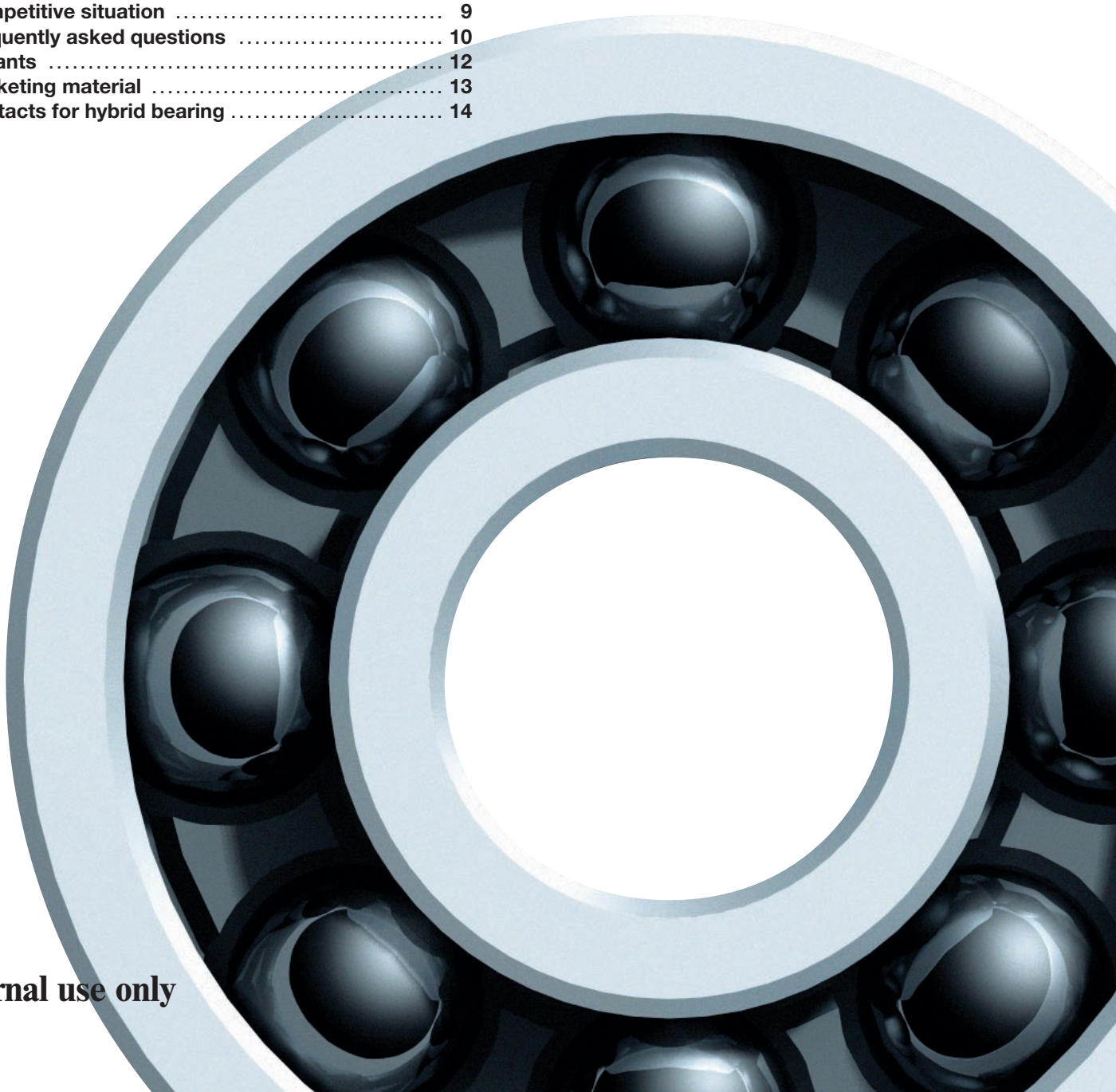
Hybrid bearings
Deep groove ball bearings

Sales information

1. Product overview 2
2. Sales information 4
3. Features and benefits 5
4. Targeted applications and industries 8
5. Competitive situation 9
6. Frequently asked questions 10
7. Variants 12
8. Marketing material 13
9. Contacts for hybrid bearing 14



Internal use only

1. Product overview

Hybrid deep groove ball bearings



The ISO dimensions for deep groove ball bearings also apply to hybrid bearings. SKF hybrid bearings are manufactured with bearing steel outer and inner rings and bearing grade silicon nitride rolling elements. There is a product range of SKF hybrid deep groove ball bearings available from stock.

Hybrid bearings can be delivered in an open or a sealed execution. There is a stock range of SKF hybrid deep groove ball bearings equipped with low-friction seals (-2RZ) or contacting seals (-2RS1). The seals are made of nitrile rubber (NBR) with steel reinforcement. These seals combine good sealing properties with electric insulation - an important feature in many hybrid bearing applications.

The low-density, high strength TN9 cage of glass fibre reinforced polyamide 6,6 is standard up to bore diameters of 45 mm. Polyamide cages with their flexibility show good performance in deep groove ball bearings at high speeds. Above 45 mm bore diameter a riveted steel cage is standard (no special suffix). For extreme speeds and high temperatures, an injection moulded PEEK cage (TNH) is recommended.

The silicon nitride balls (HC5) are produced to a surface roughness less than R_a 0,025 µm. The ceramic balls give the bearings:

- Electric insulation properties, which eliminate the risk of damages due to electric currents, even at high frequencies.
- High-speed performance thanks to low density and low friction.
- Low wear rate due to high hardness.
- Improved grease life, and resistance to seizure.

A greater bearing clearance than normal (C3) has been chosen to take account of temperature variations between bearing rings, caused by temperature transients at start-up, high temperature etc. At higher speeds, to ensure stable running and low noise, it is recommended to apply a clearance greater than normal combined with an axial preload which can be applied by using disk springs or spring washers.

The SKF grease for wide temperature range (WT) is standard for hybrid bearings that are sealed and greased for life. This grease achieves very long life in hybrids at high speeds and at typical bearing operating temperature of about 70 to 120 °C (158 to 248 °F).

Product range hybrid deep groove ball bearings

Principal dimensions				Mass	Basic load rating[1]		Max speed[2]	Designation[3]
d	D	B	$r_{1,2}$ min		Dynamic C	Static C_0		
mm				kg	N		r/min	
5	16	5	0,3	0,005	1110	380	98 000	**625-2RZTN9/HC5C3WTF1**
6	19	6	0,3	0,008	1720	620	77 000	**626-2RZTN9/HC5C3WTF1**
7	19	6	0,3	0,007	1720	620	77 000	**607-2RZTN9/HC5C3WTF1**
	22	7	0,3	0,012	3250	1370	68 000	**627-2RZTN9/HC5C3WTF1**
8	22	7	0,3	0,012	3250	1370	68 000	**608-2RZTN9/HC5C3WTF1**
10	26	8	0,3	0,018	4620	1960	56 000	**6000-2RZTN9/HC5C3WT**
	30	9	0,6	0,032	5070	2360	50 000	**6200-2RZTN9/HC5C3WT**
12	28	8	0,3	0,022	5070	2360	50 000	**6001-2RZTN9/HC5C3WT**
	32	10	0,6	0,037	6890	3100	45 000	**6201-2RZTN9/HC5C3WT**
15	32	9	0,3	0,03	5590	2850	42 000	**6002-2RZTN9/HC5C3WT**
	35	11	0,6	0,044	7800	3750	39 000	**6202-2RZTN9/HC5C3WT**
17	35	10	0,3	0,038	6050	3250	38 000	**6003-2RZTN9/HC5C3WT**
	40	12	0,6	0,059	9560	4750	35 000	**6203-2RZTN9/HC5C3WT**
20	42	12	0,6	0,062	9360	5000	32 000	**6004-2RZTN9/HC5C3WT**
	47	14	1	0,097	12700	6550	30 000	**6204-2RZTN9/HC5C3WT**
25	47	12	0,6	0,073	11200	6550	28 000	**6005-2RZTN9/HC5C3WT**
	52	15	1	0,12	14000	7800	26 000	**6205-2RZTN9/HC5C3WT**
30	55	13	1	0,11	13300	8300	24 000	**6006-2RZTN9/HC5C3WT**
	62	16	1	0,18	19500	11200	22 000	**6206-2RZTN9/HC5C3WT**
35	62	14	1	0,15	15900	10200	21 000	**6007-2RZTN9/HC5C3WT**
	72	17	1,1	0,26	25500	15300	19 000	**6207-2RZTN9/HC5C3WT**
40	68	15	1	0,19	16800	11600	19 000	**6008-2RZTN9/HC5C3WT**
	80	18	1,1	0,34	30700	19000	17 000	**6208-2RZTN9/HC5C3WT**
45	85	19	1,1	0,42	33200	21600	15 000	**6209-2RZTN9/HC5C3WT**
	100	25	1,5	0,77	52700	31500		**6309-2RS1TN9/HC5C3WT**
50	80	16	1	0,25	21600	16000		**6010-2RS1/HC5C3WT**
	90	20	1,1	0,44	35100	23200		**6210-2RZ/HC5C3WT**
55	90	18	1,1	0,37	28100	21200		**6011-2RS1/HC5C3WT**
	100	21	1,5	0,57	43600	29000		**6211-2RS1/HC5C3WT**
60	95	18	1,1	0,39	29600	23200		**6012-2RS1/HC5C3WT**
	110	22	1,5	0,71	52700	36000		**6212-2RS1/HC5C3WT**
65	100	18	1,1	0,41	30700	25000		**6013-2RS1/HC5C3WT**
	120	23	1,5	0,92	55900	40500		**6213-2RS1/HC5C3WT**
70	110	20	1,1	0,57	37700	31000		**6014-2RS1/HC5C3WT**
	125	24	1,5	0,99	60500	45000		**6214-2RS1/HC5C3WT**
75	160	37	2,1	2,6	114000	76500		**6315/HC5C3**
80	170	39	2,1	2,8	124000	86500		**6316/HC5C3**
95	200	45	3	4,9	153000	118000		**6319/HC5C3**
110	240	50	3	8,15	203000	180000		**6322/HC5C3**

1. Please note that $s_{0\ (hybrid)} = s_{0\ (all\text{-}steel)}/0,89$. See further chapter 6.
2. Maximum speed is calculated only for hybrid bearings with TN9 cage. The maximum speed should only serve as an approximate guideline. Lower speed limits may apply under high loads, high temperatures and other conditions.
3. Electrical Division is implementing a new seal for small DGBB sizes. This change will be made also on hybrid bearings. For details, take a look at the Electrical Division homepage.

2. Sales information

Hybrid bearings have additional features that improve the service life compared to all-steel bearings. They can be the solution to the customer's problem or the key components that enable a new design. The benefits of a hybrid bearing can be separated into four different areas, depending on the customer needs.

Safety: With hybrid bearings you get a safe operation in critical applications like fire exhaust fans or safety couplings that, during a limited time period, need to function in extremely tough environments, for example during a fire. In the unfortunate event of a severe failure, hybrid bearings also provide a safe failure mode since silicon nitride and steel do not seize together.

Power output: With hybrid bearings you can achieve higher power output through high speed, which enables compact size and new design opportunities.

Environmental benefits: Hybrid bearings enable low power consumption and less pollution.

Life Cycle Cost: With hybrid bearings in the production equipment you can reduce operating and maintenance costs, increase the bearing life, get higher productivity and increase production quality.

More information about features and benefits is found in chapter 3.

It is important to avoid "price wars" with competitors, since this will only destroy the price level. Instead, the SKF brand name and high quality need to be used to get a price premium even when competition is met.

To distinguish SKF hybrid bearings from competitor brands, there are a few issues that can be emphasized:

1. To ensure high quality SKF has, as the only bearing company, a comprehensive material specification for the ceramic material. The specifications include requirements on material strength, microstructure, hardness, toughness and rolling contact fatigue.
2. All components in a hybrid bearing are chosen to correspond to the high performance of the ceramic balls. The SKF grease WT has excellent grease life in hybrid bearings. Therefore, SKF offers this high performing grease as standard in the sealed and greased for life hybrid bearing product range. The low weight, high-strength TN9 cage is offered as standard because of its good performance at high speeds.
3. SKF has a good availability of stocked hybrid Deep Groove Ball Bearings compared to the competitors.
4. SKF offers technical support for the cared applications.

Customer value based pricing

When promoting hybrid bearings, a customer value based pricing should be used rather than a cost-based pricing strategy. Customer value based pricing is built on the idea that if you, as supplier, can solve a problem for the customer, or fulfill a customer need, you should set the price of your offer in accordance with the profit increase the customer makes from fulfilling the perceived need. You, as supplier of a solution, should receive a part of the customers profit increase from fulfilling the need. The customer value based price can be identified by considering the factors listed below.

1. The customer value is the increased profit the customer will make by fulfilling a need or solving a specific problem. For example in a production equipment, a problem with short bearing life may cause downtime in the production. The customer value should be estimated by taking into account:
   - Downtime costs – loss of output in production
   - Maintenance costs – man hours and spare parts

   Also, for the OEM customer that in turn sells to an end-user, it is important to consider the above costs, so that the sales person will be able to better communicate the value added with the solution offered. For the OEM customer, the purpose of investing in a hybrid bearing will be linked to one or several of the following benefits:
   - The hybrid bearing offers a solution to a problem for the end-user.
   - The hybrid bearing gives the application a longer service life.
   - Using hybrid bearings will lead to lower service costs.
   - Using hybrid bearings will lead to lower warranty costs.
   - Using hybrid bearings offers new design opportunities.
   - Using hybrid bearings will give future business from a satisfied end-user customer.
2. When the customer value has been estimated in monetary terms, an additional consideration is how much money the customer is willing to invest in a solution.
3. It is also necessary to take into account to what extent the problem will be solved by your offer, that is to what extent the SKF solution can help the customer increase the profit.

When the factors above have been considered it is possible to set a customer value based price that results in a win-win situation where both customer and supplier make good business.

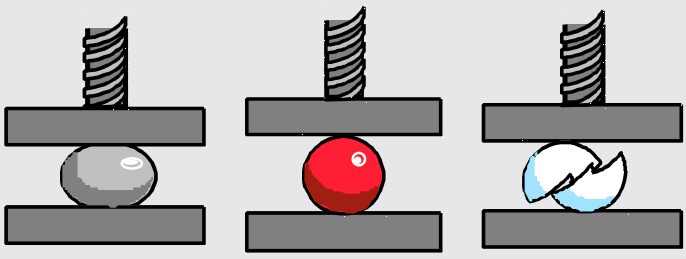
3. Features and benefits

Bearing grade silicon nitride is a ceramic material belonging to a group of materials called engineering ceramics. Engineering ceramics are intended for demanding technical applications, as opposed to traditional ceramics such as pottery and tableware. The bearing industry has selected silicon nitride as the bearing material due to its combined features, such as high hardness, strength, and also its beneficial failure mode. Bearing grade silicon nitride fails by spalling, small flakes of the material breaking out. This is the same mode of failure as that of bearing steel balls.

SKF was the first bearing company that specified a classification of bearing grade silicon nitride. There are three classes, the highest, class I for aerospace applications, class II for general bearing applications and class III for low duty applications only. SKF always uses class II material or higher for bearings.

Table 1

	Bearing steel	Silicon nitride	Porcelain
Compressive strength (MPa)	880	3000	950
Tensile strength (MPa)	800	800	150
Young's modulus (GPa)	210	310	125
Hardness, HV10 (kg/mm^2)	700	1600	800
Electrical resistivity (Ωm)	0,4 x 10^{-6}	10^{12}	10^{12}
Density (g/cm^3)	7,9	3,2	2,9
Coefficient of thermal elongation (10^{-6} K)	12	3	5



The physical properties of the silicon nitride balls give the hybrid bearings special features, which provide benefits in various applications. The benefits from the customers' point of view can be classified into four groups; Safety, Power output, Environmental benefits and Low life cycle cost (SPEL).

Table 2

Customer benefit: Safety

Safe operation in extreme situations where the bearing, during a limited time period, needs to function under extreme conditions.

Safe and reliable operation due to beneficial failure mode that prevents costly catastrophic failures.

Application examples: fire smoke exhaust fans, safety couplings

Product features
- Seizure resistance at sudden lubrication cut-off.
- Less secondary damage on housings, shafts and rotors at bearing failure.

Physical properties
Silicon nitride and steel is an excellent combination from a tribological point of view. The adhesion between silicon nitride and steel is low, micro welding does not occur and the smearing resistance is very high. Therefore, there will be no catastrophic failure in a hybrid bearing.

The most common failure mode of a hybrid bearing is cage failure, mainly caused by lubrication breakdown or too high speeds. The steel rings will fail by spalling (small pieces of material breaking out) or be severely damaged long before you will see any surface distress or damage to the ceramic balls.

Table 3

Customer benefit: High power output

Enables high power output in combination with compact size. The high speed capability of greased-for-life hybrid bearings and the long grease life enables new design opportunities, for example a design change from an oil-lubricated system to a compact grease-lubricated high speed design. Hybrid bearings give increased efficiency of equipment, thus they produce lower emissions and consume less energy.

Application examples: electric drives, industrial powertools, racing, inlines, go-karts

Product features
- Ability to run at high speed.
- Longer service life with grease lubrication
- Lower and more stable friction.

Physical properties
Low density: Silicon nitride balls have only 40 % of the weight of steel balls. This implies that at high speeds the centrifugal forces from the balls will be significantly lower in a hybrid bearing than in an all-steel bearing. The friction and thus temperature rise will be lower, which means the possibility to increase the speed. The low weight of the ceramic balls also enables rapid accelerations and retardations.

The hardness of the balls has a "healing" effect on the contact. Hybrid bearings have lower friction than steel bearings resulting in lower running temperature even with a very thin lubricant film. As a result the aging process of the grease is slower. Hybrid bearings need at least some lubrication. If they run completely dry they will eventually wear.

Silicon nitride has a 50 % higher modulus of elasticity than steel. This means that under the same osculation the contact area in a hybrid bearing will be smaller leading to lower friction.

Table 4

Customer benefit: Environmental benefits

Hybrid bearings enable less pollution and low power consumption.

The beneficial wear resistance of hybrid bearings and also the longer life under liquid ingress conditions enable a design change from an oil-lubricated system to a media-lubricated system. This leads to less pollution. Through media-lubrication you may also reduce the need of secondary equipment and thus reduce power consumption.

Lower power consumption is also achieved due to the low friction in hybrid bearings.

A design change from oil-lubricated bearings to greased-for-life hybrid bearings also results in less leakage of oil to the environment.

Thus, hybrid bearings enable equipment to meet more stringent environmental requirements of authorities.

Application examples: compressors, mixers, pumps, flow meters, process and petrochemical industries, metalworking industries.

Product features
- Can resist wear caused by solid particle contamination
- Longer life under liquid ingress conditions
- Low friction
- Long grease life

Physical properties
Silicon nitride is very hard, harder than most particles that can occur as contaminants in a bearing. The silicon nitride balls eliminate the particles either by crushing them or pressing them into the (softer) steel rings, where they are rendered harmless. Silicon nitride is non-corrosive and chemically inert. With corrosion protected bearing steel rings the hybrid bearing can provide long service life in corrosive environments.

Silicon nitride has a 50% higher modulus of elasticity than steel. This means that under the same osculation the contact area in a hybrid bearing will be smaller leading to lower friction. The low friction results in lower power consumption. The hardness of the balls has a “healing” effect on the contact. Hybrid bearings have lower friction than steel bearings resulting in lower running temperatures even with a very thin lubricant film. As a result, the aging process of the grease is slower. Hybrid bearings need at least some lubrication. If they run completely dry they will eventually wear.

Table 5

Customer benefit: Low Life Cycle Cost (LCC)

- Increased bearing life
- Reduced operating and maintenance costs
- Increased production quality
- Simple handling and mounting

Application examples: electric motors, stepping motors, encoders, pumps

Product features
1. Long grease life
2. Longer service life in applications with poor lubrication
3. Ability to run at high speed
4. Electrical insulation – one product two functions (both bearing and insulation).
5. Can resist wear caused by solid particle contamination.
6. Resist vibrations and oscillations
7. Longer life under liquid ingress conditions.
8. Bearing dimensions according to ISO.

Physical properties

1&2. The hardness of the balls has a “healing” effect on the contact. Hybrid bearings have lower friction than steel bearings resulting in lower running temperatures even with a very thin lubricant film. As a result, the aging process of the grease is slower. Hybrid bearings need at least some lubrication. If they run completely dry they will eventually wear.

3. Low density: Silicon nitride balls have only 40% of the weight of steel balls. This implies that at high speeds the centrifugal forces from the balls will be significantly lower in a hybrid bearing than in an all-steel bearing. The friction and thus temperature rise will be lower, which means the possibility to increase the speed. The low weight of the ceramic balls also enables rapid accelerations and retardations.

4. Silicon nitride is electrically non-conductive, which implies that an electric insulator, the ceramic ball or roller, separates the steel rings in a hybrid bearing and will prevent electric current from passing through and damaging the bearing. There is efficient insulation against both DC and AC currents due to high electrical resistance and low capacitance.

5. Silicon nitride is very hard, harder than most particles that can occur as contaminants in a bearing. The silicon nitride balls eliminate the particles either by crushing them or pressing them into the (softer) steel rings, where they are rendered harmless.

6. Hybrid bearings have good resistance to false Brinelling (micro-adhesion between the surfaces). The reason is that there is no steel to steel contact in a hybrid bearing and silicon nitride is unable to fuse with steel.

7. Silicon nitride is non-corrosive and chemically inert. With corrosion protected bearing steel rings the hybrid bearing can provide long service life in corrosive environments.

4. Targeted applications and industries

Table 6

Electric motors and other electrical machinery

Hybrid bearings are used in electrical machinery for electrical insulation and for improved speed capability[1]

Applications
Variable speed driven motors, fan motors, traction motors, encoders, welding robots

Industries
OEM: ABB, Siemens, Reliance, Baldor, Emerson, VEM Motoren, API Elmo, Ziehl-Abegg, Skoda Traction Motors, Bombardier, Leine&Linde etc.

Aftermarket: pulp and paper industry, process industry, petrochemical industry etc.

[1] When installing hybrid bearings in electric motors it may be sufficient to use only one hybrid bearing, at the non-drive side.

Table 7

Pumps

The use of hybrid bearings can increase the service life in contaminated environments and thereby reduce downtime and repair costs for the aftermarket customers.

Applications
Cutting fluid pumps, API pumps and other types

Industries
OEM: Allweiler AG, ABS, Weir, ITT Flygt, Flowserve, Pumpex, Sulzer etc.

Aftermarket: pulp and paper industries, petrochemical industries, process industries etc.

Table 8

Power tools

The high-speed capability of hybrid bearings enables high power output in combination with compact size. Hybrid bearings also work on eccentric shaft applications under high temperature conditions. The high tolerance to poor lubrication gives a lower running temperature, which in turn gives a longer service life.

Applications
Electric drives, carpet cutter, other professional handtools

Industries
OEM: Atlas Copco, Hilti , Bosch, Makita, Milwaukee, Narex etc

Table 9

Stepping motors

Hybrid bearings are used in stepping motors, as a solution to false Brinelling problems.

Applications
Stepping motor in for example weaving machine

Industries
OEM: Sig Positec / Berger Lahr

Aftermarket: textile industry etc.

5. Competitive situation

Bearing companies
Most bearing companies are active in the hybrid bearing business. NSK, Koyo and FAG are dominant. NSK and Koyo have series for extreme conditions in which they include hybrid bearings. In these bearing series (Koyo EXSEV Bearing Series and NSK SPACEA™ Series) they also promote other materials, such as stainless steel, as well as coatings, different cages and lubricants as solutions to various problems. FAG recently launched “X-life”, under which they promote a hybrid bearing with rings from Cronidur30. Other companies on the hybrid bearing market are Torrington, SNFA, IBC and Cerobear.

Even though NSK, Koyo and FAG promote specially designed bearings, the hybrid bearing is dominant. SKF has developed a product range of hybrid deep groove ball bearings with high availability. The focus of the product range is greased-for-life, high-speed design to meet the increasing demand for electrical insulation, greased-for-life products and higher power density. SKF also offers specially designed hybrid bearings for vacuum and high-speed applications and for corrosion protection.

Ceramic ball suppliers
SKF uses several suppliers of ceramic ball blanks, which are evaluated according to factors such as price, quality and availability. The ball sizes and material classes they provide vary. The SKF finishing plant of ceramic balls is located at the SKF owned company MRC Specialty Balls in the USA.

Supplementary products
For some applications and certain operating conditions SKF offers alternative solutions to hybrid bearings. For example, the problem with electrical damage to bearings may in many cases be solved with SKF INSOCOAT™. For cost reasons, SKF INSOCOAT™ is especially suitable for bearings with an outer diameter of 80 to 90 mm. and above. For smaller bearing sizes hybrid bearings tend to be more cost effective. For smearing, poor lubrication and false Brinelling problems SKF offers NoWear™ as an alternative solution, mainly for large size roller bearings. For temperatures up to 300 °C, HTB (High Temperature Bearing) is suitable.

6. Frequently asked questions

What is the friction in hybrid bearings?
The largest difference in friction between a hybrid and an all-steel bearing will occur for low loads and high speeds. The lower density of the ceramic balls will then have a large influence on the friction torque. The higher the speed the larger the influence. For low speed and high loads at pure rolling contact the friction will be in the same range as for steel bearings.

Tests on angular contact ball bearings (7222) have shown that at 3 000 rpm (ca 465 000 nd_m) and a radial load of 1,81 kN, the friction torque is reduced 32 % with ceramic balls!

What grease is recommended in hybrid bearings?
For the standard hybrid bearing range the SKF wide temperature grease (WT) is offered. This grease gives long life in standard bearings, and in hybrid bearings the grease life with WT is about 3 to 5 times longer. Please note that most test data for hybrid bearings as well as the current grease life model are based on WT grease! For re-lubrication, the aftermarket grease SKF LGHP2 is recommended (compatible with WT).

Grease data WT:

Base oil:	synthetic ester
Soap type:	polyurea
Temperature range:	–40 to 160 °C (–40 to 320 °F)
Typical operating temperature range:	70 to 120 °C (158 to 248 °F)
Base oil viscosity:	70 cSt at 40 °C (104 °F) 9,4 cSt at 100 °C (212 °F)
NLGI class (stiffness):	2 to 3
Noise class:	QE5
Good water resistance	

Grease data SKF LGHP2:

Base oil:	mineral
Soap type:	polyurea
Temperature range:	–40 to 150 °C (–40 to 302 °F)
Base oil viscosity:	96 cSt at 40 °C (104 °F) 10,5 cSt at 100 °C (212 °F)
NLGI class (stiffness):	2 to 3
Good water resistance	

What is the re-lubrication interval of hybrid bearings?
For the recommended aftermarket grease SKF LGHP2, the re-lubrication interval is 3 to 5 times longer than in an all-steel bearing. For hybrid bearings working at higher speeds the re-lubrication interval difference is even greater. For an application specific calculation you need to take into account the speed, temperature, load, size of bearing etc. Please contact an expert for consultancy. A technical material covering this is under development.

What are the speed ratings for hybrid bearings?
Instead of speed ratings the requirements on lubrication, operating life, speed, temperature and mounting should be considered to determine the proper hybrid bearing designation for the required speed. The limiting factors for speed are the lubrication and cage. For highest speeds a PEEK cage (TNH) is recommended.

What is the speed range for hybrid bearings?
For hybrid deep groove ball bearings the cage and the lubrication set the speed limit. This means a maximum of 1 million nd_m with a polyamide cage TN9. This can be extended with a PEEK cage to approximately 1,5 million nd_m. The speed limit of a riveted steel cage is 0,6 million nd_m. The maximum speed values should only serve as an approximate guideline. Lower speed limits may apply under high loads, high temperatures and other conditions.

At extremely high speeds the SKF GMG grease is recommended if the bearing is running in a cool environment and is only subjected to “self-induced temperatures”. If the bearing also is subjected to high temperature from an external source, WT is recommended.

What is the operating temperature range of hybrid bearings?
Hybrid bearings have standard steel rings, which are temperature stabilized to 120 °C (248 °F). This is the same temperature limit as for the polyamide cage TN9.

Higher temperatures can be accepted using steel cages and higher ring stabilization temperatures. The PEEK cage TNH has a temperature limit of 180 °C (356 °F), in peaks 200 °C (392 °F).

Is there any load reduction factor for hybrid bearings?
Yes, silicon nitride has a 50 % higher modulus of elasticity than steel. This should be taken into account by adjusting the static load safety factor

$s_0 = C_0/P_0$, where
P_0 = the equivalent static load (N) and
C_0 = static load rating (N)

The load safety factor for the hybrid bearing must be increased compared to the corresponding all-steel bearing by about 11 %:

$s_{0\,(hybrid)} = s_{0\,(steel)}/0{,}89$

The load ratings C and C_0 are the same for hybrid bearings and the corresponding all-steel bearings.

How do I calculate the hybrid bearing life?
A grease life estimation is the preferred life estimating method for greased-for-life hybrid bearings. In hybrid bearings, the grease life of WT is at least 3-5 times longer than in an all-steel bearing.

The fatigue life according to ISO (L10) is the same for hybrid bearings as for all-steel bearings. In poor lubrication conditions, the fatigue life can be much longer for hybrids than for all-steel bearings. For very high load conditions (approximately below C/P<6) and for more advanced calculations, please contact a specialist within SKF.

What are the failure modes of hybrid bearings?
Silicon nitride and steel is an excellent combination from a tribological point of view. The adhesion between silicon nitride and steel is low, micro welding does not occur and the smearing resistance is very high. Therefore, there will be no catastrophic failure in a hybrid bearing.

The most common failure mode of a hybrid bearing is cage failure, mainly caused by lubrication breakdown or too high speeds. The steel rings will fail by spalling (small pieces of material breaking out) or be severely damaged long before you will see any surface distress or damage to the ceramic balls. In the unlikely event of a failure of a silicon nitride ball, the failure mode is the same as for steel. The bearing grade silicon nitride material is specified by SKF such that it should fail by spalling, not by complete disintegration (like porcelain does).

When measuring the bearing vibrations with Condition Monitoring equipment, the signal is weaker for a hybrid bearing than an all-steel bearing because of the lower ball density and lower friction. By also measuring the bearing temperature there will be a clear signal before the bearing fails.

Can hybrid bearings work in a corrosive environment?
Silicon nitride is a non-corrosive material. The standard steel rings however, have no special anti-corrosion treatment. To get a bearing that works satisfactory in a corrosive environment, special hybrids need to be manufactured either with stainless steel rings or chromium-coated rings.

How much water contamination can a hybrid bearing tolerate?
Hybrid bearings work well in environments containing water, for instance an emulsion of oil in water. To avoid corrosion of the rings, a rust protection in the liquid will be required.

As an example, the service life of a cutting fluid pump was improved by 4 times when using hybrid bearings. The amount of water was 96 % of the process fluid passing through the bearings. There was also an anti-rust media present, which protected the rings from corrosion.

However, hybrid bearings do not function well in neat water (100 % water without any lubricant). There should always be some lubricant present.

Can hybrid bearings be process media lubricated?
Yes, to some extent they can run in non-corrosive process media. They are not suitable for neat water lubrication, because the steel rings need corrosion protection and there is an increased risk of spalling of silicon nitride, and steel in neat water.

Can hybrid bearings work in vacuum?
Yes, hybrid bearings are a solution for vacuum pumps. They can work with a very small amount of lubrication. Some lubrication is always necessary however; otherwise there will be wearing of the rings. Depending on the needed vacuum different lubricants and cages are recommended.

What is the breakdown voltage of a hybrid bearing?
The breakdown voltage over the bearing is the highest potential between the outer ring and inner ring before a flashover occurs. The value depends on the ball size (distance of the insulation), cage material and sealing. The smallest bearing in the electric motor range represents the minimum breakdown voltage measured.

Bearing: 6000-2RZTN9/HC5C3WT.
Breakdown voltage: >3,5 kV DC.

More information will be given in technical material, which is under development.

7. Variants

Table 10

Special conditions	SKF grease	SKF MAPRO Aftermarket designation
General and electric machinery, very and extremely high speeds, externally induced bearing temperature, extremely long life	WT (GWB)	Not available for sale. Recommended alternative: SKF LGHP2
Extremely high speeds, self-induced bearing temperature, long life	GMG	LGLC2
Extremely high speeds, self-induced bearing temperature, low friction and low temperatures	LT (LT20)	LGLT2
Food grade, incidental food contact	GFF	LGFP2
Temperatures up to 260 °C (500 °F) aggressive environment, or vacuum below 10^{-2} bar	VT127	LGET 2

The SKF definitions for bearing speeds (ndm) for deep grove ball bearings are
Very high: 500.000 to 700.000 mm/min
Extremely high: above 700.000 mm/min
Please be aware that above alternatives (except for the WT grease) are only produced on a customer order basis and delivery times vary depending on the availability of components. For other grease alternatives please consult an expert.

Extreme speeds

Defined as higher than 700 000 nd_m (n = speed (rpm), $d_m = (D+d)/2$), for deep groove ball bearings.

Cage recommendations:
Bearing bore diameter: d < 50 mm,
Speed: 670 000 to 1 000 000 nd_m,
Polyamide cage TN9 > 1 000 000 nd_m PEEK cage TNH (glass fibre reinforced poly-ether-ether-ketone)

A minimum quantity for the investment in tooling for a new injection moulded PEEK cage is 3 000 pcs, which corresponds to an investment of about 8 800 EUR. For smaller quantities, machined PEEK cages can be produced for any DGBB size. There is a minimum start-up cost of approximately 500 EUR for a new size. The delivery time for a new size is 9 to 10 weeks after order. Injection moulded PEEK cage is currently available in size 6202.

Lubrication recommendations:
The wide temperature grease WT reaches long grease life in hybrid bearings also at high speeds, particularly in combination with high expected operating temperatures, >70 °C (158 °F).

Oil lubrication offers the opportunity to increase speeds above the grease limits.

Temperatures above 120 °C (248 °F)

The steel rings in hybrid bearings have standard temperature stabilization. When needed for higher operating temperatures higher stabilization temperature must be specified in the enquiry. The availability for small quantities is generally limited.

Cages:
Above 120 °C (248 °F), the standard polyamide PA66 cage (TN9) is no longer suitable. The PEEK cage can run up to 150 °C (302 °F) continuously. For higher continuous temperatures, a steel cage would be recommended.

The low friction seals (RZ) should be used at maximum 120 °C (248 °F). Up to 200 °C (392 °F) peak temperature the Viton rubber seal (contacting, RS2) can be offered.

Specialties

For other problem areas such as corrosion, vacuum, very high temperatures and media lubrication, please contact a specialist

8. Marketing material

Table 11

Title	Comments
REFERENCE CASES	
"19 times longer bearing life with hybrids in steel mill" Publ. No. 4895 E	Reference case: Metal Working. Poor lubrication due to high temperature and high acceleration.
"Hybrids radically improve performance in screw pump" Publ. No. 4894 E	Reference case: Fluid Machinery. Long service life in water and particle contaminated environment
"Radical design improvements with hybrids in electric drives for core drill and stone saw systems" Publ. No. 5145 E, G	Reference case: Power Tools. High power output, long service life and maintenance free bearings at high speeds.
BROCHURES	
"Hybrid bearings – Ceramic rolling elements create new opportunities" Publ. No. 4697 E, G, F, S, SP	A general introduction to hybrid bearings in a four-page leaflet - Customer benefits and properties of hybrid bearings - Examples of applications: electric motor and pneumatic grinding machine.
"SKF hybrid bearings for professional hand tools – For servicing and upgrading products" Publ. No. 4699 E, G, F, S, SP	Especially aimed for sales of hybrid bearings to the after market, for example to hand tool repair shops. Six pages. - Stocked product range of small DGBB. Benefits of hybrid bearings in terms of improved service life. - Description of the selected design in terms of seals, cage, clearance and grease. - Available mounting tools.
"Hybrid bearings for electrical machinery" Publ. No. 5128 E, G, S, F, Sp	A description of the benefits of using hybrid bearings in electrical machinery. Brings up electrical insulation, higher speeds and longer grease life. Including product range.
"High Precision Single Row Silicon Nitride Cylindrical Roller bearings" Publ. No. 4948 E	A description of the product with benefits and planned range.
"High-precision bearings" Publ. No. 4950/I E	A catalogue covering all high precision bearings including hybrid bearings.
ARTICLE	
"Hybrid bearings for electrical machinery" Evolution 3/2001 *For printout of pdf-file, visit Ceramic Bearings on Spider.*	A pdf document from an article in Evolution 3/2001. The article brings up hybrid bearings as a solution where operating conditions include electrical-current passage, contamination and poor lubrication.
INTERNAL REPORT	
"Electric Motor Bearing Currents, cause, effect and what to do".	This is a technical report from SKF Industrial Electrical segment.

Presentation package
A pdf format overhead package consisting of 14 slides giving an introduction to ceramic bearings. The presentation focuses on the benefits that can be achieved by solving problem with ceramic bearings.

Exhibition
There is an exhibition stand available for exposing hybrid bearings at fairs and exhibitions. It is also possible to order demo bearings, 6206 TN9/HC5 C3 or 1203 ETN9/HC5. Please contact the Ceramic Bearing team in Göteborg for more information.

There is also some exhibition material available at the Exhibit Service Centre in the Marketing Support Centre in Schweinfurt.

9. Contacts for hybrid bearing

SKF Österreich AG, Austria
SKF Österreich AG, Austria has the product ownership and supply responsibility of hybrid deep groove ball bearings from January 2002. For enquiries, please contact Ms. Michaela Forster.

SKF Ceramic Bearings, Göteborg
The SKF Ceramic Bearing team in Göteborg is responsible for business development and product management for developed solutions. Team manager: Mr. Göran Lindsten.

High-Precision Bearings, Italy
For enquiries on prices and delivery times, please contact Mr. Renato Bruno

MRC Specialty Bearings, USA
MRC Specialty Bearings produce specially designed hybrid bearings. For enquiries, please contact Mr. Dave Haaksma

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Publication **5212 E**