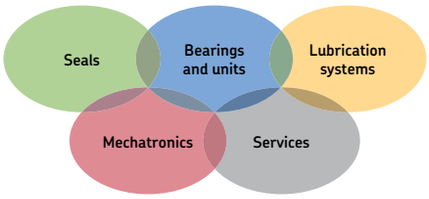
WE203: Bearing Lubrication

WE204: Bearing Damage Analysis

WE240: Precision Alignment

See inserts for more details about SKF solutions for the wind energy industry.

The Power of Knowledge Engineering



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

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

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

SKF BeyondZero is more than our climate strategy for a sustainable environment: it is our mantra; a way of thinking, innovating and acting.

For us, SKF BeyondZero means that we will reduce the negative environmental impact from our own operations and at the same time, increase the positive environmental contribution by offering our customers the SKF BeyondZero portfolio of products and services with enhanced environmental performance characteristics.

For inclusion in the SKF BeyondZero portfolio, a product, service or solution must deliver significant environmental benefits without serious environmental trade-offs.

All our solutions for the renewable energy sector have been selected for inclusion in the SKF BeyondZero portfolio, which includes products and solutions with significant environmental benefits, such as improved energy efficiency and the enabling of increased renewable energy generation.

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