

**SKF**

# **INSOCOAT® - electrically insulated rolling bearings**



# INSOCOAT<sup>®</sup> - the SKF solution to prolong bearing life in electric machinery

## What are INSOCOAT bearings?

SKF provides electrically insulated bearings, called INSOCOAT<sup>®</sup>, to protect against damages caused by electric currents. These bearings have an electrically insulating coating on the outer ring or on the inner ring. On the outer ring (VL0241 execution) the coating can be applied to diameters above and including 80 mm. Inner ring coatings (VL2071 execution) can be applied to bore diameters above and including 70 mm. For smaller bearing dimensions we recommend SKF hybrid bearings.

The coating consists of a nominal 100 µm thick aluminium oxide layer and is applied by a unique coating process using plasma-spraying technology.



*INSOCOAT bearings with outer ring coating – VL0241 execution*

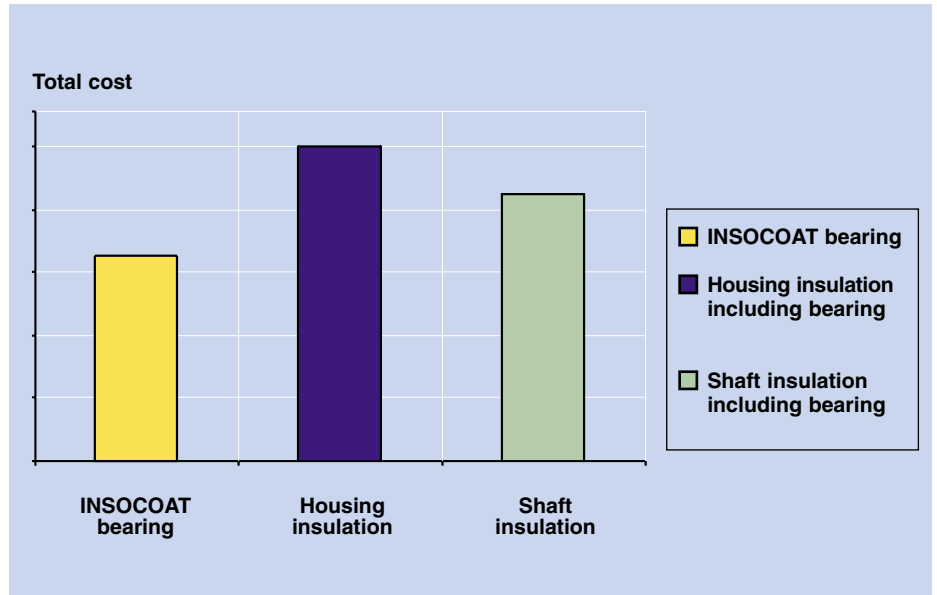
### *Industrial motors*



# Customer value

## INSOCOAT bearings

- provide two features in one solution:
  - a bearing function;
  - electrical insulation.
- reduce the number of failures and improve the machine uptime.
- reduce maintenance costs.
- are the most economical solution in comparison with other insulating solutions.
- have global availability thanks to SKF presence in more than 130 countries and at 7 000 distribution locations worldwide.



*INSOCOAT bearings provide the most economical solution in comparison with other insulating methods*

## Traction motors



## Generators





The inner ring coating provides an enhanced protection of the bearing against electric current damages. The most important feature is the improved insulation properties thanks to a smaller coated surface.

*INSOCOAT bearing with inner ring coating – VL2071 execution*

## Technical benefits

- The standard 100 µm layer thickness prevents most current passage problems.
- SKF performs 100 % testing up to 1 000 V DC. Lab tests show that electrical breakdown occurs above 3 000 V DC.
- INSOCOAT bearings provide a minimum ohmic resistance of 50 M Ω at 1 000 V DC.
- The application process using plasma spraying technique in combination with sophisticated pre- and after preparation of the bearing rings gives an outstanding coating quality.
- INSOCOAT bearings are treated with a unique sealant ensuring insulation in humid environments. It is also insensitive to heat and chemicals.
- INSOCOAT bearings provide a better electrical and mechanical performance than other insulation methods.
- SKF can supply values for relevant electric parameters for the bearing (capacitance, impedance).

## Additional benefits

- Simple mounting and dismounting. INSOCOAT bearings should be handled with the same care as standard bearings.
- Fits up to and including p6 and P6 respectively can be applied for both coating variants (VL2071 and VL0241).
- Standard boundary dimensions according to ISO 15:1998.
- Environmentally friendly
- INSOCOAT bearings are suitable for all types of housings.
- SKF has experience with ceramic coatings since more than 20 years.

### *Plasma spraying process and equipment*



## The coating process – plasma spraying technology

This unique technology has the following benefits:

- Plasma spraying is the most versatile thermal coating process – it produces high-performance coatings that deliver durability and reliability.
- The process applies coatings by injecting aluminum oxide powder into a high temperature gas stream. The plasma gas heats the powdered coating material to a molten state and sprays it onto substrates at high speeds.
- Plasma spraying is extremely flexible and is ideal for producing a wide variety of functional coatings.

## Assortment

You can find the living assortment for electrical machinery applications in the enclosed assortment list.

If you cannot find the item that you need in the standard range, please contact your local SKF representative.

### Shields and seals

Shields and seals are available on request for some bearings sizes.

## Lubrication

It is important to ensure proper lubrication by frequent regreasing.

**The three phases and their sum – common mode voltage**

## Sources of electric current

The problem of electric current passing through rolling bearings and causing damage in the contact area of balls or rollers and raceways of inner and outer rings has been known for almost 70 years. In addition to the damage to bearing elements, it was also supposed that the structure of the lubricant itself might change under the influence of a current passage. All rotating machines, both AC and DC motors as well as generators, potentially suffer from this phenomenon.

### Classical failures

With sinusoidal line voltages, the bearing current is generated due to asymmetries in the motor's magnetic circuit. The asymmetric flux distribution inside the motor induces an axial shaft voltage, which further leads to a low-frequency circulating current flowing through the bearings. Bearing current is also generated by asymmetric, non-shielded motor cabling. These 'classical' bearing currents are a problem especially for large motors with low numbers of pole pairs (e.g. 2-pole motors). They have larger flux asymmetries than small motors or motors with many poles.

### High frequency currents

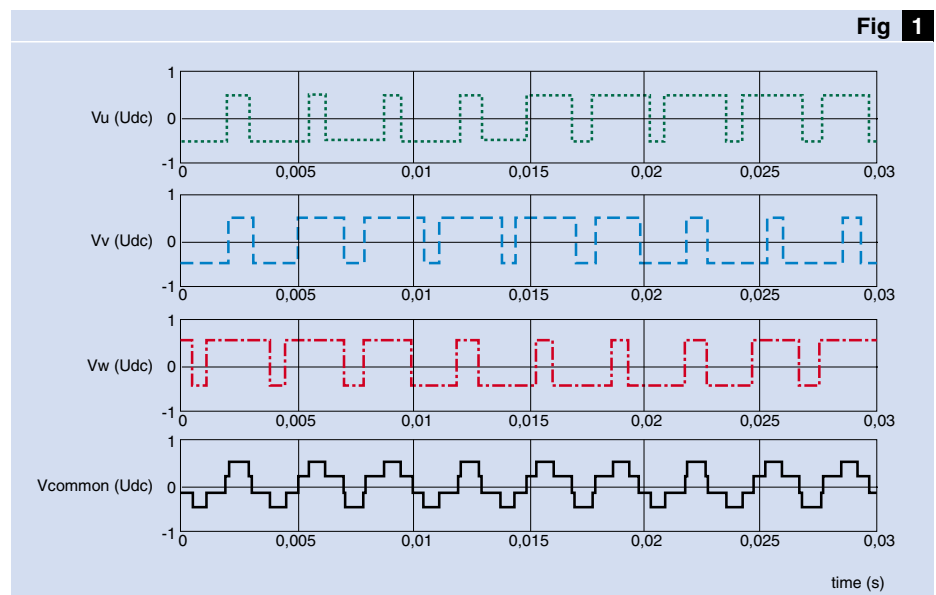
Apart from the classic voltages and currents generated by the motor itself, new effects have been observed when the motor is supplied from a pulse width modulation (PWM) converter (frequencies of 3 to 16 kHz). It has been discovered that the bearing damages are caused by a high frequency (several kHz – MHz range) current flow. The current originates from the so-called common mode voltage of the frequency converter. Another origin of current is the high switching speed of the integrated gate bipolar transistors (IGBTs) used inside the converter.

Problems arise because of three types of currents:

- High frequency shaft grounding currents
- High frequency circulating currents
- Capacitive discharge currents

The reason for the first two types of currents is the common mode voltage at the converter output. The common mode voltage is produced due to the fact that the sum of the three phase voltages is not equal to zero (→ **fig 1**).

Furthermore, the frequency converter tries to simulate a sine wave supply by PWM signals, which have a high switching frequency and very steepedged pulses, which cause capacitive discharge currents.



## Effects of electric current going through the bearing

Due to the passage of electric current in the contact zone of rolling elements and raceways heat is generated causing local melting of the bearing metal surface. Craters are formed in the contact area and particles of molten material are transferred and partly break loose. The crater material is re-hardened and much more brittle than the original bearing material. Below the re-hardened layer there is a layer of annealed material, which is softer than the surrounding material.

### Micro-cratering

Because frequency converters are more and more used micro-cratering is by far the most common effect of electric current passage. The damaged surface appears dull, characterised by molten pit marks (→ fig 2). Multiple micro-craters cover the rolling element and raceway surfaces. Crater sizes are small, mostly from 5 to 8 µm in diameter, disregarding whether it is on the inner ring, outer ring or a rolling element. The real shape of these craters can only be seen under a microscope in very high magnification.

### Fluting or washboard

They are patterns of multiple grey lines across the raceways (→ fig 3). They appear shiny and molten. The reason for this fluting is a mechanical resonance vibration caused by the dynamic effect of the rolling elements when they are over-rolling smaller craters. This means that fluting is not a primary failure mode produced by the current flow through the bearing itself. It is a secondary bearing damage that becomes visible only after time and has its initial point from craters.

### Grease-blackening

Current discharges also cause the lubricant in the bearing to change its composition and degrade rapidly. The local high temperature causes additives and the base oil to react, and it can cause burning or charring of the base oil. Additives will be used up more quickly. Thus the lubricant gets

almost hard and blackened (→ fig 4). A rapid breakdown of the grease is a typical failure mode that results from current passage.

*The dull surface of the ball is a sign of micro-cratering*



Fig 2

*Fluting or washboard in raceway*



Fig 3

*Black discoloured grease affected by current discharges*



Fig 4

# Electric behaviour of INSOCOAT bearings

One has to distinguish between DC current and AC current applications. In DC applications the insulating coating acts as a pure resistor where the ohmic resistance  $R$  of the aluminium oxide layer is the important quantity. The breakdown voltage of the standard layer is larger than 1 000 V DC and the resistance is larger than 50 M $\Omega$ , which provides efficient insulation of the bearing.

In AC applications, especially in variable speed drives (VSDs) one has to consider the impedance of the ceramic coating. The impedance describes the voltage-current relationship in AC circuits. The value of the impedance depends mainly on two electrical characteristics of the coating: the ohmic resistance and the capacitance. The capacitance should be as small as possible to counteract the effects of high frequency electric currents.

The impedance of the aluminium oxide coating can be modelled as a parallel connection of a resistor and a capacitor.

## Impedance and capacitance

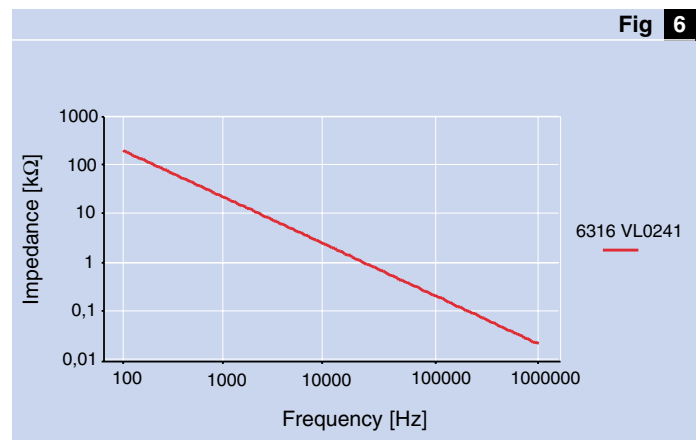
**Fig 6** shows a typical graph of the impedance of a coated deep groove ball bearing (outer ring coating). **Fig 7** shows a typical graph of the capacitance of a coated deep groove ball bearing (outer ring coating).

**Fig 5**

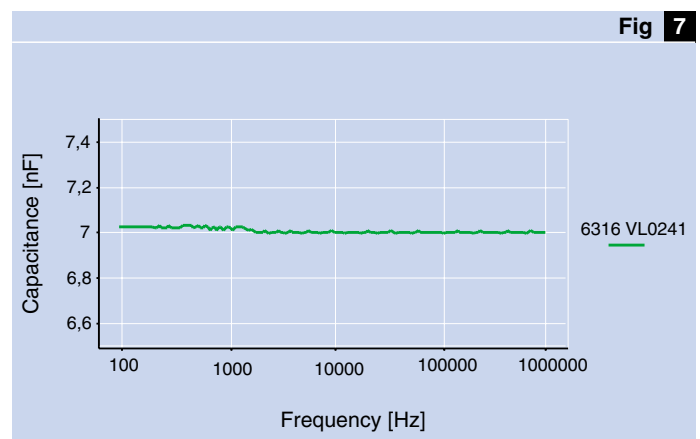
	DC	AC
Description of voltage-current relationship	Resistance <b>R</b>	Impedance <b>Z</b>
Electrical behaviour	Resistor	Resistor and capacitor in parallel
Unit	Ohm [ $\Omega$ ]	Ohm [ $\Omega$ ], Farad [F]
DC – Resistance	Guaranteed more than 50 M $\Omega$	–
AC – Impedance	–	The value depends on the bearing size and the frequency
AC – Capacitance	–	Constant over the frequency range; the absolute value is depending on the bearing size

**Electrical behaviour of INSOCOAT bearings in DC and AC applications**

**Measured impedance as a function of frequency**



**Measured capacitance as a function of frequency**



# More products for trouble-free operation

Your products should run faultlessly. At least for as long as planned – preferably even longer. To ensure this, there are three basic requirements:

- Use the right bearings. Preferably from SKF.
- Mount them correctly. Appropriate skills and the right tools for the job are imperative.
- Ensure proper maintenance. Here, the essentials are know-how, plus the appropriate tools and lubricants.

For this reason SKF, the leader not only in bearing design and manufacturing but in global service, and the SKF distributors offer customers the most comprehensive range of tools to ensure optimal bearing performance.

Induction heaters and mounting tools to preserve the quality, pullers for easy removal, equipment and software for the condition monitoring of bearings and machinery.

In addition, a wide range of greases of the highest quality for bearing lubrication, consistent in quality, for general and specific requirements, available worldwide through the SKF distribution network.

SKF bearings add value to your machine, our tools make your life easy, our distribution network, providing replacement bearing, tools and greases ensures the commitment of SKF to your business.



*SKF has a range of specific bearing greases to meet all application needs*



*SKF measuring equipment*



*SKF induction heaters and hot plate*



*SKF pullers*

# The SKF Group – a worldwide corporation

SKF is an international industrial Group operating in some 130 countries and is world leader in bearings.

The company was founded in 1907 following the invention of the self-aligning ball bearing by Sven Wingquist and, after only a few years, SKF began to expand all over the world.

Today, SKF has some 45 000 employees and around 80 manufacturing facilities spread throughout the world. An international sales network includes a large number of sales companies and some 7 000 distributors and retailers. Worldwide availability of SKF products is supported by a comprehensive technical advisory service.

The key to success has been a consistent emphasis on maintaining the highest quality of its products and services. Continuous investment in research and

development has also played a vital role, resulting in many examples of epoch-making innovations.

The business of the Group consists of bearings, seals, special steel and a comprehensive range of other high-tech industrial components. The experience gained in these various fields provides SKF with the essential knowledge and expertise required in order to provide the customers with the most advanced engineering products and efficient service.



SKF



*The SKF Group is the first major bearing manufacturer to have been granted approval according to ISO 14001, the international standard for environmental management systems. The certificate is the most comprehensive of its kind and covers more than 60 SKF production units in 17 countries.*



*The SKF Engineering & Research Centre is situated just outside Utrecht in The Netherlands. In an area of 17 000 square metres (185 000 sq.ft) some 150 scientists, engineers and support staff are engaged in the further improvement of bearing performance. They are developing technologies aimed at achieving better materials, better designs, better lubricants and better seals – together leading to an even better understanding of the operation of a bearing in its application. This is also where the SKF Life Theory was evolved, enabling the design of bearings which are even more compact and offer even longer operational life.*



*SKF has developed the Channel concept in factories all over the world. This drastically reduces the lead time from raw material to end product as well as work in progress and finished goods in stock. The concept enables faster and smoother information flow, eliminates bottlenecks and bypasses unnecessary steps in production. The Channel team members have the knowledge and commitment needed to share the responsibility for fulfilling objectives in areas such as quality, delivery time, production flow etc.*



*SKF manufactures ball bearings, roller bearings and plain bearings. The smallest are just a few millimetres (a fraction of an inch) in diameter, the largest several metres. SKF also manufactures bearing and oil seals which prevent dirt from entering and lubricant from leaking out. SKF's subsidiaries CR and RFT S.p.A. are among the world's largest producers of seals.*



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