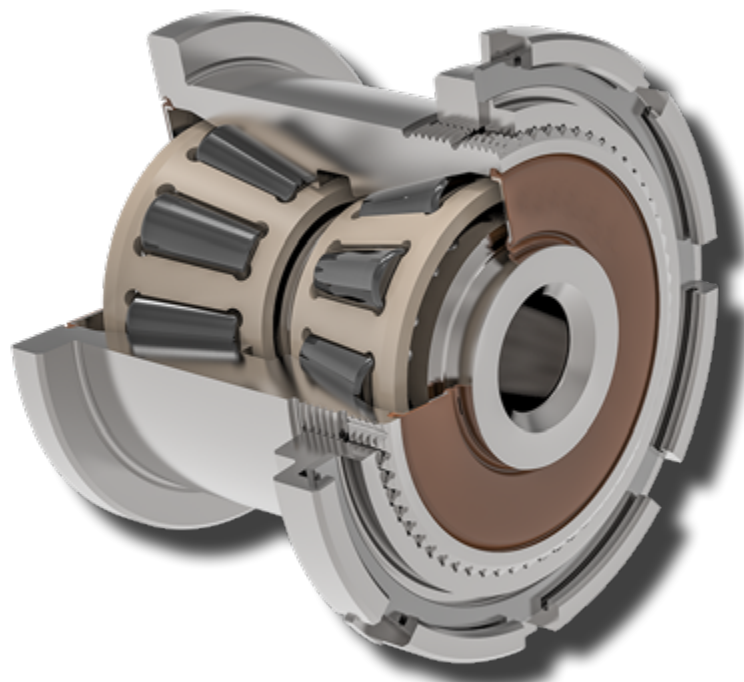


HYBRID CERAMIC BEARING TECHNOLOGY





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CEROBEAR has pioneered hybrid ceramic bearing technology, design, and manufacturing for more than 30 years since the founding of the company.

1. Hybrid Ceramic Bearing Definition

A “hybrid” ceramic bearing is defined by having the combination of high performance metal rings, typically hardened steel but can also be alloy and Silicon Nitride (Si_3N_4) rolling elements – balls or rollers.

CEROBEAR engineers and manufactures a very wide range of hybrid ceramic ball and roller bearing types. As compared to most all other bearing companies that make only hybrid ball bearings, CEROBEAR also produces every type of hybrid roller bearing as shown in [Table 1](#).

1.1. CEROBEAR's expertise in ceramic roller design and production

CEROBEAR is the world leader in Si_3N_4 roller manufacturing with capability to offer a wide range of roller sizes, shapes (cylindrical, tapered, spherical, needle, and hour-glass), and crown profiles using our advanced processes. No other bearing company in the world has this flexibility and wide roller selection. We can also produce every type of hybrid ceramic ball bearing.



Every CEROBEAR hybrid ball and roller bearing comprises Si_3N_4 rolling elements that combine: the highest quality bearing grade Si_3N_4 material, the most advanced machining processes for superior geometry and surface finish, and advanced inspection technologies to assure extremely high surface integrity and performance. Compared to other bearing companies, CEROBEAR is much more focused on controlling our Si_3N_4 ball and roller component quality to maximize hybrid bearing reliability, performance, and life.



CEROBEAR HYBRID CERAMIC TECHNOLOGY

2. CEROBEAR Product & Service Package

Table 1: CEROBEAR Product & Service Package

Rolling Element Bearing Types	Bearing Materials	Special Features	Our Services
<div>ROLLER BEARINGS</div> <div>CYLINDRICAL TAPERED SPHERICAL TAPERED DOUBLE ROW NEEDLE HOUR GLASS PURE THRUST GEARED OUTER RING</div> <div>BALL BEARINGS</div> <div>DEEP GROOVE ANGULAR CONTACT (15° TO 60°) GOTHIC ARCH (3 POINT CONTACT) GOTHIC ARCH (4 POINT CONTACT) ANGULAR CONTACT DUPLEX ANGULAR CONTACT SUPER DUPLEX ANGULAR CONTACT TRIPLEX CONSTANT SECTION PURE THRUST GEARED OUTER RING</div> <div>COMBINED BALL & ROLLER BEARINGS</div> <div></div>	<div>RING MATERIALS</div> <div><ul style="list-style-type: none">• M50 (AMS 6491)• M50 NiL (AMS 6278)• M50 & M50 NiL Nitrided• X30 CrMoN 15 1 (AMS 5898) - High Nitrogen Steel• X40 CrMoVN 16 2 (AMS 5925) - High Nitrogen Steel• Powder Metallurgical Steel (AMS 6560, ...)• AISI 440c / SAE 51440 (AMS 5880, 5618, 5630)• BG42 (AMS 5749)• Ferrium 64 (AMS 6509)• Iconel 718 (AMS 5663, ...)• 100 Cr 6 / SAE 52100 (AMS 6440, 6444)• Silicon Nitride (ASTM F2730, F2094)• Zirconia (Y-TZP, Mg-ZrO2)</div> <div>ROLLING ELEMENT MATERIALS</div> <div><ul style="list-style-type: none">• Silicon Nitride (ASTM F2730, F2094)• Zirconia (Y-TZP)• M50 (AMS 6491)• AISI 440c / SAE 51440 (AMS 5880, 5618, 5630)• 100 Cr 6 / SAE 52100 (AMS 6440, 6444)</div> <div>CAGE MATERIALS</div> <div><ul style="list-style-type: none">• PEEK (MIL-P-46183 TYPE 1)• PI, PAI• PTFE, PGM-HT, PCTFE• Phenolic (MIL-I-24768/13)• Steel (4340 & others)• Al-Bronze• Brass• Titanium</div> <div>.... AND MORE ...</div>	<div>PLATINGS & COATINGS</div> <div><ul style="list-style-type: none">• Silver (AMS 2410, 2412)• Thin Dense Chromium (AMS 2438)• Tungsten Carbide / Carbon (WC/C)• Diamond Like Carbon (DLC)• MoS₂• Dicronite DL5</div> <div>BEARING SIZES & PRECISION LEVELS</div> <div><ul style="list-style-type: none">• 0.25" (6.35 mm) ID to 20" (508 mm) OD• Bearing design according to ISO or ABEC• Standard dimensions or fully customized• Accuracy up to ABEC/RBEC 7 (9), corresponding to ISO class 4 (class 2)• Accuracy up to ABEC 7F for constant section bearings• Rollers/needles diameters from 1.5 mm to > 40 mm</div> <div>SPECIAL DESIGN FEATURES</div> <div><ul style="list-style-type: none">• Customized Outer Ring Flanges• Anti-Rotation Features (Pins or Slots)• Direct Oil Lube (Holes & Grooves)• Extended Inner or Outer Rings• Custom Shields & Seals, Integral Shields• Combined Ball & Roller Bearings• Positioning Flanges• Flexure Cages• Integrated Magnets/Encoder• Puller Grooves• Splines• Cage and Race Platings• Smart Bearings• Additive Manufacturing</div> <div>.... AND MORE ...</div>	<div>Our Services</div> <div>SERVICE</div> <div><ul style="list-style-type: none">• Short lead time 12-26 weeks typical• Low minimum order quantity: typically 10 pieces bearings• Full design capability & bearing calculation support• In-depth, simultaneous co-engineering support• New materials adapted quickly for production use• Pre-delivery friction & torque testing, pre-load measurements• Bearing inspection and analysis to support customer testing</div> <div></div>

3. The Si3N4 Advantage over Typical Bearing Steels

CEROBEAR ceramic rolling elements are made from the highest quality bearing grade Si3N4 material and provide industry leading surface integrity.

3.1. Si3N4 versus Typical Bearing Steel Material Properties



Even when compared to high performance steel rolling elements, a properly machined and inspected Si3N4 rolling element provides significant operating benefits, making hybrid ceramic bearings superior over all grades of all-steel bearings. Si3N4 has the same crystalline structure and covalent atomic bonding as diamond making it a very hard, strong, stiff, light weight, inert, and stable material – all very positive attributes for better rolling elements in a bearing.

As shown in [Table 2](#), bearing grade Si3N4 material vs. typical bearing steel is 59% lighter, 52% stiffer, and 129% harder. Additionally, Si3N4 offers a 76% lower coefficient of thermal expansion (CTE), can operate to 1000° C, and can withstand 25% higher Hertzian Contact Stress compared to steel. Si3N4 is also completely inert since its crystalline structure is based on covalent atomic bonding (identical to diamond) so electrons are not free to interact with other materials that come in contact whether mechanically or chemically. Steel is based on metallic atomic bonding with electrons free to interact with other materials. This difference in atomic bonding makes Si3N4 extremely corrosion resistant and an electrical insulator. And, for hybrid ceramic bearings, there is absolutely no possibility of seizure, fretting, cold welding, or adhesive wear between the Si3N4 rolling elements and metal raceways even in “oil-off” situations.

Table 2: Si3N4 vs. Typical Bearing Steel Material Properties

MATERIAL PROPERTIES	BEARING GRADE Si3N4	TYPICAL BEARING STEEL	Si3N4 VS. STEEL
Density [g/cm³]	3.2	7.9	-59%
CTE [x 10^-6 /K]	2.8	11.5	-76%
Young’s Modulus [GPa]	320	210	+52%
Max Hertzian Contact Stress [GPa]	5	4	+25%
Poisson’s Ratio	0.27	0.3	-10%
Hardness [HV10]	1550	700	+129%
T-max [°C]	1000	300	+233%

Finally, due to the extreme hardness, high stiffness, and very fine grain structure of Si3N4, balls and rollers can be finished to a higher precision level and with much smoother surface finish compared to steel rolling elements.



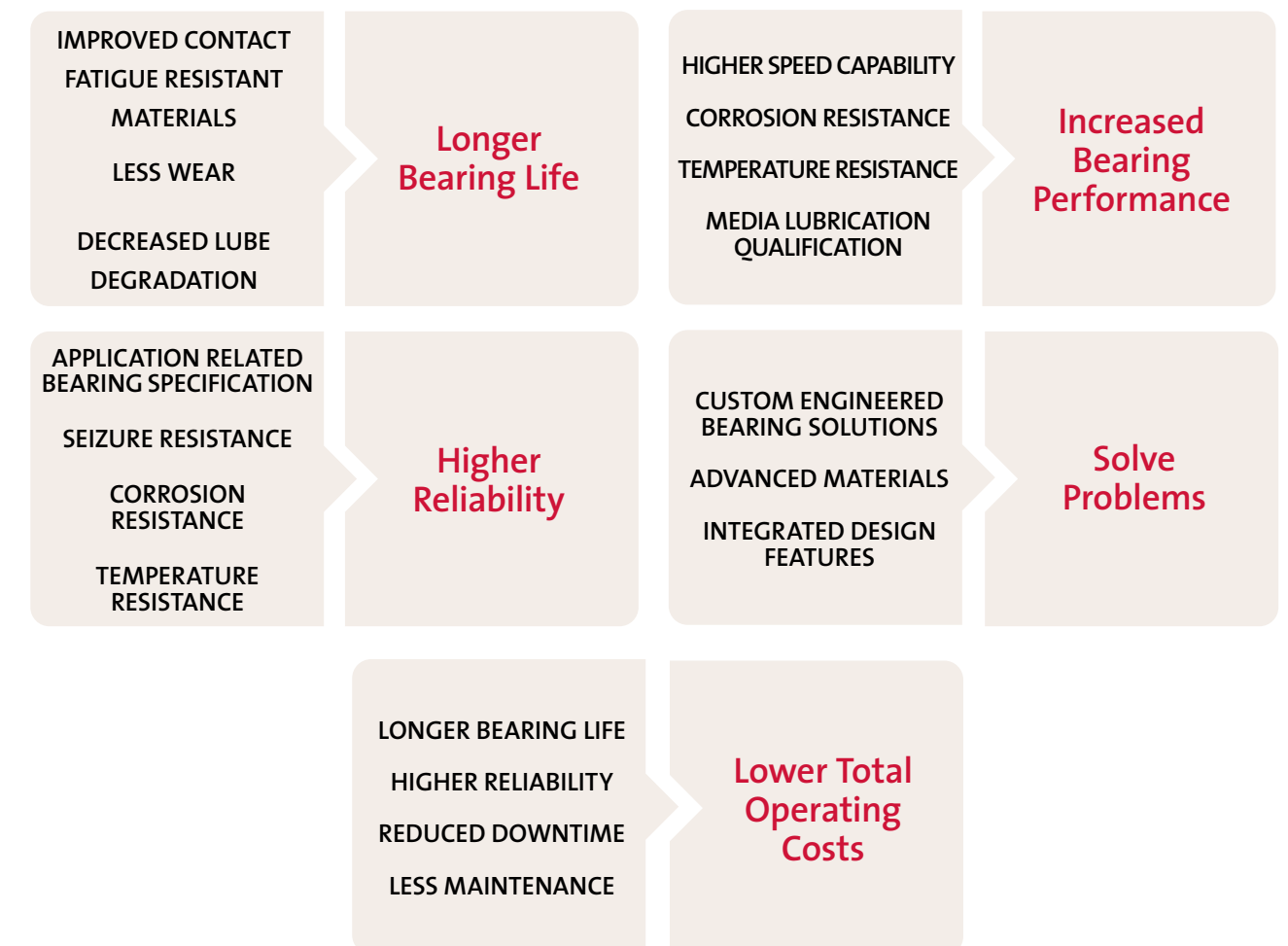
"Si₃N₄
Rolling Elements
Simply Make
Bearings Better."

4. Why Hybrid Ceramic Bearings?

[Table 3](#) shows how each Si₃N₄ material property or rolling element attribute adds to a long list of bearing improvements resulting in significant end user benefits. Si₃N₄ rolling elements simply make bearings better. For example, high hardness, smooth surface finish, and inertness lead to much less wear, and friction keeping lubricants cleaner, and cooler preventing degradation resulting in longer bearing life. High corrosion and electrical resistance further enable longer bearing life. Lighter weight results in higher speed capability.

4.1. CEROBEAR Hybrid Ceramic Bearing Technology Benefits

CEROBEAR has more than 30 years of experience in turning the properties of ceramics, higher grade steels and alloys into bearing performance. Only the careful consideration of material properties in combination with application specific bearing design leads to solutions which maximize the customer benefit.



CEROBEAR HYBRID CERAMIC TECHNOLOGY

Table 3: Why Hybrid Ceramic Bearings? Si3N4 Rolling Elements Make Bearings Better

MATERIAL OR PRODUCT ATTRIBUTE	DENSITY	HARDNESS [HV10]	ELASTIC MODULUS = STIFFNESS		COEFFICIENT OF THERMAL EXPANSION	SURFACE FINISH	BALL TO STEEL RACEWAY INTERACTION - DRY/POOR LUBE	CORROSION & ELECTRICAL RESISTANCE
Bearing Grade Si3N4 Balls - Grade 5	3.2 g/ccm	1550	320 GPa		2.8 [x 10^-6 /K]	0.005 micron	Si3N4-Bearing Steel, Not Possible to Cold Weld Bearing Steel-Bearing Steel, Cold Welds Easily Si3N4 TOTALLY INERT - CANNOT COLD WELD	Electrical Insulator, Ex- treme Corrosion Resistance
Typical Bearing Steel Balls - Grade 5	7.9 g/ccm	700	210 GPa		11.5 [x 10^-6 /K]	0.02 micron		Electrical Conductor, Low Corrosion Resistance
BEARING GRADE Si3N4 vs. BEARING STEEL	59% LIGHTER	129% HARDER	52% STIFFER		76% LOWER EXPANSION	75% SMOOTHER		SUPERIOR ELECTRICAL & CORROSION RESISTANCE
Ball Bearing Improvements								
Decreased Centrifugal Force	x							
Decreased Gyroscopic Moment	x							
Reduced Ball Skidding	x		x					
Less Friction	x		x				x	
Lower Operating Temperature	x		x		x		x	
Reduced Start-Up & Running Torque	x						x	
Lower Raceway Contact Stress	x						x	
Less Wear	x		x					x
Reduced Ball/Race Contact Area			x					
Minimum Ball Deformation			x		x			
Resists Hard Particle Contamination			x					
More Rigid			x					
Decreased Lube Degradation			x				x	
No Cold Welding/Adhesive Wear							x	
Eliminates Vibration induced False Brinelling							x	
Stable Running Pre-Load					x			
Reduced Contact Angle Change					x			
No Electrical Arcing Through Balls								x
Harsh Environment Durability								x
No Ball Degradation; Reduced Raceway Pitting								x
Ball Bearing User Benefits								
Higher Speed	x		x		x		x	
Longer Life	x		x				x	x
Expanded Design Possibilities	x							x
Lower Noise & Vibration			x				x	
Higher Precision Machinery			x					
Less Lube Needed							x	
Simpler Lube System Required (Grease vs. Oil)							x	
Increased Reliability							x	x
Reduced Energy Consumption	x		x				x	

CEROBEAR HYBRID CERAMIC TECHNOLOGY

Si₃N₄ rolling elements contribute to Bearing Improvements

HIGH WEAR RESISTANCE from extreme hardness

- Less wear debris in lubricant
- Lubricants stay cleaner and last longer
- Surface keeps smoothness over bearing life

EXTREME FATIGUE RESISTANCE from fine, needle shaped grain microstructure

- Far better than any metal leading to longer life

INERT due to covalent atomic bonding & structure identical to diamond

- No possibility of micro-welding or adhesive wear under poor lubrication
- Lubricants don't react with rolling element surface and last longer
- High corrosion and electrical resistance support longer life & higher performance

EXTREMELY SMOOTH SURFACE finish possible due to high hardness, stiffness, and fine grain structure

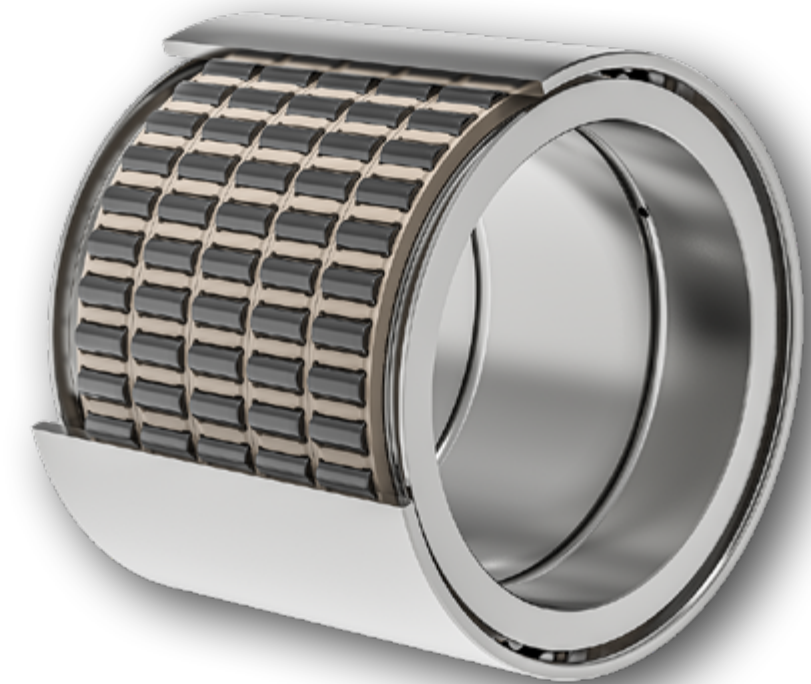
- Lower friction
- Reduced wear on counterpart in the rolling contact

LIGHT WEIGHT due to structure identical to diamond

- Higher Speed possible due to reduced centrifugal forces

5. Why Si₃N₄ Rolling Elements?

"Si₃N₄ rolling elements contribute to Bearing Improvements" on page 14 further shows how each Si₃N₄ rolling element attribute improves a bearing leading to higher reliability, increased performance, longer life, and lower total operating costs for the end-user. All these benefits of Si₃N₄ rolling elements result in hybrid ceramic bearings that last typically 2x to 100x longer than all-steel bearings of identical design.



Multiple Row Hybrid Ceramic Needle Roller Bearing

Outer ring: X30 CrMoN 15 1 (1.4108)

Inner ring: X30 CrMoN 15 1 (1.4108)

Rolling elements: Si₃N₄

Cage: PEEK, virgin

6. End-User Benefits of Hybrid Ceramic Bearings

Bearing users in all industries are continually demanding increased performance, reliability, and life while also requiring lower total operating costs.

6.1. Market Pull For Better Bearings

BETTER BEARINGS NEEDED

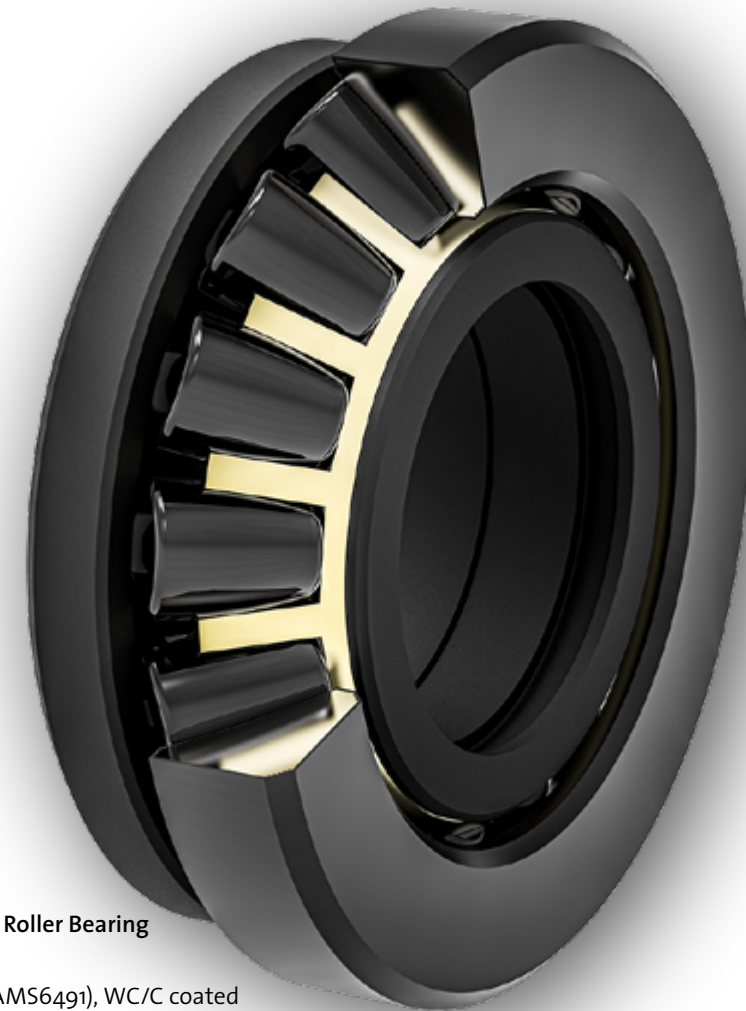
- Resistance to poor lubrication or dry running conditions or loss of lube situations
- Extended lubricant life and/or ability to use much less lubricant (grease instead of oil)
- Contamination and corrosion resistance
- Lighter weight and/or more compact designs
- Increased speed capability
- Increased temperature resistance
- Less overall wear to extend life and original equipment operating capability

TO MEET END-USER DEMANDS

- Lower maintenance cost, and lower total operating costs
- Increasing operating condition demands for temperature range, speed, loads, etc....
- Longer life, higher reliability, increased performance

CEROBEAR hybrid ceramic bearings are custom-engineered and manufactured via co-engineering cooperation with our customers to meet all their application demands. We serve a wide range of applications in Aerospace, Motor-Sport, and, Industrial market segments with a wide range of hybrid ceramic ball and roller bearings from 6.35 mm bore to 508 mm outer diameter in size.

CEROBEAR's focus on highly controlled materials and processes ensures our hybrid ceramic bearings deliver the highest reliability, best performance, longest life, and lowest total operating costs for the optimal bearing solution.



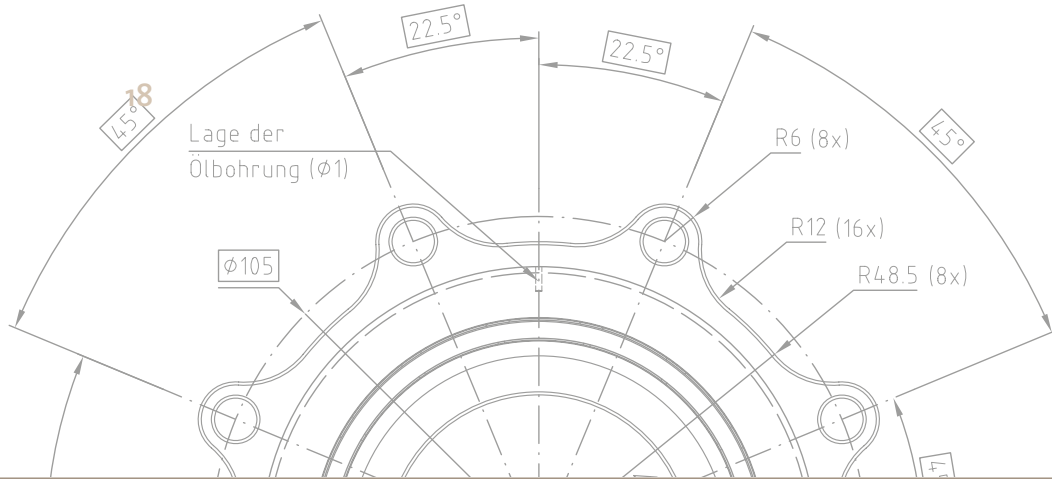
Thrust Hybrid Spherical Roller Bearing

Housing washer: M50 (AMS6491), WC/C coated

Shaft washer: M50 (AMS6491), WC/C coated

Rolling elements: Si₃N₄

Cage: Al-Bronze



We welcome your enquiries from around the world
and look forward to hearing from you.

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technology and products, please contact us:

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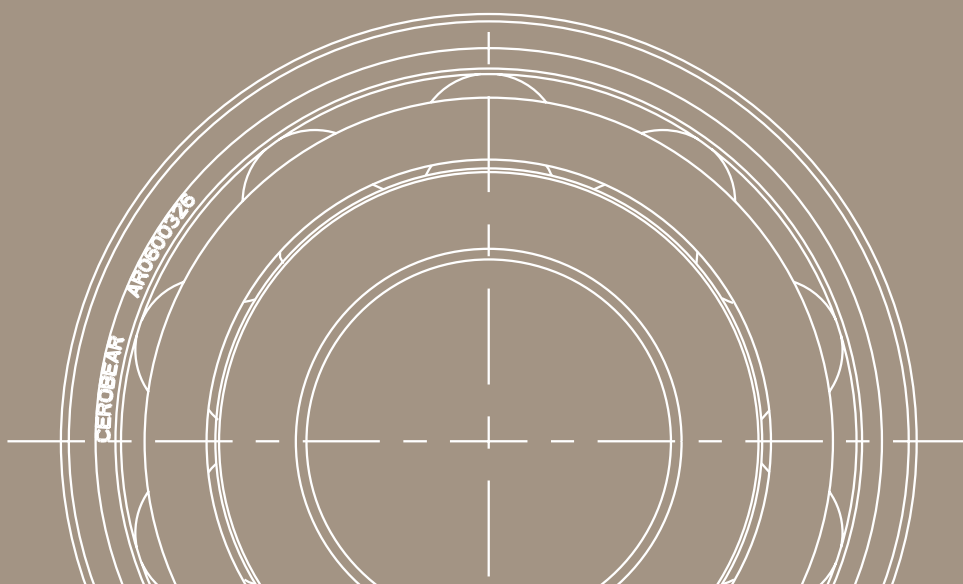
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