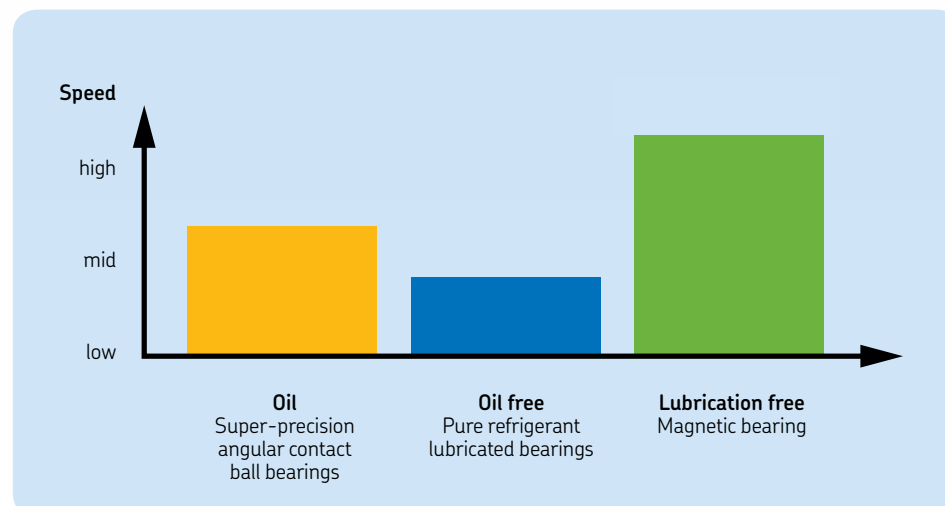
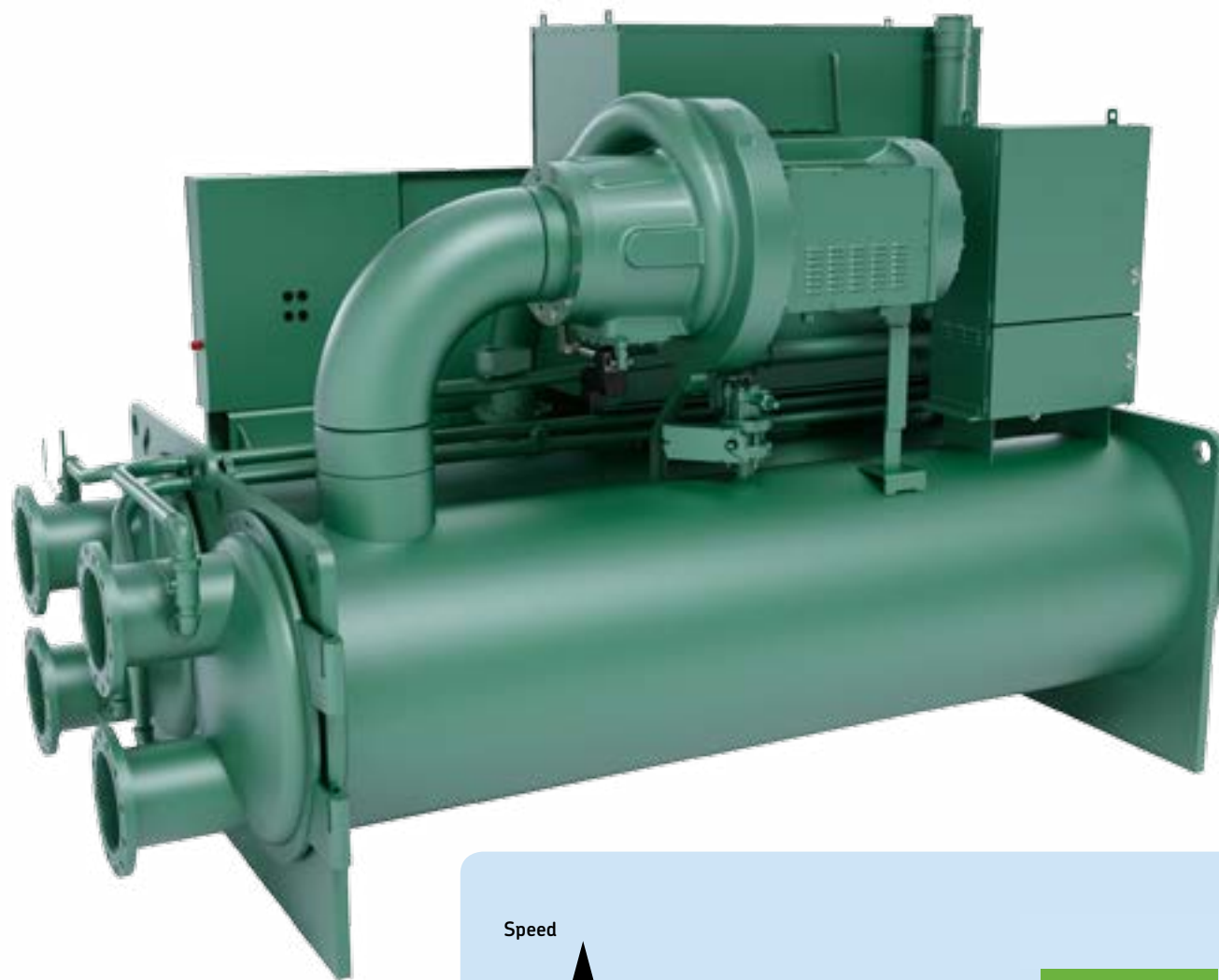


Evolving chiller and heat pump performance

SKF solutions for centrifugal compressors in chillers and heat pumps



Need to optimize your centrifugal compressor efficiency?



Boost direct drive and gear drive performance with SKF

Offering both higher efficiency and capacity than other compressor types, centrifugal compressors have long been the preferred choice for large chiller applications. Today's modern centrifugal compressors with high speed direct drive motor systems offer an even more compelling option in terms of energy efficiency, simplicity and reliability.

Mounting the impeller directly on the motor shaft means no more gearbox and lubrication of gears. Eliminating both reduces overall complexity and cost while improving compressor efficiency, reliability and footprint.

At SKF, we understand the many challenges involved in developing a robust, cost-effective centrifugal compressor. We've been helping leading chiller OEMs develop solutions for both gear drive and direct drive models for many years. Regardless of your compressor type, our broad range of products, solutions and application expertise makes SKF your partner for success.

Proven centrifugal compressor solutions

As the leading supplier of bearings and engineering solutions to the compressor industry, SKF has been at the forefront of direct drive development since the 1990s. Whether you are looking to upgrade to a lower friction high-speed output shaft on your gear drive machine, or develop a direct drive solution, SKF's proven centrifugal compressor solutions will help you achieve your goals.

The magnetic system from SKF is an oil-free solution that features a permanent magnet motor and active magnetic bearings, a combination that enables energy savings of at least 10% versus conventional centrifugal compressor designs.

Pure refrigerant lubricated bearings from SKF utilize the refrigerant for bearing lubrication, offering an oil-free solution that also enables energy savings of at least 10% versus conventional centrifugal compressor designs.

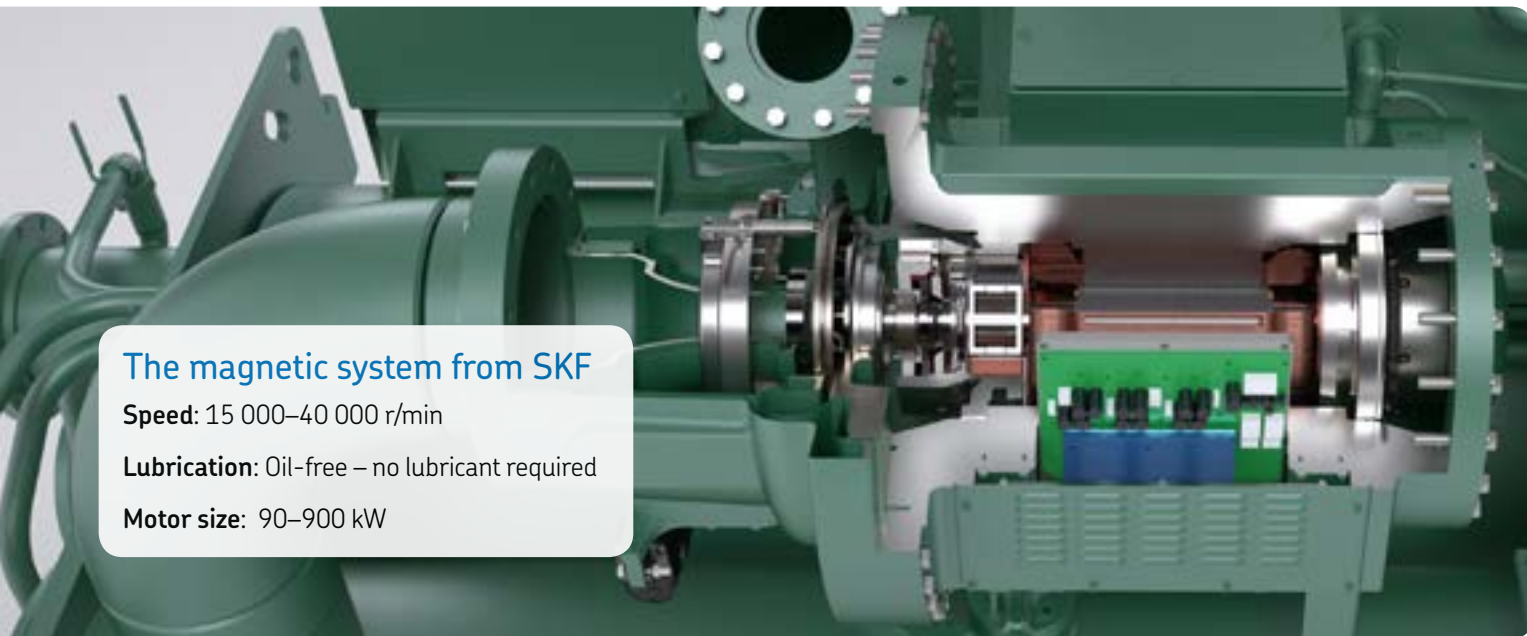
Oil-lubricated rolling bearings use the given oil-refrigerant mixture for lubrication – one that can help boost energy efficiency by 3-4% versus conventional designs.

Tested technology and support

Supported by many years of operation in the field, these proven solutions are allowing the development of the next generation of high-efficiency, low-maintenance chillers. Backed by our industry-leading engineering support and global footprint, high-speed centrifugal compressor solutions from SKF can help your team realize several benefits:

- Reduced energy use
- Eliminated oil lubrication
- Reduced maintenance requirements
- Reduced total cost of ownership
- Fast machine development
- Reduced manufacturing cost

The magnetic system from SKF



The magnetic system from SKF

Speed: 15 000–40 000 r/min

Lubrication: Oil-free – no lubricant required

Motor size: 90–900 kW

No contact, no wear, no worries

The magnetic system from SKF combines a high-speed permanent magnet motor and active magnetic bearings with integrated controls, allowing OEMs to harness the efficiency benefits of variable speed drive technology. SKF motors can be single or double stage without any design change.

Electromagnets levitate the compressor shaft, allowing it to rotate without contact. A control system actively monitors shaft position and continuously adjusts the current in the bearing coils to maintain stable shaft position.

Energy and space-saving design

This solution eliminates the mechanical contact and the losses that occur with bearings that require lubrication, significantly cutting energy consumption and costs. Offering higher power density and a smaller footprint than conventional solutions, the SKF magnetic system frees up new design possibilities for OEMs and simplifies maintenance for end-users.

Oil-free efficiency

By eliminating the need for oil lubrication, the magnetic system from SKF also improves heat transfer efficiency in the evaporator and condenser.

Extremely quiet operation

The system's vibration- and nearly friction-free performance capabilities enable super-quiet operation.

Key system components

Permanent magnet motor

- Low energy use and cooling requirements
- More energy efficient than induction motors
- Higher power factor/lower current draw than induction motors
- High rotor stiffness enables high speed operation
- Uses smaller size VFD than induction motors

Active magnetic bearings

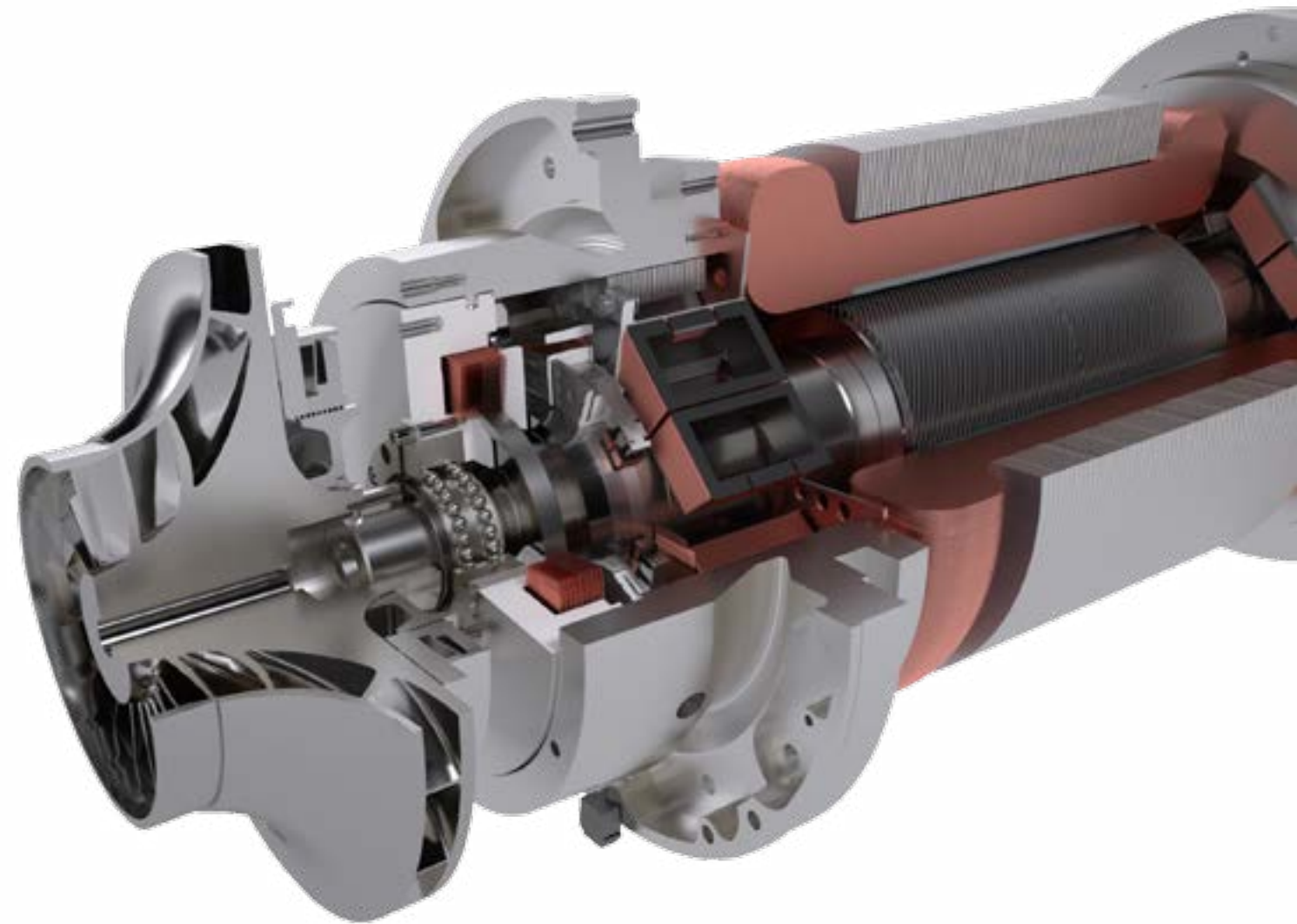
- Accommodate frequent start-ups and transient surge forces
- Active control system enables vibration-free performance
- Capable of speeds in excess of 60 000 r/min
- Magnetic levitation of the rotor means low friction and no need for oil

Magnetic bearing controller

- Tracks and registers rotor position up to 15 000 times per second
- Controls rotor position to within a micron-sized orbit
- Continuously corrects rotor position by adjusting the power supplied to each electromagnet
- Instrumentation for integration into the compressor control system
- Actively monitors compressor performance

Why SKF for magnetic solutions?

SKF is a leading producer of magnetic bearings and high-speed permanent magnet motors, thanks to our acquisition of S2M, a pioneering technology company that has been refining contact-free, levitating bearing technology for more than 40 years. When you work with SKF, our engineers will help you find the optimum magnetic system solution for your application, then recommend a suitable VSD from various manufacturers.



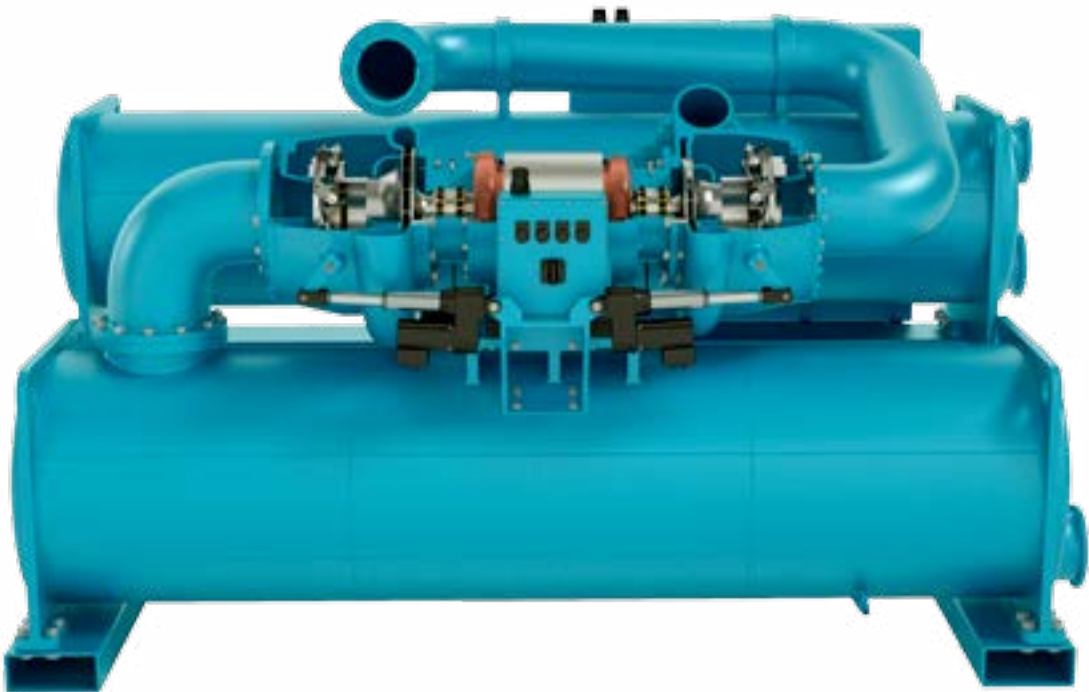
Pure refrigerant lubricated bearings from SKF

PRL - Pure refrigerant lubricated bearings from SKF

Speed: 3 000–18 000 r/min

Lubrication:
Oil-free – refrigerant-lubricated

Motor size: 100–750 kW



Refrigerant as lubricant

Centrifugal compressors using low-viscosity refrigerants have traditionally been gear-driven designs that use hydrodynamic bearings lubricated with the oil-refrigerant mixture. This design requires both a lubrication system and an oil separator to provide an oil-rich mixture to the gears and bearings and a refrigerant-rich mixture to the evaporator and condenser.

Pure refrigerant lubricated bearings from SKF offer a much simpler solution – they use the pure refrigerant as the only lubricant, a breakthrough that reduces chiller energy consumption while simplifying system design and maintenance requirements.

A proven hybrid ceramic bearing solution

Pure refrigerant lubricated bearings from SKF feature ceramic rolling elements and rings made of high nitrogen stainless steel that is heat-treated in a process developed by SKF. The result is a steel with a much finer microstructure than conventional bearing steel, significantly enhancing fatigue resistance and corrosion protection.

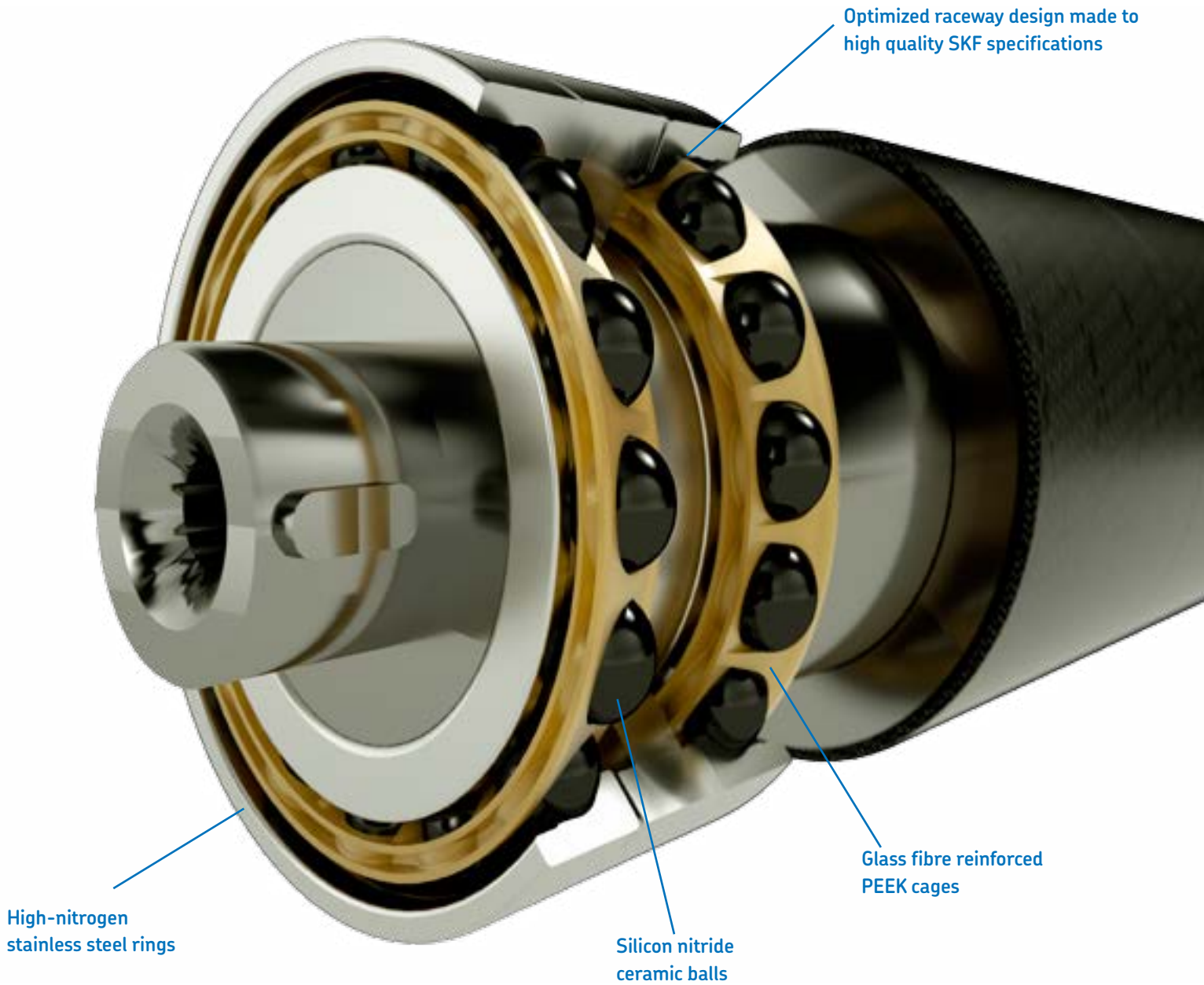
Now operating trouble-free in the field for almost two decades, pure refrigerant lubricated bearings from SKF offer several benefits:

- Increased chiller efficiency
- Oil-free operation
- Simplified maintenance
- Lower lifecycle costs
- Simplified compressor design

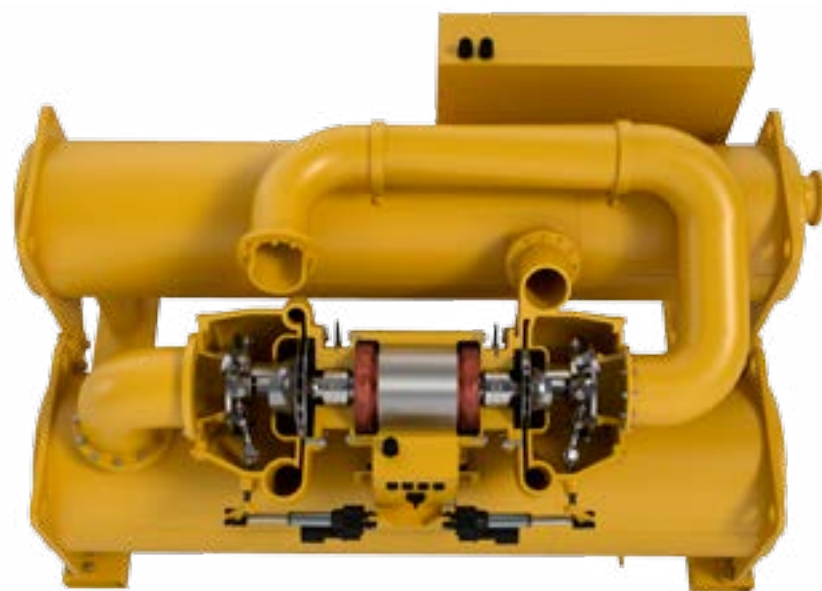
Reliability by design

Silicon nitride rolling elements have a mass less than 40% that of steel elements, a reduction that allows higher speeds, lower inertia, more rapid starts and stops, and much more uptime. They also provide electrical insulation that protects the bearings from stray currents. But their main advantage in chiller and heat pump applications is that no metal-to-metal contact occurs between raceways and rolling elements – enabling lubrication by very thin films.

The combination of high quality ceramic balls, rings made of high-nitrogen steel with special heat treatment, glass fibre reinforced PEEK cages, and demanding SKF quality manufacturing standards results in a bearing that can operate reliably with pure refrigerants as lubricant. This simple, oil-free operating solution has been field-tested for more than a decade.



Oil-lubricated rolling bearings



Oil-lubricated rolling bearings

- Motor shaft speed:** 1 500–3 600 r/min
- Impeller shaft speed:** 6 000–25 000 r/min
- Lubrication:** Oil-refrigerant lubricated
- Motor size:** 100–3 000 kW

Design and performance flexibility

Oil-lubricated rolling bearings from SKF can help boost performance for both gear drive and direct drive compressor designs. For systems under development that will use an oil-refrigerant mixture as lubricant, oil-lubricated rolling bearings from SKF will enable many of the same high-speed, high-efficiency benefits of a permanent magnet motor and variable speed drive. For existing gear-driven compressors, the bearings can be integrated in the high-speed output shaft.

Gear drive solutions

The traditional driveline used in centrifugal compressors consists of a motor and motor shaft, a gearbox and an impeller shaft. The gearbox is used to increase the speed from motor to impeller. The motor is typically a two or four-pole induction motor, driven directly from the grid with 50 or 60 Hz frequency current.

The advantages of such a driveline are that no VFD is needed and the impeller speed can be set by selecting different gear sets. For larger-size compressors, this may be the only driveline possible since large-size, medium and high-voltage VFDs are prohibitively expensive.

Traditionally, hydrodynamic bearings have been used in these geared drivelines, but newer designs take advantage of the 2% - 4% efficiency gains that rolling bearings allow. Lower bearing friction and improved impeller running accuracy enable the improvement. The lubrication system is also much more simplified and reduced in size.

Low to high-speed applications

Since oil is needed to lubricate the gears, oil is also available to lubricate the bearings. For low-speed motor shafts, standard industrial rolling bearings are used. For high-speed impeller shafts, the new single-row angular contact ball bearing with 25° contact angle can be applied or even super precision bearings are required.

Depending on speed and bearing size, bearing rolling elements are made of either steel or ceramics. SKF makes a full line of rolling bearings for both low and high-speed shaft designs.

Rolling bearing advantages

- Reduced bearing friction and power loss
- Smaller bearing clearances, improved shaft positioning
- Reduced refrigerant leakage through impeller gaps
- Smaller, simpler lubrication system

Operating benefits

- Improved energy efficiency
- Improved volumetric efficiency
- Reduced manufacturing costs
- Reduced operating costs



Able to boost performance for low to high-speed geared drivelines, SKF single-row angular contact ball bearing.

Upgrade to higher temperatures and speeds - also for screw compressors



Heat pumps and data center chillers

There are several massive market trends that require refrigerant compressors to work at much higher temperatures, speeds, and pressures, namely: data center cooling, large district heating systems, and replacing fossil boilers by heat pumps in industrial processes. The higher temperatures and higher pressures and specific features of the used green and natural refrigerants put increased demands on bearings materials and tribology.

Compressors to supply “green steam”

An important element in decarbonising industry is to use compressors or high-speed blowers to generate or supply “green steam” to industrial processes or other commercial applications. This can mean to either generate steam by using a high-temperature heat pump, or to perform mechanical vapor recompression (MVR), i.e. to compress and recycle “waste-steam”, or to produce superheated steam.

Speed in heat with SKF

Already today, derived from its long experience with chiller and high-speed applications, SKF offers cutting-edge technology and engineering support for above mentioned applications.

Rolling bearings in high temperature refrigerant compressor applications are facing tough challenges: besides higher speeds and pressures, the reduced oil viscosity and high dilution of the oil by the refrigerant can lead to very thin lubricant films. When variable frequency drives are used, the low running speeds in part load conditions reduce the film thickness even more. SKF has analysed and measured the properties of different refrigerants and oil-refrigerant mixtures and has tested different solutions for those demanding conditions, some of which are outlined below.

Speed up with 25° angular contact ball bearings

In addition to single row angular contact ball bearings with 40° contact angle (suffix BE), SKF now also offers a catalogue range with 25° contact angle (suffix AC). Same as the 40° variant, the 25° bearings are universally matchable bearings with P5 running accuracy and a newly developed brass cage. You can use them in single, duplex, tandem, or triplex arrangements to achieve higher speeds, avoid light load skidding and to accommodate higher radial loads. Different cage variants are available on request as well.



Hybrid ceramic bearings for thin films and high speeds

All-steel bearings can come to their limits in case of very high speed or when the oil film thickness is strongly reduced due to high temperatures and high dilution of the oil by the refrigerant. A well proven solution is to use high-quality SKF hybrid bearings with rolling elements made from silicon nitride ceramic material.



Hybrid cylindrical roller bearing Hybrid angular contact ball bearing

Special steels or surface treatments

For cases with ultra-thin lubricant films, particle contamination, and/or corrosive attack, SKF offers hybrid bearings that incorporate rings made out the Nitromax super-tough stainless steel which is heat treated in a process developed by SKF (suffix VC444). If corrosion resistance is not needed, special heat- or surface treatments in combination with other standard or high performance steels can be a solution.

For ultra-fast applications:
Super-precision bearings

Those are ball and roller bearings with P4 and P2 accuracy. They are also available with ceramic rolling elements, and part of the assortment even in stainless execution.



Super precision bearing

Integrated jet lubrication features

For optimum bearing lubrication, SKF offers special geometries or sets incorporating customized jet lubrication spacers or integrated oil grooves and holes to save space and cost.



For optimisation and differentiation;
Special geometries and lubrication features

Magnetic bearings and permanent magnet motors

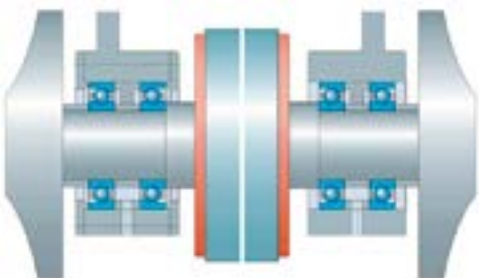
As mentioned earlier in this brochure, active magnetic bearings (AMB) are a proven and reliable solution for ultra-high speeds and/or oil-free centrifugal compressors. Permanent magnet motors (PMM) from SKF lead to higher efficiencies compared to standard motors.



SKF magnetic bearings

Engineering support

SKF has developed cutting edge knowledge and calculation tools to support you in analysing your bearing system related to lubricant film built-up, oil-dilution rates, cleanliness and jet lubrication design, hybrid ceramic bearing life and high speed performance, structural stiffness, and so on.



Rolling bearing and lubrication spaces arrangement for a centrifugal compressor chiller with two rotating impellers.

Proven solutions and worldwide support

A global footprint

Combining capabilities in application engineering, manufacturing and logistics, SKF's global footprint enables expert development and delivery of optimized centrifugal compressor solutions. Thanks to our efficient logistic services, distributors and dealers network, OEMs enjoy fast, easy access to SKF expertise at key production sites worldwide.

Wherever you need us, dedicated SKF sales, engineering and customer service teams can work with you closely throughout the compressor lifecycle, from design and serial production to operations and maintenance.



SKF has a global presence in 129 countries, operates over 100 production sites, 29 remanufacturing sites and 15 technology centres.

Visit our website for more information:



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