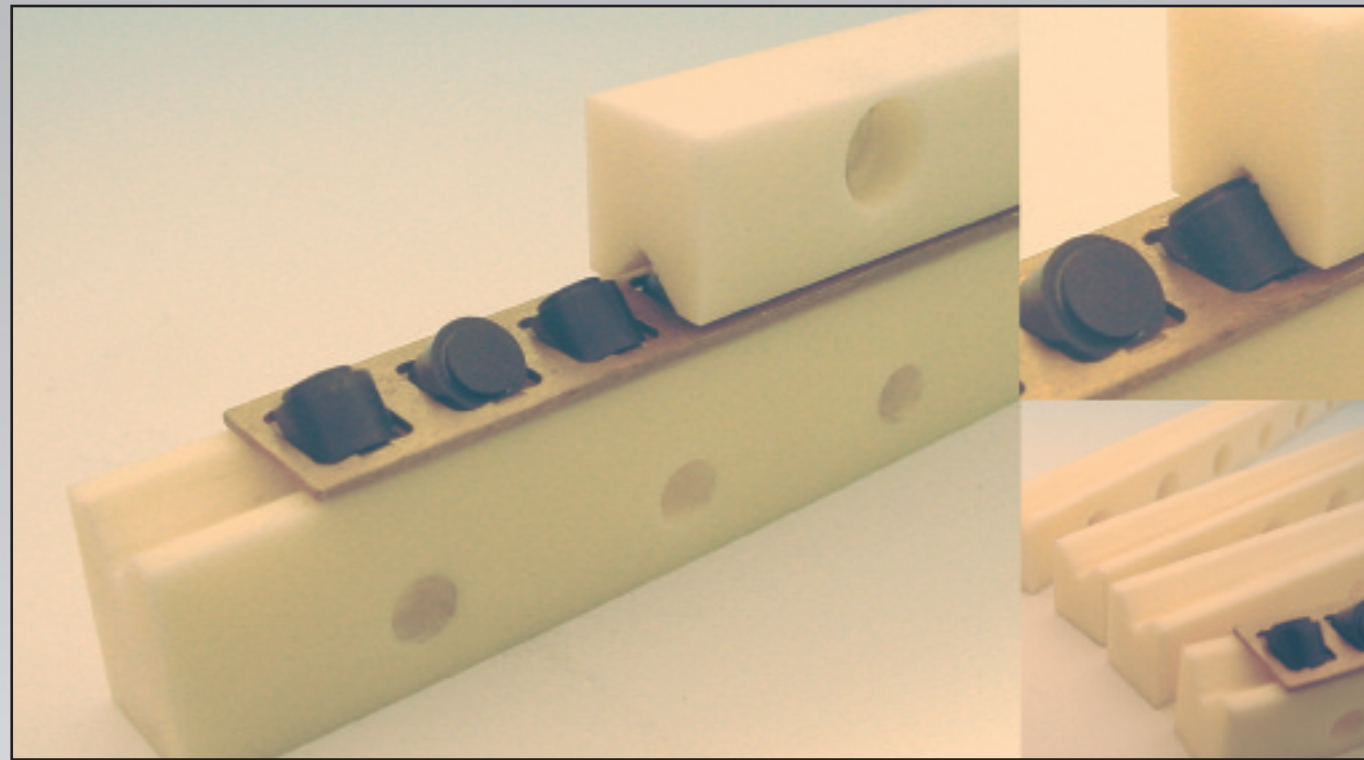


Ceramic Linear Bearings



Why ceramics? More than 2 decades of ongoing research and testing prove that ceramic linear bearings:

- Maintain longer, more reliable performance;
- Reduce friction;
- Retain stiffness;
- Operate at higher temperatures; and
- Require less lubrication.

Through the years ceramic bearings have been well accepted in demanding ball bearing applications. As shown in table 1, ceramics are superior to steel in density and hardness. Cause of their non-magnetic property they are an ideal material for use in non-magnetic or ultra-high vacuum environment as in new generation machines.

Table 1 Characteristics ceramics vs bearing steel

Characteristics	Si ₃ N ₄	Al ₂ O ₃	ZrO ₂	1.3505
Max. operating temp(°C)	800	200	300	170
Density, g/cm ³	3.2	3.8	5.6	7.87
Hardness, HRc.	78	84	80	62
Youngs modulus (Gpa)	320	360	210	210
Thermal expansion coefficient (x 10 ⁻⁶ /°C)	3.2	17-23	10.9	11.9
Flexural strength (Mpa)	800	310	710	800

Ceramic material properties according to DIN EN 12212

Today, PM is the **first** linear bearing company in the world to realize practical use of ceramic linear bearings from diverse materials in our high precision positioning stages operating under extreme environments.

CERAMIC LINEAR BEARINGS

BENEFITS at a GLANCE

- Non-magnetic
- Vacuum compatible
- High temperature
- Reduced weight
- Reduced Wear > Longer life
- Corrosion resistant
- Lower thermal expansion

APPLICATIONS

- Spectroscopy
- E-beamlines
- Lithography
- Wirebonding
- X-Ray equipment

CERAMIC'S BENEFITS

PM engineers have developed numerous of ceramics designs. We continue to focus on solutions that incorporate the silicon nitride (Si₃N₄) or oxide family (Alumina Al₂O₃ or Zirconia ZrO₂) of ceramic compounds. The selection is made on operating conditions such as speed, temperature and surface finishing. The benefits:

Lightweight

Ceramics density is about 40%-60% percent of traditional bearing steel DIN 1.3505. Because force is directly proportional to mass, the low density silicon nitride significantly reduces the starting force which is required to move the slide/stage. This enhances operations in high-dynamic applications where the reduction of the mass-moment of inertia is an ongoing issue.

High Rigidity

Ceramic ways and balls (Silicon Nitride and Alumina) have a Youngs Modulus which is about 50% higher than steel, making them an ideal linear bearing material for use in high-speed XY-stages as for wirebonding machines in the semi-conductor industry where rigidity and precision at high speed is required.

Increase Lifespan

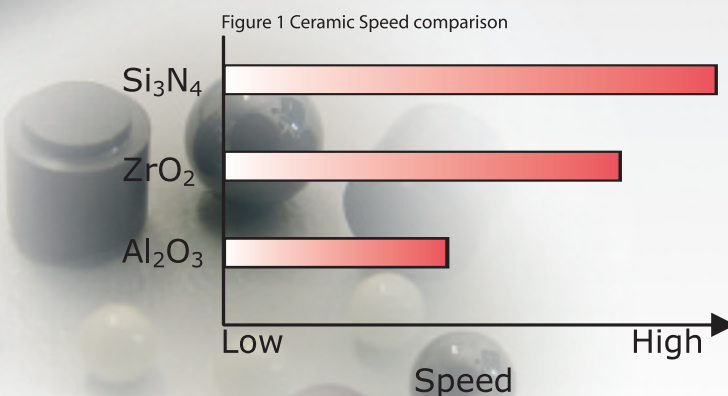
The lifespan of linear bearings is directly related to hardness, the most critical mechanical property of a bearing material. With an impressive Rockwell C 78 - hardness, twice as hard as many bearing steels - and a high compressive strength, about 5 to 7 times that of steel, silicon nitride improves wear resistance, minimizing the damaging effects of repeated surface contacts. The lifetime of ceramic bearings varies with the operating conditions.

Operation under extremely high Temperatures

The mechanical properties of ceramic bearings does not change by extreme low (cryogenic) and extreme high temperatures - approximately 800°C which makes it very suitable for use as heat resistant material. A major problem by such high temperatures is lubrication. Oil and grease can normally be used in temperatures up to 300°C. When temperature exceed this, solid lubricants can be used. However, solid lubricant can only be used for temperatures up to 500°C. Ceramic bearings can operate at temperatures up to 800°C, exceeding the best high temperature bearing steels by a factor of three.

Speed vs Performance

Due to the material characteristics each ceramic offers specific benefits. As shown in figure 1 some perform better at high speed and some at lower speed.

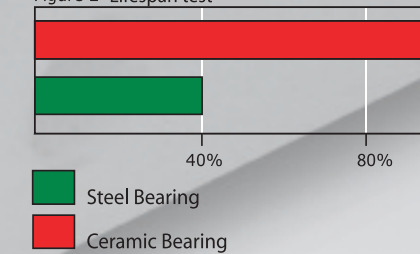


Other characteristics such as vacuum compatibility, less particle generation about 1/3 in both air and vacuum compared with stainless steel, chemically inert, corrosion resistant and electrical non-conductivity can enhance linear bearing performance in special applications. PM engineers can provide customer-focused bearing recommendations for your challenging applications.

Lifespan with zero Lube

As ceramics are extremely hard and have outstanding wear resistance, they outperform other materials in bearing life without lubrication. Results of an lifespan test of steel and all-ceramic linear bearings without lubrication are presented in figure 2.

Figure 2 Lifespan test



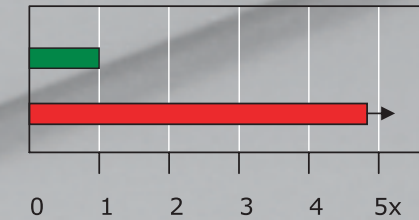
The rollers in the steel linear bearings exhibited flaking and a loss preload was observed after only 40% of the calculated life while the ceramic linear bearings were still operating after 2x the lifespan of steel. After inspection of the rails and rolling elements no wear was found at all. The accuracy of travel was still the same. The test confirmed that the life without lubrication is dramatically longer for ceramic linear bearings than for steel.

Load Capacity and Life

At the moment no standards are published by ISO or JIS regarding the static and dynamic load ratings of ceramic linear bearings. The static load ratings of ceramic bearings in which Si₃N₄ rolling elements are used are being studied by PM. PM is working on the assumption, which are based on

material testing, that the load ratings of ceramic bearings will have the same values as for the conventional steel ones based on the fracture load of silicon nitride rolling elements.

Figure 3 Tested Life



Test results prove that ceramic linear bearings often achieve longer life, 3 to 5 times longer depending on the operating conditions.

Made to Custom Order

Ceramic linear bearings and slides are manufactured on a make-to-order basis. In this way the ceramic bearing specifications can be matched with your system requirements such as speed, operating temperature, accuracy... Manufacturing starts after all technical details are clear. Our engineers are on call to assist you to find the right linear bearing. They are ready to offer you the best solution, no matter how complex and unique your problems are.

Test Data

All tests in this brochure are done with below mentioned part and operating conditions.
 Set RSD-6300 x 24AA equivalent Load: 17.5 Kg.
 Speed: 25 m/min
 Travel: 40mm
 Temperature: room temperature
 Preload: standard factory setting



ADVANTAGE 1

Vacuum Compatible

As ceramic belongs to the group of insulators and it can operate particle free they are well suited to be used under vacuum environments with a minimum amount of lubricant.

ADVANTAGE 2

Huge Weight Savings of 60%

The density of ceramics is about 60% lower of traditional bearing steels. This enhance operations in high-dynamic applications where reduction of mass in an ongoing issue.

ADVANTAGE 3

Increased Lifespan

Since bearing life is directly related to hardness. With an impressive value of at least 78 HRc. it improves wear resistance and reduces friction.

ADVANTAGE 4

High Temperature Operation

The hardness of Silicon Nitride bearings does not change until it reaches a temperature of 800°C, exceeding the best high temperature steels by a factor of two.

ADVANTAGE 5

Non-Magnetic

Due to the fact that the relative magnetic permeability of ceramic linear bearings is <math>< 1.001</math> they are well suited to operate in magnetic fields such as electron beams.

Superior Quality

Incorporating PM ceramic bearings into your application means that you can count on quality and reliability. Our standard rails and rolling elements are known for superior surface quality, our ceramic linear bearings are matching the same high and unexcelled quality standards.

In 2005 PM was the first manufacturer who introduced ceramic linear bearings in the market. We do not only pay attention to surface finishing but we also pay a great attention to total quality. All our shipments are 100% inspected and tested for running performance and accuracy, before they leave our factory.

Focused on Innovation

Innovation and to be the best global linear bearing manufacturer at commercial pricing is our goal. Quality and service makes PM stand apart the competition.

All information and specifications shown in this brochure are based upon the latest available information at the time of printing. In line with our policy of continual product improvements PrecisieMetaal-Bearings BV reserves the right to make changes at any time, without notice, to design, material, specifications. PM-Bearings shall not be liable for any damages whatsoever, direct or indirect, based upon information in this brochure. For the latest details, please consult your local dealer.



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