

# Hybrid bearings with super-tough stainless steel rings – the basics

*Rolling bearings in applications of the oil & gas and hydrocarbon process industry are typically required to accommodate contaminated and corrosive environments, inadequate lubrication conditions (e.g. low viscosity), high and low loads, and high and cryogenic temperatures. At the same time they must provide a high degree of reliability, availability and safety.*

Hybrid bearings combine rings made of bearing steel and rolling elements made of bearing grade silicon nitride ( $\text{Si}_3\text{N}_4$ ).

SKF hybrid bearings, which are dimensionally interchangeable with similarly sized all-steel bearings, can substantially improve reliability and robustness when incorporated into new or existing industrial equipment. This is particularly true in pumps, compressors, pipeline equipment, process reactors, electric drives, generators, fans and blowers – all applications where the bearings are often exposed to potentially damaging abrasive particles, corrosive gases, liquid corrosive contaminants, inadequate lubrication, vibration and stray electric currents.

## Why ceramic rolling elements in bearings?

Bearing grade silicon nitride, an engineered ceramic material, has a uniform and clean

microstructure which is extremely hard and tough. Its properties include chemical inertness and electrical insulation.

It is also dimensionally stable under severe running conditions. All these factors contribute to its suitability as rolling bearing material.

## Why super-tough stainless steel rings?

SKF has developed a new generation of hard, ultraclean, high-nitrogen steel with a high degree of impact toughness, high fatigue resistance and superior corrosion resistance when compared to common AISI 52100 bearing steel. The enhanced fatigue strength of this high-nitrogen steel, VC444, is associated with the coherent nature and fine distribution of the chromium nitride precipitates. The steel enables bearings to operate under corrosive and stress corrosion conditions caused by the presence of sour, acid and hydrogen gases and water. In addition, it enables engineers to design for increased bearing service life.



*Hybrid bearings and ceramic rolling components*





Drilling platform



Gas compressor

## Resistance to stress corrosion cracking

A common situation for rolling bearings in oil & gas applications is contamination of the lubricating oil with various liquids and gases such as brines (salt water), sour gas (H<sub>2</sub>S), acid gas (CO<sub>2</sub>) and light hydrocarbons (C<sub>x</sub>H<sub>y</sub>). Ingress of particles such as sand (quartz) may also occur.

For example, in one refinery, a vapour recovery unit was equipped with an oil-flooded screw compressor with conventional all-steel bearings. The unit was handling a gas composition of 30-40% sour gas and 35% acid gas. A statistical analysis showed a mean time between failures of only 3 800 hours. The failures were caused by stress cracking of raceways and splitting of balls. As a comparison, a compressor retrofitted with hybrid ball and roller bearings with super-tough stainless steel rings, so-called "sour gas bearings", showed a life of 23 300 hours before it was taken out of service for maintenance of a valve (→ **diagram 1**). It was replaced by another compressor with the same type of sour gas bearings.

### Comparison of material properties

Properties	Bearing steel (AISI 52100)	Super-tough stainless bearing steel (VC444)	Bearing grade silicon nitride
Compressive strength (MPa)	~ 2 300	~ 2 600	3000
Tensile strength (MPa)	~ 1 900	~ 1 800	800
Modulus of elasticity (GPa)	210	220	310
Hardness HV <sub>10</sub> (kg/mm <sup>2</sup> )	HRC>58 (~ 700 HV)	HRC>58 (~ 700 HV)	~ 1600 HV
Electrical resistivity (Ωm)	0.4 × 10 <sup>-6</sup> (Conductor)	0.8 × 10 <sup>-6</sup> (Conductor)	10 <sup>12</sup> (Insulator)
Density (g/cm <sup>3</sup> )	7.9	7.7	3.2
Coefficient of thermal elongation (10 <sup>-6</sup> /K)	11.7	10.4	3
Thermal conductivity (W/mK)	~ 45	14	30
Basic material standards*	ISO 683-17:1999 AISI 52100	AMS 5898 DIN 1.4108	ISO 26602:2009 ISO 3290-2:2008 ASTM F2094 / F2094M-08
Relative dielectric constant	Not applicable	Not applicable	4.2 to 6.1
Response to magnetic field	Responding	Reduced response	No response
Chemical resistance under seizure conditions	Reactive	Resistant	Inert

\* SKF generally applies more stringent quality assurance specifications than the referenced standards. In addition, SKF applies proprietary manufacturing and heat treat processes.



Super-tough stainless steel bearings for special applications

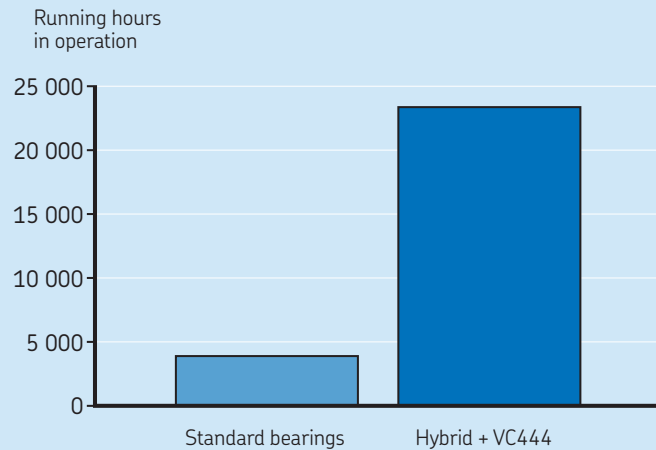


## Supplementary designations

- HC5** Rolling elements of bearing grade silicon nitride
- VC444** Bearing rings of high nitrogen steel, hardened and tempered according to SKF proprietary specifications for maximum corrosion resistance.
- VC4444** Bearing rings of high nitrogen steel, hardened and tempered according to SKF proprietary specifications, for high temperature or cryogenic applications.
- V008** HC5 + VC444

Diagram 1

### Comparison of service life



SKF bearing solution mounted in a cryogenic pump housing

Open screw compressor with rotor



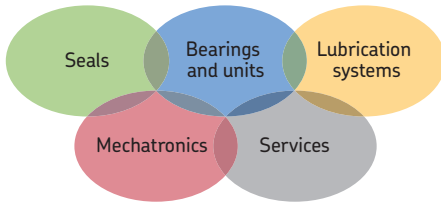
### Engineered solutions

Application	Challenge	Engineered solution
Cryogenic pumps <sup>1</sup>	<ul style="list-style-type: none"> <li>Poor lubrication</li> <li>Cavitating and low viscosity process fluids</li> <li>Cryogenic temperatures</li> <li>Ingress of particles</li> <li>Electrical erosion from variable frequency drives</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid ball bearings, specially designed (cage and clearances)</li> <li>Cryogenic variant of VC444 super-tough VC4444 stainless steel rings</li> <li>PEEK<sup>3</sup> cages</li> </ul>
Process lubricated electrical drives	<ul style="list-style-type: none"> <li>Low viscosity and corrosive process fluids</li> <li>Ingress of particles</li> <li>Electrical erosion from variable frequency drives</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid ball and roller bearings with super-tough VC444 stainless steel rings</li> <li>Cages designed for the specific application</li> </ul>
Hydraulic pumps, HFC <sup>2</sup> fire-resistant fluids	<ul style="list-style-type: none"> <li>Water-glycol mixed fluids</li> <li>Ingress of corrosive fluids</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid ball and roller bearings with super-tough VC444 stainless steel rings</li> <li>Cages according to the specific application</li> </ul>
Polyethylene reactors	<ul style="list-style-type: none"> <li>Lubrication by ethylene gas and polyethylene</li> <li>Corrosive catalysers</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid ball and roller bearings with super-tough VC444 stainless steel rings</li> <li>Cages according to the specific application</li> </ul>
Oil-flood screw compressors, sour and other process gases	<ul style="list-style-type: none"> <li>Process gases, condensing brines and low viscosity hydrocarbons getting in contact with lube oil</li> <li>Ingress of particles</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid ball and roller bearings with super-tough VC444 stainless steel rings</li> <li>PEEK<sup>3</sup> cages</li> </ul>
Sub-sea screw pumps	<ul style="list-style-type: none"> <li>High radial shaft loads causing misalignment</li> <li>High contact and edge stresses</li> <li>Ingress of fluids and particles</li> </ul>	<ul style="list-style-type: none"> <li>SKF twin CARB toroidal roller bearing arrangement with angular contact ball bearing, super-tough VC444 stainless steel rings</li> <li>Ball and roller bearings with super-tough VC444 stainless steel rings in combination with ceramic or stainless steel rolling elements</li> <li>Cages according to the specific application</li> </ul>

<sup>1</sup> Liquefied petroleum gas (-47 °C); Liquefied ethylene gas (-104 °C); Liquefied natural gas (-162 °C); Liquefied nitrogen (-196 °C); Liquefied hydrogen (-253 °C) etc.

<sup>2</sup> HFC - ISO 12922:1999 and ISO 6743-4: 1999 (min 35% water)

<sup>3</sup> Glass fiber (15%) reinforced Polyetheretherketone



### The Power of Knowledge Engineering

Drawing on five areas of competence and application-specific expertise amassed over more than 100 years, SKF brings innovative solutions to OEMs and production facilities in every major industry worldwide. These five competence areas include bearings and units, seals, lubrication systems, mechatronics (combining mechanics and electronics into intelligent systems), and a wide range of services, from 3-D computer modelling to advanced condition monitoring and reliability and asset management systems. A global presence provides SKF customers uniform quality standards and worldwide product availability.

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