Grilamid Polyamide 12
Technical Polymer
for highest demands

Grilamid®

EMS

Contents

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Introduction

EMS-GRIVORY sells its polyamide 12 products under the brand name Grilamid®. This engineering plastic has proved its worth for more than 30 years in various demanding applications. Grilamid is formed by polycondensation of laurolactam, a monomeric raw material based on crude oil.

Grilamid combines exceptional properties such as:

- high impact strength
- good weathering resistance
- good resistance to chemicals
- excellent abrasion and surface slip characteristics
- minimum water uptake and good dimensional stability
- low specific density
- excellent impact strength at low temperatures
- good barrier properties

Grilamid is the polyamide with the lowest water absorption and the lightest polyamide commercially available.

Grilamid is particularly well suited for processing using injection-moulding, extrusion and blow-moulding processes.

Typical application areas for Grilamid are the fields of automotive, electric and electronic, packaging, leisure, sport and mechanical engineering.

The high-quality basic properties of Grilamid are determined by the chemical structure of polyamide 12. Through the addition of additives, fillers, fibres and processing aids, EMS-GRIVORY can also satisfy special market requirements. These include, for example, highly filled, high-performance grades for the manufacture of polymer bonded magnets.

Making use of polymer alloys and selected chemical modifications we have been able further to improve the excellent properties of this material.

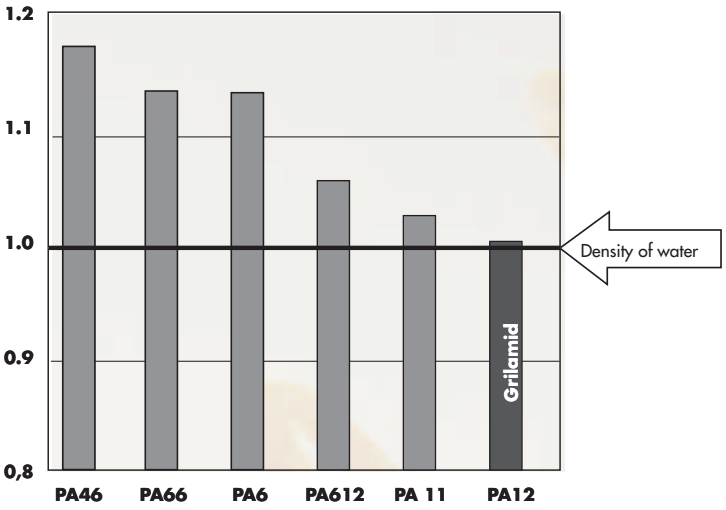
EMS-GRIVORY – your partner for tailor-made customer solutions.

Properties	PA12	PA11	PA612	PA66	PA6	PA46
E-modulus (MPa), cond.	1100	1100	1800	1700	1100	1100
Notched impact strength at 23°C (Charpy, kJ/m²), cond.	7	14	6	12	20	45
Notched impact strength at -30°C (Charpy, kJ/m²), cond.	6	11	6	4	3	12
Melting point (DSC, °C)	178	189	218	260	222	295
Heat distortion temp. HDT-B (0.45 MPa, °C)	115	145	180	225	170	280
Moisture absorption (23°C/50% rel. h., %)	0.7	0.8	1.3	2.5	3.0	3.7
Density (dry, g/cm³)	1.01	1.03	1.06	1.14	1.14	1.18

Comparison of properties

Comparison with other polyamides

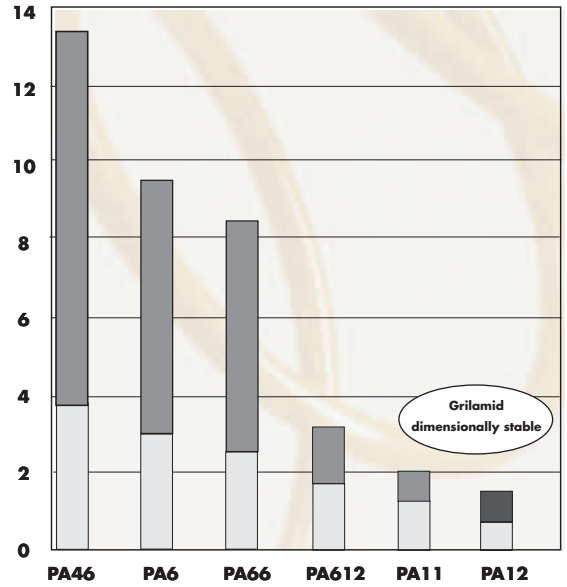
The combination of excellent properties sets Grilamid well apart from other polyamides. The wide variety of possible uses makes Grilamid a particularly successful engineering plastic.



Density

(g/cm³) according to ISO 1183, dry

Grilamid is the lightest of all polyamides and the lightest existing engineering plastic. This fact enables particularly economical solutions to be created and is of great significance for applications in the fields of aviation, automotive construction, electronics and sport.



Moisture absorption

% Water absorption at 23°C, saturated

% Moisture absorption at 23°C and 50% r.h.

Grilamid has the lowest water absorption of all polyamides. This gives it its exceptionally good dimensional stability.

Grilamid's high-performance property profile, coupled with its very good processability, makes it one of the most attractive engineering plastics.

Grilamid nomenclature

Polyamide grade

L:	Injection moulding and extrusion grade
LC:	Carbon fibre reinforced
LV:	Glass fibre reinforced
LKN:	Glass bead filled
ELY:	Polyamide 12 Elastomer
MB:	Masterbatch

Viscosity
Reinforcement

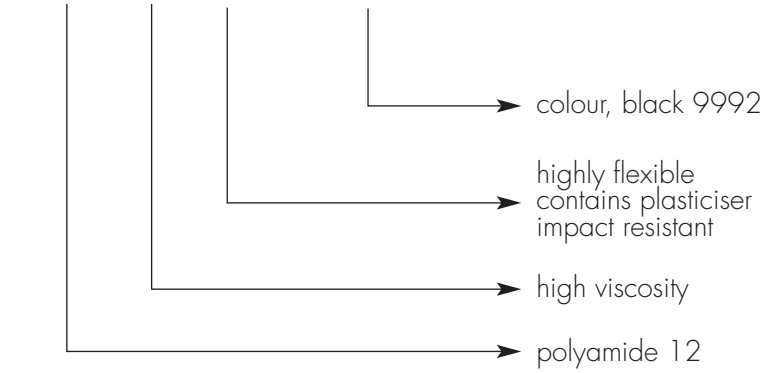
16:	Low viscosity
20:	Medium viscosity
25:	High viscosity
C:	Carbon fibres
KN:	Glass beads
S:	Stainless steel fibres
V:	Glass fibres
V-3:	30% glass fibres

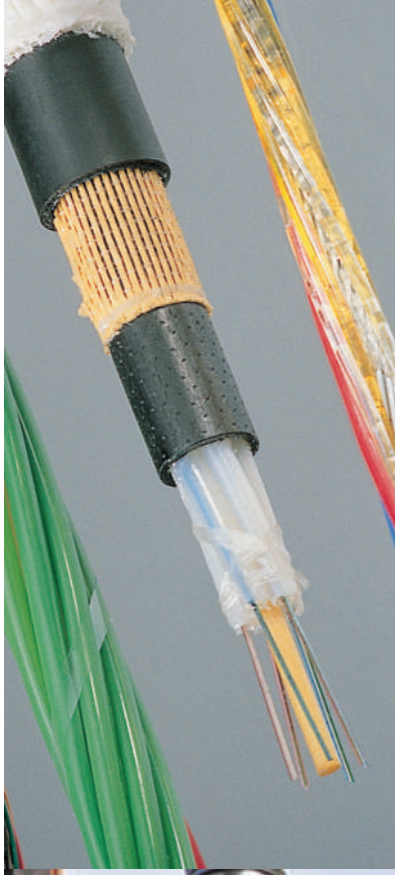
Special additives, properties

A:	Hydrolysis resistant
EC:	Electrically conductive
ESD:	Electrically anti-static
FR:	Self-extinguishing
G:	Lubricant, mould-release agent
H:	Heat stabilised
HM:	Bonding agent
L:	UV stabilised
LF:	Low coefficient of sliding friction
M:	Fine crystalline
NZ:	Extremely high impact strength
WA:	Drinking water approved
W 20:	Flexible, plasticiser
W 40:	Highly flexible, plasticiser
X:	Impact strength
Y:	Higher bursting pressure
Z:	High impact strength

Example:

Grilamid L 25 W 40 X black 9992





Electro/electronic

Examples	Suitable grades
Anti-static casings, covers and small parts	Grilamid L 20 EC black
Electro-connectors, profiles, cable ties, cable sheathing, functional parts	Grilamid L 20 H FR
Electro-connectors, casings	Grilamid LV-3H
Tape recorder components	Grilamid LKN-5H
Telephone cables, external cable sheathing	Grilamid L 20 HL Grilamid L 25
Sheathing of optical fibres (loose and tight jacket methods)	Grilamid L 20 LM Grilamid L 16 LM
Loose and semi-tight loose tube optical fibre sheathing	Grilamid L 20 LM
Flexible cable sheathing	Grilamid ELY 60 Grilamid L 25 W 40
Ballistic protection	Grilamid L 25 Z

Automotive, vehicles

Bowden cables, slide bearings, guides, sleeves	Grilamid L 20 LF grey Grilamid L 20 W 20 grey 9280
Housings and functional parts	Grilamid LKN-5H
Windscreen wiper arms	Grilamid LV-3H
Fuel-carrying parts	Grilamid L 25 NZ ESD Grilamid L 20 G, L 20 HL
Pipes for air, diesel fuel and oil lines	Grilamid L 25 Grilamid L 25 H
Pipes for air and fuel lines	Grilamid L 25 LM Grilamid L 25 black 9122
Semi-flexible pipes for air, fuel and oil lines	Grilamid L 25 W 20 X Grilamid L 25 W 20
Air brake lines, vacuum and air vent lines	Grilamid L 25 W 20 Y Grilamid L 25 W 20 X Grilamid L 25 W 40 X
Flexible pipes for fuel and oil lines, fuel filler necks	Grilamid L 20 W 40 X Grilamid L 25 W 40 X Grilamid L 25 W 40 ESD Grilamid ELY 20 NZ
Cooling systems and lines, crankshaft case ventilation	Grilamid L 25A H Grilamid L 25A NZ Grilamid LV-2A NZ Grilamid LV-3A H
Roll-over and non-return valves fuel and active carbon filters	Grilamid L 20 G Grilamid LV-3H Grilamid LV-5H
Fuel systems, connectors, fuel rails	Grilamid LV-2H Grilamid LV-23H Grilamid LV-23 ESD Grilamid LV-3H, LV-5H

Mechanical engineering

Examples	Suitable grades
Cog wheels, watch housings centrifuge containers	Grilamid L 20 G
Anti-static transport rollers, wheels, guides	Grilamid L 20 EC black
Sliding bearings, guides, sleeves	Grilamid L 20 LF grey
Casings, watch housings, watch components, functional parts	Grilamid LV-3H Grilamid LV-5H
Guides, bearing bushes, casings and functional parts, watch components	Grilamid LKN-5H
Technical parts in the textile industry, machines and sewing-machine parts	Grilamid LC-3H black
Seals, membranes, pipes	Grilamid ELY 60
Plates, bars and pipes	Grilamid L 25
Semi-flexible pipes for pneumatics and mechanical engineering	Grilamid L 25 W 20 X
Flexible pipes for pneumatics and mechanical engineering	Grilamid L 25 W 40 Grilamid L 25 W 40 X

Construction, sanitary

Construction components for: railings, hand rails etc.	Grilamid L 20 G
Construction sheeting	Grilamid L 25
Parts for sanitary fittings, valves, Mechanical functioning parts for measuring equipment, water meters, water filters, dispensers, protective caps	Grilamid L 20 G Grilamid LV-3H Grilamid LKN-5H Grilamid LV-3H WA, LV-5H WA
Safety shoes	Grilamid ELY 2475 Grilamid LV-5H

Sport & leisure

Sport article components	Grilamid LV-3H
Sport article components, tennis rackets	Grilamid LC-3H black
Sport shoe soles (sandwich moulding), Ski and snowboard boots, mountain boots, safety shoes, parts for spectacles	Grilamid ELY 2702 Grilamid ELY 2475 Grilamid ELY 2694 Grilamid LV-5H

Packaging

Foodstuff packaging, sausage skins, boiling bags, freezer bags	Grilamid L 25

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Characteristics of Grilamid grades

Grilamid non-reinforced	Characteristics and properties	Processing / Application segment
L 16 LM	UV and heat stabilised, low viscosity. Allows high processing speeds to be used.	Extrusion grade Electro/electronic, cable
L 2O G	Normal viscosity, heat stabilised, good flow properties, easy to process, high dimensional stability, low water absorption. Good slip and abrasion properties. UL-listed.	Injection moulding grade Industry, construction, optics
L 20 HL	UV and heat resistant, normal viscosity. Termite resistant.	Extrusion grade Electro/electronic, cable
L 20 LM	UV and heat stabilised, normal viscosity. Especially suitable for high haul-off speeds and low wall thicknesses.	Extrusion grade Electro/electronic, cable
L 20 H FR	Flame resistant, normal viscosity. Low water uptake, light natural colour, contains no halogen or phosphorus. UL-94 V2 from 0.8 mm. Listed according to NF 16-101.	Injection moulding and extrusion grade, Electro/electronic
L 25	Standard extrusion grade, high viscosity. Conforms to FDA and EU approvals for direct contact with non-alcoholic foodstuffs.	Extrusion grade Industry, construction, electro/electronic, packaging
L 25 LM	High viscosity, heat and UV stabilised, stiff.	Extrusion grade Industry, construction, automotive
L 25 black 9122	High viscosity, heat stabilised, stiff.	Extrusion grade Industry, construction, automotive
L 25 H	High viscosity, max. heat stabilised, stiff.	Extrusion grade Automotive
Grilamid reinforced	**Characteristics and properties**	**Processing / Application segment**
LV-2A NZ	Hydrolysis stabilised, reinforced with 20% glass fibres, heat and impact modified. Very stiff, high impact strength.	Injection moulding grade Automotive
LV-2H	Reinforced with 20 % glass fibres, normal viscosity, heat stabilised. Very stiff, high impact strength.	Injection moulding grade Automotive
LV-23 ESD	Reinforced with 20% fibres, electrically conductive, anti-static, heat stabilised.	Injection moulding grade Automotive
LV-3H/ LV-3H WA	Reinforced with 30 % glass fibres, normal viscosity, heat stabilised. Stiff with good impact strength, dimensionally accurate, low water uptake. Good resistance to chemicals, weathering resistant. Easy to process, good flow, quick mould release. «WA» grades drinking water approved	Injection moulding grade Industry, sport, leisure, electro/electronic Sanitation fittings
LV-3A H	Hydrolysis stabilised, reinforced with 30% glass fibres, heat stabilised, very stiff, high impact strength.	Injection moulding grade Automotive
LV-5H/ LV-5H WA	Reinforced with 50 % glass fibres, normal viscosity, heat stabilised. Extremly stiff with good impact strength, dimensionally accurate, low water absorption. Good resistance to chemicals, weathering resistant. Easy to process, good flow, quick mould release. «WA» grades drinking water approved	Injection moulding grade Industry, sport, leisure, electro/electronic Sanitation fittings
LKN-5H	Reinforced with 50 % glass beads, normal viscosity. Very low water absorption. Extreme dimensional accuracy and stability. Very good processing, very low, uniform shrinkage, isotropic behaviour. Good anti-friction properties, good wear-resistance. UL-listed.	Injection moulding grade Industry, construction, automotive electro/electronic
LKN-3H	Reinforced with 30 % glass beads, normal viscosity. Low water absorption. Extreme dimensional accuracy and stability. Easy to process, low and uniform shrinkage. Good anti-friction properties.	Injection moulding grade Industry, construction, automotive electro/electronic
L 20 LF grey	Graphite-filled, normal viscosity. Low coefficient of friction, dimensionally accurate, low water absorption. Easy to process, good mould release. Grey inherent colour.	Injection moulding and extrusion grade. Automotive, industry
LC-3H black	Reinforced with 30 % carbon fibres, normal viscosity, heat. stabilised. High-performance engineering polyamide, maximum stiffness.	Injection moulding grade Industry, sport, leisure.

Grilamid flexible, plasticised	**Characteristics and properties**	**Processing / Application segment**
L 20 W 20	Semi-flexible, medium viscosity, heat stabilised, contains plasticiser. Dimensional accuracy.	Injection moulding and extrusion grade. Industry
L 20 W 20 grey 9280	Semi-flexible, medium viscosity, heat stabilsed, contains plasticiser. Low coefficiency of friction, with MoS_2.	Injection mouldingn and extrusion grade. Industry, automotive
L 20 W 40 X	Flexible, medium viscosity, contains plasticiser, heat and UV stabilised. Excellent impact properties, even at low temperatures. Very easy to process.	Extrusion grade Industry, automotive.
L 25 W 20 X	Semi-flexible, high viscosity, contains plasticiser, heat and UV stabilised. Excellent impact properties, even at low temperatures. Very easy to process.	Extrusion grade Industry, automotive
L 25 W 20 Y	Semi-flexible, medium viscosity, contains plasticiser, heat and UV stabilised. High burst strength and cold impact resistance.	Extrusion grade Automotive
L 25 W 40	Flexible, high viscosity, contains plasticiser, heat and UV stabilised, easy to process.	Extrusion grade Industry, pneumatic
L 25 W 40 X	Flexible, high viscosity, contains plasticiser, heat and UV stabilised. Excellent impact properties, even at low temperatures. Very easy to process.	Extrusion grade Automotive
L 25 W 40 ESD	Flexible, high viscosity, contains plasiticiser, electrically conductive, anti-static, heat stabilised, easy to process.	Extrusion grade Automotive
Grilamid Elastomers	**Characteristics and properties**	**Processing / Application segment**
ELY 20 NZ	Very flexible, contains no plasticiser. Polyamide elastomer based on PA12. High impact resistant, good weathering resistance.	Injection moulding grade Industry, automotive
ELY 2702	Very flexible, contains no plasticiser. Polyamide elastomer based on PA12. Good weathering resistance	Injection moulding grade Sport, leisure
ELY 2475	Flexible, contains no plasticiser. Polyamide elastomer based on PA12. Good flow, good weathering resistance.	Injection moulding grade Sport, leisure
ELY 2694	Flexible, contains no plasticiser. Polyamide elastomer based on PA12. Good weathering resistance.	Injection moulding grade Sport, leisure
ELY 60	Flexible, contains no plasticiser. Polyamide elastomer based on PA12. Good flow and good weathering resistance.	Injection moulding and extrusion grade. Industry, electro/electronic, sport, leisure
Grilamid impact resist.	**Characteristics and properties**	**Processing / Application segment**
L 25 Z	Impact modified, high viscosity, very tough, heat and UV stabilised. High penetration resistance to shotgun pellets.	Extrusion grade, electro/electronic cable, ballistic protection
L 20A Z	Hydrolysis stabilised, impact modified, heat stabilised, medium viscosity. For extrusion blow moulding. Impact modified.	Extrusion blow-moulding grade Automotive
L 25A NZ	Hydrolysis stabilised, impact modified, heat stabilised, high viscosity.	Extrusion grade Automotive
LV-2A NZ	Hydrolysis stabilised, reinforced with 20% glass fibres, impact modified, heat stabilised. Very stiff, high impact strength.	Injection moulding grade Automotive
L 25 NZ ESD	Electrically conductive, anti-static, impact modified, heat stabilised.	Extrusion grade Automotive
Grilamid anti-static, electrically conductive	**Characteristics and properties**	**Processing / Application segment**
L 20 EC black	Electrically conductive, normal viscosity, heat stabilised. Easy to process, good mould release. Black inherent colour.	Injection moulding grade Industry, electro/electronic
L 25 NZ ESD	Electrically conductive, anti-static, impact modified, heat stabilised. Black inherent colour.	Extrusion grade Automotive
L 25 W 40 ESD	Electrically conductive, anti-static. Very flexible, high viscosity, contains plasticiser, heat stabilised. Suitable for tube extrusion, easy to process. Black inherent colour.	Extrusion grade Automotive
LV-23 ESD	Electrically conductive, anti-static, reinforced with 23% glass fibres, heat stabilised. Black inherent colour.	Injection moulding grade Automotive

Properties

Mechanical properties				
Tensile E-modulus	(1 mm/min)	ISO 527	MPa	cond.
Tensile strength at yield	(50 mm/min)	ISO 527	MPa	cond.
Elongation at yield	(50 mm/min)	ISO 527	%	cond.
Tensile strength at break	(50 mm/min)	ISO 527	MPa	cond.
Elongation at break	(50 mm/min)	ISO 527	%	cond.
Impact strength	(Charpy, 23 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Impact strength	(Charpy, –30 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Notched impact strength	(Charpy, 23 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Notched impact strength	(Charpy, –30 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Shore-D hardness		ISO 868	-	cond.
Thermal properties				
Melting point	(DSC)	ISO 11357	°C	dry
Heat deflection temperature HDT/A	(1.80 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/B	(0.45 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/C	(8.00 MPa)	ISO 75	°C	dry
Thermal expansion coefficient long.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient trans.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long term	ISO 2578	°C	dry
Max. working temperature	short term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	cond.
Comparative tracking index	CTI	IEC 60112	—	cond.
Volume resistivity		IEC 60093	| · m	cond.
Surface resistivity		IEC 60093	|	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	(0.8 mm)	ISO 1210	rating	
Water absorption	(23 °C/sat.)	ISO 62	%	
Moisture absorption	(23 °C/50 % r.h.)	ISO 62	%	
Processing properties				
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	trans.	ISO 294	%	dry
Nomenclature		ISO 1874-1		

* not relevant as per CAMPUS

Grilamid non-reinforced

■ only in black 9563

	Grilamid L 16 LM	Grilamid L 20 G	Grilamid L 20 HL ■	Grilamid L 20 LM	Grilamid L 20 H FR	Grilamid L 25	Grilamid L 25 H
	1100	1100	1100	1100	1500	1100	1100
	45	40	40	40	40	40	40
	15	12	12	12	10	12	12
	50	50	50	50	35	50	50
	>50	>50	>50	>50	>50	>50	>50
	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
	7	7	7	4	7	10	10
	6	6	6	3	6	7	7
	70	70	70	70	72	70	70
	178	178	178	178	178	178	178
	50	45	45	50	50	45	45
	125	115	115	125	130	115	115
	*	*	*	*	*	*	*
	1.2	1.2	1.2	1.2	0.9	1.2	1.2
	1.4	1.4	1.4	1.4	1.2	1.4	1.4
	90-110	90-110	90-110	90-110	90-110	80-100	100-120
	150	150	150	150	150	150	150
	32	32	32	32	34	32	32
	600	600	550	600	600	600	600
	10^{11}	10^{11}	10^{11}	10^{11}	10^{12}	10^{11}	10^{11}
	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}
	1.01	1.01	1.01	1.01	1.05	1.01	1.01
	HB	HB	HB	HB	V2	HB	HB
	1.5	1.5	1.5	1.5	1.4	1.5	1.5
	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	0.80	0.80	0.80	0.80	0.55	-	-
	0.85	0.85	0.85	0.85	0.75	-	-
	PA12, EHLS, 14-010N	PA12, MHR, 18-010	PA12, EHL, 18-010	PA12, MHLR, 18-010	PA12, MHF, 18-010	PA12, MHR, 24-010	PA12, EH, 24-010

Text values «conditioned» were obtained using test pieces stored according to ISO 1110.
n.b. = no break

Properties

Mechanical properties				
Tensile E-modulus	(1 mm/min)	ISO 527	MPa	cond.
Tensile strength at yield	(50 mm/min)	ISO 527	MPa	cond.
Elongation at yield	(50 mm/min)	ISO 527	%	cond.
Tensile strength at break	(50 mm/min)	ISO 527	MPa	cond.
Elongation at break	(50 mm/min)	ISO 527	%	cond.
Impact strength	(Charpy, 23 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Impact strength	(Charpy, –30 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Notched impact strength	(Charpy, 23 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Notched impact strength	(Charpy, –30 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Shore-D hardness		ISO 868	-	cond.
Thermal properties				
Melting point	(DSC)	ISO 11357	°C	dry
Heat deflection temperature HDT/A	(1.80 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/B	(0.45 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/C	(8.00 MPa)	ISO 75	°C	dry
Thermal expansion coefficient long.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
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Max. working temperature	long term	ISO 2578	°C	dry
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Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	cond.
Comparative tracking index	CTI	IEC 60112	—	cond.
Volume resistivity		IEC 60093	$\Omega \cdot m$	cond.
Surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	(0.8 mm)	ISO 1210	rating	
Water absorption	(23 °C/sat.)	ISO 62	%	
Moisture absorption	(23 °C/50 % r.h.)	ISO 62	%	
Processing properties				
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	trans.	ISO 294	%	dry
Nomenclature		ISO 1874-1		

* not relevant as per CAMPUS • testing speed 5 mm/min

Grilamid reinforced

	Grilamid LV-2H	Grilamid LV-2A NZ	Grilamid LV-3H/LV-3H WA	Grilamid LV-3A H	Grilamid LV-5H/LV-5H WA	Grilamid LKN-5H	Grilamid LKN-3H	Grilamid LC-3H
	4400	3500	6000	6000	11500	2300	1600	12000
	*	*	*	*	*	45	45	*
	*	*	*	*	*	7	10	*
	90•	80•	105•	105•	160•	40	35	140•
	10•	15•	8•	8•	5•	25	25	3•
	70	110	80	80	80	140	170	60
	70	110	80	80	80	65	60	60
	20	30	20	20	20	5	5	13
	15	20	15	15	15	4	4	8
	74	73	77	77	82	75	75	82
	178	178	178	178	178	178	178	178
	150	130	160	160	165	65	50	165
	*	160	*	*	*	*	*	*
	80	*	90	90	125	40	40	125
	0.3	0.4	0.2	0.2	0.15	1.2	1.4	0.1
	1.5	1.5	1.5	1.5	1.2	1.2	1.4	1.3
	90-120	90-120	90-120	90-120	90-120	90-120	90-120	90-120
	150	150	150	150	150	150	150	150
	35	35	35	35	35	35	35	-
	600	600	550	600	600	600	600	-
	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}	100
	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	<50
	1.16	1.12	1.22	1.22	1.47	1.44	1.21	1.15
	HB	HB	HB	HB	HB	HB	HB	HB
	1.2	1.1	1.1	1.1	0.8	0.8	1.2	1.1
	0.6	0.5	0.6	0.6	0.4	0.4	0.6	0.6
	0.10	0.30	0.10	0.10	0.10	0.80	0.95	0.10
	0.70	1.00	0.65	0.65	0.50	0.90	1.00	0.30
	PA12, MHR, 18-050, GF20	PA12, MHR, 22-040, GF20	PA12, MHR, 18-060, GF30	PA12, MHR, 22-060,GF30	PA12, MHR, 18-120, GF50	PA12, MHR, 18-020, GB50	PA12, MHR, 18-020, GB30	PA12, MHR, 18-120, CF30

Text values «conditioned» were obtained using test pieces stored according to ISO 1110.

Properties

Mechanical properties				
Tensile E-modulus	(1 mm/min)	ISO 527	MPa	cond.
Tensile strength at yield	(50 mm/min)	ISO 527	MPa	cond.
Elongation at yield	(50 mm/min)	ISO 527	%	cond.
Tensile strength at break	(50 mm/min)	ISO 527	MPa	cond.
Elongation at break	(50 mm/min)	ISO 527	%	cond.
Impact strength	(Charpy, 23 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Impact strength	(Charpy, –30 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Notched impact strength	(Charpy, 23 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Notched impact strength	(Charpy, –30 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Shore-D hardness		ISO 868	-	cond.
Thermal properties				
Melting point	(DSC)	ISO 11357	°C	dry
Heat deflection temperature HDT/A	(1.80 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/B	(0.45 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/C	(8.00 MPa)	ISO 75	°C	dry
Thermal expansion coefficient long.	(23–55 °C)	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient trans.	(23–55 °C)	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long term	ISO 2578	°C	dry
Max. working temperature	short term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	cond.
Comparative tracking index	CTI	IEC 60112	—	cond.
Volume resistivity		IEC 60093	$\Omega \cdot m$	cond.
Surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	(0.8 mm)	ISO 1210	rating	
Water absorption	(23 °C/sat.)	ISO 62	%	
Moisture absorption	(23 °C/50 % r.h.)	ISO 62	%	
Processing properties				
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	trans.	ISO 294	%	dry
Nomenclature		ISO 1874-1		

* not relevant as per CAMPUS

Grilamid flexible, plasticised

	Grilamid L 20 W 20	Grilamid L 20 W 40 X	Grilamid L 25 W 20 X	Grilamid L 25 W 20 Y	Grilamid L 25 W 40	Grilamid L 25 W 40 X
	500	360	450	450	400	360
	30	25	30	30	25	25
	20	30	20	25	20	20
	40	40	35	40	40	40
	>50	>50	>50	>50	>50	>50
	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
	40	n.b.	n.b.	n.b.	n.b.	n.b.
	3	13	6	7	4	13
	65	63	65	65	65	63
	174	173	174	178	173	173
	45	45	45	45	45	45
	100	95	95	95	95	95
	*	*	*	*	*	*
	1.4	1.4	1.4	1.4	1.4	1.4
	1.6	1.8	1.8	1.8	1.8	1.8
	80-110	80-110	80-110	80-110	80-100	80-110
	150	150	150	150	150	150
	32	32	32	32	32	32
	600	600	600	600	600	600
	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}
	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}
	1.03	1.02	1.02	1.02	1.03	1.02
	HB	HB	HB	HB	HB	HB
	1.5	1.5	1.5	1.5	1.4	1.4
	0.7	0.7	0.7	0.7	0.7	0.7
	0.85	0.90	0.80	0.80	0.90	0.90
	1.00	1.25	1.25	1.20	1.30	1.25
	PA12-P, GHL, 18-005	PA12-HIP, GHL, 18-004	PA12-HIP, EHL, 22-005	PA12-HIP, EHL, 22-005	PA12-P, EHL, 22-004	PA12, HIP, EHL, 22-004

Text values «conditioned» were obtained using test pieces stored according to ISO 1110.

n.b. = no break

Properties

Mechanical properties				
Tensile E-modulus	(1 mm/min)	ISO 527	MPa	cond.
Tensile strength at yield	(50 mm/min)	ISO 527	MPa	cond.
Elongation at yield	(50 mm/min)	ISO 527	%	cond.
Tensile strength at break	(50 mm/min)	ISO 527	MPa	cond.
Elongation at break	(50 mm/min)	ISO 527	%	cond.
Impact strength	(Charpy, 23 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Impact strength	(Charpy, –30 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Notched impact strength	(Charpy, 23 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Notched impact strength	(Charpy, –30 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Shore-D hardness		ISO 868	-	cond.
Thermal properties				
Melting point	(DSC)	ISO 11357	°C	dry
Heat deflection temperature HDT/A	(1.80 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/B	(0.45 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/C	(8.00 MPa)	ISO 75	°C	dry
Thermal expansion coefficient long.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient trans.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long term	ISO 2578	°C	dry
Max. working temperature	short term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	cond.
Comparative tracking index	CTI	IEC 60112	—	cond.
Volume resistivity		IEC 60093	$\Omega \cdot m$	cond.
Surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	(0.8 mm)	ISO 1210	rating	
Water absorption	(23 °C/sat.)	ISO 62	%	
Moisture absorption	(23 °C/50 % r.h.)	ISO 62	%	
Processing properties				
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	trans.	ISO 294	%	dry
Nomenclature		ISO 1874-1		

* not relevant as per CAMPUS

• testing speed 5 mm/min

Grilamid Elastomers

	Grilamid ELY 20 NZ	Grilamid ELY 2702	Grilamid ELY 2475	Grilamid ELY 2694	Grilamid ELY 60			
	250	200	300	450	350			
	15	15	15	25	20			
	25	20	20	20	20			
	35	40	35	45	25			
	>50	>50	>50	>50	>50			
	n.b.	n.b.	n.b.	n.b.	n.b.			
	n.b.	n.b.	n.b.	n.b.	n.b.			
	n.b.	n.b.	n.b.	n.b.	n.b.			
	n.b.	n.b.	20	8	4			
	52	54	56	64	63			
	160	162	167	176	160			
	45	45	45	55	45			
	75	65	75	75	55			
	*	*	*	*	*			
	1.6	1.3	1.4	1.6	1.4			
	1.9	1.9	1.6	1.7	1.5			
	80-100	80-100	80-100	80-100	80-100			
	140	140	140	140	130			
	32	32	32	31	38			
	600	600	600	600	600			
	10^{10}	10^{10}	10^{11}	10^{11}	10^{11}			
	10^{12}	10^{11}	10^{12}	10^{12}	10^{12}			
	0.99	1.02	1.02	1.01	1.01			
	HB	HB	HB	HB	HB			
	1.4	1.3	1.5	1.5	1.3			
	0.5	0.9	1.0	0.7	0.5			
	0.75	0.45	0.70	0.65	0.40			
	1.15	0.70	0.95	0.85	0.85			
	PA12/X, GH, 18-002	PA12/X, GH, 18-002	PA12/X, GH, 18-003	PA12/X, GH, 18-004	PA12/X, GH, 14-003			

Text values «conditioned» were obtained using test pieces stored according to ISO 1110.

n.b. = no break

Properties

Mechanical properties				
Tensile E-modulus	(1 mm/min)	ISO 527	MPa	cond.
Tensile strength at yield	(50 mm/min)	ISO 527	MPa	cond.
Elongation at yield	(50 mm/min)	ISO 527	%	cond.
Tensile strength at break	(50 mm/min)	ISO 527	MPa	cond.
Elongation at break	(50 mm/min)	ISO 527	%	cond.
Impact strength	(Charpy, 23 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Impact strength	(Charpy, –30 °C)	ISO 179/2-1eU	kJ/m^2	cond.
Notched impact strength	(Charpy, 23 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Notched impact strength	(Charpy, –30 °C)	ISO 179/2-1eA	kJ/m^2	cond.
Shore-D hardness		ISO 868	-	cond.
Thermal properties				
Melting point	(DSC)	ISO 11357	°C	dry
Heat deflection temperature HDT/A	(1.80 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/B	(0.45 MPa)	ISO 75	°C	dry
Heat deflection temperature HDT/C	(8.00 MPa)	ISO 75	°C	dry
Thermal expansion coefficient long.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient trans.	(23–55°C)	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long term	ISO 2578	°C	dry
Max. working temperature	short term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	cond.
Comparative tracking index	CTI	IEC 60112	—	cond.
Volume resistivity		IEC 60093	$\Omega \cdot m$	cond.
Surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	(0.8 mm)	ISO 1210	rating	
Water absorption	(23 °C/sat.)	ISO 62	%	
Moisture absorption	(23 °C/50 % r.h.)	ISO 62	%	
Processing properties				
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	trans.	ISO 294	%	dry
Nomenclature		ISO 1874-1		

* not relevant as per CAMPUS • testing speed 5 mm/min

Grilamid impact resistant, anti-static, electrically conductive

	Grilamid L 25 Z	Grilamid L 20A Z	Grilamid L 25A NZ	Grilamid L 20 EC	Grilamid L 25 NZ ESD	Grilamid L 25 W 40 ESD	Grilamid LV-23 ESD	Grilamid L20 LF
	900	900	750	1900	1000	350	5000	2000
	35	35	30	50	35	25	*	45
	12	10	15	10	12	20	*	12
	40	40	40	40	40	35	95•	40
	>50	>50	>50	30	>50	>50	5•	40
	>100	>100	>100	>100	>100	>100	70	>100
	>100	>100	>100	50	>100	>100	40	>100
	55	60	100	2	80	n.b.	8.	4
	13	15	75	2	20	9	6	3
	68	70	66	72	-	-	75	72
	178	175	178	178	178	173	178	178
	40	40	45	65	45	45	150	65
	85	100	80	135	95	95	*	140
	*	*	*	*	*	*	80	*
	1.2	1.2	1.2	1.2	1.3	1.4	0.2	0.8
	1.4	1.4	1.4	1.3	1.5	1.8	1.5	1.3
	90-110	90-110	90-110	90-110	90-110	90-110	90-120	90-110
	150	150	150	150	150	150	150	150
	22	28	-	-	*	*	*	21
	600	600	-	-	*	*	*	225
	10^{11}	10^{11}	10^{11}	1	1000	1000	100	10^{11}
	10^{12}	10^{12}	10^{12}	100	10^{6}	10^{6}	10^{4}	10^{12}
	1.00	1.00	0.98	1.16	1.02	1.04	1.19	1.08
	HB	HB	HB	HB	HB	HB	HB	HB
	1.5	1.4	1.3	1.1	1.1	1.1	1.0	1.5
	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.7
	0.80	0.70	1.00	1.25	1.15	1.10	0.10	0.40
	1.30	1.20	1.60	1.40	1.35	1.40	0.70	0.55
	PA12-HI, EH, 24-010	PA12-HI, MHR, 22-010N	PA12-HI, EH, 24-007	PA12, MHLRZ, 18-020, CD25	PA12-HI, EHZ, 24-010	PA12-HIP, EHLZ, 22-004	PA12, MHRZ, 18-050, (GF+C) 23	PA12, MHZ, 18-020, CD 12

Text values «conditioned» were obtained using test pieces stored according to ISO 1110. n.b. = no break

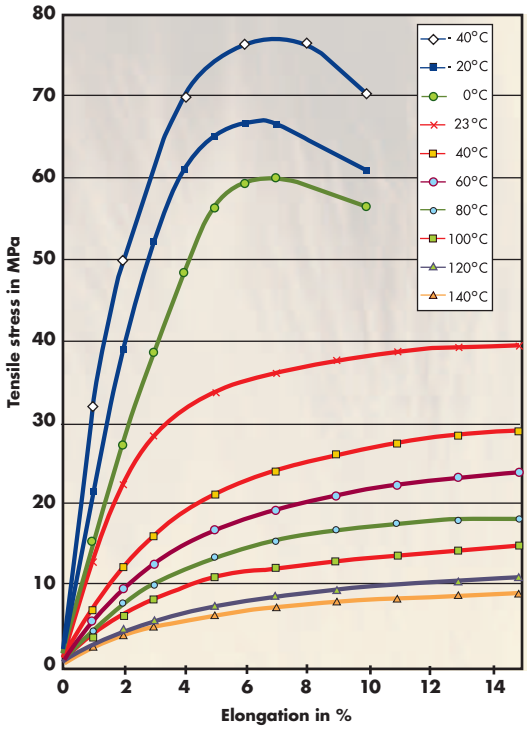
The recommendations and data given here are based on our experience to date, however, no liability. can be assumed in connection with their usage or processing.

Domat/Ems, December 2003

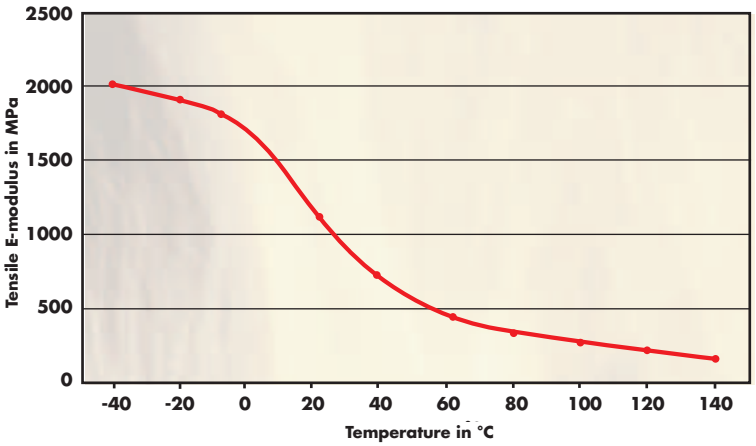
Design data - short-term behaviour

Mechanical properties of Grilamid as a function of temperature

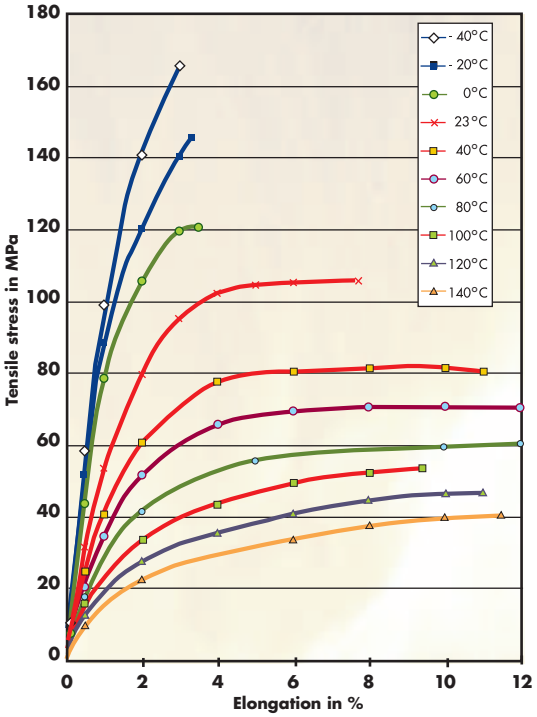
Tensile test Grilamid L 20 G - conditioned



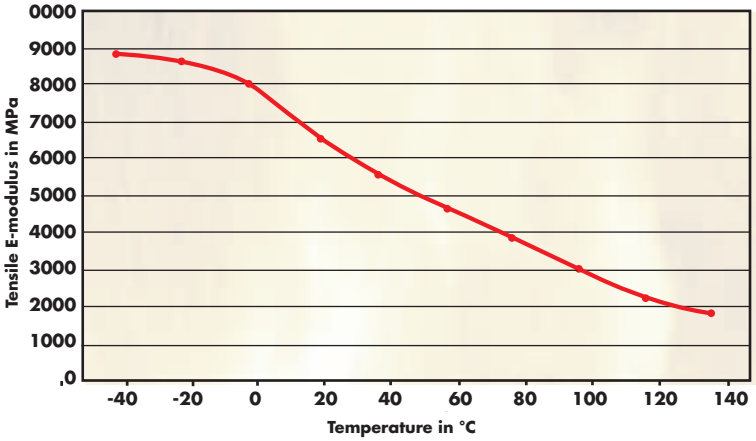
Tensile E-modulus Grilamid L 20 G - conditioned



Tensile test Grilamid LV-3H - conditioned



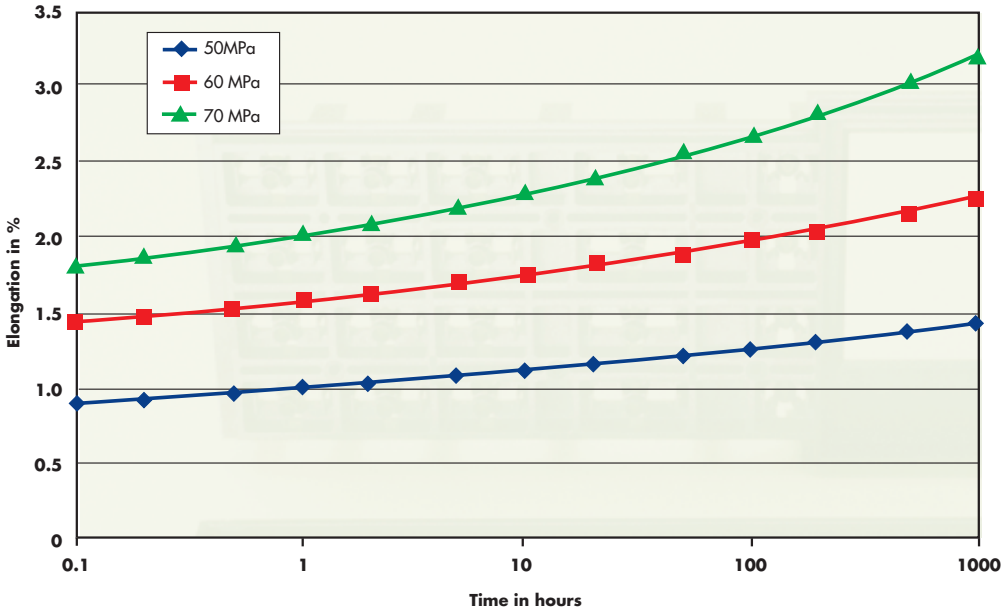
Tensile E-modulus Grilamid LV-3H - conditioned



Design data - long-term behaviour

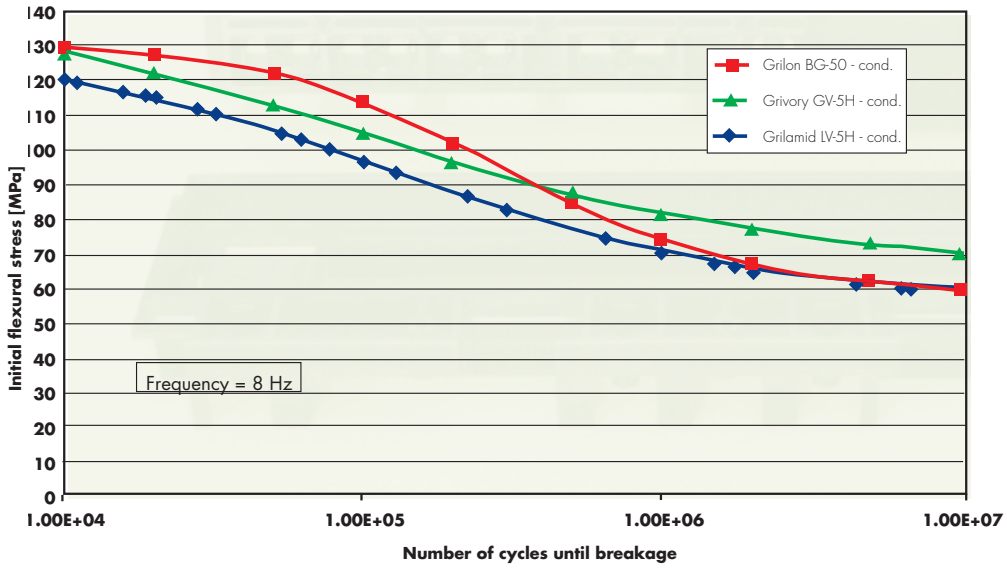
Following long-term static stressing of construction materials under different mechanical loads, characteristic time-elongation curves for each plastic material can be plotted. The material "creeps" due to the effects of stress and temperature.

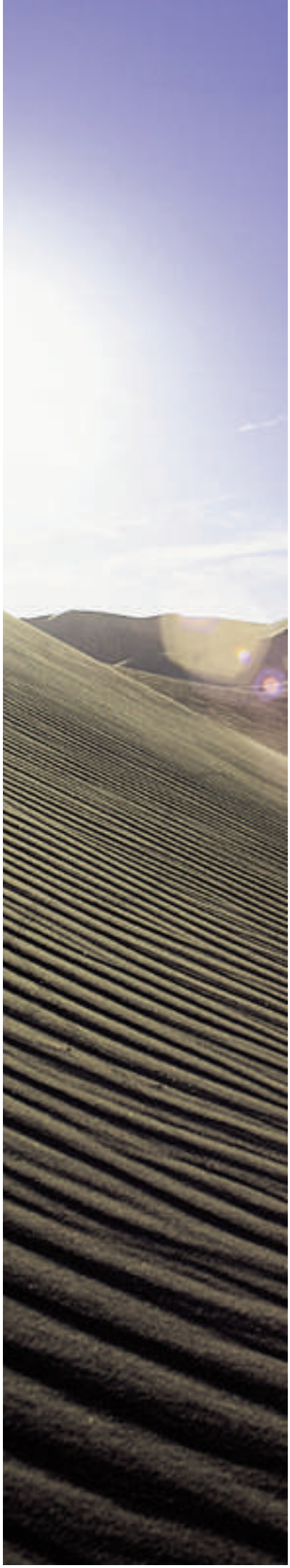
Creep curves for Grilamid LV-3H at 23°C / 50 % r.h.



Dynamic, long-term stressing can lead to failure of the construction material. Dependent on the amount of cyclic mechanical loading, breakage occurs after a certain number of load cycles.
The fatigue strength of Grilamid LV-5H is of a very high standard and is comparable to that of Grilon BG-50 (PA6 GF 50).

Comparison of "Wöhler curves" or fatigue strength in the bending range





Weathering resistance

The influence of UV-radiation causes a change in the physical and chemical properties of all plastics - and therefore, polyamides. In particular, the combination of radiation, oxygen in the air, moisture and temperature causes a reduction in the working life of a material due to chain fission, cross-linking and other oxidation processes.

The resistance to weathering is dependent on the composition of the polymer and the kind of filling material used (glass, mineral, carbon black etc.). The surface of the plastic is affected first and foremost, so that the serviceability of a part is very dependent on its thickness.

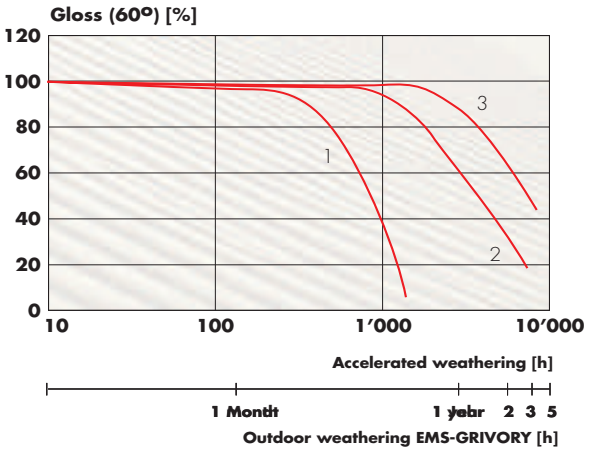
Due to its chemical construction, Grilamid is very resistant to weathering and is therefore suitable for many exterior applications.

Resistance to weathering can be further improved by suitable UV stabilisation and pigmentation with carbon black. This allows the use of Grilamid in applications under extreme climates, in particular those with high UV-radiation. The working life of polyamide components is determined both in accelerated weathering tests (filtered xenon radiation as per ISO 4892-2) and in outdoor weathering tests (alpine climate at Ems).

In order to test the weatherability 1-mm-thick test bars are exposed to weathering at EMS-GRIVORY and their tensile impact strength values measured after certain periods of time. It goes without saying that in practice, much higher working life times are achieved for thick-walled parts.

The graphs given below show mechanical and optical properties of different Grilamid grades as a function of exposure to weathering.

Lasting improvements in the resistance of non-stabilised Grilamid grades can be achieved through the addition of small amounts of the specially developed UV masterbatch Grilamid MB 3461 LUV.

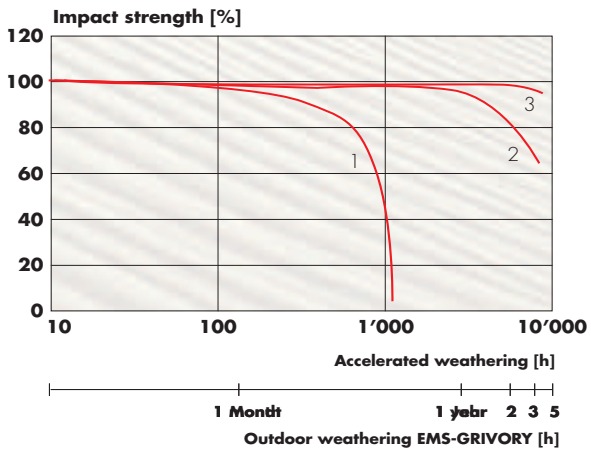


Gloss of Grilamid after weathering

Graph 1: Grilamid LV-3H nat.

Graph 2:
Grilamid L20 G nat.
Grilamid LV-3H nat. + UV-MB

Graph 3:
Grilamid L20 G black 9288 + UV-MB and Grilamid LV-3H black 9288 + UV-MB



Tensile impact strength of Grilamid after weathering

Graph 1: Grilamid L20 G nat./ Grilamid LV-3H nat.

Graph 2:
Grilamid L20 G nat. + UV-MB

Graph 3:
Grilamid L20 G black 9288 + UV-MB and
Grilamid LV-3H black 9288 + UV-MB

Heat resistance

At increased temperatures, all plastics - including polyamides - exhibit ageing phenomena which, over a length of time, have an adverse effect on the properties of the construction material.

These processes include those of a chemical nature such as oxidation reactions, but may also be caused by physical processes such as post-crystallisation or changes in morphology.

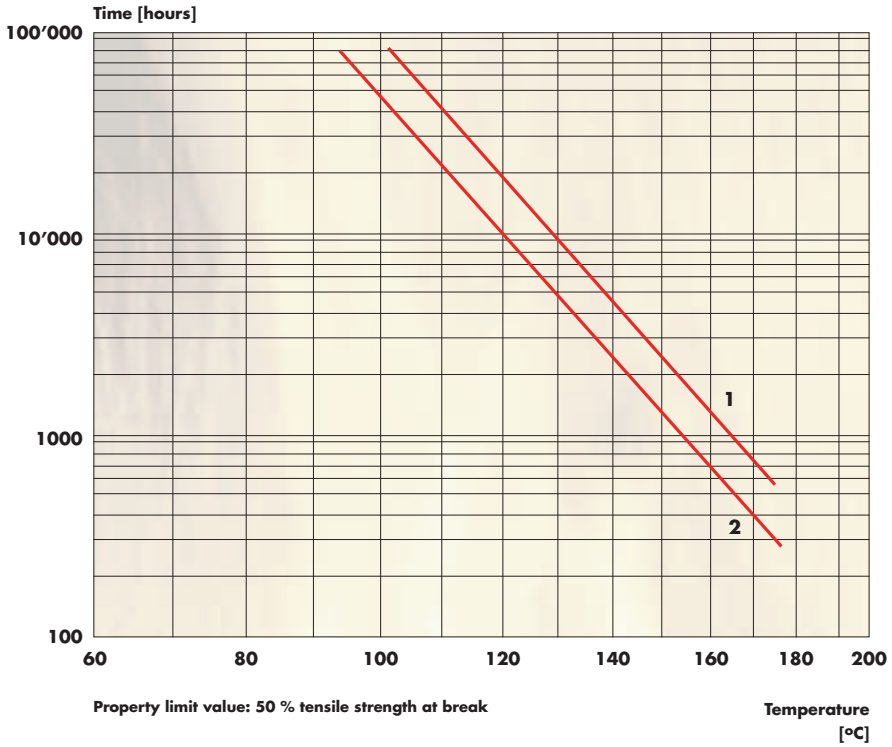
In practice, specification of a temperature-time limit, within which the properties of the thermally stressed plastic may not change in an unacceptable way, is of great importance.

In order to determine this temperature-time limit, comprehensive tests were carried out by EMS-GRIVORY. In this way, through the right choice of product, successful use of Grilamid even at elevated temperatures can be guaranteed.

The maximum temperature or time at which the material still retains 50% of the initial value for tensile strength at break, can be read from the data plotted in an Arrhenius graph.

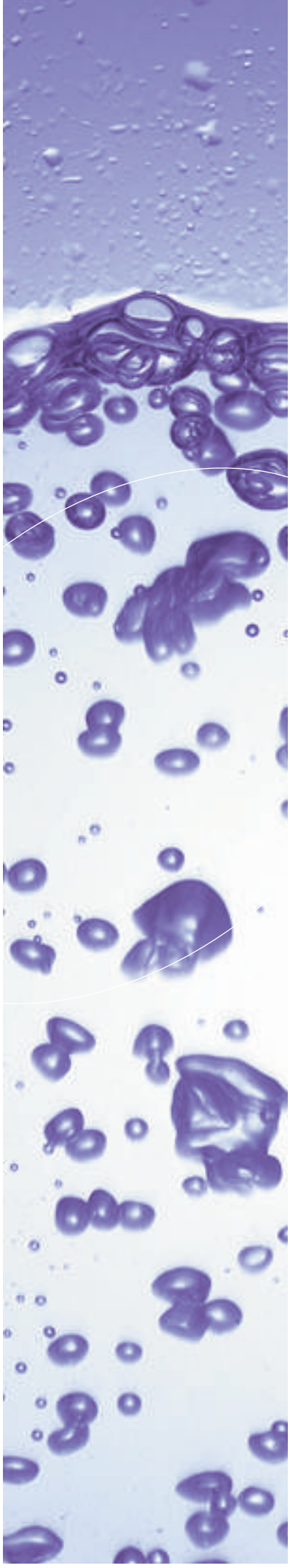
As can be seen from the graph below, addition of the heat stabilising masterbatch Grilamid MB 3287 LH can improve the heat stability.

Heat resistance of Grilamid



Graph 1:
Grilamid LV-3H
Grilamid LV-5H
Grilamid L25H
Grilamid L20G + H-MB

Graph 2:
Grilamid L25 LM
Grilamid L20G



Chemical resistance

In general, polyamide 12 is resistant to many organic solvents and alkalis. Grilamid is also unaffected by petroleum fractions, oils and fats.
Concentrated acids cause relatively rapid hydrolytic degradation of all polyamides but PA12 is resistant to dilute mineral acid and most organic acids. Homo polyamides are soluble in certain aggressive chemicals such as concentrated mineral acid, phenols, methanolic calcium chloride solution and highly halogenated acetic acid. Glycols, benzyl alcohol and cyclic ketones also have a strong affect on these materials at temperatures above 130°C.

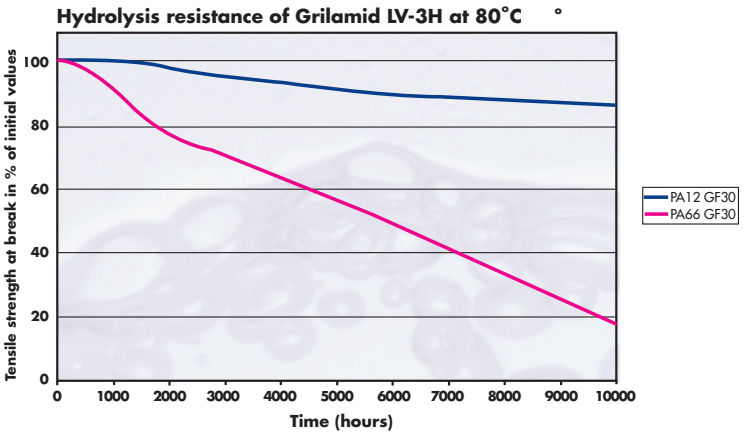
The following table shows the resistance of Grilamid to different chemicals at 23°C according to a system of graduation. Different solvents can extract the plasticiser from plasticised Grilamid. However, as long as the part affected is not allowed to dry out, the infiltrated solvent replaces the plasticiser and the original values of the mechanical properties remain largely unchanged.

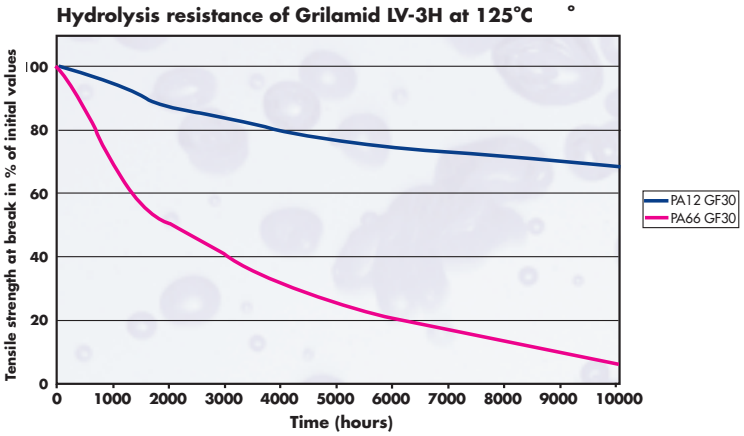
No crack formation can be observed in stressed parts exposed to all chemicals for which Grilamid has been determined to have good or limited resistance, or in which it exhibits swelling. The hydrolysis and environmental stress-cracking resistance of Grilamid are the most significant advantages of Grilamid in comparison to other engineering plastics.

Hydrolysis resistance

PA12 has a distinctly higher hydrolysis resistance than PA6 and PA66. The matrix is less hydrophilic, absorbs less water, even at elevated temperatures and, therefore, is less affected by hydrolysis.

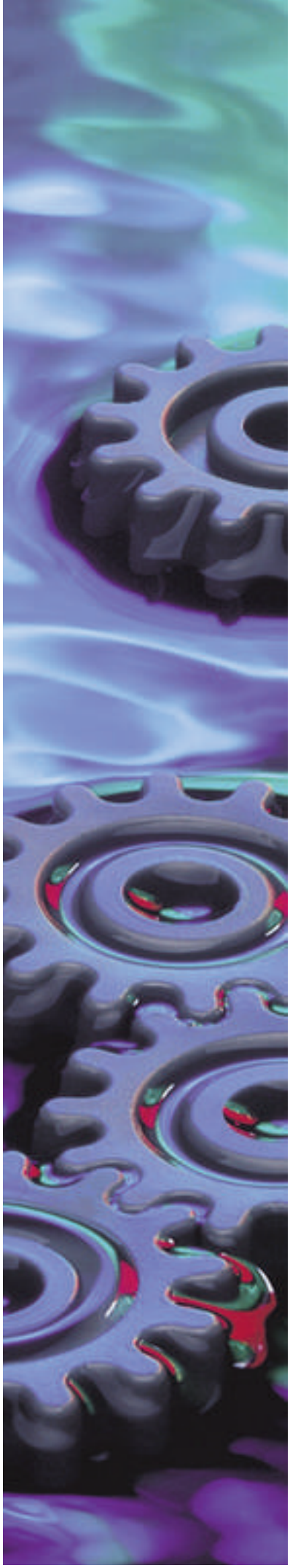
The following graphs show the change in tensile strength at break of tensile test bars made of glass-fibre reinforced PA12 GF 30 (Grilamid LV-3H) and PA66 GF 30, with original values in a conditioned state.





●●●	Acetone
●●	Acetic acid
●●●	Acetylene
●●●	Aluminium salts, aqueous
●●●	Ammonia, aqueous
●●	Amyl acetate
●●	Aniline
●●●	Antifreeze
●●●	Benzene
●	Benzyl alcohol
●	Bromine
●●●	Butane
●●●	Butanol
o	Chlorine
●	Chlorobenzene
●	Chloroform
●●	Citric acid
●●●	Copper suphate
●●	Carbon tetrachloride
o	Cresol
●●●	Decalin
●●●	Diesel fuel
●●●	Edible fat
●●●	Engine oil
●●●	Ethanol
●●●	Ether
●●●	Ethyl acetate
●●●	Ethylene oxide
●●●	Fats
●	Fluorine gas
●●	Formaldehyde
●	Formic acid conc.
●●●	Frigen F12 liquid
●	Frigen F22 liquid
●●●	Glycerine
●●●	Glycol
●●●	Heating oil
●●●	Heptane
●●●	Hydraulic oil
●●	Hydrochloric acid 1 %
●	Hydrochloric acid 10 %
●●	Hydrogen peroxide 20 %
●●●	Hydrogen sulphide
●●●	Iso-octane
●●●	Isopropanol
o	Iodine tincture
●●●	Kerosene
●●	Lactic acid
●●●	Magnesium chloride 10 %
●●●	Mercury
●●●	Methane
●●	Methanol
●	Methylene chloride
●●●	Milk
●●●	Mineral oil
●●●	Naphthalene
●●	Nitrobenzene
o	Nitric acid
●●●	Oils
●●●	Oleic acid
o	Oleum
●●●	Oxalic acid
●●●	Oxygen
●	Ozone
●●●	Paraffin oil
●●●	Perchlorethylene
●●●	Petrol
●●●	Petroleum
●●●	Petroleum ether
●●●	Petroleum fractions
●	Phenol
●●●	Potash
●●●	Propanol
●●●	Pyridene
●●●	Potassium hydroxide 10 %
●●●	Potassium hydroxide 50 %
o	Potassium permanganate
●●●	Salicylic acid
●●●	Sea water
●●●	Silicon fluid
●●●	Soap suds
●●●	Soda 10 %
●●●	Soda 50 %
●●●	Sodium chloride sat.
●●●	Sodium hydroxide 10 %
●●●	Sodium hydroxide 50 %
●●●	Sodium sulphate conc.
●●●	Starch
●●●	Stearic acid
●●●	Stearin
●●●	Styrene
●●	Sulphur dioxide
●●	Sulphuric acid 10 %
●	Sulphuric acid conc.
●●●	Table salt
●●●	Tallow
●●●	Tartaric acid
●●●	Tetralin
●●●	Toluene
●●●	Transformer oil
●●	Trichlorethane
●●	Trichlorethylene
●●●	Turpentine
●●●	Urea
●●●	Uric acid
●●	Urine
●●●	Vaseline
●●●	Vinegar
●●●	Water
●●●	Water glass
●●●	Wax
●●●	Xylol
●●●	Zinc chloride, aqueous

●●●	resistant
●●	limited resistance
●	not resistant
o	soluble, greatly affected



Special properties for tubes and pipes

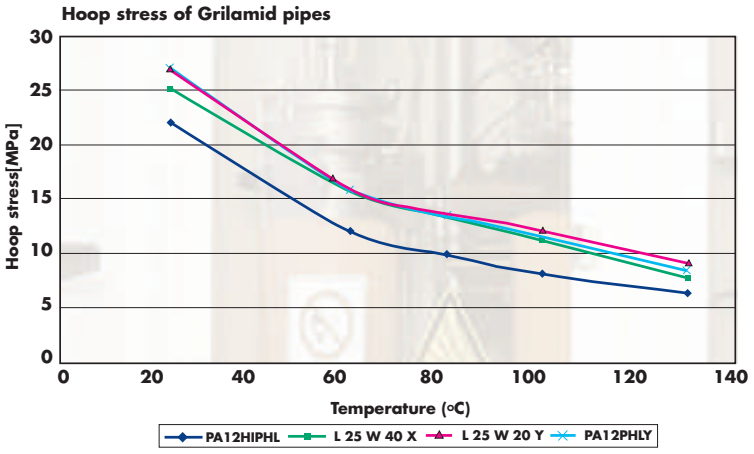
The standards DIN 73378, ISO 7628 and SAE J844 stipulate a requirement profile for extruded pipes for use in automotive construction applications. The development of PA 12 materials has been oriented towards these regulations.

Hoop stress, independent of pipe dimensions, can be calculated from the bursting pressure as follows:

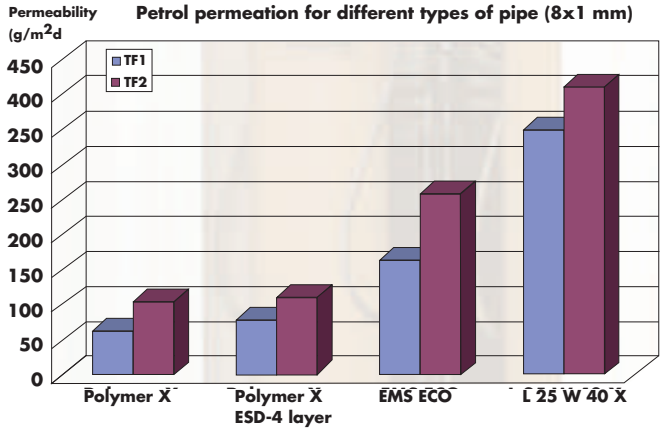
$$\sigma_V = \frac{P_B * dm}{20 * s_{min}}$$

P_B = Bursting pressure [bar]
dm = $d_1 - s_{min}$, mean pipe diameter [mm]
d_1 = outside diameter [mm]
s_{min} = minimum pipe wall thickness [mm]
σ_V = hoop stress [MPa]

The following diagram shows the guide values for hoop stress as given in DIN 73378, together with the hoop stress for Grilamid L 25 W 40 X and Grilamid L 25 W 20 Y.



Pipes made of polymer materials are being increasingly used for petrol feed systems due to their easy assembly, weight savings and resistance to corrosion.
Coextrusion methods allow petrol permeation to be reduced by use of suitable layers, chosen according to the formulation of the petrol. Due to its good mechanical properties and its resistance to chemicals e.g. zinc chloride and battery acid, Grilamid is used for the manufacture of external layers.



Polymer X, Polymer X ESD and EMS ECO are fuel-line systems from EMS-GRIVORY.

Test fuel TF1: 10% Ethanol, 45% Toluene, 45% Iso-octane
Test fuel TF2: 2.5% Ethanol, 5% Methanol, 46.25% Toluene, 46.25% Iso-octane

Approvals

Grilamid in contact with foodstuffs

…in the EU

The European Union has stipulated the conditions for polymers in contact with foodstuffs in the directive 90/128/EEC and its supplements as well as in the directive 02/72/EC. According to these guidelines, the polymer matrix of Grilamid L grades satisfies all requirements for approval of its use in contact with foodstuffs. These EU guidelines are valid for the EU countries and have been incorporated into Swiss federal legislation.

The end products must fulfil the following conditions:
Global migration limiting value: 60 mg/kg foodstuff
Specific migration limiting value of the monomer Laurolactam: 5 mg/kg foodstuff

Materials may only be used in contact with foodstuffs if all their different additives (lubricants etc.) are also approved. The following Grilamid grades satisfy all requirements of the EU directives for contact with foodstuffs:

Grilamid L 16 natural
Grilamid L 20 natural
Grilamid L 25 natural
Grilamid L 20 G black 9288
Grilamid LV-2H natural and black 9288
Grilamid LV-3H natural and black 9288
Grilamid LV-5H natural and black 9288
Grilamid LKN-3H natural and black 9288
Grilamid LKN-5H natural and black 9288

… in the United States

According to the US guideline FDA (21CFR 177.1500 (9)), Grilamid L products are only allowed for use in applications with a maximum layer thickness of 41 microns in contact with non-alcoholic foodstuffs. The following materials have been approved for use:

Grilamid L 16 natural
Grilamid L 20 natural
Grilamid L 25 natural

Our sales department will be pleased to provide you with further information regarding other Grilamid grades.

Grilamid in contact with drinking water

If fittings are to be used in contact with drinking water, the fitting itself and, in some cases, the material of which it is made, must be approved for use according to the regulations of the respective countries.

The following materials have been tested and are "Water Regulations Advisory Scheme (WRAS) - approved products" (or WRC). They are thus approved for drinking-water applications in Great Britain (UK):

Grilamid LV-2H natural and black 9288 for cold water and hot water up to 85°C
Grilamid LV-3H natural and black 9288 for cold water and hot water up to 85°C
Grilamid LV-5H natural and black 9288 for cold water and hot water up to 85°C
Grilamid L 25 natural for cold water and hot water up to 85°C
Grilamid L 20 G natural for applications with cold water and hot water up to 60°C
Grilamid LKN-5H natural for applications with cold water and hot water up to 60°C

Drying and storage

Grilamid is delivered ready dried and sealed in air-tight packaging. If these are stored correctly further drying is not necessary. If the temperatures of the storage and processing areas differ to a great extent, Grilamid should be stored at room temperature in the processing area for 24 hours before processing in order to prevent moisture absorption from condensation formed when the bags are opened. If bags become damaged during storage, the Grilamid should be dried before use. This can be carried out in a vacuum or convection oven for 6 to 16 hours at 80°C.

Sealed, undamaged bags may be stored, protected from the elements, for several years. Storage is recommended in a dry room in such a way that the bags are also protected from damage. Damaged or ripped bags should be resealed immediately although it is better to empty the material into a sealable metal container.

The packaging should be opened shortly before processing. If sacks are left open for any length of time a critical water content of >0.1% may be absorbed by the top layers of granules. If only a certain amount of material is used from an open sack, the remaining material should be emptied into a sealable metal container with as little air as possible. If long dwell times of the material in the moulding machine or extruder hopper are necessary, the use of a hopper heating system or hopper drier is recommended.

Grilamid®
EMS

Processing by injection moulding

The processing latitude for Grilamid lies between 220°C and 260°C for non-reinforced and between 240°C and 290°C for reinforced grades. The processing temperatures recommended for each type of Grilamid are given in the respective technical data sheets.

It is possible to work at the limits of the permissible melt temperature range (max. 300°C) for parts with long flow distances and low wall thicknesses. This is particularly true for reinforced Grilamid grades. The surface quality of thick-walled parts made of non-reinforced Grilamid can be improved by the choice of a low melt temperature.

Grilamid, with the exception of the Grilamid TR grades, is a partially crystalline thermoplastic material. This means that post pressure as well as sprue and gate dimensions must be sufficient to compensate for a decrease in volume due to crystallisation.

Screw geometry

Grilamid can be processed without problems using a universal three-zone screw extruder with a non-return valve. The effective screw length should be between 18 D and 20 D.

A non-return valve is necessary in order to prevent the melt flowing back into the screw flights during injection and follow-up pressure phases.

Nozzle

An open die can be used for processing Grilamid. With low viscosity grades, however, the melt may flow out of the nozzle. For this reason, needle valve nozzles have proved successful in practice.

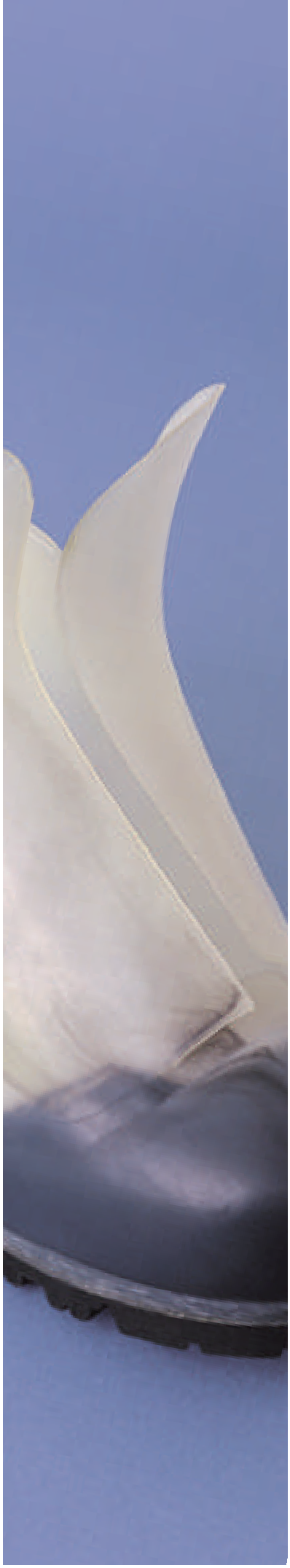
Mould design

The usual rules for all thermoplastic materials are valid for mould design. Basically, it is possible to use any kind of sprue system for processing Grilamid. As polyamides solidify over a relatively short temperature range, the sprue must be large enough to allow post pressure to be effective.

Mould temperature

As a rule, Grilamid is processsed with a mould temperature between 40°C and 60°C. This is particularly valid for non-reinforced Grilamid grades. At higher mould temperatures, Grilamid tends to stick. Reinforced Grilamid grades need to be injected at higher temperatures. The mould temperature should be between 80°C and 100°C in order to achieve good surface quality and for applications requiring shaped parts with higher hardness and strength values.

A good temperature control system, combined with the correct mould temperature, is a pre-requisite for the manufacture of high-quality injection moulded parts. The mould temperature has an influence on the degree of crystallisation, quality of surface finish, degree of shrinkage, warping, tolerance of dimensions and level of internal stresses.



Processing by extrusion

Grilamid can be processed in easily using any extruder suitable for extrusion of polyamides. Three-zone screws with a L/D-ratio of 25 and a compression ratio of 3:1 have proven very successful.

It should be noted that too low a flight depth in the feed zone and an extension of the compression zone can lead to high friction of the granules and thus to uncontrollable temperature, pressure and conveying conditions.

BM screws, patented by the extruder manufacturer Nextrom (ex Nokia Maillefer), are very well suited for processing Grilamid.

We recommend the use of smooth feed bushes for extrusion of Grilamid. The feed zone can be lightly grooved for a length of approx. 2D after the feed opening (groove depth max. 0.5 mm) in order to achieve higher specific output rates. It is recommended to control the temperature in the feed zone to between 60 - 90°C. A constant temperature in this zone is necessary in order to prevent output fluctuations.

Temperature settings on the extruder should be set 10 - 70°C above the given melting point of the material depending on its viscosity.

A die back-pressure of 80 - 250 bar is necessary for a uniform, homogeneous melt. Homogenisation can be improved by creating a higher dynamic pressure in the extruder. This can be achieved by use of a screen pack in front of the breaker plate.

Fibre optic cables / cable sheathing

Tube extrusion methods have proven suitable for production of fibre optic cables and cable sheathing.
During this process the melt parison leaving the die is "pulled" over the fibre or cable to be sheathed by its slightly reduced internal pressure.

Use of an extruder with a screw diameter of 30 - 45 mm has proven successful at conventional coating speeds.

Blown films

Grilamid can be processed using all conventional, commercially available blown film equipment. The extrusion methods vertically upwards as well as vertically downwards have both proven to be successful. Both co-extruded and mono blown films can be manufactured with Grilamid.

The choice of a blow-up ratio of 1:2 to 1:3 has been found to be suitable. Even though no pronounced drawing of the material takes place as, for example, with polyolefines, a certain orientation of the structural build-up occurs which becomes evident through improved mechanical and barrier properties of the film.

Due to Grilamid's narrow melting or solidifying range, an extrusion head with a perfectly designed flow and a clean and exactly centred die are particularly necessary to avoid the formation of differences in film thickness (streaks in the film). Different drying times for thick and thin areas can cause folds formation making it problematic to lay the film flat.

The distance between die and pinch rollers is dependent on the thickness of the film and the manufacturing speed. In general, the cooling distance should be slightly shorter in comparison to polyamid 6, in order for the film temperature to still be approx. 60 - 80°C when it reaches the pinch rollers. This helps in laying the film flat without folds forming.

It has also proven advantageous to keep the cooling air at a temperature of about 30°C to prevent a too rapid cooling of the film. The angle at which the film is laid flat should be kept as small as possible and it should reach as far as possible into the nip rollers.

A typical application for Grilamid, processed using blown-film extrusion, is for sausage skins.

Flat films

Co-extruded and mono flat films can also be manufactured using Grilamid. So-called chilled roll units are recommended for processing. This method involves the melt leaving a flat film extrusion die onto a rotating, temperature controlled, highly polished steel roller which transports the melt away from the die and cools it.

The roller temperature is set according to the draw-off speed and film thickness. In contrast to processing of polyolefines, where water is used to control the temperature, Grilamid should be processed using an oil temperature control system capable of keeping roller temperatures constant at more than 100°C depending on application.

Extrusion blow moulding

Special, highly viscous Grilamid grades for extrusion blow-moulding processes are also available.

Pipe and parison extrusion

The manufacture of pipes and tubes using polyamides is carried out using longitudinally moulded-on pipe extrusion heads. Either centre-fed dies (fig. 1) or spiral mandrel dies (fig. 2) are used as extrusion heads. When using a spiral mandrel die, flow marking and flow lines can be avoided by reducing the mandrel supports.

The design of pipe extrusion head has a significant influence on smoothly running extrusion at high speeds and on properties of the extruded pipe such as cold impact strength, bursting pressure, long-term compression set and optical quality of the finished pipe.

Mandrel supports in the form of 'spider legs' with a streamlined cross-section have proved suitable.

Die dimensions

Die land and haul-off ratio also have a decisive influence on the quality of the extruded pipes. A too short die land can lead to widening of the melt strand which makes subsequent calibration of the pipes very difficult, or which does not completely remove flow lines caused by mandrel supports. When using Grilamid we recommend a die land length of 25 x the die gap width for a centre-fed die and a miminum of 10 mm for a spiral mandrel die.

The haul-off ratio has a great influence on important pipe properties such as cold impact strength, elongation at break and resistance to chemicals. The draw-down ratio is particularly important as it has an influence on the lead into calibration as well as stretching of the melt.

$$\text{Draw-down ratio} = \frac{\frac{D}{T_{OD}}}{\frac{P}{T_{ID}}}$$

$$\text{Haul-off ratio} = \frac{D}{T_{OD}} = \frac{P}{T_{ID}} = \frac{S_1}{S_2}$$

D	=	Die diameter [mm]
P	=	Die mandrel diameter [mm]
T_{ID}	=	Internal diameter of pipe [mm]
T_{OD}	=	Outside diameter of pipe [mm]
S_1	=	Die gap [mm]
S_2	=	Pipe wall thickness [mm]

Recommendations for Grilamid: Draw-down ratio 1:1, haul-off ratio 2:1.

At higher take-off speeds, smaller haul-off ratios give somewhat better pipe properties.
Example: 60 m/min. = haul-off ratio 1.4 : 1.

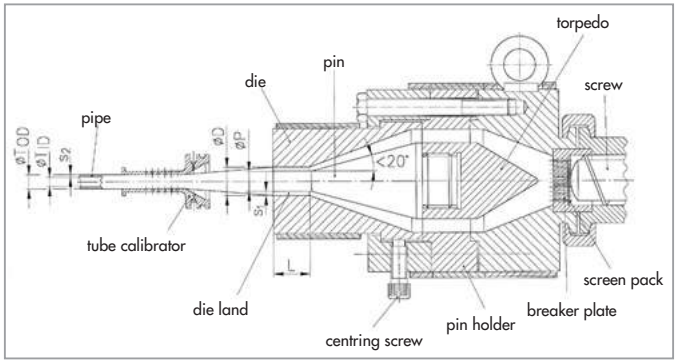


Fig. 1: Centre-fed die with pipe calibration

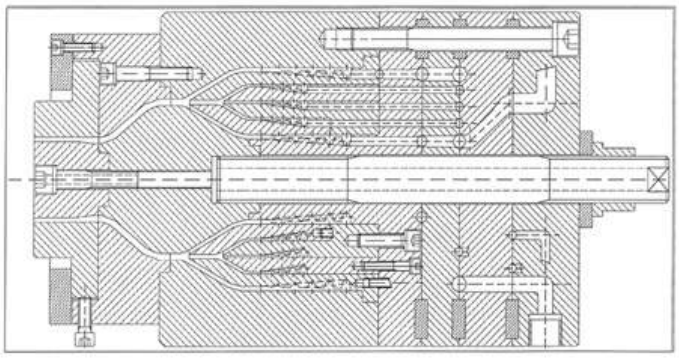


Fig. 2: Spiral distribution system from ETA Kunststofftechnologie GmbH

Calibration

The conventional method of calibration in a vacuum tank with pipe or calibrating plate is well suited for Grilamid pipes.

In general, short calibration should be used in order to avoid high calibration friction values and rapid solidification.

The surface of the calibration channel should be sand blasted. An effective and even lubricating water film should be present in the feed opening.

The shrinkage interference for Grilamid in a vacuum is dependent on the take-off speed and, at very high extrusion speeds, lies in the range between 4% and 10%.

High vacuum values should be avoided in order to prevent impairment of the mechanical properties through processing. A vacuum of 100 mbar is sufficient for stable calibration behaviour of high-quality pipes.

Further information can be found in our brochure "Tube extrusion".

Post treatment

Bonding

Grilamid is one of the construction materials which, due to their excellent resistance to chemicals and non-polar structure, are very difficult to bond. However, using the right methods and a suitable adhesive technical bonding is possible.

Adhesive solvents on a phenolic base (Resorcinol, Cresol) and reactive adhesives (both single and double component systems) are best suited for bonding Grilamid.

The most common reactive adhesives:

Single-component systems:

- Cyanoacrylate adhesives, acrylic adhesives, particularly well suited for bonding Grilamid to metal; shaped parts with a small surface area, very rapid setting.

Two-component sytems:

- Polyurethane adhesives
- Epoxy adhesives, long pot life (setting time), gap filling, large areas to be bonded

A significant improvement in the bonding quality can be achieved by pre-treatment.

Kinds of pre-treatment:

- Degreasing: use of organic solvents, such as e.g. acetone
- Mechanical removal: scrubbing, grinding, sand blasting
- Electro-chemical treatment: Corona discharge, low-pressure plasma
- Thermal: flame treatment
- Chemical: treatment with corrosive substances; adhesive manufacturers offer suitable primer systems.

The choice of suitable adhesive must be decided upon separately for each application. This is because apart from the materials to be bonded, the joint geometry, glue line and bond surface quality all have a great influence on the resulting bond. Please contact our Technical Advisory Service for more information regarding the choice of adhesive.

Welding

All welding methods developed for engineering plastics can be used to weld Grilamid. High-frequency and heat impulse welding are used for welding films.

Very good bonds can be obtained on shaped articles made of Grilamid using heated tool welding, ultra-sonic welding, spin welding, laser welding and vibration welding methods.

When using ultra-sonic welding, the best results are obtained in the weld zone. This means that this process is best suited for small parts. Glass bead or glass fibre reinforced products (e.g. Grilamid LKN-5H, Grilamid LV-3H) can be welded very successfully. It is practically impossible to weld Grilamid grades containing plasticiser (e.g. Grilamid L 25 W 40) using ultra-sonic welding. This method can, however, be used for embedding metal threads, for rivetting and for beading.

Vibration welding offers more freedom for combining different engineering plastics. Among other things, it presents the possibility of welding amorphous materials to semi-crystalline ones. A particularly interesting possiblity for designers is a bond of glass-fibre reinforced Grilamid and amorphous, transparent Grilamid TR 55 welded using vibration welding methods.

Screw fastening

Parts made of Grilamid can be fastened successfully using screws which form their own threads (self-tapping and thread-cutting screws).

Paint coating

Due to its excellent resistance to most solvents, Grilamid can be coated with one or more coats of different paints achieving good bonding without impairing the mechanical properties. Single and double component paints may be used with the binding agents being co-ordinated with the construction material to be painted.

Pre-treatment:

With Grilamid it is not normally necessary to carry out any special pre-treament. Some specific additives such as plasticiser, lubrication etc., may however, make painting difficult. In these cases, adhesion of the paint can be improved by pre-treatment. The different kinds of pre-treatment have already been listed under the heading “bonding”.

Heat embossing

Heat embossing with suitable embossing film can be carried out on Grilamid without problems.

Metal plating
Parts made of Grilamid can be given a galvanic coating after they have been given a coat of primer under a high vacuum, or have been given a corresponding pre-treatment. Excellent surface quality can be achieved with both reinforced and non-reinforced grades.

Printing
A special pre-treatment of Grilamid before using ink application printing methods is not normally necessary. In practice pre and post flaming methods have been found to give a durable printing result.

Laser technology is increasingly being used for marking and lettering. Good results on Grilamid can be obtained using Nd-Yag lasers. Such laser marking is scratch resistant and durable. Special material grades are necessary for laser marking.

General
Please contact our Technical Advisory Service for further information about post treatment of Grilamid.

Use of reclaimed material
Grilamid is exceptionally well suited for the reclaiming of faulty parts or production waste. This can be reprocessed and recycled.

The following critical points must be taken into consideration:

- water absorption
- grinding, dust content, maximum particle size
- contamination with foreign polymers, dust, oil etc.
- quantity content, percentage addition to the original material
- colour changes
- changes in mechanical properties

Grilamid® EMS

Technical advice and customer services

We offer advisory services and know-how to our customers starting from development work right through to serial production of a part. Our customer services offer quality, reliability and technical support.

- We draw up a range of optimal materials for your application.
- Our advisory services department is equipped with modern injection moulding units and extruders and is thus capable of finding solutions to problems with your moulded or extrusion parts.
- In order to offer you high-performance products our materials are continually subjected to quality control and assurance procedures.
- Modern, in-house test laboratories are available for mechanical, thermal and chemical property tests.

CAE

Using computer-assisted engineering systems EMS-GRIVORY application development centres are able to offer customers a wide range of supporting measures in this sector. CAE systems used include the Moldflow programme modules MF/Flow, MF/Cool, MF/Fiber and MF/Warp for simulation of injection moulding processes and the finite element (FE) programmes I-DEAS and ANSYS for mechanical mould design and layout. Rheological simulation enables the optimal positioning of the gate to be determined before manufacturing of the mould is begun. These programmes are also useful when changes to existing moulds are necessary as they help to find the most goal-oriented solution. The scale of calculation possible ranges from simple flow pattern simulations taking into consideration the influence of the cooling system, to qualitative statements about shrink behaviour and warping of shaped parts. Part design using FE analysis provides information about highly stressed areas. This allows weak points in the design to be determined and corresponding modifications to be made. Using the 3D CAD systems I-DEAS and CATIA, combined with VDA, IGES and STEP interfaces, EMS-GRIVORY is capable of using customer's own 3D CAD data for simulation calculations.

Prototype mould construction

The key to success is rapid realisation and quick implementation of a good idea. EMS-GRIVORY can help to limit risks of prototype mould construction and reduce time expenditure and costs. Here again, MOLDFLOW and FEM simulations can be carried out and a pilot series of parts can be manufactured (using EMS-GRIVORY engineering plastics) with a minimum of cost expenditure. In this way it is possible to carry out practical tests on moulded parts before serial production begins. This method of preparation for serial production can reduce expenditure and avoid expensive changes to manufacturing moulds before serial production begins.

Testing

EMS-GRIVORY has at its disposal state-of-the-art fully equipped laboratories for material testing and quality control.

Our instrumental infrastructure enables us not only to determine the standard mechanical, thermal and electrical property values of our materials for use in data sheets and approvals, but also to provide practical support for research and development and application development.

- The rheological laboratory of our material testing department is capable of supplying characteristic property data for materials, necessary for the simulation of injection moulding processes.

- Indications of possible uses for our materials under extreme conditions can be taken from on-going tests regarding their resistance to chemicals, heat and weathering.

- Chemical and process-technical tests ensure that the high quality levels of our products can be tested and constant property values guaranteed.

We can also provide support for specific problems facing our customers. In order to help reduce hydrocarbon emissions from heavy goods vehicles we have developed a process for the determination of permeability of different plastic materials for circulating fuel. The EMS P-Tester (p as in permeation) is now available to the automotive industry providing an apparatus with which the permeation behaviour of fuel systems can be tested under practical conditions.

In addition, our material testing department can make use of a variety of further special equipment such as a petrol circulation plant for testing the working life of plastic petrol feed lines under extreme conditions and a hot air threshold pressure test for testing shaped parts made using extrusion blow-moulding processes.

With these services we can offer our customers active support in the choice of material as well as mould design and testing of finished parts.

Grilamid® EMS

CAMPUS

Since 1989 EMS-GRIVORY has taken an active part in the creation of the CAMPUS data bank. Currently, our testing laboratories have characterised some 170 construction materials according to the CAMPUS profile regarding physical and process-technical properties. These are shown in both tabular (primary property values) and graphical (functional) forms. Material descriptions, typical applications and processing information supplement the product profile.

CAMPUS stands for Computer Aided Material Preselection by Uniform Standards.

The data bank contains a careful selection of meaningful test results which accurately describe the property profile of a material. The test bars used to obtain these test results are produced under standardised injection moulding conditions and testing itself is also carried out according to uniform ISO standards.

The particular advantage of this data bank is that customers of more than 40 material manufacturers obtain a direct property comparison for different products. Distribution of CAMPUS has allowed limitation of uneconomical duplication of specifications and test methods, while at the same time opening up new possibilities of rationalisation and automation of testing moulding compounds.

CAMPUS CD's can be obtained by customers on request from EMS-GRIVORY. The CAMPUS data and data bank software can also be downloaded free of charge from our homepage - www.emsgrivory.com.

Quality standards

Our quality management system is based on the international standards ISO 9001:2000 and is certified by the Swiss association for quality and management systems, "Schweizerischen Vereinigung für Qualitäts- und Management-Systeme" (SQS). We are currently introducing the regulations from the new standard ISO/TS 16949 developed by the automotive industry.

Our management system is process oriented; our highest goal is customer satisfaction and our efforts are concentrated on conformance with quality requirements and appropriate use of resources.

The quality planning cycle begins with market research and ends with customer service. In the intermediate development phase research and manufacturing face particular challenges.
Development projects are handled by interdepartmental teams working in a sense of simultaneous engineering. The team members do not think and act solely in categories of their departments, but are striving to attain a common goal. Modern technology (such as statistical test design) and preventive methods (such as failure mode and effect analysis) play a central role. The guiding principle of project management is "avoiding mistakes instead of correcting mistakes".

We apply the product release requested by our automotive customers to new or modified products.

Statistical process control is used for control and improvement of manufacturing processes. The accuracy of our inspection, measuring and test equipment is determined in control tests.

Continuous improvement of products, services and productivity is the subject of an official improvement programme to which all employees are committed.

Our quality management system is primarily at the service of our customers and our focus is on their actual requirements and not on bureaucratic methods.

Grilamid link

Further information can be found on our homepage:

www.emsgrivory.com

or from the following brochures, which can be ordered directly from our public relations department quoting the corresponding code number:

Product data

- Comparison table Grilamid, Grivory, Grilon: Comparison of mechanical, electrical, thermal and general properties
  Code: 2.002
- Product review: Engineering plastics
  Code: 2.001

Technical data

- Injection moulding equipment
  Code: 7.005
- Pipe extrusion
  Code: 7.002
- Designation of EMS-GRIVORY thermoplastic materials according to ISO and DIN standards
  Code: 2.003
- Campus CD-Rom
  Code: 11.002

Market segments

Automotive
- Innovative system solutions for automotive construction
  Code: 10.001

Delivery form

Grilamid is delivered as cylindrical granules packed in moisture-proof bags.

Pre-drying of material from unopened and undamaged bags is not necessary. Grilamid is available in many different natural and black grades directly from stock.

Special colours or deliveries in large containers are available on request. Our sales engineers will be happy to advise you further.

Recycling of packaging material

The disposal markings on our packaging material are criteria for sorting and guarantee type-specific disposal.

In some European countries EMS-GRIVORY pre-pays disposal fees e.g. in co-operation with the RIGK organisation in Germany where customers can deposit their empty packaging containers for disposal. Please refer to our brochure "Standard packaging" for details.

The recommendations and data given are based on our experience to date. No liability can be assumed in connection with their usage and processing. Note: EMS-GRIVORY cannot evaluate future health risks which may arise through direct contact of its products with blood or tissue. For this reason EMS-GRIVORY cannot promote use of its materials in medical applications where direct contact with blood or tissue occurs.

Domat/Ems, December 2003

Grilamid®
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EMS-GRIVORY worldwide
www.emsgrivory.com

EMS-GRIVORY - The leading manufacturer of high-performance polyamides
EMS-GRIVORY is the leading manufacturer of high-performance polyamides and the supplier with the widest range of polyamide materials. Our products are well-known throughout the world under the trade marks Grilamid, Grivory and Grilon.

We offer our customers a comprehensive package of high-capacity and high-quality products along with segment-specific advisory competence in distribution and application development. We maintain our market leadership through continual product and application development in all segments.

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