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UNASIS
PRECISION BEARINGS



Special Environment,

Hybrid, and Ceramic Bearings

Product Range

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PRECISION BEARINGS

CARTER

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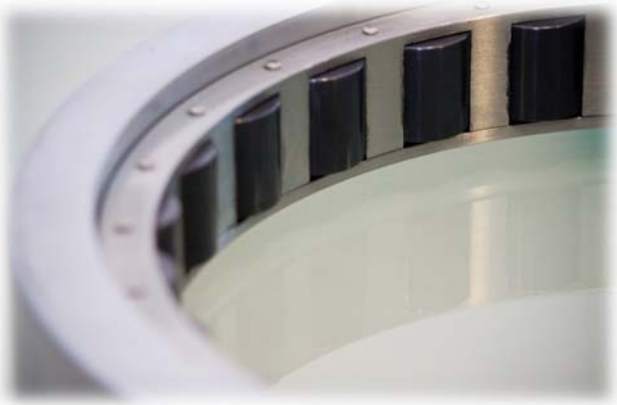

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Special Environment, Hybrid and Ceramic Bearings

Introduction

Ceramic materials have proved to be an invaluable resource when conventional bearings are unable to do the job. Whether it an issue with lubrication, speed or incompatibility of material, there is a ceramic or hybrid bearing capable of providing a solution.

With their unique properties ceramics can be used in a variety of applications where conventional materials reach their limits. They have been used widely in a host of nuclear, vacuum, cryogenic, high speed, insulating and non-magnetic applications.

High Vacuum
Rotary Positioning Tables
Rotary Drives
Valves
Sputter Coating Equipment
Chemical Vapour Deposition Equipment
Vacuum Evaporation Equipment
Turbo Molecular Pumps
Ferofluid Seals
Metal Film Deposition Equipment
Nuclear Research
X-Ray Tubes
Electron Beam Equipment
Magnetic Seals
Viewing Ports
Fusion Research Equipment
Synchrotron Applications
Photoemission Electron Microscopy Research
Vacuum Furnaces
Electron Beam Welding Equipment
Electromagnetic Plasma Manipulation Drives
Semi-conductor Production Machines
Space Satellites
Hard Disk Manufacture
Clean Environment
Pharmaceutical Equipment
Clean Room
Blood Analytical Instruments
Centrifugal Blood Separators
Transfer Robots
Surgical Drills & Saws
Liquid Crystal Panel Manufacture
Etching Machines
Cryogenic
Cryogenic Pumps
LOX Compatible Valves
Dewar Rotary Neck Joints
Cryogenic Valves
Cryostats
Non Magnetic
MRI Machines
Magnetic Couplings
Tesla Magnet Research
Waste Recycling Equipment

Optical
Guided Sights
Focus Rings
Security Camera Mounts
Optical Drivers
Airborne Camera Mounts
Electron Microscopes
Manufacturing
Bottling & Canning Equipment
Food Processing
Pharmaceutical Production Line Machinery
Welding Equipment
Labelling Machines
Kiln Conveyors
Tube Annealing Equipment
Steel Manufacturing
Furnaces Bogies
Corrugated Cardboard Manufacturing
Photographic Film Production Equipment
Electric Motors
Machine Tool Spindle
Switched Reluctance Motors
Renewable Energy
Wind Power Generation
Tidal Power & Wave Energy
Solar Panel Rotary Actuation
Hydro Electric Power Equipment
Geothermal Equipment
Oil & Gas
Downhole Pumps
Valves
Gas Turbines
Orbital Welding Equipment
Pipe Inspection
Drilling & Casing Machinery
Remote Undersea Exploration
Blow Out Equipment
Inline Flow Meters
Motorsport
Turbo Chargers
Car Wheel Bearings
Fuel Injection Systems
Suspension
Transmission Mounts

Ceramic Materials and Their Properties

There are a variety of different ceramic materials, each with their own capabilities, advantages and disadvantages; their use in bearing and rolling element applications was pioneered by many of the space agencies and continues to be at the forefront of engineering technology.

Materials

Silicon Nitride

Density	3.2 g/cm^3
Linear expansion coefficient	3.1x10^{-6}/^{o}C
Hardness	1450Kg/mm^2
Elastic modulus	310GPa
Poisson's Ratio	0.27
Electrical Resistance	10^{16}Ωcm

Zirconia

Density	6.05 g/cm^3
Linear expansion coefficient	10.3x10^{-6}/^{o}C
Hardness	1300Kg/mm^2
Elastic modulus	220GPa
Poisson's Ratio	0.31
Electrical Resistance	10^{13}Ωcm

Silicon Carbide

Density	3.1g/cm^3
Linear expansion coefficient	3.9x10^{-6}/^{o}C
Hardness	2200Kg/mm^2
Elastic modulus	380GPa
Poisson's Ratio	0.16
Electrical Resistance	10^{8}Ωcm

Stainless Steel (440C)

Density	7.6g/cm^3
Linear expansion coefficient	12.5x10^{-6}/^{o}C
Hardness	750Kg/mm^2
Elastic modulus	200GPa
Poisson's Ratio	0.3
Electrical Resistance	10^{-5}Ωcm

The most common ceramic materials and their properties are listed to the left along with 440C stainless steel as a comparison to a conventional material.

Components made of ceramic materials have a number of special properties such as being strong electrical insulators and highly resistant to temperatures opening a wider range of application than was thought possible prior to their utilisation.

Aspects such as lower density gives a weight saving and an increased life. This is because centripetal force acting upon the bearing is less, therefore reducing the wear on the rolling elements.

Special, Hybrid, and Ceramic Bearing Materials

Silicon Nitride Bearings

Silicon Nitride (SI3N4) has better high temperature capabilities than most metals, combining retention of high strength and creep resistance with oxidation resistance. In addition, its low thermal expansion coefficient gives good thermal shock resistance compared with most ceramic materials.

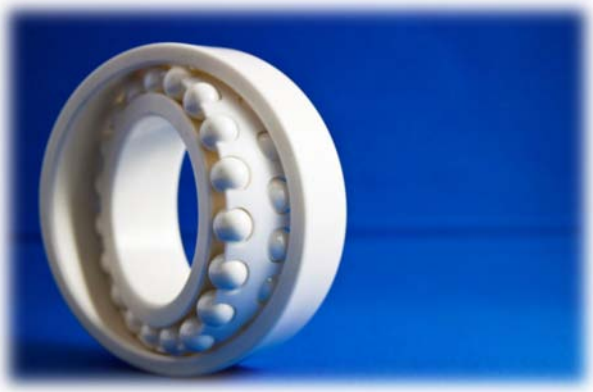
Silicon Nitride is the material of choice for vacuum and high speed rolling element applications. 58% lighter than traditional steel, Silicon Nitride provides a weight saving benefit. Due to reduction in weight, there is a reduction in centripetal force generated by the rolling elements. When used in similar applications and compared to bearing steel, Silicon Nitride offers a significantly increased fatigue life time.

Unlike other ceramic materials Silicon Nitride has the ability to carry similar loads to that of bearing steel. Due to the hardness of the material any application with shock loading is unsuitable for use of Silicon Nitride or any other ceramic materials for bearing races.

Zirconia Bearings

Zirconia (ZrO2) was developed in the 1960s and '70s and was used to produce the external thermal barrier tiles on the space shuttle. These tiles allowed the shuttle to re-enter the earth's atmosphere without burning up. Zirconia is the material of choice for high temperature applications. The thermal expansion and density of Zirconia is closer to steel than that of any other ceramic material so it does not have the same weight saving and thermal shock resistance that are found in other ceramic materials.

Best used under low loads and moderate speeds, zirconia bearings are used in high temperature and highly corrosive applications.



Silicon Carbide Bearings

Less frequently used than other ceramic materials due to its raw material costs and difficulty to machine, silicon carbide offers the best heat and corrosion resistance of all the ceramic materials.

Silicon Carbide is best used under low loads, low to moderate speeds and in highly corrosive environments.

M50 Tool Steel

M50 steel also known as 'Tool steel' has high hardness and compressive strength at standard and elevated temperatures with good hot hardness and excellent rolling fatigue characteristics. It has been a natural choice for critical aircraft engine bearings used in temperatures up to 500°C

These properties, combined with its superior fatigue resistance make it ideal for high temperature, high load bearing applications where high precision and stability are paramount. Typical applications include gas turbines and semiconductor assemblies.

Beryllium Copper Bearings

Beryllium Copper is a high strength alloy comparable to steel with non-magnetic properties that can be heat treated for use in bearings.

The use of this material in bearings offers many advantages in extreme environments, excellent heat dissipation with a thermal conductivity between that of steel and aluminium. The material structure makes it suitable for situations of occasional overload, impact, high temperature, low temperature and marginal lubrication.

The materials' properties make Beryllium Copper suitable for use in cryogenic, ultra high vacuum, magnetically sensitive environments as well as certain corrosive applications.

CRONIDUR® 30 X 30 CrMoN Bearings

CRONIDUR® 30 is a martensitic through hardened steel that has a similar corrosion resistance to 316L stainless steel. It offers a significant improvement over 440C stainless steel which is typically used in standard stainless steel bearings.

Other properties that have defined it as the material of choice for high speed spindle bearings, includes high compressive strength, extreme durability, high and low temperature stability.

CRONIDUR® 30 has been developed to provide solutions in applications such as down hole oil exploration equipment, cryogenic pumps and super precision optical equipment. When combined with ceramic balls to form a hybrid bearing life will also be significantly increased.

Stellite Bearings

Stellite is a material that consists of complex carbides in an alloy matrix; it offers a combination of extremely resilient properties that can be used for components of a rolling element bearing.

Advantages include resistance to wear, galling and corrosion (even at extremely high temperatures of 500°C) while retaining its hardness of 45HRC and non magnetic properties.

Stellite has been extensively used in aerospace applications such as inline jet engine valves, landing gear and actuation equipment. This has driven engineers to turn to this material when other exotic alloys and ceramics have not been suitable. Stellite is extensively used in applications such as high temperatures valves, equipment operating within range of Tesla magnets, semiconductor applications and cryogenic pumps.

Speciality Metal & Alloy Bearings

Due to the diversity of environments where engineers & designers are now expecting bearings to operate many speciality materials & metal and alloy combinations can be used to produce specific solutions.

Bearings can be offered from the following speciality materials: Inconel, Titanium, Monel, XD15NW, BG42 VIM-VAR, and M48 Powder Metal High Speed Steel.

Additional speciality ball options are: Ruby, Glass, PEEK, NYLON, Toloron, Titanium,

The above list is not exhaustive as new materials are constantly becoming available.

Bearing Cage and Separator Materials

It is important when considering ceramic and hybrid bearings to define the correct material for use as a separator or cage. Whether it is metal, plastic or a composite, each has its own advantages and disadvantages depending on whether the application requires it to be non-magnetic, lightweight or vacuum compatible. Selection of the correct cage or separator material is important so please contact us if you need assistance.

Nylon / Polyamide

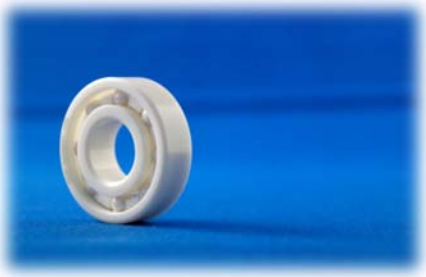
Available as either machined or moulded, Nylon/polyamide represents a low cost, light weight cage option that is suitable for applications below 100°C. Nylon/polyamide however, does not represent a good choice of cage in a vacuum application as the material will 'out-gas' and contaminate the environment. The lightweight and insulating properties make them a suitable choice for hybrid electrical or high speed bearing applications.

PEEK

Polyether Ether Ketone, more commonly known as PEEK is a preferred material for use in clean and ultra-high vacuum environments as it has low particle generation and will not out-gas in a vacuum. It is temperature resistant and stable to approximately 200˚C but is incompatible with acids and corrosive solutions. It can be used with both fully ceramic and hybrid bearings.

PTFE

Chemically resistant, insulating and non-magnetic PTFE is a widely used polymer throughout a number of industries. Due to the strong covalent bonding of the fluorine and carbon, PTFE has strong chemical resistance and is completely hydrophobic. PTFE does not have a high load bearing capacity and is not suitable for high temperature applications. PTFE can be used in both full ceramic and hybrid bearings for cages or separators.



Metal (Ribbon)

A metal ribbon cage is a standard choice for many applications with high temperature, vacuum or clean requirements. Metal cages can take many forms such as: folded tab, riveted or machined. Steel or 440C Stainless Steel cage material is common in many hybrid bearings as it matches the material used for the races and provides a low cost option that will survive many applications. Exotic alloys can be used in special circumstances. The use of Beryllium Copper in non-magnetic applications is possible but these would not be a low cost option. Needless to say carbon steels are not the ideal choice for non-magnetic or electrical applications due to their conductive behaviours. Metal cages are prevalent in hybrid bearings and more unusual in ceramic bearings.

Full Compliment

Full compliment (no cage) construction is a possibility for applications including ultra clean, vacuum, high temperature, non-magnetic, corrosive and electrical applications. The principle function of a cage or separator is to ensure the balls do not have contact with one another. Contact from the rolling elements increase friction and wear within the bearing. The opposing ball rotational direction will cause high contact stress and consequent abrasion will cause residual wear to the elements and races. A further result would be an increased torque and increased fatigue life.

Full compliment bearings are suitable for radial loading applications only. Axial capacity is considered ZERO.

Brass Cage

Brass cages can be crowned, ball pocket and riveted styles; they offer a very durable, heavy duty solution particularly at elevated running temperatures. A brass cage is not typically suitable for high speed applications and is more often found in larger bearing assemblies.

Phenolic Cage

Phenolic resin cages are light weight and strong making them ideal for high speed applications. They can be supplied as crowned, ball pocket and two part riveted versions.

Phenolic cages are produced by impregnating textile with a thermo-setting resin. The resulting component when machined to required sizes offers a very low coefficient of friction. The material is also able to absorb lubricants and maintain dimensional rigidity while offering a high strength to weight ratio.

Speciality Cage Materials and or Options

Bearing cages can also be produced from speciality materials specifically to suit applications. Ceramic, Vespel®, Meldin® Moly Disulphide impregnated PEEK, Aluminium, Delrin® and Graphite are examples that can be considered.

There is also the option to replace a traditional cage with spacer slugs, tolroid or spacer balls. These options replace the cage with a separator that floats between each of the balls.

These options are most suited to applications that have low torque and low speed for slow moving oscillating applications.

Lubrication and Coatings

XtrMD Coating

Unasis XtrMD coating is a Molybdenum Disulphide based coating that can be applied to a variety of components.

Molybdenum Disulphide (MoS2) is a naturally mined inorganic material that has become extremely popular as a dry film lubricant due to its availability, price and advantages over comparable dry film lubricants. By reducing the coefficient of friction, moly disulphide can increase the speed capacity and increase the bearing life by acting as a sacrificial lubricant. In ultra high vacuum applications where bearings are running at high speed the XtrMD coating may create small particulate that may contaminate the vacuum. Molybdenum Disulphide coating can be applied to stainless steel hybrid bearings.

	Molybdenum Disulphide	*Tungsten Disulphide*
Colour	Blue-Silver Grey	Silver Grey
Appearance	Crystalline Solid	Crystalline Solid
Density	7500kg m^{-3}	5060kg m^{-3}
Thermal Stability in Air	COF<0.1 310°C	COF<0.1 600°C
Coefficient of Friction	0.16 Dynamic, 0.19 Static	0.03 Dynamic, 0.07 Static
Chemical Durability	Inert, Non-toxic, Non-Magnetic	Inert, Non-toxic, Non-Magnetic
Corrosion Resistance	Will not prevent corrosion	Can slow corrosion but will not completely prevent corrosion

XtrTD Coating

Heavier and more stable than Molybdenum Disulphide, Tungsten Disulphide has been extensively used throughout a number of NASA, military and aerospace applications. With an even lower friction coefficient than Molybdenum Disulphide and the ability to slow corrosion in some materials, Tungsten Disulphide has been the coating of choice for a number of high-end applications. It can be used as a solution to problems such as excessive wear, seizing, galling and fretting. The coating itself is only 0.5 micron thick and will not bond to itself, negating build up. Tungsten Disulphide is inert, non-toxic and nonmagnetic but unlike Molybdenum Disulphide it will not cause particulate contamination of an ultra high vacuum. Tungsten Disulphide can be used to coat hybrid and standard bearings.

Greases and Oils

Grease and Oils are lubricants applied to the majority of bearings in order to decrease wear on rolling elements but can be altered in order to meet the demands of various applications.

All Unasis Hybrid Bearings can be greased to suit specific application requirements. High temperature, high load or high speed applications would require specialist lubricants. Please contact us for assistance in specifying your lubrication. Grease and oil lubricants can be added to full ceramic bearings as well as hybrid bearings in order to change performance characteristics such as increase speed, reduce ball skidding or reducing noise.

XtrPoly Coating

XtrPoly is a polymer that is injected and cured to fill the volume between rolling elements and races in a bearing. The polymer is filled with lubrication that is excreted under load. This provides constant and consistent lubrication in the bearing system. There is no need for additional lubrication during the life of a XtrPoly filled bearing.

Because it is a solid, XtrPoly can help block debris and reduce ingress of foreign contamination into the bearing. Reducing the incursion of debris into the bearing can significantly extend the bearing's life. The solid structure of XtrPoly also makes it suitable for environments where grease and oil leakage cannot be tolerated, as it will not drip out of the bearing and contaminate the environment.

XtrPoly filled bearings have speed limitations lower than standard oil or grease lubricated.

Filling bearings with XtrPoly does not change the dimensional tolerances of the bearing in any way, it simply fills the spaces between the rolling elements and the cage. Any standard or non standard bearing can be filled.

XtrChrome Coated Bearings

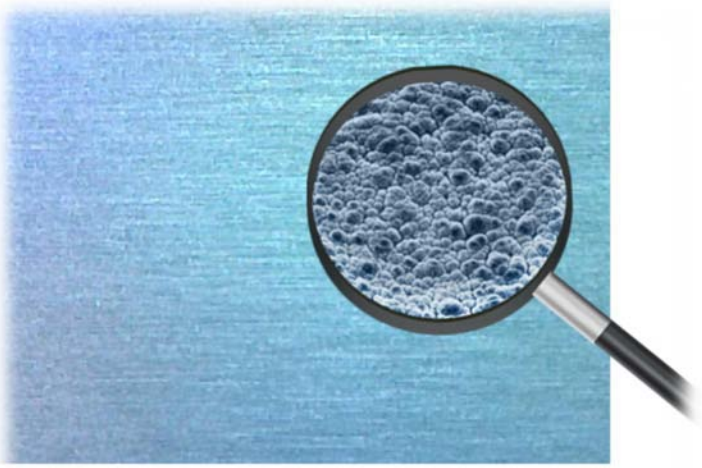
XtrChrome is a nodular thin dense chrome coating applied to the bearing components in a process that ensures precise coating deposition. The process offers many advantages including corrosion resistance, increased surface hardness, increased bearing life, cost reduction, reduced production lead time and energy saving properties due to reduced surface friction.

XtrChrome is used across a variety of industries including aerospace, naval, oil & gas, semiconductor, chemical, pharmaceutical and food processing. It is particularly useful as a coating for bearings and bearing surfaces made of 52100, M-50, M-50 NIL, BG-42. 440C, and all pH basis metals. XtrChrome enables bearing surfaces to run longer and cooler. US Air force tests have shown that XtrChrome enhances both ball and roller bearings and does not affect or induce fatigue or change base metal characteristics.

The surface texture gives exceptional performance in extreme environments especially if used in conjunction with ceramic rolling elements. The nodular microscopic surface holds lubrication within the surface structure giving advantages in the following environments: fast acceleration without full ball loading, oscillating movements which do not complete a full revolution, emergency rundown due to loss of lubrication, low rotational speeds and environments which do not allow for lubrication. Speed capabilities at lower operating temperatures are significantly increased. Fretting corrosion that is caused by micro displacement of the bearing rings can be greatly reduced.

XtrChrome Coating Benefits:

- Corrosion resistance exceeding 440C stainless steel, with additional chemical resistance
- Increased wear resistance due to 78HRC surface hardness
- Reducing wear and friction in application
- Absolute adhesion to basis metal: no chipping, cracking, flaking or peeling
- Reduced maintenance and part replacement costs
- Longer running capabilities with lower coefficient of friction
- FDA approved for product contact
- Nodular surface gives better adhesion strength of lubrication film
- Reduction of micro weld adhesion
- XtrChrome coated components are more economic and readily available the 440C Stainless Steel



Ceramic Balls

UNASIS provide a wide range of ceramic ball options across a variety of sizes. Material options include Silicon Nitride (Si3N4), Zirconia (ZRO2) and Silicon Carbide (SIC) from 0.4mm to just over 115mm in diameter with the most common sizes in between. Precision grades provided are Grades 5, 10, 16, 25 and 100.

Ceramic balls have excellent resistance to wear and seizure. They offer solutions for high temperature environments (Up to 800°C for Si3N4) high rigidity, light weight and are non magnetic with insulating properties.

Applications include high speed spindle bearings, solenoid valves, down hole pumps, vacuum equipment, gas monitoring devices and turbo chargers.

Ceramic Ball Part Numbering System

Example :	Dimension	Precision Grade	Material
	6.35mm	GD5	SI
		GD10	ZR
		GD25	SC
		GD50	
		GD100	

Size

Ball Diameter as a decimal including unit

Example

6.35mm or 0.5”

Material

SI	Silicon Nitride
ZR	Zirconia
SC	Silicon Carbide

Precision Grade

A large variety of grades are available from GD5 and up.

Precision grade is dependant on the size of ball required.

Full Ceramic Bearing Applications

Space and Satellites

Many of the modern bearing materials that are common place today have their origins from space technology. The same can be said for many of the advanced ceramic materials used in bearings. Ceramic bearings can be found in a number of space applications from space flight to satellites to unmanned exploration vehicles.

Space normally poses many problems for bearings due to the high stress and atmospheric environment. A number of benefits can be found in the use ceramic bearings, light weight and vacuum compatible ceramic bearings provide a reduction in weight and are able to withstand space flight. Additionally ceramic bearings, unlike their steel equivalents, are able to run unlubricated providing an added weight saving without the need for heavy greases or oils that will also may contaminate delicate components in the surrounding application.

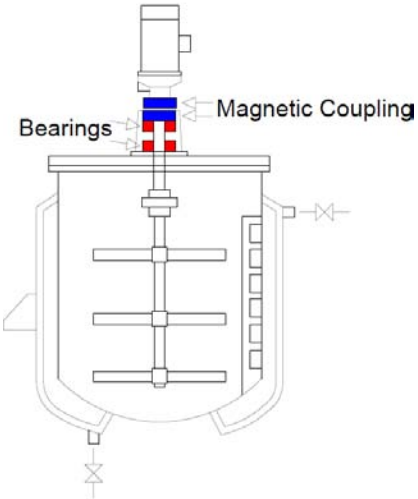
Chemical and Medical

Whether it is mixing chemicals or being used in medical equipment, ceramic bearings provide the best solutions to applications where contamination can be life threatening. Standard steels, when washed with solutions can rust. Even stainless steels can succumb to the effect of strong acids or alkali. The resulting corrosion can lead to particulate contamination. Standard bearings also must have some form of lubrication, whether it is grease or oil, which can act as a breeding ground for bacteria and be troublesome to clean.

Ceramic bearings however are inert, meaning they do not suffer the same problems of reacting with corrosive materials and will not let off particulates or react with chemically harmful by-products. Furthermore, ceramic bearings can be run dry and free of additional lubrication so will not harbour any microbiology and can be cleaned more easily with strong clean agents without worry.

Chemical Mixing Vessel Bearings

Due to the extremely corrosive nature of the chemicals being mixed, Silicon Nitride fully ceramic angular contact bearings are used inside the vessel with drive being provided through a magnetic coupling keeping the motor completely separate from the corrosive environment.



Ceramic Ball Part Numbering System

Example:	608	PP	C3	ZR	PT	SI
			C1		FC	
		.2RS	C2		TN9	
		.2RZ	C3	SI	PE	SI
		PP	C4	ZR	PT	ZR
	Size	.2PE	C5	SC	RC	SC

Size

Bearing part number defined by ISO standard part numbering

Seals/Shields

~	Open
.2RS	Two rubber seals
.2RZ	Two low contact seals
PP	Two PTFE shields
.2PE	Two PEEK shields

Clearance

C1	Less than C2
C2	Less than normal
~	Clearance Normal
C3	Greater than Normal
C4	Greater than C3
C5	Greater than C4

Ball Material

(If different from race material)

SI	Silicon Nitride
ZR	Zirconia
SC	Silicon Carbide

Cage/Separator

FC	Full Compliment
TN9	Nylon/Polyamide
PE	PEEK
PT	PTFE
RC	Metal

Race Material

SI	Silicon Nitride
ZR	Zirconia
SC	Silicon Carbide

Ceramic Bearings Suggested Combinations

	Outer Race	Inner Race	Rolling Element	Cage/ separator	Shield/Seal	Lubrication
Corrosion Resistant	Zirconia	Zirconia	Zirconia	PTFE	*	*
Highly Corrosive Resistant	Silicon Carbide	Silicon Carbide	Silicon Carbide	PTFE/PEEK/ Full Compliment	*	*
High Temperature	Zirconia	Zirconia	Zirconia	Full Compliment	*	*
Extreme High temperature	Silicon Nitride	Silicon Nitride	Silicon Nitride		*	*
Vacuum				PEEK/Stainless Steel		
Cryogenic						
Non-magnetic	Zirconia	Zirconia	Zirconia	PTFE	*	*
Insulating	Silicon Nitride	Silicon Nitride	Silicon Nitride	TN9/PTFE	*	*
Clean	Zirconia	Zirconia	Zirconia		*	*
High Speed	Silicon Nitride	Silicon Nitride	Silicon Nitride	TN9	*	*

* = Many options are available

Please contact us for assistance in choosing the most appropriate material combinations for your application.

Hybrid Ceramic Bearing Applications

Machine Tool Spindle Bearings

When speed is of paramount importance hybrid ceramic bearings hold the solution. Hybrid machine tool spindle bearings have proved popular throughout industry. Due to the lower density of silicon nitride rolling elements in comparison to traditional steel equivalent, Silicon Nitride rolling elements experience a reduction in centripetal force which acts upon them at high speeds. This reduction in centripetal force means the rolling elements suffer less slipping and, in turn, a reduction in wear.

These properties result in two key benefits of hybrid ceramic bearings over traditional bearings, a 30%-50% increase in speed and an increase in the fatigue life of the bearings. The direct benefit to the end user is that fewer breakages mean less machine down-time, increasing output and fewer replacements.

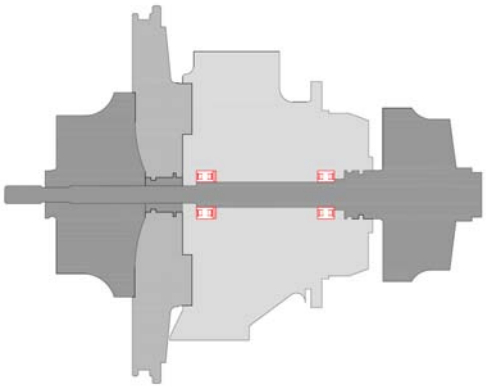
Electric Motor Bearings

Hybrid bearings have proved to be exceedingly popular in the electric motor applications. In particular the emerging wind energy market has seen major benefit in the use of hybrid bearings. Issues arise in electric motor bearings when an electrical current is passed through the bearing causing electrical pitting. The current will cause micro-welds to occur between the race and ball leading to dramatically increased wear, noise and lubricant ageing. Once this has occurred the bearing has to be replaced.

Due to the insulating properties of ceramic materials, hybrid bearings do not allow the current to be passed between the races, thus overcoming all the electrical pitting issues found with traditional steel bearings. This coupled with the additional benefits such as longer life and higher speed capacity of hybrid bearings, means that electrical motors have been revolutionised.

Turbo Charger Bearings

Manufacturers of Turbo Chargers have always aspired to replace bushes for ball bearings. This reduces turbo lag and increases performance significantly. UNASIS has successfully assisted our customer by designing a custom pair of hybrid ball bearings to enable them to achieve turbine speeds in excess of 220 000 rpm whilst boosting pressures of up to 4 Bar. The shaft temperature sees 300°C while the housing sits at around 200°C. Contact your UNASIS representative to discuss your turbo charger application.

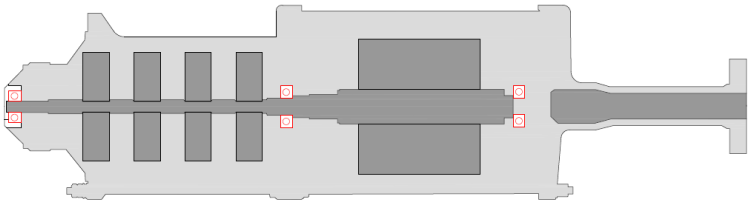


Cryogenic and Cryogenic Pump Bearings

At extreme temperatures, cryogenic applications demand the most of all their components including bearings. At -196˚C liquid nitrogen will freeze water in the air blowing past. If a standard bearing were to be used all the clearance would be pinched out of it rendering the bearing unable to rotate and it would lock up.

Due to the significantly lower thermal expansion coefficient of ceramic materials, ceramic rolling elements will not contract as significantly as their steel counterparts and as such will work under the coldest cryogenic temperatures. In addition, ceramic bearings are able to withstand thermal shock of being flooded with cryogenic fluid and the considerable instantaneous temperature drop results. The high stresses this places on materials would cause 52100 steel bearings to fail.

Unasis cryogenic pump bearings have been used to great success in an inline submerged pump. The pump works in a vertical orientation immersed in a cryogenic liquid such as liquid Argon or Nitrogen at operating temperatures of between 155° to -196°C. An angular contact bearing pair was designed with Stainless Steel Races, Silicon Nitride Ceramic Balls and a custom PEEK Cage. The UNASIS XTRTD dry film lubrication was also applied to meet with the demand of extreme low temperature, extremely high loading and speed conditions.



Actuation Bearings

The very stringent requirements of high accuracy and light weight means that a completely custom bearing had to be designed for an airborne actuation device.

The accuracy requirement meant that ABEC 7 precision race tolerances were required while limited space meant that a special fully ceramic bearing with separable inner race and stainless steel locking adaptor sleeve was designed to interact with the mating components. The inner ring and outer ring are separable to enable the bearing could be assembled with greater ease.

Hybrid Bearing Part Numbering System

Example :	S	608	ZZ	C3	RC	CB	MD

	S	Size	ZZ .2RS .2RZ	C1 C2 C3 C4 C5	FC TN9 PE PT RC	CB	MD TD

Race Material

~	AISI 52100 bearing steel
S	440C Stainless Steel

Size

Bearing part number defined by ISO standard part numbering system for bearings

Seals/Shields

~	Open
ZZ	Two shields
.2RS	Two rubber seals
.2RZ	Two low contact seals

Coating

MD	XtrMD
TD	XtrTD
~	No coating

CB	Ceramic Balls

Cage/Separator

FC	Full Compliment
TN9	Nylon/Polyamide
PE	PEEK
PT	PTFE
RC	Metal

Clearance

C1	Less than C2
C2	Less than normal
~	Normal clearance
C3	Greater than normal
C4	Greater than C3
C5	Greater than C4

Hybrid Bearings Suggested Combinations

	Outer Race	Inner Race	Rolling Element	Cage / separator	Shield/ Seal	Lubrication	
						Coating	Grease/
Corrosion Resistant	440C	440C	Silicon Nitride	PTFE	*	*	*
High Temperature				Ribbon	*	*	*
Vacuum				PEEK/ Stainless Steel		*	
Cryogenic						*	
Non-magnetic	316	316		TN9/PTFE	*	*	*
Insulating	440C	440C		PEEK	*	*	*
Clean				Ribbon	*	*	*
High Speed				TN9	*	*	*

* = Many options are available

All suggestions are subject to each individual application and are for comparative use only, in order to specify the correct specification please contact UNASIS.

Notes: