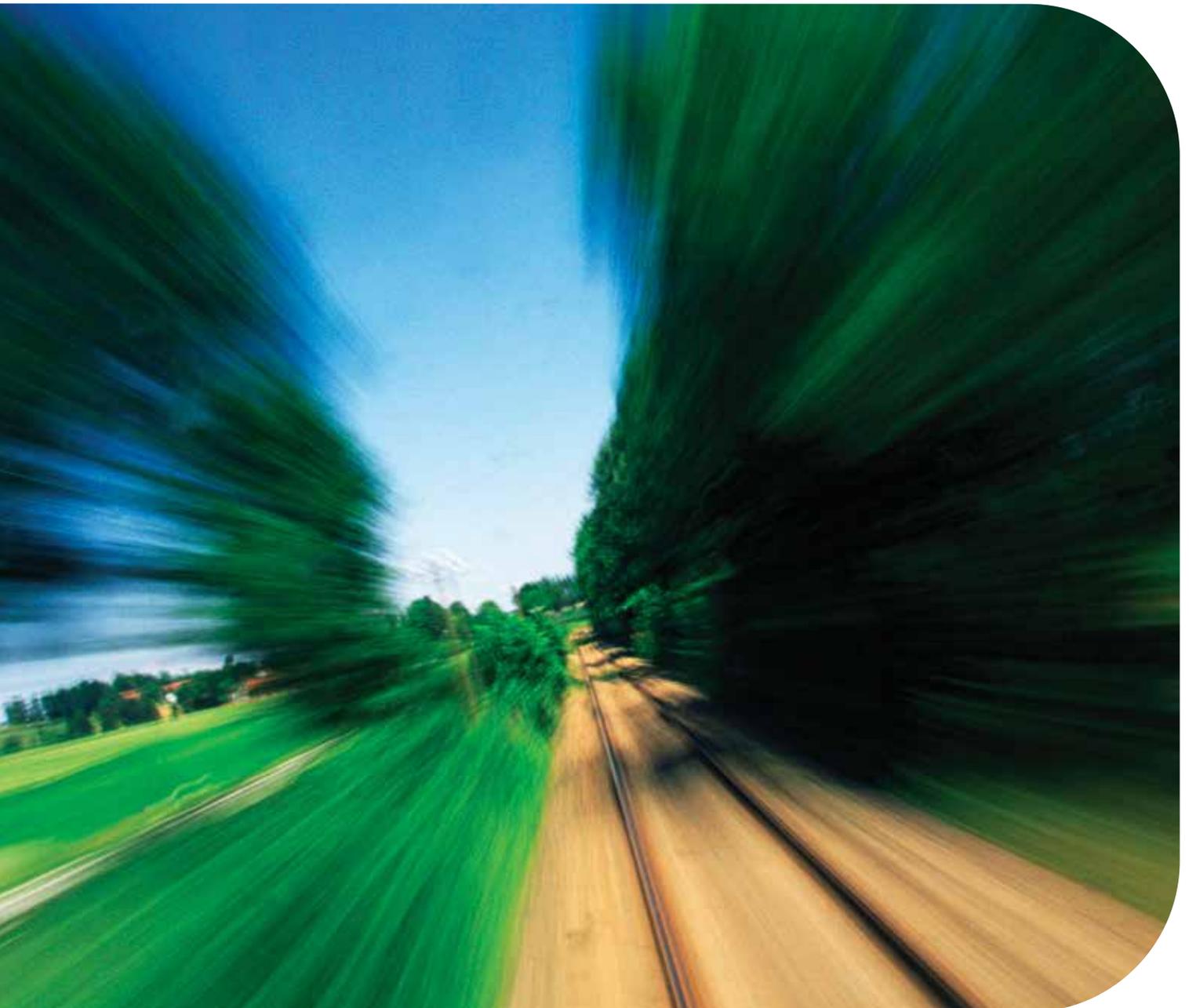




Solutions for high-speed rail

Proven SKF technologies for improved reliability, efficiency and safety



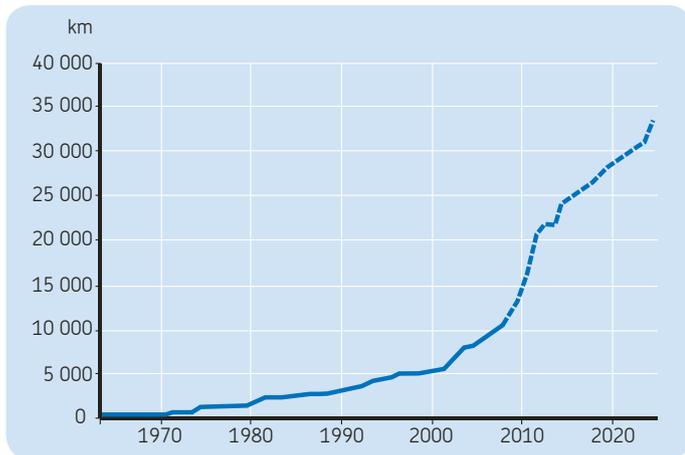
The Power of Knowledge Engineering

Knowledge engineering capabilities



for high-speed rail.

Today, high-speed trains, cruising at 300 km/h have changed Europe's geography, and distances between large cities are no longer counted in kilometres but rather in TGV, ICE, Eurostar or other train hours. The dark clouds of global warming threatening our planet are seen as rays of sunshine to this most sustainable transport medium, with other continents and countries following the growth path initiated by Europe and Japan. High-speed rail represents the solution to sustainable mobility needs and symbolises the future of passenger business.



Expected evolution of the world high-speed network, source UIC

Meet your challenges with SKF

Rail transport is a high-tech growth industry. SKF has a global leadership in high-speed railways through:

- **strong strategic partnership with global and local customers**
- **system supplier of wheelset bearings and housings equipped with sensors to detect operational parameters**
- **solutions for train control systems and online condition monitoring**
- **drive system bearing solutions**
- **dedicated test centre for endurance and homologation testing**
- **technical innovations and knowledge**
- **local resources to offer the world rail industry best customer service capabilities**



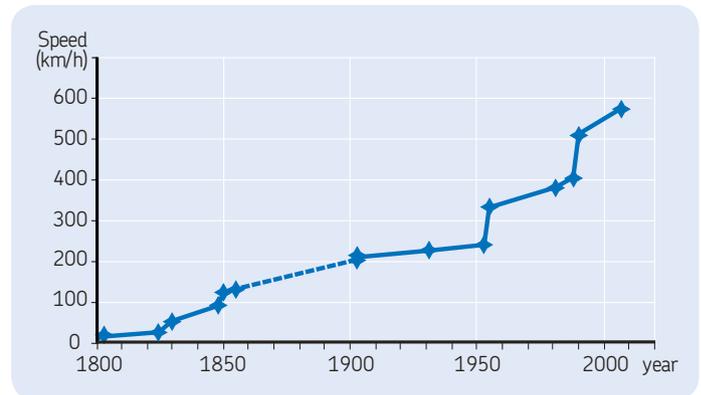


Historical development

Speed has always been the essence of railways

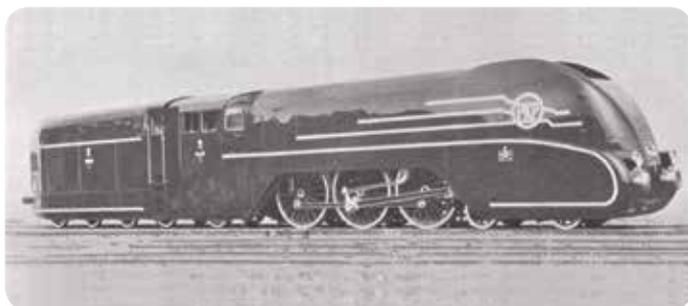
Speed has been the essence of railways since the first steam locomotive made its appearance in 1804. SKF remains at the forefront of high-speed train design, providing some of the most safety-critical components of railway vehicles – the wheelset axlebox assemblies, comprising the wheelset bearings or units, the axlebox housing and integrated sensors.

SKF has always been active in developing solutions to meet the challenging requirements of high-speed train builders and operators, for the development, design and testing of wheelset bearings. Today, high-speed rail transport is defined in some European standards as vehicles with a maximum speed of more than 200 km/h. By the 1930s, trains in Europe and North America had already reached travelling speeds of 130 km/h, with top speeds of 160 km/h.



200 years of railway speed records with conventional wheel/rail systems

1804	8 km/h	Steam	UK – Richard Trevithick's first railway steam locomotive
1825	24 km/h	Steam	UK – Locomotion No. 1
1830	48 km/h	Steam	UK – Stephenson's Rocket
1848	97 km/h	Steam	US – Boston and Maine Railroad, Antelope
1850	125 km/h	Steam	UK – Great Britain
1854	132 km/h	Steam	UK – Bristol & Exeter Railway #41
1855-1902	<i>Several unverified speed records</i>		
1903	203 km/h	Electric	Germany – Siemens Halske, Berlin test track
1903	210 km/h	Electric	Germany – AEG, Berlin test track
1931	230 km/h	Petrol	Germany – Schienenzeppelin
1953	239 km/h	Electric	France – six-axle locomotive
1955	331 km/h	Electric	France – two locomotives, one six axles and one four axles
1981	380 km/h	Electric	France – TGV PSE
1988	406 km/h	Electric	Germany – Intercity-Experimental (ICE prototype)
1990	515 km/h	Electric	France – TGV Atlantique
2007	575 km/h	Electric	France – TGV V150



Polish steam locomotive equipped with SKF wheelset bearings, with a maximum operational speed of 130 km/h.

American Union Pacific trains from the 1930s were equipped with SKF wheelset, traction motor and gearbox bearings and reached a maximum speed of 177 km/h.

High-speed rail development

North American and European steam locomotives, for example, were equipped with SKF axleboxes and spherical roller bearings. The French Michelin 23 experimental train with rubber wheels and a maximum speed of 150 km/h was equipped with an SKF gearbox and wheel bearings. In addition, one of many historical applications of the 1920s and 1930s is the Dutch diesel electric multiple unit-type DE 3 from 1934, equipped with axleboxes and spherical roller bearings. Later on, other designs were based on cylindrical and tapered roller bearings.

World War II halted the development of high-speed travel significantly, and it wasn't until Japan inaugurated the Tokaido Shinkansen train in 1964, which operates at a speed of 200 km/h, that fast train travel re-emerged. This was followed in Europe by the arrival in Germany of the E03 electric locomotives that in 1965 also achieved 200 km/h. They were equipped with SKF axleboxes and cylindrical roller bearings as well as drive system bearings. The first French TGV trains reached 270 km/h in commercial operation in 1981. They are equipped with SKF drive system bearings.

The first tilting train of the Italian Railways is the ETR 450 type that went into service in 1985. Pendolino trains have a maximum speed of 250 km/h and were built by FIAT, whose railway division is now a part of Alstom. The axleboxes were developed by SKF and equipped with SKF wheelset bearings.

The next Pendolino generation is equipped additionally with integrated speed sensors. These trains have been in operation since 1992 in Italy as ETR 460 and ETR 480 and in Finland as Sm3, in Switzerland they are running as Cisalpino ETR 470, and in Portugal they are called Pendoluso. The Pendolino train to the latest design is now running in the Czech Republic. The Swedish tilting trains X2000 developed by ADtranz in 1990 have a maximum speed of 220 km/h and are equipped with SKF tapered roller bearing units TBU 130 x 220. One train is also in operation in China.



Solutions with axlebox packages

Absolute safety and utmost reliability

Absolute safety and utmost reliability all year round, whatever the weather conditions, for maintenance-free periods of close to a million kilometres, are the expectations of SKF customers when dealing with high-speed trains. Succeeding and meeting these expectations has required a subtle blend of breakthrough innovation, combined with experience gathered over the years in optimizing every detail of the metallic and non-metallic materials, surfaces topography and lubricants.

High-speed axlebox packages consist of a wheelset unit incorporated into a housing tailored to the customer requirements, such as interfaces to the wheelset journal, suspension system, damper arrangements, earth brush return and devices and cable and connector interfaces for sensors, etc. In order to simplify the assembly and maintenance, SKF developed complete wheelset units. These already have adjusted clearance and are factory lubricated and sealed.

SKF's service can also include logistic solutions as well as mounting with our own fitters and supervision by our service engineering team.



Tapered roller bearing units

The TBU tapered roller bearing unit concept is based on a sealed and factory lubricated bearing unit that is ready to mount. This design principle offers the most universal application capabilities. Different sealing systems provide unique opportunities to select the most appropriate arrangements. These solutions are based on highly sophisticated labyrinth and low contact sealing principles.

Fretting corrosion between the inner ring/backing ring contact zones can be reduced by the use of a polymer spacer.

The TBU tapered roller bearing unit is optionally designed for monitoring of speed and bearing condition.

- **high safety and reliability**
- **low life cycle cost**
- **long maintenance intervals**
- **universal design concept**



Cylindrical roller bearing unit

The CRU cylindrical roller bearing unit for axlebox applications is a sealed and prelubricated unit concept that combines all the advantages of cylindrical roller bearings. A frictionless wear-free labyrinth seal is fitted at each side.

The design of the CRU permits the integration of speed and temperature sensors. The unit can be mounted in a single operation without any heating using a press.

- **high safety and reliability**
- **low life cycle cost**
- **long maintenance intervals**

Axleboxes

These highly sophisticated axlebox designs are tailored to customer specifications and applied in all kinds of railway vehicles. The axleboxes are made mainly of high-grade SG spheroidal graphite iron which combines both endurance characteristics and cost effectiveness.

Finite element method (FEM) computer calculations are made to optimise the design and to pre-validate the fatigue life. The next validation step of new axleboxes is done by fatigue testing before starting field-testing under real operating conditions.





Solutions for train control systems and

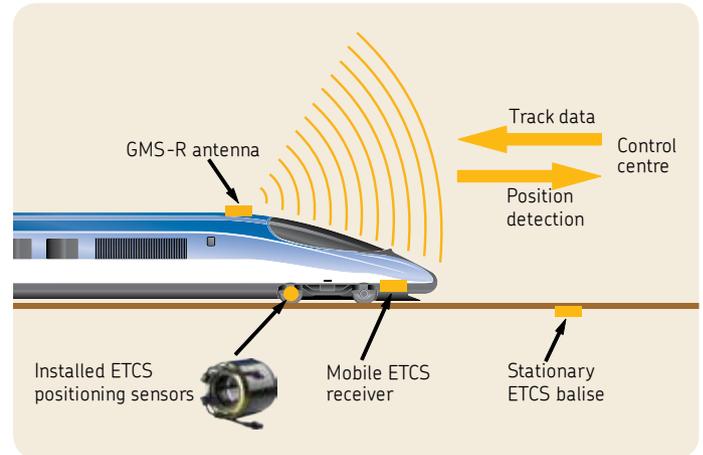


Sensorized bearing unit solutions for axleboxes

The SKF sensor system integrated into the CTBU Compact tapered roller bearing unit design results in important features with the ability to detect:

- **rotational speed for the wheel slip/slide protection (WSP or WSSP) and traction control unit (TCU)**
- **bearing temperature signal for the on board monitoring system**
- **direction of movement**
- **positioning for the European Train Control System (ETCS) and the Italian SCMT (Sistema controllo movimentazione treno) automatic train control systems**
- **vertical and/or lateral acceleration**

SKF sensors meet the requirements of the European EN standards. The sensors' signals are compatible with the electronic control units (ECU) produced by different system suppliers.

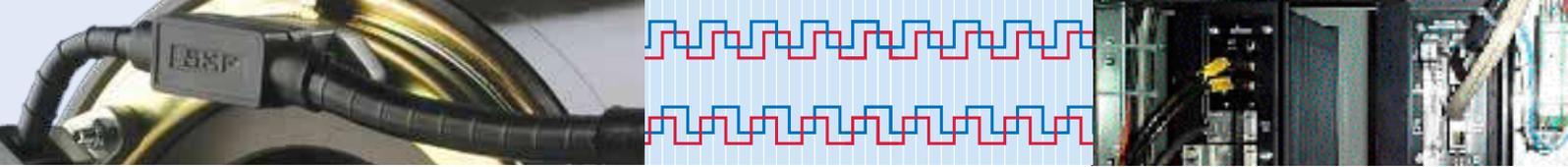


Positioning detection for the ETCS European Train Control System

The European Train Control System (ETCS) is a new signalling, control and train protection system. It will replace 14 incompatible domestic European railway safety systems, especially on high-speed lines. One important factor is the exact positioning of the high-speed trains, based on a revolution counter and direction monitoring.

SKF sealed and greased bearing units accommodate ETCS sensors that are space and part saving, as well as easy to handle. To gain redundant and independent sensor systems, several independent sensor packages are mounted onto the bearing shield. A further advantage of integrated sensors is that the original axle design can be used without any redesign. One of the first SKF ETCS sensor applications is on the Italian Pendolino.

- **modular solution**
- **space saving, free axle end for earth brush mounting**
- **easy to handle during installation and maintenance**



condition monitoring

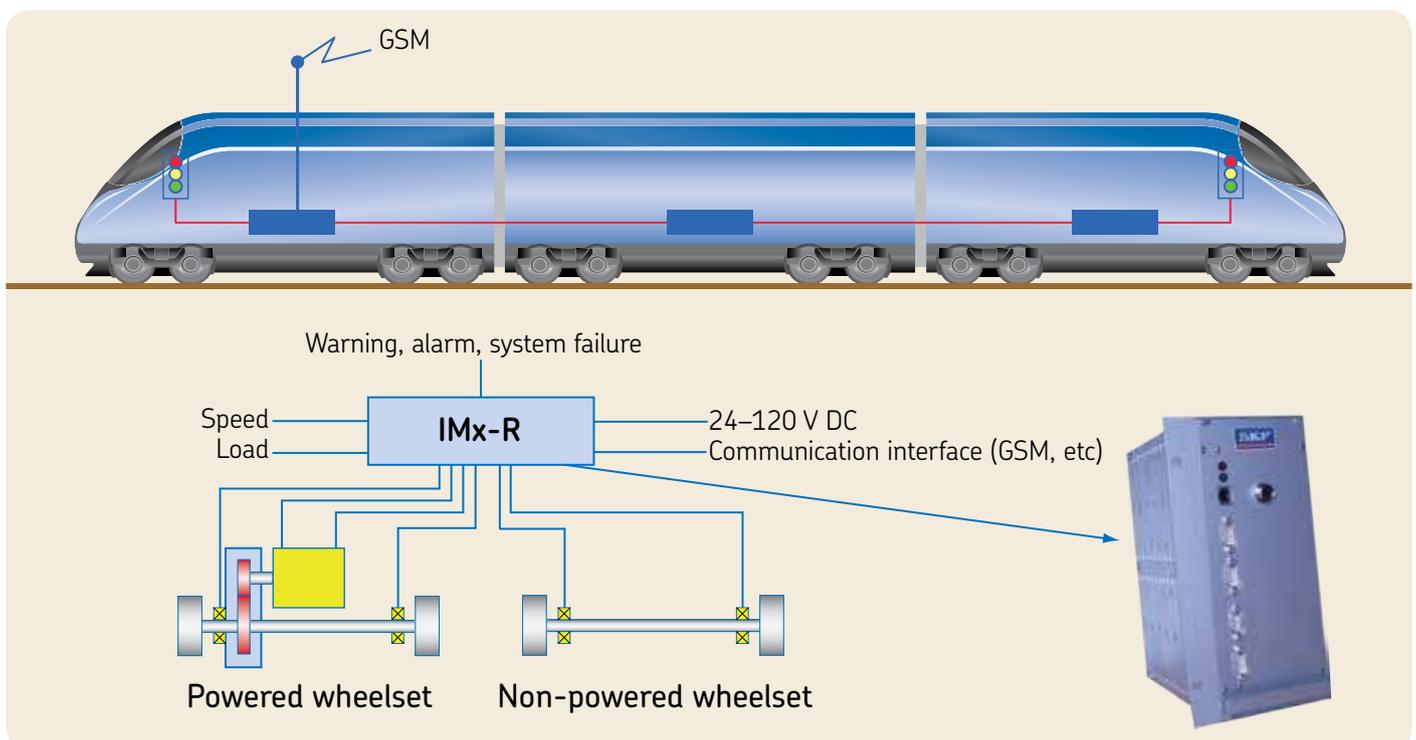
Monitoring for fault detection

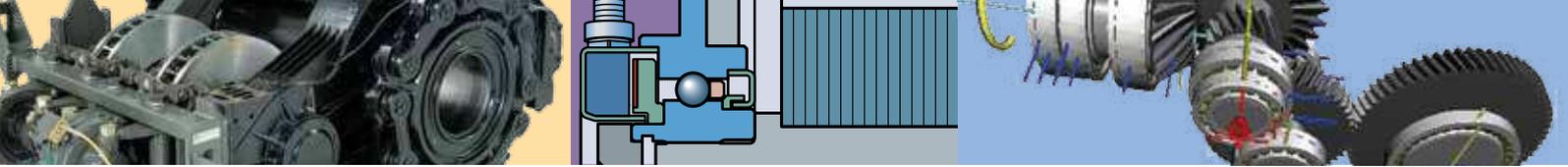
SKF online mechanical condition monitoring systems are designed to facilitate early fault detection and prevention, to provide automatic advice for correcting existing or impending conditions and to provide input to condition based maintenance management systems. The SKF Multilog online System IMx-R monitoring system, exclusively developed for the railway industry, achieves increased vehicle availability through higher operational reliability by monitoring:

- wheelset bearing conditions and grease service life
- wheel flats and shape
- bogie stability/hunting sensing
- derailment condition
- propulsion system condition, e.g. traction motors, gearboxes and cardan shafts
- unbalance and resonance conditions
- rail track conditions

The Multilog online System IMx-R provides automatic load- and speed-dependent warnings and alarms that initiate on-board and external communication, data processing for automatic diagnosis and root cause analyses, links to maintenance management systems for scheduling, spare part and work order management and end user, system and Web-site-based data access.

- increased safety and reliability
- reduced maintenance cost
- root cause analysis
- improved maintenance planning capabilities





Solutions for special applications



Drive systems

SKF offers a full assortment of bearings and units for drive system applications such as traction motors and gearboxes:

- **cylindrical and tapered roller bearings as well as deep groove, angular contact and four point contact ball bearings**
- **INSOCOAT electrically insulated bearings**
- **hybrid bearings with ceramic rolling elements**
- **traction motor bearing units which are prelubricated and ready to mount subsystems. The rotating section is flanged onto the rotor and the stationary part is bolted to the motor shield. The TMBU can be offered as a sensorized unit equipped with absolute positioning, speed and temperature sensors.**



Wheel flange lubrication

SKF offers wheel flange lubrication system solutions to reduce friction. Friction is a particular problem when train wheels encounter curves, as friction occurs between the wheel flanges and the inner sides of the rails.

SKF wheel flange lubrication systems help to reduce friction, to reconcile economy with ecology and to support the growth in more sustainable transport systems. Wheel flange lubrication systems help to protect the environment and save costs through reducing maintenance and repair requirements.





AMPEP self-lubricating plain bearings

AMPEP self-lubricating plain bearings are high quality products that provide a low coefficient of friction combined with low wear rates. This is achieved by the use of woven polytetrafluoroethylene (PTFE) and glass liners.

AMPEP XL bearings are the result of an extensive development programme to provide an acceptable lifespan in arduous aerospace applications. They exceed international standards by a considerable margin, thus ensuring long life and reliability.

AMPEP XLNT, introduced in 1999, following extensive re-search, extends bearing life even further.



Service solutions



Application and service engineering

Many years of experience in railway bearing design and application form the basis of our support skills to be able to offer you first class customer services. The worldwide SKF network is based on engineering capabilities at production and service units as well as local sales, application and service engineers.

Application engineering is focused on specific customer specifications to elaborate optimized solutions providing maximum customer value. On-site service engineering, which includes a TBU exchange service. This service can significantly save the cost of exchanging wheelsets and helps to reduce down time of vehicles.



Testing capabilities

The key for ensuring the long-term reliability and performance of high-speed rolling stock is rigorous testing. Most of SKF's facilities are located in the Railway Test Centre inside the SKF Engineering Research Centre in the Netherlands. In this centre complete axleboxes with surrounding parts such as bogie frame interfaces are tested as well as bearing units and components such as seals and cages.

Performance testing is done in accordance with the European standard EN 12 082 on special test rigs with two axleboxes mounted and subjected to repeated loading cycles that reflect accurately the service conditions of the intended application. These test rigs can run at high-speeds over 500 km/h.





Refurbishment capabilities

Bearing refurbishment is a major contributing element to life cycle cost optimization:

- **cost reduction compared to new bearings**
- **extended service life**
- **shorter lead times**
- **contribution to environment sustainability by material and energy savings**

SKF offers professional refurbishment services for high-speed axlebox bearings which is done in accordance with original specifications such as original equipment manufacturers (OEM) specifications and individual specifications of railway operators, which are based on the specific operating conditions.

SKF offers to the railway industry a global network of specialized railway refurbishment workshops in Australia, Brazil, China, Italy, Sweden, and UK.



SKF in high-speed rail applications



Photo: SBB

Italian Pendolino ETR 460 tilting train generation made by FIAT, later on Alstom, 250 km/h, in operation since 1992.

SKF wheelset bearing units, axleboxes, sensorisation and IMx-R Condition Monitoring system.



Photo: AnsaldoBreda

Italian ETR 500 generation made by the Trevi consortium, 300 km/h, in operation since 1992.

SKF wheelset bearing units, axleboxes, speed and temperature sensors plus positioning sensors for ETCS, traction motor and gearbox bearings.



Photo: DB AG/Wolfgang Klee

German ICE 1 and ICE2, first and second generation, 250/280 km/h, in operation since 1991/1997. German ICE 3 and ICE-T tilting version, third generation, 330/230 km/h, in operation since 1999. All trains made by Bombardier and Siemens, operated by DB. Tilting technology made by Alstom.

SKF wheelset bearing units, axleboxes, traction motor and gearbox bearings.



Photo: Talgo

Spanish Talgo 350 made by Talgo and Bombardier, operated by Renfe, 350 km/h, prototypes in operation since 2005.

SKF wheelset bearing units.



Photo: ČESKÉ DRÁHY

Various Pendolino tilting train types are also in operation in the Czech Republic, Finland, Portugal and Spain.

SKF wheelset bearing units, axleboxes, speed sensors, traction motor and gearbox bearings.



Chinese CRH 3, 380 km/h, in operation since 2013.

SKF wheelset bearing units.



French TGV generation made by Alstom, operated by SNCF, 300 km/h, in operation since 1981.

SKF traction motor and gearbox bearings and AMPEP self lubricating plain bearings.



Photo: KTX

Korean KTX high-speed train made by Alstom and Rotem, operated by Korail, 300 km/h, in operation since 2004.

SKF traction motor bearings and axlebox bearing units and axlebox bearing units.



Photo: THSRC

Taiwan high-speed train made by KHI Kawasaki Heavy Industries, operated by THSRC Taiwan High Speed Rail Corporation, 300 km/h, in operation since 2007.

SKF axlebox bearing units.



Photo: SJ AB

Swedish X2000 tilting train made by ABB, operated by SJ, 220 km/h, in operation since 1990.

SKF wheelset bearing units, axleboxes, traction motor and gearbox bearings.



Photo: ÖBB

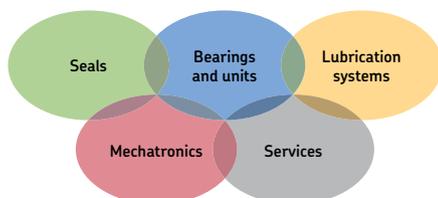
Austrian Railjet made by Siemens, operated by ÖBB, 230 km/h, entered international service in 2008.

SKF traction motor bearings and axleboxes equipped with wheelset bearing units for coaches.



Chinese CRH1 high-speed train made by Bombardier Sifang Power, operated by Chinese Railways, 200 km/h, in operation since 2007.

SKF wheelset bearing units and axleboxes.



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.

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