Electrically insulated bearings from SKF

Virtually eliminate the dama

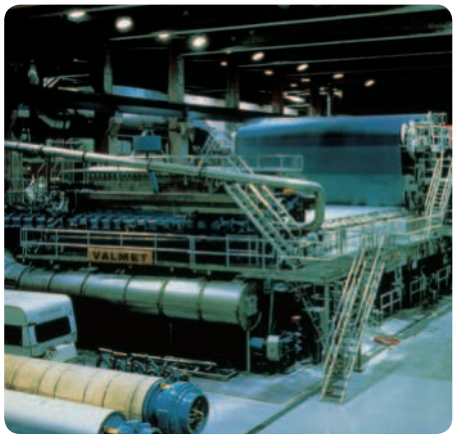
The problem of stray electric current bearing damage

When a stray current in an electric motor uses a bearing as its path to ground, bearing damage can occur. The most common causes of stray electric currents are: asymmetry in the motor's magnetic circuit, unshielded power cables, and fast switching pulse width modulated (PWM) frequency converters used in modern variable frequency drives (VFDs). The increasing popularity of VFDs is directly linked to the increase in electric current related bearing damage.

When an electric current passes through the bearing it can cause micro-cratering in the raceways of inner and outer rings and on the rolling element surfaces (→ **fig. 1**). The heat, which is generated by the discharges, causes local melting that creates small craters and changes in the structure of the metal. As a result of this initial damage, a "washboard pattern" may be found on the raceways (→ **fig. 2**) (and rolling elements for roller bearings). This secondary damage is wear caused by the dynamic effect of the rolling elements when they roll over the smaller craters. Current discharges also cause the lubricant in the bearing to change its composition, degrade rapidly and fail prematurely (→ **fig. 3**).

Once bearing damage from electric erosion has begun, increased noise levels, reduced effectiveness of the lubricant, increased heat and finally excessive vibration, all contribute to drastically decrease bearing service life.

Stray electric currents can occur almost anywhere from windmills to papermills



ging effects of stray electric currents

A cost-effective solution

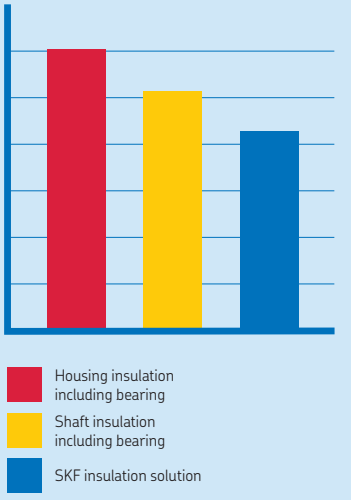
To overcome this problem, SKF has developed two electrically insulating rolling bearing solutions: SKF® hybrid bearings and INSOCOAT® bearings. The solution one chooses depends on the severity and cause of the stray electric current and size of the bearing. In either case, SKF hybrid bearings and INSOCOAT bearings provide a number of benefits

- two functions in one solution:
  - a bearing function
  - electrical insulation
- virtually eliminates premature bearing failures caused by stray electric currents
- increases machine uptime
- reduces maintenance costs
- provides an economical solution when compared with other insulation solutions
- global availability.

Recommended range

SKF has defined a recommended range of INSOCOAT and hybrid bearings specifically for electric motors and generators. This range enables fast and secure delivery around the globe.

Total cost of SKF insulated bearing solution relative to other insulation approaches

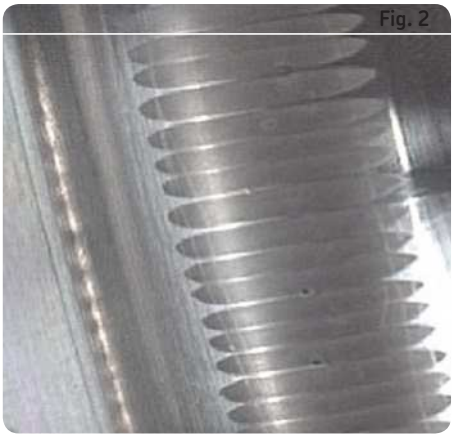


Micro-cratering
Micro-cratering is the result of electric current passage in bearings. The damaged surface appears dull and is characterized by small craters of a few microns in diameter.

Fig. 1

Fluting or washboard pattern
A pattern of lines (fluting) across the raceways can be a sign that current has passed through the bearing. Fluting is not primary damage resulting from stray electric currents but is secondary damage that becomes visible over time.

Fig. 2



Grease-blackening
Electric discharges cause the base oil in the lubricant to burn and harden to create a poor lubrication condition.

Fig. 3


SKF 6215/C3

INSOCOAT

An INSOCOAT bearing is a very economical solution when compared with other insulation methods that protect a bearing against electric current passage. By integrating the electrical insulation function into the bearing, SKF has been able to increase reliability and machine uptime by virtually eliminating the damaging effects of stray electric currents.

INSOCOAT bearing designs

The standard range of INSOCOAT bearings in the most frequently used sizes and variants are available from stock as

- single row deep groove ball bearings
- single row cylindrical roller bearings.

The performance data as well as the dimensional and running accuracy of INSOCOAT bearings are identical to standard non-insulated bearings.

INSOCOAT bearings with coated outer ring

Bearings with an electrically insulating coating on the external surfaces of the outer ring are the most common INSOCOAT bearings. They are identified by the suffix VL0241.

Outer ring coated INSOCOAT bearings are recommended for medium size motors, that use 6215, 6313 size bearings and larger. For applications where smaller bearings are used, SKF recommends hybrid deep groove ball bearings.

INSOCOAT bearings with coated inner ring

Bearings with an electrically insulating coating on the external surfaces of the inner ring provide enhanced protection against electric current damage. The enhanced protection results from the increased impedance due to the smaller coated surface area. Bearings with a coated inner ring are identified by the suffix VL2071 and are recommended for larger size motors (typically from bearing sizes 6226, 6324 sizes and larger), or other applications where the bearings risk being subjected to high shaft voltages.

Technical features and benefits

- The coating is applied using a plasma-spray technique. Sophisticated pre- and post- application processes yield an outstanding coating quality.
- INSOCOAT bearings are treated with a unique sealant to guard against humidity and water from penetrating the coating and reducing its effectiveness.
- Due to the quality of the application and finishing processes, INSOCOAT bearings provide reliable and consistent insulation, that is virtually insensitive to heat, moisture and chemicals.
- SKF can supply values for relevant electric parameters for the bearings (capacitance, impedance) to optimize the insulating solution for any application.
- INSOCOAT bearings are environmentally friendly.
- INSOCOAT bearings with an outer ring coating are suitable for all types of housings. No additional mounting precautions are necessary.

Dimensions

The boundary dimensions of INSOCOAT deep groove ball bearings and cylindrical roller bearings are in accordance with ISO 15:1998.

Tolerances and fits

INSOCOAT bearings are produced to Normal tolerances. Some deep groove ball bearings are also available with higher accuracy to tolerance class P5.

The aluminium-oxide layer applied either to the external outer ring surfaces or the external inner ring surfaces does not influence running accuracy.

INSOCOAT bearings can be mounted with the same fit as a standard bearing in an electric motor or generator, without risk of damaging the coating. Fits up to and including p6 for inner ring coated variants and P6 for outer ring coated variants can be applied.

Internal clearance

Standard INSOCOAT deep groove ball bearings and cylindrical roller bearings are manufactured with the radial internal clearance to the class shown in the bearing designation. Before ordering, check the availability of bearings with clearances other than standard.

Cages

Depending on the bearing type and size, INSOCOAT bearings are equipped with one of the following cages

- a riveted cage of pressed steel, no designation suffix, or
- a two-piece machined brass cage, rolling element centred, designation suffix M.

Electrical properties

INSOCOAT bearings provide effective protection against AC and DC currents. The specifications for different variants are:

VL0241 Electrical resistance: min. 50 MΩ, breakdown voltage: max. operating voltage 1 000 V DC.

VL0246 Electrical resistance: > 150 MΩ, breakdown voltage: max. operating voltage 3 000 V DC.

VL2071 Electrical resistance: min. 50 MΩ, breakdown voltage: max. operating voltage 1 000 V DC.

VL2074 Electrical resistance: > 150 MΩ, breakdown voltage: max. operating voltage 2 000 V DC.

Design of associated components

To maximize the effects of the insulating properties of INSOCOAT bearings, SKF recommends the following:

- For bearings with a coated outer ring designation suffix VL0241, the housing shoulder or spacer sleeve should not have a diameter smaller than the abutment dimension $d_{a\ min}$ listed in the assortment tables. For VL0246 abutment dimensions, contact SKF.
- For bearings with a coated inner ring designation suffix VL2071, the shaft shoulder or spacer sleeve should not have a diameter larger than the abutment dimension $d_{a\ max}$ listed in the assortment tables. For VL2074 abutment dimensions, contact SKF.

The coating can be applied to either the outer or inner ring to provide protection against electric current damage in bearings. Designation suffix VL0241 or VL2071 respectively.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Hybrid bearings – more than an insulator

Hybrid bearings have rings made of bearing steel and rolling elements made of bearing grade silicon nitride (Si_3N_4). Because silicon nitride is such an excellent insulator, hybrid bearings can be used effectively to insulate the housing from the shaft in both AC and DC motors, as well as in generators.

In addition to being an excellent insulator, hybrid bearings have higher speed capabilities and will provide longer bearing service life under the same operating conditions than a similarly sized all-steel bearing.

Features and benefits

Lower density

The density of a bearing grade silicon nitride rolling element is 60 % lower than a rolling element made from bearing steel. For similar sized bearings, less weight means lower inertia – and that translates into superior behaviour during rapid starts and stops as well as higher speeds.

Lower friction

The lower density of a silicon nitride rolling element combined with its low coefficient of friction, significantly reduces bearing temperatures at high speeds. Cooler running increases the service life of both the bearing and the lubricant.

High hardness and high modulus of elasticity

The high degree of hardness of a silicon nitride rolling element means high wear resistance and longer bearing service life in contaminated environments whilst the high modulus of elasticity means increased bearing stiffness.

Low coefficient of thermal expansion

A silicon nitride rolling element has a lower coefficient of thermal expansion than a rolling element made from bearing steel. This means less sensitivity to temperature gradients at high temperatures for better, more accurate preload control.

Runs faster, lasts longer

Combine the lower density of silicon nitride with its lower coefficient of friction, high hardness and the fact that silicon nitride will not smear the raceways under poor lubrication conditions, and the result is a bearing that will run faster and longer even under the most difficult operating conditions.

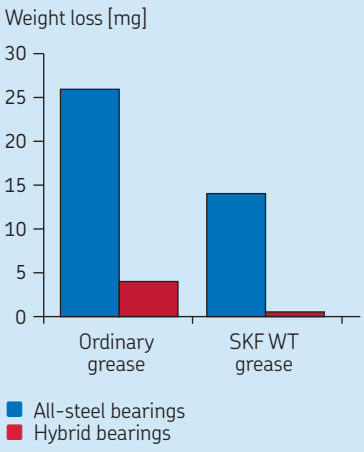
Resists false brinelling

If a stationary bearing is subjected to vibrations there is a risk that "false brinelling" will occur. False brinelling is the formation of small indentations in the raceways that will eventually lead to spalling and premature bearing failure. In cases where steel balls were replaced by ceramic balls the bearings were found to be much less susceptible to false brinelling.

Hybrid bearings supplied with SKF wide temperature grease (WT) were found to sustain less false brinelling damage than bearings containing other types of greases (→ **diagram 1**).

Diagram 1

"False brinelling" at 25 Hz



Cages

Depending on their size, standard SKF hybrid deep groove ball bearings are fitted with

- an injection moulded snap-type cage of glass fibre reinforced polyamide 6,6 or
- a riveted pressed steel cage.

Hybrid bearings with a polyamide 6,6 cage can be operated at temperatures up to + 120 °C (+250 °F).

Polyetheretherketone (PEEK)

The use of glass fibre reinforced PEEK cages is becoming more common for applications where there are high speeds or high temperatures. PEEK provides a superior combination of strength and flexibility and does not show signs of ageing due to high temperatures or oil additives. The maximum temperature for high-speed use is limited to +150 °C (+300 °F) as this is the softening temperature of the polymer. For additional information about PEEK cages, contact the SKF application engineering service.

Seals

The SKF standard range of hybrid bearings for electric motors consists primarily of single row deep groove ball bearings. Sealed and greased-for-life SKF hybrid deep groove ball bearings are protected on both sides by

- a low-friction RSL seal, fitted to bearings with an outside diameter ≤ 52 mm, designation suffix 2RSL
- a low-friction RZ seal, fitted to bearings with an outside diameter > 52 mm, designation suffix 2RZ
- an RS1 contact seal, fitted to bearings with an outside diameter ≥ 90 mm, designation suffix 2RS1.

All seals are made of acrylonitrile-butadiene rubber (NBR) with sheet steel reinforcement. The permissible operating temperature range for these seals is –40 to +100 °C (–40 to +210 °F) and up to +120 °C (+250 °F) for brief periods. For operating temperatures up to +180 °C (+355 °F), seals made from fluoro rubber are available. For additional information about these seals, contact the SKF application engineering service.

Lubrication

The standard sealed hybrid bearing is filled with a premium quality synthetic ester oil based grease, containing a polyurea thickener (designation suffix WT). This grease, which has an operating temperature range from about +70 to +120 °C (+160 to +250 °F), has excellent lubrication properties and provides extremely long service life.

Hybrid bearings perform extremely well under vibrating or oscillating conditions. It is therefore not usually necessary to use special greases for these conditions.

Comparison of the material properties of bearing steel and bearing grade silicon nitride

Material properties	Bearing steel	Bearing grade silicon nitride
Mechanical properties		
Density (g/cm^3)	7,9	3,2
Hardness, HV 10	700	1 600
Modulus of elasticity (GPa)	210	310
Thermal expansion (10^{-6}/K)	12	3
Electrical properties (at 1 MHz)		
Electrical resistivity (Ωm)	$0,4 \times 10^{-6}$ (conductor)	10^{12} (insulator)
Dielectric strength (kV/mm)	–	15
Relative dielectric constant	–	8

Grease life in hybrid bearings

Tests have shown that when used with sealed hybrid bearings, the wide temperature grease (WT) from SKF has a very long service life even at high speeds and high temperatures. One example (→ **diagram 2**) shows where the life of WT grease in hybrid bearings was four times longer than in all-steel bearings. The shaft diameter was 20 mm, the speed 20 000 r/min and the operating temperature +120 °C (+250 °F).

Most SKF hybrid deep groove ball bearings are sealed and greased-for-life.

SKF recommends relubrication of open bearings with SKF grease LGHP 2. In general, the relubrication interval is 3 to 5 times longer than for an all-steel bearing.

For very high-speed applications at temperatures below +70 °C (+160 °F) the use of either SKF grease LGLC 2 or SKF grease LGLT 2 is recommended.

The recommended temperature range for maximum grease life is +70 to +120 °C (+160 to +250 °F).

Equivalent bearing loads

The equivalent dynamic and static bearing loads of hybrid deep groove ball bearings are calculated using the equations for all-steel deep groove ball bearings.

Typical hybrid bearing designations suffixes

The designation suffixes used to identify certain features of SKF hybrid deep groove ball bearings are explained in the following.

C3 Radial internal clearance greater than Normal

HC5 Rolling elements of silicon nitride

TNH Injection moulded snap-type cage of polyetheretherketone (PEEK)

TN9 Injection moulded snap-type cage of glass fibre reinforced polyamide 6,6

WT Grease with a polyurea thickener of consistency 2–3 to the NLGI Scale for a temperature range –40 to +160 °C (–40 to +320 °F) (normal filling grade)

2RS1 Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing

2RSH2 Sheet steel reinforced contact seal of fluoro rubber (FKM) on both sides of the bearing

2RSL Sheet steel reinforced low-friction seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing

2RZ Sheet steel reinforced low-friction seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing

Dimensions, tolerances, internal clearance

Standard SKF hybrid deep groove ball bearings are manufactured as standard with

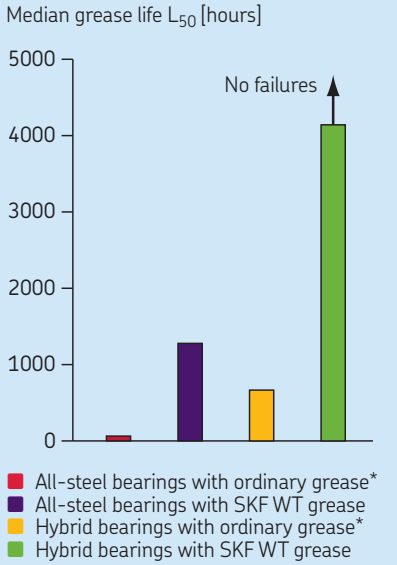
- boundary dimensions to ISO 15:1998
- Normal tolerances to ISO 492:2002
- C3 radial internal clearance to ISO 5753:1991.

Recommendations for installation

Hybrid bearings should be handled and mounted in the same manner as conventional all-steel bearings. Always use the right tools and correct methods for mounting and dismounting.

Diagram 2

Long grease life with SKF WT grease in hybrid bearings



*At +120 °C (max temperature for ordinary grease)

Grease alternatives offering long service life in hybrid bearings

SKF grease	Temperature range*
WT	– 40 to +160 °C – 40 to +320 °F
LGHP 2	– 40 to +150 °C – 40 to +300 °F

* For additional information about safe operating temperatures, refer to the chapter "Lubrication" in the SKF General Catalogue

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