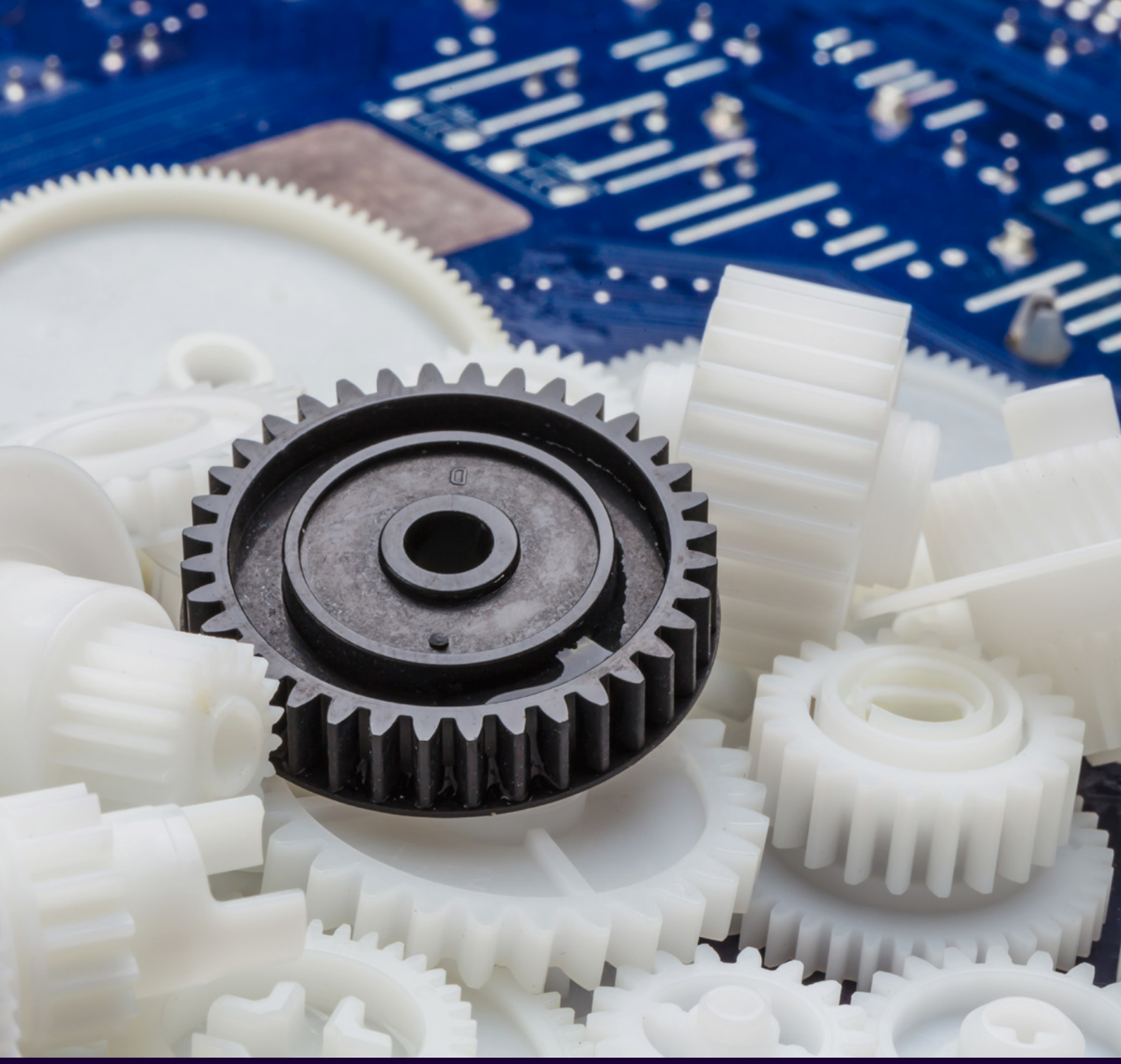


BRENNTAG

TRIBOFORCE®

Tribologically optimized compounds

Our PFAS-free solutions for reducing friction and wear

Brenntag Polymers

With extensive market knowledge, application and formulation expertise, we're dedicated to the development and provision of innovative solutions and services for the polymer processing industry, with a special focus on sustainability.

Our outstanding product portfolio includes high-performance and engineering polymers, biopolymers, compounds, recompounds, additives, colorants, pigments and much more. In addition to a distribution offering from the world's leading manufacturers, a wide range of products from our own innovative development work is available to you.

Our team works, for instance, on the development and production of **compounds according to specific customer demands** as well as on material alternatives and solutions to meet the changing requirements of the industry due to regulatory factors and sustainability goals.

With a user-centric approach, we manufacture individual materials for metal substitutes, structural and lightweight parts, functionalized compounds (e.g. thermally conductive, magnetically detectable), food-compliant or tribologically optimized, PFAS-free grades and offer various polymer recycling solutions, such as the integration of secondary raw materials into product development. You benefit from our decades of experience in thermoplastics design, application expertise and solutions competence. Thanks to our extensive polymer know-how and our global network, we can provide you with practical, cross-country support.

Contents

Reducing friction and wear with innovative materials

TRIBOFORCE® is our product series of tribologically optimized compounds. The innovative materials improve the slide-friction behavior of mechanically and tribologically highly stressed parts, thus reducing wear and increasing the efficiency and service life of components that have to function smoothly under extreme conditions. In addition to minimizing friction losses at the expense of material and efficiency, the polymers counteract noise emissions caused by stick-slip effects, making them attractive materials for future markets such as e-mobility. The compounds do not require additional lubrication.

Optimal material systems
Due to perfectly balanced polymer-additive combinations, TRIBOFORCE® compounds define a new class in wear behavior. Low coefficients of friction and exceptional wear resistance, coupled with outstanding dimensional stability, make TRIBOFORCE® the ideal material for tribological systems with high demands on friction, wear, mechanics, durability and temperature.

A broad polymer and temperature spectrum
Users can choose from TRIBOFORCE® materials with different base polymers such as PA, PPS or PEEK, which inherently have good slide-friction properties and high abrasion resistance. This covers a temperature range from - 40 °C to 260 °C, and short-term service temperatures of up to 300 °C are even possible as well.

PFAS-free sliding and bearing materials
TRIBOFORCE® compounds are preferably used as toothed wheel, sliding and bearing materials, whereby lubrication can be dispensed with in almost all applications. The properties of tribologically optimized compounds are significantly determined by additives and fillers. By substituting our specially developed additive-filler combinations for conventional lubricants such as PTFE, which belongs to the PFAS[1)] group of substances that are under scrutiny as harmful to health and the environment, we are also able to produce TRIBOFORCE® materials with a high mechanical strength and stiffness in addition to optimizing sliding friction, as the use of PTFE can impair mechanical properties, among other things.

1) Per- and polyfluorinated alkyl substances

TRIBOFORCE® features

- Ideal toothed wheel, sliding and bearing materials for extreme requirements
- Low coefficients of friction
- Exceptional wear resistance
- Outstanding dimensional stability
- Base polymers with good slide-friction properties (e.g. PA, PPS, PEEK)
- Broad temperature spectrum
- No additional lubricants required
- Substitution of conventional lubricants such as PTFE with specially developed additive combinations
- Free of PFAS
- High mechanical strength and stiffness
- Sliding effect inherent in the material, permanently tribologically effective
- Free choice of polymer-additive combinations
- Excellent tribological behavior towards metals and with similar material pairing
- Lightweight, resistant to chemicals and corrosion
- Individually modifiable
- Types available for injection moulding and extrusion

Application options

In many applications, friction and wear play a key role. The product series is used, e.g., for components in the automotive industry, medical technology, furniture industry, materials handling technology, E & E, sports and leisure industry, machine and plant construction, etc., for example, as

- Toothed wheels
- Bearing bushes
- Planetary gears
- Ball bearings and bearing cages
- Slide bearings, rails, chains and coatings
- Rollers and wheels
- Couplings
- Rolling bearings in wind turbines
- Deflection wheels in conveyor systems
- Thrust washers
- Impellers
- Joints
- Gaskets
- Valves
- Fuel distributors

Practical tribological tests

Users can have wear measurements carried out on tribological test rigs. Virtually all the operating conditions specified by the customer can be simulated on the test rig, permitting the friction and wear behaviour to be established in this way. Elaborate test series can then be dispensed with.

Your benefits

- Long-term slide-friction optimization
- Less wear and tear
- More efficiency and functionality of tribological applications
- Reduced energy requirement, lower CO_2 footprint
- Extended runtimes and component service life
- High dimensional accuracy of the parts
- Avoidance of stick-slip effects
- Optimized NVH properties[2)]
- Improved run-flat properties, more safety
- Smoother running, lower noise levels
- Material alternatives to PTFE/PFAS
- Resource-saving and low-maintenance, as no lubrication is required
- Production efficiency, less downtime and outages, more stable processes
- No additional work steps and investments required for subsequently applied sliding media
- Lean development and production cycles
- Lower manufacturing and parts costs
- Mobility: less weight, lower consumption and emissions, more range

2) NVH properties: Combination of noise, vibration and harshness

Physical, mechanical and tribological properties

TRIBOFORCE® type			PA66 C0200	PA66 C0201	PA66 C0202	PA66 C0203
Density	ISO 1183	g/cm³	1.51	1.25	1.37	1.41
Tensile strength	ISO 527	MPa	160	160	160	200
Tensile strength conditioned	ISO 527 | ISO 1110	MPa	120	115	115	145
Elongation at break	ISO 527	%	1.5	2.6	2.0	1.7
Elongation at break conditioned	ISO 527 | ISO 1110	%	2.7	5.3	4.3	3.5
Tensile modulus	ISO 527	MPa	16 000	11 000	14 500	21 500
Tensile modulus conditioned	ISO 527 | ISO 1110	MPa	10 000	7 400	8 700	13 000
Charpy impact strength unnotched	ISO 179/1eU	kJ/m²	20	40	30	40
Charpy impact strength unnotched conditioned	ISO 179/1eU | ISO 1110	kJ/m²	25	55	45	50
Charpy impact strength notched	ISO 179/1eA	kJ/m²	3	–	–	–
Specific wear rate w_s at 1 MPa, 1 m/s, dry/steel	ASTM G 137	10^{-6} mm³/Nm	0.2	0.5	0.33	0.5
Coefficient of friction μ at 1 MPa, 1 m/s, dry/steel	ASTM G 137	1	0.2	0.3	0.28	0.26
Surface resistivity	DIN IEC 60093	Ohm	10^4 – 10^5	10^5 – 10^6	10^4 – 10^5	< 10^3
Humidity absorption	ISO 1110	%	1.6	2.2	2.0	1.9
Melting temperature	ISO 3146 (10K/min)	°C	260	260	260	260
Moulding shrinkage	ISO 294[1)]	%	0.1 – 0.4	0.1 – 0.4	0.1 – 0.4	0.1 – 0.4

TRIBOFORCE® type			PPS C1800	PPS C1801	PPS C1802	PEEK C2300[2)]	PEEK C2301[3)]
Density	ISO 1183	g/cm³	1.61	1.5	1.48	1.59	1.57
Tensile strength	ISO 527	MPa	115	125	140	145	165
Elongation at break	ISO 527	%	1	1.2	0.8	2.2	1.9
Tensile modulus	ISO 527	MPa	16 000	15 000	22 500	13 000	14 300
Charpy impact strength unnotched	ISO 179/1eU	kJ/m²	15	18	18	35	32
Charpy impact strength notched	ISO 179/1eA	kJ/m²	2	4	5	4	–
Specific wear rate w_s at 1 MPa, 1 m/s, dry/steel 18 MPa, 1 m/s, dry/steel 6 MPa, 2 m/s, 75 °C, dry/steel	ASTM G 137	10^{-6} mm³/Nm	 0.1 – –	 0.1 0.2 0.2	 0.1 0.2 0.2	 0.1 – –	 0.1 – –
Coefficient of friction μ at 1 MPa, 1 m/s, dry/steel 18 MPa, 1 m/s, dry/steel 6 MPa, 2 m/s, 75 °C, dry/steel	ASTM G 137	1	 0.2 – –	 0.2 0.1 0.05	 0.3 0.15 0.05	 0.2 – –	 0.2 – –
Coefficient of linear thermal expansion (CLTE) longitudinal transverse	ISO 11359 23 °C – 55 °C	α*10^{-6}/K	 11 45	 – –	 – –	 – –	 – –
Melting temperature	ISO 3146 (10K/min)	°C	275	275	275	340	340
Moulding shrinkage	ISO 294[1)]	%	0.05 – 0.2	0.15 – 0.3	0.15 – 0.3	0.05 – 0.2	0.05 – 0.2

Unless otherwise stated, the values refer to uncoloured materials, dam 23 °C.
1) Internal test method in accordance with ISO 294 (test specimen 60 mm x 60 mm x 2 mm) | 2) For extrusion | 3) Injection moulding grade
Data sheets and processing guidelines for our TRIBOFORCE® products are available **on request**.

Continuous service temperature and chemical resistance

Continuous service temperature TRIBOFORCE®	PA66	PPS	PEEK
To 130 °C	✓	✓	✓
130 °C to 200 °C	×	✓	✓
200 °C to 260 °C	×	×	✓
To 300 °C, temporary	×	×	✓

Chemical resistance at room temperature TRIBOFORCE®	PA66	PPS	PEEK
Aqueous	—	✓	✓
Biological media	—	✓	✓
Salt spray (fog)	—	✓	✓
Hydrolysis resistant	×	✓	✓
Suitable for superheated steam sterilization	×	✓	to 200 °C
Oil	✓	✓	✓
Gasoline	✓	✓	✓
Weak mineral acids	—	—	✓
Diluted alkaline solutions	—	✓	✓
Concentrated alkaline solutions	×	—	✓
Nitric acid and other oxidising acids	×	×	×

✓ Resistant; only small influence on the properties and no irreversible degradation by the substance.
— Limited resistant; increased influence on the properties by the substance, partly irreversible.
× Not resistant; significant property changes within a short time, irreversible damages.

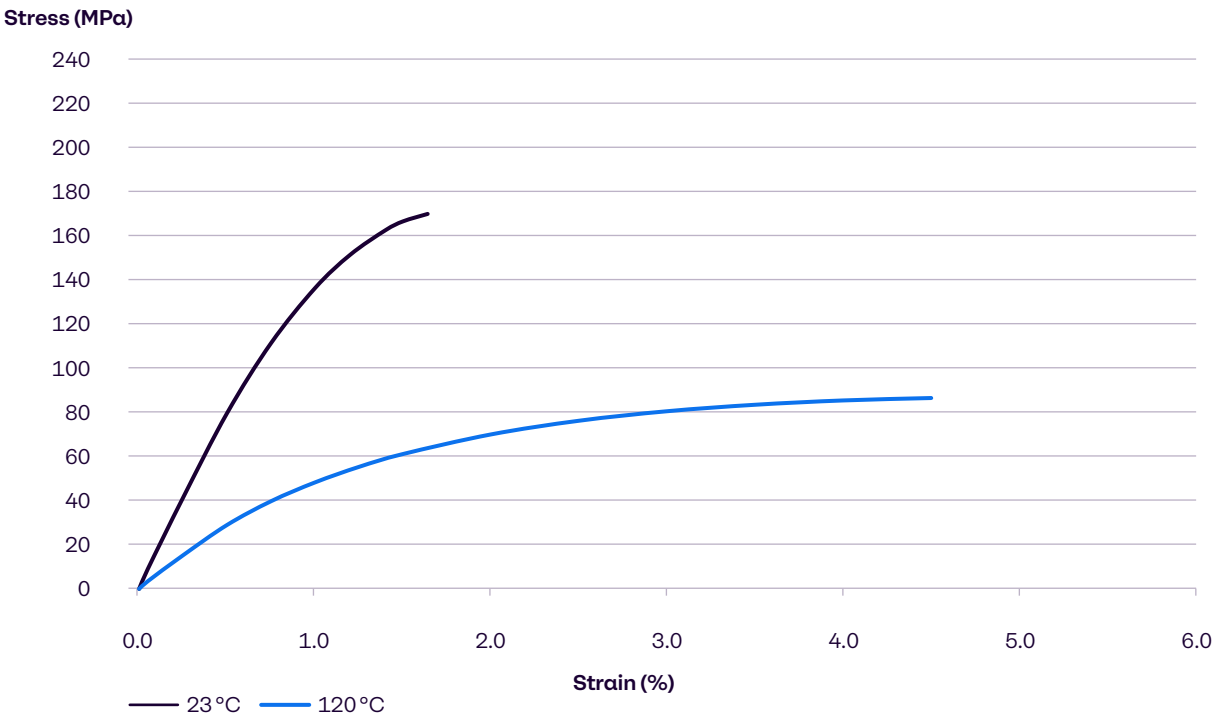
Material alternatives to PTFE and co.

Lubricants containing fluoropolymers, such as PTFE, are often used to reduce friction and wear. However, these belong to the group of per- and polyfluorinated alkyl substances (PFAS), which have been criticized due to their potential risk to humans and the environment and whose use may therefore be banned or strictly regulated.

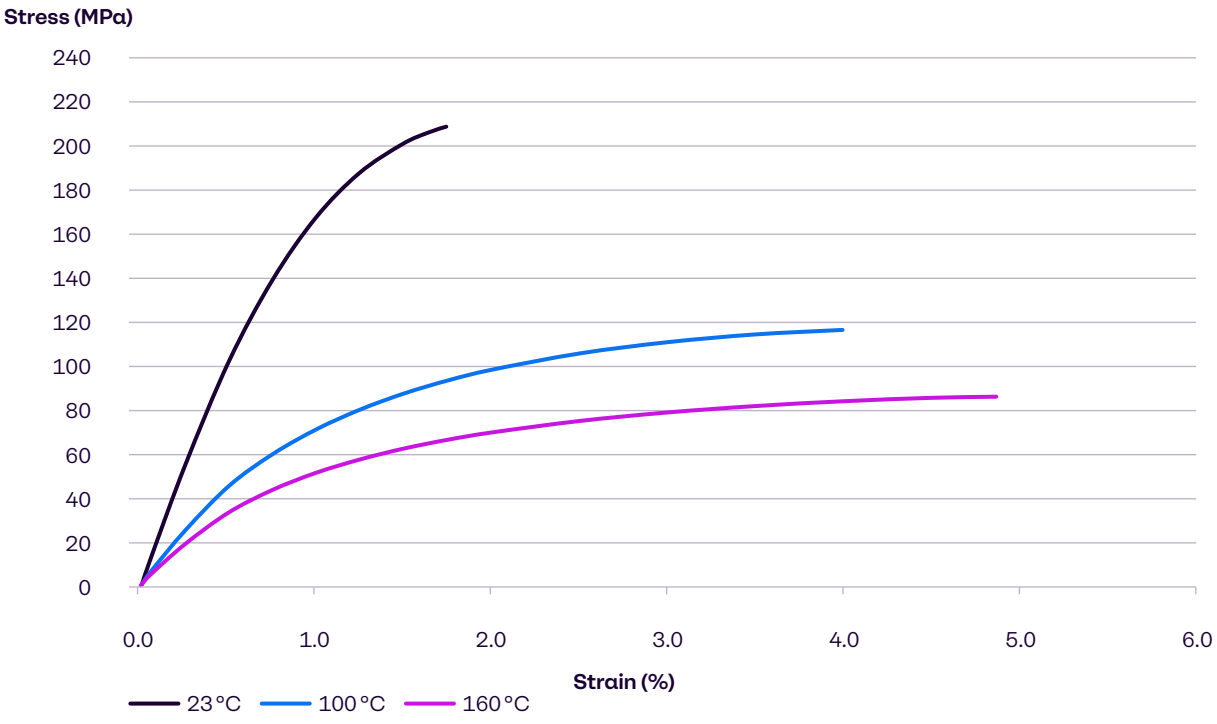
Thanks to our material expertise and the outstanding property profile of TRIBOFORCE® compounds, the slide-friction properties of components can be optimized even without additional lubricants and the switch to alternative materials can be implemented for the benefit of safety and environmental protection. Find out more about our customized polymer solutions at **brenntag.com.**

Tensile tests

TRIBOFORCE® PA66 C0200 UNGEFÄRBT (dry)

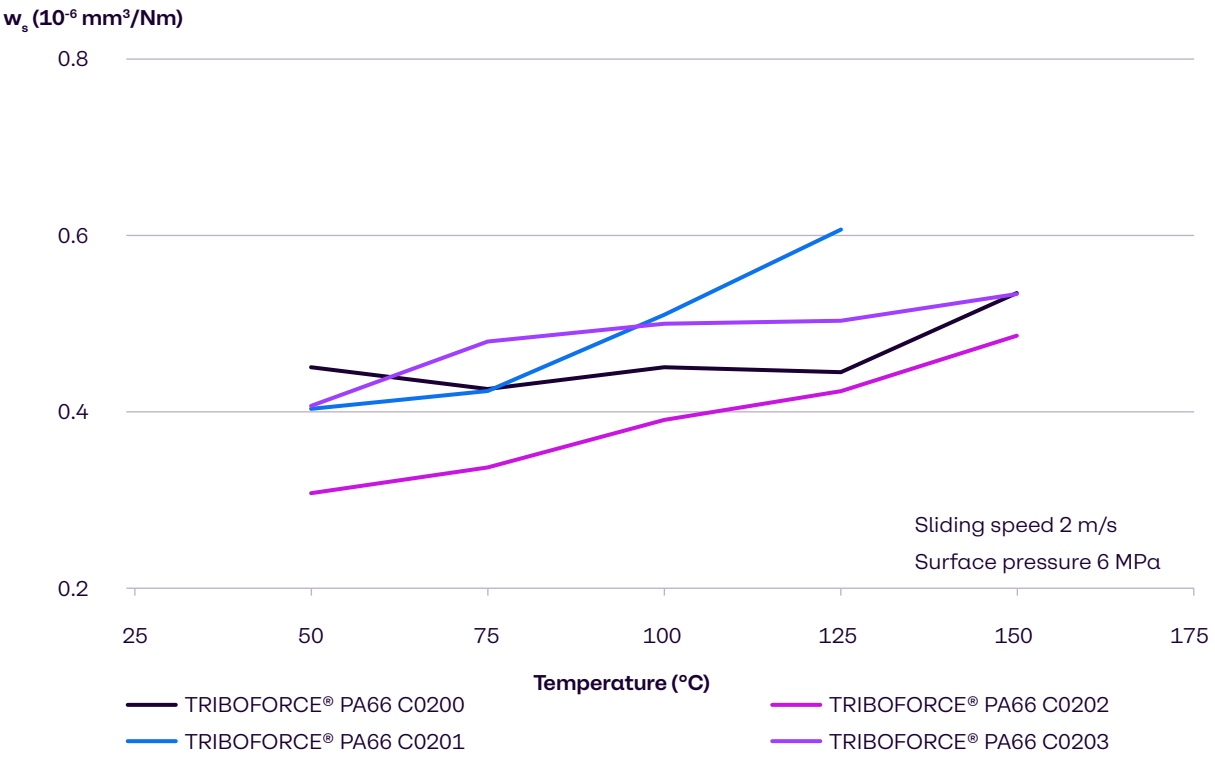


TRIBOFORCE® PA66 C0203 UNGEFÄRBT (dry)

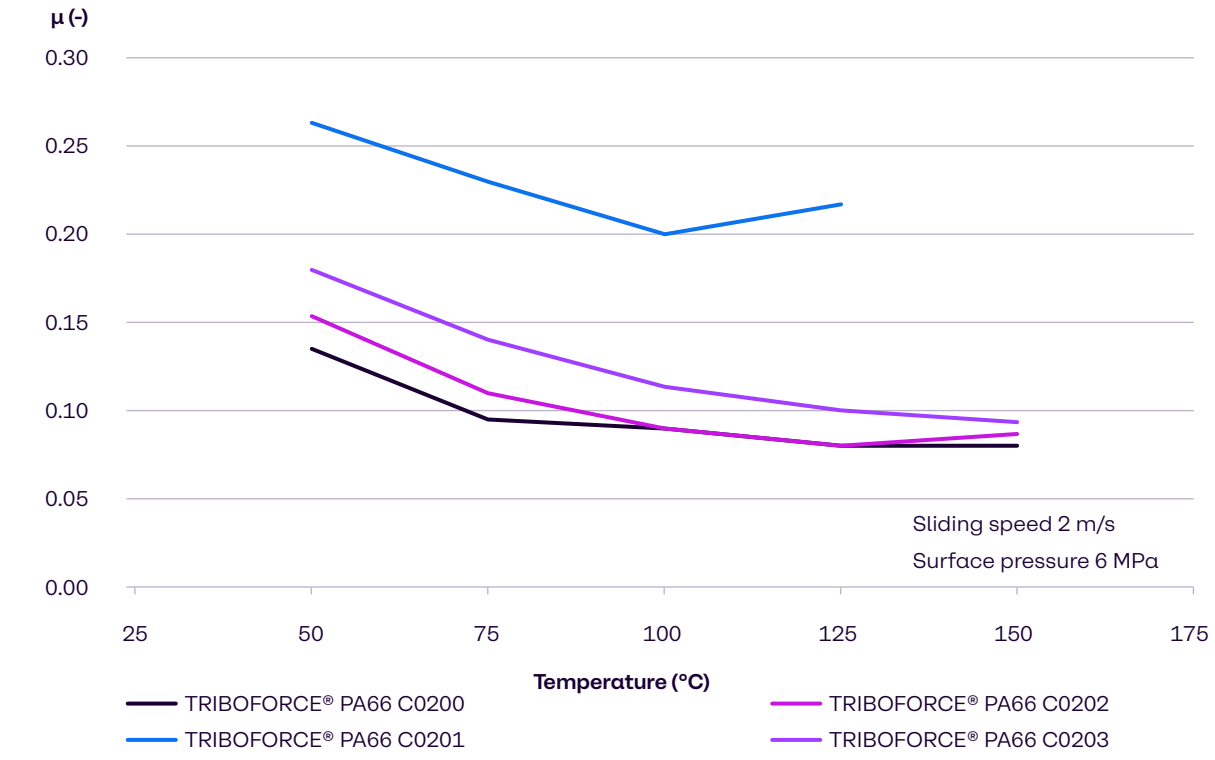


Tribological values at different temperatures

Specific wear rate w_s TRIBOFORCE® PA66 UNGEFÄRBT (dry)

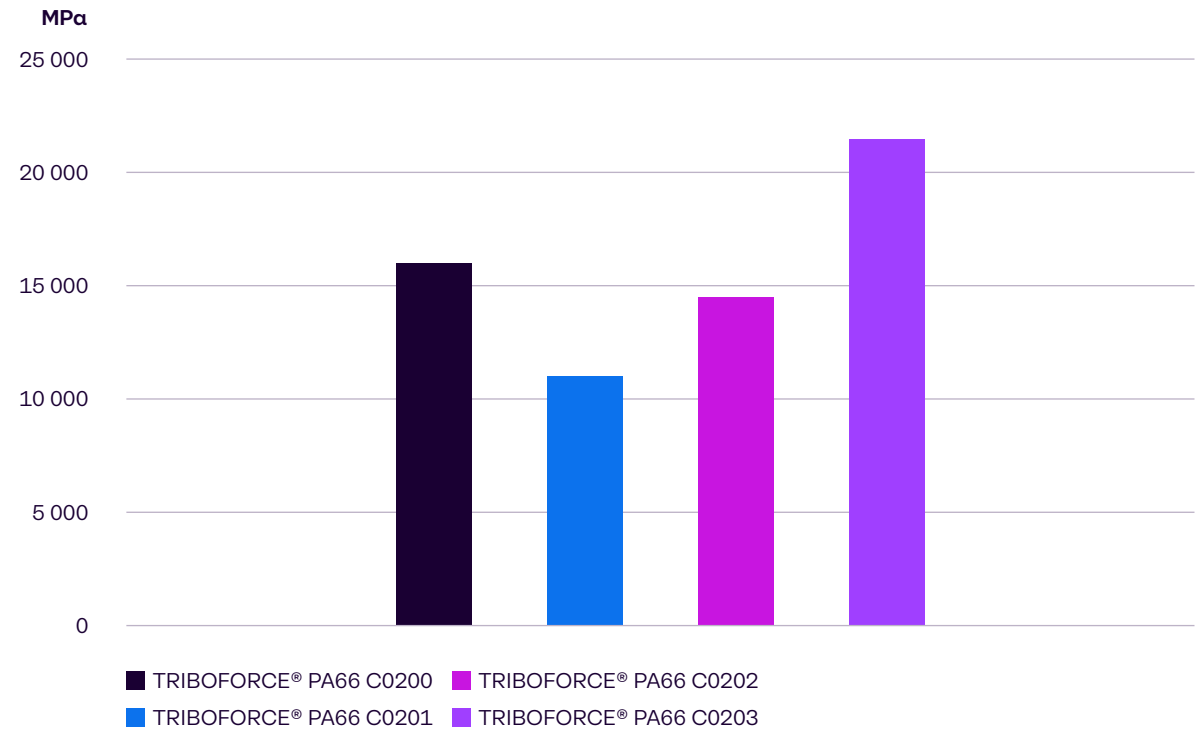


Coefficient of friction µ TRIBOFORCE® PA66 UNGEFÄRBT (dry)

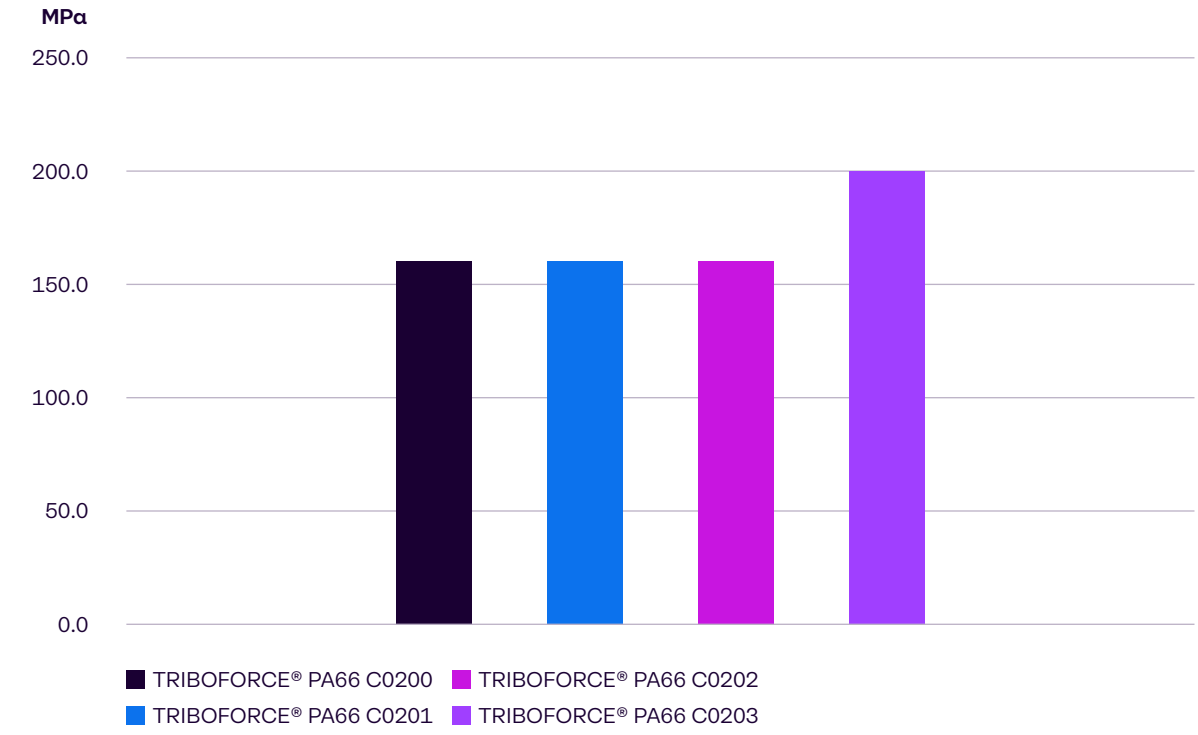


Mechanical values

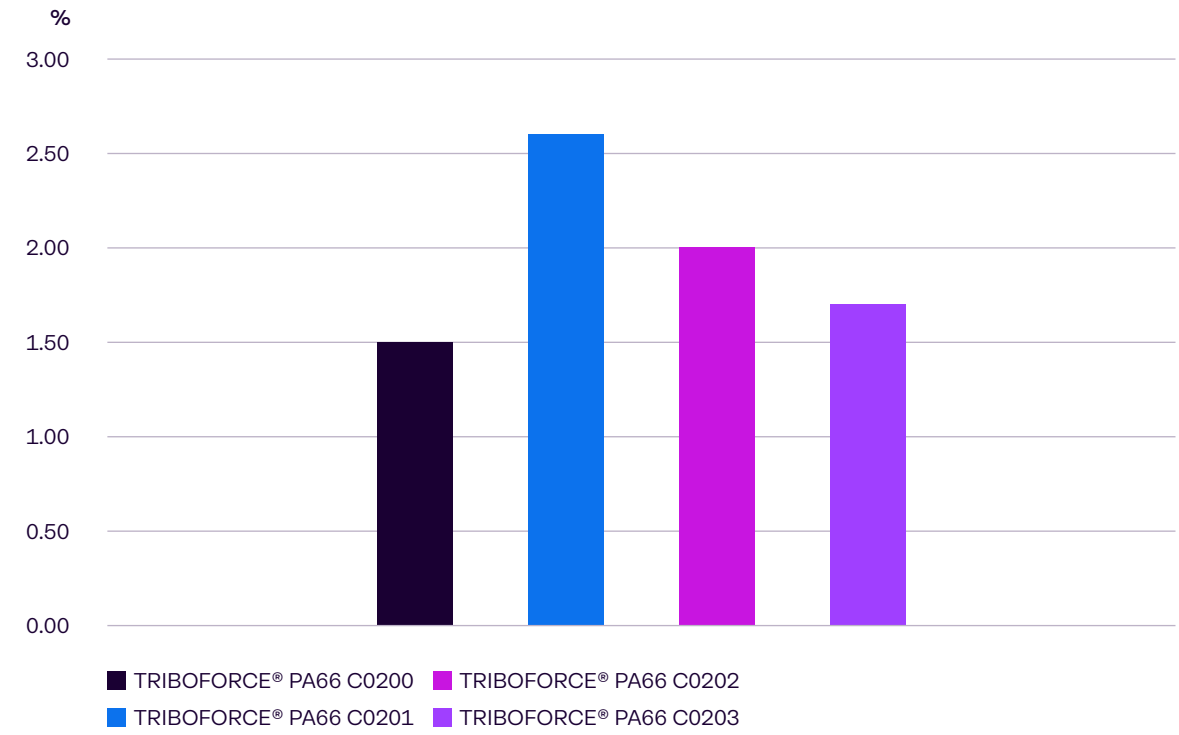
Tensile modulus TRIBOFORCE® PA66 UNGEFÄRBT (dry 23 °C)



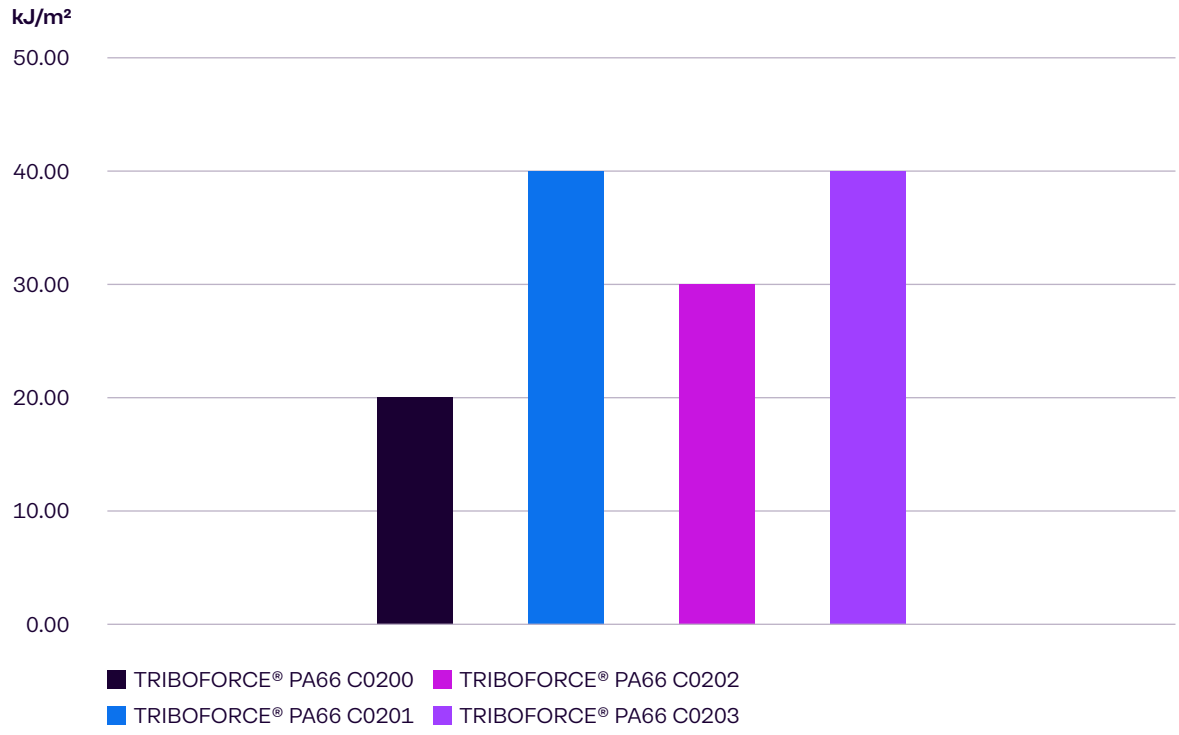
Tensile strength TRIBOFORCE® PA66 UNGEFÄRBT (dry 23 °C)



Elongation at break TRIBOFORCE® PA66 UNGEFÄRBT (dry 23 °C)

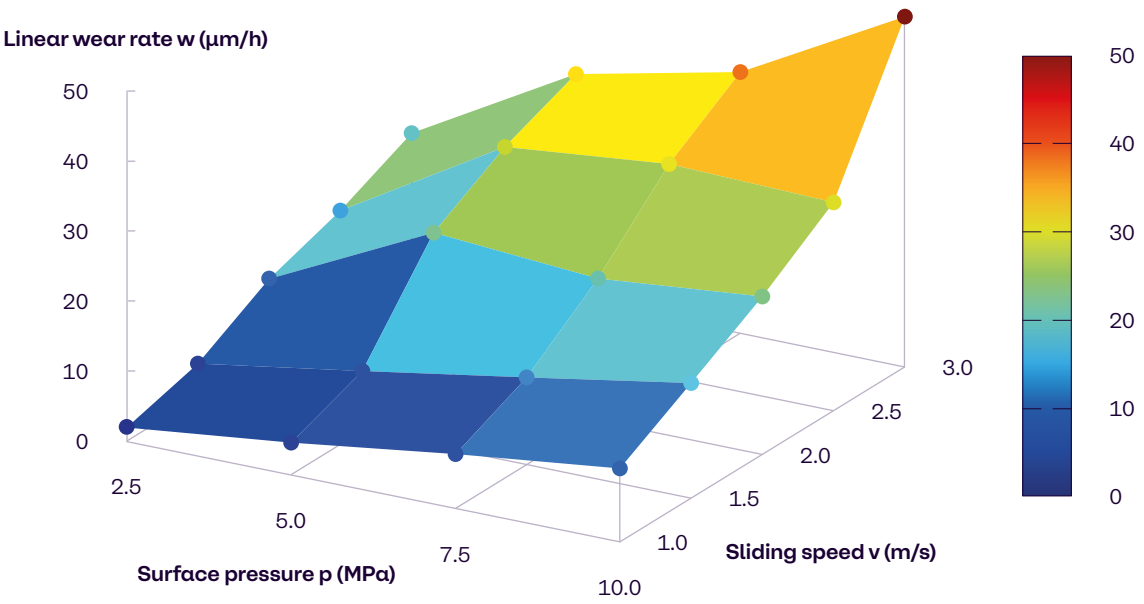


Charpy impact strength unnotched TRIBOFORCE® PA66 UNGEFÄRBT (dry 23 °C)

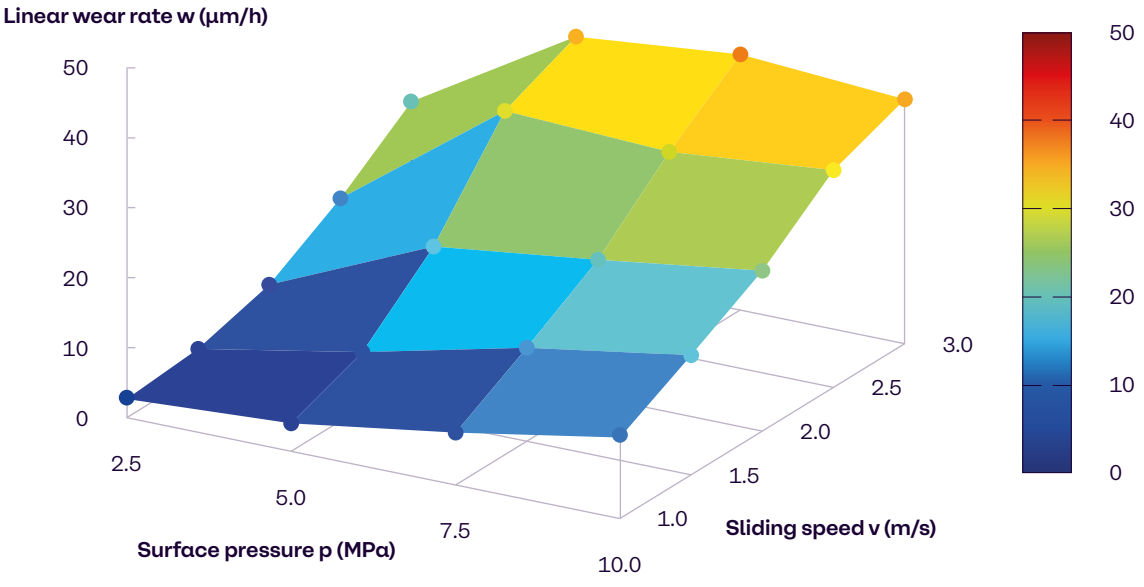


Linear wear rate

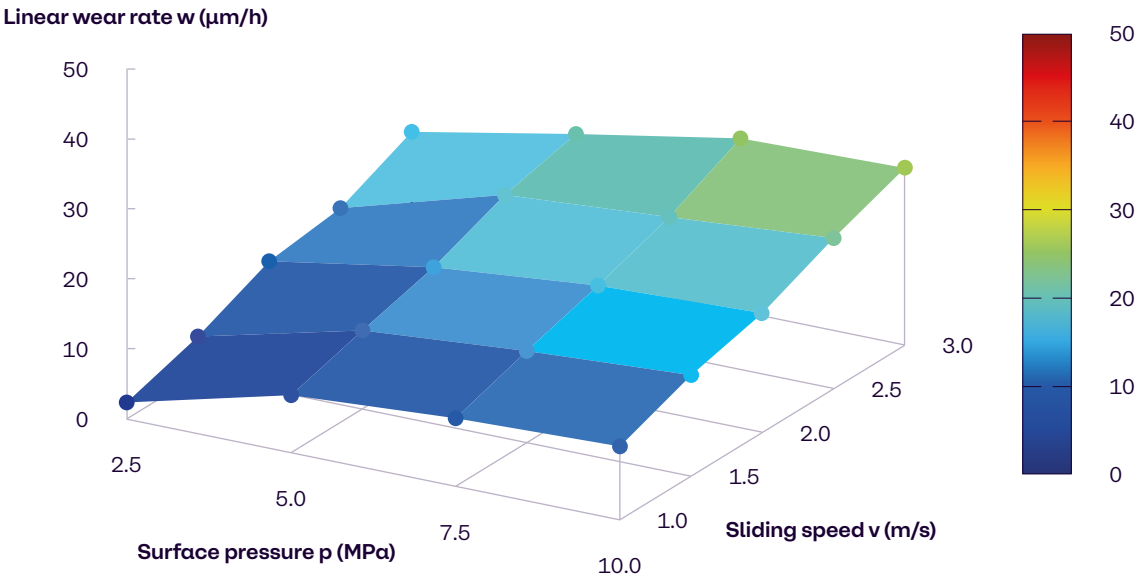
TRIBOFORCE® PA66 C0200 UNGEFÄRBT (dry)



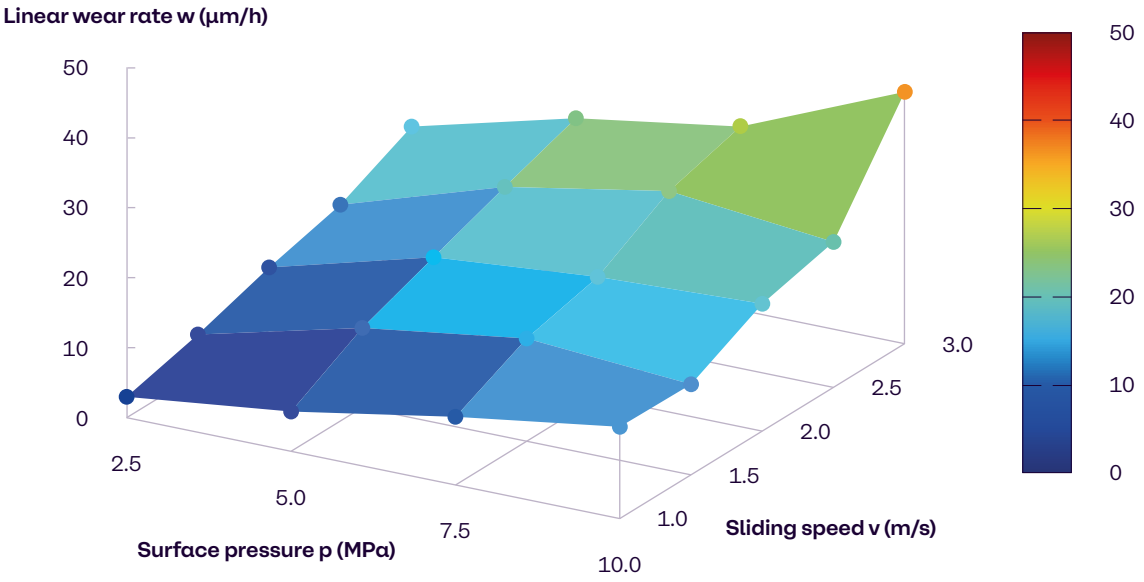
TRIBOFORCE® PA66 C0201 UNGEFÄRBT (dry)



TRIBOFORCE® PA66 C0202 UNGEFÄRBT (dry)

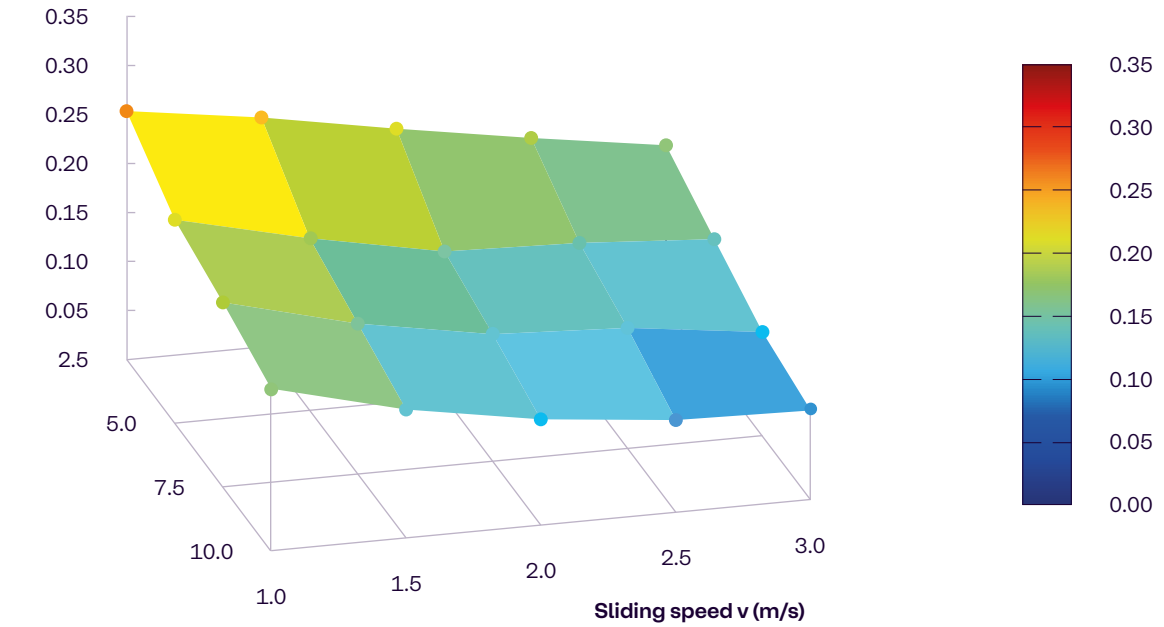


TRIBOFORCE® PA66 C0203 UNGEFÄRBT (dry)

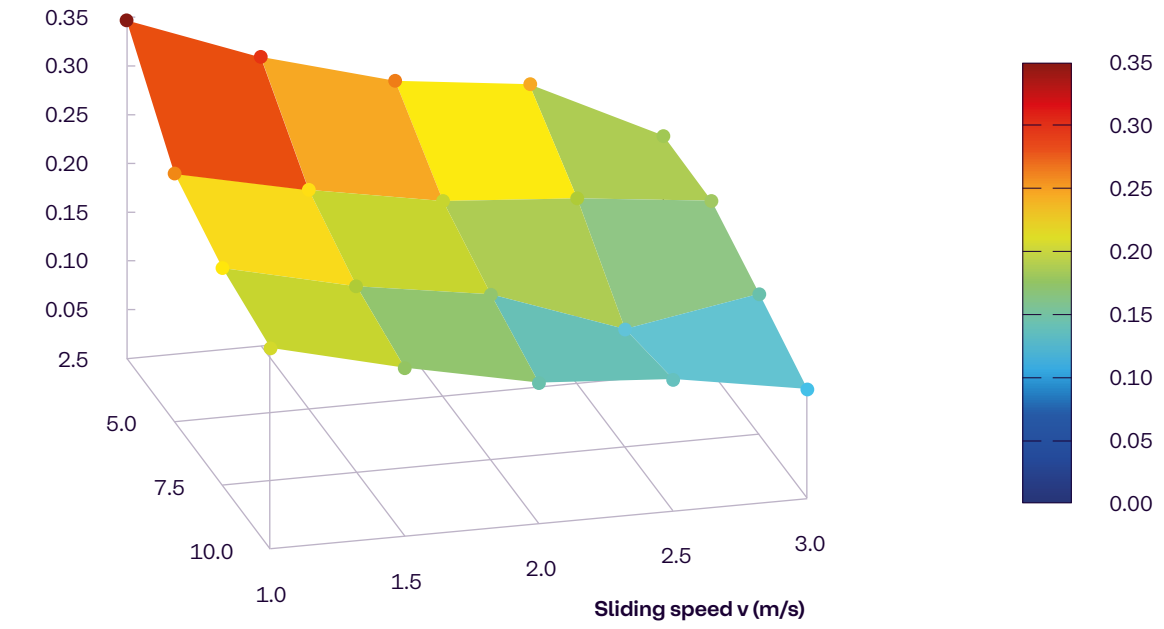


Coefficient of friction

TRIBOFORCE® PA66 C0200 UNGEFÄRBT (dry)

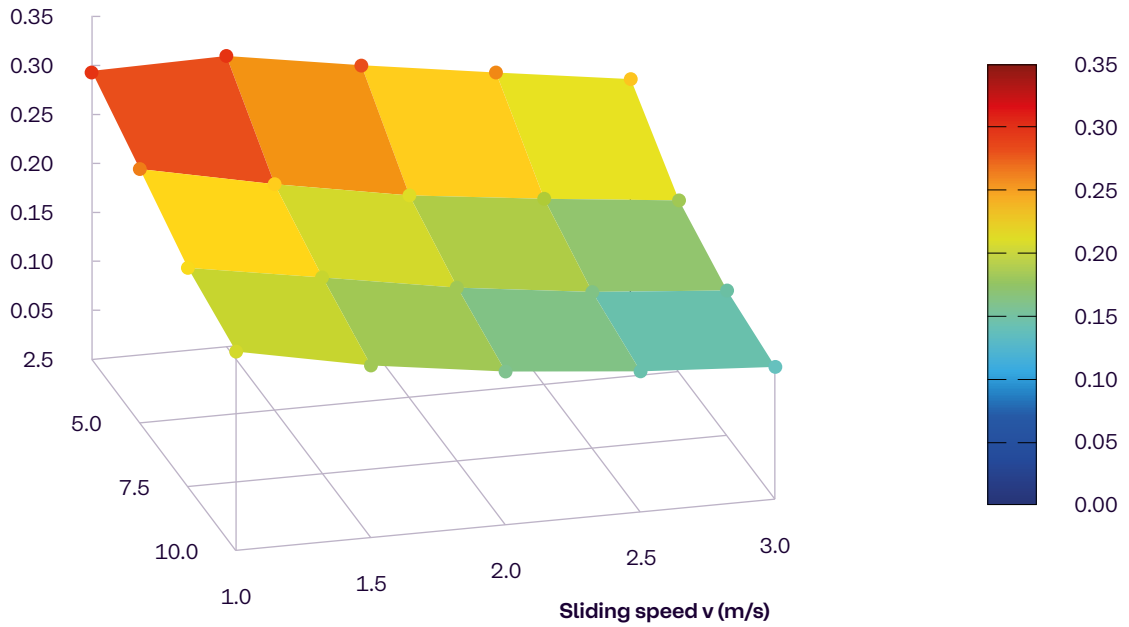


TRIBOFORCE® PA66 C0201 UNGEFÄRBT (dry)



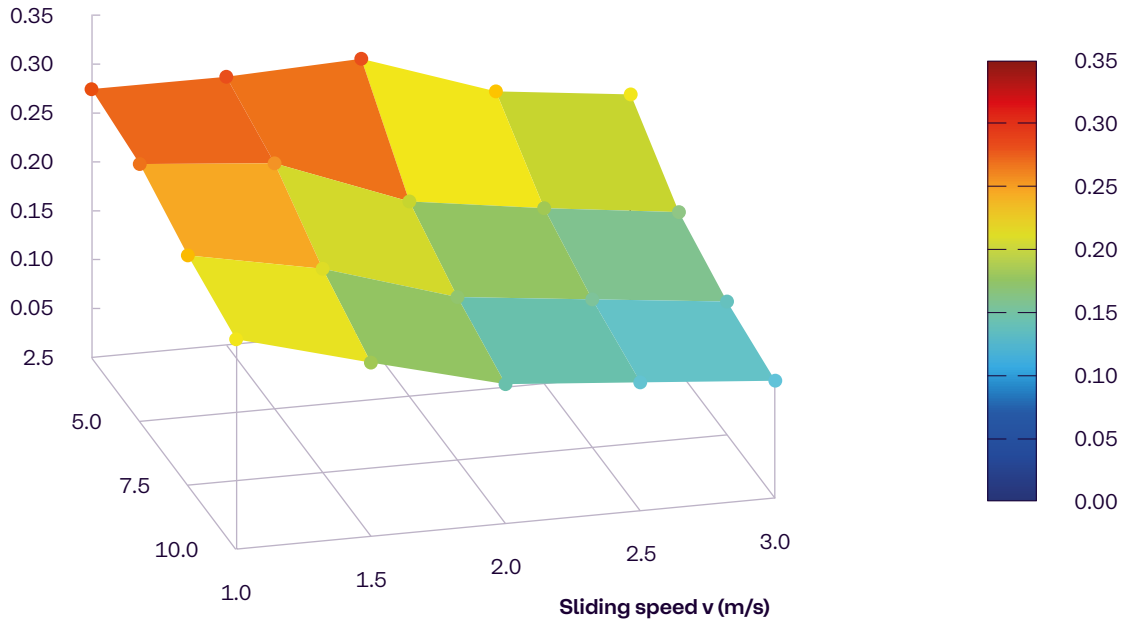
TRIBOFORCE® PA66 C0202 UNGEFÄRBT (dry)

Coefficient of friction μ (-)



TRIBOFORCE® PA66 C0203 UNGEFÄRBT (dry)

Coefficient of friction μ (-)



Brenntag Polymers in brief

- Innovative development partner for your projects
- Decades of polymer experience
- Certified to ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018
- More than 700 products from our own development work
- Cooperation with other, well-known global market leaders
- Flexible demand adjustment
- Fast reaction times
- Networked in regional and global markets
- Cross-industry solutions

Focus areas

- Individual material solutions
- Compound development
- High-reinforced compounds
- Metal substitutes
- Lightweight
- Thermal conductivity
- Magnetic detectability
- Food conformity
- Tribologically optimized compounds
- Recompounds

Compounds core portfolio

- ALAMID®
- ALAMID® D
- NYLAFORCE®
- NYLAFORCE® dynamic
- TECDUR
- THERMOFORCE®
- TRIBOFORCE®

Contact

Brenntag GmbH
Material Science/Polymers
Messeallee 11
45131 Essen
Germany
polymers.EMEA@brenntag.com

#5706 EN / 0625

brenntag.com