A solution to increase reliability and machine uptime

INSOCOAT electrically insulated rolling bearings

Prevention of electrical erosion in bearings

Whenever an electric current passes through rolling bearings, there is a potential threat to the reliability of your machines. Electrical erosion can damage and degrade bearings in traction motors, electric motors and generators, leading to costly downtime and unplanned maintenance.

With its latest generation of insulated bearings, SKF has raised the performance standard. INSOCOAT bearings offer high levels of reliability and uptime for electrical applications, even in the most challenging environmental conditions.

The impact of electrical erosion

In recent years, demands on insulated bearings used in electrical machinery have increased. Higher motor speeds and greater use of variable frequency drives mean that insulation needs to perform flawlessly if damage from electric currents is to be avoided. The insulation's properties must also remain stable regardless of environmental conditions; this is a particular issue where bearings are stored and handled in humid climates.

Electrical erosion harms bearings in three different ways:

1. Excessive current erosion

When an electric current passes through a bearing from one ring to the other via the rolling elements, it creates a process similar to electric arc welding, concentrating a high current density onto a small contact surface. This heats the material to temperatures ranging from tempering to melting levels. It creates discoloured areas, varying in size, where the material has been tempered, re-hardened or melted and can form craters where material has melted.

Ball bearing raceway with large spalls due to excessive current erosion

2. Current leakage erosion

If a current flows continuously through a bearing in service in the form of arcs, even at low intensity, the raceway surfaces are affected by the heat and erode as thousands of microcraters are formed, mostly on the rolling contact surfaces. These craters are closely positioned to one another and are small in diameter compared to the damage from excessive current.

Over time, as a secondary effect, this will lead to flutes (washboarding) on the raceways of rings and rollers. The extent of damage depends on several factors: type of bearing, bearing size, electrical regime, bearing load, speed and lubricant. In addition to bearing steel surface damage, the lubricant close to the damage might be degraded, eventually resulting in poor lubricating conditions and ultimately surface distress and spalling.

Influence of microcraters due to high frequency current leakage erosion. Comparison between a ball with (left) and without (right) microcraters

3. Lubricant degradation

Local high temperatures caused by electric current can cause the additives in the lubricant to char or burn, resulting in the additives being consumed more quickly. In case of grease lubrication, the grease turns black and hard. This rapid breakdown dramatically reduces grease and bearing service life.

Why humidity matters

Humid operating environments in countries such as India and China present an additional challenge to insulated bearings. When bearings are exposed to humidity, for example during storage, moisture can penetrate the insulating material reducing the effectiveness of electrical insulation and shorten the service life of the bearing itself.

Fluting of the raceways is secondary damage most commonly attributed to the passage of damaging electrical current across the bearing

Cylindrical roller bearing outer ring with cage, rollers and grease: current leakage resulted in burnt grease (black) on the cage bars

INSOCOAT: protection against electrical erosion

INSOCOAT bearings provided by SKF combat electrical erosion in a wide range of conditions, including high humidity. Sealed protective coatings on the outer or inner rings integrate insulating properties into the bearing. They eliminate premature bearing failures caused by stray electric current in applications including:

- Industrial electric motors
- Traction motors
- Generators

High-quality coating

INSOCOAT bearings feature an insulating layer of aluminium oxide applied by a sophisticated plasma spray process for outstanding quality, which provide the following benefits:

- Resistance to common media used in bearing applications
- Protection over a wide range of operating temperatures
- Minimum electrical resistance of 200 MOhm (**table 1**)
- Tested to withstand voltages of 3 000 V DC (coatings that can handle higher voltages can be quoted on request)

Protective sealant

Plasma spray coatings are normally hygroscopic and therefore vulnerable to being penetrated by condensation. INSOCOAT bearings are treated with a unique sealant to protect against this effect.

Engineering support

SKF can provide you with the relevant electrical parameters for your bearings so you can choose the best insulating solution for your needs.

Global availability

The most frequently used sizes and variants of INSOCOAT bearings are available from stock as single row deep groove ball bearings and single row cylindrical roller bearings. Specific customized ranges and products are available on request.

Performance data, dimensional and running accuracy are identical to non-insulated bearings (**table 2**).

Table 1

INSOCOAT specifications, T ≤ 40 °C, rH ≤ 60%

SKF specification designation suffix		**Breakdown voltage**	**Minimum electrical resistance**
		[V] DC	[MΩ]
Outer ring coating	**Inner ring coating**		
SKF standard layer VL0241	VL2071	3 000	200
SKF advanced layer VL0246	VL2076	3 000	400

Table 2

INSOCOAT bearing data

	Deep groove ball bearings and cylindrical roller bearings
Dimension standards	Boundary dimensions: ISO 15
Tolerances	Normal, higher accuracy on request
	Values: ISO 492, for additional information refer to SKF catalogues
	The aluminium oxide layer on the external surfaces of either the outer or the inner ring does not influence the accuracy
Internal clearance	C3 as standard, check availability for other internal clearance classes
	Values are valid for new bearings before mounting under zero measuring load: ISO 5753-1, see SKF catalogues
Allowable misalignment	Identical to the comparable standard bearings

The INSOCOAT advantages

Improved machine reliability

With INSOCOAT, bearing failures caused by stray electric currents are virtually eliminated, so machines are more reliable and run longer.

Cost-effective protection against electric current damage

INSOCOAT combines bearings and insulation in a single solution. Compared with shaft or housing insulation, INSOCOAT bearings protect against electrical erosion at a significantly lower total cost of ownership.

Increased machine uptime and reduced maintenance costs

INSOCOAT bearings prolong machine life which results in longer maintenance intervals.

Easy to mount, ready to use

INSOCOAT bearings can be installed with standard methods and tooling, and are highly robust during transport and handling.

Choice of coatings

Coated outer ring

Bearings with an electrically insulating coating on the external surfaces of the outer ring are the most common INSOCOAT types. They are:

- Recommended for medium-sized motors using bearing sizes with a bore diameter < 120 mm
- Suitable for all housing types
- Can be applied to bearings with an outside diameter > 80 mm
- Identified by the suffixes VL0241 and VL0246

Coated inner ring

Bearings with an electrically insulating coating on the external surfaces of the inner ring provide enhanced protection against electric current damage, as the smaller coated surface area offers higher impedance. They are:

- Recommended for larger-sized motors using bearing sizes with a bore diameter > 120 mm
- Can be applied to bearings with a bore diameter > 70 mm
- Identified by the suffix VL2071 and VL2076

INSOCOAT deep groove ball bearing with outer ring coating

INSOCOAT cylindrical roller bearing with inner ring coating

Customized solutions

SKF can also supply INSOCOAT bearings with complex ring geometries, large size bearings and bearing units.

INSOCOAT flanged tapered roller bearing with outer ring coating

INSOCOAT traction motor bearing unit with inner ring coating

INSOCOAT tapered roller bearing unit with outer ring coating

The influence of electrical parameters

INSOCOAT bearings behave differently in DC and AC electrical regimes.

In DC applications, an INSOCOAT bearing acts as a normal (pure ohmic) resistor. The aluminium oxide layer is an insulator and, therefore, only ohmic resistance (R) of the layer is of importance. The breakdown voltage of the standard layer is stated as 3 000 V DC and the resistance is higher than 200 MΩ, providing efficient insulation of the bearing.

In AC applications, especially at high frequencies provided by frequency-converters, bearing behaviour is different. An electrically insulating layer such as the ceramic INSOCOAT coating layer functions as a parallel connection of a resistor and a capacitor. Therefore, the impedance (Z) must also be considered, as described in the equation 1 above:

$$|Z| = \frac{1}{\sqrt{\frac{1}{R^2} + (2\pi f C)^2}}$$

EQUATION 1: Electrical impedance of an electrical capacitance in parallel to a ohmic resistor.

Equation 1 illustrates that with increasing frequency, the term incorporating the capacitance becomes stronger and causes a decrease of the impedance.

The electrical impedance in this case depends on the ohmic resistance (R) of the resistor, on the capacitance (C), and on the frequency (f) of the applied voltage. The electrical capacitance (equation 2) of an INSOCOAT bearing depends on the size of the coated surface area of the bearing (A), the thickness of the insulating coating (s), the coating material itself (εr) and the electrical permittivity (ε0, a material constant).

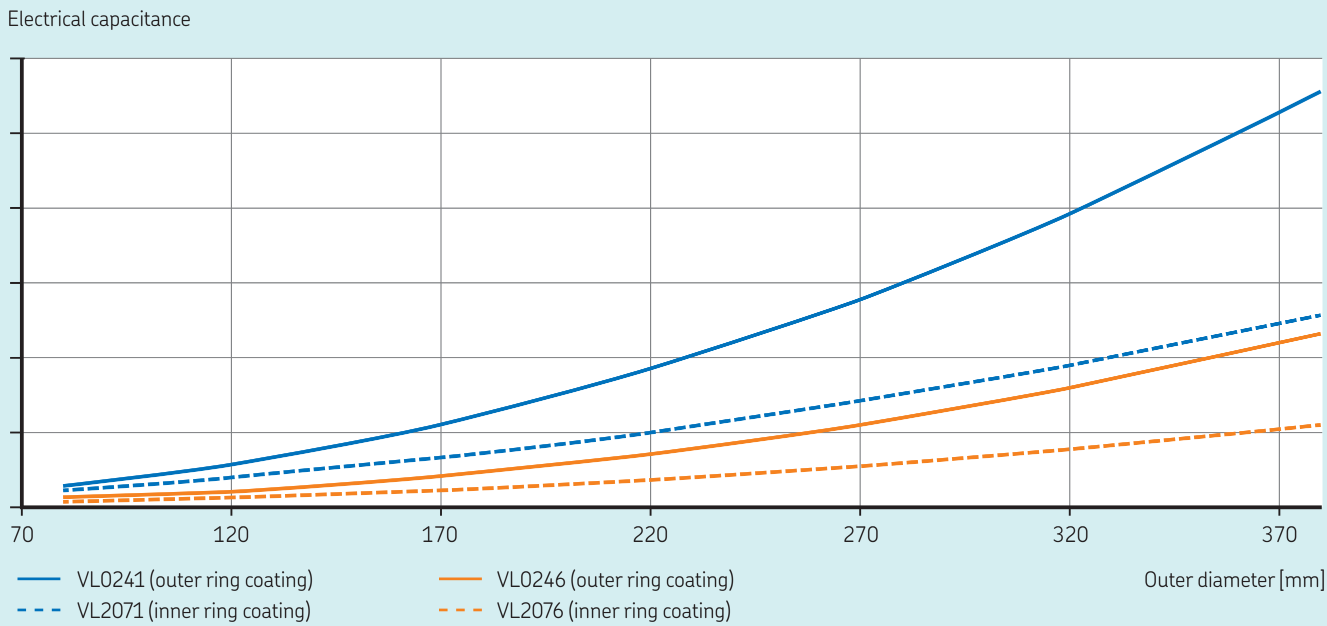
$$C = \varepsilon_0 \, \varepsilon_r \frac{A}{s}$$

EQUATION 2: Electrical capacitance of a plate capacitor.

To increase the impedance of the bearing, the electrical capacitance of the coating should be kept as small as possible. In practice, this means that an inner ring coating always has higher impedance than an outer ring coating. The same is valid for the coating thickness. VL0246 has much higher electrical impedance than VL0241 (**diagram 2**).

Diagram 2

Electrical capacitance as a function of bearing outer diameter



How SKF measures electrical parameters for INSOCOAT bearings

Valid ohmic resistance measurements can only be obtained in controlled environmental conditions, as the result can be influenced by many different factors, such as humidity, cleanliness, temperature and contact surfaces.

Fig. 1 and **fig. 2** show the measuring principle for INSOCOAT bearings with outer ring or inner ring coating, which is in line with real mounting conditions. Therefore, the electrical parameters described in **table 1** are only valid in mounted conditions, a dry and clean environment, and relevant shaft and housing dimensions as described in the general catalogue.

Fig. 1

Electrical insulation measurement principle for outer ring coated bearings

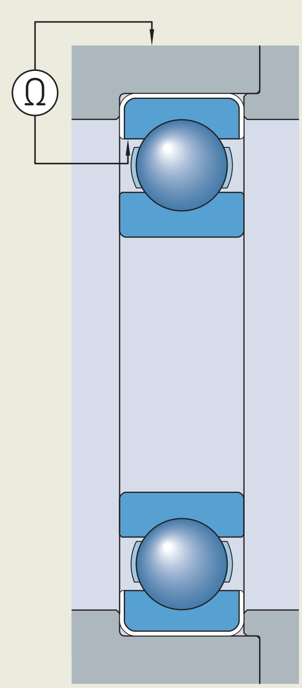
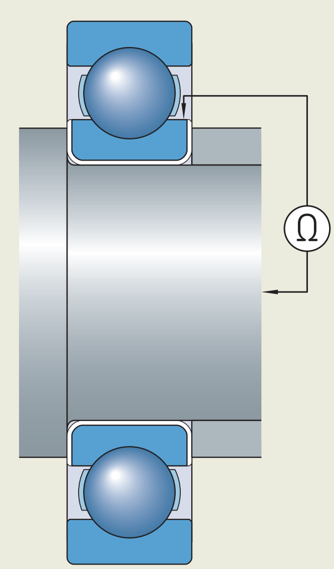


Fig. 2

Electrical insulation measurement principle for inner ring coated bearings



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