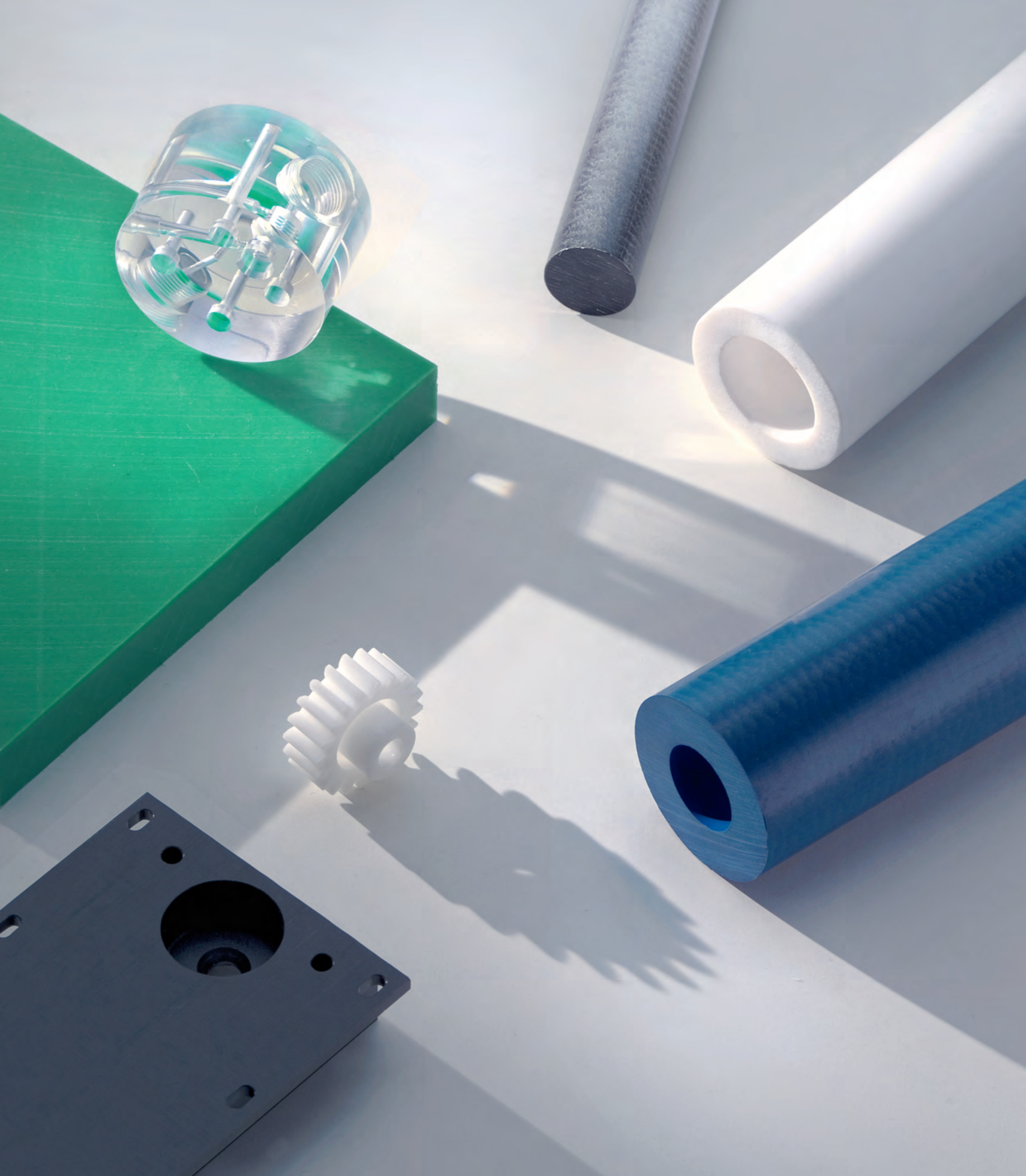
Angst+Pfister

APSOplast® Technical Plastics

Engineering Fundamentals



Introduction

Plastics are substances whose basic elements are synthetic or semi-synthetically generated polymers. The choice of raw material, production method, and additives enables the technical properties of plastics – such as meltability, hardness, elasticity, break resistance, and resistance to temperature and chemicals – to be widely varied.
These moulding compounds with additives are designated accordingly: Thermoplastics (DIN EN ISO 1043), thermosets (DIN 7708), or elastomers (DIN ISO 1629). Plastics are further processed to create finished parts, semi-finished products, fibres, or films.

Topic areas

Angst+Pfister has a comprehensive range of plastics that cover the needs of the market. We are particularly strong when it comes to high-performance materials, especially in high temperature ranges. Plastics specifically for use in the foodstuff and medical technology industries are new additions to the range. This catalogue has four new topic areas to enable the materials to be classified in accordance with the needs of the market:

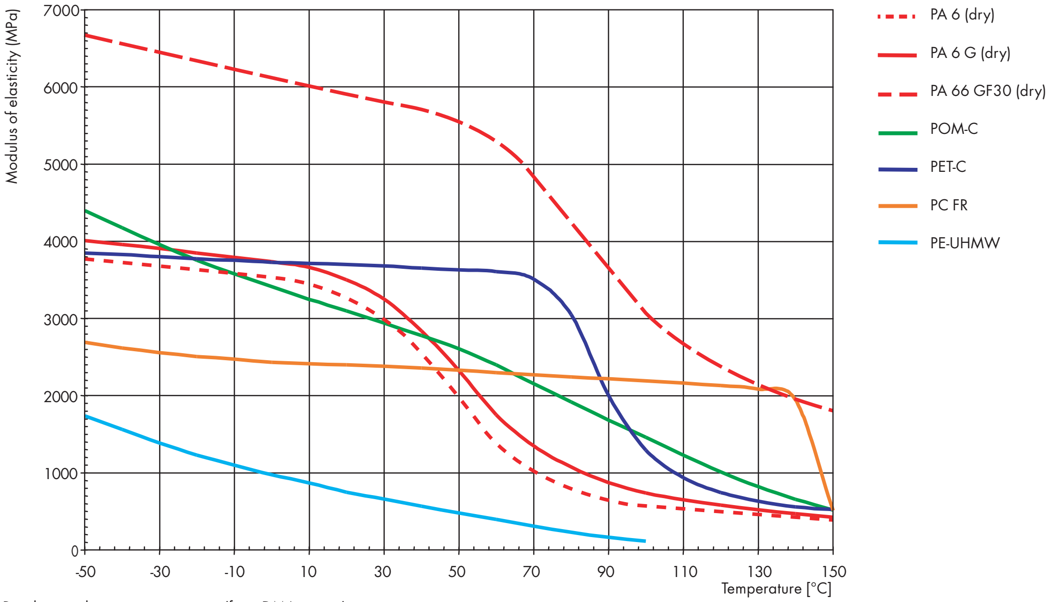
- Plastics for the food industry
- Plastics for medical technology
- Plastics for sliding functions
- Electrostatically dissipative/electrically conductive plastics

Extensive training and many years of practical experience are required in order to feel at home in the diverse world of plastics. Our expert advisors constantly research the products on offer on the market to ensure that we remain a competent dialogue partner. Our well-equipped warehouse and collaboration with powerful partners guarantee a high delivery readiness for all current materials and sizes.
The material descriptions provided here for informative reasons and the technical data contained herein are based on the tested values of our manufacturers. This information is used by designers and application engineers as an aid when choosing the most appropriate plastic. The specified values were determined in accordance with standard test methods and can be significantly influenced by additional determining factors such as temperature, environmental factors, residual tension, and so on.

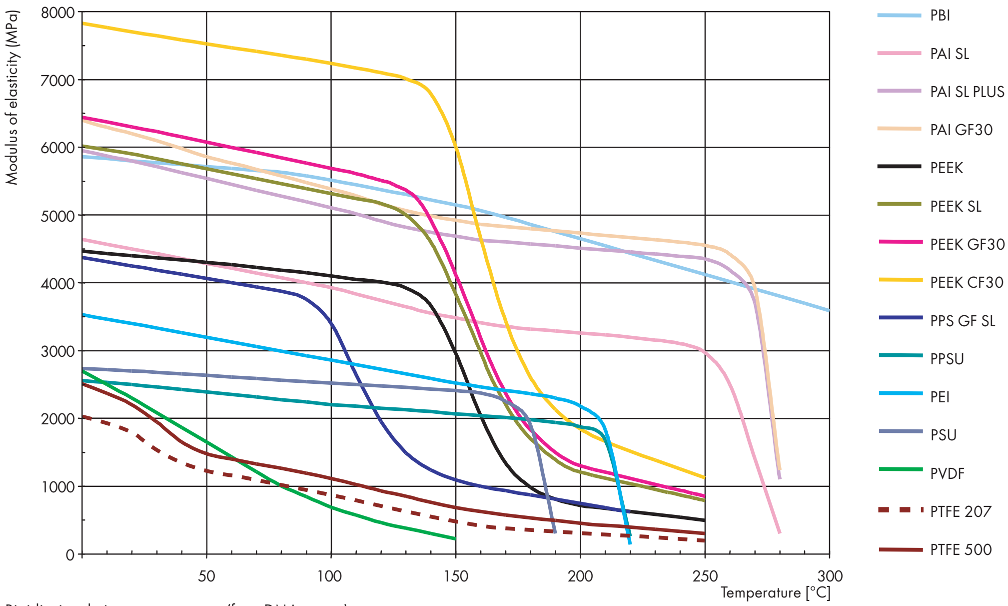
Introduction

The mechanical behaviour of plastics is more heavily influenced by relatively small changes in temperature than that of other materials such as metals. This correlation is particularly noticeable with regard to deformation behaviour. However, strength under short-term and long-term loads is also temperature-dependent. The two diagrams below clearly show the relationship between rigidity and temperature.

Rigidity in relation to temperature



Rigidity in relation to temperature (from DMA curves)



Rigidity in relation to temperature (from DMA curves)

Physical properties of standard plastics (guideline values in standardized climate +23 °C/50 % relative humidity)

APSOplast®-denomination				**PVC-U**	**PVC-U FO**	**PE-LD**	**PE-HD**	**PE-HMW**	**PE-HMW**	**PE-UHMW**	**PE-UHMW Regenerat**	**PE-UHMW ED**	**PE-UHMW ED FDA**	**PE-UHMW FR**	**PP**	**PP LSG**	**ABS**
Properties	**Test parameter**	**Test method**	**Unit**	**Colour** grey	white, grey	natural (opal)	black	natural (white)	coloured	natural (white)	coloured	black	black	black	grey	white, black	grey
Density		DIN EN ISO 1183-1	g/cm^3	1.44	0.55	0.93	0.96	≥0.95	≥0.95	≥0.93	≥0.94	≥0.95	≥0.95	0.99	0.91	0.92	1.07
Ball indentation hardness		DIN EN ISO 2039-1	MPa	–	–	21	40	50	50	35	36	35	35	–	–	100	90
Shore Hardness		DIN EN ISO 868	Shore D	82	49	54	64	65–67	65–67	61–65	62–67	61–65	61–65	63	72	72	78
Tensile strength at yield	50 mm/min	DIN EN ISO 527	MPa	58	16	13	22	≥26	≥26	≥20	≥ 20	≥18	≥18	22	32	38	45
Elongation at yield	50 mm/min	DIN EN ISO 527	%	4	3	12	9	–	–	–	–	–	–	–	–	–	–
Elongation at break	50 mm/min	DIN EN ISO 527	%	–	–	–	–	≥350	≥50	≥350	≥ 50	≥300	≥50	>200	>50	>25	20
Flexural strength	2 mm/min	ISO 178	MPa	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Modulus of elasticity (tensile test)	1 mm/min	DIN EN ISO 527	MPa	3300	900	350	900	≥1100	≥1100	≥700	≥ 700	≥750	≥750	700	1300	2000	2400
Impact strength	Charpy	DIN EN ISO 179-1eU	kJ/m^2	–	12	o.B.	o.B.	–	–	–	–	–	–	–	–	–	–
Notched impact strength	Charpy	DIN EN ISO 179-1eA	kJ/m^2	4	–	–	19	–	–	–	–	–	–	o.B.	8	4.0	11
		ISO 11542-2	kJ/m^2	–	–	–	–	≥25	≥15	≥190	≥ 100	≥140	≥100	–	–	–	–
Tensile strength	50 mm/min	DIN EN ISO 527	MPa	–	–	–	–	–	–	≥35	≥ 20	≥28	≥28	–	–	–	–
Coefficient of friction against hardened and polished steel		ASTM D 1894		–	–	–	–	0.10 – 0.15	0.10–0.15	0.10–0.15	0.10–0.16	0.10–0.15	0.10–0.15	–	–	–	–
Abrasion-Index (Sand-Slurry-Test)	PE-UHMW, natural = 100%	ISO 15527	%	–	–	–	–	400	400	100	120–140	100	100–110	–	–	–	–
Melting temperature		ISO 11357-1/-3	°C	–	–	–	–	133–136	133–136	133–135	133–137	133–135	133–135	135	162	167	–
Heat distortion temperature	HDT/B	DIN EN ISO 75	°C	–	–	–	–	–	–	–	–	–	–	79	90	–	–
	HDT/A	DIN EN ISO 75	°C	–	–	–	–	–	–	–	–	–	–	–	–	90	–
Min. service temperature			°C	0	0	–50	–50	–	–	–	–	–	–	–250	0	0	–40
Max. service temperature long term			°C	60	60	80	80	80	80	80	80	80	80	80	100	100	80
Max. service temperature short term			°C	–	–	–	–	–	–	–	–	–	–	130	150	150	100
Thermal conductivity			W/(K*m)	0.16	–	0.32	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.40	0.20	0.20	0.17
Coefficient of linear thermal expansion		DIN 53752	10^{-6}/K	80	70	200	180	150–200	150–200	200	200	200	200	150–230	120–190	120–190	90
Dielectric constant		IEC 60250		–	–	–	–	–	–	–	–	–	–	–	2.4	–	3.1
															IEC 60250		IEC 60250
Dielectric loss factor		IEC 60250		–	–	–	–	–	–	–	–	–	–	–	0.0002	–	0.015
Specific volume resistance		IEC 60093	Ω*cm	–	–	–	–	≥10^{14}	≥10^{14}	≥10^{14}	≤ 10^{14}	≤10^{8}	≤10^{5}	<10^{3}	>10^{14}	>10^{13}	10^{15}
Specific surface resistance		IEC 60093	Ω	10^{13}	>10^{15}	10^{14}	10^{14}	≥10^{13}	≥10^{13}	≥10^{13}	≤ 10^{13}	10^{6}–10^{8}	≤10^{5}	<10^{4}	>10^{14}	>10^{13}	10^{14}
Dielectric strength		IEC 60243	kV/mm	39	–	45	47	45	–	45	–	–	–	–	45	50	20
Tracking resistance		IEC 60112	CTI	–	–	–	–	–	–	–	–	–	–	–	600	>600	600
Water absorption	at 23 °C/50% r.h.	DIN EN ISO 62	%	–	–	–	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.1	<0.1	0.3
Flammability (UL 94)		UL 94		–	–	–	–	HB	HB	HB	HB	HB	HB	–	–	–	–
	thickness from 1 mm	UL 94		V0	–	–	–	–	–	–	–	–	–	–	–	–	–
	thicknesses 3 / 6 mm	UL 94		–	–	–	–	–	–	–	–	–	–	V0/V0	HB/HB	HB/HB	HB/HB

w/o = without break

Physical properties of transparent plastics (guideline values in standardized climate +23 °C/50 % relative humidity)

APSOplast®-denomination				**PVC-U**	**PMMA-XT**	**PMMA-GS**	**PMMA-XT ED**	**PET-A**	**PET-G**	**PC EC**	**PC LSG**	**PC**
Properties	**Test parameter**	**Test method**	**Unit**	**Colour** clear transparent	clear transparent	coloured transparent	clear transparent	clear transparent	clear transparent	clear transparent	natural, translucent	clear transparent
Density		DIN EN ISO 1183-1	g/cm³	1.36	1.20	1.20	1.19	1.33	1.27	1.20	1.20	1.20
Ball indentation hardness		DIN EN ISO 2039-1	MPa	120	–	–	–	–	–	–	140	–
Shore hardness		DIN EN ISO 868	Shore D	82	–	–	–	–	–	–	–	–
Tensile strength at yield	50mm/min	DIN EN ISO 527	MPa	55	–	–	–	>55	>45	60	74	>60
Elongation at yield	50mm/min	DIN EN ISO 527	%	3	–	–	–	4	4	6	6	6
Elongation at break	50mm/min	DIN EN ISO 527	%	≥10	5	5	5	>25	>35	70	>50	>50
Flexural strength	2 mm/min	ISO 178	MPa	90	–	–	–	–	80	100	–	90
Modulus of elasticity (tensile test)	1 mm/min	DIN EN ISO 527	MPa	3000	3200	3000	–	2500	2020	2400	2400	2350
Impact strength	Charpy	DIN EN ISO 179-1eU	kJ/m²	o.B.	20	12–26	–	o.B.	o.B.	o.B.	o.B.	o.B.
Notched Impact strength	Charpy	DIN EN ISO 179-1eA	kJ/m²	3	2	2	–	4	7	11	9	11
Tensile strength	50 mm/min	DIN EN ISO 527	MPa	30	83	67–75	74.5	>55	>45	60	74	>60
Heat distortion temperature	HDT/B	DIN EN ISO 75	°C	72	–	–	–	–	–	–	–	–
	HDT/A	DIN EN ISO 75	°C	–	95	105	–	63	63	–	130	127
Min. service temperature			°C	–15	–40	–40	–	–	–	–	–50	–100
Max. service temperature long term			°C	60	70	80	–	60	65	–	120	120
Max. service temperature short term			°C	–	95	100	–	–	–	–	135	135
Thermal conductivity			W/(K*m)	0.14	–	–	0.21	0.25	0.20	–	0.21	0.20
Coefficient of linear thermal expansion		DIN 53752	10^{-6}/K	80	80	80	70	50	50	65	65	65
Dielectric constant		IEC 60250		3.0	–	–	3.0	3.4	2.6	12	3.0	3.0
Dielectric loss factor		IEC 60250		0.01	–	–	–	0.015	0.005	–	0.001	0.009
Specific volume resistance		IEC 60093	Ω*cm	$\geq 10^{15}$	–	10^{15}	–	10^{15}	10^{15}	–	$>10^{14}$	10^{14}
Specific surface resistance		IEC 60093	Ω	$\geq 10^{13}$	10^{13}	10^{14}	10^{6}–10^{8}	10^{16}	10^{16}	10^{5}–10^{7}	$>10^{13}$	10^{16}
Dielectric strength		IEC 60243	kV/mm	20–40	–	–	–	60	16	–	28	34
Tracking resistance		IEC 60112	CTI	600	–	–	–	–	–	–	350	–
Water absorption	at +23 °C / 50% r.h.	DIN EN ISO 62	%	0.2	0.6	0.17	0.3	0.5	0.6	–	0.15	0.3
Flammability	thickness from 1 mm	UL 94		V0	–	–	–	–	–	–	–	–
	thicknesses 3 / 6 mm	UL 94		–	– /HB	– /HB	–	–	–	–	HB/HB	–
Light transmission	3 mm	DIN 5036 / ASTM D-1003 / ISO 13468-1/-2	%	88	92	92	85	87	88	89	–	88
Refraction index		ISO 489		–	1.491	1.491	1.49	1.587	1.567	1.586	–	1.586
Light reflectance factor		DIN 5033/5036	%	–	4	4	–	–	–	8	–	–
Haze		–	%	–	–	–	2	–	–	<1	–	–

w/o = without break

Physical properties of technical plastics (guideline values in standardized climate +23 °C/50% relative humidity)

APSOplast®-denomination				**PA 6**	**PA 6 MO**	**PA 66**	**PA 66 MO**	**PA 66 GF30**	**PA 66 CF20**	**PA 46**	**PA 12**	**PA 6 G**	**PA 6 G MO**	**PA 6 G HS**	**PA 6 G LO**	**PA 6 G Plus**	**PA 6 G SL**	**PA 6 G SL PLUS**
Properties	**Test parameter**	**Test method**	**Unit**	**Colour** natural (white), black	black	natural (cream), black	black/ anthracite	black	black	reddish brown	natural, black	natural (ivory), black	black/ anthracite	black	green	blue	grey	dark blue
Density		DIN EN ISO 1183-1	g/cm^3	1.14	1.14	1.15	1.15	1.32	1.23	1.18	1.02	1.15	1.15	1.15	1.14	1.19	1.14	1.18
Ball indentation hardness		DIN EN ISO 2039-1	MPa	170	170	180	180	210	200	168	100	180	185	170	165	190	170	180
Shore hardness		DIN EN ISO 868	scale D	82	82	83	83	86	–	84	78	83	83	82	82	82	81	82
Tensile strength at yield	50 mm/min	DIN EN ISO 527	MPa	80	80	85	90	100	104	95	50	75	82	75	70	76	75	70
Elongation at yield	50 mm/min	DIN EN ISO 527	%	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–
Tensile strength	50 mm/min	DIN EN ISO 527	MPa	–	–	–	–	–	104	–	–	–	–	–	–	–	–	–
Elongation at break	50 mm/min	DIN EN ISO 527	%	≥50	≥50	50	20	5	13	30	200	≥45	≥35	≥15	≥50	≥7	≥35	≥4
Flexural strength	2 mm/min 10N	DIN EN ISO 178	MPa	–	–	–	–	–	135	–	–	–	–	–	–	–	–	–
Modulus of elasticity (tensile test)	1 mm/min	DIN EN ISO 527	MPa	3200	3200	3300	3400	5000	5100	3100	1800	3400	3500	3700	3300	4000	3400	4000
Modulus of elasticity (flexural test)	2 mm/min 10N	DIN EN ISO 178	MPa	–	–	–	–	–	4300	–	–	–	–	–	–	–	–	–
Compressive strength 1%	5 mm/min 10N	EN ISO 604	MPa	–	–	–	–	–	16	–	–	–	–	–	–	–	–	–
Compressive strength 2%	5 mm/min 10N	EN ISO 604	MPa	–	–	–	–	–	33	–	–	–	–	–	–	–	–	–
Compression modulus	5 mm/min 10N	EN ISO 604	MPa	–	–	–	–	–	3800	–	–	–	–	–	–	–	–	–
Impact resistance	Charpy	DIN EN ISO 179-1eU	kJ/m^2	–	–	–	–	–	116	–	–	–	–	–	–	–	–	–
Notched impact strength	Charpy	DIN EN ISO 179-1eA	kJ/m^2	≥3	≥3	≥3	≥2	6	–	6	20	≥3	≥2.5	≥2.5	≥4.0	≥2.5	≥3.5	≥2.5
Melting temperature		ISO 11357-3	°C	220	220	260	260	260	260	295	178	216	216	216	213	218	215	217
Glass transition temperature		DIN 53765	°C	–	–	–	–	–	48	–	–	–	–	–	–	–	–	–
Heat distortion temperature		DIN EN ISO 75/A	°C	75	75	100	100	150	–	160	50	95	95	95	90	100	90	100
Min. service temperature			°C	–40	–40	–30	–30	–20	–	–40	–50	–40	–40	–40	–40	–40	–40	–40
Max. service temperature short term			°C	160	160	170	170	200	170	200	140	170	170	180	160	170	160	170
Max. service temperature long term			°C	85	85	95	95	120	100	135	80	110	110	120	110	110	110	110
Thermal conductivity			W/(K*m)	0.23	0.23	0.23	0.23	0.24	0.72	0.3	0.3	0.25	0.25	0.25	0.25	0.27	0.25	0.25
Specific heat			kJ/(kg*K)	1.7	1.7	1.7	1.7	1.5	1.4		1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Coefficient of linear thermal expansion 23° – 60 °C		DIN 53752	$10^{-6}/K$	90	90	80	80	50	90	80	100	80	80	80	80	60	80	60
Coefficient of linear thermal expansion 23° – 100 °C		DIN EN ISO 11359-1-2	$10^{-6}/K$	–	–	–	–	–	100	–	–	–	–	–	–	–	–	–
Dielectric constant		IEC 60250		3.9	–	3.8	–	–	–	3.8	3.8	3.7	–	–	–	–	–	–
Dielectric loss factor	50 Hz	IEC 60250		0.02	–	0.015	–	–		0.13	0.04	0.02	–	–	–	–	–	–
Specific volume resistance		IEC 60093	Ω*cm	10^{15}	–	10^{15}	–	–	$10^{3} – 10^{9}$	10^{15}	10^{15}	10^{15}	–	–	–	–	–	–
Specific surface resistance		IEC 60093	Ω	10^{13}	–	10^{13}	–	–	$10^{4} – 10^{10}$	10^{16}	10^{13}	10^{13}	–	–	–	–	–	–
Dielectric strength		IEC 60243	kV/mm	20	–	25	–	–	–	22	26	20	–	–	–	–	–	–
Tracking resistance		IEC 60112		600	–	600	–	–	–	400	600	600	–	–	–	–	–	–
Moisture absorption at saturation in standardized climate		DIN EN ISO 62	%	3	3	2.8	2.8	1.7	–	3.7	0.8	2.5	2.5	2.5	2	2	2	2
Water absorption 24 h	24 h (23 °C)	DIN EN ISO 62	%	–	–	–	–	–	0.1	–	–	–	–	–	–	–	–	–
Water absorption 96 h	96 h (23 °C)	DIN EN ISO 62	%	–	–	–	–	–	0.3	–	–	–	–	–	–	–	–	–
Flammability	Thicknesses 3/6 mm	UL 94		HB/HB	HB/HB	HB/V2	HB/V2	HB/HB	HB/–	HB/HB	HB/HB	HB/V2	HB/HB	HB/V2	HB/HB	HB/V2	HB/HB	HB/HB

APSOplast®-denomination	**POM-C**	**POM-C LSG**	**POM-C SL**	**POM-C EC**	**POM-C ED**	**POM-C GF25**	**POM-C ID**	**POM-C SAN**	**POM-H**	**POM-H SL**	**PET-C**	**PET-C SL**
Properties / **Colour**	various	various	blue	black	cream	greyish white	grau, opaque	white opaque	natural (white), black	brown	natural (white), black	grey
Density	1.41	1.41	1.52	1.4	1.34	1.59	1.49	1.41	1.42	1.54	1.38	1.44
Ball indentation hardness	165	150	120	100	90	180	174	163	160	–	170	160
Shore hardness	–	81	80	79	76	–	–	–	83	–	84	–
Tensile strength at yield	67	67	50	40	42	51	68	69	75	50	85	76[1]
Elongation at yield	9	–	–	–	–	9	8	7	–	–	–	4[1]
Tensile strength	67	–	–	–	–	51	68	67	–	–	–	76[1]
Elongation at break	32	30	16	30	20	12	10	18	30	10	15	5[1]
Flexural strength	91	–	–	–	–	88	100	93	–	–	–	–
Modulus of elasticity (tensile test)	2800	2800	2500	1900	1800	4200	3200	2900	3200	2900	3000	3300
Modulus of elasticity (flexural test)	2600	–	–	–	–	4100	3100	2800	–	–	–	–
Compressive strength 1%	20	–	–	–	–	23	17	18	–	–	–	24[2]
Compressive strength 2%	35	–	–	–	–	39	31	31	–	–	–	47[2]
Compression modulus	2300	–	–	–	–	3600	2400	2200	–	–	–	–
Impact resistance	–	–	–	–	–	36	59	102	–	–	–	30
Notched impact strength	8	6.0	4	5	5	–	11	–	10	–	2.0	2.5
Melting temperature	165	165	165	165	165	165	165	165	175	175	255	245
Glass transition temperature	–60	–	–	–	–	–60	–60	–60	–	–	–	–
Heat distortion temperature	110	110	98	89	106	–	–	–	110	118	80	75
Min. service temperature	–	–50	–50	–20	–50	–	–	–	–50	–40	–20	–20
Max. service temperature short term	140	140	140	140	140	140	140	140	150	150	180	160
Max. service temperature long term	100	100	100	100	85	100	100	100	90	90	115	100
Thermal conductivity	0.39	0.31	–	0.31	–	0.47	0.39	0.39	0.31	–	0.28	0.29
Specific heat	1.4	1.5	–	–	–	1.2	1.3	1.4	1.5	–	1.1	–
Coefficient of linear thermal expansion 23° – 60 °C	110	110	120	130	170	80	130	130	100	95	60	65
Coefficient of linear thermal expansion 23° – 100 °C	140	–	–	–	–	80	140	140	–	–	–	85
Dielectric constant	3.8	3.8	3.7	–	–	–	–	–	3.8	3.2	3.4	3.4
Dielectric loss factor	0.002	0.002	0.002	–	–	–	–	–	0.002	0.009	0.001	0.001
Specific volume resistance	10^{13}	10^{13}	10^{15}	$5*10^{3}$	$10^{9} – 10^{12}$	10^{14}	–	–	10^{15}	10^{15}	10^{18}	$>10^{14}$
Specific surface resistance	10^{13}	10^{13}	–	10^{3}	$10^{9} – 10^{11}$	10^{14}	$>10^{13}$	–	10^{15}	10^{15}	10^{16}	$>10^{13}$
Dielectric strength	40	40	33	–	–	–	–	–	25	16	20	21
Tracking resistance	600	600	600	–	–	–	–	–	600	–	600	600
Moisture absorption at saturation in standardized climate	–	0.2	0.65	0.25	0.2	–	–	–	0.2	0.18	0.25	–
Water absorption 24 h	0.05	–	–	–	–	0.07	0.05	0.05	–	–	–	0.06
Water absorption 96 h	0.1	–	–	–	–	0.2	0.1	0.1	–	–	–	0.13
Flammability	HB/HB	HB/HB	HB/HB	HB/HB	HB/HB	HB/–	HB/–	HB/–	HB/HB	HB/HB	HB/HB	HB/HB

[1] Test parameter 5 mm/min
[2] Test parameter 1 mm/min

Physical properties of high-performance plastics (guideline values in standardized climate +23 °C/50 % relative humidity)

APSOplast®-denomination				PPE	PPE GF30	PSU	PPSU	PEI	PEI EC	PPS GF40	PPS GF SL	PPS SL	PEEK	PEEK SL	PEEK SL FDA natur	PEEK SL FDA blau	PEEK GF 30	PEEK CF 30	PEEK EC	PAI SL	PAI SL PLUS	PAI GF30	PAI ED	VESPEL PI SP1	VESPEL PI SP21	VESPEL PI SP22	VESPEL PI SP211	PBI
Properties	**Test parameter**	**Test method**	**Unit**	**Colour** grey	beige	natural (yellow, translucent)	black	natural (amber, transparent)	black	black	dark blue	black	natural (brownish grey), black	black	natural	blue	natural (brownish grey)	black	black	yellow ochre	black	khaki	black	brown	anthracite	anthracite	anthracite	black
Density		DIN EN ISO 1183-1	g/cm³	1.10	1.30	1.24	1.29	1.27	1.14	1.65	1.42	1.50	1.31	1.46	1.36	1.41	1.51	1.40	1.36	1.41	1.45	1.61	1.54	1.43	1.51	1.65	1.55	1.30
Ball indentation hardness		DIN EN ISO 2039-1	MPa	140	200	155	143	220	–	250	160	238	230	220	220	220	250	310	253	200	200	275	–	–	–	–	–	375
Shore hardness		DIN EN ISO 868	Shore D	82	87	85	–	86	–	92	–	–	88	85	86	86	89	91	–	–	–	–	93	–	–	–	–	–
Tensile strength at yield		DIN EN ISO 527	MPa	50	70	80	77	110	–	90	–	53	110	75	87	85	80	120	106	150	–	–	–	–	–	–	–	–
Elongation at Yield	50 mm/min	DIN EN ISO 527	%	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	4	9	–	–	–	–	–	–	–	–
Tensile strength		DIN EN ISO 527	MPa	–	–	–	–	–	62	–	78	53	–	–	–	–	–	–	–	150	110	125	85	–	–	–	–	130
Tensile strength at break	50 mm/min	DIN EN ISO 527	MPa	–	–	–	–	–	–	–	–	53	–	–	–	–	–	–	106	–	110	–	85	–	–	–	–	–
	5 mm/min	DIN EN ISO 527	MPa	–	–	–	–	–	–	–	78	–	–	–	–	–	–	–	–	–	–	125	–	–	–	–	–	130
		ASTM D 1708	MPa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	86	66	52	45	–
Elongation at break		DIN EN ISO 527	%	10	3	15	30	12	–	2	–	2	20	4	3	3	5	7	4	20	5	–	4	–	–	–	–	–
	5 mm/min	DIN EN ISO 527	%	–	–	–	–	–	2	–	3.5	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	3
		ASTM D 1708	%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7.5	4.5	3.0	3.5	–
Flexural strength		DIN EN ISO 178	MPa	–	–	–	–	–	–	–	–	91	–	–	–	–	–	–	178	–	–	–	135	–	–	–	–	–
Modulus of elasticity (tensile test)		DIN EN ISO 527	MPa	2400	4500	2600	2500	3100	5850	6500	4000	4600	4000	4900	3700	3700	6000	6500	4800	4200	5500	6400	4500	–	–	–	–	6000
		ASTM D 638	MPa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3280	–	–	–	–
Modulus of elasticity (flexural test)		DIN EN ISO 178	MPa	–	–	–	–	–	–	–	–	4800	–	–	–	–	–	–	4700	–	–	–	4200	–	–	–	–	–
		ASTM D 790	MPa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3100	3790	4830	3100	–
Compressive strength 1%		EN ISO 604	MPa	–	–	–	–	–	–	–	33	19	–	–	–	–	–	–	27	34	39	55	240	–	–	–	–	58
Compressive strength 2%		EN ISO 604	MPa	–	–	–	–	–	–	–	65	36	–	–	–	–	–	–	47	67	72	104	–	–	–	–	–	118
Compressive modulus		EN ISO 604	MPa	–	–	–	–	–	–	–	–	3300	–	–	–	–	–	–	3600	–	–	–	–	–	–	–	–	–
Impact strength	Charpy	DIN EN ISO 179-1eU	kJ/m²	–	–	–	–	–	–	24	25	14	–	28	–	–	33	62	58	–	45	30	17.8	–	–	–	–	20
	Izod	ASTM D 256	J/m	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	747	320	–	–	–
Notched impact strength	Charpy	DIN EN ISO 179-1eA	kJ/m²	11	5	6	10	4	4	–	4	–	4	5	3.5	2.0	3	–	–	15	4	3.5	2.8	–	–	–	–	2.5
	Izod	ASTM D 256	J/m	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	42.7	42.7	–	–	–
Coefficient of friction against hardened and polished steel	p=0.05 N/mm² v=0.6 m/s			–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.35	0.30	0.27	0.20	–
Melting temperature		ISO 11357-3	°C	–	–	–	–	–	–	285	280	281	343	343	343	343	343	343	341	–	–	–	–	–	–	–	–	–
Glass transition temperature		DIN 53765	°C	–	–	–	–	–	220	–	–	94	–	–	–	–	–	–	147	280	280	280	340	–	–	–	–	415
Heat distortion temperature		DIN EN ISO 75 / A	°C	100	135	175	205	200	200	260	115	–	152	293	150	150	315	315	–	280	280	280	–	360	360	–	–	425
Min. service temperature			°C	–40	–20	–50	–50	–50	–20	0	–20	–	–60	–30	–30	–30	–20	–20	–	–50	–20	–20	–	–	–	–	–	–50
Max. service temperature long term			°C	100	100	160	180	170	170	220	220	230	250	250	250	250	250	250	260	250	250	250	300	300	300	300	300	310
Max. service temperature short term			°C	110	110	180	210	210	200	250	260	260	310	310	310	310	310	310	300	270	270	270	–	360	360	360	360	500
Thermal conductivity			W/(K*m)	0.23	–	0.26	0.00	0.24	0.35	–	0.30	0.58	0.25	0.24	–	–	0.43	0.92	0.46	0.26	0.54	0.36	–	0.35	0.87	0.89	0.76	0.40
Specific heat		DIN 52612	kJ/(kg*K)	1.20	1.30	1.10	–	1.10	–	–	–	0.90	1.34	–	–	–	–	–	1.10	–	–	–	–	1.13	–	–	–	–
Coefficient of linear thermal expansion	23–60 °C	DIN 53752	10^{-6}/K	80	–	55	55	45	35	30	50	50	50	30	55	55	30	25	50	40	35	35	–	54	49	27	54	25
Coefficient of linear thermal expansion	23–150 °C	DIN 53752	10^{-6}/K	–	–	–	–	–	35	–	50	60	50	30	–	–	40	40	50	40	35	35	33	–	–	–	–	25
Dielectric constant		IEC 60250	50 Hz	2.8	–	3.2	3.44	3.2	–	–	–	–	3.2	–	–	–	3.2	–	–	–	–	–	–	–	–	–	–	–
		IEC 60250	100 Hz	–	–	–	–	–	–	–	3.3	–	–	–	–	–	–	–	–	4.2	6	4.4	–	–	–	–	–	3.3
		ASTM D 150	100 Hz	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.62	13.53	–	–	–
Dielectric loss factor		IEC 60250	50 Hz	0.008	–	0.001	–	0.0015	–	–	–	–	0.001	–	–	–	0.001	–	–	–	–	–	–	–	–	–	–	–
		IEC 60250	100 Hz	–	–	–	–	–	–	–	0.003	–	–	–	–	–	–	–	–	0.026	0.037	0.022	–	–	–	–	–	0.001
		ASTM D 150	100 Hz	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0018	0.0053	–	–	–
Specific volume resistance		IEC 60093	Ω*cm	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{4} – 10^{6}	–	>10^{14}	–	4.9 * 10^{16}	10^{7} – 10^{9}	–	–	10^{14}	<10^{4}	–	>10^{14}	>10^{13}	>10^{14}	–	–	–	–	–	>10^{14}
		DIN EN 61340-2-3	Ω*cm	–	–	–	–	–	–	–	–	10^{7}–10^{12}	–	–	–	–	–	–	10^{3}–10^{5}	–	–	–	–	–	–	–	–	–
		ASTM D 257	Ω*cm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10^{14}–10^{15}	10^{12}–10^{13}	–	–	–
Specific surface resistance		IEC 60093	Ω	10^{15}	10^{15}	10^{14}	–	10^{15}	–	–	–	–	10^{18}	10^{7}–10^{9}	10^{16}	10^{17}	10^{13}	<10^{4}	–	–	–	–	10^{9}–10^{11}	–	–	–	–	–
		ANSI/ESD STM 11.11	Ω	–	–	–	–	–	10^{4}–10^{6}	–	>10^{13}	–	–	–	–	–	–	–	–	>10^{13}	>10^{13}	>10^{13}	–	–	–	–	–	>10^{13}
		DIN EN 61340-2-3	Ω	–	–	–	–	–	–	–	–	10^{4}–10^{6}	–	–	–	–	–	–	10^{2}–10^{4}	–	–	–	–	–	–	–	–	–
		ASTM D 257	Ω	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10^{14}–10^{16}	–	–	–	–
Dielectric strength		IEC 60243	kV/mm	30	25	30	15	30	–	–	24	–	20	–	20	20	20	–	–	24	–	28	–	–	–	–	–	28
		ASTM D 149	kV/mm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22	9.84	–	–	–
Comparative tracking index	CTI	IEC 60112		450	–	125	100	150	–	–	100	–	150	–	–	–	175	–	–	175	175	175	–	–	–	–	–	–
Moisture absorption at saturation, standardized climate		DIN EN ISO 62	%	0.05	0.04	0.2	0.6	0.5	–	0.015	–	0.03	0.2	0.15	0.2	0.2	0.14	0.14	–	2.5	1.9	1.7	–	1.3	1.1	–	–	7.5
Water absorption 24 h	24 h (23 °C)	DIN EN ISO 62	%	0.02	0.01	0.06	0.3	0.05	–	<0.01	0.01	0.01	0.02	0.02	–	–	0.02	0.02	0.02	0.35	0.3	0.26	0.46	–	–	–	–	0.74
Water absorption 96 h	96 h (23 °C)	DIN EN ISO 62	%	0.04	0.02	0.1	0.65	0.1	–	0.01	0.02	0.01	0.03	0.03	–	–	0.03	0.03	0.03	0.67	0.55	0.52	–	–	–	–	–	1.37
Flammability (UL94)		UL 94		–	–	–	–	–	–	–	–	V0	–	–	–	–	–	–	V0	–	–	–	V0	V0	V0	V0	V0	–
	Thicknesses 3/6 mm	UL 94		HB/HB	HB/HB	HB/V0	V0/V0	V0/V0	–	V0/V0	–	–	V0/V0	V0/V0	V0/V0	V0/V0	V0/V0	V0/V0	–	–	–	–	–	–	–	–	–	–
	Thicknesses 1.5/3 mm	UL 94		–	–	–	–	–	V-0/V-0	–	V-0/V-0	–	–	–	–	–	–	–	–	V-0/V-0	V-0/V-0	V-0/V-0	–	–	–	–	–	V-0/V-0

Physical properties of fluoro plastics (guideline values in standardized climate +23 °C/50% relative humidity)

APSOplast®-denomination Properties	Test parameter	Test method	Unit	PTFE	PTFE 125	PTFE 225	PTFE 660	PTFE 904	PTFE 207	PTFE 500	PTFE HP 107	PTFE HP 108	PTFE HP 110
Colour				white	beige	black	bronze	light blue	white	ivory	black	dark red	black
Density		DIN EN ISO 1183-1	g/cm^3	2.15	2.24	2.1	3.85	2.25	2.3	2.3	2.08	2.28	2.08
Ball indentation hardness		DIN ISO 2039-1	MPa	≥23	≥27	≥34	40	–	40	–	>25	>28	>30
Shore hardness		DIN EN ISO 868	Shore D	≥54	≥60	≥63	65	60	–	–	≥55	≥55	≥60
Tensile strength (yield stress)		DIN EN ISO 527	MPa	≥20	≥13	17	15	15	10	8	≥20	≥10	≥11
Deformation under load	p = 13.7 N/mm^2, 24 h	ASTM D 621	%	10–13	9–11	≤7	9	–	–	–	≤14	≥7	≥7
Residual deformation	after 24 h	ASTM D 621	%	6–7.5	5–6.5	≤6	5	–	–	–	≤9	≤5	≤5
Elongation at break	50 mm/min	DIN EN ISO 527	%	≥200	≥180	170	125	300	>50	10	≥200	≥125	≥80
Dynamic coefficient of friction	pv = 0.7 N/mm^2 • m/s	ASTM D3702		0.06–0.08	0.15–0.17	0.12–0.25	0.13	0.15–0.30	–	–	0.10–0.20	0.15–0.28	0.12–0.25
Modulus of elasticity (tensile test)		DIN EN ISO 527	MPa	–	–	–	1300①	–	1450②	2200②	–	–	–
Notched impact strength	Charpy	ISO 179-1/1eU	KJ/m^2	–	–	–	13	–	30	10	–	–	–
Impact strength	Izod	ASTM D 256-81	J/m	–	–	–	–	–	–	–	–	–	–
Compressive strength	Deformation of 1% Deformation of 1%	ASTM D 695 ISO 604	N/mm^2 MPa	7 –	≥9 –	≥8 –	12 –	– –	– 10.5	– 17	≥7.5 –	≥8 –	≥9 –
Thermal conductivity		DIN 52612-1	W/(K*m)	0.24	–	–	0.7	–	–	0.77	–	–	–
Static coefficient of friction		ASTM D1894 ASTM D3702		0.08–0.10 –	0.17–0.19 –	– 0.05–0.18	– 0.10	– –	– –	– –	– 0.05–0.15	– 0.08–0.20	– 0.06–0.18
Wear rate	pv = 0.7 N/mm^2 • m/s	ASTM D3702	µm/h	–	–	0.60–0.12	–	–	–	–	0.015–0.025	0.010–0.020	0.010–0.020
Melting temperature			°C	327	327	327	327	327	327	327	327	327	327
Service temperature min			°C	–200	–200	–260	–200	–200	–50	–20	–260	–260	–260
Max. service temperature short term			°C	–	–	–	–	–	280	280	–	–	–
Max. service temperature long term				260	260	280	260	260	260	260	280	280	280
Coefficient of linear thermal expansion	25–95 °C 25–95 °C	ASTM D 696 DIN 53752	10^{-6}/K 10^{-6}/K	– –	75–115 –	80–110 –	100 –	85 –	85 –	50 –	80–140 –	50–150 –	80–110 –
Dielectric constant	1 MHz	IEC 60250		2.1	–	–	–	–	2.65	2.85	–	–	–
Dielectric loss factor	1 MHz	IEC 60250		0.0006	–	–	–	–	0.008	0.008	–	–	–
Specific volume resistance		DIN IEC 60023	Ω*cm	10^{18}	10^{15}	–	–	–	$>10^{13}$	$>10^{13}$	–	–	–
Spefcific surface resistance		DIN IEC 60023 ANSI/ESD STM 11.11	Ω Ω	10^{17} –	10^{16} –	– –	10^{8} –	– –	– $>10^{13}$	– $>10^{13}$	– –	– –	– –
Dielectric strength		IEC 60243-1	kV/mm	20–70	13	–	–	9	8	11	–	–	–
Comparative tracking index		IEC 60112		600	–	–	–	–	–	–	–	–	–
Water absorption at saturation		DIN EN ISO 62	%	<0.05	–	–	–	–	–	0.1	–	–	–
Flammability	Thicknesses 1.5 / 3.0 mm	UL 94		V0/V0	–	–	–	–	V0/V0	V0/V0	–	–	–

APSOplast®-denomination Properties	PTFE HP 115	PTFE HP 117	PTFE HP 123	PTFE HP 125	PTFE HP 128	PTFE EC	PVDF	ECTFE	PCTFE	PFA	FEP
Colour	pale yellow	black	black	cream	cream	black	natural (white)	natural	natural (white)	transparent	transparent
Density	2	2.08	2.16	2.06	2.06	2.14	1.78	1.71	2.14	2.15	2.15
Ball indentation hardness	–	–	>30	–	–	27	–	–	–	–	–
Shore hardness	55	65	≥56	65	65	–	77	71	–	–	–
Tensile strength (yield stress)	14	14	≥10	20	18	25	55	30	34–50	–	–
Deformation under load	8	<3	≤9	13	12	–	–	–	–	–	–
Residual deformation	6	<2	≤7	8	8	–	–	–	–	–	–
Elongation at break	190	25	≥150	250	220	280	>60	250	120–175	–	–
Dynamic coefficient of friction	0.10–0.20	0.20	0.10–0.20	0.10–0.20	0.10–0.20	–	–	–	–	–	–
Modulus of elasticity (tensile test)	–	–	–	–	–	–	2200	1500	1400	–	–
Notched impact strength	–	–	–	–	–	–	15	–	–	–	–
Impact strength	–	–	–	–	–	–	–	–	80	–	–
Compressive strength	6.5 –	– –	≥7 –	7.5 –	8.5 –	– –	– –	– –	– –	– –	– –
Thermal conductivity	–	–	–	–	–	–	0.19	0.15	–	–	–
Static coefficient of friction	– 0.05–0.15	– 0.13	– 0.05–0.15	– 0.05–0.15	– 0.05–0.15	– –	– –	– –	– –	– –	– –
Wear rate	0.010–0.020	0.025	0.015–0.025	0.012–0.018	–	–	–	–	–	–	–
Melting temperature	327	327	327	327	327	327	172	240	215	305	285
Service temperature min	–200	–260	–260	–200	–260	–200	–60	–50	–250	–200	–200
Max. service temperature short term	–	–	–	–	–	300	150	180	–	–	–
Max. service temperature long term	280	280	280	280	280	260	140	150	–	–	–
Coefficient of linear thermal expansion	100 –	80 –	80–130 –	110 –	100 –	– –	– 100–140	– 90	– 50–80	– 120–140	– 85–105
Dielectric constant	–	–	–	–	–	–	8	2.3–2.6	2.5–2.7	2.1	2.1
Dielectric loss factor	–	–	–	–	–	–	0.17	0.001–0.0015	0.009–0.014	0.0006	0.0006
Specific volume resistance	–	–	–	–	–	10^{4}	$>10^{14}$	10^{15}	10^{16}	10^{18}	10^{17}
Spefcific surface resistance	– –	– –	– –	– –	– –	10^{4} –	$>10^{14}$ –	10^{13} –	10^{16} –	10^{17} –	10^{16} –
Dielectric strength	–	–	–	–	40	–	20	15	40	40	40
Comparative tracking index	–	–	–	–	–	–	600	600	600	600	600
Water absorption at saturation	–	–	–	–	–	–	<0.05	<0.05	<0.05	<0.05	<0.05
Flammability	–	–	–	–	–	–	V0/V0	V0/V0	V0/V0	V0/V0	V0/V0

① Test paramter 50 mm/min
② Test paramter 1 mm/min

Physical properties of thermosets (guideline values in standardized climate +23 °C/50% relative humidity)

APSOplast®-denomination				PF CP 201	PF CP MF	PF CC 201	PF CC 42	EP GC 202	EP GC 203	EP GM 203	UP GM 203-1	UP GFK
Properties	**Test parameter**	**Test method**	**Unit**	**Colour** braun	light grey (RAL 7035)	brown	brown				white	white
Density		ISO 1183	g/cm^3	1.3–1.4	1.4	1.3–1.4	1.20–1.40	2	1.8–2.0	2	1.81	1.9
Tensile strength		ISO 527	MPa	120	120	80	–	240	300	280	70	250
Flexural strength		ISO 178	MPa	150	140	130	90	350	350	360	130	250
Modulus of elasticity (flexural test)		ISO 178	MPa	7000	16000	7000	7000	22000	22000	≥20000	9000	25000
Compression resistance	perpendicular to layers	ISO 604	MPa	300	250	–	80	500	350	≥600	250	240[1]
Impact strength	Charpy	ISO 179/3C	kJ/m^2	–	–	8.8	–	50	50	≥50	40	300[2]
Thermal conductivity		DIN 52612	W/m*K	0.2	0.2	0.2	0.2	0.3	0.3	0.35	0.274	0.2–0.6
Coefficient of linear thermal expansion		VDE 0304/2	10^{-6}/K	20–40	20–40	20–40	20–40	10–20	10–20	10–20	20–30	12
Thermal longtime behaviour		IEC 60216	T.I.	120	120	120	120	180	180	180	155	155
Dielectric constant		DIN 53483		<5.5	5	5	–	5	5	5	–	<5
Dielectric loss factor	after 24 h immersed in water	DIN 53483		–	0.08	–	–	0.04	0.04	–	0.01	0.01
Specific volume resistance	after 24 h immersed in water	IEC 60167	Ω*cm	–	10^{9}	10^{6}	10^{8}	$5*10^{10}$	$5*10^{10}$	$5*10^{9}$	–	–
Dielectric strength	at 90°C in oil parallel to layers	IEC 60243-1	kV/mm	7	10	2	–	13	13	≥13	23	5
Disruptive discharge voltage	at 90°C in oil parallel to layers	IEC 60243-1	kV	20	30	5	3	50	50	≥60	41	10
Tracking resistance		IEC 60112	CTI	100	600	100	100	200	180	180	600	600
Water absorption	test thickness 4 mm	ISO 62	mg	250		100	–	–	23	–	–	–
	test thickness 10 mm	ISO 62	mg	–	200	–	–	30	–	< 40	–	–
Flammability	thickness ≥ 3 mm	UL 94		–	–	–	–	V0	–	–	V0[3]	V1

[1] Test parameter lengthwise
[2] Test parameter IZOD
[3] Test parameter thickness 2.4 mm

Physical properties of polyurethanes (guideline values in standardized climate +23 °C/50% relative humidity)

APSOplast®-denomination Properties	Test parameter	Test method	Unit	PUR D15 70 Sh. A	PUR D15 80 Sh. A	PUR D15 90 Sh. A	PUR D15 95 Sh. A	PUR D44 70 Sh. A	PUR D44 80 Sh. A	PUR D44 90 Sh. A
Hardness		DIN 53505	Shore A	70	80	90	95	70	80	90
Tensile strength at break		DIN 53504	MPa	35	44	41	35	26	33	29
Elongation at break		DIN 53504	%	600	663	741	702	600	620	500
Tension at 20% strain		DIN 53504	MPa	–	–	–	–	0.3	1.5	2.95
Tension at 100% strain		DIN 53504	MPa	2.5	4.3	8.0	10.6	–	–	–
Tension at 300% strain		DIN 53504	MPa	4.0	7.8	12.8	15.8	4.3	8.8	13.7
Tear propagation resistance		DIN 53515	N/mm	18	25	48	57	21	47	60
Rebound resilience		DIN 53512	%	45	65	62	61	–	–	–
Abrasion resistance		DIN 53516	mm³	40	37	28	26	–	33	44
Compression set 70/23	70 h/23 °C	DIN 53517	%	10	12	12	13	–	–	–
Compression set 24/70	24 h/70 °C	DIN 53517	%	15	20	20	21	–	–	–

APSOplast® SB

Material denomination: SB
Chemical denomination: Styrene butadiene copolymer

General description

Polystyrene, an amorphous, thermoplastic mass plastic, is primarily used in the packaging sector. This material has a brittle-hard behaviour. PS is therefore modified through the addition of elastic components to make it more resistant to impact for use in technical applications. The grade described here is an SB, i.e. a styrene copolymer modified with butadiene rubber. This highly impact-resistant plastic is very cost-effective but still has functional properties that can be used in a wide range of applications.

Characteristics and properties

- Increased rigidity and hardness
- High impact resistance
- Good low temperature toughness
- good thermoforming properties
- Low notch sensitivity
- Coloured white, mat finish on both surfaces
- Good adhesion of printing inks and adhesives
- Cost-effective

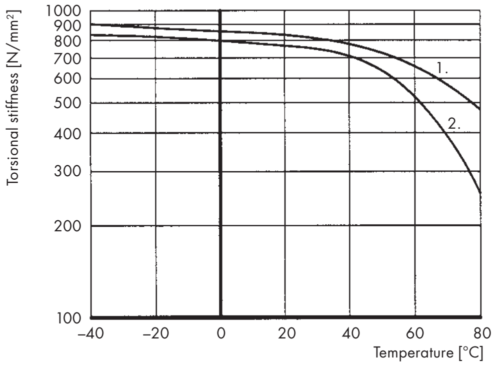
Please note:
- Inadequate weather resistance (not suitable for use outside)
- Not resistant to solvents
- Not suitable for sliding functions
- High combustibility

APSOplast® SB

Colour: White

The good low temperature resistance of all polystyrene grades is noteworthy. In the case of SB, good impact resistance can be expected up to –40 °C. However, SB cannot be described as a heat-resistant material. A maximum, long-term service temperature of around +70 °C should not be exceeded. The material begins to soften from +80 °C. The glass transition temperature is +120 °C. Above this temperature, the melting temperature range starts.
The very good electrical insulation behaviour of standard polystyrene (PS) is somewhat attenuated through the addition of butadiene rubber in SB but can still be described as really good. The dielectric constant and loss factor are practically frequency-independent at room temperature.
SB board is extremely well-suited to thermo-forming, printing, and gluing. However, due to a lack of resistance to UV and weather influences, its use outside is not recommended. The high combustibility of SB should be borne in mind for electrotechnical applications.

Torsional stiffness of PS in relation to temperature



1. PS
2. SB

Range of applications and application examples

Covers, cladding, and housings

As a general rule, SB should only be used for inside applications. Primarily, SB is used as a cost-effective sheet material for static purposes (not suitable for sliding functions) or electrical insulation functions, e.g. housing/model-making material, covers, cladding, front panels, refrigerator cladding, organizer boxes, partitions, electrical insulation, base plates, furniture and interior design, labelling panels, advertising materials, and so on.

Conformity

–

Biocompatibility

–

APSOplast® PVC

Material denomination: PVC
Chemical denomination: Polyvinyl chloride

General description

PVC, a primarily amorphous thermoplastic, is an important mass plastic but also has an important role in technology. In particular, this applies to long-term applications in electrotechnology and civil engineering. PVC, which is by nature fragile and hard, is modified using additives – primarily plasticizers, stabilizers, and modifiers – in line with an extremely wide range of application areas. The additives improve physical properties such as resistance to temperature, light, and weather influences, toughness, elasticity, notch impact resistance, and gloss. They also improve processing of PVC. Today, PVC is classified as soft PVC (PVC-P) and hard PVC (PVC-U). Transparent sheets enable see-through covers and glazing. PVC has a range of really good properties and is also cost-effective.

Characteristics and properties

– High rigidity and strength
– Good mechanical strength
– Good chemical resistance to various acids and alkalis
– Resistant to weather influences
– Low moisture absorption
– Very good dielectric insulation behaviour
– Flame-retardant
– Very good bonding behaviour
– Good coating characteristics
– Very good welding behaviour
– Very good vacuum-forming behaviour
– Cost-effective

Please note:
– Lack of impact resistance at minus temperatures
– Limited temperature application range (0 to +60 °C)
– Not suitable for contact with foodstuffs
– Not resistant to solvents
– PVC not suitable for sliding functions

APSOplast® PVC-U

Hard, unplasticized PVC
Colour: Grey, red, transparent

PVC-U is a traditional material for the construction of chemical apparatus and containers, since it combines excellent properties such as high strength and rigidity as well as UV-stabilization, which enables its use outside. In addition, hard PVC has very good chemical resistance and is flame-retardant acc. to DIN 4102 B1 and UL94 V-0 with a wall thickness from 1.0 mm.
PVC-U Transparent is a standard shock-resistant, hard PVC with a transparent design.

APSOplast® PVC-U FO

Hard foamed PVC
Colour: Grey, white

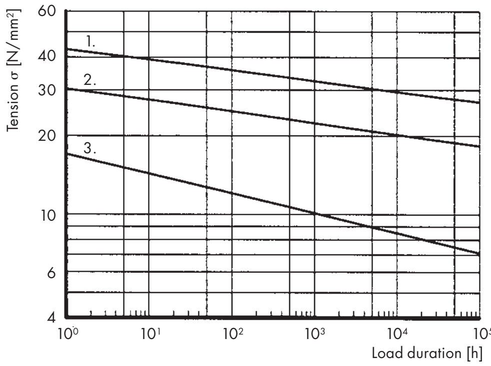
These lightly foamed, closed-celled hard foamed sheets are particularly fine-celled with a homogeneous structure and satin-mat surfaces. This renders an excellent printing substrate. This material is easy to process, flame-retardant, self-extinguishing, and suitable for use inside and outside.

APSOplast® PVC-P

Soft, plasticized PVC
Colour: Transparent

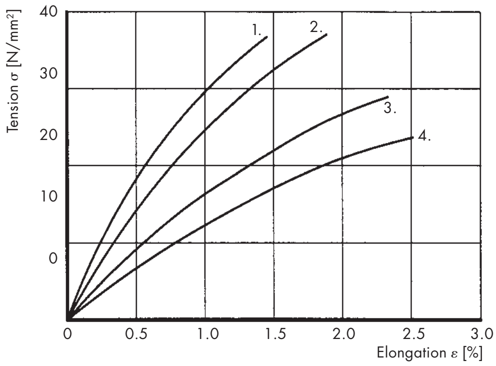
PVC-P is a material produced from PVC powder, plasticizers, and additives such as stabilizers, UV absorbers, lubricants, pigments, etc.
A PVC-P has a plasticizer content of more than 20%. Soft PVC has an elastomer-like behaviour at room temperature and is therefore tough and very flexible.

Creep rupture strength of PVC-U



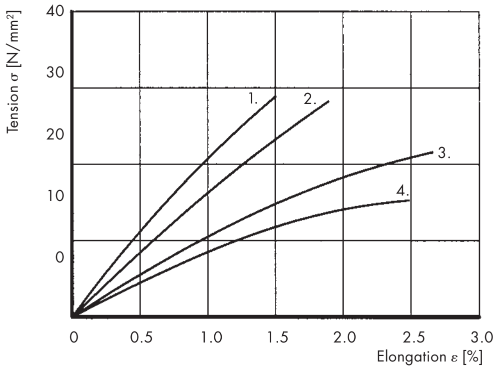
Test conditions:
- Temperature:
  1. +20 °C
  2. +40 °C
  3. +60 °C

Isochronic stress-strain curve for PVC-U



Test conditions:
- Temperature: +20 °C
- Load duration:
  1. 1 h
  2. 10^2 h
  3. 10^3 h
  4. 10^4 h

Isochronic stress-strain curve for hard PVC



Test conditions:
- Temperature: +40 °C
- Load duration:
  1. 1 h
  2. 10^2 h
  3. 10^3 h
  4. 10^4 h

Range of applications and application examples

Mechanical engineering, tank construction, ventilation equipment, chemical apparatus construction, and laboratory construction

Very often, PVC-U is used as an inexpensive material for turned and milled parts for static functions such as housings, base plates, spacers, insulation parts, flanges, pump parts, covers, extraction plants, pickling plants, etc.

Electrotechnology

Due to the good insulating properties of PVC-U, it is used for switch and meter cabinets, switch panels, and cable ducts.

Building sector

Many of PVC's applications are in the building sector, where PVC is used for window profiles, pipes, floor coverings, and roof sheeting. Other applications include facade elements, boards for exposed concrete, basement light shafts, sound absorption walls, slide valves for ventilation strips, air filters for cooling towers, etc.
The thin-walled, transparent hard PVC sheets are generally used for glazing, sight protection, spray protection, pipeline construction, vacuum-formed parts, displays, signs, sight glasses, and advertising components where optical properties are not quite so important. PVC-U FO (foamed) is really popular with sign manufacturers, exhibition and fair stand builders, display manufacturers, advertising agents, and image laminators.

Conformity

–

Biocompatibility

–

APSOplast® PE

Material denomination: PE
Chemical denomination: Polyethylene

General description

Polyethylene (PE) is known for its waxy, anti-adhesive surface. Polyethylenes fall into the range of soft, flexible thermoplastics. They are semi-crystalline. The molecular mass, crystallinity, structure, and properties of the material largely depend on the polymerization method. Along with PVC, PE is one of the most diverse thermoplastic. In its basic form, PE ranges from colour-free transparent to milky white.

Characteristics and properties

– Good wear resistance (PE-UHMW)
– High impact resistance, even at low temperatures (particularly PE-UHMW)
– Excellent resistance to chemicals
– Low coefficient of friction (PE-UHMW)
– Excellent anti-adhesion behaviour
– Very good electrical insulation properties and favourable dielectric behaviour (unmodified types only)
– Physiologically safe (suitable for contact with foods)

Please note:
– Flammable, not self-extinguishing, other than special flame-retardant types
– Difficult to bond
– Moderate mechanical strength, rigidity, and creep resistance

APSOplast® PE-LD

Soft PE, high-pressure PE
Colour: Natural (opal)

LD-PE is soft and particularly flexible. It is resistant to low temperatures of up to –50 °C and high temperatures of max. +60 °C.

APSOplast® PE-HD

Hard PE, low-pressure PE
Colour: Black

HD-PE is more rigid and abrasion-resistant than soft PE. It is characterized by its resistance to low temperatures of up to –50 °C and high temperatures of max. +80 °C.

APSOplast® PE-HMW

High-molecular hard PE
Colour: Natural (white), reddish-brown and other colours

PE-HMW, also often called PE-500, is more rigid and harder than hard PE. The molecular mass (weight) of the material is around 500 000 g/mol. This type has a good combination of rigidity, toughness, mechanical damping ability, and wear resistance. It is also very suitable for welding processes.

APSOplast® PE-UHMW

Ultra-high molecular hard PE
Colour: Natural (white)

PE-UHMW, often also called PE-1000, has very good sliding and wear properties. The molecular mass (weight) ranges from around 4.5 to $9.0 \cdot 10^6$ g/mol. This material combines excellent wear resistance with exceptional impact resistance, even at temperatures below –200°C. Due to its really low moisture absorption, PE-UHMW is particularly dimensionally stable.

Reclaimed APSOplast® PE-HMW

Colour: Green, black

Reclaimed APSOplast® PE-UHMW

Colour: Green, black

These types are grades with an amount of re-granulated material. Regenerated PE-HMW and PE-UHMW are used for applications where the slight decrease in the material’s properties are offset by the economic advantage offered.

APSOplast® PE-UHMW ED

Electrostatically dissipative
Colour: Black

This anti-static PE-UHMW type is frequently in demand for applications which require high machine speeds or feed performance. The tailored addition of high-performing types of carbon black brings about a surface resistance of $< 10^9\ \Omega$.

APSOplast® PE-UHMW ED FDA

Electrostatically dissipative
Colour: Black

PE-UHMW ED FDA is a modified, anti-static material that is suitable for use in the foodstuff and pharmaceutical industries. It meets the requirements of European Commission Foodstuffs Directive 1935/2004 and FDA Directives 21 CFR 177.1520 and 21 CFR 178.3297 on plastics for contact with foodstuffs.
PE-UHMW ED FDA is also approved as per the US 3-A Dairy Sanitary Standards.

APSOplast® PE-UHMW FR

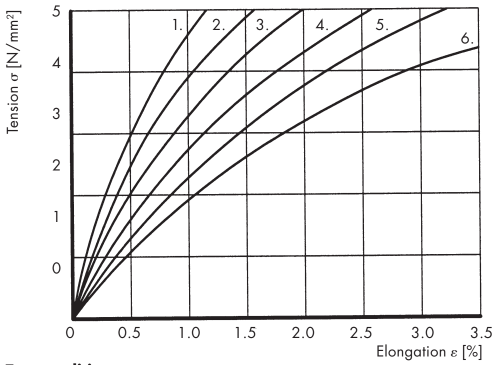
Flame-retardant
Colour: Black

PE-UHMW FR is a flame-retardant material which also has anti-static and UV-stable properties in conjunction with the proven properties of PE-UHMW.

As per test standard	In thickness	Classification
UL 94	≥ 6 mm	V-0
DIN 5510-2	≥ 10 mm	S4, SR2, ST2
FMVSS 302	≥ 15 mm	Non-flammable
BS 476, Part 7	≥ 6 mm	Class 2

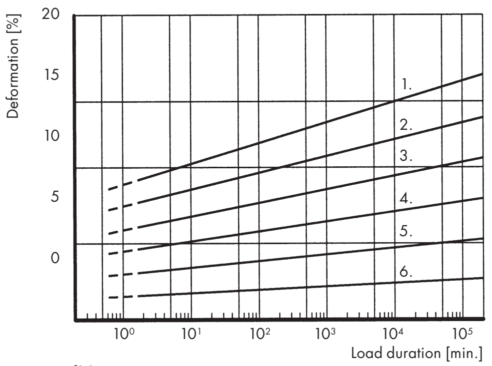
Further information:
– Chapter 10: Plastics for the food industry
– Chapter 13: Electrostatically dissipative / electrically conductive plastics

Isochronic stress-strain curve for PE-HD



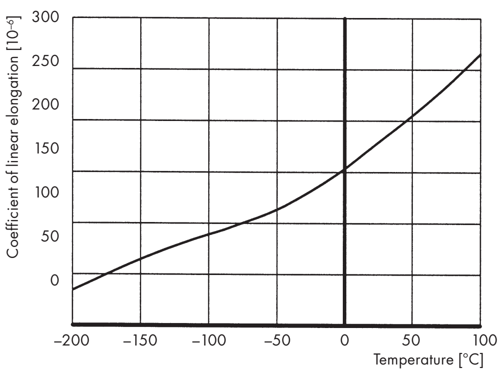
Test conditions:
– Temperature: +23 °C
– Load duration:
1. 1 h
2. 10 h
3. 10^2 h
4. 10^3 h
5. 10^4 h
6. 10^5 h

Creep-pressure behaviour at various compressive stresses



Test conditions:
– Temperature: +50 °C
– Compressive stress:
1. 12 N/mm²
2. 10 N/mm²
3. 8 N/mm²
4. 6 N/mm²
5. 4 N/mm²
6. 2 N/mm²

Coefficient of linear expansion of PE-UHMW in relation to temperature



Range of applications and application examples

Flat gaskets, packaging

PE-LD is used for flat gaskets for various chemical, pharmaceutical, and foodstuff applications. Other applications include films for packaging, shrink film, carrier bags, agricultural films, watervapour barriers for composite films, etc.

Chemicals, apparatus construction

Due to its good chemical resistance, PE-HD is used in the electroplating and chemical industry and in chemical apparatus construction. Examples include construction parts for chemical plant engineering, fittings, shelves, stacking boxes, etc.

Foodstuffs industry and restaurants

PE-HMW is a versatile material whose primary use is in the foodstuff industry (e.g. meat, fish, poultry, and fruit and vegetable processing) and in various mechanical, chemical, and electrical applications. In most countries, wooden chopping boards are no longer allowed for bacteria-related reasons. Wood provides an excellent breeding ground for germs and cannot be thoroughly cleaned on a regular basis. Today, PE-HMW has taken over most of the wooden board sector of the market. Moreover, the addition of differently coloured material enables a distinction to be made between the different food types.

Mechanical engineering, apparatus construction, and cryoengineering

The main fields of application of PE-UHMW are in general mechanical engineering and apparatus construction, filling and packaging machines, in the chemical industry, electroplating, cryoengineering, and textile industries, in bunker and conveying and handling systems for bulk goods, and in the paper and electrical industry. Examples include the following: Rope guide pulleys, chain diversion wheels, chain guides, slide valves, suction strips and plates, doctor blades, scrapers, internal handling panels, abrasion protection strips. The special type RCH® 1000 is used as a raw material for the production of technical orthopaedic products (e.g. trunk, foot, and calf orthoses, blank inserts).
PE-UHMW ED is used for belt guides, sliding elements, and conveying elements.
PE-UHMW ED FDA is used for sliding and drive elements and in the foodstuff and pharmaceuticals industry.
PE-UHMW FR is used in railway transportation, vehicle construction, building, and mechanical engineering.

Conformity

PE-LD, -HD, -HMW, -UHMW, and PE-UHMW ED FDA are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility

–

APSOplast® PP

Material denomination: PP
Chemical denomination: Polypropylene

General description

Polypropylene (PP, sometimes also called polypropene) is an inexpensive semi-crystalline thermoplastic. It belongs to the polyolefins group. In comparison with PE-HD, PP has a higher rigidity, hardness, and strength. Moreover, in comparison with PE, PP has higher heat distortion stability. This, however, is associated with insufficient low-temperature toughness.

Characteristics and properties

- Low density
- Higher rigidity and hardness than PE-HD
- Good mechanical properties
- Good heat distortion stability
- Very good chemical resistance
- Very good resistance to hydrolysis (hot water, steam)
- Low moisture absorption
- Very good dielectric insulation behaviour
- Suitable for contact with foodstuffs
- Inexpensive

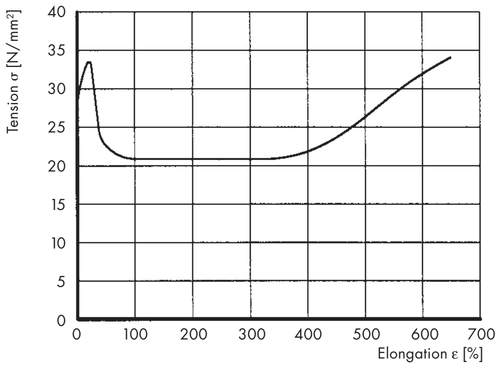
Please note:
- Glass transition temperature of 0 °C; becomes fragile in cold temperatures (lack of impact resistance)
- Flammable, not self-extinguishing
- Difficult to bond
- Not suitable for sliding functions

APSOplast® PP

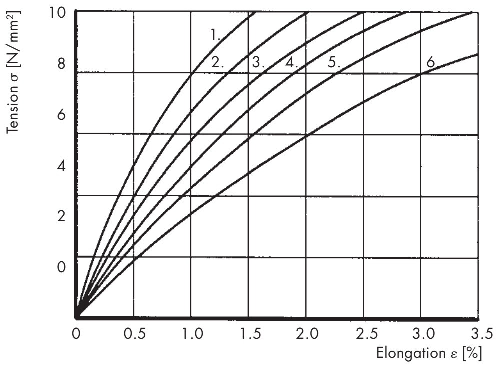
Colour: Grey

A distinction is made between isotactic, syndiotactic, and atactic polypropylene. Isotactic PP is primarily used for technical applications, since an increase in isotacticity is associated with an increase in the level of crystallinity, melting point, tensile strength, rigidity, and hardness. The rigidity of polypropylene in conjunction with good mechanical strength values and a high surface hardness enables the manufacturing of machined parts and welded construction with relatively thin wall thicknesses.
An increase in tensile strength is made possible by controlled stretching (can be seen in the diagram though the drop in tensile stress after the yield point with a subsequent elongation phase at low force). Following the stretching process and subsequent constriction of the test specimen, a higher tensile strength with lower ultimate elongation is achieved. This effect can be used for film hinge applications.
Semi-finished products made from PP are also used in chemical apparatus construction at temperatures of between 0 °C and +100 °C. The maximum service temperature is between +100 to +110 °C.

Stress-strain diagram for PP



Isochronic stress-strain curve for PP



Test conditions:
- Temperature: +23 °C
- Load duration:
  1. 1 h
  2. 10 h
  3. 10^2 h
  4. 10^3 h
  5. 10^4 h
  6. 10^5 h

APSOplast® PP LSG

Heat-stabilized
Colour: White, black

PP LSG is a biocompatibility-tested polypropylene. Tests are carried out as per ISO 10993-5 and -10 on a semi-finished product and USP Class VI on the granules.
In addition, the raw material used is compliant with the stipulations of the FDA. This polypropylene was developed for use in medical technology and is very resistant to cleaning agents and disinfectants. Thanks to its stabilization, it can withstand higher temperatures and has an improved dimensional stability in comparison with standard polypropylene. This means that it can be repeatedly sterilized using superheated steam. These properties are useful for the production of sterilization containers for surgical accessories, for example.

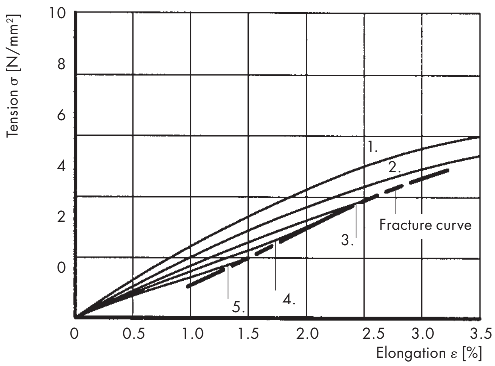
Further information:
– Chapter 11: Plastics for medical technology

PP-GM40

Glass-mat-reinforced
Colour: Black

The homogeneous lamination of an endless glass fibre mat with polypropylene results in a composite material which – in comparison with basic polypropylene and common polypropylene injection-moulded or extrusion types reinforced with short glass fibres - has much improved mechanical properties. Unlike in the case of fibreglass-reinforced injection-moulded materials and SMC, these properties are evenly distributed in all directions and demonstrate a rising tendency as temperature decreases.

Isochronic stress-strain curve for PP



Test conditions:
- Temperature: +110 °C
- Load duration:
  1. 1h
  2. 10 h
  3. 10^2 h
  4. 10^3 h
  5. 10^4 h

Range of applications and application examples

Chemical apparatus and tank construction
Due to its excellent set of properties, in particular – its high resistance to chemicals and corrosion, – PP is the most frequently used material in chemical apparatus and tank construction and has an excellent cost-benefit ratio.

Household appliances
Here, the material is used in boil-proof films, dishwasher machines, and reusable containers.

Foodstuffs industry
Like PE-HMW, PP is used in various colours for cutting boards.

Medical technology
PP LSG is used for surgical containers and test specimen for implants.

Packaging technology
In packaging technology, polypropylene is used for packaging parts and containers for goods and foodstuffs.

Electrotechnology
In electrotechnology, it is used for transformer housings and wire/cable sheathing.

Civil engineering
It is used for valves, fittings and pipelines, and as a damping/insulating material in civil engineering.

Corrosive environments
PP-GM40 is used to create inexpensive structural panels with a high flexural strength for use in corrosive environments and for electrical/thermal insulation, e.g. for battery boxes, chemical troughs, covers, and shelves.

Conformity
Polypropylene is suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
PP LSG is biocompatibility-tested for applications in medicine, pharmaceuticals, and biotechnology.

Further information:
– Chapter 11: Plastics for medical technology

APSOplast® PMMA

Material denomination: PMMA
Chemical denomination: Polymethyl methacrylate, acrylic glass

General description

PMMA is one of the oldest thermoplastics. Its structure is amorphous. Within the group of polyacrylic esters, the transparent homopolymer PMMA and impact-resistant modified copolymer AMMA are the most significant materials. A distinction must be made between high-molecular 'cast' acrylic glass and PMMA moulding compounds for extrusion and injection moulding. Due to their extremely high molecular weight, sheets, blocks, and shaped parts manufactured from cast monomer are no longer meltable; however, they can be thermoformed. Polymethyl methacrylates have the best-quality optical properties of all plastics. They are primarily used for optically challenging glazings.

Characteristics and properties

– Clear transparent
– High hardness and rigidity
– Good mechanical strength
– High surface hardness
– High scratch-resistance and polishability
– Excellent optical properties
– Good resistance to the weather
– Good resistance to temperature changes
– Good dielectric properties

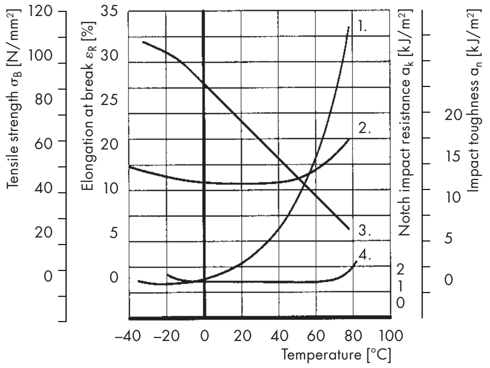
Please note:
– Low impact resistance
– Tendency towards stress cracking
– High electrostatic charging
– Flammable (not self-extinguishing)
– Sensitive to solvents
– Not suitable for sliding functions

APSOplast® PMMA

Colour: Natural (clear transparent)

The high hardness and modulus of elasticity make PMMA a highly rigid material, which has major advantages for glazing applications in particular. However, as a result, acrylic glass loses therefore a certain amount of impact toughness, which often results in stress concentrations and cracking. The notch impact sensitivity of this material should also not be underestimated. Stresses can build up as a result of machining or localized warming. However, these stresses can be reduced through annealing at between +60 and +80 °C in a convection oven (for at least 3 hours with subsequent slow cooling). This annealing process is recommended in particular for bonded constructions. For the reasons above, glazings/constructions which are at risk of breakage should not be made from PMMA; instead, PC (polycarbonate) or PET-A (polyethylene terephthalate) should be used. The optical properties of acrylic glass are comparable to those of window glass based on silicate. The best quality is reached in casting processes (in the case of sheets and finished optical parts). During the machining of semi-finished products, the machined PMMA surfaces lose their transparency. Subsequent polishing restores their gloss.
Mechanical polishing can be carried out using a buffing wheel and a polishing agent/compound or by means of flame polishing, solvent polishing, or polish milling.

Tensile strength, elongation at break, impact strength, and notched impact resistance of PMMA in relation to temperature



1 Elongation at break ε_R
2 Impact toughness a_n
3 Tensile strength σ_B
4 Notched impact resistance a_k

APSOplast® PMMA-XT

Extruded PMMA
Colour: Natural (clear transparent), coloured

This material is extruded PMMA with exceptional optical properties. It is particularly suited to thermo-forming and vacuum-forming.
PMMA-XT is available as a standard or modified impact-resistant type and as smooth, structured, mat, or satinized sheets, pipes, and rods. As a rule, the coloured types are evenly coloured all the way through.

APSOplast® PMMA-GS

Cast PMMA
Colour: Natural (clear transparent), coloured

The cast types have excellent optical properties and are available in larger dimensions than the XT types.
PMMA-GS is produced in the form of sheets, blocks, rods, and pipes with a smooth, mat, or satinized surface.

APSOplast® PMMA-XT ED

PMMA + electrostatically dissipative surface coating
Colour: Natural (clear transparent)

This extruded PMMA-XT ED sheet has an anti-static surface coating on both sides, which reduces electrostatic charging. Dust attraction is significantly reduced, which means that cleaning is not required so frequently.
This type of PMMA is particularly suitable for covering chalk, charcoal and similar drawings.

Further information:
– Chapter 13: Electrostatically dissipative / electrically conductive plastics

Range of applications and application examples

Civil engineering
PMMA is used for glazing applications and for transparent structures such as light domes, door/window/stair glazings, partitions, etc.

Mechanical engineering
In mechanical engineering, PMMA is used for sight glasses, tanks, troughs, and so on.

Advertising
PMMA is also used in applications with high optical requirements and to help to create lighting effects in advertising and the lighting industry: signs, labels, displays, pedestals, illuminated sign parts, display items, etc.

Art and architecture
Applications in the field of art and architecture include use in furniture, partitions, sculptures, design elements, light effects, and so on.

Modelling
PMMA is a popular material for show models, functional models, pattern constructions, etc.

Conformity
Some semi-finished products made from PMMA are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
–

APSOplast® PET-A

Material denomination: PET-A
Chemical denomination: Polyethylene terephthalate, amorphous

General description

There are three different types of PET:
– Semi-crystalline PET-C
– Amorphous PET-A
– Amorphous, glycol-modified PET-G
The mechanical properties are significantly determined by the degree of crystallinity. Crystalline PET-C is described in more detail in the chapter on technical plastics, due to its properties. Amorphous PET is produced by integrating bulky comonomers which reduce crystallinity to enable the manufacture of transparent semi-finished products and finished parts.

Characteristics and properties

– Clear transparent
– Good optical properties
– High impact resistance, break resistance, and rigidity
– Low tendency towards stress cracking
– Good resistance to chemicals
– Good weathering behaviour
– Physiologically safe (suitable for contact with foods)
– Flame-retardant
– Cold- and hot-line-bending
– Thermoformable

Please note:
– Restricted temperature resistance to max. +65 °C
– Not suitable for technical sliding functions
– Restricted bonding properties
– Scratch-sensitive

APSOplast® PET-A

Amorphous PET
Colour: Natural (transparent)

PET-A is a transparent polyester material with a high translucency and surface gloss. It is particularly characterized by high dielectric strength and break resistance along with excellent cold-bending properties. PET-A has a good UV- and chemical resistance and is suitable for use in the food industry. PET-A is flame-retardant as per Fire Class B1 in accordance with DIN 4102 and is tested for rail vehicles in accordance with DIN 5510 (S4, SR2, and ST2).

APSOplast® PET-G

PET + glycol
Colour: Natural (transparent)

PET-G is a transparent copolyester material with a high translucency and surface gloss. Even at low temperatures, it has very good break resistance and impact resistance. PET-G can easily be printed upon and has exceptionally good thermal properties (suitable for thermo-forming and vacuum-forming). PET-G is also suitable for use in the foodstuffs industry.

Range of applications and application examples

The unique combination of outstanding mechanical, thermal, and chemical properties makes PET into a diverse and fully dependable material.

Architecture and civil engineering
Due to its diverse properties, PET-A has many applications. They include: Light domes, barrel vaults, bus stops, carports, partitions in indoor markets/sports stadiums/schools, telephone boxes, conservatories, greenhouses, balcony glazing, etc.

Advertising and decoration
In this field, possible applications include the following: illuminated panels, display cabinets, signposts, signs, show cases, billboards, information boards, etc.

Industry, transport, and traffic
PET-A is used in: housings, engine covers, machine housings, chemical tanks, packaging, technical lighting, windows of utility vehicles, structural elements for rail vehicles and aircraft, cold stores, refrigerated counters, junction boxes, and packing for foodstuffs and pharmaceutical products, etc.
PET-G sheets are found in the most diverse of applications from vacuum-formed applications and protective glazing to displays, prosthetics, and special medical devices.

Conformity
PET is suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
–

APSOplast® PC

Material denomination: PC
Chemical denomination: Polycarbonate

General description

Polycarbonate, an amorphous thermoplastic, is primarily used in injection moulding for applications with elevated requirements. Decisive advantages here include good mechanical strength, above average impact resistance, high heat stability, and transparency with high translucency.
As a semi-finished product, PC is increasingly important in break-resistant safety and protective glazing.

Characteristics and properties

– Clear transparent
– High mechanical strength
– Good creep resistance
– Very high impact resistance, even at low temperatures
– Retention of rigidity over a broad temperature range
– Very high dimensional stability (extremely low moisture absorption and low coefficient of linear thermal expansion)
– Good electrical insulation properties and favourable dielectric behaviour
– Physiologically safe (PC is suitable for contact with foodstuffs)

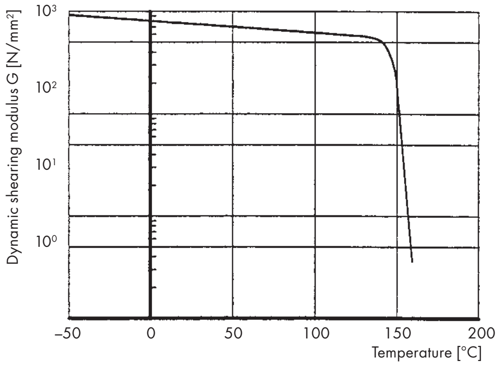
Please note:
– Tendency towards stress cracking due to mechanically or chemically induced stress concentrations
– Can be damaged by hydrolysis (exposure to hot water or steam)
– PC is not suitable for technical sliding functions.

APSOplast® PC

Colour: Natural (clear transparent)

PC sheets are often used for break-resistant safety glazing. They enhance the range of clear transparent sheets made from PVC-U, PET-A, and PMMA (acrylic glass) for applications requiring high impact resistance and heat distortion resistance heat stability in conjunction with good weathering behaviour and good optical properties. In addition to the standard range, the following variants are available on request:
– Smoky brown, grey
– Transparent grey (sun protection design)
– Bronze-tinted (sun protection design)
– Transparent flame-retardant (UL94 V-0, from 2 mm)
– UV-stabilized
– Transparent, textured on both sides

Dynamic shear modulus of PC in relation to temperature



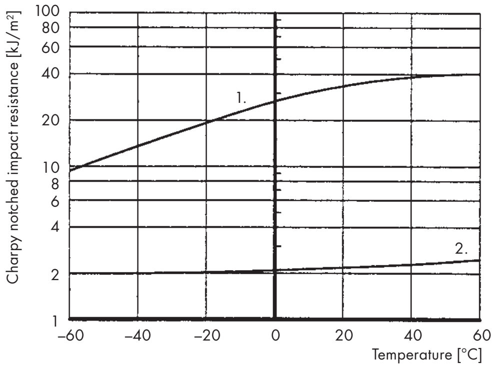
APSOplast® PC EC

PC + electrically conductive surface coating
Colour: Natural (clear transparent)

PC EC is a scratch-resistant polycarbonate characterized by electrically conductive surfaces (surface resistance of 10^3–10^5 Ω) and excellent transparency and translucency as well as high impact resistance and dielectric strength. This challenging combination of properties is always in demand for glazing material in special production areas where electrostatic charging must be avoided.

Further information:
– Chapter 13: Electrostatically dissipative / electrically conductive plastics

Notched impact resistance of PC in relation to temperature



1. PC
2. PMMA

APSOplast® PC FR

PC + flame-retardant additives
Colour: Clear transparent

Special PC grade for applications with elevated requirements regarding fire behaviour.

APSOplast® PC round bars

Colour: Natural (milky-transparent)

The non-UV-stabilized PC round bars constitute a 'non-optical' industrial grade. Frequently, transparent round bars are used to manufacture PC prototypes of later injection-moulded parts such as all kinds of electrical and thermal insulation parts. They are suitable for contact with foodstuffs.

APSOplast® PC LSG, round bars

Colour: Natural (milky-transparent)

PC LSG is a biocompatible polycarbonate material used to make semi-finished products that meet the requirements of USP Class VI and ISO 10993-4, -5, -10, and -11. This should give end users additional safety and the assurance that the LSG materials successfully pass tests on finished products.

Further information:
– Chapter 11: Plastics for medical technology

Range of applications and application examples

Insulators
Insulators made from polycarbonate offer excellent dielectric strength.

Sight glasses
On petrol tanks, a sight glass made from PC round bar provides an easy way of checking the fill level.

Multiple distributors
Polycarbonate sheets can be used to easily manufacture impact- and shock-resistant multiple distributors for a large number of industrial applications.

Glazing
Polycarbonate sheets are often used for break-resistant safety and protective glazing in the machine building sector. Electrically conductive PC is used if glazing products with electrically conductive surfaces and thus static charges are used for operational and work safety reasons (e.g. in clean rooms, ex-zones, and for machine protection).

Biocompatibility:
PC is biocompatibility-tested for applications in medicine, pharmaceuticals, and biotechnology

Further information:
– Chapter 11: Plastics for medical technology

APSOplast® PA

Material denomination: PA
Chemical denomination: Polyamide

General description

Polyamides are used for a wide range of technical applications which require high toughness, mechanical strength, and good sliding and abrasion behaviour. Of particular note here are construction elements for drives technology such as gear wheels, plain bearings, and idler pulleys.

Characteristics and properties

– High mechanical strength, rigidity, hardness, and toughness
– Good fatigue resistance
– High mechanical damping ability
– Good sliding and emergency running properties
– Very high wear resistance
– Good electrical insulation properties
– Good resistance to high-energy radiation (gamma and X-rays)
– Good machinability

Please note:
The absorption of moisture is associated with volume changes and thus dimensional changes. In the case of a moisture absorption of e.g. one percent per weight, the linear swelling is around 0.3%. This value should be seen as the upper limit value which occurs when moisture is evenly distributed throughout the test specimen. This means that the dimensions of parts made from polyamide 6, 4.6, 66 lying in water at +23°C can change linearly by 2.7% or 2.4% respectively at full saturation.

See the diagram in section 5.2.

APSOplast® PA 6

Colour: Natural (white), black

PA 6 offers an optimum combination of mechanical strength, rigidity, toughness, and mechanical damping in conjunction with very good wear resistance, good electrical insulation properties, and good chemical resistance. PA 6 is therefore a universal material for construction and maintenance.

APSOplast® PA 66

Colour: Natural (cream), black

PA 66 differs from PA 6 due to its higher strength, rigidity, temperature resistance, and wear resistance as well as improved creep resistance. However, it has lower impact toughness and mechanical damping behaviour.

APSOplast® PA 46

Colour: reddish brown

In comparison with other polyamide types, PA 4.6 has better rigidity and creep resistance retention over a broad temperature range as well as an increased resistance to heat ageing. For this reason, PA 4.6 is primarily used at high temperature ranges (+80 to +150 °C), where the rigidity, creep resistance, heat stability, ageing resistance, and wear resistance of PA 6, PA 66, POM, and PET-C are no longer sufficient.

APSOplast® PA 66 GF30

PA 66 + 30% glass fibre
Colour: Black

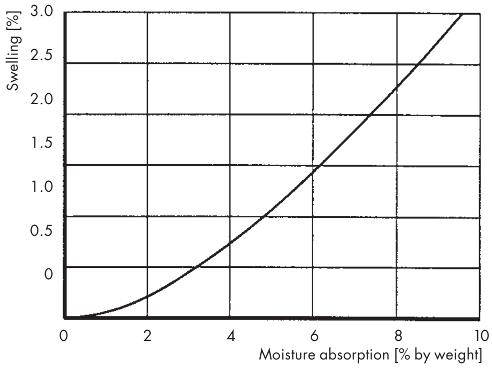
These polyamide types, reinforced with 30% glass fibre – retain a high resistance to wear and have – a higher mechanical strength, rigidity, creep resistance, and dimensional stability than non-reinforced PA 66. It can also be used at higher upper service temperatures.
Because the glass fibres tend to result in abrasion of the mating surface, the suitability of this material for slide bearings must be carefully checked in advance for each specific application.

APSOplast® PA 66 CF20

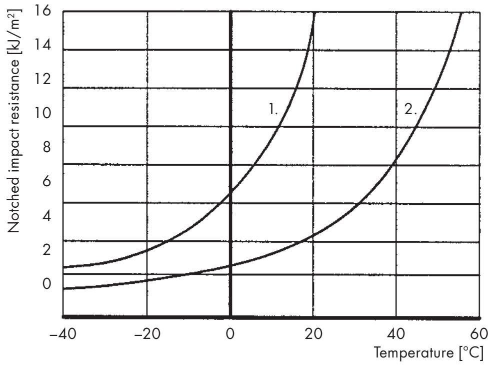
PA 66 + 20% carbon fibre
Colour: Black

This reinforced polyamide type, reinforced with 20% carbon fibres, unites very high rigidity, mechanical strength, and creep resistance with optimum wear resistance. The carbon fibre content increases the thermal and electrical conductivity of the material and improves its sliding properties. This means that in the case of sliding elements the frictional heat and static charge are dissipated from the friction surface more quickly and the mating surface is protected from wear.

Dimensional change of PA6 in relation to moisture content

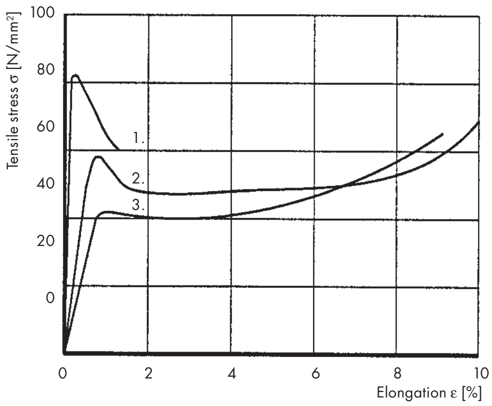


Notched impact resistance of PA 66 and PA 66 MO in relation to temperature and moisture content



Test conditions:
1. Moisture content: 2%
2. Dry material

Influence of moisture content and temperature on tensile stress/elongation behaviour of PA 66/PA 66 MO



Test conditions:
1. Dry material: +23%
2. Moisture content: 2.3%
3. Dry material: +80 °C

APSOplast® PA 6 G

Colour: Natural (ivory), black

This high-quality, unmodified cast polyamide has a similar set of properties to PA 66. Cast polyamides unite high mechanical strength, rigidity, and hardness with a good creep and wear resistance, resistance to heat ageing, and machinability.

APSOplast® PA 6 MO

PA 6 + molybdenum disulphide
Colour: Black

This extruded type has similar properties to the cast type (PA 6 G MO) but is the more inexpensive variant in the case of smaller dimensions due to the production procedure.

APSOplast® PA 66 MO

PA 66 + molybdenum disulphide
Colour: Black/anthracite

The addition of MoS_2 gives rise to a material with slightly higher rigidity, hardness, and dimensional stability than PA 66. However, impact resistance is slightly lower. The nucleation effect of the molybdenum disulphide brings about a finely crystalline structure and an improvement in the friction and wear behaviour.

APSOplast® PA 6 G MO

PA 6 cast polyamide + molybdenum disulphide
Colour: Black/anthracite

This cast polyamide contains finely distributed molybdenum disulphide particles which increase the crystallinity. This increases the mechanical properties as well as the friction and wear behaviour without adversely affecting the high impact and fatigue resistance which are inherent to the non-modified cast polyamide 6 types. This material is used for various machine parts, plain bearings, sliding rails, gear wheels, idler pulleys, scrapers, chain sprockets, and pulleys.

APSOplast® PA 6 G HS

PA 6 cast polyamide + molybdenum disulphide
Colour: Black

This heat-stabilized cast polyamide has a high level of crystallinity with a homogeneous structure. In comparison with traditional extrusion and cast polyamide types, this type has an increased resistance to heat ageing (better resistance to thermal-oxidative degradation), which enables usage at permanent service temperatures that are 15 to 30 °C higher. This material is particularly recommended for sliding elements and other wearing parts with a service temperature above +60 °C.

APSOplast® PA 6 G LO

PA 6 cast polyamide + oil
Colour: Green

This cast polyamide incorporates a liquid lubricant and is self-lubricating in the truest sense of the word. This material, which was developed especially for heavy-duty, slow-moving non-lubricated sliding elements, significantly enhances the range of possible applications of polyamides thanks to its low coefficient of friction (up to 50% less) and high wear resistance (up to 10 times higher).

APSOplast® PA 6 G LO FDA

PA 6 cast polyamide + oil
Colour: Natural (ivory), blue

Type FDA (a food grade material with lubricants) is a cast polyamide with an integrated lubrication system. It is available in natural (ivory) and blue. It is self-lubricating in the truest sense of the word, and its composition complies with US FDA guidelines.
This material was developed especially for heavy-duty, slow-moving non-lubricated sliding elements. In comparison with polyamides with no lubrication system, the coefficient of friction is up to 50% lower and wear resistance is up to ten times higher. It considerably broadens the application range of polyamides and enables lower maintenance costs along with longer service lives.

APSOplast® PA 6 G PLUS

PA 6 cast polyamide
Colour: Blue

This modified cast polyamide PA 6 G is easily identifiable by its blue colouring. It has a higher toughness, flexibility, and fatigue strength than unmodified PA 6 G. These characteristics make this type ideal for gear wheels, pinions, and toothed racks.

APSOplast® PA 6 G SL

PA 6 cast polyamide + solid lubricant
Colour: Grey

This special cast polyamide PA 6 G has an evenly distributed, embedded solid lubricant which gives this self-lubricating material excellent sliding properties, exceptional wear resistance, and an extraordinary dynamic load-bearing capacity (a PV limit value of up to 5 times higher than traditional cast polyamide types). This material is particularly suited to high sliding speeds in the case of non-lubricated bearings and wearing parts and is thus the perfect complement to oil-filled PA 6 G LO.

APSOplast® PA 6 G SL PLUS

PA 6 cast polyamide + solid lubricant
Colour: Dark blue

This cast polyamide PA 6 G has a solid lubricant. It is highly resistant to heat and has an excellent mechanical strength when exposed to high loads. Thanks to its low coefficients of dynamic and static friction without any stick-slip behaviour, this material ensures precise, finely attuned motion control, – i.e. increased precision for small movements like those carried out by modern, highly developed guide and control systems, as well as better cost-effectiveness at the system concept stage. The high wear resistance ensures a longer service life for construction elements and moving parts.

APSOplast® PA 12

Colour: Natural, black

PA 12 is a high-value construction material for special fields of use. The special set of properties of this tough, yet hard material includes a low moisture absorption in comparison with other polyamides and high flexibility, fatigue strength, and toughness.

Range of applications and application examples

Bearings
PA 6 G SL offers a service life up to 10 times longer than that of an unmodified polyamide 6, e.g. for the pivot bearing bushing of a mining dumper truck.

Rollers, wheels, wearing components
Polyamide offers improved wear protection and better compressive and fatigue strength than other materials for the most diverse of wearing applications.

Wear covers
Wear covers manufactured from PA 6 G SL save on weight and can support heavy loads. They are low-wearing on the mating partner surfaces.

Gear wheels
Gear wheels manufactured from PA 6 G L are significantly quieter and have a longer service life even without additional lubrication.

Nozzles
PA 6 G PLUS can be cast to the specific dimensions required by the customer. This enables a reduction in the production time and costs for applications such as e.g. sealing caps and atomizer nozzles. The new part only weighs a fraction of comparable metallic components, which results in improved, easier handling and lower installation costs.

Conformity
Some polyamide types are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
–

APSOplast® POM

Material denomination: POM
Chemical denomination: Polyacetal, polyoxymethylene

General description

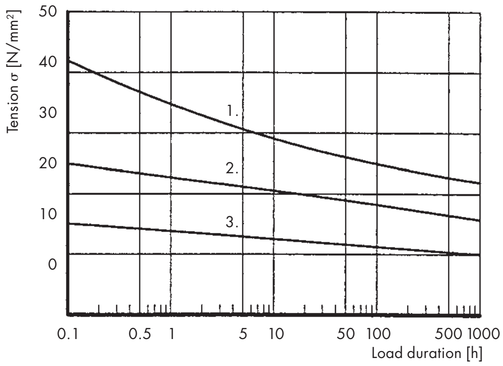
POM has a combination of higher hardness and dimensional stability while remaining highly impact-resistant. This plastic has a low coefficient of friction, moderate resistance to wear, excellent spring characteristics, high alternating fatigue resistance, good dielectric properties, high dielectric strength, low dielectric loss factor, good chemical resistance – particularly to solvents – and is very resistant to stress cracking.

Characteristics and properties

– High mechanical strength, rigidity, hardness, and toughness
– Very high resilience capacity
– Good creep resistance
– High impact resistance, even at low temperatures
– Very high dimensional stability (low moisture absorption)
– Good sliding properties and wear resistance
– Excellent machinability
– Good electrical insulation properties and favourable dielectric behaviour
– Physiologically safe (suitable for contact with foods)

Please note:
– Not self-extinguishing
– Can be damaged by the effects of hydrolysis (particularly POM-H in a warm, moist environment - (condensation, hot water, and steam should be avoided!))
– Degrades if exposed to UV (not suitable for use outside)
– Possibility of porous centre zones in the case of large dimensions

Isometric tensile stress curve of POM



Test conditions:
– Elongation: 2 %
– Temperature:
1. 20 °C
2. 50 °C
3. 80 °C

APSOplast® POM-H

POM homopolymer
Colour: Natural (white), black

POM homopolymer has a higher tensile strength, rigidity, hardness, creep resistance, and wear resistance than POM-C (copolymer).

APSOplast® POM-H SL

POM homopolymer + PTFE
Colour: Brown

This material has better sliding properties in comparison with POM-C and POM-H. Sliding elements made from this material have a lower coefficient of friction, good wear resistance, and an exceptionally low tendency towards stick-slip behaviour.

APSOplast® POM-C

Colour: Natural (white), black, orange, red, brown, yellow, blue, green, and grey

This is a polyacetal copolymer which - in comparison with POM-H - is more resistant to hydrolysis, strong lyes, and thermal-oxidative degradation.

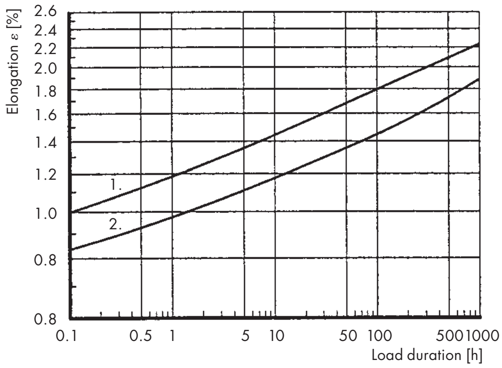
APSOplast® POM-C LSG

Colour: Various

POM-C LSG is a biocompatible polyacetal copolymer. Semi-finished products made from this material meet the requirements of ISO 10993-5. This should give end users additional safety and the assurance that the LSG types successfully pass tests on finished products.

Further information:
– Chapter 11: Plastics for medical technology

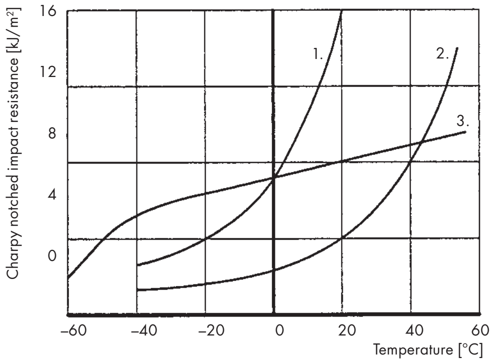
Time-dependent creep resistance of POM-H and POM-C



Test conditions:
– Temperature: 23 °C
– Constant tension: 25 N/mm²

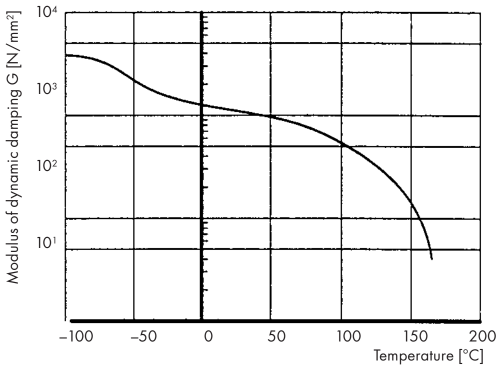
1. POM-C
2. POM-H

Notched impact resistance of POM-C in relation to temperature in comparison with polyamide



Test conditions:
1. PA 66 with moisture
2. PA 66 (dry)
3. POM-C

Modulus of dynamic damping of POM-C in relation to temperature



APSOplast® POM-C SL

POM-C + solid lubricant
Colour: Blue

This POM-C has an integrated solid lubricant, better sliding properties, and higher wear resistance.

APSOplast® POM-C EC

POM-C + conductive carbon black
Colour: Black

This POM-C contains conductive carbon black and is thus electrically conductive. It is therefore particularly suited to applications in the safety sector, explosion protection field (e.g. ATEX), electronic protection, transport and mechanical conveying and handling, etc.

APSOplast® POM-C ED

POM-C + anti-static agent
Colour: Beige

POM-C ED is an electrostatically dissipative material based on acetal. It is extremely suited to applications in conveyor technology. It avoids problems resulting from discharge on parts touched by people.
POM-C ED is also an excellent choice for retaining devices used for the conveyance of silicon wafers in production processes or for the manufacture of sensitive electronic components including hard disks and PCBs.

Further information:
– Chapter 13: Electrostatically dissipative / electrically conductive plastics

APSOplast® POM-C GF25

POM-C + 25% glass fibre
Colour: Greyish white

This POM copolymer, reinforced with 25% glass fibre, is characterized by increased rigidity and strength in comparison with non-reinforced types. This can be advantageous in various applications in mechanical engineering, transport and mechanical conveying and handling, electrotechnology, precision engineering, domestic appliances, etc.

Range of applications and application examples

Bearings and bushings
POM is a good, versatile sliding material which – thanks to its mechanical properties – enables high bearing loads. However, it is not as wear-resistant as e.g. PA or PET-C.

Electrical components
Natural POM-H is used to manufacture complex electrical inspection parts which require dozens of narrowly toleranced longitudinal boreholes. Glass fibre reinforced POM-C is also used for applications which require high rigidity and strength.

Construction parts
POM-C offers exceptional fatigue strength and notched impact resistance properties for construction parts for prosthetic devices which are exposed to sustained loads. Glass fibre reinforced POM-C is used for spring elements, housing parts, snap fits, and levers which require high rigidity and strength.

Gear wheels
Precision parts made from POM remain dimensionally stable regardless of the ambient conditions to which they are exposed.

Rollers
Guide rollers made from POM-C round bars are friction-free and reliable in hoists for loading trucks.

ATEX
Due to its good electrical conductivity, POM-C EC is a preferred material for this area.

Conformity
POM-H and POM-C are suitable for contact with foodstuffs. POM-C is suitable for contact with water.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
POM-C LSG is a biocompatibility-tested material for applications in medicine, pharmaceuticals, and biotechnology.

Further information:
– Chapter 11: Plastics for medical technology

APSOplast® PET-C

Material denomination: PET-C
Chemical denomination: Polyethylene terephthalate

General description

There are three different types of PET: Semi-crystalline PET (PET-C), amorphous PET (PET-A), and glycol-modified PET (PET-G), a copolymer with increased impact resistance.
PET-C is a non-reinforced, semi-crystalline polyester, a thermoplastic with unusually high hardness, rigidity, and dimensional stability. The excellent sliding behaviour of PET-C along with very low wear makes it ideal for precision machine elements with sliding functions.

Characteristics and properties

– High mechanical strength, rigidity, and hardness
– Very good creep resistance
– Low, constant coefficient of friction
– Very high wear resistance (comparable to or even higher than polyamides)
– Very high dimensional stability (better than that of polyacetal)
– Excellent stain resistance
– Better resistance to acids than polyamide and polyacetal
– Good electrical insulation properties
– Physiologically safe (suitable for contact with foods)
– High resistance to high-energy radiation (gamma and X-rays)

Please note:
– Low notched impact resistance
– Degradation as a result of hydrolysis at > 60 °C
(hot and damp environment, condensation, hot water, and steam)

PET films
– High mechanical strength and toughness
– High temperature resistance (–70 to +150 °C)
– Good resistance to chemicals
– Very good dielectric properties
– Self-extinguishing

Please note:
– Degradation as a result of hydrolysis at > 60 °C (hot and damp environment, condensation, hot water, and steam)
– Certain residual shrinkage at higher temperatures

APSOplast® PET-C

Colour: Natural (white), black

The specific properties of PET-C make this material particularly suited for mechanical precision and wearing parts.

APSOplast® PET-C SL

PET-C + solid lubricant
Colour: Grey

This material has a homogeneously distributed, integral solid lubricant. The specific material composition results in a unique, self-lubricating material for plain bearings. In addition to having a very high wear resistance, this material offers a lower coefficient of friction and higher dynamic load-bearing capacity (PV limit value) than PET-C.

Range of applications and application examples

Multiple distributors

Multiple distributors made from PET-C offer improved dimensional stability along with excellent resistance to corrosion and chemicals.

Plants for foodstuff processing

Many parts for plants used to produce and process foodstuffs are made from PET-C. This includes – e.g. moulds for creating hamburgers which meet high tolerance requirements and can be cleaned very easily using chemicals.

Carousels, filter plants, adjusting disks, and adjusting rings

Thanks to its rigidity and clean, hygienic appearance in conjunction with dimensional stability and resistance to diluted hydrochloric acid, PET-C is ideal for various parts in pharmaceutical test units.

Distributor valves

PET-C is characterized by good wear resistance under high pressures and at high speeds. It is ideal for applications where metal and plastic surfaces slide against each other. The distributor valves on foodstuff filling machines are often made from PET-C + solid lubricant. This material replaces stainless steel parts which would lead to high wear on the housing and associated unacceptable maintenance costs. The clearance between the distributor shaft and housing must be as small as possible to prevent leaks.

Conformity

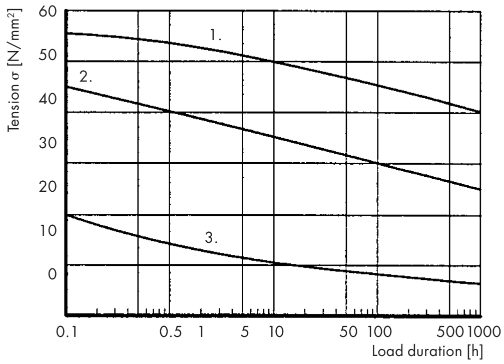
PET-C and PET-C + solid lubricant are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility

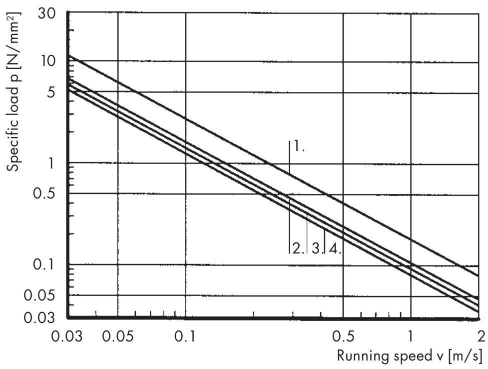
–

Isometric tension-time curves of PET-C from tensile test



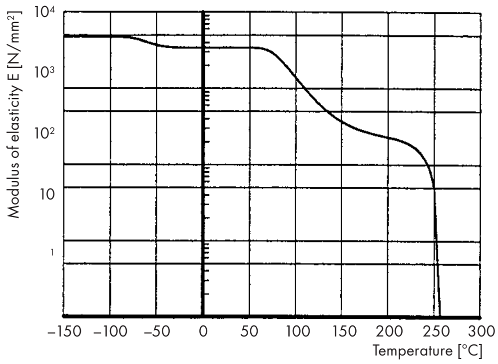
Test conditions:
– Elongation: 2 %
– Temperature:
1. +20 °C
2. +50 °C
3. +80 °C

Max. specific load/running speed



Test conditions:
– Non-lubricated
– Material:
1. PET-C SL
2. POM-C/POM-H
3. PET-C
4. PA 66

Modulus of elasticity of PET-C in relation to temperature



5

APSOplast® PPE

Material denomination: PPE
Chemical denomination: Modified polyphenylene ether

General description

Modified polyphenylene ethers (PPE) – also called polyphenylene oxides (PPO) – are amorphous thermoplastics with interesting properties. They can be classified in the middle ground between technical and high-performance plastics. Pure PPE has practically no applications. However, blends of PPE and PS have gained in economic importance. This type of blend is more resistant to oxidation. In addition, this dimensionally stable plastic is very resistant to chemicals and has a useful thermal stability.

Characteristics and properties

– High dimensional stability and dimensional stability
– High rigidity and strength
– Good dielectric properties
– Very low moisture absorption
– Very good chemical resistance
– Very good resistance to hydrolysis
– High resistance to temperature

Please note:
– Not suitable for sliding functions
– Notch-sensitive, stress concentrations on sharp edges, blind tapped holes etc. should be avoided
– Solvents - including anaerobic adhesives - cause stress corrosion (risk of cracking)

APSOplast® PPE

Modified PPE
Colour: Grey

This material is ideal for all applications with heat distortion stability to +110 °C and good impact resistance over a broad temperature range.
PPE has very low moisture absorption and therefore remains unaffected in the case of relatively long and repeated exposure to water. Due to its resistance to hydrolysis, this material is also often used in applications where there is direct contact with boiling water.

APSOplast® PPE LSG

Modified PPE
Colour: Natural, black, coloured

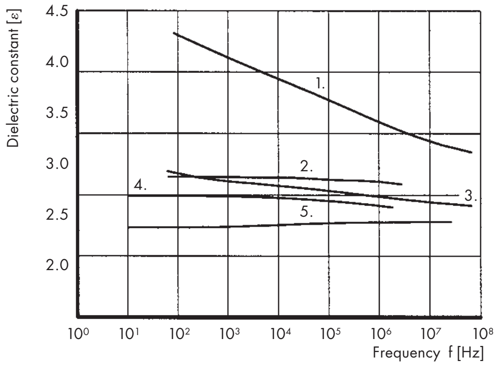
This material was specially developed for medical applications. The plastic consists of the raw material Noryl® HNA055 from GE Plastics. It has high resistance to repeated sterilization with gamma rays, superheated steam, and ethylene oxide.
PPE LSG can be sterilized in an autoclave at +134 °C for up to 1,000 cycles without notable degradation in its mechanical properties. The material is ideal for technical medical applications such as the manufacture of reusable surgical instruments.
It has a good service life and constantly high impact strength as well as being easy to machine.
Noryl® HNA055 meets the requirements of EC Directive 2002/72/EC for EUFC (European Food Contact) and FDA 21 CFR 177.2460. The semi-finished product is tested for cytotoxicity as per ISO 10993-5.

APSOplast® PPE GF30

Modified PPE + 30% glass fibre
Colour: Beige

This PPE is reinforced with 30% glass fibre. In comparison with versions which are not reinforced, it has even better mechanical and thermal properties and higher dimensional stability. Moreover, it retains excellent electrical properties and resistance to hydrolysis.

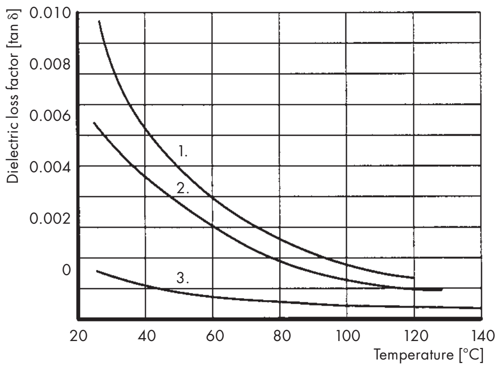
Dielectric constant



Test conditions:
– Temperature: 23 °C
– Relative humidity: 50%

1. PA 6
2. PSU
3. PET
4. PC
5. PPE

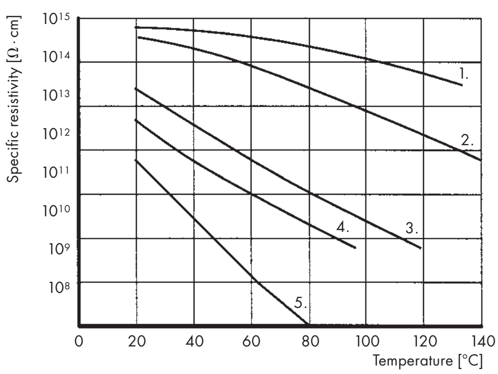
Dielectric loss factor



Test conditions:
– Frequency: 1 MHz
– Relative humidity: 50%

1. PC
2. PSU
3. PPE

Specific volume resistivity



Test conditions:
– Frequency: 1 MHz
– Relative humidity: 50%

1. PPE
2. PC
3. PET
4. PVC
5. PA 6

Range of applications and application examples

Heating and cooling systems
The heating and cooling systems of a car place high requirements on the material. During the entire service life of the car, parts of these systems are exposed to constant temperature cycles. Moreover, the material must be resistant to the effects of chemicals and have good mechanical properties.

Water technology applications
This material – particularly the version reinforced with glass fibre – is suitable for numerous applications for hot and cold water including housings and impellers for pumps, central heating pumps, water meters and flow controllers for mixing valves, engine housings, and spray-proof flooring.

Electrical appliances
Typical applications for glass fibre reinforced PPE include coil bodies. In solenoid valves, transformers, relays, and thermal/electrical insulation parts of all kinds – where brief overloads mean that high temperatures must be permissible – glass fibre reinforced PPE offers excellent creep resistance and high rigidity.

Medical technology
PPE LSG is suitable for reusable surgical instruments, test implants, sterilization basins, instrument handles, and any components which need to be sterilized or exposed to radiation.

Conformity
PPE LSG is suitable for contact with foodstuffs.

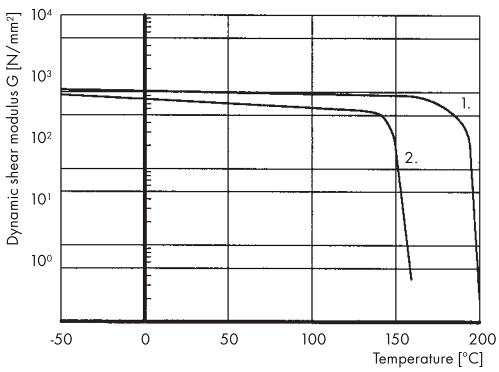
Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
PPE LSG is biocompatibility-tested for applications in medicine, pharmaceuticals, and biotechnology.

Further information:
– Chapter 11: Plastics for medical technology

APSOplast® PSU, PPSU, PEI

Shear modulus G of PSU in comparison with PC



1. PSU
2. PC

Material denomination: PSU, PPSU, PEI
Chemical denomination: Polysulfone, polyphenylene sulfone, polyetherimide

General description

These non-reinforced amorphous thermoplastics are characterized by a combination of favourable mechanical, thermal, and electrical properties.

Characteristics and properties

– High long-term service temperature in air (PPSU: +180 °C, PEI: +170 °C, and PSU: +150 °C)
– High mechanical strength, rigidity, and creep resistance over a broad temperature range
– Excellent resistance to hydrolysis (suitable for repeated steam sterilization)
– High toughness, even at low temperatures
– Physiologically safe (suitable for contact with food)
– Very high dimensional stability
– Translucent, but not optical quality (except for PPSU, which is black)
– Extremely good resistance to high-energy radiation (gamma and X-rays)
– Good electrical insulation properties and favourable dielectric behaviour

Please note:
– Tendency towards stress cracking due to mechanically or chemically induced stress concentrations
– A certain amount of notch sensitivity (primarily in the case of PSU)
– Not UV-stable, so not recommended for use outside
– Not suitable for applications with a sliding function
– Possible volume changes due to moisture absorption

APSOplast® PSU

Colour: Natural (yellow, translucent)

These PSU semi-finished products are manufactured from a non-UV-stabilized polysulfone raw material. This material offers very good resistance to radiation, good ionic purity, and favourable resistance to chemicals and hydrolysis. In comparison with PEI, PSU has a lower profile of properties and is often used as a replacement for polycarbonate if higher temperature resistance, improved chemical resistance, and steam sterilization options are required. PSU is often used in the food processing industry (for milking machines, pumps, valves, filter plates, and heat exchangers) and for technical medical components which need to be repeatedly cleaned and sterilized.

APSOplast® PPSU

Colour: Black

These PPSU semi-finished products offer better impact resistance and chemical resistance than PEI and PSU. PPSU also has excellent resistance to hydrolysis on the basis of the number of steam autoclave cycles before failure. This material has a practically unlimited superheated steam sterilizability. In addition, the raw material used to make PPSU semi-finished products meets the requirements of Class VI of the USP Standards and is thus a very popular material for the medical technology and pharmaceutical industries, for use in sterilization trays, handles of dental and surgical instructions, orthopedic test implants, and fluid technology couplings and fittings.

APSOplast® PPSU LSG XRO

Colour: Black, coloured

This radiopaque LSG material can master any challenges posed by the needs of minimally invasive, image-controlled surgery. A contrast agent is added to the standard product range of coloured PPSU round bars to allow the clear visibility of components in fluoroscopy and X-ray applications. It gives surgeons an accurate view of instruments or orthopedic test implants during image-controlled surgeries.
LSG XRO is tested in accordance with the requirements of ISO 10993 for external equipment (communication devices) which are in contact with body fluid, bone substance, and dentin for less than 24 hours.
The semi-finished products are regularly tested as per ISO 10993-5.

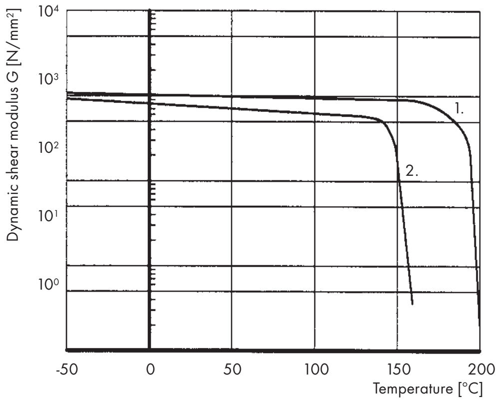
Further information:
– Chapter 11: Plastics for medical technology

APSOplast® PEI

Colour: Natural (amber, transparent)

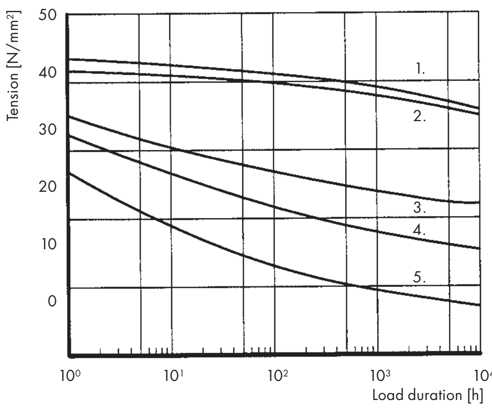
PEI, manufactured from ULTEM® granules, has outstanding thermal, mechanical, and electrical properties. It is also extremely flame-retardant and results in particularly low levels of smoke development in the case of a fire. PEI is therefore very suitable for use in electrical/electronic insulators and a range of load-bearing components which need to be strong and rigid at relatively high temperatures. The raw material for the manufacture of these semi-finished products meets the requirements of Class VI of the USP Standards. Thanks to the good resistance to hydrolysis of polyetherimide, it is not surprising that technical medical devices and analytical instruments constitute an important application area for this material.

Shear modulus G of PSU in comparison with PC



1. PSU
2. PC

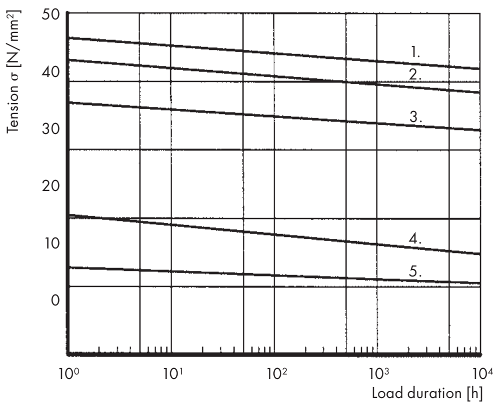
Isometric tension curve of PSU at different temperatures



Test conditions:
– Medium: Air
– Elongation: 2%

1. 23 °C
2. 60 °C
3. 100 °C
4. 125 °C
5. 150 °C

Isometric tension curves of PEI at different temperatures



Test conditions:
– Medium: Air
– Elongation: 2%

1. 23 °C
2. 65 °C
3. 90 °C
4. 140 °C
5. 165 °C

APSOplast® PSU LSG
APSOplast® PPSU LSG
APSOplast® PEI LSG

These three grades are biocompatible materials used to make semi-finished products that meet the requirements of USP Class VI and ISO 10993-4, -5, -10, and -11. This should give end users additional safety and the assurance that the LSG materials successfully pass tests on finished products.

Further information:
– Chapter 11: Plastics for medical technology

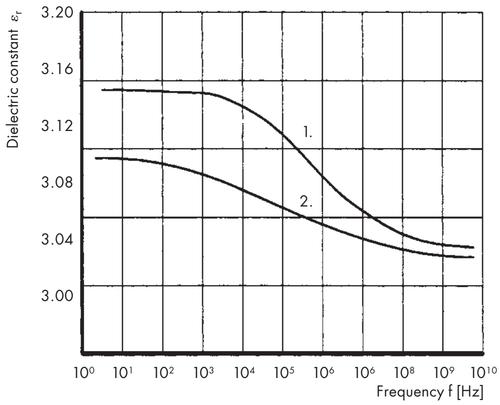
APSOplast® PEI EC

Electrically conductive
Colour: Black

With outstanding mechanical behaviour to a temperature of +210 °C, PEI EC is the solution for electrically conductive applications in relatively high temperature ranges. In addition, this material is extremely dimensionally stable (low thermal linear expansion and moisture absorption) and is highly valued for transportation systems in the electrical/electronic and semi-conductor industries.

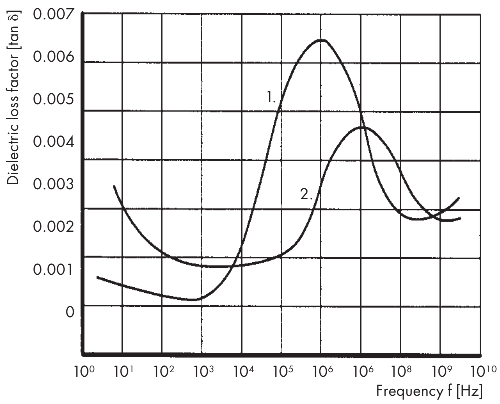
Further information:
– Chapter 13: Electrostatically dissipative / electrically conductive plastics

Dielectric constant of PEI in relation to frequency



1. 23 °C
2. 80 °C

Loss factor of PEI in relation to frequency



1. 23 °C
2. 80 °C

Range of applications and application examples

Multiple distributors
Multiple distributors made from PSU sheets are transparent, can be sterilized using high-energy radiation, and are extremely resistant to scratching.

Distributors
In the food industry (e.g. poultry sector), valves are made from polysulfone due to its high chemical resistance.

Inserts for cleaning devices
Inserts made from PSU reduce the chemical effects of polyamide distribution blocks in hot-water and steam cleaning devices.

Clamping sleeves
The high dielectric strength and inherent flame-retardant behaviour of PEI make this material ideal for clamping sleeves used to connect PCBs to video screen systems in planes, tanks, and ships.

Medical technology
PSU, PPSU, and PEI in the LSG range have exceptional resistance to traditional sterilization techniques, which provides additional safety for medical applications. Example applications include surgical instruments, sterilization containers, instrument handles, test pieces, apparatus parts, and so on.
Due to its radiopaque design, PPSU LSG XRO is used for surgical instruments and orthopedic test implants for applications which require the clear visibility of components when exposed to X-rays.

Components of medical devices
Parts made from PSU are blood-compatible (suitable for use in dialysis equipment) and resistant to repeated cycles of autoclave sterilization.

Positioning rings for endoscopy devices
Due to its excellent suitability for sterilization with superheated steam, PPSU was chosen as the material for the positioning ring on the handle of surgical endoscopy devices.

Positioning arms and styluses
A positioning arm with a stylus coordinates the exact positioning of screws during operations to fix broken thigh bones. These PEI components allow the surgeon to monitor positioning on the screen without exposing his or her hands to the X-rays. Once the stylus is engaged in a specific position, it is pulled out of the positioning arm. Then, a hole is drilled in the bone for the fixation of a titanium retaining screw.

Conformity
PSU, PPSU, and PEI are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
– PSU LSG
– PPSU LSG
– PEI LSG
– PPSU LSG XRO
All of the above materials are tested for biocompatibility for use in applications in medical technology, pharmaceutical technology, and biotechnology.

Further information:
– Chapter 11: Plastics for medical technology

APSOplast® PPS

Material denomination: PPS
Chemical denomination: Modified polyphenylene sulphide

General description

Polyphenylene sulphides have a whole range of useful properties such as wear resistance, mechanical load-bearing capacity, dimensional stability, and resistance to the effects of contact with chemically aggressive media and high temperatures.

Characteristics and properties

- Very high maximum service temperature limit in air (long-term exposure to +220 °C, short-term exposure to +260 °C)
- High mechanical strength, rigidity, and creep resistance, even at high temperatures
- Exceptional resistance to chemicals and hydrolysis
- Exceptional friction and wear behaviour (only grades modified for sliding applications)
- Very high dimensional stability
- Exceptional resistance to high-energy radiation (gamma and X-rays)
- Good resistance to UV
- Inherent flame-retardant properties
- Good electrical insulation properties and favourable dielectric behaviour

APSOplast® PPS GF40

PPS + 40% glass fibre
Colour: Black

This semi-crystalline polymer is filled with 40% glass fibre. It has exceptional rigidity and hardness, even at a service temperature of up to +220 °C. Its very good chemical resistance, low creep tendency, and high dimensional stability allow applications for components with high thermal and mechanical stresses in the fields of pumps, fittings, chemical plants, and mechanical engineering. This material is also used for small high-precision parts with high dimensional stability in the electrical and nuclear industries. This glass fibre filled PPS does, however, tend to have brittle-like breaking behaviour.

APSOplast® PPS SL

PPS + carbon fibre + graphite + PTFE
Colour: Black

This semi-crystalline polymer is filled with carbon fibre, graphite, and PTFE. It is very rigid and hard as well as having exceptional sliding and friction properties. The service temperature of up to +220 °C, very good chemical resistance, low creep tendency, and high dimensional stability enable applications for components which are exposed to high thermal and static/dynamic loads in the fields of pumps, fittings, vacuum technology, packaging machines, paper machines, precision engineering, aeronautics, and astronautics.

APSOplast® PPS GF SL

PPS + glass fibre + solid lubricant
Colour: Dark blue

This fibre-reinforced type of polyphenylene sulphide has an integral solid lubricant. It has an exceptional combination of properties with regard to its wear resistance, mechanical load-bearing capacity, and dimensional stability, even when exposed to chemicals and high temperatures. This material is used wherever other technical plastics such as PA, POM, PET, PEI, and PSU are no longer sufficient or where a more cost-effective alternative to PI, PEEK, or PAI is sought in less challenging high-tech applications.
Thanks to the homogeneously distributed, integral solid lubricant, PPS GF SL has excellent wear resistance and a low coefficient of sliding friction. It is able to overcome the disadvantages of unfilled PPS (high coefficient of sliding friction) and of glass fibre reinforced PPS (early wear of mating surface) in the case of sliding elements. Naturally, these characteristics combined with exceptional chemical resistance open up a wide range of possible applications in all possible industrial sectors, e.g. industrial drying furnaces and ovens for food processing, devices for chemical processing, and electrical insulation systems.

Range of applications and application examples

Lantern rings in stuffing boxes
PPS GF SL lantern rings in stuffing boxes reduce wear corrosion problems on centrifugal pumps for use in mining and enable more narrow bearing clearances. This leads to fewer failures and improved efficiency.

Pump housings
High-precision components made from PPS reinforced from glass fibre or carbon fibre enable high efficiency for a large range of different chemical pump media.

HPLC (high-performance liquid chromatography)
Components for high-performance liquid chromatography are made from PPS due to its high resistance to chemicals.

Chip sockets
Plug-in modules are primarily made from PPS plates that are used at high voltage and speed when semi-conductor boards are tested.

Connector parts, light sockets
The high thermal and mechanical resistance of the glass fibre- and carbon-fibre-reinforced PPS types enable its usage in connector parts and light sockets. The glass fibre types have very good electric insulation properties.

Retaining rings
Retaining rings for the retention of wafers in mechanochemical polishing processes are made from PPS.

Sliding elements
The two modified PPS types PPS GF SL and PPS SL are suitable for sliding applications such as slide bearings, sliding rails, thrust washers, sliding blocks, slide rings, and so on.

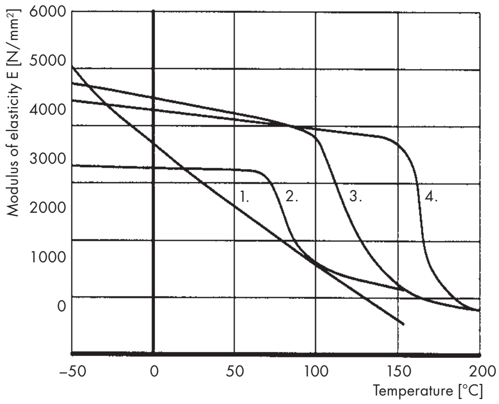
Bearing yokes
Aggressive chemicals are used in continuous solvent extraction plants for the extraction of oil or sugar from plant material. The PPS GF SL breaking yokes used for the drive shafts of the conveyor are constantly positioned in solvent. In these conditions, where it is impossible to use lubricant, wear-resistant PPS provides an enduring, low-maintenance solution.

Insulating printer bearings
Electrically insulating bearings made from PPS GF SL provide a low-maintenance solution for industrial recto-verso printers.

Conformity
PPS GF SL is suitable for contact with foodstuffs.

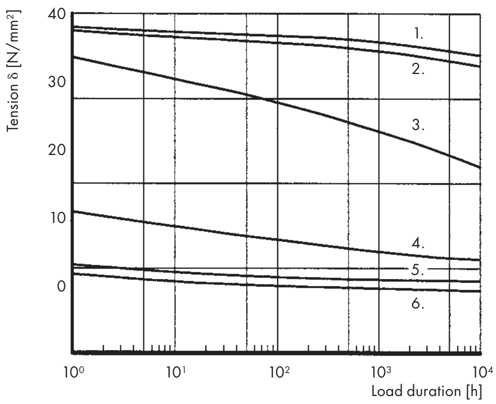
Further information:
– Chapter 10: Plastics for the food industry

Modulus of elasticity in tensile test in relation to temperature



1. POM-C
2. PA 46
3. Mod. PPS
4. PEEK

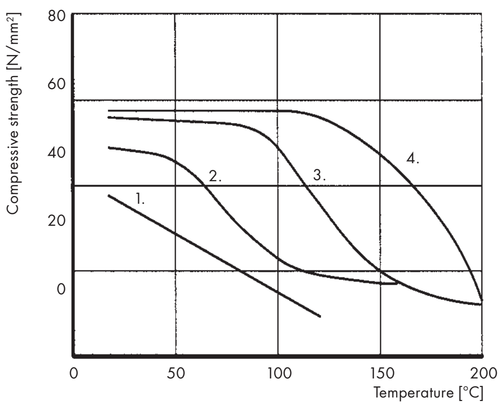
Isometric tension-time curves for PPS GF SL in tensile test



Test conditions:
– Medium: Air
– Elongation: 1%

1. 20 °C
2. 50 °C
3. 80 °C
4. 100 °C
5. 125 °C
6. 150 °C

Comparison of compressive strength at 2% deformation in relation to temperature



Test conditions:
– Compression test: As per ISO 604
– Test specimen: Ø 12 × 30 mm
– Compression: 2%

1. POM-C
2. PA 46
3. Mod. PPS
4. PEEK

APSOplast® PEEK

Material denomination: PEEK
Chemical denomination: Polyether ether ketone

General description

PEEK is a semi-crystalline thermoplastic which has practically all of the properties expected of a high-performance plastic. It is ideal for applications requiring high performance in extreme conditions with regard to temperature, chemicals, weather resistance, mechanical properties, abrasion resistance, resistance to high-energy radiation, and flame-retardant behaviour, etc. Along with its modified types, PEEK forms a unique group of materials for challenging applications.

Characteristics and properties

– Very high maximum service temperature limit in air (long-term exposure to +250 °C, short-term exposure to +310 °C)
– High mechanical strength, rigidity, and hardness, even at high temperatures
– Exceptional resistance to chemicals and hydrolysis
– Exceptional wear resistance and good sliding properties (particularly in the case of types containing CF and CF + PTFE + graphite)
– Very high dimensional stability
– Inherent flame-retardant behaviour and very low smoke development in the case of a fire
– Good electrical insulation properties and favourable dielectric behaviour (this does not apply to the types with added graphite and carbon fibres)
– Exceptional resistance to high-energy radiation (gamma and X-rays)

Please note:
– The high price in comparison to standard and technical plastics restricts usage.

APSOplast® PEEK
Colour: Natural (brownish grey), black

PEEK semi-finished products are made from non-reinforced polyether ether ketone raw material and offer the highest toughness and impact resistance of all PEEK types.

APSOplast® PEEK SL
PEEK + carbon fibre + graphite + PTFE
Colour: Black

The addition of carbon fibre, PTFE, and graphite gives this PEEK slide bearing material exceptional tribological properties (low coefficient of friction, high wear resistance, and high PV limit value) and makes it into the ideal material for components subject to high wear, friction, and thermal and mechanical loads.

APSOplast® PEEK SL FDA
PEEK + solid lubricant
Colour: Blue

This semi-crystalline PEEK contains a solid lubricant suitable for contact with foodstuffs. As a result, this modified PEEK has a unique combination of excellent mechanical properties and temperature resistance as well as favourable resistance to chemicals in conjunction with improved wear resistance and a lower coefficient of friction.

APSOplast® PEEK GF30
PEEK + 30% glass fibre
Colour: Natural (brownish grey)

This material type, reinforced with 30% glass fibre, has a higher rigidity and creep resistance than non-reinforced PEEK and has much better dimensional stability. It is well-suited for use in parts which are exposed to high and static loads at high temperatures. Because the glass fibres tend to result in abrasion of the mating surface, the suitability of this material for slide bearings must be carefully checked for each specific application.

APSOplast® PEEK CF30
PEEK + 30% carbon fibre
Colour: Black

This grade, reinforced with 30% carbon fibre, combines high rigidity, mechanical strength, and creep resistance along with optimum wear resistance. Moreover, the carbon fibres give a thermal conductivity that is 3.5 times higher than that of non-reinforced PEEK, which means that frictional heat is dissipated from the mating surface more quickly.

APSOplast® PEEK EC
Conductive PEEK
Colour: Black

This PEEK is reinforced with carbon fibre and is electrically and thermally conductive. It can be used for applications where problems can arise due to discharge on parts which come into contact with people. This material is also ideally suited for holding or fixing devices used for the conveyance of silicon wafers in production processes or for the manufacture of sensitive electronic components including hard disks and PCBs.

APSOplast® PEEK LSG
PEEK Life Science Grade
Colour: Natural, black, coloured

The LSG range consists of biocompatible materials used to make semi-finished products which meet the requirements of USP Class V and ISO 10993-4, -5, -10, and -11. Their characteristics should give end users additional safety and the assurance that the LSG materials successfully pass tests on finished products.

APSOplast® PEEK CLASSIX® LSG
PEEK
Colour: Natural

This material type was developed for technical medical applications which require contact with blood or tissue for up to 30 days and is certified as per USP Class VI and ISO 10993-4, -5, -10, and -11.

Range of applications and application examples

Pump wearing rings
Wearing rings made from PEEK + 30% CF in centrifugal pumps allow more narrow running tolerances, which increases efficiency. In addition, corrosion, pitting, and wear problems are eliminated.

Load-bearing components
PEEK is used for bar-shaped vacuum grips in the manufacture of semi-conductor components. They combine thermal stability with high resistance to commercially available chemicals.

Bearing bushings, bearings, seals, and retaining rings
In application scenarios ranging from the aeronautics industry to drilling machines in oil fields, components made from PEEK are used due to improved performance and reliability.

Doctor blades for scraped surface heat exchangers
The doctor blades for scraped surface heat exchangers in the foodstuff, dairy, and chemical industries are made from PEEK. The exceptional mechanical strength and rigidity of PEEK at high temperatures along with its high wear resistance and excellent resistance to chemical and hydrolysis make PEEK into the ideal material for this application.

Bearing bushings in steel wire guide rollers
Bearing bushings made from PEEK SL for steel wire guide rollers as used in etch baths in wire drawing offer a longer service life with much lower costs in comparison with the steel ball bearings used previously. The decision to use this type was due to its chemical resistance, exceptional wear resistance, and high load-bearing capacity at high temperatures.

Load-bearing housing bodies in gas analysis devices
The three main housing bodies of the gas analysis devices used by NASA in satellites are made from PEEK. With very good chemical resistance, high resistance to temperatures, and exceptional resistance to high-energy radiation, this type of material offers a long service life and high operational reliability. Two further reasons for choosing PEEK are its excellent machinability and very good dimensional stability.

Medical technology
– PEEK (Industrial Grade): For applications that do not require biocompatibility.
– PEEK LSG: For applications for which biocompatibility is required for up to 24 hours of body contact.
– PEEK CLASSIX® LSG: For applications for which biocompatibility is required for up to 30 days. Exception: healing caps and abutments to 180 days; DENTAL with Invibio special certificate by consultation!

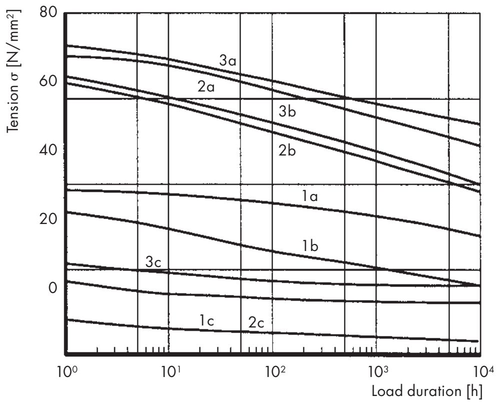
Conformity
PEEK and PEEK SL FDA, like other material types in the LSG range, are suitable for contact with food.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
The material types in the LSG range are tested for biocompatibility for applications in medicine, pharmaceutical technology, and biotechnology.

Further information:
– Chapter 11: Plastics for medical technology

Isometric tension-time curves of PEEK



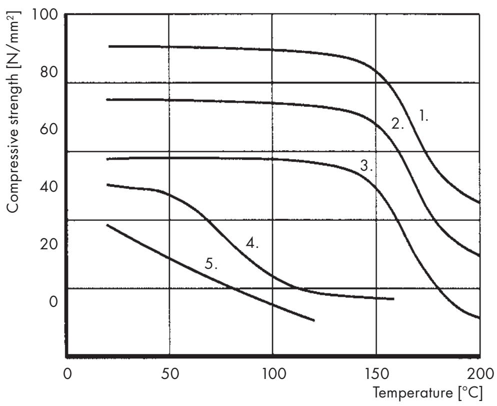
Test conditions:
– Medium: Air
– Elongation: 1%

1a. PEEK 20 °C
1b. PEEK 125 °C
1c. PEEK 200 °C

2a. PEEK SL 20 °C
2b. PEEK SL 125 °C
2c. PEEK SL 200 °C

3a. PEEK GF30 20 °C
3b. PEEK GF30 125 °C
3c. PEEK GF30 200 °C

Compressive strength at 2% deformation in relation to temperature



Test conditions:
– Compression test: As per ISO 604
– Test specimen: Ø 12 x 30 mm

1. PEEK GF30
2. PEEK SL
3. PEEK
4. PA 46
5. POM-C

6

APSOplast® PAI

Material denomination: PAI
Chemical denomination: Polyamide imide

General description

PAI is a plastic with a very high flexural strength, extremely low creep tendency, and top mechanical strength at very high temperatures. It also has excellent sliding and wear properties.

Characteristics and properties

– Very high maximum service temperature limit in air (long-term exposure from –200 to +250 °C, short-term exposure to +270 °C)
– Excellent retention of mechanical strength, rigidity, and creep resistance over a broad temperature range
– Extremely low coefficient of linear thermal expansion up to +250 °C (see diagram)
– Exceptional friction and wear behaviour (especially PAI SL PLUS)
– Excellent resistance to UV
– Inherent flame-retardant properties
– Exceptional resistance to high-energy radiation (gamma and X-rays)

Please note:
– Modest resistance to chemicals
– Not resistant to hydrolysis (hot water, steam, etc.)
– Relatively high moisture absorption
– Restricted weather resistance
– Not suitable for contact with foodstuffs

PAI SL

PAI + TiO_2 + PTFE
Colour: Yellow ochre

This grade offers the highest toughness and impact resistance of all polyamides. Due to its inherent high resistance to temperature, high dimensional stability, and good machinability, this extruded PAI is extremely popular for use for high-precision parts in high-tech devices. In addition, its good electrical insulation properties give rise to numerous possible uses in the field of electrical components.
In the case of larger dimensions, semi-finished products of this material can also be produced in a press-sintering method.

PAI SL PLUS

PAI + graphite + PTFE
Colour: Black

The addition of graphite and PTFE gives rise to a higher wear resistance and a lower coefficient of sliding friction in comparison with unfilled types. This material also offers exceptional dimensional stability over a wide temperature range. This type is ideal for high-wear applications, such as is the case for non-lubricated sliding elements, seals, bearing cages, and parts for lifting movements. In the case of large semi-finished product dimensions, this material can also be processed in a press-sintering method.

PAI GF30

PAI + 30% glass fibre
Colour: Khaki

This press-sintered polymer is reinforced with 30% glass fibre and has a higher rigidity, mechanical strength, and creep resistance than PAI SL. It is well-suited for use in parts which are subjected to long-term, heavy exposure to static loads at high temperatures. In addition, PAI GF30 offers exceptional dimensional stability up to +250 °C, which makes it a very popular material for precision parts such as those used in the electrical and semi-conductor industries. Because the glass fibres tend to result in abrasion of the mating surface, the use of this material for slide bearings must be carefully checked for each specific application.

Range of applications and application examples

Chip mounting devices
Mounting devices made from PAI GF30 are used to check chips. Parts made from this material have a long service life and ensure highly reliable test connections thanks to their retained dimensional stability over a broad temperature range.

Electrical high-temperature plugs
PAI SL offers exceptional electrical characteristics and high temperature stability.

Labyrinth seals
Thanks to the good tribological properties of PAI SL PLUS in comparison with steel, improved efficiency values and flow rates can be achieved in applications such as turbo compressors, since the seal clearance can be reduced.

Bearing cages
The low coefficient of linear thermal expansion and excellent wear properties of PAI SL PLUS allow manufacturers to increase bearing speeds while improving the service life.

Mandrels for tin can machines
On a carousel printing machine for aluminium drink cans, the cans are supported by mandrels made from PAI SL during printing. Thanks to their exceptional dimensional stability and high abrasion resistance, these mandrels have a long service life and enable high production speeds.

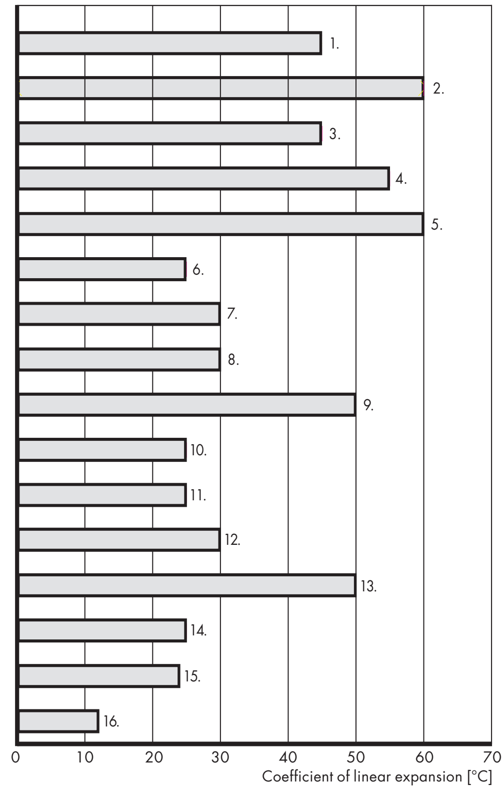
Slide valves of rotary compressors
Due to its efficiency and reliable service life behaviour, PAI SL PLUS is the ideal material for slide valves in rotary compressors. The high rigidity and exceptional dimensional stability of the material – even at high temperatures – mean that the slide valves can move back and forth without getting jammed in the rotor slots.

Yogurt cup sealing supports
PAI SL PLUS supports are used in food packaging machines for the sealing of plastic yogurt cups with an aluminium foil lid. The supports must be able to withstand high demands on the wear factor at temperatures of up to +200 °C.

Conformity
–

Biocompatibility
–

Coefficient of linear thermal expansion of various high-performance plastics (average value between +23 and +150°C)



1. PTFE 500
2. PSU
3. PEI
4. PPSU
5. PPS GF SL
6. PEEK CF30
7. PEEK GF30
8. PEEK SL
9. PEEK
10. **PAI GF30**
11. **PAI SL PLUS**
12. **PAI SL**
13. VESPEL® SP-1
14. PBI
15. Aluminium
16. Steel

APSOplast® PI

Material denomination: PI
Chemical denomination: Polyimide

General description

Finished and semi-finished products made from PI (polyimide) are tailored for use in applications which require high thermal stability, good electrical properties, and excellent wear and abrasion behaviour. The absence of a glass transition temperature and melting point has a significant influence on the product's properties and explains why PI acts like a thermoset. Unlike most other materials, PI acts isotropically, which means that the typical properties of parts machined from semi-finished products (such as tensile strength, elongation, and the coefficient of thermal elongation) are independent of the direction of production.

Characteristics and properties

– Very high maximum service temperature limit in air (long-term exposure to +288 °C, short-term exposure to +482 °C)
– Excellent retention of mechanical strength, rigidity, and creep resistance over a broad temperature range
– High resistance to oxidation
– Low coefficient of linear thermal elongation
– Exceptional abrasion and wear behaviour
– Inherent flame-retardant properties
– Good electrical insulation properties and favourable dielectric behaviour
– Low degassing in vacuum (dry material)
– Good resistance to high-energy radiation (gamma and electron beam radiation)
– Good machinability
– Production of finished products in a direct forming process

Please note:
– Not resistant to hydrolysis
– Restricted weather resistance
– High moisture absorption
– Very high price level

VESPEL® PI SP1

PI
Colour: Brown

PI SP1 is the unfilled standard type with maximum strength and elongation and the lowest modulus of elasticity. In addition, this material has a low thermal conductivity and optimum electrical properties.

VESPEL® PI SP21

PI + 15% graphite
Colour: Anthracite

The 15% graphite content improves the coefficient of friction, wear resistance, and heat ageing. This type is suitable for lubricated and non-lubricated applications which require low friction and wear properties.

VESPEL® PI SP22

PI + 40% graphite
Colour: Anthracite

The addition of 40% graphite improves the sliding behaviour and decreases the coefficient of thermal expansion. This is particularly important in the case of applications where a low coefficient of thermal expansion is more important than strength, which is slightly reduced in this case.

VESPEL® PI SP211

PI + 15% graphite + 10% PTFE
Colour: Anthracite

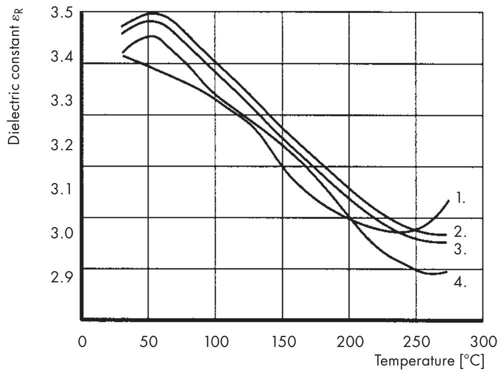
The addition of 15% graphite and 10% PTFE gives rise to the lowest coefficient of friction of all PI types along with the lowest wear. This type is suitable for applications where low friction and wear properties are required at temperatures of up to +150 °C.

VESPEL® PI SP3

PI + 15% MoS2
Colour: Anthracite

Due to the addition of molybdenum disulphide, the best wear properties in dry environments are achieved here. This is particularly true in the case of applications subjected to friction and wear in a vacuum or inert gases, such as bearings, piston rings, and seals.

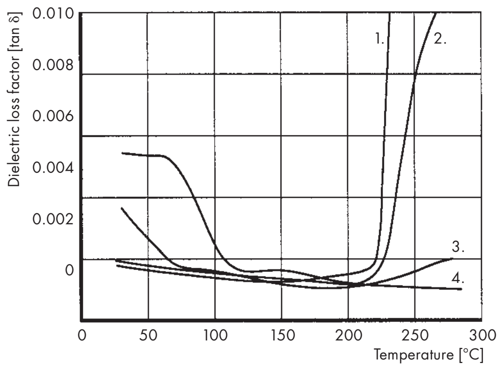
Dielectric constant of PI SP-1



Test conditions:
Frequency:

1. 10^2 Hz
2. 10^3 Hz
3. 10^4 Hz
4. 10^5 Hz

Loss factor PI SP-1



Test conditions:
Frequency:

1. 10^2 Hz
2. 10^3 Hz
3. 10^4 Hz
4. 10^5 Hz

Range of applications and application examples

Slide bearings

Polyimide slide bearings can be exposed to higher PV-values (PV) than all other high-performance plastics. In addition, the function of PI slide bearings is unsurpassed over a broad range of temperatures and loads, since they have excellent track resistance, abrasion resistance, and mechanical strength.

Gaskets

In high-temperature applications which require flexibility and excellent sealing behaviour, polyimides increase the function of gaskets tremendously. Type SP21 is the standard material for valve seats, seals, bearings, thrust washers, and gaskets, since it offers the best combination of mechanical strength and abrasion resistance.

Valve seats

In order to prevent hydraulic oil from flowing back into an automatic transmission, the transmission non-return valve seat requires a precise opening diameter of 0.38 mm. This could be achieved with polyimide. In addition, wear was reduced with valve seats manufactured from PI.

Rod guidances

A rod guidance made from polyimide was able to increase the upper service temperature limit for a compressed air control system. At a temperature of +260 °C, this material still works reliably. It remains self-lubricating, has a low coefficient of friction – even at high valve operating temperatures, and does not deform in the case of long-term exposure.

General processing procedures

Semi-finished products made from polyimide are relatively easy to machine due to their mechanical strength, rigidity, and dimensional stability.

Direct forming process

Direct forming is particularly cost-effective for the large-scale production of precision parts made from polyimide. Direct forming uses manufacturing processes which are commonly used for the production of precision parts or blanks in powder metallurgy.

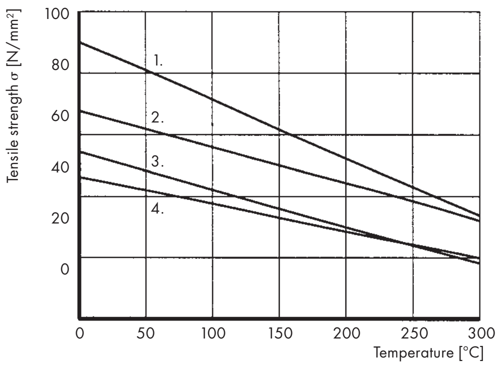
Conformity

–

Biocompatibility

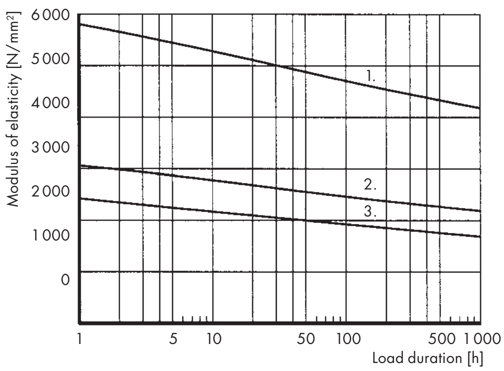
–

Tensile strength of PI in relation to temperature



1. SP1
2. SP21
3. SP22
4. SP211

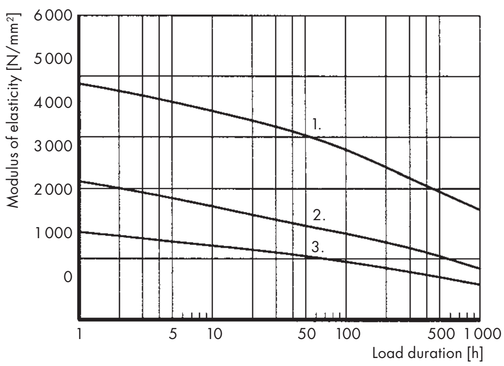
Modulus of elasticity of PI (long-term behaviour)



Test conditions:
Temperature: +100 °C
Specific load: 15 N/mm²

1. SP22
2. SP21
3. SP1

Modulus of elasticity of PI (long-term behaviour)



Test conditions:
Temperature: +300 °C
Specific load: 15 N/mm²

1. SP22
2. SP21
3. SP1

APSOplast® PBI

Material denomination: PBI
Chemical denomination: Polybenzimidazole

General description

PBI is an absolute top material among the range of high-performance materials. Thanks to its unique combination of properties, PBI can offer a solution where other plastics fail. This material is in high demand in the high-tech industry such as the semi-conductor, aeronautics, and astronautics industries.

Characteristics and properties

– Extremely high maximum service temperature limit in air (long-term exposure to +310 °C, short-term exposure to +500 °C)
– Excellent retention of mechanical strength, rigidity, and creep resistance over a broad temperature range
– Very low coefficient of linear thermal expansion
– Exceptional abrasion and wear behaviour
– Inherent flame-retardant properties
– Good electrical insulation properties and favourable dielectric behaviour
– Low degassing in vacuum (dry material)
– High ionic purity
– Exceptional resistance to high-energy radiation (gamma and X-rays)

Please note:
– Not resistant to hydrolysis
– Modest resistance to chemicals
– High moisture absorption
– High material hardness makes machining more difficult
– Very high price level

PBI

Colour: Black

It offers the highest temperature resistance and best retention of mechanical properties of all non-reinforced high-performance plastics. PBI is ionically very pure and does not degas (dry material). Thanks to its unique combination of properties, PBI can offer a solution where other plastics fail. This material is in high demand in the high-tech industry such as the semi-conductor, aeronautics, and astronautics industries. In these areas, PBI is primarily used for critical, complex components in order to reduce maintenance costs and win valuable operating time during production.

Range of applications and application examples

High-temperature insulators
PBI sleeves used in the hot runner systems of injection moulding tools keep the melted plastic in a molten state while the shaped part starts to harden in the cooled mould. The sleeves have a longer service life and are easier to clean, since the melted plastic molding compound does not adhere to the PBI sleeve.

Electrical plugs
To increase safety, an aircraft engine manufacturer replaced plugs made out of PI (polyimide), exposed to a temperature of over +205 °C, with PBI (polybenzimidazole).

Valve seats of ball cocks
PBI valve seats are particularly suitable for applications in the field of high-temperature fluids.

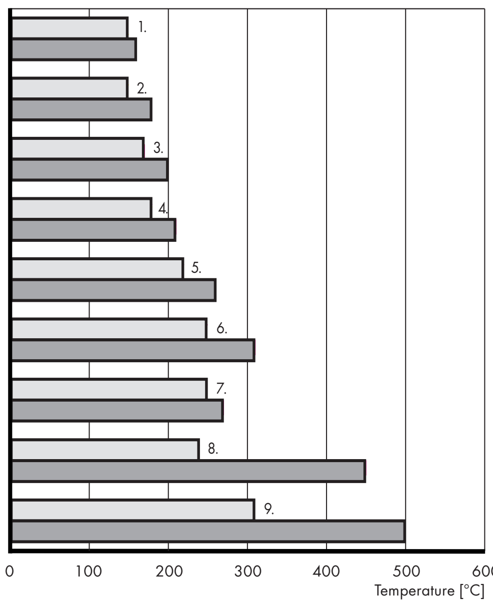
Clamping rings
Parts made from PBI for gas plasma etching systems are more durable than PI (polyimide) parts due to the reduced high-energy removal rates. PBI parts thus increase the lifetime and availability of machines.

Contact parts for lamps
The manufacturers of incandescent and fluorescent lamps use PBI contact parts such as vacuum cups, grippers, and sockets in the high-temperature field. In comparison with PI (polyimide), PBI offers an increased resistance to temperature, better abrasion resistance, and a longer service life. In addition, PBI contact parts reduce scrap such as broken glass in comparison with frequently used ceramic materials.

Conformity
–

Biocompatibility
–

Permitted service temperature in air



1. PVDF 1000
2. PSU
3. PEI
4. PPSU
5. PPS GF SL
6. PEEK
7. PAI SL
8. VESPEL® SP1
9. **PBI**

long-term
short-term (four hours)

APSOplast® PTFE

Material denomination: PTFE
Chemical denomination: Polytetrafluoroethylene

General description

PTFE (polytetrafluoroethylene) is a polymer with a linear macromolecular structure, made by means of the polymerization of tetrafluoroethylene. PTFE passes into a gel-like state above the melting point of +327 °C. Its high viscosity and shearing sensitivity prevent thermoplastic processing using traditional techniques such as injection moulding and screw extrusion. PTFE is compression moulded at room temperature and then sintered. Due to its unique combination of excellent properties, PTFE can be considered to be a special-grade technical plastic.

Characteristics and properties

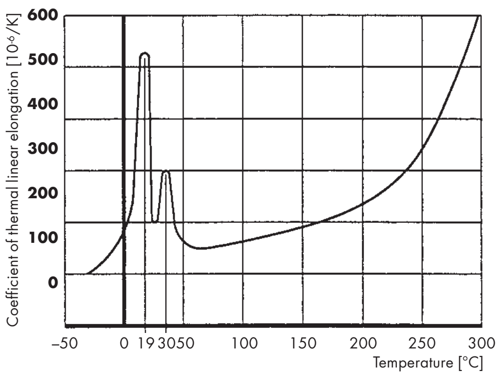
– High maximum service temperature limit in air and excellent resistance to low temperatures (long-term exposure from –260 to +260 °C)
– Exceptional resistance to chemicals and hydrolysis
– Good electrical insulation properties
– Exceptional dielectric properties
– Excellent UV- and weather resistance
– Inherent flame-retardant properties
– Extremely low coefficient of friction (the lowest of all solid materials)
– Anti-adhesive surface properties
– Virgin PTFE and modified types are suitable for contact with foodstuffs

Please note:
– Virgin (unfilled) PTFE can only be exposed to low mechanical loads due to its low modulus of elasticity and hardness (cold flow).
– Virgin (unfilled) PTFE is not wear-resistant, unlike the filled types.

The fact that PTFE is made from finely ground powder in a compression and sintering process gives rise to ideal prerequisites for the manufacture of compounds. For this reason, PTFE compounds are usually filled with anorganic fillers such as powdered metal to achieve really specific properties. The standard blends of PTFE compounds thus have considerable advantages with regard to their mechanothermal behaviour:
– Increased wear resistance
– Lower deformation under load
– Lower linear thermal elongation
– Increased thermal conductivity

PTFE materials can be exposed to long-term service temperatures of up to +260 °C and to short-term peak temperatures of +280 °C if only subject to a really low mechanical load. Within this temperature range, no structural breakup (depolymerization) which could change the material's properties takes place. Flexibility and elongation at break remain practically unchanged even at low temperatures of up to –200 °C. The coefficient of linear thermal expansion of PTFE reaches a peak at the glass transition temperature of +19 °C (see the diagram below) and reaches values which are otherwise only reached at high temperatures. This change in volume is between 0.5 and 1% for filled types.

Influence of temperature on linear thermal expansion for virgin PTFE



APSOplast® PTFE
Colour: White

The diverse properties of virgin, unfilled PTFE are particularly in demand for anti-adhesive coatings, sliding functions with extremely low friction values, dielectric materials for high-voltage and HF applications, and for applications where the material comes into direct contact with aggressive chemicals and foodstuffs.

APSOplast® PTFE 125
APSOplast® PTFE GF25 FDA
PTFE + 25% glass fibre
Colour: Beige

The glass fibres result in increased compressive strength, which is particularly useful at high temperatures. Chemical resistance is only negligibly restricted. The dielectric and anti-adhesion properties are reduced somewhat in comparison with virgin PTFE. This type is unsuitable for non-lubricated sliding functions with a soft steel mating partner due to the abrasive glass fibres. This material is more suited to static applications. Type PTFE GF25 FDA is suitable for contact with foodstuffs.

APSOplast® PTFE 225
PTFE + 25% carbon powder
Colour: Black

The carbon filler confers PTFE extremely good sliding behaviour in both lubricated and non-lubricated applications as well as increased compressive strength and wear resistance. It is also thermally and electrically conductive. Chemical resistance is only negligibly restricted. However, the small amount of black carbon abrasion should be noted.
This material is the standard type for parts with sliding functions.

APSOplast® PTFE 660
PTFE + 60% bronze
Colour: Bronze

The high filler content results in significantly improved compressive strength and dimensional stability. This grade is not recommended for completely non-lubricated applications but is suitable for use with partially lubricating fluids such as hydraulic oil. The chemical resistance of the material is heavily restricted by the filler.

APSOplast® PTFE 904
PTFE + glass fibre + metal oxide
Colour: Light blue

This material behaves in a similar way to PTFE 125, but is frequently used for low-wear plain bearings for hardened shafts in order to achieve low pv-values. The blue colouring does not bleed.

APSOplast PTFE 207

PTFE + mica
Colour: White

The composition of the raw materials used to manufacture PTFE 207 corresponds to the stipulations of the European Union and the regulations of the US FDA with regard to suitability for contact with foodstuffs. Along with PTFE's excellent inherent chemical resistance and resistance to hydrolysis as well as its good mechanical strength, these properties mean that the material can be used for numerous applications in the foodstuff, pharmaceutical, and technical medical industries.

APSOplast® PTFE 500

PTFE + mica
Colour: Ivory

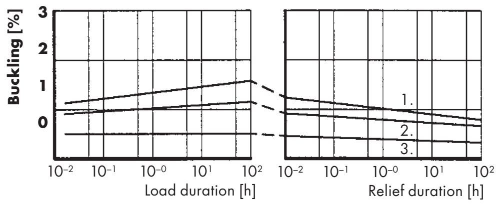
This grade is subject to nine times less deformation under load than unfilled PTFE (tested as per ASTM D 621; compressive stress of 14 MPa at 50 °C). Its coefficient of linear thermal expansion approaches the elongation rate of aluminium and is five times that of unfilled PTFE. PTFE 500 is considerably harder than unfilled PTFE but – at practically the same coefficient of friction – has improved wear resistance and does not attack most mating partners.

APSOplast® PTFE EC

Electrostatically dissipative PTFE
Colour: Black

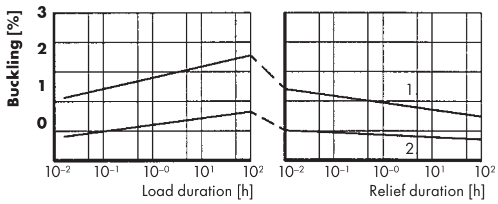
Reinforced with special synthetic mica, PTFE EC offers an excellent combination of a low coefficient of friction, good dimensional stability, and static dissipation capability. In cases where virgin PTFE results in problems as a result of electrical discharge, PTFE EC ensures the controlled dissipation of static charges while retaining typical PTFE properties such as excellent chemical resistance, temperature resistance, and a low coefficient of friction.

Creep rupture-compression test for virgin PTFE in relation to load duration and subsequent stress relief



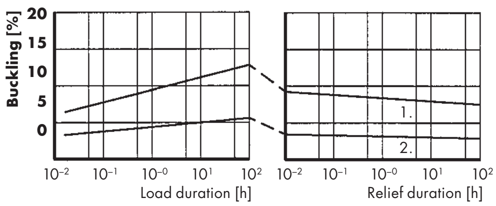
Test conditions:
Temperature: +20 °C

1. 5 N/mm²
2. 3 N/mm²
3. 1 N/mm²



Test conditions:
Temperature: +100 °C

1. 5 N/mm²
2. 3 N/mm²



Test conditions:
Temperature: +150 °C

1. 5 N/mm²
2. 3 N/mm²

Range of applications and application examples

Mechanical engineering
Thanks to its anti-friction and sliding properties, PTFE – usually filled – is primarily used for bushings, plain bearings, slideway strips, piston rings for non-lubricated compressors, poppet valves, and sealing elements.

High-voltage technology and electronics
In this field, virgin PTFE is used for the following main applications: locomotive roof insulators, brush holders for traction engines, etc.

Chemical apparatus construction and foodstuff sector
In these sectors, virgin PTFE is mainly used for pump and valve housings, cladding, membranes, dip tubes, plain bearings, sealing elements, bellows, guides, slideways, slides, anti-adhesive covers, etc.

Building and civil engineering
PTFE is used for support plates for elongation bearings for bridges, steel structures, buildings, facades, pipelines, etc.

Offshore applications
PTFE 904 is used as a slideway cover when building or launching constructions from offshore oil rigs.

Labyrinth seals
Seals with let-flow coatings in turbomachines, manufactured from PTFE 500 rods, are extremely reliable in harsh chemical environments while remaining really cost-effective to use.

Bearing bushings for dishwasher spraying arms
These PTFE 207 bearing bushings offer a service life of up to 20 years and are FDA-compliant.

Sealing rings for power transmission/steering systems
The most successful European automotive manufacturers have chosen to use PTFE 500 instead of other filled PTFE rings due to their improved performance values and service life.

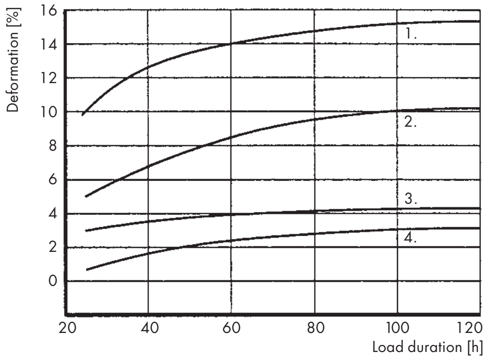
Valve seats
Valves seats made from PTFE 207 are characterized by their impermeability, excellent dimensional stability, and low wear rate in steam and hot air applications.

Conformity
PTFE, special grade PTFE GF25 FDA, and PTFE 207 are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
–

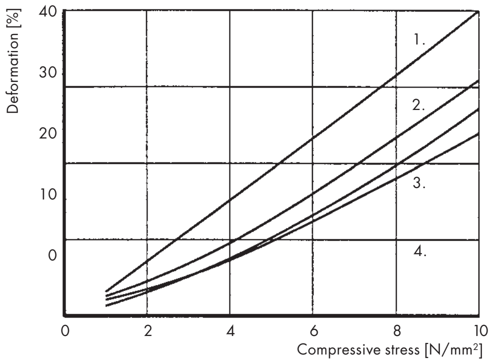
Creep strain of various PTFE compounds



Test conditions:
– Room temperature
– Constant load: 13.7 N/mm^2

1. Pure PTFE
2. PTFE 125
3. PTFE 225
4. PTFE 660

Deformation of various PTFE compounds



Test conditions:
– Temperature: +150 °C
– Load duration: 100 h
– Constant load of 13.7 N/mm^2

1. PTFE 125
2. PTFE 904
3. PTFE 660
3. PTFE 225

APSOplast® PTFE HP

Material denomination: PTFE HP
Chemical denomination: Polytetrafluoroethylene compound

General description

The brand name PTFE HP denotes a range of high-performance fluoroplastic compounds based on the PTFE matrix. The structural setup of PTFE HP is identical to that of the PTFE standard range. However, the targeted formulation of this PTFE material with organic or anorganic fillers and additives along with the homogeneous compounding of the materials and special processing to create high-quality plastic compounds means that this type is ideal for tribological functions. The main benefits of PTFE HP lie in these tribological functions which contribute to the special compounds being chosen for nonlubricated sliding elements. For the values of the coefficient and wear rates, see the technical tables. They allow you to carry out a cross-comparison of the PTFE compounds and only provide indicative values for specific applications.

Characteristics and properties

– Ideal for sliding and sealing elements in non-lubricated applications
– Extremely low coefficient of friction
– High maximum service temperature limit in air and excellent resistance to low temperatures (long-term exposure from –260 to +260 °C)
– High wear resistance (depending on the grade)
– Excellent resistance to chemicals and hydrolysis (depending on the grade)
– Suitable for contact with foodstuffs (depending on the grade)
– High thermal conductivity, anti-static (depending on the grade)

Please note:
– Grades with abrasive anorganic fillers require hardened steel mating surfaces

APSOplast® PTFE HP 102

PTFE + glass fibre + polymer + additives
Colour: Dark yellow

Low coefficient of friction, high wear resistance, relatively low wear on mating partners in comparison with PTFE + glass fibre, good chemical resistance.
Caution: The wear of this material increases in damp/wet environments.

APSOplast® PTFE HP 107

PTFE + carbon fibre
Colour: Black

This PTFE, reinforced with carbon fibres, has a particularly low coefficient of friction and high wear resistance, particularly in wet running conditions. This grade is also suitable for non-hardened friction partners, has good mechanical property values, excellent flexibility, and good chemical resistance, and is heat-dissipating.

APSOplast® PTFE HP 108

PTFE + glass fibre + metal oxide
Colour: Dark red

Low coefficient of friction and very high wear resistance, increased compressive strength, suitable for universal use in non-lubricated bearings with tempered mating partners, good electrical insulation properties
Caution: Higher wear in damp environments than PTFE HP 102.

APSOplast® PTFE HP 110

PTFE + carbon powder + graphite
Colour: Black

Low coefficient of friction and high wear resistance along with high compressive strength, heat-dissipating, anti-static, suitable for sliding functions in damp, wet, or chemically aggressive environments, also suitable for use with non-hardened mating partner surfaces. In addition, PTFE HP 110 has the most universal chemical resistance of all PTFE-HP grades.

APSOplast® PTFE HP 114

PTFE + bronze + MoS_2
Colour: Dark brown

Low coefficient of friction and high wear resistance, can be exposed to high compressive stress, high dimensional stability and long-term heat stability, heat-dissipating. For highly stressed sliding elements and seals with minimum lubrication, e.g. guide rings, piston rings, valve slides, etc. in hydraulic systems.
Caution: Only partially suitable for non-lubricated applications, not recommended for watery environments, restricted resistance to chemicals.

APSOplast® PTFE HP 115

PTFE + polymer
Colour: Pale yellow

Extremely low coefficient of friction and high wear resistance, high compressive strength, high flexibility and tensile strength, excellent dielectric properties.

APSOplast® PTFE HP 117

PTFE + long carbon fibres
Colour: Black

This type is superior to all other HP types with regard to compressive strength, cold flow behaviour, rigidity, and modulus of bending elasticity. Very high wear resistance and low coefficient of friction, anti-static.

APSOplast® PTFE HP 118

PTFE + polymer + carbon powder + graphite + MoS_2
Colour: Dark grey

Very low coefficient of friction, high wear resistance and rigidity, extremely low wear even on soft mating partners, anti-static, heat-dissipating, also suitable for damp and wet environments.

APSOplast® PTFE HP 123

PTFE + graphite
Colour: Black

Lowest coefficient of friction of all HP types but only moderately wear-resistant in non-lubricated applications, very low wear on soft mating partner surfaces, good wear resistance in lubricated applications, anti-static, and heat-dissipating.

APSOplast® PTFE HP 125
APSOplast® PTFE HP 128

PTFE + polymer
Colour: Cream

Very low coefficient of friction and good wear resistance, very low wear on soft mating partner surfaces, good mechanical strength, chemically inert, good dielectric properties.
PTFE HP 128 has a higher content of polymer filler than HP 125, which results in it improved compressive strength.

Range of applications and application examples

Mechanical engineering

PTFE HP 102 is suitable for non-lubricated applications for bearing bushings, sliding elements, mechanical seals, O_2 compressors, sliding coatings for rapier weaving machines, etc.

PTFE HP 107 is suitable for sliding elements in damp, wet, or aggressive chemical environments and for guide rings for pneumatic brake cylinders on railway cars, plain pump bearings, and sealing elements etc.

PTFE HP 108 is the standard type for non-lubricated plain bearings for hardened friction partner surfaces in mechanical engineering and for slide guides on machine tools.

PTFE HP 110 is ideal for non-lubricated sliding elements of all kinds, such as guide rings for oil-free piston compressors and shock absorbers.

PTFE HP 114 is suitable for heavy-duty sliding elements and seals with minimal lubrication such as guide and piston rings and valve slides in hydraulic systems.

PTFE HP 115 is ideal for non-lubricated sliding elements with soft mating partners such as stainless steel.

PTFE HP 117 is a good choice for heavy-duty plain bearings, guides, and sealing elements such as piston rings for non-lubricated compressors with spring preload characteristics.

PTFE HP 118 is beneficial for sliding elements and seals in non-lubricated and lubricated applications, e.g. piston rings, cup seals, and lip seals which come into contact with soft mating partner surfaces.

PTFE HP 123 is suitable for sliding and sealing elements in non-lubricated and lubricated applications which require low friction and the protection of the mating partner.

PTFE HP 125 and HP 128 are ideal for applications where contact with foodstuffs is required and are thus suitable for sliding applications in this area.

Conformity

PTFE HP 125 and HP 128 are suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility

–

APSOplast® PVDF

Material denomination: PVDF
Chemical denomination: Polyvinylidene fluoride

General description

PVDF is a non-reinforced, highly crystalline fluorinated polymer which unites good mechanical, thermal, and electrical properties with excellent chemical resistance. The properties of PVDF make it into a diverse construction material which is especially popular in the petrochemical, chemical, metallurgical, pharmaceutical, foodstuffs, paper, textile, and nuclear industries.
Its excellent welding properties and thermoplastic formability are particularly important. PVDF can be extruded and injection-moulded on machines with corrosion protection.

Characteristics and properties

– High maximum service temperature in air (long-term exposure to temperatures up to +150 °C)
– Good mechanical strength, rigidity, and creep resistance (better than other fluorinated polymers)
– Exceptional resistance to chemicals and hydrolysis
– High toughness, even at low temperatures
– High wear resistance
– High dimensional stability
– Suitable for contact with foodstuffs
– Good electrical insulation properties
– Good dielectric properties
– Excellent UV- and weather resistance
– Inherently flame-retardant (UL94 V-0)
– Reasonably good resistance to high-energy radiation (much better than other fluorinated polymers)

Please note:
– The sliding behaviour and electrical insulation behaviour of this material are somewhat poorer than those of virgin PTFE
– Restricted bonding properties

APSOplast® PVDF
Colour: Natural (white)

PVDF is used in high-tech applications where absolute safety is a must. PVDF has impressively high chemical and thermal resistance and an anti-adhesive surface. In the chemical industry, PVDF is known for its high corrosion protection qualities; in the semi-conductor sector and pharmaceuticals, it is used for the completely contamination-free transportation of ultra-pure media.

APSOplast® PVDF ED
Colour: Natural

Electrically conductive grade

Range of applications and application examples

Chemical apparatus construction, valve manufacture, electrotechnology
PVDF is used in the following applications:
Cladding for reactors, tanks, chemical tanks, pump/valve parts, filter parts, fittings, flanges, slides, guides, insulation parts, gear wheels, housings, solderable insulators, cellulose and paper industry, semi-conductor process stations, etc.

Conformity
PVDF is suitable for contact with foodstuffs.

Further information:
– Chapter 10: Plastics for the food industry

Biocompatibility
–

APSOplast® PCTFE

Material denomination: PCTFE
Chemical denomination: Polychlorotrifluoroethylene

General description

PCTFE (polychlorotrifluoroethylene) is a semi-crystalline polymer. As a rigid material, it appears to have a slightly yellowish/whitish translucency or is transparent depending on the fabrication process used. In comparison with PTFE, PCTFE is significantly harder and more dimensionally stable. It is the hardest of the fluoroplastics. Even at very low temperatures of around –255 °C, it retains its excellent dimensional stability. It also has the lowest gas permeability rate. PCTFE can be processed using injection moulding, extrusion presses, and thermoplastic extrusion.

Characteristics and properties

– Very wide temperature range - including very low temperatures - of –255 to +150 °C (brief exposure to +200 °C)
– Very good mechanical strength; in particular, low creeping under compressive stress
– Non-flammable, even at high oxygen concentrations (100% oxygen index limit)
– High chemical resistance to mineral acid and a number of organic acids
– Excellent resistance to ageing
– Practically no moisture absorption and therefore very dimensionally stable
– Impermeable to water and steam

Please note:
– Restricted suitability for sliding functions
– Restricted bonding properties

APSOplast® PCTFE
Colour: Natural (white)

Thanks to its extraordinary combination of properties, PCTFE has managed to find entry to numerous industrial sectors such as cryogenics and other applications with very low temperatures, nuclear technology, chemistry, medicine, the military, electrotechnology, electronics, aeronautics, and astronautics.

Range of applications and application examples

Cryogenics (low temperatures)
PCTFE is ideal for use in the presence of liquid gas, particularly air and liquid oxygen. Applications: connecting pieces, pump bodies, fittings, seats, valve flaps, insulation units, shaft seals, piston seals etc. Broadly speaking, PCTFE can be used on all plants which work at extremely low temperatures. Above all, PCTFE is suitable as a material for connection pieces in grid gas lines in extremely cold atmospheres such as Siberia and Alaska.

Medicine, pharmaceutical, and laboratory sector
Due to its resistance to UV rays and X-rays and lack of sensitivity and impermeability to oxygen, PCTFE can be use to protect medicinal and pharmaceutical products from oxygen or for packaging which needs to be sterilized. Applications: various parts of diagnostic devices, blood analysis equipment, attachments for syringes, etc.

Electrotechnology
Due to good electrical properties, resistance to ageing, and exceptionally low moisture absorption of almost zero, PCTFE is an ideal material for microcomponents in the electrotechnology and electronics industries. Components made with this material are extremely reliable when used in maritime, tropical, or corrosive environments. In addition, thanks to its high resistance to heat, it is suitable for sustained use in soldering iron applications without deformation of the connecting parts. The most important uses of this material in this sector are conductor rails, spindles, coaxial connectors, aerial towers, connection pieces for optical fibres, etc.

Conformity
–

Biocompatibility
–

APSOplast® ECTFE

Material denomination: ECTFE
Chemical denomination: Ethylene chlorotrifluoroethylene

General description

ECTFE is a semi-crystalline copolymer made from ethylene and chlorotrifluoroethylene. In addition to good mechanical, electrical, and thermal properties, this fluoroplastic has excellent chemical resistance. ECTFE can be injection-moulded or processed using thermoplastic extrusion.

Characteristics and properties

– High elongation at break
– Very high impact resistance
– Good resistance to stress cracking, even in contact with lyes, chlorine, and alkaline media
– Low permeation of liquids, gases, and vapours
– Very good resistance to weather and radiation
– Low coefficient of linear thermal expansion in comparison with other fluoroplastics

APSOplast® ECTFE
Colour: Natural

Range of applications and application examples

Primarily, this versatile material is used for components which are exposed to high thermal and chemical stresses in the chemical, pharmaceutical, semi-conductor, and solar industries. ECTFE is also used to build corrosion-resistant covers and cladding laminate for pipe/line construction in the chemical industry.

Conformity

–

Biocompatibility

–

APSOplast® FEP

Material denomination: FEP
Chemical denomination: Fluoroethylene propylene

General description

FEP is produced through the copolymerization of tetrafluoroethylene and hexafluoropropylene. Like PTFE, its carbon structure is completely surrounded by fluorine atoms. FEP is a thermoplastic which can be processed using traditional thermoplastic processing techniques such as screw extrusion, injection moulding, and blow extrusion. FEP can be thermoformed and is easy to weld.

Characteristics and properties

– Extremely broad service temperature range (long-term temperatures of –190 to +205 °C)
– FEP is very tough and flexible even at low temperatures thanks to its high impact resistance
– FEP has a low permeability with regard to gases and chemicals and is subject to practically no moisture absorption (less than 0.01%)
– Excellent resistance to most chemicals and solvents except for liquid sodium, fluorine, chemicals at elevated temperatures, and certain halogen compounds
– Good weather resistance
– Good anti-adhesive properties
– Excellent dielectric properties
– The dielectric constant and loss factor of FEP are extremely low and relatively constant over a broad temperature and frequency range
– High insulation resistance
– High dielectric strength
– Flame-retardant

Please note:
– Not suitable for sliding functions
– Semi-finished products are not available as standard (exception: Film and hose range)

APSOplast® FEP

Colour: Transparent

FEP films unite excellent mechanical, thermal, dielectric, chemical, and optical properties. The films can be thermoformed, e.g. by means of vacuum forming, and heat-sealed. In addition, films already pre-etched on one or both sides are available. These are ideal for bondings and lamination bondings.

Range of applications and application examples

Chemical apparatus construction and mechanical engineering

Separating film for mould construction, film sleeves for special chemical sealing applications, sealed bags for air samples or chemicals, transparent protective curtains for chemicals, chemical sight glass covers, moulded diaphragms, hot melt adhesive films for composite metal laminations, intermediate film layers when welding PTFE/PTFE-glass-fabric films.

Foodstuffs and packaging

This material is relatively soft and is therefore particularly suitable for vacuum-forming or blow extrusion for the manufacture of bottles, cups, bags, etc.

Electrical industry

Other traditional uses of FEP are cable sheathing - particularly in the case of flat cables, flexible printed circuit boards, protective film for solar applications, slot insulation for electric motors, and shrink hoses.

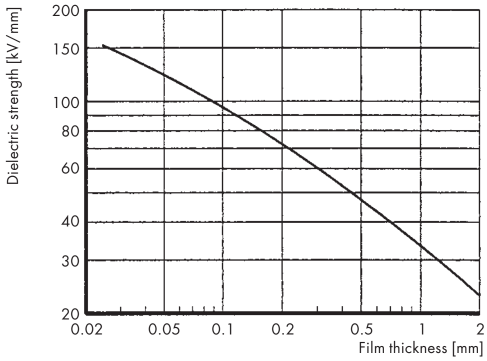
Conformity

–

Biocompatibility

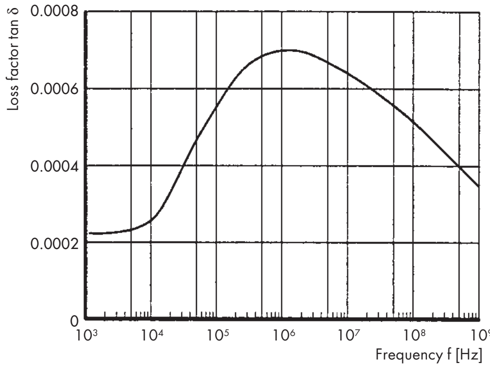
–

Dielectric strength in relation to film thickness



Test conditions:
- ASTM D 149-59T (short-time test)
- Temperature: +25 °C
- Medium: Oil

Dielectric loss factor in relation to frequency



Test conditions:
- Temperature: +23 °C
- ASTM D150-54T

7

APSOplast® PFA

Material denomination: PFA
Chemical denomination: Fluoroethylene propylene

General description

PFA is a semi-crystalline copolymer manufactured through the copolymerization of tetrafluorethylen and perfluorovinyl ether.
Its melt viscosity is several powers of ten lower than that of PTFE. Unlike the sintered PTFE, PFA can be processed using traditional thermoplastic processing methods such as screw extrusion, transfer moulding, and injection moulding. PFA is also thermo-formable and weldable.
The chemical and thermal resistance, anti-adhesion behaviour, and dielectric properties of PFA are largely the same as those of PTFE. In comparison with PTFE, PFA is harder and has better dimensional stability.
In addition, the cold flow tendency of PFA is lower.

Characteristics and properties

– Excellent service temperature range (long-term exposure to temperatures from –200 to +260 °C)
– Excellent and universal resistance to chemicals, almost the same as that of PTFE
– Exceptional mechanical properties, harder and more dimensionally stable than PTFE, with a significantly better bending fatigue strength
– Extremely high UV- and weather resistance
– High air permeability
– Very good dielectric properties
– Anti-adhesive surface properties
– Flame-retardant

Please note:
– Not suitable for sliding functions
– Semi-finished products are not available as standard (exception: Film and hose range)

APSOplast® PFA

Colour: Transparent

PFA films also have a combination of extraordinarily good properties. The characteristics of special note include high tear strength, very good dielectric behaviour, excellent resistance to chemicals, and a service temperature of up to +260 °C. PFA films can also be thermoformed, e.g. by means of vacuum forming, or heat-sealed for welding operations.

Range of applications and application examples

Chemical apparatus construction and plant engineering
Corrosion- and temperature-resistant cladding for fittings, pumps and apparatus, cladding boards, corrosion- and temperature-resistant hoses for heat exchangers, gas desulphurization systems for power plants

Mechanical engineering and vehicle construction
Injection-moulded parts, wire and cable sheathing, hoses, corrugated pipes

Laboratory equipment
Extrusion- and injection-moulded laboratory equipment, volumetric and round-bottomed flasks for trace analysis, bottles for storing ultra-pure chemicals

Semi-conductor industry
Containers, bottles, pipes for transporting and storing ultra-pure chemicals

Electrotechnology and electronics
Wire and cable sheathing, injection-moulded parts, shrink hoses

Welding films
Hot melt adhesive for welding PTFE and PTFE-compound parts, PTFE-coated glass fabrics, metals

Electroplating
Heat exchangers and cladding of electrical heaters

Paper and textile industries
Roller coatings/shrink hoses

Conformity
–

Biocompatibility
–

APSOplast® PF CP, PF CC

Material denomination: PF CP, PF CC
Chemical denomination: Phenolic resin: laminated paper fabrics, special laminated paper fabrics, laminated cotton fabrics

General description

These laminate materials are among the oldest plastics to be used industrially. Sheets, tubes, and profiles are based on layers of cellulose papers with high tear strength, impregnated with duroplastic resins, compressed, and hardened. Primarily, phenol formaldehyde (PF) is used as the binding resin. For both decorative and electrotechnical reasons, special laminated sheets are coated on one or both sides with melamine formaldehyde resin (MF).
The tried-and-tested laminated fabrics can be seen as the predecessors of today's fibre-composite materials. Layers of cotton are soaked in appropriate impregnation resin – primarily based on phenol formaldehyde – and are then processed in presses with duroplastic hardening to create high-quality, homogeneous laminate materials for a wide variety of construction tasks.

Characteristics and properties

– Low specific weight
– High flexural strenght and hardness
– High mechanical strength (depending on layer direction)
– Good heat distortion stability
– Low creep tendency
– Good electrical insulation properties
– Flame-retardant
– Inexpensive

In the case of special laminated paper:
– High track resistance
– Low moisture absorption

In the case of laminated cotton:
– Good emergency run properties for sliding functions
– Good wear resistance
– Good impact resistance

Please note:
Laminated papers:
– Laminated papers are subject to high moisture absorption and are brittle in the case of thin wall thicknesses (delamination on the edges)
– Not suitable for sliding functions
– Laminated papers and fabrics are not suitable for direct contact with foodstuffs!

APSOplast® PF CP 201

Laminated paper, Hp 2061 (phenolic resin/cellulose paper)
Colour: Brown

This material grade has good mechanical strength and electrical properties as are required in the low-voltage range. Since it has good punching behaviour, when pre-heated, up to 2.5 mm thickness, it is suitable for manufacturing punched parts for vehicle electrics and for machined mounting plates in switch panel construction.
As grade PF CP 202 (Hp 2061.5), phenolic resin laminated paper has high dielectric strength and is thus a successful material for use in the high-voltage range.
Grade PF CP 203 (Hp 2061.6) has impressively good dielectric properties and a lower moisture absorption.

APSOplast® PF CP MF

Special laminated paper, MKHP
(phenolic resin/cellulose paper + melamine resin composite laminate material)
Colour: Light grey (RAL 7035)

This special laminated paper is coated with a 0.3 mm layer of melamine resin on both sides. It has extremely high track resistance and dielectric strength, is scratch-resistant and generally resistance to chemicals. This material can easily be labbelled, printed, laminated and is flame-retardant.

APSOplast® PF CC 201

Laminated fabric, Hgw 2082
(laminated fabric sheets made from phenolic resin and fine cotton fabric)
Colour: Brown

Thanks to the use of fine cotton fabric, this laminated fabric has very good mechanical properties. This construction grade is particularly suitable for parts with high demands in mechanical engineering. If value is placed upon particularly good dielectric properties – ensuring that parts are suitable for purposes where good insulation is required – type PF CC 202 (Hgw 2082.5) is recommended. This material is manufactured using special resins and electrolyte-free fabric.

APSOplast® PF CC 42

Laminated fabric, Hgw 2088
(solid rods wound from phenolic resin/fine cotton fabric)
Colour: Brown

This material is suitable for use as an electrically insulating material and for applications with a high mechanical load (e.g. guides and rollers). It is not suitable for gear wheels!

Range of applications and application examples

Electrotechnology, mechanical engineering, and apparatus construction

Suitability of laminated paper:
– Ideal for electrically/thermally insulating materials in applications with a relatively high mechanical load
– Drilling templates
– Mounting plates
– Punched parts
– Construction elements in mechanical engineering and the textile and automotive-industries

Because of its melamine coating, special laminated paper is particularly suitable for:
– Creep-resistant bulkhead partitions, inter-phase insulation
– Electrical and thermal insulation
– Front panels, instruments, and device panels
– Table coverings, room partitions, drawer parts

As a versatile construction material, the strengths of laminated fabric lie in the construction of electrical installations, mechanical engineering, apparatus construction, and the construction of transformers and switches. Its applications include:
– Vanes for compressed-air engines, compressors, and vacuum pumps
– Rollers, gear wheels, bearings, bearing shells, segmented bearings
Comment:
Sheets should be used for the manufacture of gear wheels!

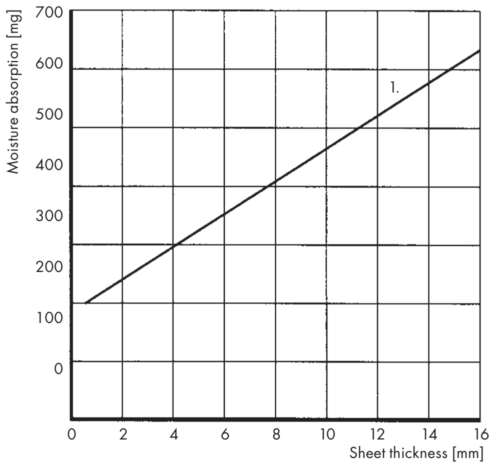
Conformity

–

Biocompatibility

–

Moisture absorption of laminated fabric in relation to sheet thickness



Test conditions:
– EN ISO 62

1. Grade Hgw 2082

8

APSOplast® EP GC, EP GM

Material denomination: EP GC, EP GM
Chemical denomination: Epoxy laminated glass fabric/mat

General description

EP GC is a laminate material based on epoxy resin and glass filament fabric. In addition to exceptional mechanical and electrical properties, flame resistance, and temperature resistance, this material has an impressively low moisture absorption and complete resistance even to extreme climates.
Laminated glass fabric thus fully complies with NEMA standards as well as with the values defined in DIN 7735.
EP GM is a laminate material based on glass fibre mat with an epoxy resin matrix that offers good mechanical properties at elevated temperatures.

Characteristics and properties

– Extremely high flexural strength and hardness
– Extremely high mechanical strength and load-bearing capacity (regardless of the layer direction)
– High impact resistance
– No creeping under load
– Very good heat distortion stability (Class F/H)
– Good resistance to chemicals
– Very low moisture absorption
– Very good dielectric properties

Please note:
– Hard to process (with diamond tools)
– Not suitable for contact with foodstuffs
– Not suitable for sliding functions
– Depending on the resin mix during production, the colour can vary from light to dark grey, yellowish, or brownish.

APSOplast® EP GC 201
Hgw 2372
(epoxy resin/laminated glass fabric)

Grade Hgw 2372 has excellent electrical and mechanical properties. It has a temperature limit of +130 °C, which means that it meets the requirements of Heat Class B.

APSOplast® EP GC 202
Hgw 2372.1
(epoxy resin/laminated glass fabric)

With regard to all electrical and mechanical properties, this grade corresponds to Hgw 2372. The special characteristic of this grade is its flame resistance. It meets the requirements of Flammability Class UL94 V-0 from 0.8 mm.

APSOplast® EP GC 203
Hgw 2372.4
(epoxy resin/laminated glass fabric)

This grade is ideal in applications where high temperature resistance and mechanical strength are required. The temperature limit as per DIN 7735 is +155 °C, which means that this grade meets the requirements of Heat Insulation Class F. Even at +150°C, the drop in flexural strength is less than 50 %. The reason for the high level of heat resistance is the special combination of resins that makes this type of glass fabric somewhat harder than Hgw 2372 and Hgw 2372.1 while still good to machine. We offer the same grade in Heat Insulation Class H, too. This top grade reaches a temperature limit of +180 °C and meets the requirements of Heat Insulation Class H. It achieves a glass transition temperature (Tg) of +200 °C.

APSOplast® EP GM 203
(epoxy resin/glass filament mat)

Thanks to the use of the temperature-resistant, mechanically strong epoxy resin system, this EP glass filament mat can often replace an epoxy laminated glass fabric, as well as offering a commercial advantage. Grade EP GM 203 has good resistance to seawater and chemicals, exceptional electrical properties such as high track resistance, and very good heat stability with a temperature limit of +180 °C. This meets the requirements of Heat Insulation Class H. Its mechanical strength remains unchanged over a broad temperature range. At elevated temperatures, it even has a lower loss in mechanical properties than epoxy laminated glass fabric Hgw 2372.4 and is thus often preferred.

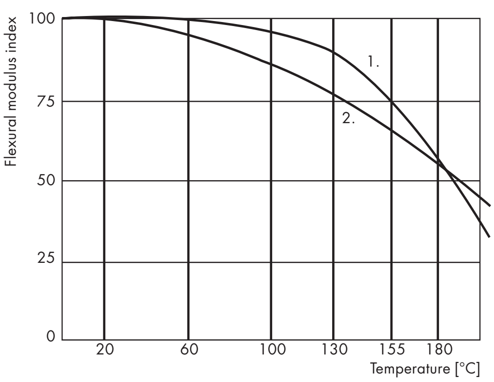
Range of applications and application examples

Electrical industry and mechanical engineering
EP GC glass filament fabric is the ideal material for electrical insulation in electrical machine construction, the construction of transformers and switches, and the production of high-temperature-resistant machine parts for aeronautics, astronautics, and chemical apparatus construction. EP GM glass filament mat is suitable for drive chains of line switches, chocks for three-phase machines, tension rods with threads/nuts, coil support elements, partitions, spacer sleeves, and so on.

Conformity
–

Biocompatibility
–

Index 100 at 20 °C



1. EP GC
2. EP GM

APSOplast® UP GM

Material denomination: UP GM
Chemical denomination: Polyester resin laminated glass mat

General description

In cases where laminated paper is not strong enough but the top values of laminated glass fabric are not required, polyester resin laminated glass mat makes for an inexpensive alternative.
This grade impresses users with its high mechanical strength and top electrical insulation. As well as complying with the most important standards, polyester resin laminated mats are suitable for further requirements. Due to the good electrical properties of this grade, it is used successfully in the electrical industry. Winding supports for dry transformers, partitions, switch levers in high-voltage switches, and insulators for choke coils – just some of the numerous possible uses.

Characteristics and properties

– High dimensional stability
– Very good dielectric properties
– High temperature resistance, temperature limit of +155 °C as per VDE (Heat Insulation Class F)
– Self-extinguishing, meets the requirements of UL94 V-0 from 2.4 mm (type GPO-3)
– High track and arc resistance (type GPO-3)

Please note:
– Hard to process (with diamond tools)
– Not suitable for contact with foodstuffs
– Not suitable for sliding functions

APSOplast® UP GM 203-1

UP GM Hm 2471
(polyester resin glass filament mat)
Colour: White

The special strengths of this top grade lie in its exceptional resistance to high voltage and tracking resistance and in its excellent thermal properties. The temperature limit as per VDE is +155 °C. This corresponds to Heat Insulation Class F. It also meets the requirements of Flammability Class UL94 V-0 from 2.4 mm.
Since not all grades of type HM 2471 are UL-listed, users are asked to state the required property when placing your order. This grade corresponds to NEMA GPO-3.

APSOplast® UP GM 203-2

UP GM Hm 2472
(polyester resin glass filament mat)
Colour: White

In comparison with type GM 203-1, this grade has a higher glass content. Therefore it is able to withstand mechanical loads higher than that of GM 203-1, particularly if also exposed to heat. This grade also has the excellent properties of high track resistance, very good dielectric values, and high temperature resistance.
Its temperature limit as per VDE is +155 °C. This means that this type meets the requirements of Heat Insulation Class F. It also complies with the criteria for Flammability Class UL94 V-1.

Range of applications and application examples

Electrical industry

Due to their good electrical properties, these grades are used successfully in the electrical industry. Applications such as winding supports for dry transformers, partitions, switch levers in high-voltage switches, and insulators for choke coils are just some of the numerous possible uses.

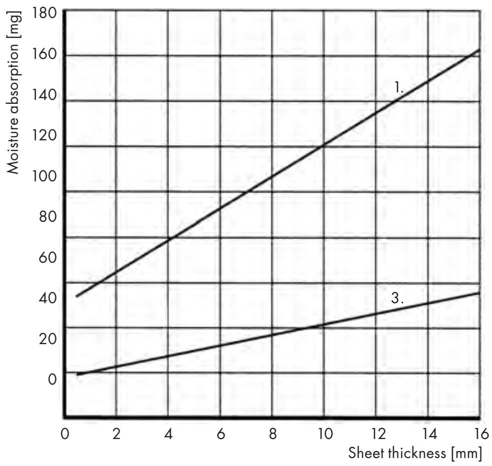
Conformity

–

Biocompatibility

–

Moisture absorption of laminated glass fabric in relation to sheet thickness



Test conditions:
– EN ISO 62

1. Type:
– Hm 2471
– Hm 2472

3. Type:
– Hgw 2372
– Hgw 2372.1
– Hgw 2372.4

APSOplast® UP GFK

Material denomination: UP GFK
Chemical denomination: Polyester resin profiles, pultrusion profiles

General description

Glass-reinforced plastic (GRP) is a composite fibre-reinforced polymer made from a synthetic material such as polyester resin, epoxy resin, or polyamide and glass fibres. GRP is also known as fibre glass.
Often, plastics reinforced with short and long fibres are used to create injection-moulded and die cast parts. Since GRP is easy to shape and leaves room for the design ideas. Plastics reinforced with short fibres usually have a certain degree of isotropic behaviour, since the short fibres are randomly distributed.
Endless fibre-reinforced plastics have defined material properties depending on the structure of the fibres. Increasingly, they are used in lightweight construction. The construction profiles have a good flexural strength and combine the advantages of corrosion-resistant, thermally and electrically insulating plastics with modern fibre composites and their mechanical strength in the same range as that of metals. They are produced by means of a continous casting method similar to aluminium. Depending on the profile, the structure consists of glass fibre mats for transverse reinforcement. Longitudinal forces are absorbed by means of rovings (unidirectional glass fibre) in the core of the profiles. As standard, isophtalic acid polyesters are used as the matrix.

Characteristics and properties

– Extremely high mechanical strength with low specific weight
– Longitudinal tensile strength in the range of metallic materials
– High impact resistance, even at low temperatures
– Exceptionally high dimensional stability
– Good shape recovery without lasting deformation
– Good dielectric properties
– Good thermal insulation properties
– Very low coefficient of thermal expansion
– High dimensional stability
– Good resistance to corrosion and moisture
– Good weather resistance and chemicals
– Flame-retardant
– Good adhesion of glues and paints
– Good price/performance ratio

Please note:
– In the case of machining: High tool wear as a result of the high glass fibre content (carbide/diamond tools required)
– Not suitable for sliding functions (wear of mating partner)
– Not suitable for contact with foodstuffs

APSOplast® UP GFK

Polyester resin + endless glass fibres
Colour: White

The mechanical properties of the profiles vary depending on the choice of fibre reinforcement. The GRP pultrusion profiles are available in various shapes. A distinction can be made between the following three types, although smooth transitions are possible:
– Roving reinforcement in the case of round bars and small profiles
– Glass fibre mats with roving reinforcement, the standard design for construction profiles (like flat profiles, angle profiles, and U-profiles)
– Fabric cross-winding with roving reinforcement, the typical method for the production of tubes
The use of these UP GFK profiles enables the design of constructions which can bear high static loads and are enduring and corrosion-resistant. Thanks to these good properties, there are numerous applications in the chemical industry, electrical industry, transportation, agriculture, sport and leisure, and plant engineering.

Range of applications and application examples

Primarily used as construction profiles with high flexural strength and with a high load-bearing capacity, retaining its shape, and low weight; used for thermal and electrical insulation functions or in corrosive environments in:

Electrical industry, mechanical engineering, apparatus construction, and chemical apparatus construction
Fixing profiles in switching and transformer stations, power distribution boxes, phase separators, actuator rods, conductor rail holders, section insulators for overhead lines, girder sections, support profiles, gratings, support frames, aerial masts, etc.

Transport and mechanical conveying and handling, vehicle technology, electroplating, metal construction
Construction profiles for: Refrigerated rooms, refrigerated trucks, utility vehicles, waste containers, conveyor belts, transportation belts, gondola lifts, overhead railways, railings, garden fences, greenhouse construction profiles, etc.

Sport and leisure industry
Snow poles, kite profiles, arc profiles, arrows, hang-glider profiles, slalom poles, high jump bars, sail battens, support profiles for tents, caravans and motor homes, modelling parts, etc.

Conformity

–

Biocompatibility

–

APSOplast® PUR

Material denomination: PUR
Chemical denomination: Polyurethanes

General description

Polyurethanes (PUR) are materials (synthetic resins) which result from the polyaddition reaction of a polyester or polyether and a polyisocyanate. Polyurethanes can have completely different properties depending on the choice of isocyanate and alcohol. The hardness of the material is determined through the varying quantity ratios of raw materials (no plasticizers).

The urethane group is characteristic of polyurethanes. Polyurethanes can be foamed or solid, hard and brittle, or soft and elastic. The glycol-containing polyurethane elastomers described here are compact PUR cast in open moulds in a hot moulding process. This oldest and best known polyurethane elastomer has unsurpassed mechanical property values in comparison with other types. The rubber-like, elastic behaviour of this material in conjunction with excellent resistance to abrasion and tear propagation enables applications where synthetic rubbers would fail.

Characteristics and properties

– Rubber-like, elastic behaviour
– Extremely high resistance to wear and abrasion
– High mechanical structural strength
– Very high impact resistance
– High impact resilience
– Good damping values
– High tear resistance
– Very good weather resistance
– Resistance to oils and greases
– Relatively high coefficient of friction
– Good machinability (from 90 Shore A)

Please note:
– PUR can be damaged as a result of hydrolysis if exposed to hot water, steam, tropical climates, and condensation.
– PUR is not light-fast, which means that the material can discolour from a light colour to almost
black within a few months. However, this discolouration does not have a negative effect on mechanical properties.
– All types of polyurethane are unsuitable for non-lubricated sliding functions.

APSOplast® PUR D15

Polyester urethane (AU)
Colour: Light to dark brown

Chemically, PUR D15 is based on polyester polyol + naphthylene-1.5-diisocyanate (DESMODUR® 15). PUR D15 is a high-quality polyurethane with unsurpassed abrasion and structural strength; however, it is not stable when exposed to hydrolysis. In comparison with other PUR elastomers, PUR D15 has increased resistance to heat. Short-term exposure to temperatures of up to +120 °C are possible. However, the material should not be exposed to a long-term temperature of over +100 °C. A further advantage of PUR D15 is that it has a higher modulus of elasticity in comparison with other PUR elastomers of the same Shore hardness, and thus has a higher load-bearing capacity while retaining the same deformation values. The hardness of PUR D15 is between approx. 65 Shore A to 70 Shore D.

APSOplast® PUR D44

Polyester urethane (AU)
Colour: reddish brown

Chemically, PUR D44 is based on polyester polyol + diphenylmethane-4.4-diisocyanate (DESMODUR® 44). PUR D44 is a high-quality polyurethane with good abrasion resistance and structural strength. In comparison with PUR D15, this material is somewhat cheaper and more resistant to hydrolysis but less suitable for parts exposed to dynamic stress. PUR D44 should not be used at a long-term temperature of over +80 °C. However, short-term exposure to temperatures of up to +100 °C is possible. This material has a hardness of between approx. 65 Shore A and 60 Shore D.

APSOplast® PUR AP

Polyether urethane (EU)
Colour: Light, translucent

Chemically, this polyurethane is based on polyether polyol + toluene diisocyanate. This material has very high abrasion resistance and structural strength, is particularly microbe- and hydrolysis-stable, and is very flexible at low temperatures. However, it is less resistant to petroleum-based fuels and oils than the polyester product.

Range of applications and application examples

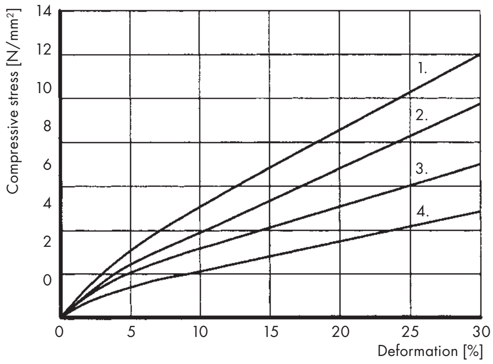
Due to their good mechanical properties, PUR elastomers are primarily used in applications where stresses would be too high for conventional natural and synthetic rubbers. In addition, PUR has an elastic behaviour that is not found in any thermoplastic.

Mechanical engineering, apparatus construction, and vehicles
Roller scrapers, snow plough bars, scrapers, wearing parts, roller coatings, stop buffers, clutch packs, chain sprockets, cutting pads, wearing parts for the concrete industry (mixer blade linings, concrete mixer inserts, sieves, etc.)
Pump parts, roll coverings, heavy-duty rollers and wheels, seals, hoses, etc.

Conformity
–

Biocompatibility
–

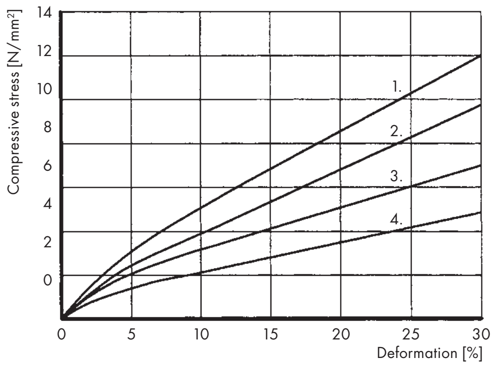
Compression test for PUR D15 at 0 °C



Test conditions:
– Temperature: 0 °C
– Test specimen: Ø 29 mm x 12.5 mm in height
– Deformation speed: 10 mm/min

1. 45 Shore D
2. 92 Shore A
3. 89 Shore A
4. 84 Shore A

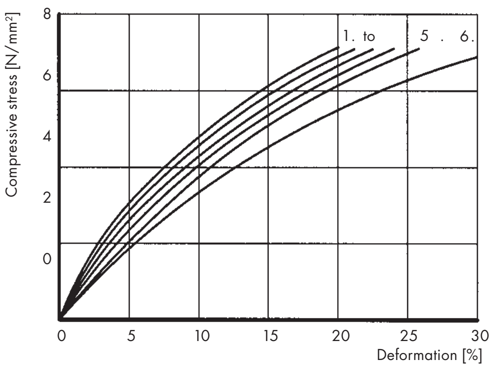
Compression test for PUR D15 at +80 °C



Test conditions:
– Test specimen: Ø 29 mm x 12.5 mm in height
– Deformation speed: 10 mm/min

1. 45 Shore D
2. 92 Shore A
3. 89 Shore A
4. 84 Shore A

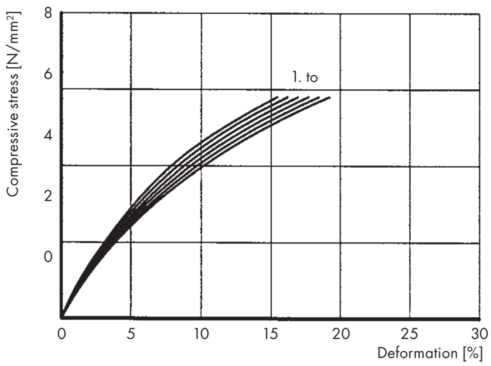
Isochronous stress-strain curve for PUR D15 92 Sh A



Test conditions:
– Temperature: +80 °C
– Air humidity RH 50%
– Test specimen: Ø 20 mm x 20 mm in height

Load duration:
1. 10^{-2} h
2. 10^{-1} h
3. 10^{0} h
4. 10^{1} h
5. 10^{2} h
6. 10^{3} h

Isochronous stress-strain curve for PUR D15 92 Sh A



Test conditions:
– Temperature: +23 °C
– Air humidity RH 50%
– Test specimen: Ø 20 mm x 20 mm in height

Load duration:
1. 10^{-2} h
2. 10^{-1} h
3. 10^{0} h
4. 10^{1} h
5. 10^{2} h
6. 10^{3} h

Introduction

An increasing number of plastics are now also used in the foodstuff industry. Angst+Pfister offers a comprehensive range of plastics with different dimensions (from standard types to highly-developed special types), tailored to the needs of the market. These materials were specially developed for contact with foodstuffs and comply with a range of stipulations for plastics which come into contact with food. Our plastics have a high chemical resistance to a wide range of aggressive substances used in the processing, cleaning, and sterilization of devices used in the food industry. The standard portfolio for use in the foodstuff industry ranges from semi-finished products to finished parts.
The self-lubricating properties of the materials – described separately in Section 10.2 – are noteworthy.
If requested, when placing your order, we will provide you with declarations of conformity for our plastic materials used in the foodstuff industry in accordance with the appropriate standard.

Main areas of application in the processing of foodstuffs

Bakeries
Tunnel furnace, kneading machines, shaping and filling machines, bread mills, and dough conveyors

Processing and packaging of dairy products
Separating machines, machines for making and filling milk/butter/cheese, homogenizers

Meat and sausage processing
Cutting machines, comminution plants, bone removal machines, conveyor belts, sausage filling machines, kebab machines, mixers, cooking machines

Packaging
Forming technology, blister forming technology, sealing, and cardboard packaging plants

Drink processing and filling
Centrifuges, separators, bottle and can filling plants, clarification tanks, heat exchangers

Modified grades

APSOplast® PE-UHMW ED FDA
APSOplast® PE-UHMW EC FDA
Colour: Black

These materials are modified antistatic, electrically conductive respectively, suitable for use in the foodstuff and pharmaceutical industries. They meet the requirements of European Commission Foodstuffs Directive 1935/2004/EC and FDA Directives 21 CFR 177.1520 and 21 CFR 178.3297 on plastics for contact with foodstuffs. PE-UHMW ED FDA is also tested as per US 3-A Dairy Sanitary Standards.

Typical applications
Sliding and drive elements in the foodstuffs and pharmaceutical industries for ATEX zones

The following **self-lubricating materials** are available for applications where it is not possible or permitted to apply any or sufficient lubrication externally. These grades have integrated lubrication, are suitable for contact with foodstuffs, and are available in a broad range of semi-finished products with different dimensions. This results in lower maintenance costs and top application performances.

APSOplast® PA 6 G LO FDA
Colour: Natural (ivory), blue

This material type is a cast polyamide 6 with an integrated lubrication system. It is available in natural (ivory) and blue. It is genuinely self-lubricating and its composition complies with US FDA guidelines. This material was developed for high-duty, slow-moving non-lubricated sliding elements. In comparison with polyamides with no lubrication system, the coefficient of friction is up to 50% lower and wear resistance is up to ten times higher. It considerably broadens the application range of polyamides and allows lower maintenance costs along with longer service lives.

Typical applications
– Packaging plants
– Automatic processing
– Milk and cheese processing

APSOplast® PET-C SL
Colour: Grey

This material is based on polyethylene terephthalate (thermoplastic polyester) with an integrated (homogeneously distributed) solid lubricant. Its composition makes it ideally suited for contact with foodstuffs. The specific material composition makes this plastic a unique, «self-lubricating» material for slide bearings. As well as being very resistant to wear, this plastic offers an even lower coefficient of friction and a higher dynamic load-bearing capacity pv-limit value than PET-C (unmodified type).

Typical applications
– Cutting machines and comminution plants
– Drink filling
– Butter packaging plants

APSOplast® PPS GF SL
Colour: Dark blue

This reinforced semi-crystalline polyphenylene sulphide material with integrated solid lubricant has an exceptional combination of properties with regard to wear resistance, mechanical load-bearing capacity, and dimensional stability in contact with chemicals, high temperatures, and conditions where hydrolysis occurs. Thanks to the homogeneously distributed solid lubricant, this grade has excellent wear resistance and a low coefficient of friction.

Typical applications
Filter drums, meat and milk production plants, forming machines, extraction plants, cheese processing plants, heating and drying plants

APSOplast® PEEK SL FDA
Colour: Blue, natural

This semi-crystalline PEEK has a unique combination of excellent mechanical properties, temperature resistance, and an outstanding resistance to chemicals, making it into a really popular high-performance plastic. Like unmodified PEEK, this new, self-lubricating material is characterized by its food-safe composition. However, it also offers a higher degree of improved wear resistance and lower friction.

Typical applications
Cooking systems, heat exchangers, fermentation and brewery installations, large, high-speed cutting machines

Cleaning and sterilization

Cleaning and sterilization procedures in the foodstuff and food processing industries are extremely important in order to safeguard health. Strict procedures are developed and applied vigorously both for surfaces which come into contact with foodstuffs (machines, devices, etc.) and surfaces without contact with foodstuffs (guards, walls, ceilings, etc.).
Cleaning and sterilization procedures for surfaces aim to remove sources of nutrients that bacteria can feed upon in order to grow and to kill off any bacteria already present:
– Cleaning should completely remove unwanted particles (residual nutrients) from the surface being cleaned, killing off all existing bacteria at the same time.
– Sterilization aims to kill off residual bacteria which could cause diseases (pathogenic organisms). Most bacteria which remain following cleaning can be eliminated by sterilization with hot water, steam, or chemicals in special conditions with regard to temperature, concentration, and contact time.

Cleaning and sterilization procedures
CIP Clean-in-place
COP Clean-out-of-place
SIP Sterilization-in-place

The choice of the most suitable plastic is dependent on the available data with regard to chemical composition and empirical evidence. Often, a single trial in practical conditions can provide information on the actual suitability of a plastic for a specific application (appropriate chemicals, concentration, temperature, contact time, and load condition).

Requirements for plastic parts in the foodstuff industry
– Appropriate physical properties for special applications with regard to strength, rigidity, impact resistance, dimensional stability, temperature resistance, and lubrication properties (wear and friction)
– Suitable for contact with foodstuffs
– Chemical resistance to certain foodstuffs and cleaning/sterilization agents
– Smooth surfaces, free from cracks, pinholes, and other surface damage which might impair the effectiveness of cleaning and sterilization measures

Food regulations

Material	USA: FDA Code of Federal Regulation [21 CFR] or FDA FCN Food Contact Notification	EU: 1935/2004/EC incl. 10/2011/EU
PA 6	Yes	Yes*
PA 66	Yes	Yes*
PA 6 G	Yes*	Yes*
PA 6 G SL	Yes	No
PA 6 G SL Plus	Yes	No
PA 6 G LO FDA	Yes	No
POM-C natural	Yes	Yes*
POM-C black	Yes*	Yes*
POM-C ID	Yes*	Yes*
POM-C SAN	Yes*	Yes*
POM-H natural	Yes*	Yes*
POM-H SL	Yes*	Yes*
PET-C natural	Yes*	Yes*
PET-C black	Yes*	Yes*
PET-C SL	Yes*	Yes*
PPE	Yes*	Yes*
PSU	Yes*	No
PPSU black	Yes	No
PEI	Yes*	No
PPS GF SL	Yes	Yes*
PEEK	Yes	Yes*
PEEK black	Yes*	No
PEEK SL FDA	Yes	Yes
PVDF	Yes*	Yes*
PE-LD natural	Yes	No
PE-HD black	No	Yes*
PE-HMW natural	Yes*	Yes*
PE-HMW reddish brown	Yes*	Yes*
PE-UHMW	Yes*	Yes*
PE-UHMW ED FDA	Yes	Yes
PE-UHMW EC FDA	Yes	Yes
PP grey	Yes	Yes
PTFE natural	Yes	Yes
PTFE + glass	Yes	Yes*
PTFE + carbon	Yes*	No

*Possible upon special request (must be specified when placing your inquiry/order)

Standards

Standard	Country	Description
FDA	USA	**F**ood and **D**rug **A**dministration – Department of Health, Education, and Welfare – like the German BGA (German Federal Public Health Department)
CFR	USA	**C**ode of **F**ederal **R**egulations (designation in conjunction with FDA no. in the USA)
1935/2004/EC	EU	European ordinance on materials and items that are intended to come into contact with foodstuffs
10/2011/EU	EU	European ordinance on materials and items that are intended to come into contact with foodstuffs (specific measure as per Art. 5(1) of 1935/2004/EC)
2023/2006/EC	EU	European ordinance on good manufacturing processes (GMPs) for materials and items that are intended to come into contact with foodstuffs
BfR	D	**B**undesinstitut **f**ür **R**isikobewertung (German Federal Institute for Risk Assessment, previously BGA and then BgVV)
3-A Dairy Sanitary Standard	USA	American standard issued by representatives of the dairy, foodstuffs, and milking industry and the Department of Public Health for business processes and equipment
BAG	CH	Swiss Department of Health
BgVV	D	Federal Institute for Consumer Health Protection and Veterinary Medicine (previously BGA/Federal Department of Health, now BfR)
NSF	USA	**N**ational **S**anitation **F**oundation (NSF testing laboratory); similar to the FDA but only for drinking water, similar to the German DVGW; also registers products (in the USA)
KTW	D	Drinking Water Ordinance (KTW = Kunststoffe/Trinkwasser – plastics and drinking water)
WRAS	GB	**W**ater **R**egulation **A**dvisory **S**cheme (British drinking water approval)
ACS	FR	**A**ttestation de **C**onformité **S**anitaire (French drinking water approval)
KIWA	NL	Dutch drinking water approval
DVGW	D	**D**eutsche **V**ereinigung des **G**as- und **W**asserfaches (German professional association for the gas and water industry
DVGW-W270	D	The stipulations of DIN 2000 require this microbiological spproval.
SVGW	CH	Schweizerischer Verein des Gas- und Wasserfaches Swiss professional association for the gas and water industry
ÖVGW	AT	**Ö**sterreichische **V**ereinigung des **G**as- und **W**asserfaches Austrian professional association for the gas and water industry
LMHV	D	Food Hygiene Act
LMBG	D	German Foods, Consumer Goods, and Feedstuff Code

Plastics for medical technology

Plastics are increasingly gaining importance in medical technology devices. On the one hand, they increase the functionality of the devices; on the other, they contribute to maximizing the cost-cutting potential. For uses involving contact with skin, blood and tissue, the materials used must be biocompatible as well as suitable for sterilization at high temperatures. Chemical resistance and resistance against aggressive disinfectants are also required.

Range of products

The **LSG** (**L**ife **S**cience **G**rade) product line includes biocompatible engineering and high-performance plastics. These grades are specially designed for components that must be processed mechanically for use in medical technology, pharmaceutics and biotechnology. These materials comply with the regulations as per USP Class V, VI and ISO 10993.
Responsibility for obtaining the certificates for the required standards should be taken by the appliance manufacturer or the distributors of the appliances.
Thanks to the tests carried out in accordance with USP and ISO 10993, the customer benefits from reduced development time and lower development costs for the approval testing of the end product.

APSOplast® LSG range summary

Trade name	Base material
PEEK CLASSIX™ LSG	PEEK
PEEK CF30 LSG	PEEK
PEEK GF30 LSG	PEEK
PEEK LSG	PEEK
PPSU LSG	PPSU
POM-C LSG 7 colours	POM-C
PEI LSG	PEI
PSU LSG	PSU
PC LSG	PC
PPSU LSG XRO	PPSU
PPE LSG	PPE modified
PP LSG	PP stabilized

Biocompatibility

Materials or assembly groups that do not have any negative impact on living creatures in their environment are labeled as biocompatible (bio = living + compatible = compatible with). Biocompatibility therefore describes the compatability of a material or medical product inserted in the body with the tissue. The assessment is carried out in accordance with the various tests as per USP (U.S. Pharmacopeia) Class I to VI or in accordance with ISO 10993.
In medical technology, devices are often used multiple times. Plastics must therefore be able to tolerate a variety of sterilization processes and chemicals. Biocompatibility is not a material specification and requires a prior examination and, if necessary, a special production.

Approval testing in accordance with USP and ISO guidelines: Comparison of biocompatibility testing in accordance with USP 23 Class V + VI and ISO 10993

ISO 10993

In vivo
- sub-chronic/chronic toxicity
- Carcinogenicity
- Sensitization
- Long-term implantation

In vitro
- Genotoxicity
- Cytotoxicity

USP 23 Class V
- acute systematic toxicity
- intracutaneous reactivity

USP 23 Class VI
- Short-term implantation attempt (5–7 days)

Conformity with guidelines on biocompatibility and contact with foodstuff (FDA)

Identification	Composition	USP conformity Semi-finished products	ISO 10993 conformity Semi-finished products	FDA conformity Raw materials ④
PEEK CLASSIX™ LSG white ①	PEEK white	Class VI ②	ISO 10993	yes
PEEK CF30 LSG black	PEEK +30% GF	Class VI ②	ISO 10993	not tested
PEEK GF30 LSG blue (RAL 5019)	PEEK +30% GF	Class VI ②	ISO 10993	not tested
PEEK LSG natural	PEEK natural	Class VI ②	ISO 10993	yes
PEEK LSG black	PEEK black	Class VI ②	ISO 10993	yes
PPSU LSG black ①	PPSU black	Class VI ②	ISO 10993	yes
PEI LSG natural ①	PEI natural	Class VI ②	ISO 10993	yes
PSU LSG natural ①	PSU natural	Class VI ②	ISO 10993	yes
PC LSG natural ①	PC natural	Class VI ②	ISO 10993	yes
POM-C LSG natural	POM-C natural	not tested ③	ISO 10993	yes
POM-C LSG black	POM-C black	not tested ③	ISO 10993	yes
POM-C LSG yellow (RAL 1007)	POM-C yellow	not tested ③	ISO 10993	yes
POM-C LSG red (RAL 3027)	POM-C red	not tested ③	ISO 10993	yes
POM-C LSG blue (RAL 5005)	POM-C blue	not tested ③	ISO 10993	yes
POM-C LSG blue (RAL 5005)	POM-C blue	not tested ③	ISO 10993	yes
POM-C LSG green (RAL 6016)	POM-C green	not tested ③	ISO 10993	yes
POM-C LSG brown (RAL 8016)	POM-C brown	not tested ③	ISO 10993	yes
PPSU LSG XRO black	PPSU	Raw material	ISO 10993 ⑤	yes ⑦
PPSU LSG XRO green	PPSU	Raw material	ISO 10993 ⑤	yes ⑦
PPSU LSG XRO red	PPSU	Raw material	ISO 10993 ⑤	yes ⑦
PPSU LSG XRO yellow	PPSU	Raw material	ISO 10993 ⑤	yes ⑦
PPSU LSG XRO blue	PPSU	Raw material	ISO 10993 ⑤	yes ⑦
PPSU LSG XRO ivory	PPSU	Raw material	ISO 10993 ⑤	yes ⑦
PPE LSG black	PPE mod.	no	ISO 10993 ⑥	yes ⑦
PPE LSG green	PPE mod.	no	ISO 10993 ⑥	yes ⑦
PPE LSG yellow	PPE mod.	no	ISO 10993 ⑥	yes ⑦
PPE LSG brown	PPE mod.	no	ISO 10993 ⑥	yes ⑦
PPE LSG gray	PPE mod.	no	ISO 10993 ⑥	yes ⑦
PPE LSG blue	PPE mod.	no	ISO 10993 ⑥	yes ⑦
PP LSG white	PP stab.	Polymer	ISO 10993	yes ⑦
PP LSG black	PP stab.	Polymer	ISO 10993	yes ⑦

① According to the raw material manufacturer, the type of raw materials used to produce these semi-finished products comply with the regulations as per USP CLASS VI.

② This Life Science Grade testing was carried out by an independent international inspecting authority to examine the compliance with the regulations of the United States Pharmacopeia (USP) and the ISO 10993-1 on biocompatibility tests of materials (the tests were carried out on 50 mm thick bars of the manufactured samples shortly after being produced).

③ The pure, natural coloured POM copolymer materials used to manufacture all POM-C LSG semi-finished products comply with the regulations as per USP Class VI (according to the biocompatability tests commissioned by the supplier of the raw materials). In addition, Drug Master Files (DMF) for these raw materials are available in the DMF database of the American Food and Drug Administration (FDA).

④ The composition of the raw materials used to manufacture these LSG semi-finished products comply with the requirements of the FDA's applicable Food Contact Notification and/or Food Additive Regulation(s).

⑤ Tested on the semi-finished products PPSU LSG XRO and the corresponding colours (without barium sulfate). As polymer and barium sulfate are biocompatible, it can be assumed that all semi-finished products comply with the ISO 10993 standard.

⑥ Tested on PPE LSG blue. It can be assumed that this also applies for all other colours.

⑦ FDA 21 CFR 178.3297 (Pigments)

Definition of 'sterile'

Sterile means being free from potentially reproductive micro-organisms. However, sterility can only be guaranteed with a defined probability. Sterilization processes must be designed in such a way that the bacterial count is reduced to a millionth of the initial value, i.e. when the the theoretical probability that a living germ is present in each object is smaller than 1:1000000. The likelihood of contamination is not dependent solely on the sterilization processes, but rather also on the initial bacterial count (bioburden) of the sterilized item. The standardized cleaning and disinfection of the sterile item are therefore prerequisites for a safe sterilization.

Sterilization processes

Steam sterilization

Steam sterilization is sterilization using pure, saturated steam of at least +121 °C that affects all surfaces of the sterilized item. Steam sterilization is the safest process in hospitals and in practice. It is preferable to all other methods of sterilization. A complete ventilation and steam penetration must take place in the case of porous sterilization goods (e.g. textiles).
For a sterilization temperature of +121 °C, an exposure time of at least 15 minutes must be observed; for +134 °C, an exposure time of at least 3 minutes must be observed. Any deviations from this require prior validation. Nowadays, fractionated vacuum techniques are used in order to completely remove air from the chamber and sterilized item and to achieve a uniform steam penetration.

Autoclave

Steam pressure sterilization is generally used in medical technology to sterilize all types of reusable devices, pieces of equipment, instruments and shells, and is carried out in a pressure tank that is suitable for superheated, saturated steam. The main purpose of sterilization is to kill off all micro-organisms by means of steam. Tests in which the effects of repeated steam sterilization at +134 °C on the notched impact resistance (Charby) were examined in accordance with ISO 179/1eA (measured on dry samples at +23 °C) show:
– The excellent suitability of PVDF, PEEK and PPSU (>500 autoclave cycles)
– The materials PEI, PSU and PPS withstand up to 250 autoclave cycles
– POM-C is suitable for parts that only need to be steam sterilized a few times
– PC is rather less suitable

Hot air sterilization

Hot air sterilization is sterilization with dry heat. However, the process involves a range of uncertainties:
– With dry heat, the transfer of heat to the sterilized item takes place relatively slowly
– The success of the sterilization can be affected by the formation of 'cold zones'
– The preparation of the items to be sterilized – above all the sterilizer's type of feeding – heavily influences the safety of the sterilization
– Process validation is not possible

Apart from exceptional cases beyond the direct care of patients, hot air sterilization is also not a reliable method for the proper preparation of the sterile item. Hot air sterilization is therefore no longer acceptable in the hospital and in practice! If this process is used in spite of the known defects, a temperature of +180 °C for a minimum of 30 minutes' exposure time is required.

Gas sterilization

Gas sterilization is sterilization using a microbicidal gas at the lowest temperature possible in a closed system. As a rule, only thermolabile objects can be sterilized with gas.
When purchasing new or replacement instruments and devices, those which can be steam sterilized should be favored at all times. The conditions required for sterilization (temperature, humidity, gas concentration, exposure time) must be met at all inner and outer surfaces that are to be sterilized. In hospitals, the extent to which gas sterilized objects are not steam sterilizable must be examined; if necessary, toxological risks for personnel and patients on the one hand and increased material wear during steam sterilization on the other must be weighed up against one another. The choice of gas sterilization process and the allocation of the sterilized item must be clarified with a hospital hygienist. We must strive towards regional centralization of gas sterilization.

Ethylene oxide (EO) sterilization

Due to its toxic, carcinogenic and mutagenic properties, ethylene oxide is a hazardous substance and is subject to the appropriate current regulations. This sterilization process is characterized by its low sterilization temperature and high penetration power. The desorption of ethylene oxide must take place in the sterilization chamber long enough so that the threshold limit value (TLV) is sure to be undershot. Compliance with the so-called medium triggering level must be documented through metering.

Formaldehyde gas sterilization

Formaldehyde is a hazardous substance due to its toxic properties. However, formaldehyde is less toxic than ethylene oxide. Sterilization with formaldehyde is also subject to the statutory regulations, prEN14180. The process is implemented in temperatures between +48 und +60 °C. For safety reasons, the highest selectable temperature within the indicated ranges that the sterilized item can tolerate, as specified by the manufacturer, should always be used at the sterilizer. If the process is implemented precisely, it is equivalent to the sterilization process with ethylene oxide, though allows comparatively smaller desorption phases.

Plasma sterilization

Sterilization with the help of hydrogen peroxide plasma at a temperature of +45 °C and a batch time of 45 to 80 minutes, depending on the program, is a non-poisonous and gentle process for sterilizing thermolabile and moisture-sensitive instruments. This type of instrument can be sterilized in a routine operation if it meets the formulary's conditions or if the sterilizability has been proven as part of a product validation. Long, narrow-lumen tubular parts – especially those made from metallic materials – can now be sterilized within the respectively indicated limits.

Radiation sterilization

– X rays easily penetrate the sterilized item
– Gamma rays reach surfaces more easily
– Electron accelerator (beta rays)

Resistance to sterilization processes

Life Sciences Grades	Sterilization processes				
	Ethylene oxide	Steam 121 °C/134 °C	Hot air 160 °C	Plasma	Gamma rays
PEEK CLASSIX™ LSG	A	A/A	A	A	A
PEEK CF30 LSG	A	A/A	A	A	A
PEEK GF30 LSG blue	A	A/A	A	A	A
PEEK LSG	A	A/A	A	A	A
PPSU LSG	A	A/A	A	A	B
PEI LSG	B	A/B	A	B	B
PSU LSG	B	A/B	B	B	B
PC LSG	B	C/D	D	B	B
POM-C LSG	B	B/C	D	B	D

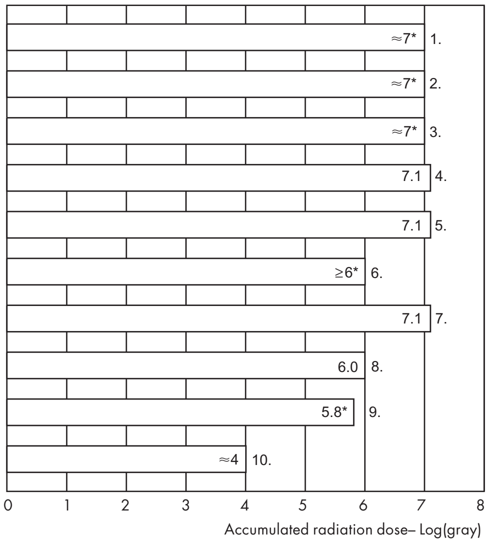
A: very good
B: good
C: less suitable
D: not suitable

The Life Science Grade product line is compatible with the most frequently used sterilization processes.

Radiation resistance of plastics

Depending on their area of application, plastics come into contact with various radiations that affect the structure of the plastic.
The spectrum of electromagnetic waves ranges from radio waves with large wavelengths and normal daylight with short-wave UV rays, up to the very short-wave X-rays and gamma rays. The shorter the wavelength of the radiation, the more damaged the plastic can become.
An important link to electromagnetic waves is the dielectric loss factor indicating the proportion of energy, which is absorbed from the plastic. Plastics with a high dielectric loss factor heat up significantly in the alternating electric field and are therefore not suitable as high frequency and micro-wave insulation material.
Gamma rays and X-rays are frequently found in the fields of medical diagnostics, radiation therapy, the sterilization of disposable products, material testing and measurement technology. High-energy radiation often leads to reduced elongation and therefore to embrittlement. The lifespan thereforce depends on the overall dose of radiation absorbed.
PEEK, PI and amorphous sulfur polymers (PES, PSU, PPSU), to name a few examples, have proven to be highly resistant to gamma rays and X-rays. Materials such as PTFE and POM tend to be more sensitive and, in practice, less suitable.

Resistance to gamma radiation



1. PEEK CLASSIX™ LSG white
2. PEEK CF30 LSG
3. PEEK GF30 LSG blue
4. PEEK LSG natural/black
6. PPSU LSG black
7. PEI LSG natural
8. PSU LSG natural
9. PC LSG natural
10. POM-C LSG

*: estimated values
1 gray = 100 rad

Approvals and clearances

Construction parts used in exposed and critical applications, for example, in contact with medical products and foodstuffs or with drinking water, are being realized more and more frequently in approved materials. The large number of national approvals is geared towards practical application, depending on the type of testing and requirements.
Our manufacturers or Angst+Pfister have allowed the responsible authorities to examine a variety of mixtures or materials and obtained the appropriate clearances.

Food and Drug Administration FDA, USA

The FDA regulates the material substances that are used for processing. This list of raw materials (white list) must be adhered to in order to qualify for FDA conformity. The substances are free from poisonous or carcinogenic materials. The expensive FDA approval certificate can be attained by means of an extraction test.

USP (United States Pharmacopeia)

American Pharmacopoeia
It defines applicable standards in relation to the quality of medicinal products for humans and animals during their production and in their application. These materials are suitable for containers of pharmaceuticals and the production of syringes and blood bags.

ISO 10993

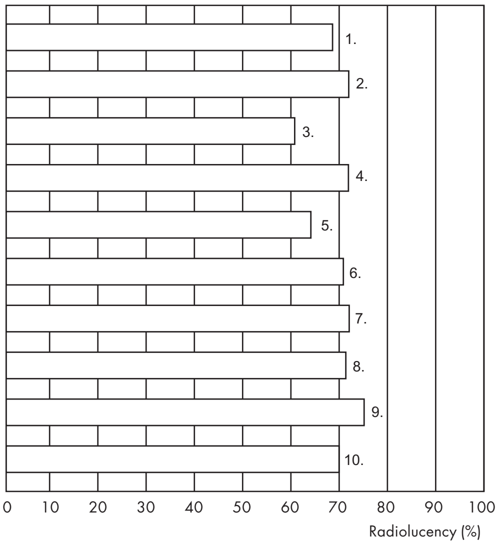
This standard includes the biological assessment of materials for contact with the body.
ISO 10993-1 includes the category of medical devices.
The duration of the contact of the respective materials with the body is the decisive factor.
This is divided into 3 categories:
– A limited ≤ 24 h
– B continuous > 24 h up to a max. of 30 days
– C permanent > 30 days

Applications

The new materials are applied in the following ways:
– In appliances such as pumps, cases, motors, sterilization tools, ducts
– In analytical devices for tomography, chromatography and chemical tests
– For instruments for anesthesia, endoscopy, etc.
– For feeder systems for air, medication and blood

Note:
Angst+Pfister does not under any circumstances allow, approve or support its semi-finished products being used for applications involving implants in the human body.

Resistance to gamma radiation



Test conditions:
– measured at 23 °C
– 12 mm thick test sheet
– Radiant energy:: 59 keV

1. PEEK CLASSIX™ LSG white
2. PEEK CF30 LSG
3. PEEK GF30 LSG blue
4. PEEK-LSG natural/black
6. PPSU LSG black
7. PEI LSG natural
8. PSU LSG natural
9. PC LSG natural
10. POM-C LSG

Classification of plastic materials as per USP (Class I to VI)

Test	Extract	Class I	Class II	Class III	Class IV	Class V	Class VI
Acute systematic Toxicity	saline solution	●	●	●	●	●	●
	Alcohol	–	●	●	●	●	●
	Oil	–	–	●	●	●	●
	PEG	–	–	●	–	●	●
Intracutaneous Reaction	saline solution	●	●	●	●	●	●
	Alcohol	–	●	●	●	●	●
	Oil	–	–	–	●	●	●
	PEG	–	–	–	–	●	●
5/7 day implant		–	–	–	●	–	●

● = required class

Life Science market– Biocompatibility ISO 10993

Device category	Type of body contact	Duration of contact	Biological effect							
			Cytotoxicity	Sensitization	Irritation/Intracutaneous reactivity	Acute systematic toxicity	Sub-chronic toxicity	Genotoxicity	Implantation	Hemocompatibility
Surface devices	Skin	limited (< 24 h)	●	●	●	–	–	–	–	–
		prolonged (24 h – 30 d)	●	●	●	–	–	–	–	–
		permanent (> 30 d)	●	●	●	–	–	–	–	–
	Mucous membrane	limited (< 24 h)	●	●	●	–	–	–	–	–
		prolonged (24 h – 30 d)	●	●	●	–	–	–	–	–
		permanent (> 30 d)	●	●	●	–	●	●	–	–
	Injured or affected surfaces	limited (< 24 h)	●	●	●	–	–	–	–	–
		prolonged (24 h – 30 d)	●	●	●	–	–	–	–	–
		permanent (> 30 d)	●	●	●	–	●	●	–	–
Externally communicating devices	Blood vessel system indirect	limited (< 24 h)	●	●	●	●	–	–	–	●
		prolonged (24 h – 30 d)	●	●	●	●	–	–	–	●
		permanent (> 30 d)	●	●	–	●	●	●	–	●
	Tissue, bones, tooth enamel comminicating	limited (< 24 h)	●	●	●	–	–	–	–	–
		prolonged (24 h – 30 d)	●	●	●	●	●	●	●	–
		permanent (> 30 d)	●	●	●	●	●	●	●	–
	Circulating blood	limited (< 24 h)	●	●	●	●	–	–	–	●
		prolonged (24 h – 30 d)	●	●	●	●	●	●	●	●
		permanent (> 30 d)	●	●	●	●	●	●	●	●
Implants	Tissue, bones	limited (< 24 h)	●	●	●	–	–	–	–	–
		prolonged (24 h – 30 d)	●	●	●	●	●	●	●	–
		permanent (> 30 d)	●	●	●	●	●	●	●	–
	Blood	limited (< 24 h)	●	●	●	●	●	–	●	●
		prolonged (24 h – 30 d)	●	●	●	●	●	●	●	●
		permanent (> 30 d)	●	●	●	●	●	●	●	●

● = First series of evaluation tests in accordance with ISO 10993-1

Introduction

A good sliding performance is characterized by a variety of factors. These include low friction coefficients for minimum wear under dry running conditions. Even if these are present, a large number of slide bearing applications cannot be optimally solved with a single quality of plastic. The technical requirements concerning plastic sliding bearings are too diverse. It will therefore never be practical to use a 'universal plastic', e.g. for operating at high temperatures, with extreme loads, with the required minimal friction, at high speeds, in rough conditions, in a chemically aggressive environment or as precision bearings. From a technical and economical viewpoint, it is therefore expedient to strive towards individual solutions.

Slide bearing materials

The following materials are suitable for slide bearing applications. Choosing the appropriate material depends on its respective use:

Bearing materials for mechanical engineering
– PE-UHMW natural
– PE-UHMW ED
– PA 6, PA 6 MO
– PA 66, PA 66 MO
– PA 6, PA 6 G MO
– PA 6 G LO
– PA 6 G SL
– PA 6 G SL PLUS
– POM-C and POM-H
– POM-C SL, POM-H SL
– PET-C
– PET-C SL
– PPS SL, PPS GF SL
– PEEK, PEEK SL and PEEK CF30
– PAI SL, PAI SL PLUS
– VESPEL® SP21, SP22, SP211
– PTFE, PTFE mod.
– PTFE-HP range
– PTFE 500

Bearing materials for the food industry
– PE-UHMW ED FDA
– PA 6 G LO FDA
– PET-C SL
– PPS GF SL
– PEEK SL FDA
– PTFE HP 125 und HP 128
– PTFE 207

Along with plastic slide bearing materials, we offer the following standard slide bearings in our product range:

Metal/PTFE-fabric is a self-lubricating bearing material made from woven TEFLON® (PTFE) and applied to a solid supporting body. Dry running metal/PTFE-fabric slide bearings are recommended where low peripheral speeds occur under heavy loads.

PERMAGLIDE® slide bearings are bearings for the smallest radial or axial installation spaces. These products are available as bushes, collar bushes, thrust washers and bands, as well as in two groups of materials. The bushes are available in both metric dimensions as well as in inch sizes.

Advantages
Slide bearings made from plastics offer the following additional features in comparison to lubricated metal slide bearings or rolling bearings:
– Maintenance-free operation during dry runs and under mixed friction conditions, within certain limits
– Large damping capacity (corresponding quality)
– Electrical insulating capability
– Resistant to corrosion from water, steam, acids, lyes and solvents (corresponding quality)
– Slide bearings can be used directly in abrasive or aggressive fluids
– Not sensitive to edge pressure
– Minimal noise level
– No contamination of the fluids from lubricants during pharmaceutical, analytical and food applications
– Low weight
– Price advantage due to efficient processing by injection moulding or high chip removal capacity during semi-finished product machining.
– Direct bearing possible in housing bores without additional bearing bushes

Semi-crystalline thermoplastic plastics can primarily be used as bearing elements during dry run operations or during partial lubrication (mixed friction) for bearing bushes, sliding plates and guides, as well as for gearwheels and rollers. In order to attain a homogenous service life, it is imperative to pay particular attention to the choice of material as well as the operating conditions.

Lubrication
As a rule, slide bearings made from polymer materials can be operated in a dry run. However, an increased service life can be expected from lubricated bearings – depending on the quality of lubrication – as the amount of wear and the bearing temperature will be reduced. The sliding friction coefficient, though, can only be lowered in mixed friction operation by using nonpolar lubriants in polar polymers however, not in nonpolar polymers (PTFE, PE, PP). However, run-in lubrication is advisable in all instances.

Plastic in dry-running conditions

Tribological pairing of plastic/metal

The most favorable sliding performance and the highest loading capacity of a dry running slide bearing are achieved through being paired with a hardened steel partner. The steel ensures good heat dissapation and the surface hardness ought to prevent metal abrasion, which for soft metals can only be avoided through sufficient lubrication. The hardening of the steel partner when being paired with plastics containing inorganic filler, such as glass fibres or metal oxides, is unavoidable. Over time, this causes to roughen the metal partner, leading to excessive wear. However, carbon and graphite additives are suitable in dry and wet runs. The surface roughness of the steel partner must be chosen in line with the desired tribological properties of the polymer material, whereby it should be noted whether the roughness is anisotropic and in which direction the sliding movement takes place. For example, the machining grooves of a finished shaft run somewhat tangentially, so that a significantly higher level of roughness takes effect in the direction of the axis rather than perpendicular to it. The surface roughness of the plastic plays a secondary role.

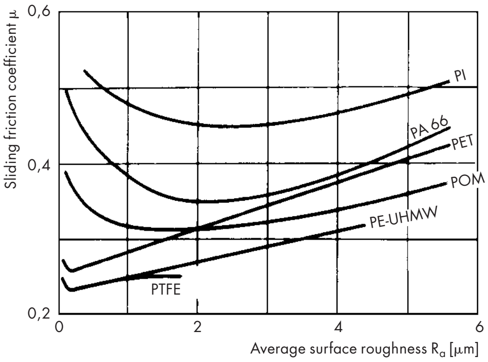
Tribological pairing of plastic/plastic

If polymer materials are paired with one another, a higher level of wear to the polymer material can be expected, which shows the lower level of strength or resistance to wear.
Insufficient heat dissipation results in the surface temperature increasing during dry runs, leading in turn to increased wear. Furthermore, thermal elongation can give rise to zero clearance, which can result in welding when using plastics with the same quality on both sides. If, however – you have to resort to a plastic/plastic-pairing – prior in a wet run or at very low sliding speeds – it is worth pairing a hard and a soft material together (e.g. PET-C with PTFE).

Effect of the surface roughness

This is relevant to the metal mating partners both in terms of the run-in period as well as the service life. It affects the friction coefficient, the sliding temperature and wear. As the following diagram shows, a high friction coefficient was established for very highly polished steel surfaces (R_a <2 µm for PI, PA 66 and POM), as uneven distribution of adherence («adherence bridges») occurs due to adhesive forces. Optimum values are then present for a surface roughness of 2–3 µm.

Friction coefficient of several plastics depending on the roughness of the steel surface (in dry-running operation)



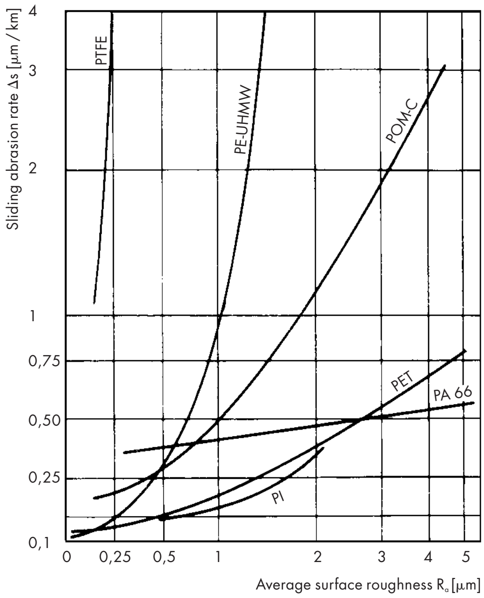
Surface roughness

Plastic	Average roughness value R_a µm	SNV roughness category
PA 6/ PA 66/ PA 46	1,5–3	N7/N8
POM	1,0–2	N6/N7
PET	0,5–1	N5/N6
PE-UHMW	0,5	N5/N6
PTFE virgin	0,5–1	N5/N6
PTFE-carbon	0,5–1	N5/N6
PI	1,5–3	N7/N8

Recommended roughness value (R_a) for metal partners in contact with plastic

As previously mentioned, the surface roughness of the plastic sliding surface plays a secondary role. As the roughness of the metal partner increases, so too does the sliding abrasion, as shown in the diagram opposite.

Sliding abrasion depending on the surface roughness of the metal partner (in dry-running operation)



Effect of the surface load

As can be seen from the diagram opposite, plastic sliding elements demonstrate a significantly higher friction coefficient in a dry run with very low surface load compared to specific loads of approx. 0.1 N/mm².

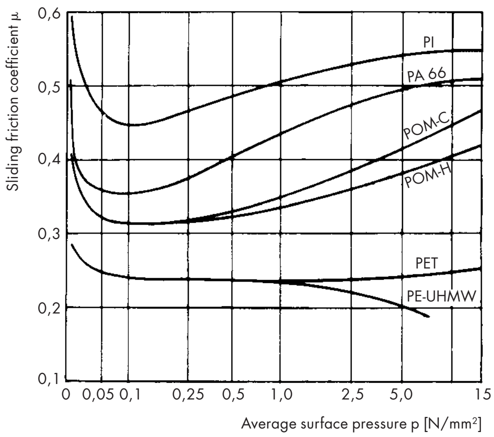
Effect of the sliding speed

During the dry-running operation, it must be borne in mind that exceeding a certain sliding speed rapidly increases the frictional heat and therefore the level of wear. A highest value of 2 m/s can be assumed as the standard value for conventional engineering plastics. Naturally, this limit is load-dependent and will be taken into account along with the pv-values.

Stick slip effect

This is taken to mean the jerky movements upon start-up as the transition is made from static to sliding friction. It occurs primarily at extremely low speeds with an increasing sliding friction coefficient. This is often the result of the metal partner's surface being smoothened. Particular attention must be paid to stick slip for PA by establishing a particular plastic abrasion in the roughness grooves. The plastics PTFE und PE-UHMW are virtually free of the stick slip effect.
The effect can frequently be rectified by reducing the surface load, by using a somewhat rougher or hardened metal surface, as well trough lubrication.

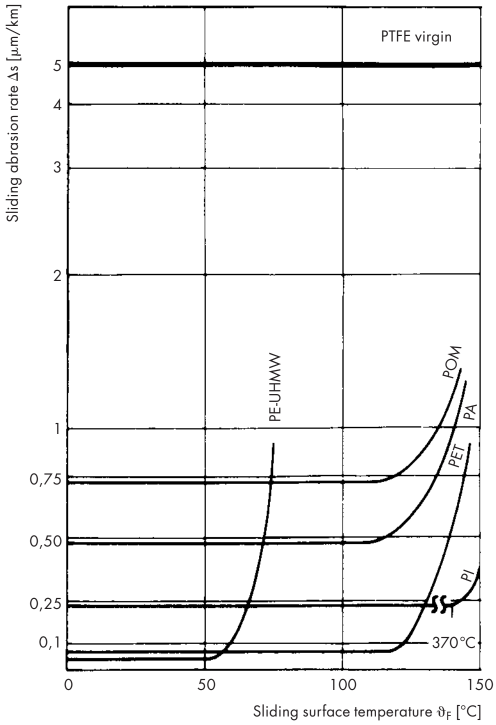
Sliding friction coefficient depending on the surface loading during a dry run with metal



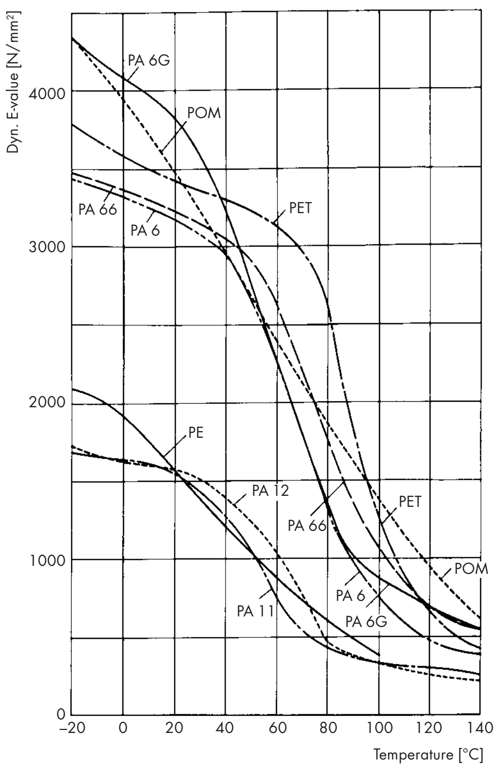
Effect of the temperature

The friction coefficient does not increase significantly until the maximum permissible slide bearing temperature has been reached. The sliding abrasion in dry runs behaves uniformly in this area. If this limit is exceeded, the sliding surface temperature – which rests considerably above the 'slide bearing temperature' due to frictional heat, reaches – its threshold value. As a result, the friction coefficient and wear increase rapidly, which can lead to substantial damage. The following diagram shows the limit for several plastics.
The maximum permissible slide bearing temperatures stated in the table will not be exceeded during dry runs if the maximum permissible pv-values are observed.
For these thermoplastic plastics, an increase in the ambient temperature results in a decrease of modulus of elasticity (diagram). At the same time, the permitted specific load p decreases as the temperature increases.
In addition, increased ambient temperatures have a strong effect on the thermal elongation of the plastic, which must be taken into account both for the bearing calculation and during construction.

Sliding abrasion depending on the sliding surface temperature (in dry-running operation)



Modulus of elasticity in tensile testing depending on the temperature



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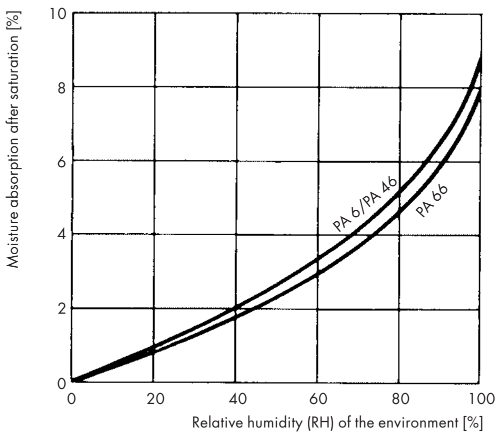
Effect of humidity

Certain plastics, particularly polyamides, absorb humidity from the environment and thus change their volumes. Except for slotted, very thin-walled bearings, the dimensional change must be included (see following diagram about PA).
Even if the humidity level for PA 6, 66 and 46 increases due to prior conditioning (immersing in hot water), an approximation of the dimensional changes in the applica-tion can only be estimated. Precision bearings with narrow clearance are not possible with PA.
The plastics POM and PET are not resistant to hydrolysis. These plastics must avoid direct contact with hot water above +80 °C, as well as with tropical climates and condensation.

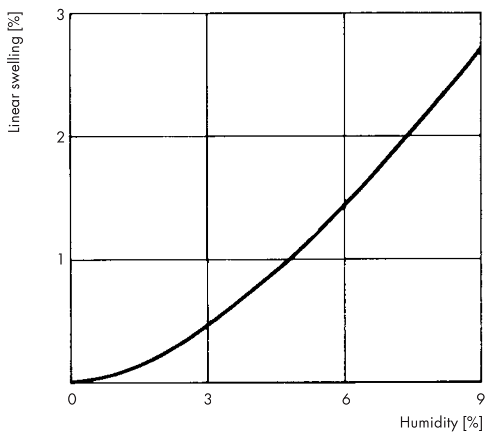
Effect of chemicals

Before each plastic bearing comes into contact with aggressive gases or liquids, the respectively suitable quality of plastic material must be selected with the help of our chemical resistance lists. A distinction must be made between continuous contact (e.g. for immersed bearings), where the resistance index A is mandatory, and a mere cleaning process or splashing, where index B suffices.
Plastics which are chemically not resistant generally change their volumes – along with increasing their mass and weight and losing their strength – or else they become brittle. The problem of corrosion on the metal side must be specially taken into account by using corresponding stainless steels. Immersed bearings can be viewed as wet roller bearings. The medium aids the cooling of sliding surfaces, decreases the friction coefficient or even forms a 'water film'. The service life increases in comparison to dry running bearings.
For example, PTFE/carbon bearings prevent expensive construction with rolling bearings and sealing elements for acid pumps.

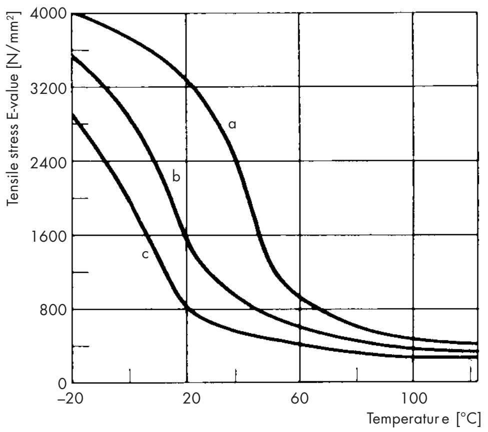
Moisture absorption of polyamide 6, 46 and 66 depending on the ambient humidity



Linear swelling (dimensional change) of PA depending on the humidity



Modulus of elasticity in the tensile test of PA 6 depending on the temperature and the humidity



a: 0.4 % humidity
b: 2.5 % humidity
c: 9 % humidity

Plastic slide bearings with lubrication or in dry running conditions

If no absolute dry run is required or the permissible load or sliding speed lie at the limits of the permissible values, lubrication must be applied. This is of benefit to the friction coefficient as well as the wear. This also primarily affects the long-term use of slide bearings. When lubricating plastic slide bearings, a distinction is made between

– conventional lubrication using appropriate oil or fat lubricating films and
– an incorporated lubrication by means of embedding solid lubricants, such as PTFE and graphite, as well as liquid lubricants (oils).

In the initial phase of running increased abrasion will occur, after which a wear-reducing lubrication film is applied (e.g. PA 6 G LO with liquid lubrication or PA 6 G SL and PET-C SL with solid lubrication).

Conventional lubrication can take place as a one-off initial lubrication during assembly (with oils, fats, pastes) or as a system with intervals or even continuously. The type of lubrication should match the specified requirements as well as the type of plastic. Usually, these are mineral or synthetic based lubricants containing additives, though none made from MoS_2 or graphite. Our application engineers are happy to make appropriate recommendations. During the lubrication process, it must be ensured that lubrication oil or fat is not paired with dust or dirt particles, as this can result in a 'grinding paste' that can cause increased wear.
It must be emphasised that lubrication has advantages over pure dry runs in terms of the friction coefficient and wear. In terms of both mixed friction as well as full liquid friction, the lubrication film reduces the danger of excessive wear by keeping the sliding surfaces apart. Lubricating using lubricant varnish or powders does not have the desired success rate in the long run. Polyamides with MoS_2 also fail to bring any benefits, whereas PTFE qualities with carbon or graphite additives offer major advantages. The pv-values for dry running as well as lubricated slide bearings can be found in the table on page 12.9.
Wet running is taken to mean immersed bearings that were not lubricated, but rather run in a wet film made from water, acids, lyes, etc. By separating the two sliding surfaces as a consequence of the resulting of the adjusted lubrication or wet film, the quality of plastic in the tribological pairing ceases to play a significant role. A friction coefficient of 0.05 to 0.15 is established. Also permissible specific load can be increased in this case.
As previously mentioned, during wet runs with water and acids both the corrosion problem for metal parts as well as water absorption for polyamides must be borne in mind.

Design of slide bearings

Static slide bearings and guides

There is virtually no frictional heat for stationary bearings or at very low speeds (<0,03 m/s). For calculating the permissible bearing load F, deformation is the only limiting factor. Very often, such a deformation of approx. 2% is tolerated. The table on page 12.9 shows the maximum permissible average specific load bearing p (in N/mm^2) for the respective plastic for a deformation of approx. 2% in a standard atmosphere (+23 °C/50% RF). A distinction is made between short and long term values for non-chambered or chambered assembly for applications at higher temperatures, the correction factor as per the diagram must be taken into account.

Terms and units

F = load bearing (N)
p = specific load (N/mm^2)
(for bearing bushes: average specific load bearing)
A = loaded surfaces (mm^2)
v = Sliding or peripheral speed (m/s)
n = speed (min^{-1})
s = Bearing wall thickness (mm)
l = Bearing length (mm)
d = Shaft diameter (mm)
D = Outer diameter (mm)

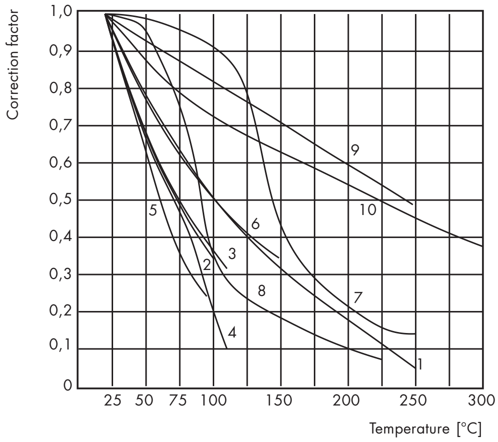
Calculating static slide bearing

A = loaded surface = Width x Length (mm^2) for sliding plates
= Diameter x Length (mm^2) for sliding plates

$$p = \frac{\text{specific}}{\text{Load bearing}} = \frac{F\ \text{(Load bearing)}}{A\ \text{(loaded surface)}} \left(\frac{N}{mm^2}\right)$$

(The calculated value p must be compared with the maximum permissible specific load static in the table on page 12.9 – it must be smaller!)
For ambient temperatures above +23 °C, the correction factor as per the diagram must be included.

Correction factor of the permitted spec. load depending on the temperature



1. PTFE 225
2. PA 6/66
3. POM
4. PET
5. PE-UHMW
6. PA 4.6
7. PEEK SL
8. PPS GF SL
9. VESPEL® PI SP21/PAI
10. PBI

Plastics for sliding functions and slide bearing calculation (Standard values in a standard atmosphere +23 °C/50% RH)

Designation acc. to DIN	APSOplast® designation	Modulus of elasticity ① ⑨	Service temperature ②	max. permissible slide bearing temperature	max. permissible pv-value ③ ⑪: dry-running conditions		with lubrication		max. permissible spec. load ⑩: Long-term values		Short-term values	Sliding friction coefficient dynamic ⑤	Sliding wear ⑥	Moisture absorption ⑦	Coefficient of linear thermal expansion ⑧	Factor of thermal elongation α ⑫: in a standard environment = 50% RH				in water or above 80% RH			
				$T_{max.}$	V=0.1 m/s	V=1.0 m/s	V=0.1 m/s	V=1.0 m/s	non-chambered ④	chambered	non-chambered					at +50 °C	at +70 °C	at +150 °C	at T_{max}	at +50 °C	at +70 °C	at +150 °C	at $T_{max.}$
		N/mm²	°C	°C	N/mm² · m/s	N/mm² · m/s	N/mm² · m/s	N/mm² · m/s	N/mm²	N/mm²	N/mm²	–	µm/km	%	10⁻⁶/K	α	α	α	α	α	α	α	α
PE-HMW	PE-HMW	1200	–100 to+80	+65	0.04	0.03	0.30	–	6	24	17	0.20–0.25	>100	0.01	180	0.006	0.005	–	0.012	0.006	0.010	–	–
PE-UHMW	PE-UHMW	>650	–260 to+95	+80	0.08	0.05	0.35	0.22	5	20	12	0.15–0.25	35	0.01	180	0.006	0.005	–	0.012	0.006	0.010	–	–
PA 6	PA 6	1400	–40 to+85	+80	0.12	0.07	0.40	0.25	15	50	33	0.25–0.50	19	2.6–9.0	90	0.009	0.011	–	0.013	0.030	0.032	–	–
PA 6 G	PA 6 G	1700	–30 to+105	+90	0.13	0.08	0.50	0.31	20	68	44	0.25–0.50	12	2.2–6.5	80	0.008	0.010	–	0.013	0.022	0.024	–	–
PA 6 G mod.	PA 6 G HS	1650	–30 to+120	+100	0.14	0.09	0.50	0.31	20	68	44	0.25–0.50	9	2.2–6.5	80	0.008	0.010	–	0.013	0.022	0.024	–	–
	PA 6 G PLUS	1550	–30 to+105	+90	0.13	0.08	0.50	0.31	18	60	40	0.25–0.50	12	2.3–6.6	80	0.008	0.010	–	0.012	0.022	0.024	–	–
	PA 6 G MO	1600	–30 to+105	+90	0.13	0.08	0.50	0.31	19	64	42	0.25–0.50	8	2.4–6.7	80	0.008	0.010	–	0.012	0.022	0.024	–	–
	PA 6 G SL	1500	–30 to+105	+90	0.39	0.25	0.50	0.31	17	58	38	0.10–0.25	4	2.0–6.3	80	0.007	0.009	–	0.011	0.021	0.023	–	–
	PA 6 G SL PLUS	1350	–20 to+105	+90	0.48	0.30	0.50	0.31	14	48	31	0.10–0.20	2.5	2.0–6.3	85	0.007	0.009	–	0.011	0.021	0.023	–	–
	PA 6 G LO	1450	–20 to+105	+90	0.23	0.15	0.50	0.31	17	58	38	0.15–0.25	4.5	2.0–6.3	80	0.007	0.009	–	0.011	0.021	0.023	–	
PA 66	PA 66	1650	–30 to+95	+90	0.13	0.08	0.50	0.31	18	60	39	0.25–0.50	14	2.4–8.0	80	0.008	0.010	–	0.012	0.026	0.028	–	–
PA 66 GF30	PA 66 GF30	3200	–20 to+120	+100	0.18	0.12	0.50	0.31	35	74	55	0.25–0.50	11	1.7–5.5	50	0.008	0.010	–	0.012	0.026	0.028	–	–
PA 66 mod.	PA 66 MO	1675	–20 to+95	+90	0.13	0.08	0.50	0.31	18	60	39	0.25–0.50	12	2.3–7.8	80	0.008	0.010	–	0.012	0.026	0.028	–	–
PA 4.6	PA 4.6	1300	–40 to+155	+120	0.16	0.10	0.55	0.35	19	64	42	0.25–0.50	18	2.8–9.5	80	0.009	0.012	–	0.017	0.031	0.033	–	–
POM-C	POM-C	3100	–50 to+115	+90	0.16	0.10	0.50	0.31	22	70	46	0.25–0.35	45	0.2–0.85	110	0.004	0.005	–	0.009	0.007	0.011	–	–
POM-H	POM-H	3300	–50 to+105	+90	0.16	0.10	0.50	0.31	24	75	50	0.25–0.35	40	0.2–0.85	95	0.004	0.005	–	0.009	0.007	0.011	–	–
	POM-H SL	3200	–20 to+150	+90	0.26	0.16	0.50	0.31	19	60	41	0.15–0.25	8	0.17–0.72	105	0.004	0.005	–	0.009	0.007	0.011	–	–
PET-C	PET-C	3700	–20 to+115	+90	0.15	0.09	0.50	0.31	40	84	62	0.25–0.35	3	0.25–0.5	60	0.003	0.004	–	0.006	0.003	0.005	–	–
	PET-C SL	3450	–20 to+115	+90	0.26	0.16	0.50	0.31	35	74	55	0.15–0.25	2	0.23–0.47	65	0.003	0.004	–	0.006	0.003	0.005	–	–
PPS mod.	PPS GF SL	3700	–20 to+220	+220	0.43	0.27	0.85	0.54	47	90	71	0.20–0.35	5	0.03–0.09	50	0.002	0.004	0.008	0.014	0.002	0.003	0.009	0.011
PEEK	PEEK	4400	–60 to+250	+250	0.33	0.21	0.95	0.60	49	93	73	0.25–0.50	28	0.20–0.45	50	0.002	0.005	0.007	0.018	0.003	0.004	0.009	0.011
PEEK mod.	PEEK SL FDA	3750	–20 to+250	+250	0.50	0.32	0.95	0.60	40	76	58	0.25–0.35	9	0.20–0.40	55	0.001	0.002	0.004	0.011	0.002	0.003	0.006	0.007
	PEEK SL	5900	–20 to+250	+250	0.66	0.42	0.95	0.60	57	100	83	0.20–0.30	2	0.14–0.3	30	0.001	0.002	0.004	0.011	0.002	0.003	0.006	0.007
PAI mod.	PAI SL	4500	–200 to+250	+250	0.32	0.20	0.95	0.60	59	100	74	0.25–0.50	5	2.5–4.5	30	0.004	0.005	0.006	0.010	0.005	0.006	0.008	–
	PAI SL PLUS	5800	–200 to+250	+250	1.10	0.69	1.20	0.76	73	115	88	0.10–0.40	1	1.9–3.5	25	0.003	0.004	0.005	0.008	0.004	0.005	0.006	–
PI mod.	VESPEL® SP-21	2800	–271 to+288	+250	2.10	1.32	1.70	–	45	88	54	0.30–0.40	3	1.0–2.0	40	0.003	0.004	0.007	0.012	0.004	0.006	0.007	–
PBI	PBI	5800	–250 to+310	+310	1.80	1.14	1.00	0.63	57	100	77	0.10–0.40	3	≤14	25	0.005	0.006	0.007	0.011	0.013	0.013	0.014	–
PTFE	PTFE	550	–200 to+260	+160	0.06	0.04	>0.50	–	5	30	10	0.08–0.10	>500	≤0.01	100–160	0.005	0.008	0.020	0.032	0.005	0.008	0.020	0.032
PTFE+carbon powder	PTFE 225	1275	–200 to+260	+200	0.60	0.50	>1.00	–	12	35	20	0.10–0.15	35	≤0.01	95	0.003	0.005	0.013	0.020	0.003	0.005	0.013	0.020
PTFE+Bronze	PTFE 660	1375	–200 to+260	+200	–	–	>1.00	–	12	40	22	0.10–0.15	–	≤0.03	85	0.003	0.004	0.012	0.018	0.003	0.004	0.012	0.018
PTFE fibrous tissue	Metal/PTFE fibrous tissue	–	–160 to+180	+150	0.60	–	>0.50	–	210	210	210	approx. 0.05	–	≤0.02	–	–	–	–	–	–	–	–	–
PTFE mod.	PTFE HP 108	900	–260 to+280	+260	~1.0	0.70	>1.60	–	12	35	20	0.15–0.28	4	≤0.02	70–95	0.002	0.005	0.014	0.024	0.002	0.005	0.014	0.024
	PTFE HP 110	900	–260 to+280	+260	~1.0	0.70	>1.60	–	12	35	20	0.12–0.25	4	≤0.02	70–95	0.002	0.005	0.014	0.024	0.002	0.005	0.014	0.024
	PTFE HP 117	900	–260 to+280	+260	~1.0	0.70	>2.00	–	12	40	22	0.15–0.25	3.5	≤0.02	85	0.002	0.004	0.011	0.018	0.002	0.004	0.011	0.018
	PTFE HP 115	850	–260 to+280	+220	~0.80	0.55	>1.60	–	10	30	18	0.10–0.20	30	≤0.02	95	0.002	0.005	0.014	0.024	0.002	0.005	0.014	0.024
	PTFE HP 125	850	–260 to+280	+221	~0.80	0.55	>1.60	–	10	32	19	0.10–0.20	30	≤0.02	105	0.003	0.005	0.015	0.024	0.003	0.005	0.015	0.024
PTFE mod.	PTFE 207	1800	–200 to+260	+260	0.40	0.25	1.00	0.63	14	48	20	0.15–0.25	5	≤2.0	100	0.003	0.004	0.007	0.014	0.006	0.007	0.010	0.013
	PTFE 500	2200	–200 to+260	+260	0.40	0.25	1.00	0.63	20	60	30	0.15–0.25	5	≤3.0	45	0.003	0.004	0.007	0.014	0.006	0.007	0.010	0.013
PVDF	PVDF	2300	–50 to+150	+150	0.16	0.10	0.55	0.35	14	45	31	0.25–0.50	455	≤0.05	130	–	–	–	–	–	–	–	–

① Tensile test in accordance with ISO 527
② Dimensional stability long-term regardless of the mechanical loading
③ In a dry run under conditions ⑤ und ⑥
Specific compressive load of thin-walled parts with a deformation of approx. 2%, non-chambered
⑤ In a dry run against steel (C35, Ra 0.7 to 0.9 µm, p=3 N/mm², v=0.33 m/s)
⑥ Under condition ⑤ on overall sliding distance of 28 km
⑦ Lower value for an indoor climate, upper value in water
⑧ In the temperature range +20 to +60 °C
⑨ Values for polyamides up to saturation in a standard atmosphere 23 °C/50% RH
⑩ Max. specific compressive load in a standard atmosphere (+23 °C/50% RH)
For higher temperatures, the correction factor from the ROT diagram must be taken into account
non-chambered = bearings exposed on the front side, e.g. pressed-in bearing bushes
chambered = bearings bordered by metal on all sides
⑪ For bearings with operational interruptions, the max. permissible pv values increase by the correction factor as per the ROT (Relative Operating Time) diagram
⑫ The factor of thermal elongation α serves the bearing clearance calculation and is dependent on the temperature and humidity. The max. permissible slide bearing temperature $T_{max.}$ can be inferred from the synoptic table above.

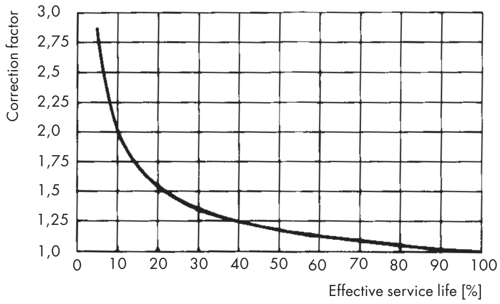
Note:
The values of the friction and wear tests are system values.
They are heavily dependent on the test conditions. They are therefore only provisionally viable as absolute values for specific applications, though are suitable for comparing materials.

Dynamic slide bearings (pv value)

As already mentioned previously, the maximum permissible sliding surface temperature should under no circumstances be exceeded to prevent undue wear. The pv-value – the product of the specific load p and the sliding surface v – must be determined as the key dimension for applications under dry-running conditions.

This is to be taken into account along with additional factors such as the ambient temperature, extreme wall thickness and edge pressure. If the calculated pv value exceeds the maximum dimensions stated in the table on page 12.9, a cooling or lubrication process must be arranged if the problem cannot be solved by increasing the load space.

ROT (Relative Operating Time) diagram



pv-value correction factor for operating conditions with interruptions

Calculating the dynamic slide bearings (pv-value)

Specific load

$$p = \frac{F \text{ (Load bearing)}}{A \text{ (Shaft diameter} \cdot \text{Bearing length)}} \quad \left(\frac{N}{mm^2}\right)$$

Peripheral speed

$$v = \frac{d \text{ (Shaft diameter)} \cdot \pi \cdot n \text{ (Speed)}}{1000 \cdot 60} \quad \left(\frac{m}{s}\right)$$

$$\text{pv-value} = p \cdot v \quad \left(\frac{N \cdot m}{mm^2 \cdot s}\right)$$

An upper limit is set on the sliding speed v in a dry run.
Even for minimum loads, the maximum value for PTFE, PA, POM, PETP and PE stands at approx. 2 m/s.
For slide bearings with interrupted operating conditions (cooling period), the pv values are increased as per the diagram.

12

Introduction

Plastics generally are known as excellent insulators, but are also sensitive to electrostatic charge. The mutual friction of the technical components that are responsible for the phenomenon of static electricity and its discharge cannot always be avoided. By choosing appropriate materials, however, static charge can often be prevented, right in the beginning.
The insulating properties are characterized by the resistance with which the material opposes the flow of electrical current. A distinction is made between volume resistance, which only considers the current flowing inside the material and excludes the amount flowing on the surface, and surface resistance. The latter is measured between electrodes placed on the surface. Different levels of conductivity are achieved by using electrically conductive fillers that can cope with special requirements.

Preventing electrostatic charge

At many production facilities, abrasion or damage to the process materials due to electrostatic charge can lead to breakdowns. An unintentional explosion is a purely accidental, unforeseeable occurrence in which an explosive mixture of material and a source of ignition come into contact with sufficient ignition energy at the same time and in the same place.
In order to make processes safer, this coincidents must be replaced by opposing safety mechanisms.
With ATEX-RL 94/9/EG (ATEX 95), a basis – for devices and protective systems intended for use in potentially explosive areas – was established and is applicable Europe-wide. This means, apart from avoiding explosive materials or concentrations, to apply correspondingly modified plastics which can eliminate ignition sparks by controlled discharging of electrical charge.
The good insulating properties of plastics can be altered stepwise by additives achieving statically dissipative and electrically conductive materials.
In the field of electrostatically dissipative plastics, anti-static additives – called anti-static agents – are often used.
Most conductive thermoplastic compounds contain fillers in the form of conductive soots, carbon fibres, metal powders or metal fibres. This group lies within a surface resistance value range of approx. 10^2 to 10^6 Ω and is therefore very attractive for technical solutions requiring explosion protection.

Electrostatically dissipative / electrically conductive plastics

Trade name of material		Surface resistance
PE-UHMW ED		10^6–10^8 Ω
PE-UHMW EC		< 10^6 Ω
PE-UHMW ED FDA		≤ 10^5 Ω
PE-UHMW FR		< 10^4 Ω
PVC-U FO		> 10^{15} Ω
PVC-U FO ED		10^{12} Ω
PA 66 CF20		10^2–10^4 Ω
POM-C ED		10^9–10^{11} Ω
POM-C EC		10^3 Ω
PMMA XT ED	electrostatically dissipative surface coating	10^6–10^8 Ω
PC EC	electrically conductive surface coating	10^5–10^7 Ω
POM-C ED	for material handling applications	10^9–10^{11} Ω
PEEK EC	at high temperatures and loads	10^2 – 10^4 Ω
PEI EC	excellent mechanical properties	10^4–10^6 Ω
PTFE EC	for high temperatures and low friction	10^4 Ω
PAI ED	high mech. strength at high temperatures	10^9–10^{11} Ω

Introduction

PTFE and silicone-coated fabrics offer unique properties. Both products are based on a glass or aramid fibre fabric which is impregnated with polytetrafluoroethylene (PTFE) or silicone. This combination results in a composite material which combines the superb chemical and physical properties of PTFE or silicone with the dimensional stability and mechanical stability of the glass fabric.

Properties

Polytetrafluoroethylene (PTFE)-coated fabrics:
Several grades of different PTFE-coated glass or aramid fibre fabrics provide a wide range of options for finding the right product for a range of different applications, such as for heat-seal beams in packaging machines, non-stick coatings in food processing, pharmaceuticals and chemicals systems, etc.

Key properties:
– Extremely non-stick surface
– Minimum friction coefficient
– Broad application temperature range (from –200 °C to +260 °C)
– Very high chemical resistance
– Resistant to mould, fungus and bacteria
– Non-toxic
– High level of mechanical strength and dimensional stability
– Low thermal elongation
– Good dielectric properties
– Permeability to microwaves and UV light

Silicone-coated glass fabrics:
Combine the excellent strength and dimensional stability of glass fabrics with the superb properties of the high-temperature-resistant silicone coating. This product offers excellent thermal and mechanical properties. The silicone coating also offers a higher level of frictional force than PTFE-coated glass fabric, while retaining the excellent non-stick properties, especially when in contact with sticky substances. With a maximum long-term use temperature of up to +250 °C, these fabrics can be used in an exceptionally wide range of applications, such as heat protection curtains, non-stick surfaces and non-stick belts, etc.

Key properties:
– Excellent non-stick properties up to +250 °C
– Good chemical resistance
– Very high wear resistance and high flexibility
– Good dielectric properties

Self-adhesive fabrics and belts

This range includes all PTFE-coated glass fabrics in rolls and cut to different widths. The fabric of these rolls is equipped with a pressure-sensitive adhesive coating on one side. This adhesive can be based on silicone or acrylic contact adhesive. Silicone contact adhesive offers an enormously wide continuous temperature range of application from –73 °C to +200 °C, over the short term up to +260 °C. Acrylic contact adhesive, in comparison, has a higher initial bond and an application range from –40 °C to +175 °C. The adhesive layer is protected by a protective film and can be removed before use.

PTFE-coated glass fabrics

Categorization and type of use		Grade	Nominal thickness mm	Nominal weight g/m²	PTFE content (nominal) %	Tensile strength lengthwise × horizontal N/cm	Standard width mm
Standard – roll material Ideally suited for general use. These fabrics have a smooth surface and exceptional non-stick properties They are primarily used as plastic foils in heat sealing and lamination procedures, and as non-stick surfaces for paints, adhesives, resins and food products.	■	203	0,070	130	63	180 × 140	1000
	■	205	0,120	250	58	290 × 260	1000
	■	310	0,225	470	56	520 × 410	1000
	■	314	0,315	630	54	660 × 510	1000
Premium – roll material Extra thick PTFE coating for transport belts which require an extra smooth surface, e.g., laminate plastic foils and other heat-seal and non-stick applications.	■	206	0,140	300	65	310 × 260	1010
Anti-static – roll material Non-stick, semi-conducting coatings with carbon fibres for semi-conducting and anti-static material properties. These properties prevent or reduce electrostatic charges on sliding and frictional applications.	■	205 ED	0,120	250	58	300 × 280	1000
	■	310 ED	0,225	470	56	520 × 410	1000

■ Standard, in stock

Note:
All fabrics are available in different roll widths.
The data on nominal strength and tensile strength are to be understood as indicative and not as minimum values. A complete and up-to-date product specifications data sheet is available from our customer service department. The available widths are subject to occasional changes. Certain widths may be removed from the range, while others may be added. Details are available upon request.
Weight g/m² ±5% process fluctuations, PTFE content ±2% process fluctuations.

PTFE-coated fabrics (self-adhesive on one side)

Categorization and type of use		Grade	Nominal Thickness without adhesive mm	Weight g/m²	PTFE content %	Adhesive thickness Micron	Adhesive strength N/cm	Roll width mm
Industrial – roll material Medium PTFE coating, primarily used in the packaging industry and as plastic foils during the production of plastic bags.	■	203 SA	0,070	130	63	45	5,3	1000
Standard – roll material For almost all applications which require a smooth surface. A product with exceptional non-stick properties. Primarily used as plastic foils in heat sealing and lamination procedures, and as non-stick surfaces for paints, adhesives, resins and food products.	■	205 SA	0,120	250	58	45	6,2	1000
	■	310 SA	0,225	470	56	45	7,5	1000
Premium – roll material Extra thick PTFE coating for special applications which require an extra smooth surface, e.g. laminate plastic foils and other heat-seal and coating applications.	■	206 SA	0,140	300	65	45	6,3	1010
Anti-static – roll material Non-stick, semi-conducting coatings with carbon fibres for semi-conducting and anti-static material properties. These properties prevent or reduce electrostatic problems on belt and slip sheet applications.	■	205 ED SA	0,120	250	58	45	6,2	1000
	■	310 ED SA	0,225	470	56	45	7,5	1000

■ Standard, in stock

Note:
All fabrics are available in different roll widths.
The data on nominal strength and tensile strength are to be understood as indicative and not as minimum values.
A complete and up-to-date product specifications data sheet is available from our customer service department. The available widths are subject to occasional changes. Certain widths may be removed from the range, while others may be added.
Details are available upon request. Weight g/m² ±5% process fluctuations, PTFE content ±2% process fluctuations.

SILICONE-coated glass fabrics

Categorization and type of use		Grade	Nominal thickness without adhesive	Weight	Tensile strength lengthwise × horizontal	Roll width	Roll length
			mm	g/m²	N/cm	mm	m
Coated both sides – roll material This type of silicone-coated glass fabric is often used in the packaging industry for curtains in front of continuous furnaces.	■	S–6006 W	0,180	260	200 × 90	1000	50
Coated one side – roll material This group is used mostly as economic disengaging cylinders for pressure plates or rollers, as low cost buffers and as covers.	■	S–6014 W OS	0,260	360	–	1000	50

■ Standard, in stock
W white coating
OS coating on one side

Note:
All fabrics are available in different roll widths.
The data on nominal strength and tensile strength are to be understood as indicative and not as minimum values.
A complete and up-to-date product specifications data sheet is available from our customer service department. The available widths are subject to occasional changes. Certain widths may be removed from the range, while others may be added.
Details are available upon request. Weight g/m² ±5% process fluctuations, silicone content ±2% process fluctuations.

Processing of semi-finished plastic products

Guidelines for the processing of semi-finished plastic products

To become acquainted with the diverse world of plastics, considerable training and many years of experience are required. Our specialist consultants keep constant track of what the market is able to offer to ensure they are a competent dialogue partner for you. Our well-stocked warehouse and our cooperation with excellent partners guarantees you high stock availability in all current materials and sizes.
Thermoplastics and reinforced plastics can be processed without any problem on standard metal processing machines and on wood processing machines for rough machining. To achieve the best results it is necessary to take the special properties of the plastics into account.
Due to the poor heat conductivity and the relatively low melting temperatures of thermoplastics it is necessary to ensure that as little heat as possible develops during processing and/or is transferred to the component that is to be processed.
To prevent the consequences of a thermal overstraining of the plastic (colouration or even melting of the surface), it is necessary to take the following points into account:
– Only use tools which are properly sharpened
– Ensure the proper dissipation of heat (provide air or water cooling)

The considerably larger thermal expansion of plastics (up to ten times higher compared with steel) have to be taken into account. Measurements have to take place at +23 °C.
Since the forces that are generated during the machining of technical plastics are considerably lower than with metals, this means lower clamping forces are also sufficient. Excessive clamping forces often cause distortions to the components. Prevent every possibility of the component being able to come free from the clamping system. As plastics are not as stiff as metals it is important for them to be supported during processing in order to prevent their being pushed away or distorted. During the processing of thin-walled bushings. for example, a core can be used to provide stabilization in order to be able to achieve a good concentric running out and smaller tolerances.

Tools

HSS tools are suitable for many plastics. In the case of serial production, hard metal and ceramic tools or diamond cutters are preferred and are indispensable in the processing of thermoplastics with graphite, glass fibre or carbon fibre additives, and especially with glass filled thermosets (long lifespan of the tools and high surface quality). Working with diamond tools is also recommended when processing PBI or PAI, because optimum results can be achieved. Hard metal tools can be used with very short work sequences.

Cooling

With the exception of drilling, cooling is not normally a necessity with thermoplastics. If the cutting surface is cooled, however, superior surfaces and/or tolerances can be achieved.
Where cooling is required due to high processing temperatures the standard coolants or drill emulsions can be used. This does not apply to amorphous plastics, however, which have a tendency to develop stress cracking, such as PC, PSU, PPSU, PEI, PEI EC, etc. For these materials, pure water or compressed air are the most suitable coolants.
If it is impossible to avoid the use of liquid coolants on an oil soluble basis or universal oil during the cutting of amorphous thermoplastics (e.g. during large diameter drilling and/or drilling deep holes or thread-cutting), the parts have to be cleaned with isopropyl alcohol immediately after cutting and then rinsed with pure water in order to keep the risk of developing cracks as low as possible.
A strong jet of compressed air or coolant removes chips from the component so that they do not get wrapped around the cutting tool.

Dimensional stability and processing tolerances

The processing tolerances for parts made from plastics are considerably greater than those on metal components.
The reasons for this are as follows:
– The considerably greater coefficient of thermal expansion of plastics
– The change in volume due to a possible moisture absorption (primarily with polyamides)
– Warping and/or distortion occurring during and after processing because of the releasing of residual stress
The latter phenomenon has an especially serious effect on large volume changes of cross-sectional dimensions and on components for parts that are machined assymetrically. In many cases, depending on the necessary tolerances, a thermal treatment proves to be necessary (procedure to reduce the residual stress) after pre-processing and prior to the completion of the final processing (see corresponding temperature guidelines).
As a basic rule, it is the case for turned and milled components in order to comply with a dimensional tolerance of 0.1 to 0.2% of the nominal dimensions and this without any especial precautionary measures (the minimum tolerance for small dimensions is 0.05 mm). In this context it is possible to use the ISO 2768 (formerly DIN 7168) and the Swiss 'Statement of recommendations on plastics tolerances' from the specialist group FABH of the specialist association KVS as a guideline.

Mechanical processing methods

The recommended tool cutting angles, cutting speeds and feeds are provided in the table ‘Standard values for the machining of plastics’.

Turning

During turning and drilling it is possible to achieve a continuous removal of chips by using a suction device (direct disposal of chips). For surfaces of especially high quality cutting edge is to be executed as a broad finishing cutter. During cutting the cutter (image 4) should be sharpened in order to prevent the formation of burrs. On thin walled, and especially flexible components by contrast, working with sharpened blade-like tools is advantageous (images 2 and 3).

Milling

During milling, elongated hole milling cutters, plane milling cutters or cylindrical milling cutters can be used. For flat surfaces, face milling is more economical than circumferential milling. During circumferential and form milling the tools should not have more than two cutters to ensure vibrations remain limited due to the number of cutters and the chip spaces are big enough. Single cutter tools offer the advantage of the most optimum removal of chips, cutting performances and surface quality.
The recommended tool cutting angles, cutting speeds and feeds are provided in the table ‘Standard values for the processing of plastics’.

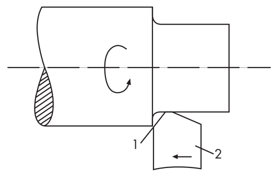
Drilling

HSS spiral drills can generally be used. These should have an angle of twist of 12° to 16° and have very smooth helical grooves for the good removal of chips. Good cooling with a liquid coolant is required under all circumstances during drilling because of the considerable build up of heat. To achieve a good removal of heat and chips, the drill should be regularly removed from the drill hole, especially in the case of deep drilling. Larger diameters should be pre-drilled in advance and/or created using a hollow drill or via trepanning off. When drilling into solid material it is especially necessary to ensure the drills are properly sharpened otherwise the compressive stress can cause the material to split.
Reinforced plastics (such as PEEK SL or PEEK GF30, PA 66 GF30, etc.) have higher residual processing stresses and a lower impact resistance than non-reinforced plastics and are therefore particularly sensitive to cracking. Where possible, they should be heated up to between +120 and +150 °C before drilling (heating time approx. 1 hour per 10 mm cross-section). It is necessary to ensure that subsequent to drilling, meaning prior to further processing, the component has to be allowed to cool back down to room temperature.

Sawing

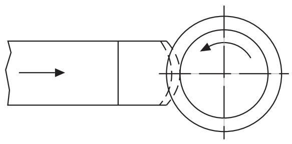
Band saws, circular saws and hack saws with a relatively big tooth pitch and tooth setting are especially suitable so that a good removal of chips is achieved and the saw blade is not obstructed. To prevent vibrations and the resulting rough edge trims or even breakages, it is necessary for the parts requiring cutting to be properly clamped on the workbench.
Please note: Reinforced materials should ideally be cut with a band saw, the blade of which has a tooth pitch of 4 to 6 mm (PBI: 2 to 3 mm). The use of circular saws often causes cracks and is not therefore recommended.

Image 1



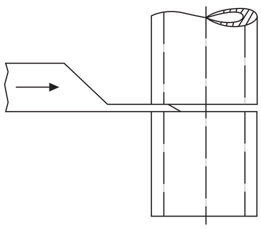
1 Secondary cutter
2 Lathe tool

Image 2



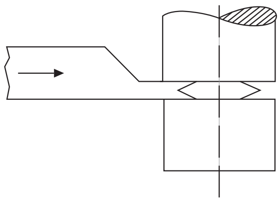
Cutting of flexible plastics

Image 3



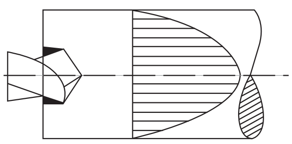
Cutting of flexible plastics

Image 4



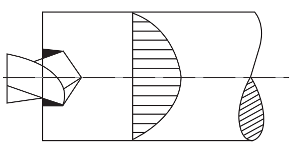
Proper sharpening prevents burr formation

Image 5



Stress formation of blunt drills

Image 6



Stress formation of sharp drills

Allocation of tolerance series (recommendation)

Dimensions stating tolerances

Tables according to DIN ISO 286-1 (SN EN 20286-1)
ISO-Tolerance qualities in 0.001 mm (µm)

For milled plastic parts

Nominal dimensions	ISO-tolerance class										
	6	7	8	9	10	11	12	13	14	15	16
≥ 1 ≤ 3 mm	6	10	14	25	40	60	100	140	250	400	600
> 3 ≤ 6 mm	8	12	18	30	48	75	120	180	300	480	750
> 6 ≤ 10 mm	9	15	22	36	58	90	150	220	360	580	900
> 10 ≤ 18 mm	11	18	27	43	70	110	180	270	430	700	1100
> 18 ≤ 30 mm	13	21	33	52	84	130	210	330	520	840	1300
> 30 ≤ 50 mm	16	25	39	62	100	160	250	390	620	1000	1600
> 50 ≤ 80 mm	19	30	46	74	120	190	300	460	740	1200	1900
> 80 ≤ 120 mm	22	35	54	87	140	220	350	540	870	1400	2200
> 120 ≤ 180 mm	25	40	63	100	160	250	400	630	1000	1600	2500
> 180 ≤ 250 mm	29	46	72	115	185	290	460	720	1150	1850	2900
> 250 ≤ 315 mm	32	52	81	130	210	320	520	810	1300	2100	3200
> 315 ≤ 400 mm	36	57	89	140	230	360	570	890	1400	2300	3600
> 400 ≤ 500 mm	40	63	97	155	250	400	630	970	1550	2500	4000

Dimensional corrections: **A,** IT 10 bis 13 **B,** IT 11 bis 14

For turned plastic parts

Nominal dimensions	ISO-tolerance class										
	6	7	8	9	10	11	12	13	14	15	16
≥ 1 ≤ 3 mm	6	10	14	25	40	60	100	140	250	400	600
> 3 ≤ 6 mm	8	12	18	30	48	75	120	180	300	480	750
> 6 ≤ 10 mm	9	15	22	36	58	90	150	220	360	580	900
> 10 ≤ 18 mm	11	18	27	43	70	110	180	270	430	700	1100
> 18 ≤ 30 mm	13	21	33	52	84	130	210	330	520	840	1300
> 30 ≤ 50 mm	16	25	39	62	100	160	250	390	620	1000	1600
> 50 ≤ 80 mm	19	30	46	74	120	190	300	460	740	1200	1900
> 80 ≤ 120 mm	22	35	54	87	140	220	350	540	870	1400	2200
> 120 ≤ 180 mm	25	40	63	100	160	250	400	630	1000	1600	2500
> 180 ≤ 250 mm	29	46	72	115	185	290	460	720	1150	1850	2900
> 250 ≤ 315 mm	32	52	81	130	210	320	520	810	1300	2100	3200
> 315 ≤ 400 mm	36	57	89	140	230	360	570	890	1400	2300	3600
> 400 ≤ 500 mm	40	63	97	155	250	400	630	970	1550	2500	4000

Dimensional corrections: **A,** IT 9 bis 11 **B,** IT 10 bis 13

Dimensions without stating tolerances

Tables according to DIN ISO 2768-1 (SN EN 22768-1)
(previously DIN 7168/SN258440, not for new constructions)

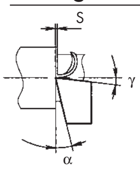
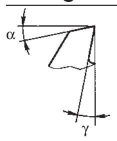
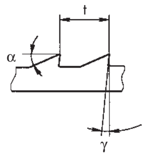
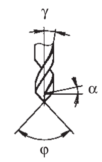
Recommended general tolerance for milled parts and turned parts

	Nominal dimension range							
Degree of precision	up to 6 mm	over 6 up to 30 mm	over 30 up to 120 mm	over 120 up to 400 mm	over 400 up to 1000 mm	over 1000 up to 2000 mm	over 2000 up to 4000 mm	over 4000 mm
fine	±0.05	±0.1	±0.15	±0.2	±0.3	±0.5	–	–
medium	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2	±3
rough	±0.2	±0.5	±0.8	±1.2	±2	±3	±4	±5
very rough	±0.5	±1	±1.5	±2.5	±4	±6	±8	±10

Recommendation:
For technical machine components with dimensioning without stating tolerances the degree of accuracy is m (medium), and in special cases f (fine) is to be chosen.

Processing by machining

Guidelines for the machining of plastics

Processing method	Formula-sign	Unit	Elastic Plastics	Thermoplastics					Duroplastics
			e.g. PUR from 90 Shore A	soft **PE, PP, PTFE**	semi-rigid **PA, PC PVDF**	rigid non-reinforced **Hard PVC, POM, PET, PPE, PMMA, PEEK**	rather brittle **PSU, PEI, PAI, PBI grades reinforced with short glass fibres**	**Laminated paper fabrics, Laminated cotton fabrics Hp, Hgw, PI**	**Laminated glass fabrics, EP-Hgw, Pultruded profiles UP-GF**
			HSS ①	HSS ①	HSS ①/HM ②	HSS ①/HM ②	HM ②	HM ②	Diamond ③
Turning 									
Clearance angle	α	°	8–10	10–15	5–15	5–15	5–10	10–15	5–11
Rake angle	γ	°	25	5–10	0–10	0–10	2–6	5–25	0–12
Cutting speed	v	m/min	100–150	200–300	200–500	200–500	200–400	100–300	<40
Feed rate	S	mm/U	0.1–0.3	0.05–0.5	0.05–0.5	0.05–0.5	0.1–0.2	0.05–0.5	0.05–0.2
Milling 									
Clearance angle	α	°	10	5–15	5–15	5–15	5–15	up to 15	up to 10
Rake angle	γ	°	25	5–10	0–15	0–15	1–6	5–15	5–15
Cutting speed	v	m/min	200–400	<500	200–500	<200	<200	100–200	<200
Feed rate	S	mm/tooth	>0.05	0.1–0.5	<0.05	<0.05	<0.05	0.05–0.5	0.05–0.2
Sawing 									
Clearance angle	α	°	20–40	20–30	10–15	10–15	15–20	30–40	Diamond-cutting disc
Rake angle	γ	°	5–10	5–8	0–15	0–15	0–10	3–6	
Cutting speed	v	m/min	~2000	<3000	<3000	<3000	<3000	<4000	
Tooth pitch	t	mm	5–10	3–8	8–45	8–25	8–25	6–10	
Drilling 									
Clearance angle	α	°	8–10	10–16	10–12	5–10	5–10	8–12	Diamond bit
Rake angle	γ	°	80	3–5	3–5	3–5	3–5	6–10	
tip	φ	°	>90	90	90–120	90–120	90–120	80–90	
Cutting speed	v	m/min	40–50	50–200	50–100	50–100	50–80	100–120	
Feed rate	S	mm/U	0.01–0.04	0.1–0.5	0.1–0.3	0.1–0.3	0.1–0.3	0.04–1	

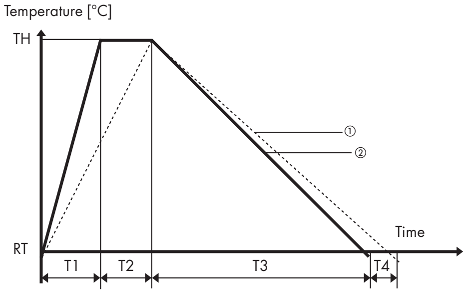
① HSS-tool
② Carbide-tipped tool
③ Diamond-coated tool

Heat treatment of plastics (annealing)

Annealing is a thermal treatment which serves the following purposes:
– Increases the crystalline value to improve mechanical strength and chemical resistance
– Reduces internal stress which may be caused by extrusion or cutting
– Increases the dimensional stability over a wide range of temperatures

Semi finished products from Angst+Pfister have already been subjected to a tension reducing annealing process, through which the residual stresses that occur through the production process are reduced to a minimum. This guarantees optimum dimensional stability during and after the mechanical processing.
Should there be special requirements (tolerances, warping…) on the processing of plastic semi-finished products using machining processes, it is recommended under certain circumstances that an interim annealing process is carried out after rough machining and prior to the final machining, in order to achieve the best dimensional stability and resistance. The annealing of plastics can be carried out in air, nitrogen or oil. With applications in air at over +100 °C, with polyamide in particular (natural) as a result of oxidation, discolouration may occur on the surface, which mostly disappears again during the mechanical processing. A second approach is to store the component under environmental conditions for at least 48 hours prior to the final processing, thereby allowing it to stabilize.

Recommended annealing process



RT: Room temperature
TH: Holding temperature
T1: Required heating time for oven or oil bath; heating rate: 10–20 °C per hour
T2: Holding time in order to reach the temperature equilibrium in the centre of the plastic component, dependent on the wall thickness: 10 minutes per mm wall thickness
T3: Required time to cool the oven or oil bath down; Cooling rate: 5–10 °C per hour
T4: Additional time required to reach room temperature in the centre of the component
Depending on wall thickness: 3 minutes per mm wall thickness

① Temperature in the centre of the plastic component
② Temperature of oven or oil bath

Standard temperature values for heat treatments (annealing)

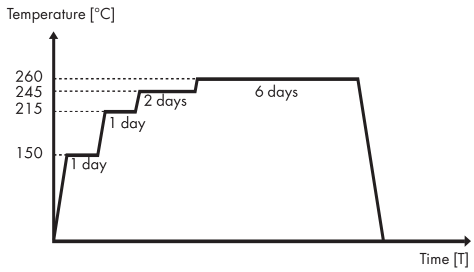
Plastic	Temperature °C
PVC-U (Hard PVC)	65
PE	120
PP	140
PMMA	80
PC	130
PA 6, PA 66	150
PA 66 GF30	170
POM-H and POM-C	150
PET-C	150
PPE	130–160
PSU	170
PPSU, PEI	200
PPS	200
PEEK	250
PAI	①
PI	220–260
PBI	②
PTFE	250
PVDF	150
PCTFE	160–200

① **PAI** To achieve a maximum chemical resistance as well as the highest abrasion resistance, PAI can be annealed after the final mechanical processing, or in the case of critical dimensions, in advance. This thermal treatment can be carried out in an air or nitrogen oven. If the mechanical processing is completed afterwards the mechanical removing of the surface rate should total more than 0.5 mm, so that the improved mechanical and chemical values are maintained. Although the ideal cross linking cycle depends on the design and geometry of the parts, according to the following diagram, a wall thickness of up to 12 mm can be assumed for parts.

During thermal treatment in air the surface colour of PAI SL changes to dark brown as a result of lower oxidation. This does not have any influence on the properties, however. During treatment in nitrogen this phenomenon does not occur.

② **PBI** The stated annealing process can also be applied to PBI. The heating process should take place in a nitrogen convection oven with a holding temperature of + 20°C above the expected operating temperature (min. +150 to max. +350 °C). If the temperature of the annealing process is over +200 °C it is recommended that the component is pre-dried at +150 °C for 24 h.

Heating and cooling speed



Heating and cooling speed: 10–20 °C per hour

Important information

Environmental conditions

The basic tolerances suggested here and/or the maximum dimensions permitted can only be maintained if the parts are stored without interruption in standard atmosphere 23/50 (+23 °C at 50% RH). Only brief or minimal deviations from them are permitted.

Measuring technology

In comparison with metals, the measurement of – narrow-tolerance dimensions on plastic components – is rather difficult. In this context, for example, soft thermoplastics become deformed under the pressure of micrometer spindles, and their tightening torque is seriously falsified due to the lowest frictional values. For this reason, non-contact measuring systems are worthwhile. In critical cases, the measuring methods are to be specified between the manufacturer and enduser subsequent to agreement.

Geometric form

On parts with an extreme diameter-length relationship or with thin wall thicknesses, the suggested series of tolerance are to be corrected accordingly.

Bonding of plastics

Bonding is the joining of components with an adhesive layer. The adhesive hardens through drying or a chemical reaction and therefore holds the materials together. Two factors influence the quality of a bonding:

Adhesion (interfacial adhesion)

Adhesion is the connecting force between molecules from two different materials and/or the bonding of two materials or objects with each other.

Cohesion (the internal stability of the adhesive)

Cohesion is the coherence of the adhesive components (molecules) with each other. The higher the cohesion, the higher the stability of the adhesive.

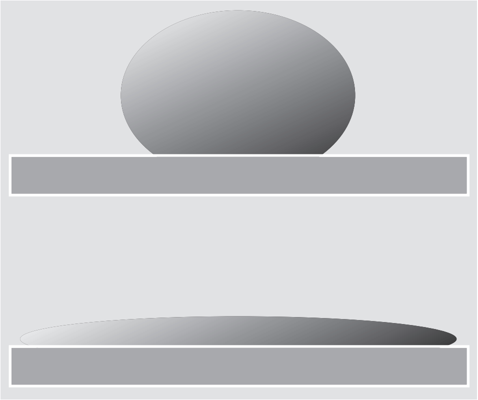
The joining areas are pretreated with one of the treatment procedures (listed in terms of the increasing stability of the adhesive joint):
1. Cleaning and degreasing
2. Cleaning, degreasing and grinding
3. Cleaning, degreasing and chemical pretreatment

In general amorphous thermoplastics bond together well. Their bonding strength with adhesives is very good. In most cases it is sufficient if the bonding surfaces are cleaned, degreased and roughened with abrasive paper.
It is more difficult to bond semi-crystalline thermoplastics, which do not allow the adherence of adhesive agents because of their non-polar surfaces. Technically flawless bonding with a good tear strength is only possible subsequent to pretreatment with singing, electrical discharging (corona procedure), plasma or etching.
Thermosets in the form of laminated materials on a PF, MF, EP and UP basis as well as GFK elements and profiles on a UP and EP basis do not provide any problems for high-strength technical bonding. For these materials, as well as for fibre composite finished parts with supporting functions, two component reaction adhesives on an MMA, EP or PUR basis are used only.

Surface energy, interfacial energy, polarity

The printing or bonding of plastic components requires easy wettability of the plastics surfaces. In this context the «wettability» is described with the surface energy.
High energy (polar) surfaces offer the print colour or the adhesive superior bonding than low energy (non-polar) surfaces.
With printing it is generally the case that the surface energy of the surfaces to be printed on must be at least as high as the surface tension of the print colour.
The wettability of plastics can be evaluated quickly and easily by dripping water onto the surface. If a drop of water forms the surface is low energy. If the drop of water rolls away, it is a high energy surface.

The test with the water drop



The water drop shows whether a surface is low energy (above) or high energy (below).

Critical surface energy

Material designation	Abbreviation	Critical interfacial energy σc
	ISO 1043-1	mN/m ①
Polystyrene	PS	32.8–43
Polymethylmethacrylate	PMMA	33–44
Polycarbonate	PC	33–37
Polyvinyl chloride	PVC	39–40
Polyethylene	PE	31
Polypropylene	PP	29
Polyamide 6	PA 6	42
Polyamide 66	PA 66	40–46
Polyethylene terephthalate	PET	43
Polyoxymethylene, Polyacetal	POM	36
Polytertafluorethylene	PTFE	18
Polyurethane	AU/EU (PUR)	42–50
Aluminum	Al	1200
Chrome	Cr	2400
Iron	Fe	2550
Water	H_2O	72.8

① The surface tension is measured by surface energy ink and measurement pods.

Physically bonding adhesives

Physically bonding adhesives are those in which the bonding only occurs through physical processes. They contain thermoplastic resins or rubbers as their basic materials.

Contact adhesives

A contact adhesive is the designation for a subgroup of solvent adhesives, the raw material basis of which consists of resins and synthetic rubber. Contact adhesives are suitable for the bonding of wood, metal, leather, plastics, rubber and cellular products. The advantage of contact adhesives is that they enable the bonding of non-porous materials.
Contact adhesives are applied to both of the parts that are to be bonded. After the flash-off period (evaporation of the solvent) of 5 to 15 minutes is over, both sides are bonded together, at as high a degree of pressure as possible. A long pressing time is not required to ensure the bonding, the most important thing is the level of pressure. Bonding work with contact adhesives is immediately strong and durable and also stays flexible (e.g. bonding of shoe soles).

Diffusion adhesives

This solvent based, physically drying adhesive is used for the bonding of PVC-U and other thermoplastics. The bonding process is also known as ‘swell welding’. The adhesive is applied to both sides of the surfaces requiring bonding using a brush. In this context it is necessary to ensure that not too much adhesive is applied as the solvent will otherwise attack the base material (stress corrosion). If the adhesive is applied, it starts to swell the plastic. The bonding of the parts must take place within a few minutes as otherwise the rapid formation of a dried skin (refer to technical worksheet) will impair the bonding. After the application of the adhesive the parts are either joined or pushed together. The advantage of this form of bonding is that the bonded joint has the same properties as the base material (in the event of pressure and temperature load).

Pressure-sensitive adhesives

Pressure-sensitive adhesives are products which remain permanently adhesive. These permanently adhesive materials are used if permanent bonding is not necessary and separation at a later date is required.

Dispersion adhesives
Dispersion adhesives contain thermoplastic resins or rubbers that are dispersed in water. They are suitable for the surface bonding of porous materials which can absorb and release water, between each other or with dense materials.

Chemically bonding reaction adhesives

Chemically bonding reaction adhesives contain reaction resins as their base materials which cure in the adhesive layer. Depending on the material an etching or the application of a primer on the surface to be joined can be helpful.

Single component reaction adhesives
Single component adhesives are adhesives that depending on their type, react with air humidity, UV light or oxygen (aerobic adhesives) or, under the exclusion of air, with metal ions (anaerobic adhesives). With single component adhesives the adhesive is applied to one side of the bonding area. The reaction starts immediately due to the reaction components in the environment or on the surface to be bonded. Single component reaction
adhesives are based on:
– Dimethacrylatester (anaerobic sealing agent)
– Cyanacrylate (superglue)
– Polyurethane (PUR)
– Silicone rubber

Dual component reaction adhesives
Depending on their type, dual component adhesives consist of liquid, paste or powder type components. As a rule, they have to be mixed exactly in the stated mixing ratio. Only a limited processing time (pot life) is available for use. The hardening starts immediately. The hardening times also depends on the type of adhesive and the environmental temperature. The bonding area has to be fixed prior to the complete hardening.
Dual component reaction adhesives are based on:
– Methylmethacrylate (MMA)
– Epoxy resin (EP)
– Polyurethane (PUR)

Protective measures

– Ensure good ventilation
– Wear protective gloves
– For single and dual component materials: wear protective goggles
– Comply with the instructions
– Comply with the safety datasheet

Choice of adhesive

The following table is intended as a general classification for the selection of the adhesive.

Please note:
Not every adhesive is equally suitable for every material. Special adhesives are often suitable for certain materials. In general, practical experimentation is necessary for the bonding of plastics and metals. Contacting experienced adhesive manufacturers is also recommended.

Guideline for the preselection of the adhesive

Material	Solvent Adhesives	1 comp. – Reaction adhesives				2 comp. – Reaction adhesives		
		anaerobic	Cyanacrylate (superglue)	Polyurethane (PUR)	Silicone-rubber	Methylmeth-acrylate (MMA)	Epoxy resin (EP)	Polyurethane (PUR)
PVC	●	–	●	●	–	●	●	●
PS, SB, PS-foam	–	–	●	●	–	●	●	●
PE, PP	–	–	○	○	–	–	○	○
PMMA, PET-A, PC	●	–	●	●	–	●	●	●
PA, PET-C	○	–	○	○	–	–	○	○
POM	–	–	○	○	–	–	○	○
PPE, PEI, PSU, PPSU	●	–	●	●	–	●	●	●
PPS, PEEK	–	–	○	○	–	–	○	○
PI	●	–	●	●	–	–	●	●
Fluoroplastics	–	–	○	○	–	–	○	○
Thermosets	●	–	●	●	–	●	●	●
Silicone rubber	–	–	–	–	●	–	–	–
FPM	●	–	●	●	–	–	–	●
EPDM	●	–	●	●	–	–	–	●
PUR	–	–	●	●	–	–	–	–
NR, SBR, CR, NBR	●	–	●	●	–	–	–	●
Thread seal/-lock	–	●	–	–	–	–	–	–
Wood, textiles	●	–	●	●	–	●	●	●
Glass, ceramics, stone	●	–	●	●	–	●	●	●
Metals	●	–	●	●	–	●	●	●

○ only possible with corresponding pre-treatment

Hazard symbols (H and P sets)

Adhesives can contain hazardous products. The use of such products and/or mixtures is defined in the EU directive (EC) no. 1272/2008 'Classification, Labeling and Packaging of Substances and Mixtures', also defined as the CLP directive. This guideline replaces and/or changes the prior guidelines 67/548/EEC, 1999/45/EC and directive (EC) no. 1907/2006.
In the new guideline the previous R-statements are replaced with H-statements (Hazard Statements) and the S-statements are replaced with P-statements (Precautionary Statements). This guideline also contains a list of hazardous materials. In this list the corresponding hazard pictogram and the corresponding H- and P-statements are provided for every hazardous substance. For certain preparations, combinations of hazard pictograms and wide ranging H- and P-statements can apply. The specified hazard pictograms are defined globally on a uniform basis (GHS, Globally Harmonized System of Classification, Labelling and Packaging of Chemicals) and are also understandable without explanatory text.
The H-statements describe hazards which can result from chemical materials or preparations; the P-statements provide precautions/safety measures that are required to be taken with their use.
The H- and/or P-statements are supplemented with a three figure code which defines the type of hazard and the associated safety measures. The wording for the individual codes is standardized in the EU guideline in several languages.

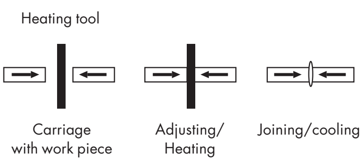
Welding of plastics

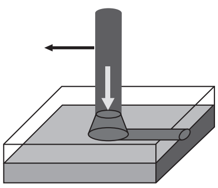
A common bonding technique for plastics is welding. This means the bonding of thermoplastic materials under the application of heat and pressure with or without filler material. Depending on the process the corresponding design guidelines are to be complied with during the design phase.
Plastics welding is attributed with a considerable level of importance in apparatus and pipeline construction; welding is also an important bonding procedure in mounting and joining of technical parts, joining of plastic flims in construction and the processing of packaging film.
Theoretically, all thermoplastic synthetics can be welded. Since welding is carried out in the thermoformable state of joining surfaces, the possibility of plasticizing is an important criterion for welding plastic materials. This means that due to their considerable molecular mass and/or their structure, the materials PTFE, PMMA (cast) and PE, with their very high molecular weight like PE-UHMW, are very hard to plasticize,
and cannot therefore be technically welded.

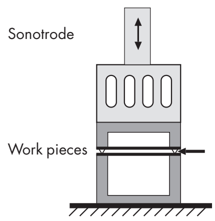
Subsequently, only similar thermoplastics can be welded with each other. With high performance plastics it is important that very high energy input is to be applied for the plasticization of the material.

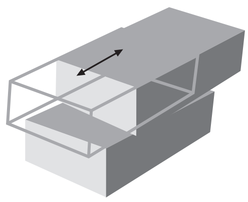
Comparison of welding processes

Process	Heated tool and hot gas welding	Laser welding	Ultrasound welding	Vibration / friction welding
Principle	Heating of elements to be joined through a heat tool or with hot gas joining under pressure	Heating of elements to be joined through a laser beam	Heating of a joint to be bonded (with special geometry) through ultrasound vibration	Heating of elements to be joined through vibration or friction, joining under pressure
Welding time	20 to 40 s		0.1 to 2 s	0.2 to 10 s
Advantages	high strength, low cost	high strength, nearly all seam geometries, high precision	short cycle times, light automatable	suitable for large components, oxidization sensitive plastics are weldable









1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Chemical resistance of plastics

The information provided below is of guideline character only and only serves general information.
It is based on our current technical knowledge and experience and on the available literature and information from raw materials manufacturers and cannot be transferred to all operating conditions. We are therefore unable to assume any guarantee and exclude all claims for compensation.
The evaluation can also be influenced by codetermining factors such as increased temperatures, high concentrations, duration of exposure, high permanent mechanical loads, dynamic stress, the effect of light and sun and further additional influences. The following information on chemical resistance was determined in the normal concentrations and unless stated otherwise at room temperature. For specific cases it is necessary to carry out individual tests, taking the operating conditions into account, with the operating conditions with the specific semi-finished product or finished part.
In the 'Chemical resistance of plastics' table, only pure media are stated. The effects that mixtures have on plastics are hard to predict. The effect may be greater or smaller than the sum of the individual components. For pure solutions and mixtures it has proven to be the case that the pH-value of the solution is a reliable help in determining the chemical resistance of semi-crystalline plastics.
The diagram states the pH limit values at room temperature, which generally apply to the different semi-finished products.

Chemical resistance at +23 °C

Materials	Acid	Alkaline
PE-HD, -HMW, -UHMW	0.5	13.5
PA	4	12
POM-C	4	13
POM-H	4	9
PET-C	1	9
PPS mod.	0.5	13.5
PEEK	0.5	13.5
PTFE	0	14
PVDF	0.5	13.5

Attention to be paid to the fact that the glass fibre reinforced types show a greater sensitivity to strong alkaline solutions than the unreinforced ones. In addition to this, stress crack formation can occur on PVDF components if they are simultaneously subject to a mechanical load and a chemical with a pH-value ≥ 12 or a medium in which atomic chlorine is developed.

Chemical resistance of plastics

	Polyolefine		Polystyrene	Polyvinyl chloride	Polyamide			Polyacetals		Thermoplastic Polyester		Fluorine-based plastics			Linear Polyarylenether -etherketones, -sulfide, -sulfone				Polyimide			Thermosets			Polyurethane
	PP, PE-HMW, PE-UHMW	PE-HD	PS, SB	PVC hart, PVC-U	PA 6, PA 66, PA 46 (extr.)	PA 6 G (molded)	PA 12	POM-C	POM-H	PEC-C	PC	PTFE	PVDF	PCTFE	PPE (PPO)	PSU	PPSU	PEEK	PAI	PEI	PI	Polyester	Epoxy	Phenol	PUR
Acetaldehyde	A	A	①	C	B	B	A	A	A	A	C	A	①	①	A	C	①	A	A	A	B	①	A	A	C
Acetamide	①	①	A	①	A	A	①	A	①	①	①	A	①	①	①	①	①	A	①	A	①	①	A	A	①
Acetone	A	A	D	C	A	A	A	B	B	B	C	A	①	A	A	C	C	A	①	A	B	D	A	B	D
Acrylonitrile	A	A	①	①	A	A	A	A	①	①	C	A	B	①	①	C	①	A	①	①	B	D	A	A	D
Allyl alcohol	A	A	C	B	B	B	①	B	B	A	①	A	①	①	①	C	①	A	A	①	①	①	A	A	D
Aluminum chloride	A	A	A	A	①	①	A	A	A	①	A	A	A	A	A	A	①	A	A	A	C	A	A	A	C
Aluminum sulfate	A	A	A	A	①	①	A	A	B	①	A	A	A	①	A	A	①	A	A	A	C	①	A	A	C
Formic acid	A	A	B	B	C	C	C	D	C	A	C	A	A	A	A	A	A	B	D	A	C	D	①	①	D
Anhydrous ammonia	A	A	A	A	A	A	A	A	C	A	C	A	A	A	A	A	①	A	B	①	D	①	B	B	D
Aqueous ammonia	A	A	A	A	A	A	A	A	A	A	C	A	A	A	A	A	①	B	①	A	D	①	B	B	D
Ammonium carbonate	A	A	A	A	A	A	A	A	A	A	B	A	A	A	A	A	①	A	①	①	C	①	A	A	C
Ammonium chloride (salammoniac)	A	A	A	A	①	①	A	A	B	A	A	A	A	A	A	A	①	A	①	①	C	D	A	A	C
Ammonium thiolycolate	①	①	①	①	C	C	①	①	①	①	①	A	①	①	①	①	①	A	①	①	①	①	A	A	①
Amyl acetate	B	C	D	C	A	A	A	A	A	①	①	A	A	A	A	B	①	①	A	①	B	①	A	A	D
Amyl alcohol	A	A	B	B	A	A	A	A	A	A	①	A	A	①	A	B	①	①	A	①	B	A	A	A	C
Aniline	A	A	C	C	C	C	B	A	B	A	①	A	A	A	A	D	①	①	A	C	C	D	B	B	D
Anisole (Methoxybenzene)	B	B	C	C	A	A	①	①	①	①	C	A	A	①	①	①	①	①	①	①	①	D	①	①	D
Anone	A	A	D	D	A	A	①	A	A	①	C	A	A	A	A	C	①	①	①	①	①	①	①	①	D
Antimony trichloride	A	A	①	A	C	C	①	A	①	①	A	A	①	A	①	①	①	①	①	①	D	①	A	A	D
Aspirin	①	①	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Barium chloride	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	①	①	①	A	①	C	A	A	A	A
Barium sulfate	A	A	A	A	①	A	①	A	A	A	A	A	A	A	A	A	①	①	①	①	C	①	A	A	A
Benzaldehyde	B	A	C	A	B	B	D	A	A	A	①	A	A	A	B	C	①	A	A	C	①	①	B	B	D
Benzine	B	A	C	C	A	A	A	A	A	A	B	A	A	A	C	B	A	A	A	C	①	①	A	A	B
Benzene	B	B	D	C	A	A	A	A	B	A	C	A	A	B	A	C	B	A	①	C	B	D	A	A	D
Benzoic acid	①	①	①	①	C	C	①	①	①	A	①	A	①	①	①	①	①	①	C	①	①	①	B	B	①
Benzyl alcohol	A	A	D	A	B	B	①	A	A	A	C	A	A	A	①	B	①	①	①	C	①	①	A	A	C
Bitumen	A	A	A	A	B	B	①	A	A	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	C
Lead acetate	A	A	A	A	A	A	①	A	A	①	①	A	A	①	①	A	①	①	①	①	①	A	A	A	C
Bleaching lye	A	A	A	A	D	D	C	C	C	A	①	A	A	①	A	C	①	①	A	A	①	①	①	①	D
Lead stearate	①	①	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	①	①	①
Boric acid	A	A	A	A	A	B	A	B	A	A	A	A	A	A	A	A	①	A	①	A	C	A	A	A	A
Brake fluid	B	A	B	A	A	A	A	A	A	A	B	A	A	A	①	A	B	①	①	①	①	①	A	A	①
Pyrocatechol	①	①	①	①	C	C	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	①	①	①
Bromine, liquid	C	C	C	C	D	①	D	C	①	①	①	①	A	A	①	①	①	C	A	①	C	D	A	B	D
Hydrobromic acid 50%	A	A	C	A	D	D	D	C	C	①	①	A	A	A	①	①	①	①	①	①	D	A	D	D	C
Butanol	A	A	A	A	A	A	①	A	A	B	A	A	A	A	A	B	A	①	A	A	①	①	A	A	B
Butter	A	A	A	A	A	A	①	A	A	①	①	A	A	①	①	①	①	①	①	①	①	①	A	A	A

A **Resistant, does not attack:**
None or only limited changes to weight or dimensions; no significant change to the mechanical properties

B **Resistant, slight attack:**
Absorption of the medium, slight swelling and limited deterioration of the mechanical properties possible

C **Conditionally, moderate attack:**
Noteworthy changes to weight and dimensions after some time, possible discolouration, reduction of strength and reduction in toughness. Conditionally applicable, depending on the requirements in the individual case

D **Volatile, soluble:**
Strong attack within a short period of time (considerable changes to weight and dimensions and reduction of strength and toughness). Use is not recommended

① No evaluation available

Please note:
The resistance values stated here are only reference values and can be subjected to considerable changes due to codetermining factors such as filler materials, changed temperatures, high load levels, environmental influences, etc. We are therefore unable to provide any guarantee for this information. These data were determined at room temperature and in standard concentrations.

Chemical resistance of plastics

	Polyolefine		Polystyrene	Polyvinyl chloride	Polyamide			Polyacetals		Thermoplastic Polyester		Fluorine-based plastics			Linear Polyarylenether -etherketones, -sulfide, -sulfone				Polyimide			Thermosets			Polyurethane
	PP, PE-HMW, PE-UHMW	PE-HD	PS, SB	PVC hart, PVC-U	PA 6, PA 66, PA 46 (extr.)	PA 6 G (molded)	PA 12	POM-C	POM-H	PEC-C	PC	PTFE	PVDF	PCTFE	PPE (PPO)	PSU	PPSU	PEEK	PAI	PEI	PI	Polyester	Epoxy	Phenol	PUR
Butyric acid	A	A	C	B	A	B	①	B	B	①	C	A	A	A	①	①	①	①	①	①	①	①	A	A	D
Butyl acetate	B	A	D	C	A	A	A	A	A	A	①	A	A	A	B	C	A	①	A	A	①	D	A	A	D
Butylene glykol	A	A	①	C	A	①	①	A	①	A	①	A	①	①	①	①	①	①	①	①	①	①	A	A	A
Butyrolactone	①	①	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	①	①	①
Calcium chloride, alcoholic	A	A	①	A	①	①	A	D	D	A	①	A	A	A	①	B	①	A	A	A	①	A	A	A	①
Calcium chloride, aqueous	A	A	A	A	B	B	A	A	A	A	A	A	A	A	①	A	①	①	①	A	①	A	A	A	B
Camphor	A	B	B	C	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	D
Carnallite	①	①	①	①	①	A	①	①	①	①	①	A	①	①	①	①	①	①	①	A	①	①	①	①	①
Chlorobenzene	B	B	D	C	A	A	C	A	A	①	D	A	A	A	A	D	①	A	A	A	①	D	A	A	D
Chlorbrommethane	D	D	①	①	A	B	①	B	B	①	①	A	①	①	①	①	①	①	①	A	①	①	①	①	C
Chloroacetic acid	A	A	B	A	D	D	①	C	C	①	①	A	A	A	①	①	①	①	①	①	①	①	①	①	C
Chlorine gas	B	B	①	B	①	C	D	C	B	①	C	A	A	A	①	C	①	①	①	A	①	A	D	D	D
Hydrochloride	①	①	①	①	D	C	①	①	①	①	①	A	①	①	①	①	C	①	①	①	①	①	B	B	①
Chlorinated hydrocarbon	①	①	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	A	①	①	①	①	①
Chloroform	B	C	D	C	B	B	C	C	C	①	D	A	A	B	D	D	①	A	A	A	①	D	A	A	D
Chlorosulfonic acid	C	C	C	C	D	D	①	C	C	D	①	A	C	A	C	C	①	①	①	①	①	D	A	A	D
Chlorine water	C	C	C	A	D	D	①	C	C	D	①	A	A	①	①	A	①	D	D	C	①	①	B	B	①
Chromic acid 50%	A	A	A	A	①	①	D	B	C	①	B	A	A	A	B	C	①	A	①	C	①	D	D	D	D
Clophen (Polychlorbiphenyl)	A	A	①	B	A	A	①	A	A	①	C	A	A	①	①	①	①	①	①	①	①	①	①	①	D
Cyclohexanol	A	A	B	C	A	A	A	A	A	①	B	A	A	①	A	B	①	①	A	A	①	A	A	A	B
Cydohexane	A	A	C	A	A	A	A	A	A	①	B	A	A	A	A	A	A	A	A	A	①	①	A	A	B
Decaline (Decahydronaphtelene)	B	A	D	A	A	A	①	A	A	B	A	A	A	①	①	A	①	①	①	A	①	①	A	A	D
Dibromoethane	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	A	①	①	A	A	①
Dibutyl phthalate	A	A	C	C	A	A	①	A	A	A	C	A	A	A	①	B	①	①	A	①	①	①	A	A	D
Dichloroethylene	B	D	D	D	A	A	①	B	C	D	D	A	A	①	D	B	①	①	A	①	①	A	A	A	D
Diesel oil	A	A	C	B	A	A	A	A	A	A	①	A	A	A	①	A	①	①	A	①	①	A	A	A	B
Diethyl ether	B	①	D	C	①	①	A	A	①	C	C	①	A	A	A	A	①	①	①	①	①	D	A	A	B
Dimethylformamide	A	A	D	C	A	A	A	B	A	A	C	A	D	①	A	D	①	①	①	①	①	D	A	A	D
Dimethylsulphoxide	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	B	B	①
Dioctylphthalate Palatinol	B	B	C	C	A	A	①	A	A	A	B	A	A	A	A	B	①	①	①	C	①	①	①	①	①
Dioxane	C	A	D	C	A	A	A	B	B	A	D	A	B	A	A	C	①	①	A	①	①	①	A	A	D
Iron II chloride (Ferrochloride)	A	A	A	A	B	B	A	B	B	①	A	A	A	A	①	A	①	①	①	①	①	A	A	A	①
Iron III chloride (Ferrochloride)	A	A	A	A	C	C	①	B	B	①	A	A	A	A	①	A	①	①	①	①	①	A	A	A	C
Vinegar	A	A	A	A	A	A	A	A	A	①	A	A	①	A	A	A	①	①	①	①	①	①	A	A	C
Acetic acid	B	B	①	B	D	D	D	C	C	A	①	A	①	①	①	A	B	A	A	①	D	D	D	D	D
Ethanol	A	A	A	A	B	B	A	A	A	A	A	A	A	A	B	A	B	A	A	A	①	①	A	A	B
Ether	A	B	D	A	A	A	A	A	A	A	C	A	A	B	A	A	C	①	A	①	①	①	A	A	B
Ethyl acetate	A	A	D	C	A	A	A	B	B	B	①	A	A	A	B	C	①	A	A	A	①	D	A	A	D

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Ethyl chloride	A	B	D	C	A	A	A	B	C	A	①	A	A	A	A	C	①	①	A	①	①	①	A	A	C
Ethylene chloride	A	B	D	C	B	A	B	B	B	C	D	A	A	A	A	D	①	①	A	C	①	①	B	B	C
Ethylene diamine	A	A	A	B	B	A	A	①	A	①	①	A	B	A	A	B	①	①	D	C	①	①	A	A	C
Ethylene glycol	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	B	①	A	①	①	A	A	A	C
Ethyl ether	B	B	D	C	A	A	A	A	A	A	C	A	A	A	A	C	①	①	①	A	①	①	①	①	B
Potassium ferrocyanide 30%	①	A	①	①	B	B	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Potassium ferrocyanide 30%	①	A	①	①	B	B	①	①	①	①	①	A	①	①	①	①	①	①	①	C	①	D	A	A	①
Fats, cooking fats	B	A	A	A	A	A	A	A	A	A	A	A	①	A	A	A	①	①	①	C	①	①	A	A	A
Hydrofluoric acid	①	C	A	A	D	D	①	C	C	D	C	B	A	A	B	B	①	①	①	C	①	D	D	D	①
Fluoric acid	①	C	A	A	D	D	B	C	C	D	C	B	A	①	①	C	①	D	①	①	①	①	①	①	①
Formaldehyde	A	A	A	A	B	B	B	A	A	A	B	A	A	A	A	C	A	①	A	C	①	①	A	A	D
Formamide	A	A	A	A	A	A	①	A	①	①	①	A	A	①	A	①	①	①	①	①	①	①	C	B	C
Freon 11	C	①	C	A	A	A	①	A	B	A	B	A	A	B	A	B	①	①	①	A	①	①	A	A	D
Frigen (see Freon)	C	①	C	A	A	A	①	A	B	A	B	A	A	B	A	B	①	①	①	A	①	①	A	A	D
Fruit juices	A	A	A	A	A	A	A	A	A	A	A	A	A	①	①	①	①	①	A	①	①	①	A	A	C
Furfural	A	A	D	C	A	B	①	①	①	A	①	A	A	A	A	A	①	①	C	A	①	D	A	A	D
Glycerin	A	A	A	A	A	A	A	A	A	A	B	A	①	A	A	A	①	①	A	①	①	A	A	A	A
Glycol	A	A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	①	A	①	①	①	①	A	A	C
Glysantin 40%	①	A	①	①	B	B	①	①	①	D	①	A	①	①	①	①	①	①	①	①	①	①	①	①	①
Aqueous urea	A	A	A	A	A	A	A	A	A	A	A	A	A	①	①	①	①	①	①	①	①	A	①	①	C
Fuel oil	A	A	A	A	A	A	A	A	A	A	B	A	A	A	①	①	①	①	①	A	①	①	A	A	A
Heptane	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	①	A	A	①	①	①	A	A	A
Hexane	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	①	A	A	①	①	A	A	A	A
Hydraulic oil	①	A	①	①	A	A	A	①	①	①	①	A	①	①	①	①	A	A	①	A	A	①	A	A	①
Hydroquinone	①	A	D	①	B	B	①	①	①	A	①	A	①	①	①	①	①	①	①	①	①	A	A	A	①
India Ink	①	A	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Isooctane	A	A	A	A	A	A	A	A	A	A	①	A	A	①	①	A	①	①	A	A	①	①	A	A	B
Isopropyl alcohol	A	A	A	A	B	B	A	A	A	①	A	A	A	A	A	B	①	①	①	A	①	①	A	A	C
Isopropyl ether	①	A	①	A	①	A	①	①	①	①	①	A	①	A	①	A	①	①	A	①	①	①	A	A	C
Iodine, wet	A	A	B	A	C	C	①	A	A	①	①	A	A	①	①	①	①	B	①	A	①	①	B	B	D
Iodine, dry	A	A	①	C	①	①	①	①	①	A	①	A	A	①	①	①	①	B	①	A	①	①	B	B	①
Caustic potash 10%①	A	①	①	A	A	A	①	①	D	①	A	①	①	①	A	①	①	①	A	①	①	①	①	①	
Caustic potash 20%①	A	①	①	C	C	A	①	①	D	①	A	①	①	①	A	①	①	①	①	①	①	①	①	①	
Potassium acetate	A	A	①	A	①	A	①	①	A	①	①	A	①	①	①	①	①	①	①	①	①	①	①	①	D
Potassium bichromate	A	A	A	A	C	B	①	①	①	①	A	A	A	①	①	A	①	①	①	①	①	①	A	A	C
Potassium bromide	A	A	A	A	B	B	①	A	A	A	A	A	A	①	①	①	①	①	①	①	①	①	A	A	C
Potassium carbonate	A	A	A	A	A	A	A	A	A	①	B	A	A	A	A	①	①	①	①	①	①	①	A	A	C
Potassium chloride	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	①	A	①	①	①	A	A	A	C

A **Resistant, does not attack:**
None or only limited changes to weight or dimensions; no significant change to the mechanical properties

B **Resistant, slight attack:**
Absorption of the medium, slight swelling and limited deterioration of the mechanical properties possible

C **Conditionally, moderate attack:**
Noteworthy changes to weight and dimensions after some time, possible discolouration, reduction of stability and reduction in toughness. Conditionally applicable, depending on the requirements in the individual case

D **Volatile, soluble:**
Strong attack within a short period of time (considerable changes to weight and dimensions and reduction of strength and toughness). Use is not recommended

① No evaluation available

Please note:
The resistance values stated here are only reference values and can be subjected to considerable changes due to codetermining factors such as filler materials, changed temperatures, high load levels, environmental influences, etc. We are therefore unable to provide any guarantee for this information. These data were determined at room temperature and in standard concentrations.

Chemical resistance of plastics

	Polyolefine		Polystyrene	Polyvinyl chloride	Polyamide			Polyacetals		Thermoplastic Polyester		Fluorine-based plastics			Linear Polyarylenether -etherketones, -sulfide, -sulfone				Polyimide			Thermosets			Polyurethane
	PP, PE-HMW, PE-UHMW	PE-HD	PS, SB	PVC hart, PVC-U	PA 6, PA 66, PA 46 (extr.)	PA 6 G (molded)	PA 12	POM-C	POM-H	PEC-C	PC	PTFE	PVDF	PCTFE	PPE (PPO)	PSU	PPSU	PEEK	PAI	PEI	PI	Polyester	Epoxy	Phenol	PUR
Potassium hydrate 10%①	A	①	①	A	A	①	①	①	①	①	A	①	①	①	①	A	①	①	①	①	①	C	C	①	
Potassium hydrate 50%①	A	①	①	C	C	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	D	D	①	
Potassium nitrate	A	A	A	A	A	A	A	A	A	A	A	A	A	①	①	A	①	①	①	A	①	①	A	A	C
Aqueous potassium permanganate	A	A	A	A	D	D	C	B	B	①	A	A	A	①	①	A	①	①	A	①	①	①	A	A	D
Potassium silicate	①	A	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Potassium sulfate	A	A	A	A	A	A	A	A	B	①	A	A	A	①	①	①	A	A	①	①	①	A	A	A	A
Kerosene	A	①	B	A	①	①	①	A	A	①	A	①	A	A	B	A	A	A	①	①	①	①	A	A	B
Carbon dioxide	A	①	A	A	①	①	①	A	A	①	A	A	A	A	A	A	A	A	①	①	①	①	A	A	A
Carbon disulfide	A	B	D	B	A	A	①	A	A	①	C	A	A	A	①	B	①	①	①	①	①	D	A	A	D
Carbon tetrachloride	B	①	D	B	①	①	①	A	A	①	C	A	A	B	B	B	①	A	①	①	①	①	A	A	C
Aqua regia	C	①	C	C	①	①	D	C	C	①	C	①	B	A	C	①	①	D	①	①	①	D	①	①	C
Cresols	A	A	C	B	D	D	D	D	D	D	①	A	A	A	A	①	①	①	①	①	①	D	①	①	D
Refrigerant	①	①	①	①	A	A	①	A	①	A	A	A	①	①	①	①	①	①	①	①	①	①	①	①	①
Copper nitrate	A	A	A	A	①	①	①	A	A	①	①	A	A	①	A	①	①	①	①	①	①	①	A	A	C
Copper sulfate	A	A	A	A	B	C	A	A	A	①	A	A	A	A	①	A	①	①	①	①	①	A	A	A	D
Lavender oil	A	A	①	A	A	A	①	A	A	①	①	A	①	①	①	①	①	①	①	①	①	①	A	A	D
Linseed oil	①	A	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	A	A	A	①
Lithium bromide 50%	A	①	①	①	D	D	①	A	A	A	①	A	①	①	①	①	①	①	①	①	①	①	A	A	C
Maelic acid	①	A	①	①	①	C	①	①	①	①	①	A	①	①	①	①	①	①	①	①	①	①	B	B	①
Magnesium chloride	A	A	A	A	B	B	A	A	A	A	A	A	A	①	①	A	①	B	A	A	①	A	A	A	B
Magnesium hydroxide	A	A	①	①	A	A	①	A	A	①	①	A	A	①	A	①	①	A	①	①	①	①	B	B	A
Malonic acid	①	①	①	①	①	C	①	A	①	①	①	A	①	①	①	①	①	①	①	①	①	①	①	①	A
Manganese sulfate	①	①	①	①	B	B	①	①	①	①	①	A	①	①	①	A	①	①	①	A	①	①	A	A	①
Methanol	A	A	A	A	B	B	A	A	A	A	C	A	A	A	A	B	B	A	①	A	①	①	A	A	D
Methyl acetate	A	①	D	C	A	A	①	B	B	B	①	A	A	A	B	C	①	①	①	C	①	①	A	A	D
Methyl alcohol (Methanol)	A	①	A	A	B	B	A	A	A	A	C	①	A	A	A	B	B	A	①	A	①	①	A	A	C
Methylene chloride	C	B	D	C	C	C	C	B	B	D	D	A	B	B	D	D	C	①	①	D	①	D	A	A	D
Methyl ethyl keton	①	C	①	①	A	A	①	①	①	C	①	A	①	①	①	C	C	A	A	C	①	①	A	A	①
Milk	A	A	A	A	A	A	①	A	A	①	A	A	A	A	①	A	①	①	①	①	①	①	A	A	C
Lactic acid	A	A	A	B	D	D	D	A	B	A	A	A	A	①	①	A	①	A	A	①	①	A	①	①	①
mineral oil	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	A	①	①	A	①	B	A	A	A	A
Naphthalene	①	A	B	B	A	A	A	A	A	A	①	A	A	A	A	A	①	①	①	①	①	A	A	A	C
Sodium acetate	①	A	A	B	B	B	①	①	①	①	①	A	A	①	A	①	①	①	①	①	①	A	A	A	C
Sodium bisulfite	A	A	B	A	A	A	①	A	①	A	①	A	A	①	①	①	①	①	A	①	①	A	A	A	C
Sodium bromide	①	①	A	①	A	A	①	A	A	①	①	A	A	①	①	①	①	①	①	①	①	①	A	A	①
Sodium carbonate	A	A	A	A	A	A	A	A	A	①	A	A	A	A	①	A	①	A	A	A	①	①	A	A	D
Sodium chloride (cooking salt)	A	A	A	A	B	D	A	A	A	①	A	A	A	A	A	A	①	①	A	A	①	①	A	A	A
Sodium hypochloride	①	A	A	A	D	C	B	C	C	B	①	A	A	①	A	①	①	A	A	①	①	A	C	C	D

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Sodium nitrate	A	A	A	A	A	A	A	A	A	①	A	A	A	A	A	A	①	①	①	①	①	①	A	A	A
Sodium hydrosulfide	①	A	①	①	A	A	①	①	①	A	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Sodium sulfate	A	A	A	A	A	A	A	A	A	①	A	A	A	A	①	A	①	①	A	B	①	A	A	A	①
Sodium sulfite, neutral	①	A	A	A	A	①	A	A	A	①	①	A	A	①	①	A	①	①	B	①	①	A	A	A	①
Sodium thiosulfate	A	A	A	A	A	A	A	B	B	①	①	A	A	A	①	①	①	①	①	①	①	A	A	A	A
Sodium hydroxide	A	①	A	A	A	A	A	B	C	D	C	①	B	A	A	A	A	①	D	C	①	①	①	①	B
Nitrobenzene	A	A	C	C	B	B	B	B	B	A	D	A	A	A	B	D	①	A	①	C	C	①	A	A	D
Nitromethane	A	①	①	C	A	B	①	①	①	①	①	A	A	①	①	①	①	①	①	①	①	①	①	①	D
Oil, lubricating oil	A	A	B	①	A	A	A	A	A	A	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Oil, cooking oil	A	A	A	①	A	A	A	A	A	①	①	A	①	①	①	①	①	①	A	①	①	①	A	A	①
Oleum	C	①	C	B	D	D	D	C	C	D	C	A	D	A	①	C	①	①	①	①	①	D	D	D	C
Oleic acid	B	A	A	A	A	A	B	B	①	A	A	A	A	①	A	A	A	①	①	A	①	A	①	①	B
Oxalic acid	A	A	B	A	C	C	B	C	C	A	A	A	A	A	①	A	①	①	①	A	①	A	B	B	A
Ozone	B	B	A	A	B	C	B	C	C	C	A	A	A	A	A	①	①	A	①	①	①	①	B	B	A
Paraffin oil	A	A	A	A	A	A	A	A	A	A	①	A	①	A	①	①	①	A	A	①	①	①	A	A	A
Perfume	A	A	C	A	A	A	①	①	①	①	①	A	A	①	①	①	①	①	①	①	①	①	A	A	①
Perchlorethylene	B	D	D	C	D	D	①	A	B	D	B	A	A	A	A	C	①	A	①	①	A	①	A	A	D
Petroleum	C	A	B	A	A	A	①	A	①	A	B	A	A	①	A	A	①	①	A	①	①	①	A	A	B
Petroleum jelly	①	A	①	①	A	A	①	①	①	①	①	A	①	①	①	①	①	①	A	①	①	①	A	A	①
Phenol	A	A	C	B	D	D	D	C	C	D	D	A	A	A	A	C	①	D	①	C	①	D	A	A	C
Phenyl ethyl alcohol	A	A	C	B	B	C	①	A	A	①	C	A	A	A	①	①	①	①	①	①	①	①	A	A	①
Phosphoric acid	A	A	①	①	D	D	D	D	D	A	①	A	①	①	①	A	①	A	A	C	①	A	D	C	C
Phthalic acid	A	A	A	①	B	B	①	①	①	A	①	A	A	①	①	①	①	A	①	①	①	①	A	A	①
Polyester resin with styrene	①	A	①	①	A	A	①	①	①	A	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Propane, liquid	B	A	B	A	①	①	A	A	A	①	A	A	①	①	①	A	①	A	①	①	①	①	A	A	A
Propanol	A	A	A	B	B	B	①	A	A	A	A	A	A	A	①	A	①	A	①	①	①	①	A	A	C
Mercury	A	①	A	A	A	A	A	A	A	A	A	A	A	A	①	A	①	①	①	①	①	①	A	A	A
Mercury chloride	A	①	A	A	D	D	①	A	A	①	A	A	A	B	①	①	①	①	①	①	①	①	A	A	A
Resorcin	B	A	D	C	D	D	①	①	①	D	①	A	①	①	①	C	①	①	①	A	①	①	A	A	①
Crude oil	A	A	B	A	A	A	①	A	A	①	①	A	A	A	①	A	①	A	①	①	①	①	A	A	B
Salicylic acid	①	①	①	①	A	A	①	①	①	B	①	A	①	①	①	A	①	①	①	①	①	①	B	B	①
Nitric acid, concentrated	C	①	C	C	D	D	D	C	C	①	C	①	A	A	C	C	①	A	①	A	D	D	D	D	D
Nitric acid, fuming	C	①	C	C	D	D	D	C	C	①	①	①	B	A	C	B	D	①	①	①	①	D	D	D	D
Hydrochloric acid 10%	A	A	A	A	D	D	D	C	C	①	A	A	A	A	A	A	A	A	①	A	①	A	C	C	C
Hydrochloric acid, concentrated	A	①	B	A	D	D	D	C	C	①	C	A	A	A	B	A	①	A	①	①	①	①	D	D	D
Oxygen	A	①	A	A	①	①	①	①	①	①	A	A	A	A	①	①	①	A	①	①	①	①	A	A	A
Sulfur	A	A	A	A	A	A	A	A	①	①	A	①	A	A	①	A	①	①	①	①	①	A	A	A	①
Sulfuric acid 10%	A	A	A	A	D	D	B	A	C	A	A	A	A	A	A	A	A	A	A	A	①	A	C	C	C

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Sulfuric acid 60%	A	①	A	A	D	D	D	C	C	C	A	①	A	A	B	A	①	①	①	①	①	A	D	D	C
Sulfuric acid 95%	①	①	C	A	D	D	D	C	C	C	C	①	A	A	B	C	C	①	①	C	①	D	D	D	D
Sulfuric acid, fuming	C	①	C	B	D	D	D	C	C	C	C	①	D	A	①	C	①	①	①	①	①	①	D	D	C
Hydrogen sulfide	A	A	B	A	A	A	A	C	C	A	A	A	A	A	①	A	①	A	①	①	①	A	B	B	C
Silver nitrate	A	A	B	A	A	A	A	A	①	①	A	A	A	①	①	A	①	①	①	①	①	①	A	A	B
Silicone oil	A	A	B	A	A	A	A	A	A	A	A	A	A	A	①	A	①	①	A	①	B	A	A	A	A
Silicon hydrogen fluoride	①	A	①	①	C	C	①	①	①	①	①	A	①	①	①	①	①	①	A	①	①	①	B	B	①
Soda solution	A	A	A	A	B	B	①	A	A	①	A	A	A	A	A	B	B	①	①	①	①	①	①	①	D
Cooking fat, cooking oil	B	A	A	A	A	A	A	A	A	①	A	A	A	A	①	C	①	①	A	①	①	①	A	A	A
Styrene	B	A	①	①	A	A	①	①	①	①	C	A	①	①	①	B	B	A	①	①	①	①	A	A	D
Tar	①	A	A	B	B	B	A	A	A	①	①	A	A	A	A	A	C	①	A	①	①	①	A	A	D
Carbon tetrachloride	B	B	D	B	A	A	A	A	A	A	C	A	A	B	B	C	C	①	A	C	①	①	A	A	C
Tetrahydrofuran (solvent)	B	B	D	D	A	A	B	B	A	A	C	A	B	B	A	D	①	①	①	C	①	D	A	A	D
Tetralin	A	A	D	C	A	A	①	A	B	A	C	A	①	A	①	A	①	①	①	A	①	D	①	①	D
Thionyl chloride	C	C	D	C	D	C	①	B	①	①	①	A	A	B	①	A	①	①	①	①	①	D	B	B	D
Ink, paint, India ink	A	①	A	A	A	A	A	A	A	①	A	A	A	A	A	A	①	①	①	①	①	①	A	A	A
Toluene	A	B	D	C	A	A	A	A	A	①	C	A	A	B	D	D	B	A	A	C	①	①	A	A	D
Transformer oil	A	A	B	A	A	A	A	A	A	A	A	A	A	A	①	A	A	①	①	①	①	A	①	①	A
1,2,3-Trichlorobenzene	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	①	A	A	①
Trichloroethylene	B	C	D	C	B	B	B	B	B	D	①	A	A	C	D	D	A	A	①	D	①	D	A	A	D
Triethanolamine	①	A	①	①	A	A	①	①	①	A	①	A	①	①	①	①	①	①	①	①	①	①	A	A	①
Trisodium phosphate	①	A	①	①	B	①	①	①	①	①	①	A	①	①	①	A	①	①	①	①	①	①	A	A	①
Perchloric acid	A	B	①	A	C	C	①	①	B	①	B	A	A	A	A	A	①	①	①	A	①	①	B	B	D
Vaseline	A	A	A	A	A	A	①	A	①	①	①	A	A	①	A	A	①	①	A	①	①	①	A	A	B
Vinyl chloride	①	①	①	①	A	A	①	①	①	A	①	A	A	①	①	①	①	①	①	①	①	①	A	A	①
Wax, melted	①	A	①	①	A	A	A	①	①	①	①	A	①	①	①	A	①	①	A	A	①	①	A	A	①
Water <60°C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	①	A	A	A	①	A	A	A	A
Water, lake, river, spring <30°C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	①	①	①	A	①	A	A	A	A
Water glass	A	A	①	A	A	A	①	①	①	①	①	A	A	①	①	A	①	①	①	①	①	①	①	①	C
Hydrogen peroxide	A	①	①	A	B	B	A	C	A	①	A	①	A	①	A	A	①	A	①	A	①	①	B	B	C
Hydrogen superoxide	①	A	①	A	C	C	A	①	①	A	①	A	①	①	①	①	①	①	①	①	①	①	①	①	C
Wine	①	A	A	A	B	B	①	①	①	A	①	A	A	①	①	A	①	①	①	A	①	①	A	A	①
Tartaric acid	①	A	A	A	B	B	①	B	B	①	A	A	A	A	①	①	①	①	①	①	①	①	①	①	①
Xylenol	①	①	①	①	D	①	①	①	①	①	①	A	①	①	①	A	①	①	①	①	①	①	A	A	①
Xylol	C	C	D	C	A	A	A	A	A	A	C	①	A	B	A	C	①	A	①	B	①	①	A	A	D
Zinc chloride	A	A	A	A	C	C	A	B	B	①	A	A	A	①	①	A	①	A	①	A	①	A	A	A	D
Zinc oxide	①	A	①	①	A	A	①	C	C	①	①	A	①	①	①	B	①	①	①	①	①	①	①	①	①
Citric acid	A	A	A	A	A	B	①	A	B	A	A	A	A	A	①	A	A	①	①	①	①	A	A	A	①

A **Resistant, does not attack:**
None or only limited changes to weight or dimensions; no significant change to the mechanical properties

B **Resistant, slight attack:**
Absorption of the medium, slight swelling and limited deterioration of the mechanical properties possible

C **Conditionally, moderate attack:**
Noteworthy changes to weight and dimensions after some time, possible discolouration, reduction of strength and reduction in toughness. Conditionally applicable, depending on the requirements in the individual case

D **Volatile, soluble:**
Strong attack within a short period of time (considerable changes to weight and dimensions and reduction of strength and toughness). Use is not recommended

① No evaluation available

Please note:
The resistance values stated here are only reference values and can be subjected to considerable changes due to codetermining factors such as filler materials, changed temperatures, high load levels, environmental influences, etc. We are therefore unable to provide any guarantee for this information. These data were determined at room temperature and in standard concentrations.

Product ranges, services and facilities

General information

Semi-finished plastic products

Available in original dimensions or cut-to-size:
– Films
– Sheets
– Round bars
– Tubes
– Profiles

Information:
Materials, technical properties and dimensions are available from our online shop at www.angst-pfister.com

Finished plastic components

Standard range in stock:
– Plain bearing bushing made from PA 66
– Plain bearing bushing made from PTFE HP 108 – 300
– Plain bearing bushing made from FIBERGLIDE® with steel jacket and PTFE sliding layer
– Plain bearing bushing made from PET-C SL for precision bearings
– Slideway guide strips made from PTFE and PTFE HP
– PTFE-coated glass fabrics and KEVLAR® fabrics
– Self-adhesive tapes for electrical insulation functions
– Shrink hose range
– Non-stick roller coatings made from FEP
– Adhesives

Information:
Materials, technical properties and dimensions are available from our online shop at www.angst-pfister.com

Plastic components according to customer drawing

Turned and milled parts according to customer drawing, processed ready to fit and all made from our own APSOplast® plastics on CNC-controlled turning and milling machines. Our know-how on materials, even those difficult to process, ensures the production of tolerance-compliant parts.
– Turning, milling, drilling, thread cutting
– Punching, water-jet cutting
– Punching components:
– SMC pressed parts or thermosets
– Molded parts made from PA 6 and PUR
– Vacuum-formed parts:
– Thermoformed parts through line bending and vacuum-forming
  e.g. transparent covers, guards, etc.
– Welded constructions:
  – Ready-to-install casings, covers, etc. made from a wide range of thermoplastics

Information:
Please contact our specialists (see last page for addresses)

Workshop services

In many cases, the outsourcing of individual processing steps can offer a positive rationalization potential. Thanks to our modern workshops at home and abroad, Angst+Pfister are able to take certain production tasks off your hands. An exceptionally wide range of services is on offer.

Application consultation and engineering

With advising on products solutions and by taking on engineering tasks, the specialists at Angst+Pfister pass on their materials knowledge and their technical production-based know-how. They support customers in the selection of materials, the optimization of products and the rationalization of production steps. Designing new or improving present products and production processes, early contact with the engineers at Angst+Pfister is worthwhile. Through cooperation based on partnership, with short development times and low development and production costs, even more competitive products can be realized.

Capable logistics infrastructure

Angst+Pfister offer a wide range of rational logistics concepts as well as order and invoicing processes. They are all based on an advanced logistics and IT infrastructure, the hub of which is the Angst+Pfister logistics centre in Embrach. Here, over 100000 item positions are stored, for which two automatic high bay storage solutions are available – one with approx. 15400 standard pallet spaces and one with 34100 spaces for plastic containers. A warehouse management system that is backed up by two computers guarantees the high availability and rapid completion of orders. Several tens of thousands of orders are picked and sent each month – some with our own vehicle fleet and some in close cooperation with large haulers.

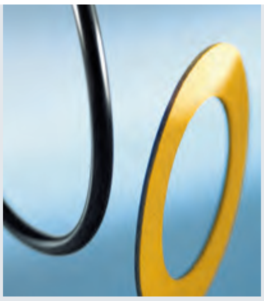
Uncompromising quality management

The quality management system according to ISO 9001:2000, which applies to all process and logistics stages within the Angst+Pfister Group, provides a guarantee for the complete assurance of the quality of all services and the traceability of the supplied products. As such, Angst+Pfister is a partner which satisfies its customers' strict demands with its market services and can slot seamlessly into their quality management systems. Quality management as defined by the Angst+Pfister Group also includes the areas of environmental management and workplace safety.

Angst + Pfister Group: The Leading Supply and Solutions Partner for Industrial Components We help our manufacturing clients to save hundreds of thousands of euros every year by providing custom-engineered components, a vast product range comprising of more than 150,000 standard items and integrated supply chain solutions.

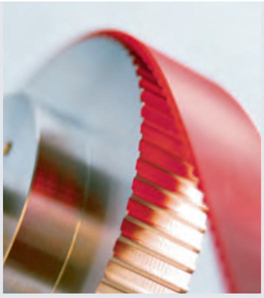
Our core product divisions

APSOplast®
Engineering Plastics Technology



APSOseal®
Sealing Technology

APSOfluid®
Fluid Handling Technology



APSOdrive®
Drive Technology

APSOvib®
Antivibration Technology

The Angst + Pfister Group serves its customers internationally with uncompromisingly high-quality products and comprehensive solutions. Our global supplier and distribution platform enables us to guarantee the same product quality and price regardless of whether you are manufacturing across Europe or Asia. The breadth of our standard product assortment makes us a one-stop shop that not only simplifies your search, but also enables you to consolidate suppliers. Our engineering solutions are designed to seamlessly interface with your R&D in ways that save you research time and money in the product development stage.

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