

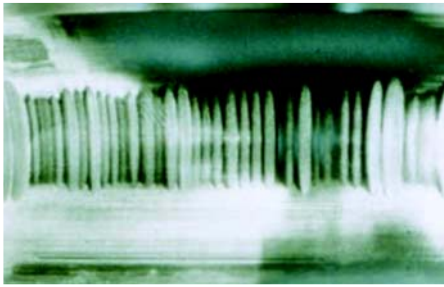
SKF

Hybrid bearings for electrical machinery

Electrically insulating - higher speeds - longer grease life



SKF[®] hybrid bearings increase service life



Electric current damages bearings

When a stray current in an electrical machine uses a bearing as its path to ground, the resulting damage is referred to as “electric arc bearing damage”. The most common causes of electric arc bearing damage are: asymmetry in the motor’s magnetic circuit; unshielded power cables; and fast switching variable frequency drives (VFD). The VFDs and their increased popularity are directly linked to the increase in electric arc bearing damage. When an electric current passes or “arcs” through the bearing it can create transverse ridges or “wash boarding” on the raceways or “pits” and craters in the raceways and rolling elements. Arcing also discolours the raceways and rolling elements turning them a dull, dark grey. The heat from a stray current will also age the lubricant prematurely turning it dark quickly.

Once electric arc bearing damage has begun, excessive vibrations, increased heat, increased noise levels, and the reduced effectiveness of the lubricant all contribute to shorten the bearing’s service life.

Stray electric currents

Electric arcing occurs if there is a difference in potential between the shaft and the bearing housing. Even a difference of a few volts in potential can produce the effect. Not only the motor or generator bearings can be affected – a stray current can damage bearings in the machinery directly coupled to the motor or generator. To prevent electric currents from arcing through the bearings, either the housing or bearings should be insulated.

Hybrid bearings

– more than an insulator

SKF offers a wide range of hybrid bearings to eliminate premature bearing failure caused by electric arc bearing damage. Hybrid bearings have rings of bearing steel and rolling elements of bearing grade silicon nitride (Si₃N₄). Because silicon nitride has high resistivity, hybrid bearings provide insulation from electric currents in both AC and DC motors.

In addition to being an excellent insulator, hybrid bearings have a higher speed capacity and will provide longer service life than all-steel bearings in most applications.

The density of silicon nitride is only 40 % of the density of bearing steel. Because silicon nitride rolling elements weigh less they have lower inertia. This means less damage to the cage during rapid starts and stops and also significantly lower friction at high speeds. Lower friction means cooler running

and thus longer lubricant life. Hybrid bearings are thus suitable for operating at high speeds.

If the lubrication for some reason becomes insufficient, there is no risk of smearing between silicon nitride and steel. Also, the friction coefficient between steel and silicon nitride is low. This enables hybrid bearings to run cooler and last longer in applications where there is inadequate lubrication. Silicon nitride has higher hardness and higher modulus of elasticity than steel. This means high wear resistance, increased bearing stiffness and longer bearing service life in contaminated environments.

Silicon nitride rolling elements have a lower thermal expansion than steel balls of similar size. This means less sensitivity to temperature gradients at high temperatures for better, more accurate preload control.

¹⁾ Hybrid bearings have rings of bearing steel and rolling elements of silicon nitride. The ceramic material is produced by sintering silicon nitride powder at a temperature of 1 800 °C under a pressure of approx. 200 MPa. The process specified by SKF results in a solid, pore-free ceramic with excellent wear resistance.

Material properties	Bearing steel	Bearing grade silicon nitride
Mechanical properties		
Density [g/cm ³]	7,9	3,2
Hardness, HV10 [kg/mm ²]	700	1 600
Modulus of elasticity [GPa]	210	310
Thermal expansion [-10 ⁻⁶ /K]	12	3
Electrical properties (at 1 MHz)		
Electrical resistivity [Ω·m]	~0,4·10 ⁻⁶ (conductor)	~10 ¹² (insulator)
Dielectric strength [kV/mm]	–	~15
Relative dielectric constant	–	~8

Hybrid bearings give longer service life thanks to

- electrical resistivity
- long grease life (especially at high speeds or with vertical shaft)
- high wear resistance in applications with particulate contamination (sand, pigments, abrasive substances, steel, iron oxides etc.)
- good performance under vibration, air currents and water condensation

Life and reliability in electric

6205 **2RZ** **TN9** **HC5** **C3** **WT**

Hybrid bearings have ISO standard dimensions.

Hybrid bearings are available in sealed or open (unsealed) versions. The SKF service assortment includes sealed bearings fitted with a low-friction seal at each side (-2RZ) or a rubbing seal at each side (-2RS1). The seals are of steel reinforced nitrile rubber, do not conduct electricity and are specially designed to exclude dust efficiently.

A glass fibre reinforced polyamide 6,6 cage is standard in hybrid bearings having a bore diameter up to and including 45 mm. This lightweight, flexible, high-strength cage performs very well in high speed deep groove ball bearings.

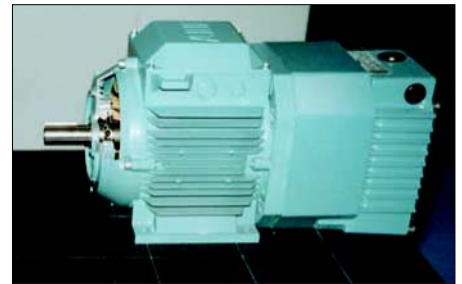
Hybrid bearings > 45 mm use a riveted pressed steel cage (no special designation).

Silicon nitride balls (Si_3N_4) impart:

- electrical insulation properties which eliminate the risk of current passing through the bearing;
- excellent high speed capability thanks to low density and low friction;
- minimum wear because of very high hardness;
- extended grease life and reduced risk of seizure.

Greater than normal radial internal clearance (C3) is standard for the hybrid bearings normally used for electric motor bearings.

SKF grease for wide temperature range (WT) is standard for sealed hybrid bearings and achieves very long lives (see grease life **diagram 3** on **page 5**) even at high speeds and high temperature

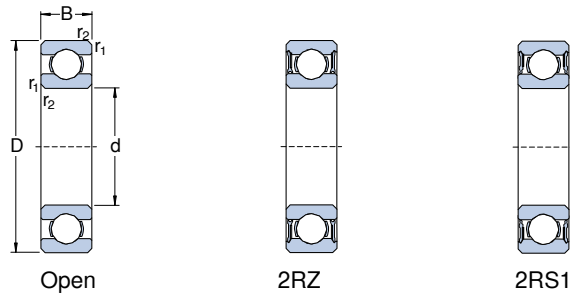


Top: Electric motor from ABB Motors
Above: Shaft encoder from Leine & Linde
Below: Traction motor from Skoda Traction Motors



SKF hybrid bearings for electrical machinery

SKF stocks the range¹⁾ of hybrid bearings for electrical machinery shown here. For other bearing sizes and designs please contact the nearest SKF distributor.



Boundary dimensions				Mass	Designation
d	D	B	r _{1,2} min		
mm				kg	—
10	26	8	0,3	0,018	6000-2RZTN9/HC5C3WT
	30	9	0,6	0,032	6200-2RZTN9/HC5C3WT
12	28	8	0,3	0,022	6001-2RZTN9/HC5C3WT
	32	10	0,6	0,037	6201-2RZTN9/HC5C3WT
15	32	9	0,3	0,03	6002-2RZTN9/HC5C3WT
	35	11	0,6	0,044	6202-2RZTN9/HC5C3WT
17	35	10	0,3	0,038	6003-2RZTN9/HC5C3WT
	40	12	0,6	0,059	6203-2RZTN9/HC5C3WT
20	42	12	0,6	0,062	6004-2RZTN9/HC5C3WT
	47	14	1	0,097	6204-2RZTN9/HC5C3WT
25	47	12	0,6	0,073	6005-2RZTN9/HC5C3WT
	52	15	1	0,12	6205-2RZTN9/HC5C3WT
30	55	13	1	0,11	6006-2RZTN9/HC5C3WT
	62	16	1	0,18	6206-2RZTN9/HC5C3WT
35	62	14	1	0,15	6007-2RZTN9/HC5C3WT
	72	17	1,1	0,26	6207-2RZTN9/HC5C3WT
40	68	15	1	0,19	6008-2RZTN9/HC5C3WT
	80	18	1,1	0,34	6208-2RZTN9/HC5C3WT
45	85	19	1,1	0,42	6209-2RZTN9/HC5C3WT
	100	25	1,5	0,77	6309-2RS1TN9/HC5C3WT
50	80	16	1	0,25	6010-2RS1/HC5C3WT
	90	20	1,1	0,44	6210-2RZ/HC5C3WT
55	90	18	1,1	0,37	6011-2RS1/HC5C3WT
	100	21	1,5	0,57	6211-2RS1/HC5C3WT
60	95	18	1,1	0,39	6012-2RS1/HC5C3WT
	110	22	1,5	0,71	6212-2RS1/HC5C3WT
65	100	18	1,1	0,41	6013-2RS1/HC5C3WT
	120	23	1,5	0,92	6213-2RS1/HC5C3WT
70	110	20	1,1	0,57	6014-2RS1/HC5C3WT
	125	24	1,5	0,99	6214-2RS1/HC5C3WT
75	160	37	2,1	2,6	6315/HC5C3
80	170	39	2,1	2,8	6316/HC5C3
95	200	45	3	4,9	6319/HC5C3
110	240	50	3	8,15	6322/HC5C3

¹⁾ SKF makes continuous quality improvements to its hybrid bearings. This can involve changes to the product range, materials, designs and lubricant without prior warning. Such changes do not in any way detract from the bearing's performance and interchangeability is guaranteed

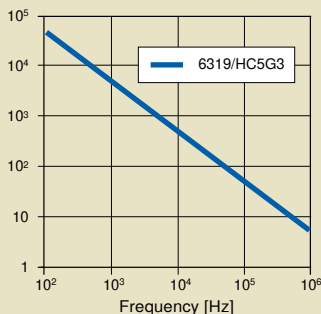
Characteristics of hybrid bearings

Electrical properties

Hybrid bearings provide effective protection against electric arc bearing damage caused by both AC and DC stray currents. The voltage level when arcing occurs depends on ball size, cage type and seal design. For two bearings of the same size, arcing occurs at a higher voltage level for the open variant than for the sealed variant. If the bearing is equipped with pressed steel shields, the risk of arcing is higher, because the “insulating part” is only the air gap between the electrically conducting shield and the bearing inner ring. Therefore rubber seals are offered as standard. The voltage level when arcing occurs for the smallest bearing in the standard range (6000-2RZTN9/HC5C3WT) has been measured to >2,5 kV DC.

The problem of electric arc bearing damage has increased with the use of VFDs. The stray electric currents caused by VFDs can have very high frequencies. To prevent a high frequency current from passing through the bearing, the insulation needs to have very a low capacitance. The lower the capacitance the more efficient the insulation. A hybrid bearing has a very low capacitance thanks to the large size of the insulating part – the ceramic rolling element. The impedance therefore is high also at high frequencies, providing a good protection against high frequency stray currents (see diagram 1).

Diagram 1 Diagram 2 Diagram 3



The impedance vs. frequency for a hybrid bearing (6319/HC5C3) with a bore size of 95 mm

High speed capability

SKF hybrid bearings for electrical machinery can be operated at speeds in excess of the ratings given for all-steel bearings in the SKF General Catalogue. This is possible because of the lower density of silicon nitride compared with steel. The centrifugal force on a ceramic ball is 40 % of that on a steel ball at the same speed (see diagram 2). Higher centrifugal forces give rise to higher bearing temperatures.

$$v = n \cdot d_m \text{ [mm/min]}$$

$$n = \text{speed [r/min]}$$

$$d_m = \text{mean bearing diameter} \\ = (d + D)/2 \text{ [mm]}$$

$$L_{10h} = \text{basic rating life [operating hours]}$$

$$L_{10h} = \text{basic rating life [operating hours]}$$

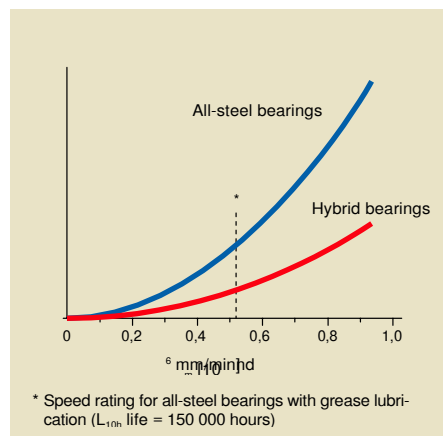
Grease life in hybrid bearings

Tests show 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. The diagram below shows one example where the grease life of WT in hybrid bearings was four times longer than in all-steel bearings. (See diagram 3. The shaft diameter was 20 mm, the speed 20 000 r/min and the temperature 120 °C.)

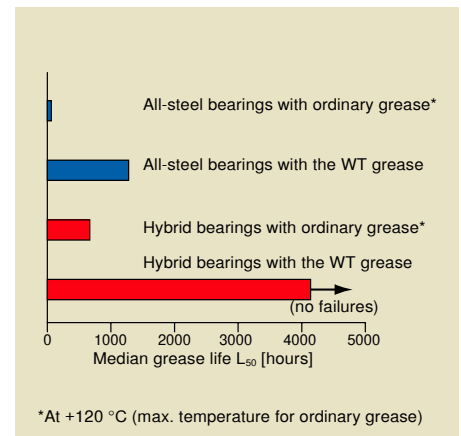
SKF recommends re-lubrication of open bearings with SKF LGHP 2. In general, the re-lubrication interval is 3 to 5 times longer than for an all-steel bearing.

The recommended bearing operating temperature range for maximum grease life is 70–120 °C (160–250 °F).

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



* Speed rating for all-steel bearings with grease lubrication (L_{10h} life = 150 000 hours)



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

Hybrid bearings withstand vibrations

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.

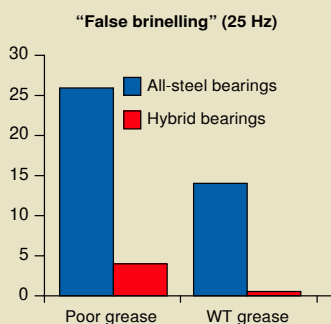
Hybrid bearings supplied with SKF wide temperature grease (WT) were found to sustain less false brinelling damage than bearings containing other types of greases (see diagram 4).

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.

Before installing hybrid bearings in an electric motor to solve arcing problems, consult with the motor manufacturer for advice. Depending on the design of the motor and the application, it may be sufficient to use only one bearing on the non-drive side.

Diagram 4



For more information contact your local SKF representative or SKF authorised distributor.

® SKF is a registered trademark of SKF.

© Copyright SKF 2001
The contents of this publication are the copyright of the publisher and may not be reproduced (even extracts) unless permission is granted. Every care has been taken to ensure the accuracy of the information contained in this publication but no liability can be accepted for any loss or damage whether direct, indirect or consequential arising out of the use of the information contained herein.

Publication 5128 E