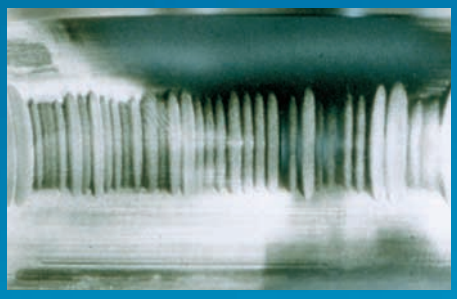
Hybrid bearings for electrical machinery

Electrically insulating - higher speeds - longer grease life

SKF® hybrid bearings increase service li



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 (Si_3N_4). 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 [$\times 10^{-6}$/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

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

ife and reliability in electric machines

6205 - 2RZ / 2RS1 TN9 / HC5 C3 WT

Hybrid bearings have ISO standard dimensions.

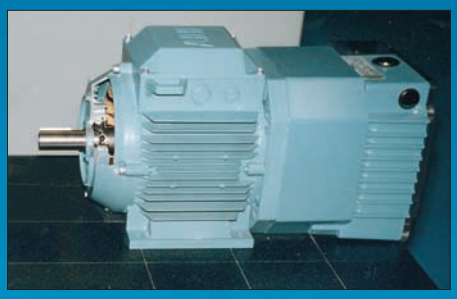
Hybrid bearings are available in sealed or open (unsealed) versions. The SKF service assortment includes sealed bearings fitted with a low-friction seal at each side (-2RZ) or a rubbing seal at each side (-2RS1). The seals are of steel reinforced nitrile rubber, do not conduct electricity and are specially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



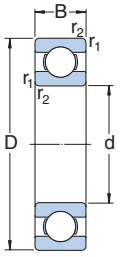
Top: *Electric motor from ABB Motors*

Above: *Shaft encoder from Leine & Linde*

Below: *Traction motor from Skoda Traction Motors*

SKF hybrid bearings for electrical machinery

SKF stocks the range[1)] of hybrid bearings for electrical machinery shown here. For other bearing sizes and designs please contact the nearest SKF distributor.



Open


2RZ


2RS1

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.

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. Higher centrifugal forces give rise to higher bearing temperatures.

$nd_m = n \times d_m$ [mm/min]
n = speed [r/min]
d_m = mean bearing diameter
= (d + D)/2 [mm]
L_{10h} = basic rating life [operating hours]

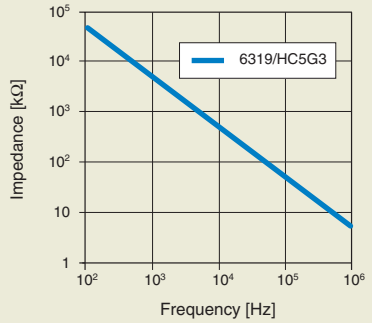
Grease life in hybrid bearings

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. (The shaft diameter was 20 mm, the speed 20 000 r/min and the temperature 120 °C.)

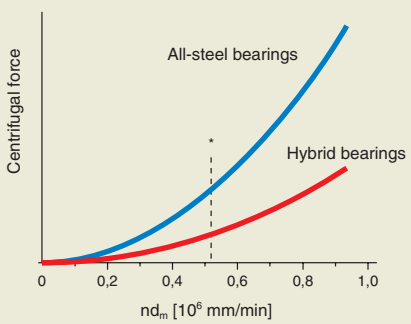
SKF recommends re-lubrication of open bearings with SKF LGHP 2. In general, the re-lubrication interval is 3 to 5 times longer than for an all-steel bearing.

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

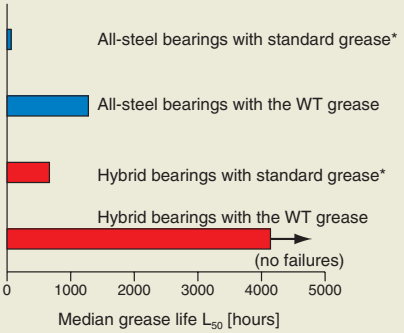
SKF grease	Temperature range
WT	–40 to +160 °C –40 to +320 °F
LGHP 2	–40 to +150 °C –40 to +300 °F



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



* Value for all-steel bearings (basic rating life L_{10h} = 150 000 h)



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

Hybrid bearings withstand vibrations

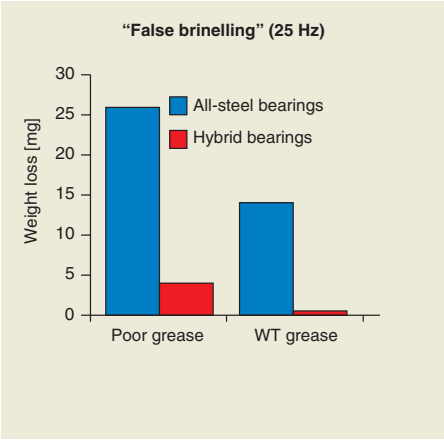
If a stationary bearing is subjected to vibrations there is a risk that “false brinelling” will occur. False brinelling is the formation of small indentations in the raceways that will eventually lead to spalling and premature bearing failure. In cases where steel balls were replaced by ceramic balls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

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.



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

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