CONTAINMENT SHELLS FOR THE PUMP INDUSTRY

High-performance ceramics

WELL-ESTABLISHED ON THE MARKET

Top performance for modern sealing systems
In the further development of modern sealing systems in pump construction, the magnetic coupling has established itself as the leading technology. A central element of these systems is the containment shell made of oxide ceramic – a material that sets standards with its magnetic, corrosive and mechanical properties.

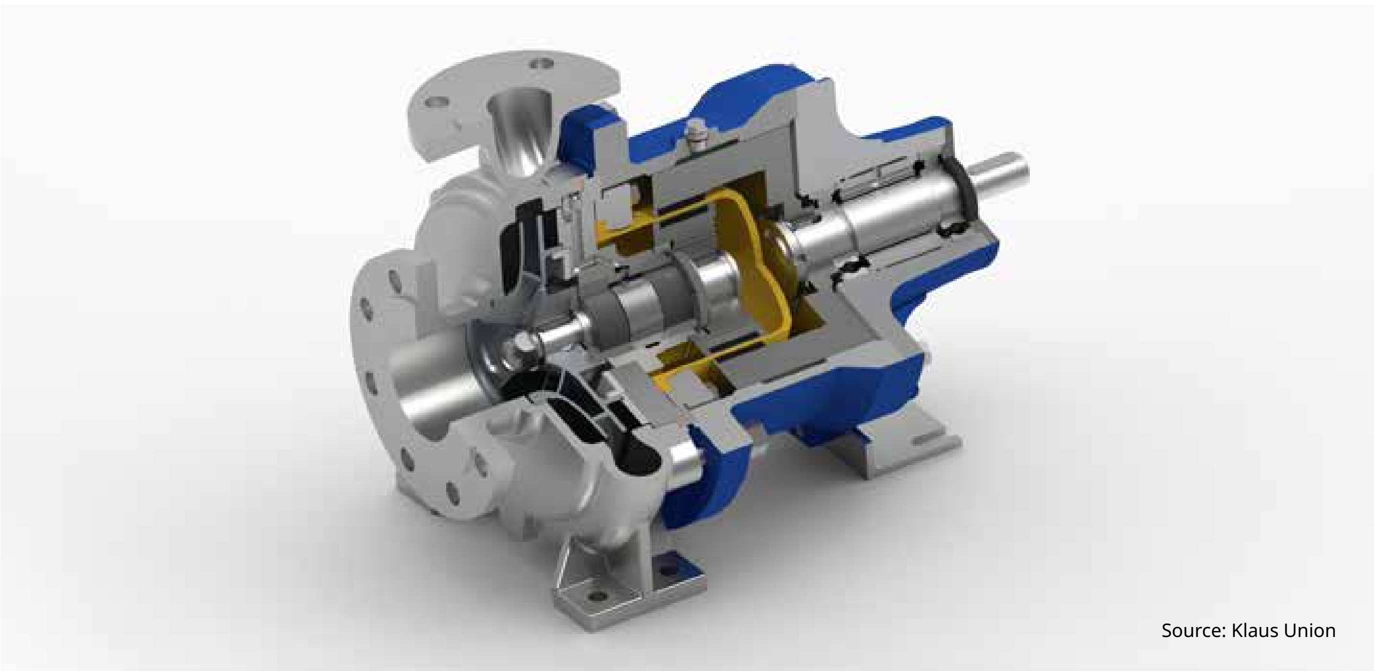
Customised development – precise manufacturing
With over 20 years of experience and in close cooperation with our customers, we develop customised containment shells that are optimally adapted to the respective application. Every year, we manufacture over 1,000 units, guaranteeing the highest precision and quality.

Containment shells protect pumps, environment and employees

TECHNICAL CERAMICS FROM KYOCERA

Magnetically coupled centrifugal pumps require non-magnetic components highly resistant to mechanical forces and corrosion. High-performance ceramics hold suitable material properties to meet such exceptional combination of requirements.

Magnetic couplers ensure hermetic sealing of the pump against the drive. Minimum maintenance requirements allow for leakagefree operation. This prevents any environmental impact caused by spilt pumping media from the outset.



Source: Klaus Union

Meeting highest pumping standards

Compared to conventional materials, containment shells made of high-performance ceramics hold the following benefits:

- **Zirconia is not electrically conductive** - eliminating the creation of performance-impairing eddy currents and reducing electrical drive power by 10 to 15%. In addition, eddy current losses generate up to 20 kW of heat, which can pose a safety risk depending on the process and the pumped media. For substances close to boiling point or explosive materials, additional heat input should be avoided. This can minimise hazards from any boiling distortions or deflagrations that may occur.
- **Zirconia is corrosion-resistant** - allowing for universal application to virtually all acids and bases.
- **Zirconia offers high mechanical stability** – depending on the size of the inner diameter, test pressure conditions up to PN 63 bar can be achieved at temperatures from 200 °C to 450 °C and more.
  A relatively small elastic modulus ensures a certain elastic deformation capacity.

To keep the magnetic split as little as possible the wall thickness in the cylindrical section of the containment shell ranges between 1.5 and 3 mm, only – again depending on the inner diameter.

Thanks to the above-mentioned properties, containment shells made from advanced ceramics for magnetically coupled pumps stand for the ideal choice for any application in the chemical industry. The design of the containment shell is adapted to the individual pump type specified by our customers.

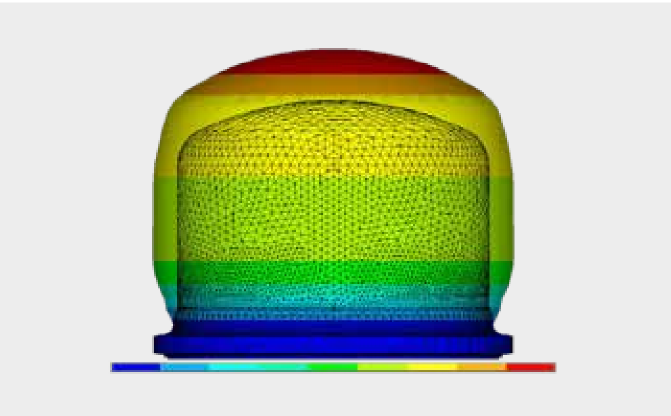
The optimal design of the transitions to the dished end and to the flange base allows for a smaller wall thickness of the containment shell and thus a more

ZIRCONIA FZM AND FZM+

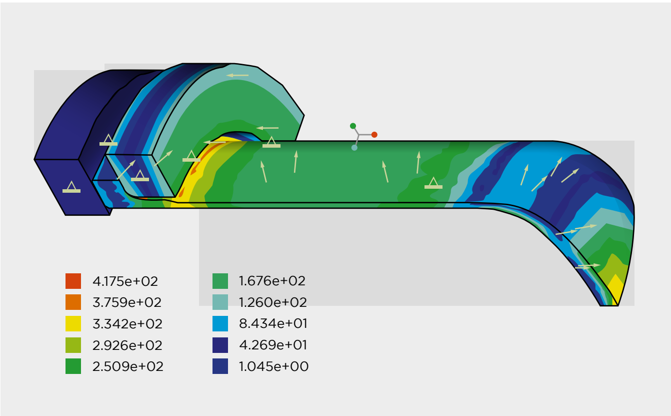
FZM has well proven as an ideal ceramic material characterised by high fracture toughness as well as wear and corrosion resistance. Low thermal conductivity, excellent thermal shock resistance and superb thermal expansion properties comparable to cast iron round off the unique features of the material.

With the further development of FZM+, the application range of our components can be extended even further.

The white zirconia is characterised by higher flexural strength and high fracture toughness. This allows test pressures of up to 95 bar (pressure rating PN 63) for a temperature range from -200 °C to over 450 °C. This makes the material suitable for use in cryogenic applications as well as for external pressure applications in cans with gas as the medium.



Global deformation (50-fold stilted presentation)
Pressure: inner pressure 36 bar, inner temperature 250 °C



FE evaluation assembly

Mechanical and physical properties of the material (typical)

Material Type: Magnesia partially stabilized zirconia (Mg-PSZ) (ZrO_2, MgO)

Characteristic	Standard	Specification	Unit	FZM	FZM+
Content			[%]	> 99.7	≥ 99.9
Density (ρ_b)	DIN EN ISO 18754		[g/cm³]	≥ 5.70	≥ 5.75
Open (apparent) porosity (π_a)	DIN EN ISO 18754		[vol-%]	0	0
Average size of crystallites (g_{mli})	ISO 13383-1	A1	[µm]	50	25
Flexural strength ($\sigma_{f,4}$)	DIN EN 843-1	Three-Point-Bending	[MPa]	718*	800
Weibull modulus (*m*)	EN ISO 20501		[-]	> 15	> 20
Fracture toughness ($K_{1c,\ SEVNB}$)	DIN EN ISO 23146	SEVNB	[MPa·m^{0,5}]	6.3	8.7
Compressive strength ($\sigma_{c,m}$)	DIN ISO 17162		[MPa]	2000	2000
Young's modulus of Elasticity (*E*)	EN 843-2	dynamic	[GPa]	207	215
Poisson's ratio (μ)	EN 843-2	resonance	[-]	0.31	0.32
Vickers Hardness (HV 1.0)	DIN EN ISO 14705	Procedure A	[GPa]	12.0	11.8
Maximum service temperature (T_{max})		in air	[°C]	900	900
Mean coefficient of linear thermal expansion ($\bar{\alpha}$)	DIN EN ISO 17562	-100 – 20 °C -75 – 20 °C 20 – 100 °C 20 – 500 °C 20 – 900 °C	[10^{-6}/K]	7.7 - - 10.4 10.6	- 7.8 9.3 10.3 -
Specific heat capacity (c_p)	DIN EN 821-3	20 °C	[J/(kg·K)]	400	400
Thermal shock resistance	DIN EN 820-3	R_1, Type A, in water	[°C]	250	-
Thermal conductivity (λ)	DIN EN ISO 18755	20 °C 250 °C 500 °C 900 °C	[W/m·K]	3 - 2.3 2	3.8 3.5 - -
Volume resistivity (ρ)	DIN EN 62631-3	20 °C 900 °C	[Ω·cm]	10^{10} 84	10^{10} -
Dielectric strength	DIN EN 60243-1		[kV/mm]	> 30	-
Typical colour			[-]	yellow	white

* Conversion based on measured values obtained from four-point bending

The preliminary remark in DIN 60672-2 applies analogously to the property values given in the table, according to which the reported values apply only to the test specimens on which they were determined. Assignment to other forms is therefore only conditional permissible. The reference values given are to be understood as such. They refer to a temperature of 20 °C, unless otherwise stated.

The material is extremely resistant to corrosion. We should be pleased to send you brochures about the corrosion resistance of oxide ceramics.

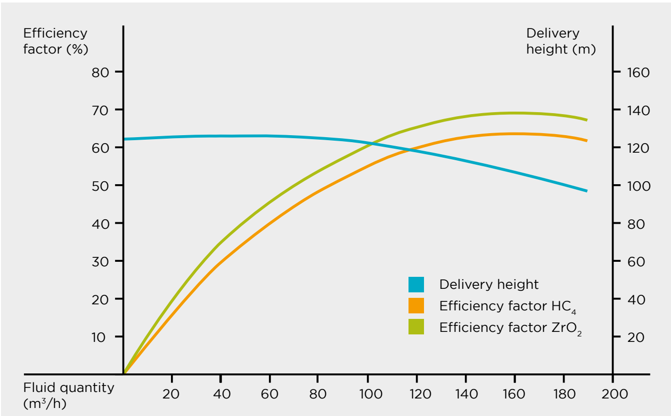
ENERGY EFFICIENCY

Electric drives in industry and commerce consume almost two-fifths of all electricity in Germany. In these two sectors, their share of electricity consumption is even around 80%. The Federal Environment Agency, for example, calculates that the use of energy-efficient pumps alone could save around 5 bn kWh of electricity[1]. The latest climate balance published by the Federal Environment Agency states that this would correspond to around 401 kt of CO2 in 2019. Assuming an electricity price of 15 ct/kWh, the industries concerned could also reduce their energy costs by around EUR 750 m.

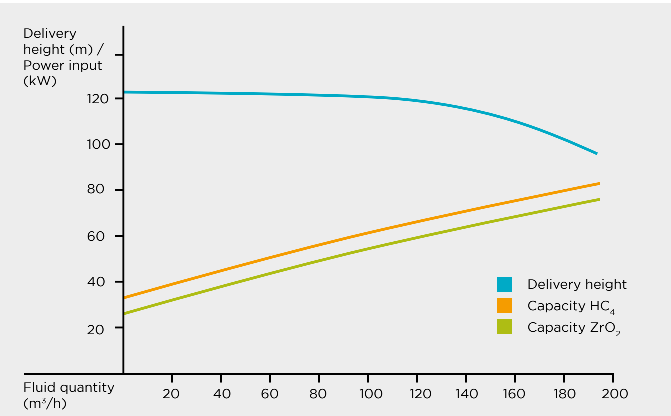
Against this background, magnetic drive pumps with metallic containment shells are increasingly coming into focus. The power loss generated in these systems has a negative effect on the efficiency of the pumps and causes a high proportion of the energy costs incurred.

Unlike metallic containment shells, ceramic containment shells are not capable of being magnetized. Eddy currents that reduce performance are prevented and energy efficiency is significantly improved It is therefore possible to reduce the drive power of a pump by up to 15%.

[1] Source: https://www.umweltbundesamt.de/themen/klimaenergie/energiesparen/energiesparen-in-industriegewerbe#energieeinsparpotenziale



Comparison of efficiency ceramics / steel;
Source: Klaus Union



Comparison of power input ceramics / steel;
Source: Klaus Union

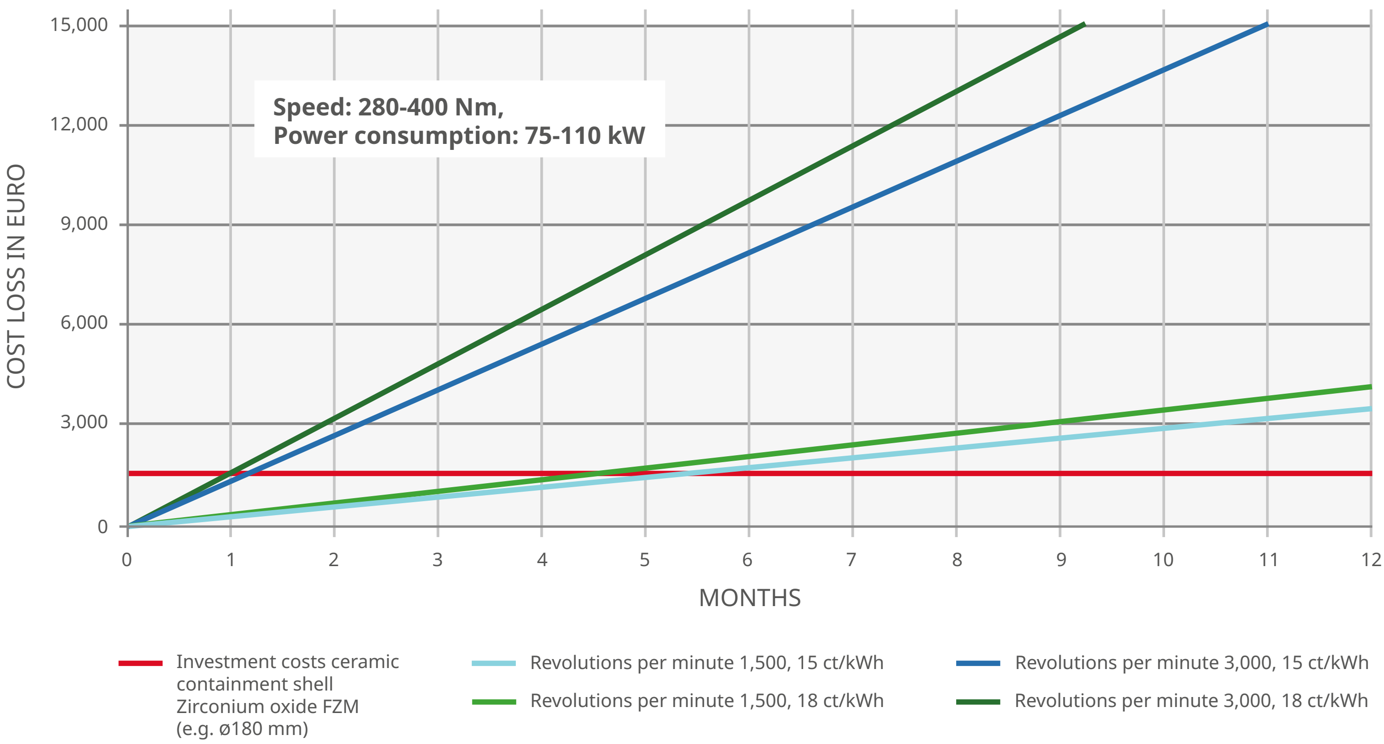
Investment in the future

Magnetic coupling with metal containment shell

Revolutions per minute [rpm]	1,500	3,000
Power loss [kWh]	20,000	100,000
Cost loss at 12 ct/kWh [Euro]	2,600	13,000
Cost loss at 15 ct/kWh [Euro]	3,300	16,000
Cost loss at 18 ct/kWh [Euro]	4,000	20,000
Cost loss at 3 ct/kWh [Euro]	650	3,300
CO_2 reduction [kg]	13,400	68,000

Assumptions: 8,000 operation hours per year, speed with 280-400 Nm, power consumption with 75-110 kW

Costs due to eddy current loss with metallic containment shells

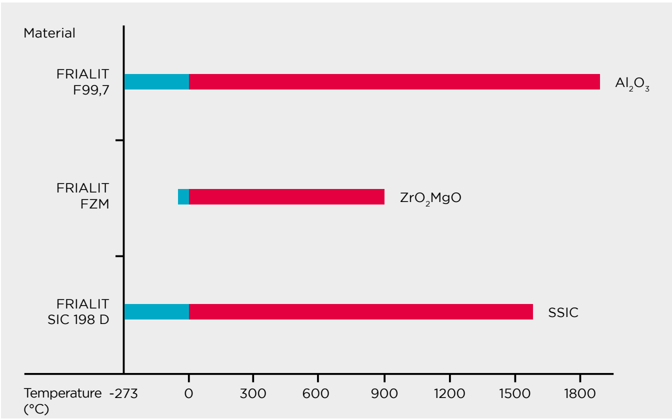


CONCEIVED FOR AGGRESSIVE PUMPING MEDIA

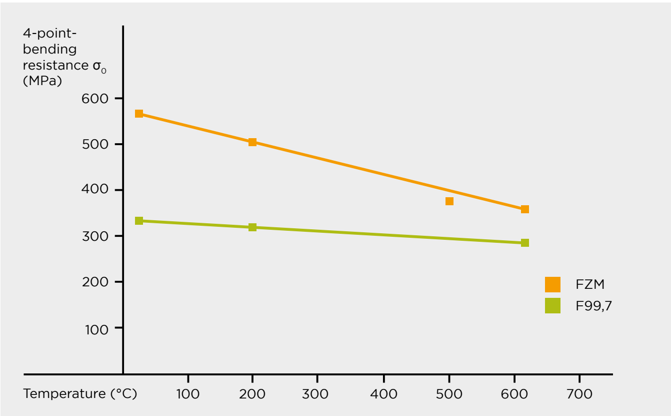
Containment shell made of zirconia are used for pumping widely varying and – in particular – very aggressive media.

These can be, e.g. heat transfer oils that are pumped up to temperatures of 350 °C or heavy oils that are pumped up to 160 °C.
Other chemicals such as methanol, acrylamide, propane, ethylene oxide, nitric acid, phenol, etc. are pumped at temperatures between -30 °C and 250 °C.

To protect the ceramic material against the extremely aggressive hydrofluoric acid (HF) the inner surface of the containment shell may be coated with a chemically resistant and pore-free lining.



Operating temperature of oxide ceramic materials applied in oxidizing atmosphere



Bending resistance in relation to temperature

Excellent materials containing corrosion

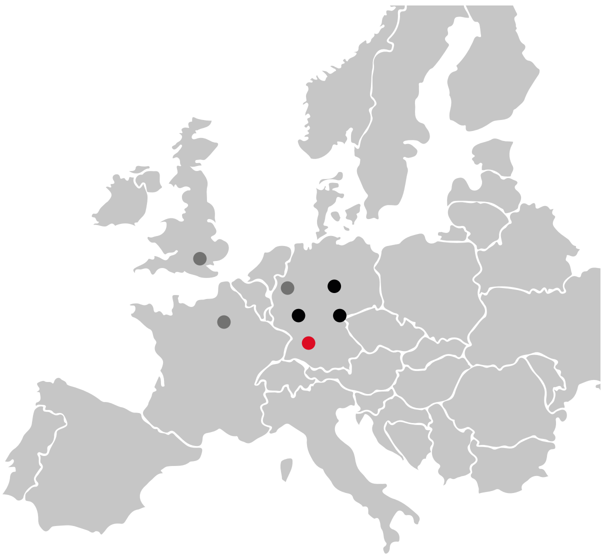
Corrosion resistance list

Agent	Chemical formula	Concentration (%)	Temperature (°C)	F99.7	FZM / FZM+
Methanol	CH_3OH	all	Rt	A	A
Phenol	C_6H_5OH	pure	Rt	A	A
Nitric acid	HNO_3	7	Rt	A	A
Hydrochloric acid	HCI	0.5	Rt	A	A
Sulfuric acid	H_2SO_4	2	Rt	A	A

Excerpt. Full list available on www.kyocera-fineceramics.de.

A resistant
Rt room temperature

ABOUT KYOCERA



The global Kyocera corporation - a strong partner.

- **Headquarters:** Kyoto, Japan
- **Foundation:** 1959
- **Employees:** over 80,000 worldwide
- **European headquarters:** Esslingen, Germany
- **European production sites:** Mannheim, Germany
Selb, Germany
Erfurt, Germany
(further subsidiaries in Europe)

KYOCERA = KYOTO CERAMICS

KYOCERA – it all began with ceramics

KYOCERA Fineceramics Europe GmbH is a subsidiary of KYOCERA Europe GmbH, which has been successful in Europe for over 50 years. The Kyocera Group is one of the world's leading providers of high-performance ceramic components for the technology industry, offering over 200 different ceramic materials, as well as state-of-the-art technologies and services tailored to the specific needs of each market.

KYOCERA Fineceramics Europe GmbH has grown steadily in recent years – and is now a leading European supplier of customised solutions made of technical ceramics. Working in partnership, we develop and manufacture products that offer our customers added value in their respective markets and secure their technological lead in the long term. We are committed to this every day.

We have also been active in the field of environmental technology for 30 years. Our solutions for treatment of exhaust air and waste water from chemical laboratories and industrial processes are known worldwide under the FRIDURIT brand.

Throughout Europe, we are represented by three production and development sites in Mannheim, Selb and Erfurt, as well as six sales offices – in Mannheim, Selb, Esslingen, Neuss, Rungis (France) and Frimley (United Kingdom).

Our business partners benefit from the fact that we think and work across divisions within the Kyocera Group. Because innovations and real milestones can only be achieved together – across industries and national borders.

This is what we believe.

About the KYOCERA Group

KYOCERA Europe GmbH is a company of the KYOCERA Corporation headquartered in Kyoto/ Japan, a world leader in semiconductor, industrial and automotive components as well as electronic components, printing and multifunction systems, and communications technology. The technology group is one of the world's most experienced manufacturers of smart energy systems, with more than 45 years of industry expertise. The Kyocera Group comprises of around 300 subsidiaries.

Kyocera aims to create a better future for the world, using the power of technology to solve issues we face as a global society. This ambition is rooted in our Kyocera Management Rationale: to contribute to the advancement of society and humankind.

We will continue to work together with people around the world to solve issues critical to society leveraging all of the technologies and management capabilities we have accumulated during our 60-plus year history.

The company also takes an active interest in cultural affairs. The Kyoto Prize, a prominent international award, is presented each year by the Inamori Foundation established by Kyocera founder Dr Kazuo Inamori to individuals worldwide who have contributed significantly to the scientific, cultural, and spiritual betterment of humankind.

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