AKROMID® HI – The polyamide with high impact resistance

AKRO-PLASTIC
Think Polyamide

AKRO-PLASTIC GmbH
Member of the Feddersen Group

High-performance materials – impact-modified AKROMID® compounds

Polyamides are the largest product group of engineering plastics. They are typically used in engineering parts in the form of compounds. Alongside non-reinforced compounds, filled or reinforced compounds are used primarily to increase stiffness and strength.

It is known that the mechanical properties of thermoplastics are significantly influenced by environmental conditions. In addition to temperature, this includes water absorption and humidity, since components made from conditioned polyamides exhibit different strengths than freshly moulded parts. Thermoplastics are modified appropriately to perform under a wide range of ambient conditions.

AKRO-PLASTIC GmbH have developed a product range of impact-modified compounds for this purpose. These are suited specifically for applications which are exposed to harsh conditions. There are two types of **modified compounds: cold-impact-resistant (S1)** and **dry-impact-resistant (S3) compounds**. Non-reinforced and reinforced compounds with differing glass-fibre content are available.

AKROMID® HI (PA 6.6)

Typical values for black colored products at 23 °C	Test Specification	Test Method	Unit	A3 1 (2417)		A3 S1 (1071)		A3 S1 (4567)		A3 S1 (1114)		A3 GF 30 S1 (1365)		A3 GM 20/10 S1 (2006)		A3 1 S3 (1139)		A3 5 S3 15 (1434)	
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.
Tensile modulus	1 mm/min	ISO 527-1/2	MPa	3,200	1,100	2,000	900	2,000	900	3,000	2,000	9,600	8,000	6,900	4,800	2,700	1,300	2,500	1,220
Yield stress[1]/Tensile stress at break	5 mm/min	ISO 527-1/2	MPa	85	50	50	40	50	40	77	56	180	120	130	92	63	45	65	45
Elongation at break	5 mm/min	ISO 527-1/2	%	>20	>20	>50	>100	>50	>100	> 20	> 50	5	6	3.5	6	>35	>100	30	>100
Charpy impact strength	23 °C	ISO 179-1/1eU	kJ/m²	o.B.	o.B.	o.B.	o.B.	o.B.	o.B.	o.B.	o.B.	105	110	77	77	o.B.	o.B.	o.B.	o.B.
Charpy impact strength	-30 °C	ISO 179-1/1eU	kJ/m²	o.B.		o.B.	o.B.	o.B.	o.B.	o.B.	o.B.	85	100	76		o.B.	o.B.	o.B.	o.B.
Charpy notched impact strength	23 °C	ISO 179-1/1eA	kJ/m²	5	13	>80	>100	90		8		17	20	15	16	15	25	15	25
Charpy-notched impact strength	-30 °C	ISO 179-1/1eA	kJ/m²	2		35	35	20		7		12	12	8		10	13	15	
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.	
Melting point	DSC, 10 K/min	ISO 11357-1	°C	262		262		262		262		262		262		262		262	
Heat distortion temperature, HDT/A	1.8 MPa	ISO 75-1/2	°C	75		60				70		255		245		70			
Flammability																			
Flammability acc.UL 94	1.6 mm	UL 94	Class	V2		HB		HB		HB		HB		HB		HB		HB	
Rate acc. FMVSS 302 (<100 mm/min)	> 1 mm thickness	FMVSS 302	mm/min	+		+		+		+		+		+		+		+	
General Properties																			
Density	23 °C	ISO 1183	g/cm³	1.14		1.07				1.12		1.34		1.31		1.10		1.11	
Moisture absorption	70 °C/62 % r.h.	ISO 1110	%	2.9 – 3.1		2.0				2.3		1.7				2.1		1.9	
Processing																			
Flowability	Flow spiral[2]	AKRO	mm	1,040		770						690				800		800	
Processing shrinkage, flow		ISO 294-4	%	1.9		1.4				1.4		0.3		0.5		2.1			
Processing shrinkage, transverse		ISO 294-4	%	2.3		1.4				2.1		1.2		1.3		2.2			

Despite identical nomenclature the AKROMID® materials produced by AKRO in China are identified by differential batch numbering.

"cond." test values = conditioned, measured on test specimens stored according to ISO 1110
"d.a.m." = dry as moulded test values = residual moisture content < 0.10 %
n.b. = not broken + = passed

[1] = yield stress and elongation at break: test speed 50 mm/min for non-reinforced compounds
[2] = AKROMID® A – mould temperature: 100 °C, melt temperature: 320 °C, injection pressure: 750 bar, cross section of flow spiral: 7 mm x 3.5 mm

AKROMID® HI (PA 6)

Typical values for black colored products at 23 °C	Test Specification	Test Method	Unit	B3 1 (2501)		B3 S1 (3726)		B4 S1 (1327)		B3 GF 15 S1 (1270)		B3 GF 15 S1 (3228)		B3 GF 30 S1 (1281)		B3 GF 30 S1 (2091)		B3 GF 50 S1 (2000)	
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.
Tensile modulus	1 mm/min	ISO 527-1/2	MPa	3,600	1,200	2,000	550	2,300	550	5,800	3,000	6,000	3,100	8,800	5,500	7,500	4,200	15,000	7,800
Yield stress[1]/Tensile stress at break	5 mm/min	ISO 527-1/2	MPa	85	45	50	45	60	55	115	70	120	75	150	90	125	70	190	120
Elongation at break	5 mm/min	ISO 527-1/2	%	20	>50	>50	>100	50	>100	3,5	10	4	10	3,5	6	6	13	5	8
Charpy impact strength	23 °C	ISO 179-1/1eU	kJ/m²	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.	70	95	70	95	85	100	110	135	>100	>110
Charpy impact strength	-30 °C	ISO 179-1/1eU	kJ/m²	n.b.		n.b.	n.b.	n.b.	n.b.	50	45	50	45			>100	>100	>100	
Charpy notched impact strength	23 °C	ISO 179-1/1eA	kJ/m²	5	12	45	110	30		6	15	4	14	15	20	35	45	25	40
Charpy-notched impact strength	-30 °C	ISO 179-1/1eA	kJ/m²	2		55	40			5	5	6	5	10		25	22	20	
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.	
Melting point	DSC, 10 K/min	ISO 11357-1	°C	220		222		220		222		222		222		222		222	
Heat distortion temperature, HDT/A	1.8 MPa	ISO 75-1/2	°C	60		48		55		200		200		190		200		210	
Flammability																			
Flammability acc.UL 94	1.6 mm	UL 94	Class	V2		HB		HB		HB		HB		HB		HB		HB	
Rate acc. FMVSS 302 (<100 mm/min)	> 1 mm thickness	FMVSS 302	mm/min	+		+		+		+		+		+		+		+	
General Properties																			
Density	23 °C	ISO 1183	g/cm³	1.13		1.07		1.1		1.22		1.22		1.35		1.28		1.54	
Moisture absorption	70 °C/62 % r.h.	ISO 1110	%	2.6 – 3.4		2.3				2.3		2.3				1.4		1.3	
Processing																			
Flowability	Flow spiral[2]	AKRO	mm	1,070		600						730				530			
Processing shrinkage, flow		ISO 294-4	%	1.1		1.5						0.6		0.4		0.4		0.5	
Processing shrinkage, transverse		ISO 294-4	%	1.0		1.9						0.9		0.9		0.9		0.9	

"cond." test values = conditioned, measured on test specimens stored according to ISO 1110
"d.a.m." = dry as moulded test values = residual moisture content < 0.10 %
n.b. = not broken + = passed

[1] = yield stress and elongation at break: test speed 50 mm/min for non-reinforced compounds
[2] = AKROMID® B – mould temperature: 80 °C, melt temperature: 270 °C, injection pressure: 750 bar, cross section of flow spiral: 7 mm x 3.5 mm

AKROMID® HI (PA 6) + (PA 6.6/6 Blend)

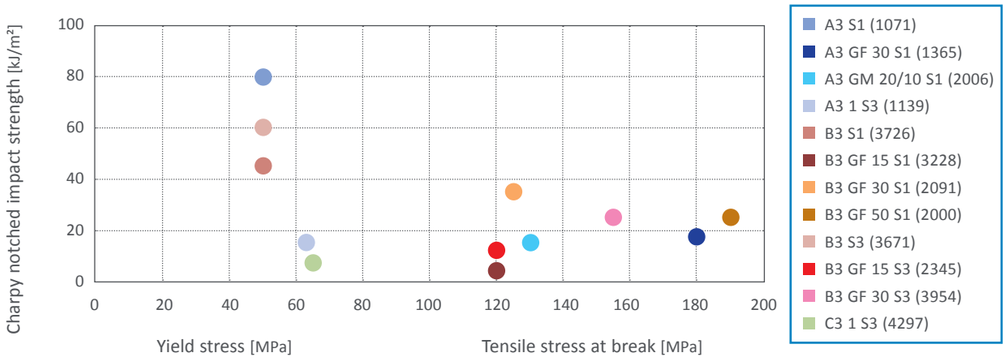
Typical values for black colored products at 23 °C	Test Specification	Test Method	Unit	B3 1 (2501)		B3 S3 (3671)		B3 3 S3 10		B3 GF 15 S3 (2345)		B3 GF 30 S3 (3954)		C3 1 (4546)		C3 1 S3 (4294)		C3 1 S3 (4297)	
Mechanical properties				d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.	d.a.m.	cond.
Tensile modulus	1 mm/min	ISO 527-1/2	MPa	3,600	1,200	2,000	650	2,700	955	5,800	3,000	9,000	5,500	3,100	1,100	2,500	1,100	2,500	1,100
Yield stress[1]/Tensile stress at break	5 mm/min	ISO 527-1/2	MPa	85/	45/	50/	30/	70/	40/	/120	/75	/155	/110	80/	45/	65/	45/	65/	45/
Elongation at break	5 mm/min	ISO 527-1/2	%	20	>50	>40	>100	>45	>100	4	10	5	10	5	> 50	30	> 100	25	> 100
Charpy impact strength	23 °C	ISO 179-1/1eU	kJ/m²	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.	75	100	>100	>100	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Charpy impact strength	-30 °C	ISO 179-1/1eU	kJ/m²	n.b.		n.b.	n.b.	n.b.	n.b.			>100	>100			n.b.		n.b.	
Charpy notched impact strength	23 °C	ISO 179-1/1eA	kJ/m²	5	12	>60	>100	10	28	12		25	50	3	13	10	30	7	20
Charpy-notched impact strength	-30 °C	ISO 179-1/1eA	kJ/m²	2		15	20	8	10			15	15			6		6	
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.	
Melting point	DSC, 10 K/min	ISO 11357-1	°C	220		222		222		222		222		260		260		260	
Heat distortion temperature, HDT/A	1.8 MPa	ISO 75-1/2	°C	60		50		60		200								60	
Flammability																			
Flammability acc.UL 94	1.6 mm	UL 94	Class	V2		HB		HB		HB		HB		V2		HB		HB	
Rate acc. FMVSS 302 (<100 mm/min)	> 1 mm thickness	FMVSS 302	mm/min	+		+		+		+		+		+		+		+	
General Properties																			
Density	23 °C	ISO 1183	g/cm³	1.13		1.05		1.10		1.21		1.33		1.14				1.12	
Moisture absorption	70 °C/62 % r.h.	ISO 1110	%	2.6 – 3.4		2.1		2.6				1.4		2.6		2.6		2.6	
Processing																			
Flowability	Flow spiral[2]	AKRO	mm	1,070		580		850				520		1,600		1,200		1,200	
Processing shrinkage, flow		ISO 294-4	%	1.1		1.2		1.3				0.3		1.2		1.4		1.4	
Processing shrinkage, transverse		ISO 294-4	%	1.0		1.8		1.7				0.8		1.9		2.1		2.2	

"cond." test values = conditioned, measured on test specimens stored according to ISO 1110
"d.a.m." = dry as moulded test values = residual moisture content < 0.10 %
n.b. = not broken + = passed

[1] = yield stress and elongation at break: test speed 50 mm/min for non-reinforced compounds
[2] = AKROMID® B – mould temperature: 80 °C, melt temperature: 270 °C, injection pressure: 750 bar, cross section of flow spiral: 7 mm x 3.5 mm
AKROMID® C – mould temperature: 90 °C, melt temperature: 300 °C, injection pressure: 750 bar, cross section of flow spiral: 7 mm x 3.5 mm

Product characterisation

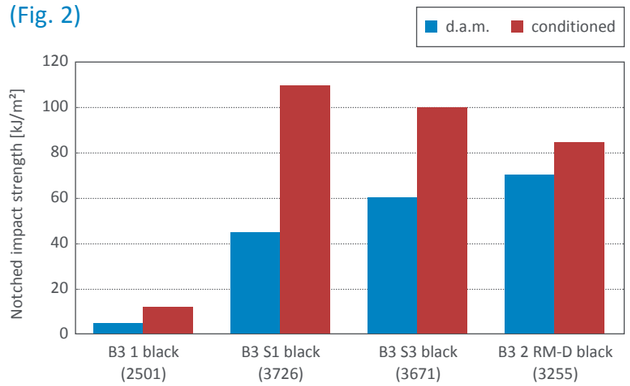
Notched impact strength through yield stress/tensile stress at break
(Fig. 1)



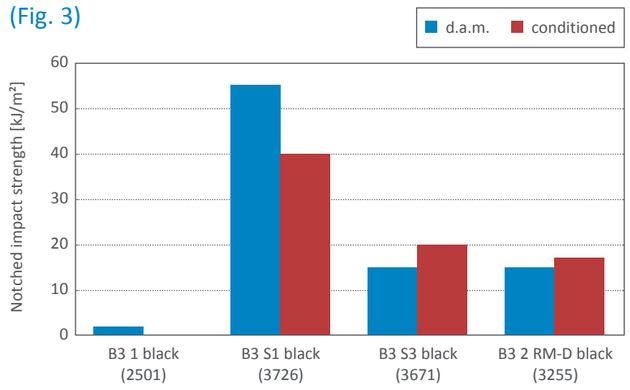
The requirements of the material to be used depend on the type of component. The optimal combination of strength and toughness can be formulated based on the composition of impact-modified compounds. Non-reinforced impact-modified compounds can exhibit extremely high impact strengths (see Fig. 1). By contrast, the glass-fibre grades in this product family are designed to provide a good balance of properties at significantly higher strengths.

As to be expected, impact strength increases at room temperature for all polyamide compounds in this overview as a result of conditioning. Dry-impact-resistant AKROMID® grades were developed for use in dry climates or to bypass pre-fitting conditioning. Thus in many cases, parts with snap-on connections can be clipped in immediately following injection moulding, which can accelerate the production process. AKROMID® B3 2 RM-D black (3255) – a special PA-ABS blend with good dry-impact properties – is an interesting alternative to conventional impact-modified compounds.

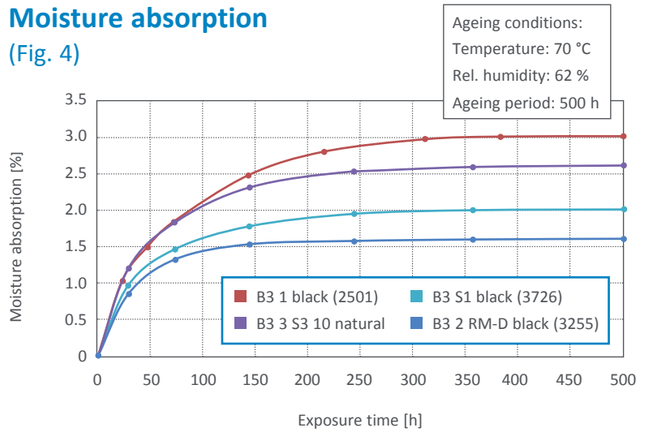
Notched impact strength at 23 °C
(Fig. 2)



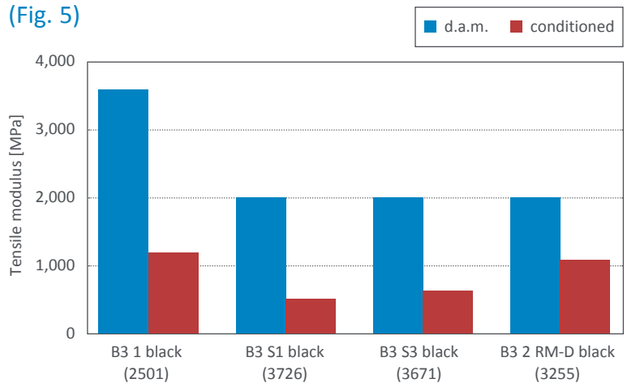
Notched impact strength at -30 °C
(Fig. 3)



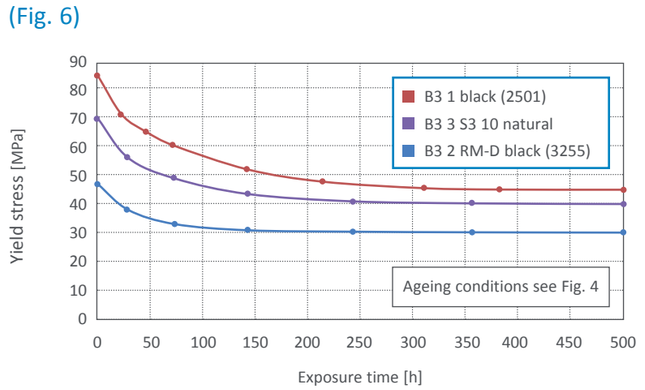
Moisture absorption
(Fig. 4)



Tensile modulus
(Fig. 5)



Yield stress as a function of exposure time
(Fig. 6)



The effect of conditioning is the lowest with the RM (reduced moisture) formulation (see AKROMID® RM brochure). A standard B3 1 black (2501), that is, a PA 6, was used as the reference product (see Fig. 2).

The impact strength diminished in the conditioned material at -30 °C, however. This was likely due to a complex interaction between the impact-strength modifier and the polymer matrix (see Fig. 3).

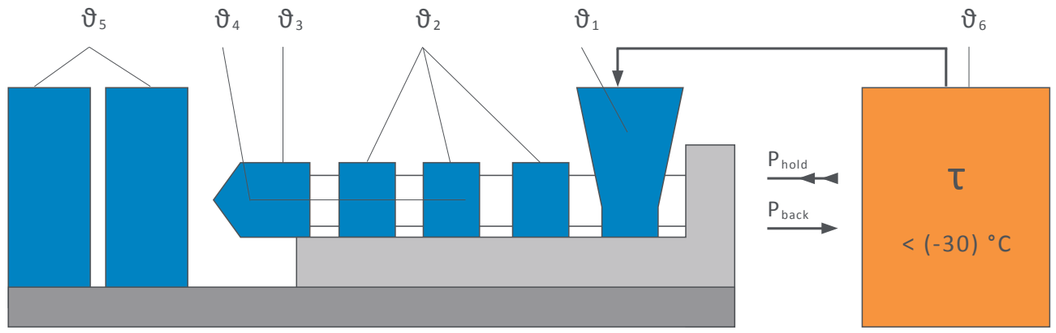
It is in the nature of polyamides to absorb moisture. Conditioning changes not only toughness, but also strength. The greater the moisture absorption, the more dramatic it is. The impact-strength modifiers themselves absorb very little moisture, which is why moisture absorption and thus the effect of strength due to conditioning are lower in these compounds than in unmodified compounds (see Fig. 4).

One of the advantages of AKROMID® B3 1 black (2501) is its greater stiffness when freshly moulded. With a reduction of the tensile modulus by more than 2 GPa, however, moisture absorption has a significantly greater effect than is the case in impact-modified compounds. This must be taken into account when designing parts (see Fig. 5).

As can clearly be seen, the yield stress of AKROMID® B3 1 and AKROMID® B3 3 S3 10 colourless is approximately the same when conditioned (see Fig. 6).

Processing recommendations

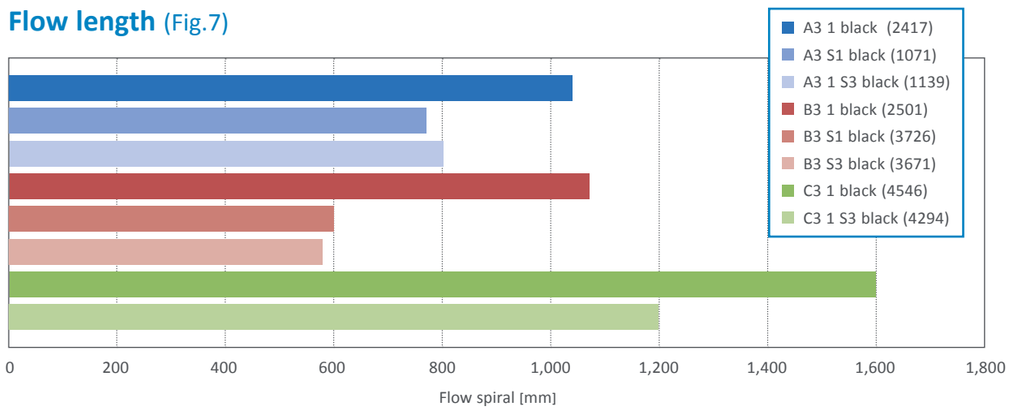
In terms of processing, it must be noted that impact-modified compounds have a higher viscosity than standard polyamides. These different flow characteristics can be clearly evident in certain cases, as demonstrated by AKROMID® B3 S1 black (3726) and AKROMID® B3 S3 black (3671) (see Fig. 7). It is generally possible, however, to formulate special compounds with favourable flow characteristics.



		AKROMID® A	AKROMID® B	AKROMID® C
Flange	ϑ_1	60 – 80 °C	60 – 80 °C	60 – 80 °C
Sector 1 – Sector 4	ϑ_2	260 – 300 °C	225 – 300 °C	225 – 300 °C
Nozzle	ϑ_3	280 – 295 °C	240 – 280 °C	280 – 295 °C
Melt temperature	ϑ_4	280 – 310 °C	260 – 300 °C	280 – 310 °C
Mould temperaturee	ϑ_5	80 – 100 °C	80 – 100 °C	80 – 100 °C
Drying	ϑ_6	80 °C, 2 h	80 °C, 2 h	80 °C, 2 h
Holding pressure, spec.	P_{hold}	300 – 800 bar	300 – 800 bar	300 – 800 bar
Back pressure, spec.	P_{back}	50 – 100 bar	50 – 100 bar	50 – 100 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 between 0.05 and 0.1 % are recommended.
The drying time of freshly-opened bags is up to 4 h. It is recommended to use opened bags completely.
Material processed from silo or boxes requires a minimum drying time of 4 h.

Flow length (Fig.7)



Applications

Impact-modified AKROMID® compounds are used in all industrial sectors.

Components for sports and leisure activities are frequently confronted with high forces or even impact loads. An interesting example is an ice skate from T-Blade, for which an impact-resistant AKROMID® was used to make the blade holder. The blade itself can be replaced with a new one as soon as it is worn out. The material meets the high standards of the component even at the low temperatures at work here.

Highly reinforced compounds are typically used as metal substitutes. Glazpart Ltd. (UK) have replaced a steel design with an intelligently developed plastic part made of a high-impact-modified AKROMID® compound which is used to protect a gas canister valve. It has passed all tests in the -40 °C to +65 °C range required for gas canisters with a gross weight of 100 kg.

In the motorcar industry, typical applications include window frame trim, cable ducts, fasteners and housings which may be subjected to impact loads. In these cases, dry-impact-resistant compounds are frequently used to bypass the conditioning step during assembly. Because polyamides are significantly more brittle at low temperatures than at room temperature, cold-impact-modified compounds are used when the requirements call for this.

Valve guard for gas canisters,
Glazpart Ltd. (UK):
AKROMID® A3 S1 grey (4377)

The examples shown here are just a few of the possible applications. We will be happy to discuss further specific applications personally with you.

Ice skate blade holder,
T-Blade:
AKROMID® B3 GF 30 S1 black (2091)

Application areas

Automotive industry
- Airbag clips
- Airbag housings
- Aerial housings
- Fastening clips
- Seat add-on parts
- Belt guides/holders
- Cable ducts
- Fan blades

Electric/Electronic
- CEE plugs
- Electrical plugs
- Housing parts
- Cable ties

Industry
- Dowels
- Cable ties
- Chain drives
- Valve guard for gas canisters
- Furniture fittings
- Tool parts
- Pump housings

Sports
- Ice skate blade holders
- Ski binding parts
- Parts for inline skates