Technical Ceramic solutions for the Oil & Gas market

for severe service environments

Innovative solutions for severe service environments in Oil & Gas applications

Contents

Our outstanding capability for the manufacture of complex components is supported by our team of experienced technical specialists, design engineers and applications experts.

We work in partnership with our customers to develop competitive tailored solutions to meet their needs.

As well as manufacturing in over 30 different countries, our global network of Centres of Excellence are focused on delivering differentiated materials technology and scalable process solutions for current and future technologies.

Our Centres of Excellence are at the forefront of development in:

- Structural Ceramics
- Metals and Joining
- Carbon Science
- Insulating Fibre

Our team of experienced technical specialists and design engineers will work with you to develop solutions that meet your specific requirements

Nilcra® Zirconia range

Originally referred to as “Ceramic Steel” Nilcra® Zirconia is a unique toughened ceramic material known as Mg-PSZ (Magnesia Partially Stabilized Zirconia).

It has exceptionally consistent material properties with high strength and toughness, excellent corrosion resistance and is much harder than metals. These properties provide a solution for wear and corrosion in severe service environments.

Morgan’s range of Nilcra® Zirconia’s include both Mg-PSZ with our MS and TS grades and 3Y-TZP with HIP’ed options so we can select the right material for your application.

Nilcra® Zirconia’s are frequently used to replace conventional metal alloys, hardened steels and tungsten carbides that suffer from wear and corrosion and are therefore used in a wide variety of severe service industries experiencing high maintenance costs, high downtime costs and poor product quality that is a consequence of lack of process control.

Nilcra® Zirconia’s are used in industries as diverse as oil and gas, mining, food and battery production have enjoyed the benefits of long life, high production rates and low maintenance.

MACOR Machining China Inc. Australia were the first licensee of the original Mg-PSZ material patent and have been making this material for over thirty years still producing the strongest and most reliable version of this material in the world.

Our Nilcra® range of zirconia provides:

- High mechanical strength and fracture toughness to survive the application environment
- Exceedingly high resistance to corrosion
- Erosive and abrasive wear resistance
- Excellent resistance to cavitation

Our grades of Nilcra® Zirconia include:

Most reliable ceramic properties

These are the most mechanically reliable grades of ceramic in the world with a Weibull Modulus over >30, providing peace of mind that components will perform the same every time.

- **Nilcra® Zirconia MS** – “Maximum Strength” grade ideal for wear and corrosion solutions and used extensively in materials handling industries.
- **Nilcra® Zirconia TS** – “Thermal Shock” grade provides high resistance to thermal shock and is used in non-ferrous metal extrusion applications.
- **Nilcra® Zirconia 3Y-TZP** – A fine grain grade extensively used in the Petrochemical industry and for applications required to maintain a sharp edge.
- **Nilcra® Zirconia HIP’ed 3Y-TZP** – An ultra-high density grade used widely in the manufacture of food and beverage cans.

MACOR Machining China Inc. Australia were the first licensee of the original Mg-PSZ material patent and have been making this material for over thirty years

Nilcra® ZIRCONIA MS

Nilcra® ZIRCONIA TS

Nilcra® ZIRCONIA 3Y-TZP

Nilcra® ZIRCONIA HIP’ed-3Y-TZP

Industries served include:

- Severe service valves and pumps
- Mineral processing
- Food processing
- Scientific instrumentation
- Canneries
- Metal forming
- Wire drawing
- Materials handling
- Power stations

Nilcra® SSN E 'Engineering Grade'

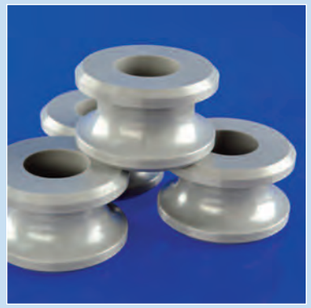
Nilcra® SSN E grade is an exceptionally reliable material designed for applications demanding high strength, toughness, corrosion and wear resistance even at very high temperatures of 1000°C (1832°F).

Key features of Nilcra® SSN E Engineering Grade:

- **Mechanical:** Nilcra® SSN E, a tough monolithic ceramic material that maintains strength and hardness even at high temperatures, making it highly resistant to wear, deformation, galling and corrosion. SSN E has a low coefficient of friction.

- **Engineering:** Due to its reliability and toughness Nilcra® SSN E Engineering Grade can be used to manufacture highly engineered and reliable ceramic components. Additionally highly polished surface finishes can be achieved for applications such as tube metal forming, e.g. extrusion and tube welding.

- **Temperature:** Nilcra® SSN E Engineering Grade has better high temperature capabilities than most conventional metals combining retention of high strength and creep resistance with corrosion resistance. In addition, its low thermal expansion coefficient gives good thermal shock resistance compared with most other ceramic materials.



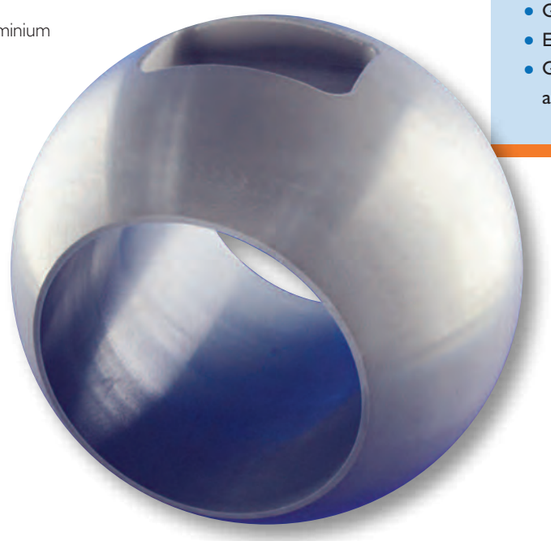
Nilcra® SSN E

Engineering grade offers:

- High temperature strength
- Superior thermal shock resistance
- Excellent wear resistance
- Good fracture toughness
- Excellent mechanical strength
- Good resistance to corrosion and erosion

Typical Nilcra® SSN E applications include:

- Severe duty valves and pumps
- HF weld rolls for steel and aluminium tube production
- Scientific instrumentation
- Canneries
- Wire drawing
- Molten metals handling



Nilcra® Sintered Silicon Carbide

An Alpha sintered silicon carbide, Nilcra® Sintered Silicon Carbide has a combination of hardness, strength, and temperature resistance giving it excellent capabilities for service in a wide range of applications where chemical, erosion and abrasion resistance is demanded.

The high thermal conductivity allows it to be used where high surface speeds or high pressures demand the heat generated be safely conducted away. Nilcra® Sintered Silicon Carbide is an excellent counter face material when paired with premium mechanical carbon grades.

Due to its non-toxicity Nilcra® Sintered Silicon Carbide can be used for applications in the food industry.

Applications for Nilcra® Sintered Silicon Carbide include:

- Valve and pump components
- Wear resistant components
- Mechanical seal faces
- Nozzles
- Bearings and bushings

Nilcra® SSN E grade is a super hard but robust material designed for applications demanding high strength, toughness, corrosion and wear resistance even at very high temperatures of 1000°C (1832°F)

Zirconia and Silicon Nitride Oil and Gas products

Oil and Gas providers are faced with increasing challenges for resilient, wear resistant materials and solutions to manage projects within harsh environments. Customers within these industries are looking for greater durability and more robust options to replace traditional materials.

Nilcra® Zirconia range provides:

- High mechanical strength and fracture toughness
- Chemical wear resistance to the vast majority of reagents and abrasive slurries
- Corrosion and abrasion wear resistance
- Excellent resistance to cavitation – the killer of process control valves

Nilcra® SSN E range provides:

- High strength at ambient and high temperatures up to 1000°C (1832°F)
- Excellent fracture toughness
- Extremely high hardness and wear resistance
- Low coefficient of thermal expansion
- Very high thermal shock resistance
- Excellent corrosion resistance in acids and alkaline

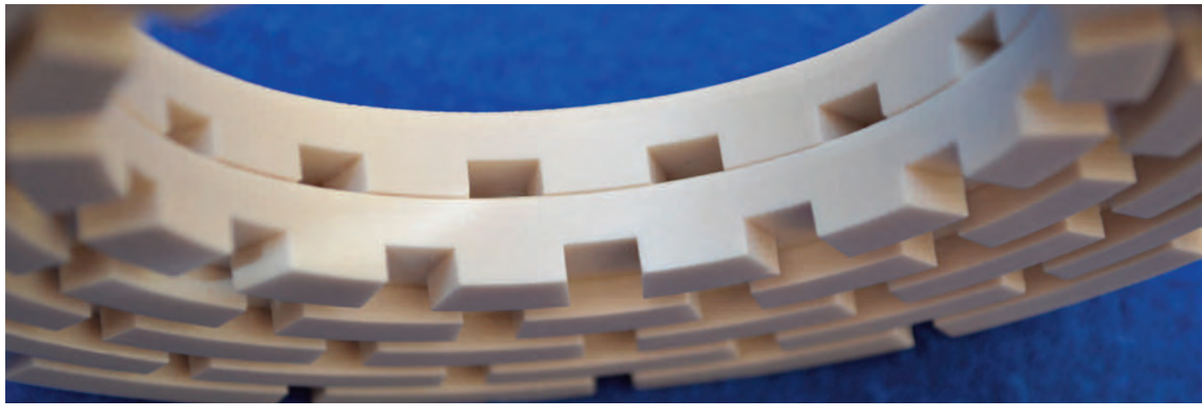
Our materials are found in products that are evident in a wide range of applications including:

- Directional drilling tool components,
- Ball valves
- Control valves, (plugs, seats and cages)
- Frac buttons
- Pump plungers
- Dosing / metering pumps
- Liners and sleeves
- Pipeline inspection

Zirconia Pump and Valve products

We use our advanced ceramic materials to make high performance valve components for corrosive and abrasive fluid flows in demanding processing environments such as chemical processing, paper and pulp manufacturing, oil and gas extraction and refining. The range includes options for ball valves, butterfly valves and rotary and linear control valves.

Our valve components are made using Nilcra® Zirconia, an advanced ceramic material that is strong, tough and highly resistant to chemical reagents and abrasive slurries. It provides a reliable, high performance option where other materials tend to fail, even in the most challenging process applications, because it offers excellent resistant to cavitation, a major problem for process control valves. Used for critical duties in high value processing environments, Nilcra® Zirconia valve components offer processors the potential for substantial savings in downtime and valve repair costs. As a result, processors and their equipment suppliers are increasingly demanding it for use in applications that use difficult chemicals such as sour oil, bitumen, bleached wood pulp, concentrated sodium hydroxide, bauxite (alumina), lime slurries and sulphur dioxide (SO_2).



Nilcra® products provide a reliable, high performance option where other materials tend to fail, even in the most challenging process applications

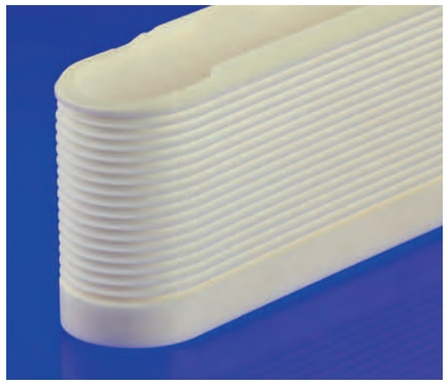
Alumina materials for Oil and Gas applications

Alumina is the most widely used technical ceramic material, due to its combination of mechanical and electrical properties. Each Morgan alumina grade is tailored to optimise a specific property, giving a versatile range of bespoke material choices for a wide range of applications.

Typical characteristics of alumina include:

- High compressive strength and stiffness
- Good stability at elevated temperatures
- Good hardness and wear resistance
- Good corrosion resistance
- Excellent dielectric properties for electrical insulation
- Suitability for metallising and brazing
- Long service life compared to other material options, particularly in demanding environments
- Excellent cost to performance ratio, compared to other ceramic and non-ceramic alternatives

Our Materials experts are able to suggest the material grade best suited to meet the requirements of each specific application.



Our grades of alumina include:

- **Deranox 975 (97.5% alumina)**
  Fine grain material optimised for dynamic applications where resistance to abrasion and chemical attack are essential, such as hydrocyclone liners and cementing components.

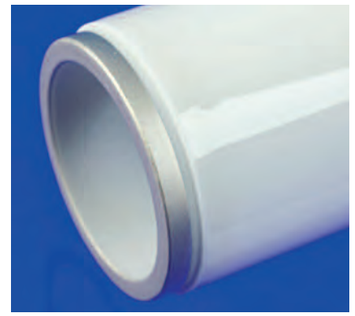
- **Deranox 970 (97.0% alumina)**
  High dielectric strength material that can be metallised for high-temperature brazing of assemblies. Optimised for high-vacuum systems and consistent electrical connectivity.

- **Deranox 995 (99.5% alumina)**
  Highest purity grade for applications requiring exceptional electrical resistance combined with resistance to chemical attack.

Glazes and coatings

Morgan glaze bonding process ensures a strong, reliable joint between ceramic components. This enables large multi-piece components, and complex internal geometries not possible in a single piece. Glaze can also be offered to give a smooth, protective and wipe-clean surface. Materials for metallisation include molybdenum-manganese, copper, precious metals and conductive paste for a circuit path or face.

Charge dissipative coatings enable equipment manufacturers to optimise performance at higher voltages and reduced component size. Our range of coatings reduce surface charging effects and enable operation at high voltages with tailorable surface resistivity.

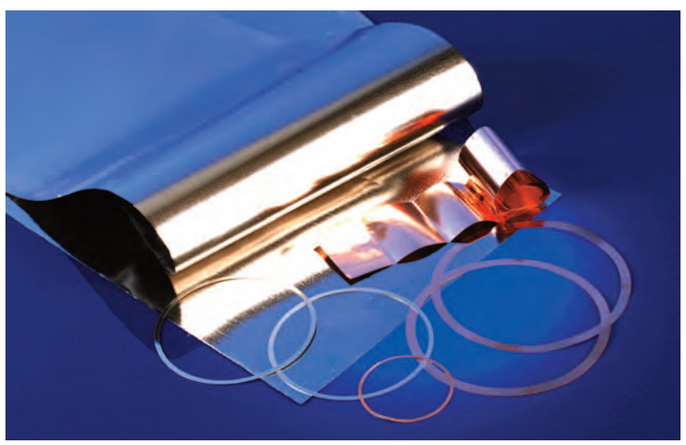


Morgan WESGO braze alloys

Morgan's wide range of precious and non-precious brazing filler metals are manufactured in various forms such as sheets, disc, rings, wire and paste. These low-vapour pressure brazing alloys are used in our brazed assemblies, with Morgan the only manufacturer able to offer a fully vertically integrated brazing solution using our own manufactured ceramic, metallising inks and braze alloys.

As well as our range of standard metals, if required our braze alloys can be tailored to specific requirements for optimisation of the braze joint.

All parts are manufactured bespoke to customer requirements. Information and datasheets are available on request for our full range of alumina, coatings and brazes.



Alumina is the most widely used technical ceramic material, due to its combination of mechanical and electrical properties

Hydrocyclone liners for the Oil and Gas market

Morgan manufacture robust ceramic liners for hydrocyclone sand separation systems widely used in the oil and gas industry.

Designed to withstand the harsh operating environment, Morgan's proprietary Deranox 975 alumina ceramic grade is specially formulated for wear resistance and mechanical strength. Superior glaze bonding technology facilitates high strength joining of liner components, allowing complex internal flow geometries whilst minimising risk of joint breakage. Tests have shown that the bond strength exceeds the ceramic strength, ensuring a strong and reliable assembly with a long-lasting service life.

Larger hydrocyclone liners can be custom built in multiple sections using specially formulated joint technology. Proven for lengths up to 1.2m and internal diameters up to 250mm, the technology is scalable to larger sizes where requested.

The longer overall lifespan of Morgan's hydrocyclone liners reduces both total cost of ownership and downtime compared to other material solutions. Our liners reliably protect downstream equipment and enable users to save costs associated with maintenance and replacement parts.

Investment in process engineering, prototyping and development capability allows Morgan to continue delivering hydrocyclone liners that are truly best in class.

Morgan hydrocyclone liners offer:

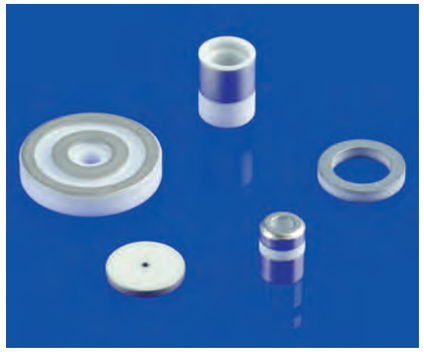
- Proven ceramic grades with high wear resistance and mechanical strength
- Superior bonding system giving longer lifetime
- Experienced custom design and prototyping service, including 3D printed models
- Full volume production capability
- Range of sizes available, with extensive experience up to 1.2m length and up to 250mm internal diameter

Metallised products and ceramic-to-metal connectors

Morgan's brazed ceramic-to-metal assemblies are used to transmit fluids, energy or data through a hermetically sealed barrier.
The combination of electrical insulation provided by the ceramic and strong, hermetic braze joints offer a solution with distinct advantages over glass or polymer alternatives.

The drive to maximise efficiencies in the oil and gas industry is leading to increasingly demanding temperature and pressure environments. Morgan work directly with customers to engineer bespoke solutions that meet the requirements of the specific application, through materials selection and braze joint design coupled with decades of manufacturing expertise.
The resulting connector is designed and manufactured to maintain electrical properties and joint integrity at ultra-high levels of vacuum, elevated temperatures and pressures required in downhole and subsea applications.

Morgan offer a truly vertically integrated solution, combining proprietary ceramic grades, bespoke metallising inks and WESGO braze metals.



Benefits of Morgan ceramic-to-metal connectors include:

- Proven ceramic grades with high dielectric strength maintained at high temperature and pressure, outperforming glass and polymer alternatives such as PEEK
- Resistance to harsh, corrosive chemical environments
- Hermetic assemblies, 100% helium leak tested to 10^{-9} mbar l/s
- Precision assemblies for optimal connections to subsystems and devices
- Design expertise, digital prototyping and simulation capabilities
- Full volume production capability
- Proprietary braze metals and tailored metallising inks
- Capability to braze large assemblies where inferior adhesive or mechanical joining would otherwise have to be used

The drive to maximise efficiencies in the Oil & Gas industry is leading to increasingly high temperature and pressure requirements

Properties and materials overview

Properties [1]	Units	Magnesia Partially Stabilized Zirconia		Yttria Tetragonal	Zirconia Polycrystal	Silicon Nitride	Silicon Carbide	Alumina[5]		
		Nilcra® Zirconia MS Grade	Nilcra® Zirconia TS Grade	Nilcra® Zirconia 3Y-TZP	Nilcra® Zirconia HIP'ed 3Y-TZP	Nilcra® SSN E	Nilcra® Sintered Silicon Carbide	Deranox™ 970 (97.0%)	Deranox™ 975 (97.5%)	Deranox™ 995 (99.5%)
Density	g/cm³	5.74	5.74	6.05	6.08	3.21	3.1	3.74	3.8	3.89
Fracture Toughness	MPa√m	12	>12	10	10	8	3	3.5	3.6	Data not available
Flexural Strength [2]	MPa (kpsi)	820 (118)	650 (94)	1000 (145)	1400 (203)	650 (94)	450 (65)	280 (41)	350 (51)	330 (48)
Weibull Modulus [3]		>30	>30	20	20	15	12	Data not available	Data not available	Data not available
Compressive Strength	MPa (kpsi)	1990 (289)	1800 (273)	2300 (334)	2300 (334)	3500 (435)	3000 (435)	2000 (290)	2500 (363)	2000 (290)
Hardness, Vickers	Hv 0.3 kg/mm²	1120	1020	1300	1350	1630	2650	1305 (@Hv0.5 kg)	1529 (@Hv0.5 kg)	1458 (@Hv0.5 kg)
Modulus of Elasticity	GPa (x10⁶ psi)	205 (30)	205 (30)	205 (30)	205 (30)	320 (46)	400 (58)	330 (48)	340 (49)	370 (54)
Poisson's Ratio		0.31	0.31	0.3	0.3	0.28	0.16	Data not available	Data not available	Data not available
Average Grain Size	µm	40	45	0.4	0.4	1 - 10	1 - 5	14	4	10
Electrical Resistivity	ohm.cm	>10 [11]	>10 [11]	>10 [11]	>10 [11]	>10 [12]	>10 [4]	>10 [15]	>10 [16]	>10 [15]
Thermal Conductivity	W/m.K (BTU/hr/ft.°F)	3.08 (1.8)	3.05 (1.8)	3.0 (1.7)	3.0 (1.7)	25 (14)	125 (72)	24 (14)	24 (14)	31 (18)
Coefficient Thermal Expansion	x 10⁻⁶/°C (/°F)	10.2 (5.7)	9.9 (5.5)	9.0 (5.0)	9.0 (5.0)	3.2 (1.7)	3.2 (1.7)	8.1 (4.5)	8.1 (4.5)	7.8 (4.3)
Specific Heat	J/g.K	0.47	0.47	0.5	0.5	0.65	0.67	0.88	0.88	0.88
Thermal Shock Resistance, ΔT	°C (°F)	375 (705)	500 (930)	200 (390)	200 (390)	600 (1100)	900 (1650)	150 (302)	190 (374)	160 (320)
Maximum No-Load Temperature	°C (°F)	800 (1472)	800 (1472)	800 (1472)	800 (1472)	1200 (2192)	1650 (3002)	1550 (2822)	1600 (2912)	1500 (2732)
Dielectric Constant	@1MHz	27 (@10GHz)	22 (@10GHz)	Data not available	Data not available	8	Data not available	9.2	9.6	9.97
Dielectric Strength [4]	kV/mm (V/mil)	40 (1020)	Data not available	33 (838)	Data not available	Data not available	Data not available	30.6 (777)	20 (508)	30.5 (775)
Colour		White	White	White	Grey	Black	Black	White	White	Ivory

* All values quoted are based on test pieces and may vary according to component design.
These values are typical and should be treated as indicative and for guidance only.

Notes:
1. Testing carried out at room temperature 20°C (70°F).
2. Four point bend test for zirconia, SSN, SSC. Three point bend test for alumina.
3. Calculated from production batch flexural strength data.
4. Sample thickness 0.33±0.02mm (Deranox 970, Deranox 995); 2-3mm (Deranox 975).
5. Alternative alumina grades available with different properties. Datasheets and further information available on request.

Deal direct with the manufacturer