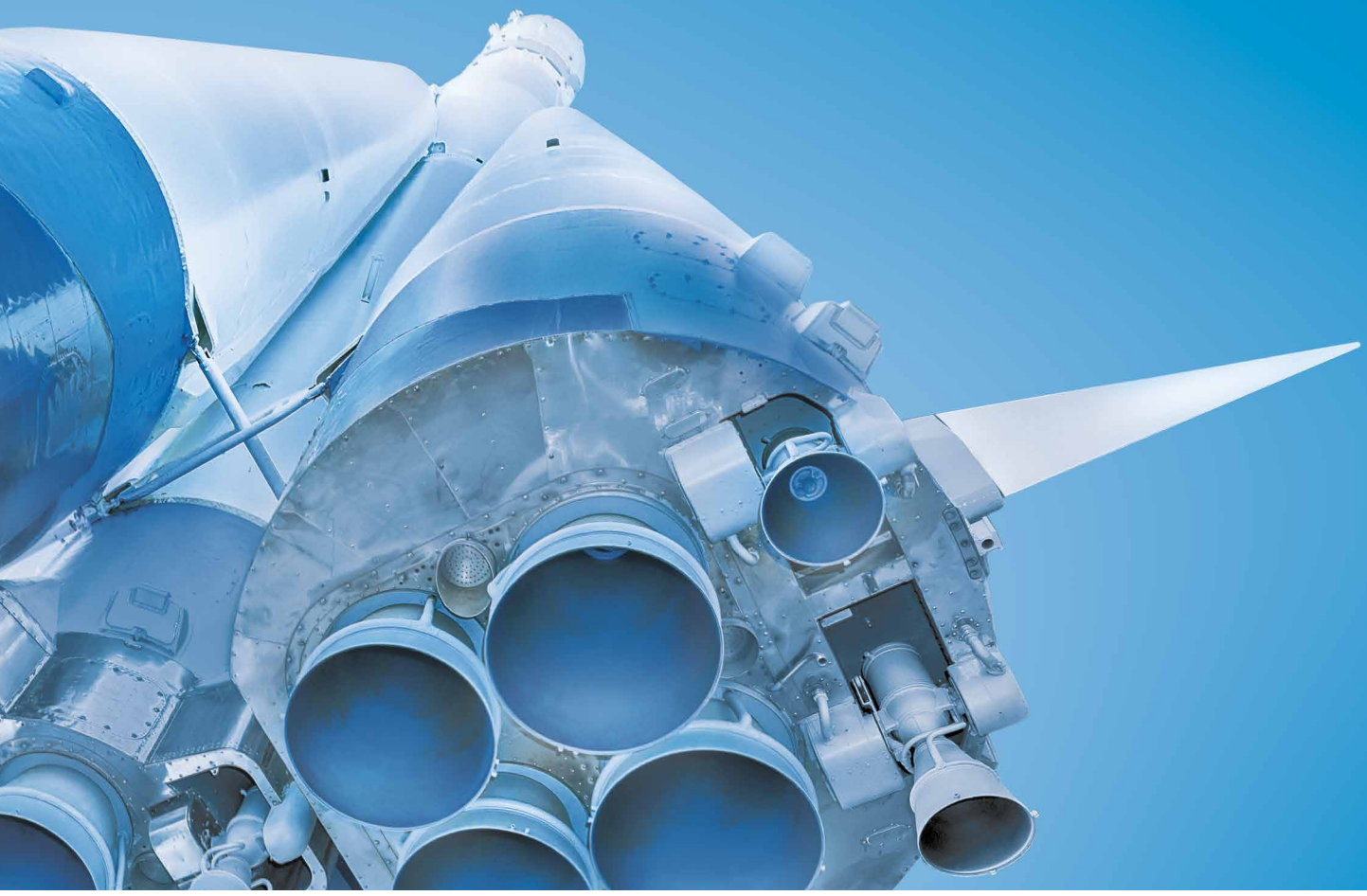
AKROTEK® PEEK and PAEK – Best performance in plastics



AKRO-PLASTIC
Think Polyamide

AKRO-PLASTIC GmbH
Member of the Feddersen Group

AKROTEK® PEEK and PAEK – Best performance in plastics

With AKROTEK® PEEK and AKROTEK® PAEK, AKRO-PLASTIC GmbH are breaking new ground to expand and upgrade their high-performance compounds. As one of the leading compounders for polyamides (PA), polyphthalamides (PPA) and polyketones (PK), we have the skills and expertise needed to provide tailor-made solutions to our customers in the area of high-performance polymers.

Alongside conventional glass fibre and carbon fibre filled compounds, tribologically modified grades are now available. Our primary goal is always to develop innovative products. To achieve this, we sometimes pursue unconventional paths in partnership with our customers.

AKROTEK® PEEK exhibits several outstanding characteristic properties:

- high continuous operating temperature (above 342 °C)
- excellent room-temperature properties
- very good chemical resistance
- inherent V0 to UL 94
- good radiation resistance
- excellent hydrolysis resistance
- extremely good impact strength
- minimal creep
- extremely low outgassing rate

AKRO-PLASTIC:
Think polyamide and beyond.

AKROTEK® PEEK

Typical values for natural color material at 23° C	Test specification	Test method	Unit	PEEK natural (4447)		PEEK GF 30 natural (5047)		PEEK GF 30 9 natural (5567)		PEEK GF 40 natural (5904)		PEEK GF 50 9 natural (5625)		PEEK GF 60 9 natural (5425)		PEEK CF 30 black (5448)		PEEK CF 30 black (5049)		PEEK CF 40 black (5099)		PEEK CF 40 9 black (5446)	
Mechanical properties				d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.
Tensile modulus	1 mm/min	ISO 527-1/2	MPa	3,700	3,700	12,000	12,000	12,000	12,000	15,000	15,000	20,000	20,000	24,000	23,500	30,000	30,000	25,500	25,500	34,500	34,500	33,000	33,000
Tensile stress at break/Yield stress[1]	5 mm/min	ISO 527-1/2	MPa	/100	/100	195	185	205	190	215	205	235	215	230	210	270	265	235	230	245	240	250	240
Elongation at break	5 mm/min	ISO 527-1/2	%	>25	>40	2.8	2.8	2.8	2.8	2.3	2.3	2	2	1.5	1.4	1.6	1.5	1.4	13	1.1	1.0	1.2	1.1
Flexural modulus	2 mm/min	ISO 178	MPa	3,800		11,500		11,700	11,200	15,000	14,200	20,000		24,000		28,000	28,000	22,800		33,000		30,000	
Flexural stress	2 mm/min	ISO 178	MPa	155		305		310	290	340	305	350		360		370	365	345		365		360	
Flexural strain at break	2 mm/min	ISO 178	%	6		3		3	3	2.6	2.5	2		1.8		1.7	1.7	1.8		1.4		1.5	
Charpy impact strength	23 °C	ISO 179-1/1eU	kJ/m²	n.b.	n.b.	80	75	75	70	80	75	62	55	55	45	50	45	42	38	40	35	40	35
Charpy notched impact strength	23 °C	ISO 179-1/1eA	kJ/m²	6	6	11	11	10	10	13	13	11	11	10	10	8	8	6	6	6	6	5	5
Thermical properties				d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.	
Melting point	DSC, 10 K/min	ISO 11357-1	°C	342		342		342		342		342		342		342		342		342		342	
Heat distortion temperature, HDT/A	1.8 MPa	ISO 75-1/2	°C	155		>280		>280		>280		>280		>280		>280		>280		>280		>280	
Heat distortion temperature, HDT/C	8 MPa	ISO 75-1/2	°C			200		225		230		260		265				230		250		260	
Flammability																							
Flammability acc.UL 94	1.6 mm	UL 94	Class	V0		V0		V0		V0		V0		V0		V0		V0		V0		V0	
General properties																							
Density	23 °C	ISO 1183	g/cm³	1.30		1.50		1.50		1.60		1.73		1.85		1.40		1.40		1.45		1.44	
Mineral/reinforcement content		ISO 1172	%	0		30		30		40		50		60		30		30		40		40	
Moisture absorption	70 °C/62 % r.h.	ISO 1110	%	0.2 – 0.3		0.1 – 0.2		0.1 – 0.2		0.1 – 0.2		0.1 – 0.2		0.1 – 0.2		0.2 – 0.3		0.2 – 0.3		0.2		0.2	
Processing																							
Flowability (1 mm)	Flow spiral[2]	AKRO	mm			100		100						80									
Flowability (2 mm)	Flow spiral[3]	AKRO	mm			190		200						150									

[1] = yield stress and elongation at break: Test speed 50 mm/min for non-reinforced compounds n.b. = without fracturing
"d.a.m." dry as moulded test values = residual moisture content <0.1 %
"cond." test values = conditioned, measured on test specimens stored according to DIN EN ISO 1110.

[2] = mould temperature: 170 °C, mass temperature: 390 °C, injection pressure: 2450 bar, cross section of flow spiral: 8.4 mm x 1 mm
[3] = mould temperature: 170 °C, mass temperature: 390 °C, injection pressure: 2450 bar, cross section of flow spiral: 8.4 mm x 2 mm

AKROTEK® PEEK and PAEK

Typical values for natural color material at 23° C	Test specification	Test method	Unit	PEEK CF 50 9 black (5447)		PEEK TM black (5069)		PEEK TM black (5051)		PEEK CF 10 TM black (5050)		PAEK CF 30 black (5216)	
Mechanical properties				d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.
Tensile modulus	1 mm/min	ISO 527-1/2	MPa	40,000	40,000	3,200	3,200	5,000	5,100	13,500	13,500	25,000	25,000
Tensile stress at break/Yield stress[1]	5 mm/min	ISO 527-1/2	MPa	240	230	/75	/75	75	75	160	150	250	245
Elongation at break	5 mm/min	ISO 527-1/2	%	0.9	0.8	>15	>15	2.6	2.6	2	2	1.5	1.4
Flexural modulus	2 mm/min	ISO 178	MPa	37,000		3,300		6,000		13,000		24,000	
Flexural stress	2 mm/min	ISO 178	MPa	370		125		135		235		370	
Flexural strain at break	2 mm/min	ISO 178	%	1.2		7		4		2.4		1.9	
Charpy impact strength	23 °C	ISO 179-1/1eU	kJ/m²	35	32	105	105	35	35	35	35	40	40
Charpy notched impact strength	23 °C	ISO 179-1/1eA	kJ/m²	5	5	6	6	3	3	4	6	6	6
Thermical properties				d.a.m.		d.a.m.		d.a.m.		d.a.m.		d.a.m.	
Melting point	DSC, 10 K/min	ISO 11357-1	°C	342		342		342		342		340	
Heat distortion temperature, HDT/A	1.8 MPa	ISO 75-1/2	°C	>280		150		155		>280		>280	
Heat distortion temperature, HDT/C	8 MPa	ISO 75-1/2	°C	270		140		145		175		195	
Flammability													
Flammability acc.UL 94	1.6 mm	UL 94	Class	V0		V0		V0		V0		V0	
General properties													
Density	23 °C	ISO 1183	g/cm³	1.48		1.40		1.42		1.44		1.40	
Mineral/reinforcement content		ISO 1172	%	50		0		0		10		30	
Moisture absorption	70 °C/62 % r.h.	ISO 1110	%	0.2		0.2 – 0.3		0.2 – 0.3		0.2 – 0.3		0.2 – 0.3	
Processing													
Flowability (1 mm)	Flow spiral[2]	AKRO	mm	80									
Flowability (2 mm)	Flow spiral[3]	AKRO	mm	160									

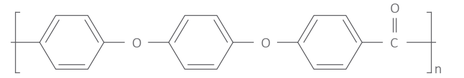
[1] = yield stress and elongation at break: test speed 50 mm/min for non-reinforced compounds ([2] and [3] see page 3) n.b. = without fracturing
"d.a.m." dry as moulded test values = residual moisture content <0.1 %
"cond." test values = conditioned, measured on test specimens stored according to DIN EN ISO 1110.

Product characterisation

Classification of PAEK grades

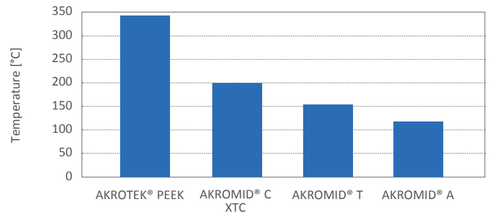
Polymer	Ketone content %	T_G °C	T_M °C
PEEEK	25	129	324
PEEK	33	141	335
PEK	50	152	365
PEKK	67	165	391

AKROTEK® PEEK

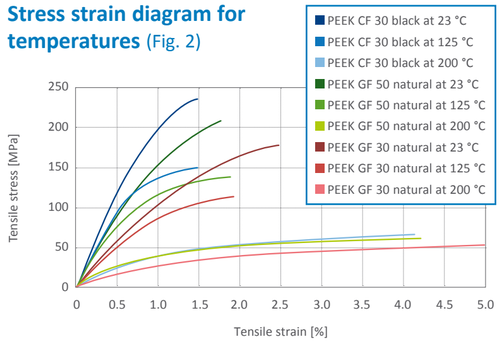


Source: Chemgapedia

Continuous operating temperature (Fig. 1)



Stress strain diagram for temperatures (Fig. 2)



AKROTEK® PEEK and **AKROTEK® PAEK** are used whenever several unfavourable general conditions are present, such as extreme operating temperatures, contact with aggressive substances, unfavourable wear and friction situations, etc.

PEEK (polyetheretherketone) belongs to the PAEK (polyaryletherketone) group. PAEK plastics are semi-crystalline polymers whose T_M (melting point) and T_G (glass transition temperature) are determined by the number of ketone groups (see table opposite).

AKROTEK® PEEK belongs to the group of high-temperature polymers. Plastics which, due to their property profile, can be used continuously at ambient temperatures of over 150 °C are classified as high-temperature polymers. Fig. 1 shows a comparison of continuous operating temperatures of various plastics. As is evident, AKROTEK® PEEK ranks significantly above others, with a temperature of up to 340 °C.

AKROTEK® PEEK and **AKROTEK® PAEK compounds** feature several striking properties. The mechanical values, measured at higher temperatures, demonstrate the many different possible uses of our compounds. Our high-fill glass- and carbon fibre compounds provide excellent performance in the tensile and flexural moduli. Fig. 2 shows that as with other compounds, strength depends greatly on the temperature.

Product characterisation

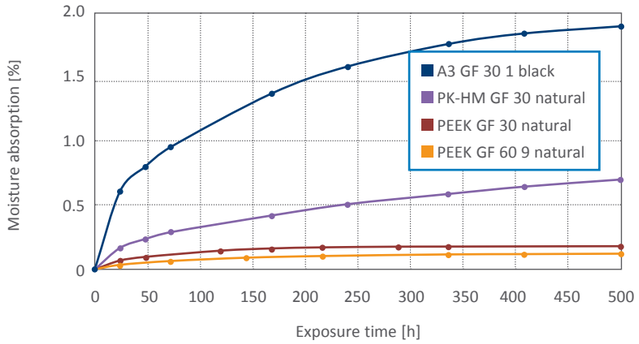
Low moisture absorption in glass fibre reinforced PEEK compared with A3 GF 30 1 black (see Figure 3) ensures a high degree of dimensional stability.

During extended heat ageing, **AKROTEK® PEEK** and **AKROTEK® PAEK compounds** provide consistent performance figures (see Fig. 4). The heat distortion temperature, measured according to ISO 75 HDT, is over 300 °C at loads of 1.8 MPa.

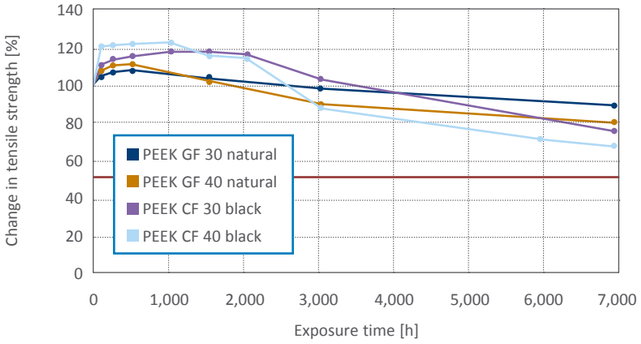
The tensile modulus diminishes only slightly as a result of conditioning (see Fig. 5). This constant behaviour of AKROTEK® PEEK and PAEK grades is a great advantage for component design.

AKROTEK® PEEK and AKROTEK® PAEK compounds provide extremely good resistance to a number of critical chemical compounds across a broad temperature range. AKROTEK® PEEK and AKROTEK® PAEK compounds have excellent barrier properties against liquids and gases. Their hydrolysis resistance is excellent, allowing for frequent contact with water vapour.

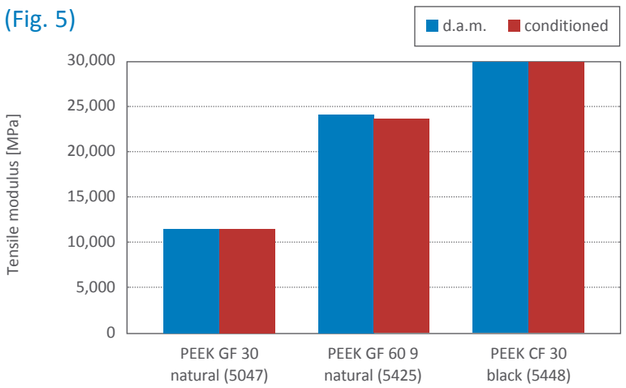
Moisture absorption at 70 °C and 62 % rel. humidity (Fig. 3)



Change in tensile strength during exposure time at 260 °C (Fig. 4)



Tensile modulus (Fig. 5)

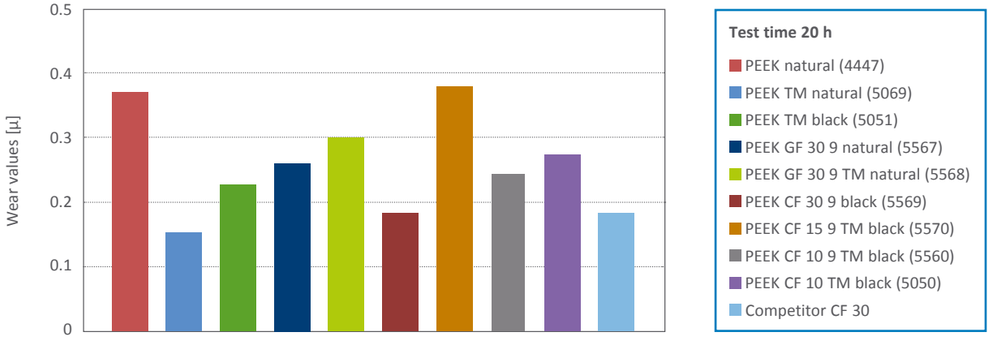


Wear rate and friction coefficient of AKROTEK® PEEK compounds in accordance with ASTM G137

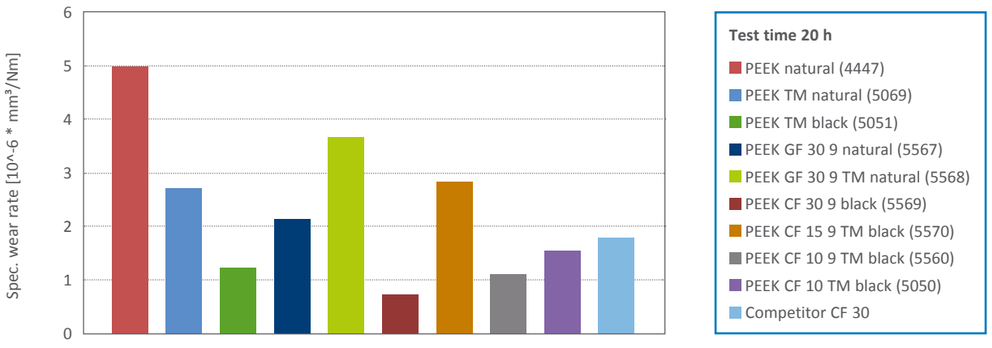
A test in accordance with ASTM G137 (block-on-ring) was conducted in collaboration with the Institute for Composite Materials (IVW GmbH) on the University of Kaiserslautern campus in order to examine the tribological properties of various AKROTEK® PEEK compounds. For this purpose, the composite to be tested was pressed against a ring-shaped metal piece at a defined pressure. The metal ring was set in motion. This creates a friction which subjects the test object to wear (Fig. 6). All AKROTEK® PEEK compounds tested were compared with a reference material under the same conditions. The test object was composed of 100Cr6 steel with a surface roughness of Ra ~0.3 µm.

Fig. 6: Schematic diagram of block-on-ring wear measurement

Medium kinetic wear values at 5 MPa, 1 m/s, block-on-ring pursuant to ASTM G137 (Fig. 7)



Medium specified wear rate at 7.5 MPa, 2 m/s, block-on-ring pursuant to ASTM G137 (Fig. 8)



Product characterisation

AKROTEK® PEEK CF 30 (5569) shows identical values at the dynamic friction coefficients under a load of 5 MPa and a speed of 1 m/s over 20 hours of testing time compared to the reference material (Fig.7). Both samples have an almost identical composition. The other AKROTEK® PEEK compounds show behaviour that is typical of the product due to their components.

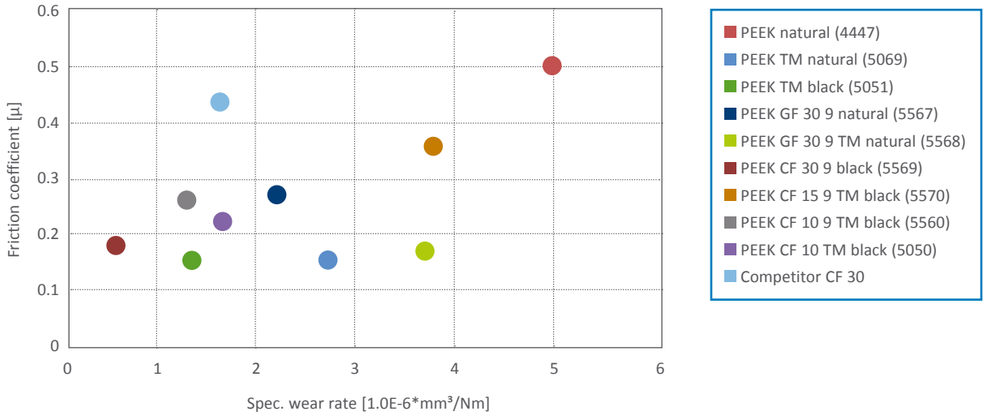
Figure 8 shows that even under higher loads, a load of 7.5 MPa and a speed of 2 m/s over 20 hours of testing time, AKROTEK® PEEK CF 30 (5569), AKROTEK® PEEK CF 10 9 TM (5560) and AKROTEK® PEEK TM (5051) achieve much better values than those specified by the reference material.

This becomes all the more apparent when taking the specific wear rate into account. Under increased load and speed, AKROTEK® PEEK compounds are able to ensure the function of components in critical applications due to their properties.

We would be happy to develop more solutions with you in order to make your products even better and more competitive.

Friction coefficient against wear rate, at 7.5 MPa, 2 m/s

(Fig. 9)



Wear – tribological definition

Tribology is the science of interacting surfaces in relative motion. This friction results in wear.

The two underlying mechanisms are:

Adhesive wear
When components in contact adhere to each other. When in relative motion to each other, particles from the softer material will usually adhere to the harder component.

Abrasive wear
Where hard particles or material penetrate the edge layer of one of the two components in contact, this could result in damage to the softer friction bodies. The penetration of foreign particles can increase the wear effect.

Friction coefficient

Friction is the natural resistance against the sliding motion of two surfaces against each other. The friction coefficient indicates its strength and is differentiated by:

Static friction coefficient
µs = Fx/Fy
Fx: driving force of the motion
Fy: Adhesion of the surfaces

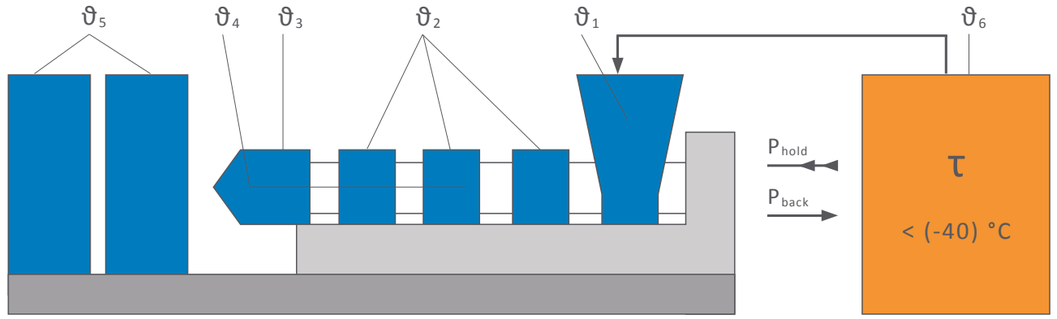
Kinetic friction coefficient
µk = Fx/Fy
Fx: Force to steadily continue a motion
Fy: Adhesion of the surfaces

Processing recommendations

AKROTEK® PEEK and AKROTEK® PAEK can be processed on commercially available injection moulding and extrusion machines. A heating system designed for temperatures up to 450 °C is required to achieve optimal processing results.

The mould heating/cooling system should enable mould surfaces to reach up to 190 °C. This ensures an optimal degree of crystallinity.

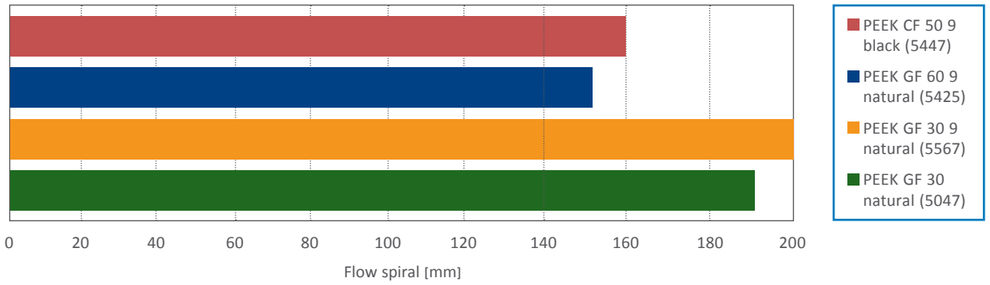
The flow rates achieved, due to the favourable filler behaviour, allow both development engineers and designers a great deal of freedom when designing components (see Fig.10). Time consuming and expensive additional processing steps can be eliminated and significant weight savings can be realised. In addition to performance, it was important that AKRO-PLASTIC product developers created materials that could be processed effectively using traditional plastics industry processes (such as injection moulding, extrusion and film production).



Injection moulding		AKROTEK® PEEK GF	AKROTEK® PEEK CF	AKROTEK® PAEK CF
Flange	ϑ_1	60 – 80 °C	60 – 80 °C	60 – 80 °C
Sector 1 – sector 4	ϑ_2	365 – 390°C	370 – 395 °C	390 – 410 °C
Nozzle	ϑ_3	400 °C	410 °C	410 °C
Melt temperature	ϑ_4	380 – 400 °C	370 – 400 °C	390 – 410 °C
Mould temperaturee	ϑ_5	160 – 200 °C	180 – 200 °C	180 – 210 °C
Drying	ϑ_6	150 – 160 °C, 2-4 h	150 – 160 °C, 2-4 h	150 °C, 2 – 4 h
Back pressure, spec.	P_{back}	300 – 800 bar	300 – 800 bar	300 – 800 bar

The specified values are for reference values. For increasing filling contents the higher values should be used.
For drying, we recommend using only dry air or a vacuum dryer. Processing moisture levels is 0.02 % are recommended.
The drying time of freshly-opened bags is up to 4 h at 150 °C. It is recommended to use opened bags completely.
Depending on storage conditions material processed from open packages or silo may have absorbed moisture and require a longer drying time.

Flow distance, 2 mm (Fig. 10)



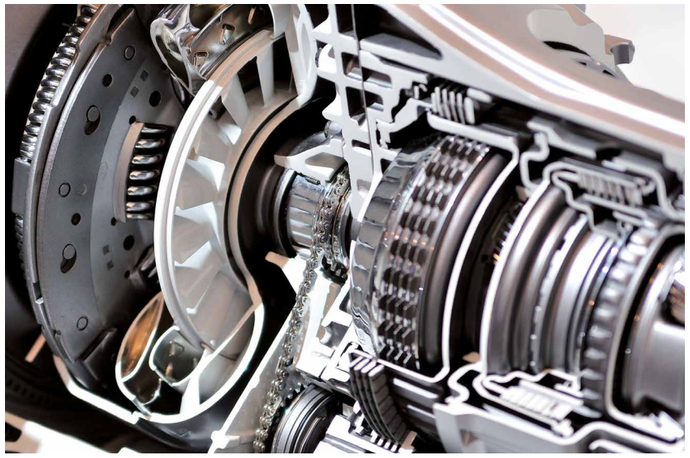
Applications

The combination of high impact strength, tensile strength and flexural strength in high-fill glass and carbon fibre compounds allows for use in a broad range of applications. Particularly in applications where the use of metals would not be optimal or where weight reduction is necessary, **AKROTEK® PEEK** and **AKROTEK® PAEK compounds** may be the right alternative.

AKROTEK® PEEK and **AKROTEK® PAEK compounds**, which are modified with appropriate additives such as PTFE, MoS_2, and carbon and aramide fibres, are used in many applications subject to increased wear and friction problems. The compounds can be modified to suit specific requirements profiles.

Due to the partially extreme applications and the standard processing temperatures for polyether ether ketone (PEEK), the use of commercial color pigments is hardly possible or not possible at all. The colour will usually bleed, and standard pigments will lose their brilliance and colour strength over a certain period of time. In combination with intensive UV radiation, this process is even accelerated.

In collaboration with our branch AF-COLOR, we have now succeeded in developing some color settings that meet the requirements of AKROTEK® PEEK. These innovative solutions are mainly used in the electrical & electronics markets, as well as medical technology.



Friction components in gearbox systems.

AKROTEK® PEEK is also available in different colors.

Application areas

Aviation
- Interior trim
- Seat components
- Fasteners

Automotive industry
- Gearbox components
- Clutch components
- Chassis components

Industry
- Pump components
- Compressor components
- Sealing rings
- Transport systems

Renewable energy
- Heat pumps
- Pipe couplings
- Hose connectors

Electric/electronic
- Cable coatings
- Contact strips
- Plug-in connectors

Medicine
- Dental implants
- Orthopaedic accessories
- Laboratory equipment

Resistance to media

Medium	Resistance at 23 °C	Resistance at 100 °C
1,1,1-trichlorethane	very good	
Acetone	very good	very good
Ammonia	very good	very good
Aromatic solvents	good	good
Bases	very good	good
Benzene	good	
Petrol	good	
Biodiesel	good	
Brake fluid DOT 3	very good	very good
Dimethyl sulfoxide (DMSO)	good	good
Iron(III)-oxide	very good	very good
Ethylene glycol	very good	very good
Formaldehyde	very good	very good
Hydrochloric acid, conc.	very good	good
Hydraulic fluid	good	good
Isopropanol	good	
Kerosene	very good	
Carbon monoxide	very good	very good
Engine oil	very good	very good
Sodium carbonate	very good	very good
Sodium hydroxide, 50% conc.	very good	very good
Nickel chloride	very good	very good
Organic nitrogen compounds	very good	good
Phosphoric acid, 50% conc.	very good	
Cleaning solutions	very good	good
Acids	good	good
Sulphuic acid, < 40% conc.	good	good
Sulphur trioxide	very good	very good
Toluene	very good	
Water vapour	very good	very good
Hydrogen peroxide	very good	very good

Good means: resistant
Limited resistance under the stated conditions.

Very good means: extremely resistant
Unlimited resistance under the stated conditions.

We will be pleased to meet you!

AKRO-PLASTIC GmbH
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