Grivory GV

The proven material for metal replacement

GRIVORY®
EMS

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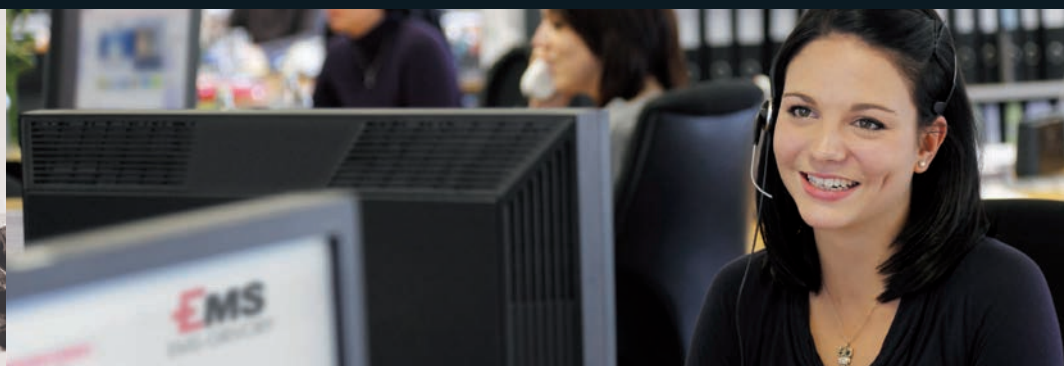


Introduction

Grivory® GV is the brand name of a group of engineering plastics manufactured and marketed by EMS-GRIVORY.

The materials in this group are based on semi-crystalline polyamides with some partially aromatic content. Grivory GV is available in granular form for processing by injection moulding in generally available machines and moulds.

The grades of material within this group are differentiated by the type and composition of the base polymers and their modification with reinforcing materials (glass fibres, minerals), stabilisers and processing aids.

Grivory GV is used for the manufacture of technical components which are characterised by:

- high stiffness and strength
- property values which are little influenced by the absorption of moisture
- high dimensional stability and low warpage
- good resistance to chemicals, typical of polyamides
- good surface quality
- efficient, cost effective manufacturing

This strong profile of properties ensures that Grivory GV is ideally suited for the replacement of metal. The important parameters for metal replacement, such as stiffness and strength, are largely unaffected by the absorption of moisture. Grivory GV is physiologically safe and can be used in sensitive applications involving direct contact with foodstuffs and drinking water.

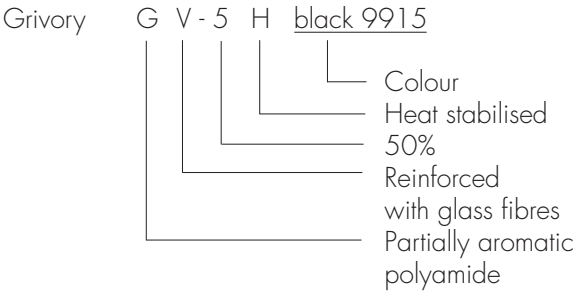
The product portfolio of Grivory GV

Grivory GV:	reinforced with glass fibres, very stiff
Grivory GVX:	reinforced with glass fibres, maximum stiffness, low warpage
Grivory GVL:	reinforced with long fibres, very stiff, maximum notched impact strength and energy absorption
Grivory GVN:	reinforced with glass fibres, impact resistant
Grivory GM:	reinforced with minerals, low warpage
Grivory GV V0:	reinforced with glass fibres, halogen-free, self-extinguishing
Grivory GC:	reinforced with carbon fibres, very stiff
Grivory G4V:	reinforced with glass fibres, good surface quality, good flow properties
Grivory GVS:	reinforced with glass fibres, good surface quality, very good flow properties
Grivory GV EF:	reinforced with glass fibres, flows easily, good surface quality
Grivory GV FWA:	reinforced with glass fibres, approved for contact with foodstuffs and drinking water

Grivory XE designates products which are newly being launched onto the market.

Nomenclature

Example, reinforced:



Characteristics and properties of Grivory grades

Grade	Grivory	Characteristics and properties	Processing / application segment
Basic grades	GV-2H GV-4H GV-5H GV-6H	Injection moulding grades with 20 – 60% by weight glass fibre reinforcement. Stiff and strong, even after absorption of moisture. Good resistance to chemicals, dimensionally stable and low warpage. Heat-stabilised.	Stiff, dimensionally precise engineered parts for machine construction, the automotive industry and the electrical industry. Functional parts with system integration. Substitution of metal die-cast alloys.
Contact with drinking water / foodstuffs	GV-2 FWA GV-4 FWA GV-5 FWA GV-6 FWA	Injection moulding grades suitable for contact with foodstuffs and drinking water, with 20 – 60% by weight glass fibre reinforcement. Stiff and strong, even after absorption of moisture. Heat stabilised. Comply with EU guidelines for direct contact with foodstuffs, unrestricted FDA approval for contact with all foodstuffs, approval in accordance with ACS, KTW, W270, WRAS and NSF for contact with drinking water.	Stiff, dimensionally precise engineered parts for sanitary fittings, the foodstuffs industry and domestic appliances which come into direct contact with foodstuffs and drinking water. Functional parts with system integration. Substitution of metal die-cast alloys.
Impact modified	GVN-35H GVN-5H	Injection moulding grades with 35 or 50 per cent by weight glass fibre reinforcement. Stiff and strong, even after absorption of moisture. Impact resistant and heat stabilised.	Stiff, dimensionally precise and impact resistant mechanical parts for the engineering, automotive and electrical industries. Functional parts with system integration.

Grade	Grivory	Characteristics and properties	Processing / application segment
Flow properties and high surface quality	GVS-5H GVS-6H G4V-5H G4V-6H GV5H EF GV-6H EF	Injection moulding grades with 50 or 60% by weight glass fibre reinforcement. Stiff and strong also after absorption of moisture. Improved surface quality and resistance to chemicals, dimensionally stable and low warping. Very good flow properties. Heat stabilised.	Stiff, dimensionally precise parts in industrial engineering, domestic appliances plus the automotive, electrical and sanitary fittings industries. Functional parts with system integration. Replacement of metal die-cast alloys.
Special reinforcement materials	GVL-4H GVL-5H GVL-6H	Injection moulding grades with 40, 50 and 60% by weight long glass fibre reinforcement. Stiff and strong also after absorption of moisture. Good resistance to chemicals, dimensional stability and very low warpage. High notched impact strength and energy absorption. Low creep behaviour, also at higher temperatures. Heat stabilised.	Stiff, dimensionally precise components in industrial engineering, the automotive and electrical industries, with wall thicknesses from 2 mm. Functional parts with system integration. Replacement of metal die-cast alloys.
	GVX-5H GVX-6H GVX-65H GVX-7H	Injection moulding grades with 50, 60, 65 and 70% by weight glass fibre reinforcement. Stiff and strong also after absorption of moisture. Good resistance to chemicals, high dimensional stability and minimal tendency to warp. Excellent flow properties and surface quality. Low influence of fibre orientation results in high transverse strength and stiffness.	Stiff, dimensionally precise components in industrial engineering, automotive and the electrical industries. Functional parts with system integration. Components under internal pressure loading. Components with high dimensional stability and minimal warpage. Replacement of metal die-cast alloys.
	GC-4H	Injection moulding grade, GV reinforced with carbon fibres, maximum stiffness, electrically and thermally conductive. Very low density, maximum specific stiffness.	Very stiff, very dimensionally precise engineered components in industrial engineering, the automotive industry, sport & leisure, components in the explosion protection sector.
Reinforced with minerals	GM-4H	Injection moulding grade with 40% mineral reinforcement, minimum warpage, high surface quality, high dimensional stability.	Low warpage engineered components with excellent surface, can be easily metal plated. Components for sanitary fittings and the automotive industry.
Flame retardant	GV-3H V0 GV-4H V0 GVX-5H V0 GVX-5H FR	Flameproof, halogen-free injection moulding grades with 30 and 40% by weight glass fibre reinforcement. Self-extinguishing (UL-94 V0). Stiff and strong even after absorption of moisture. Good resistance to chemicals, dimensionally stable and low warpage. Light natural colour, colourable. UL listed.	Self-extinguishing, stiff, dimensionally precise engineered parts in the electrical industry. RoHS: Parts made of these materials comply with RoHS requirements (2002/95 IEC, Restriction of Hazardous Substances). WEEE (waste electrical and electronic equipment): The "selective utilisation" requirement in accordance with guideline 2002/96/EC concerning waste electrical and electronic equipment does not apply to parts made of these materials.

Properties
Reinforced for injection moulding

Mechanical properties					GV-2H GV-2H FWA
Tensile E modulus	1 mm/min	ISO 527	MPa	dry	8200
				cond.	7200
Stress at break	5 mm/min	ISO 527	MPa	dry	145
				cond.	125
Strain at break	5 mm/min	ISO 527	%	dry	3
				cond.	4
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry	50
				cond.	50
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry	35
				cond.	35
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry	7
				cond.	7
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry	6
				cond.	6
Ball indentation hardness		ISO 2039-1	MPa	dry	225
				cond.	200
Thermal properties					
Melt temperature	DSC	ISO 11357	°C	dry	260
Heat deflection temperature HDT/A	1.80 MPa	ISO 75	°C	dry	230
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry	65
Therm. expansion coefficient, long.	23–55°C	ISO 11359	10^{-4}/K	dry	0.10
Therm. expansion coefficient, trans.	23–55°C	ISO 11359	10^{-4}/K	dry	1.00
Max. working temperature	long-term	ISO 2578	°C	dry	100–120
Max. working temperature	short-term	ISO 2578	°C	dry	220
Electrical properties					
Dielectric strength		IEC 60243-1	kV/mm	dry	33
				cond.	33
Comparative tracking index	CTI	IEC 60112		cond.	575
Specific volume resistivity		IEC 60093	Ω · m	dry	10^{12}
				cond.	10^{12}
Specific surface resistivity		IEC 60093	Ω	cond.	10^{13}
General properties					
Density		ISO 1183	g/cm³	dry	1.28
Flammability (UL 94)	0.8 mm	ISO 1210	Rating	-	HB
Water absorption	23°C/r.h.	ISO 62	%	-	5
Moisture absorption	23°C/50% r.h.	ISO 62	%	-	1.5
Linear mould shrinkage	long.	ISO 294	%	dry	0.15
Linear mould shrinkage	trans.	ISO 294	%	dry	0.75
Product designation as per ISO 1874				PA66 + PA6 I/X	MH, 14-080,GF20

GV-4H	GV-5H	GV-6H	GVL-4H	GVL-5H	GVL-6H	GVX-5H	GVX-6H	GVX-65H	GVX-7H	GVN-35H GVN-35 FA
14000	18000	22000	14300	17500	22500	18000	22500	25500	28000	10500
13000	17000	21000	13000	16500	21000	17000	22000	25000	27500	9000
230	250	260	240	270	290	250	290	300	290	170
210	220	240	205	235	255	220	260	280	260	140
3	2.5	2	2.5	2.4	2.1	2.5	2.0	1.9	1.5	4
3	2.5	2	2.6	2.4	2.1	2.5	2.0	1.9	1.5	5
90	90	80	85	105	115	80	75	75	60	85
90	90	80	80	100	110	75	70	70	60	85
70	80	80	75	90	95	65	70	70	60	80
70	80	80	75	90	95	60	70	70	60	80
13	15	14	30	35	40	15	15	15	15	15
13	15	14	30	35	40	15	15	15	15	15
11	13	13	30	35	40	15	15	15	15	13
11	13	13	30	35	40	15	15	15	15	13
255	280	315	265	290	315	290	320	345	370	215
230	255	290	250	270	290	265	305	330	360	185
260	260	260	260	260	260	260	260	260	260	260
235	235	235	255	255	255	245	250	250	250	235
145	165	175	210	220	225	175	205	215	220	70
0.15	0.15	0.15	0.20	0.20	0.20	0.20	0.15	0.15	0.10	0.15
0.90	0.90	0.90	0.60	0.50	0.40	0.50	0.50	0.50	0.30	0.90
100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120
220	220	220	220	220	220	220	220	220	220	220
33	33	33	33	33	33	33	33	33	33	35
33	33	33	33	33	33	33	33	33	33	35
600	600	600	600	600	600	600	600	600	600	575
10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{10}	10^{10}	10^{10}	10^{10}	10^{12}
10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{10}	10^{10}	10^{10}	10^{10}	10^{12}
10^{13}	10^{13}	10^{13}	10^{13}	10^{13}	10^{13}	10^{12}	10^{11}	10^{12}	10^{10}	10^{13}
1.47	1.56	1.69	1.47	1.56	1.69	1.56	1.69	1.79	1.85	1.40
HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB
4.5	4	3.5	4.5	4.0	3.5	4.0	3.5	3.2	2.9	4.5
1.4	1.4	1.2	1.4	1.3	1.2	1.4	1.2	1.1	1.0	1.5
0.10	0.05	0.05	0.15	0.10	0.10	0.05	0.05	0.05	0.10	0.15
0.60	0.40	0.30	0.40	0.30	0.20	0.30	0.25	0.25	0.25	0.45
MH, 14-140,GF40	MH, 14-190,GF50	MH, 14-220, GF60	MH, 14-140, GF40	MH, 14-190, GF50	MH, 14-220, GF60	MH, 14-190, GF50	MH, 14-220 N, GF60	MH, 14-250 N, GF65	MH, 14-280, GF70	MH, 14-110 N, GF35

The "conditioned" test values were determined using test specimens stored in accordance with ISO 1110

Properties
Reinforced for injection moulding

Mechanical properties					GVN-5H black
Tensile E modulus	1 mm/min	ISO 527	MPa	dry	15500
				cond.	14500
Stress at break	5 mm/min	ISO 527	MPa	dry	230
				cond.	190
Strain at break	5 mm/min	ISO 527	%	dry	3.0
				cond.	4.0
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry	95
				cond.	95
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry	85
				cond.	85
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry	16
				cond.	16
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry	14
				cond.	14
Ball indentation hardness		ISO 2039-1	MPa	dry	265
				cond.	235
Thermal properties					
Melt temperature	DSC	ISO 11357	°C	dry	260
Heat deflection temperature HDT/A	1.80 MPa	ISO 75	°C	dry	240
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry	165
Therm. expansion coefficient, long.	23–55°C	ISO 11359	10^{-4}/K	dry	0.15
Therm. expansion coefficient, trans.	23–55°C	ISO 11359	10^{-4}/K	dry	0.90
Max. working temperature	long-term	ISO 2578	°C	dry	100–120
Max. working temperature	short-term	ISO 2578	°C	dry	220
Electrical properties					
Dielectric strength		IEC 60243-1	kV/mm	dry	35
				cond.	35
Comparative tracking index	CTI	IEC 60112		cond.	575
Specific volume resistivity		IEC 60093	Ω · m	dry	10^{12}
				cond.	10^{12}
Specific surface resistivity		IEC 60093	Ω	cond.	10^{13}
General properties					
Density		ISO 1183	g/cm³	dry	1.55
Flammability (UL 94)	0.8 mm	ISO 1210	Rating	-	HB
Water absorption	23°C/sat.	ISO 62	%	-	4.0
Moisture absorption	23°C/50% r.h.	ISO 62	%	-	1.3
Linear mould shrinkage	long.	ISO 294	%	dry	0.05
Linear mould shrinkage	trans.	ISO 294	%	dry	0.40
Product designation as per ISO 1874				PA66 + PA6 I/X	MH, 14-160, GF50

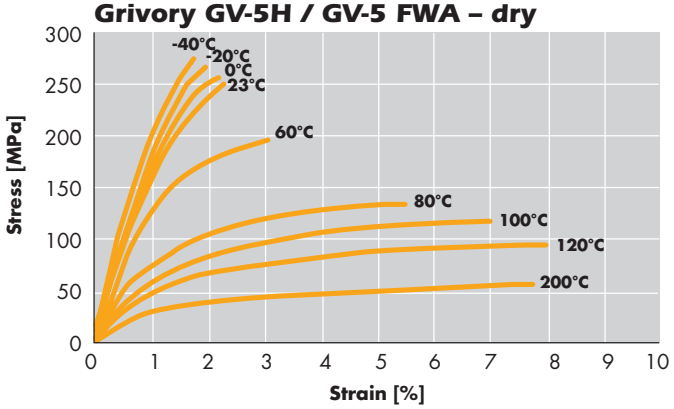
G4V-5H	G4V-5HS black	G4V-6H	GVS-5H	GVS-6H	GV-5HL black	GV-6HL black	GV-3H V0	GV-4H V0	GC-4H	GM-4H
16500	18000	20000	17000	22000	17000	22000	10500	14000	31000	7000
16500	18000	19500	16000	21000	16000	21000	9500	12000	28000	6000
230	230	250	250	260	220	215	130	150	260	100
200	200	220	220	240	200	195	110	120	225	80
2.0	2.0	2.0	2.5	2.0	2.0	1.5	2.0	2.0	1.5	3.0
2.5	2.0	2.0	2.5	2.0	2.0	1.5	2.0	2.0	2.0	5.0
75	65	80	90	80	70	60	50	40	40	80
75	65	70	80	75	60	50	45	40	40	100
60	60	-	75	80	50	50	50	40	45	75
50	50	-	60	65	40	40	45	40	50	90
15	14	13	15	15	14	13	8	8	7	6
14	14	13	15	15	13	12	8	8	7	6
15	14	-	15	15	15	14	8	8	8	8
14	14	-	15	15	14	13	8	7	8	7
290	300	-	280	315	270	305	250	265	250	265
275	280	-	255	290	250	285	220	230	220	230
235	235	235	260	260	255	255	260	260	260	260
215	215	225	240	240	230	235	220	220	235	105
165	170	160	185	200	170	180	105	115	175	60
0.10	0.15	0.10	0.15	0.15	0.15	0.15	0.25	0.25	0.20	0.90
0.60	0.60	0.50	0.70	0.50	0.70	0.50	0.65	0.65	0.60	0.90
140	140	140	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120
220	220	220	220	220	220	-	220	220	220	220
35	35	35	33	33	29	25	35	35	-	26
35	35	35	33	33	28	25	35	35	-	26
600	600	600	600	600	225	225	600	600	-	600
10^{10}	10^{10}	10^{10}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	< 50	10^{12}
10^{10}	10^{10}	10^{11}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	< 50	10^{12}
10^{12}	10^{12}	10^{12}	10^{13}	10^{13}	10^{13}	10^{13}	10^{13}	10^{13}	10^{10}	10^{13}
1.59	1.70	1.71	1.58	1.71	1.60	1.73	1.40	1.53	1.34	1.45
HB	HB	HB	HB	HB	HB	HB	V0	V0	HB	HB
4.0	4.0	4.0	4.0	3.5	4.0	3.5	4.0	3.6	4.5	4.5
1.4	1.4	1.4	1.4	1.2	1.4	1.2	1.4	1.3	1.4	1.4
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.10	0.10	0.05	0.80
0.40	0.40	0.40	0.50	0.50	0.50	0.50	0.60	0.60	0.20	0.85
MH, 14-160, GF50	MH, 11-190, GF50	MH, 14-220, GF60	MH, 14-190, GF50	MH, 14-190, GF60	MHL, 14-190, GF50	MHL, 14-220, GF60	MH, 11-110, GF30	MH, 14-160, GF40	MH, 14-250, CF40	MH, 14-070, MD40

The "conditioned" test values were determined using test specimens stored in accordance with ISO 1110

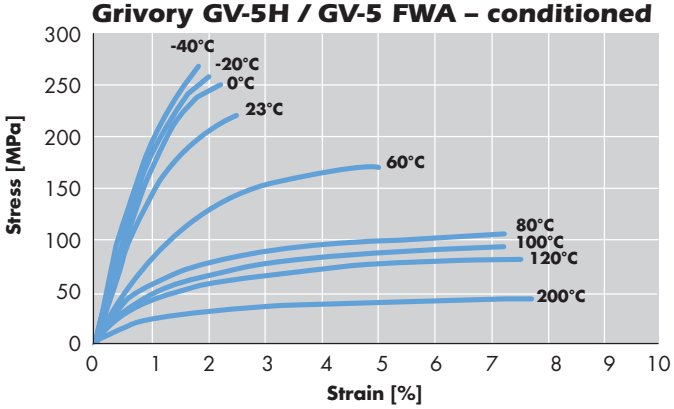
Design data – short-term behaviour

Mechanical properties as a function of temperature

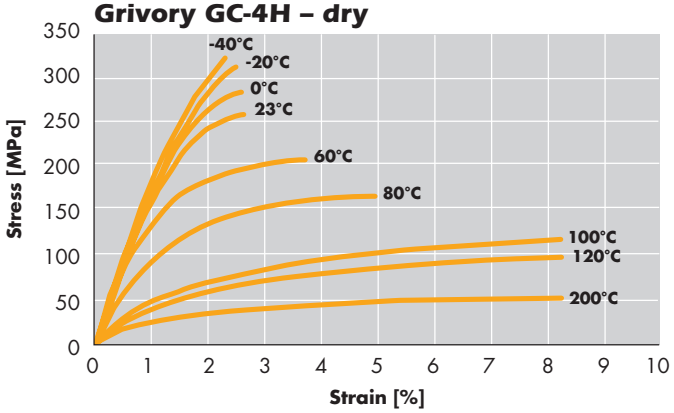
Stress-strain diagram
Grivory GV-5H / GV-5 FWA – dry



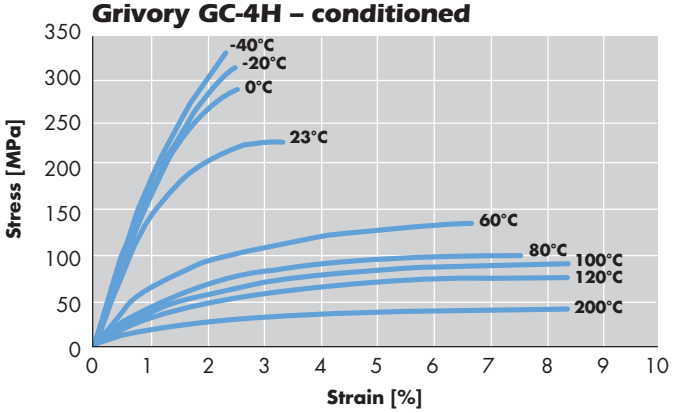
Stress-strain diagram
Grivory GV-5H / GV-5 FWA – conditioned



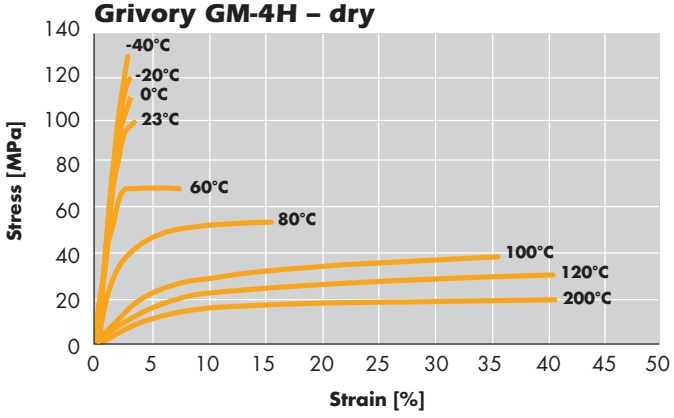
Stress-strain diagram
Grivory GC-4H – dry



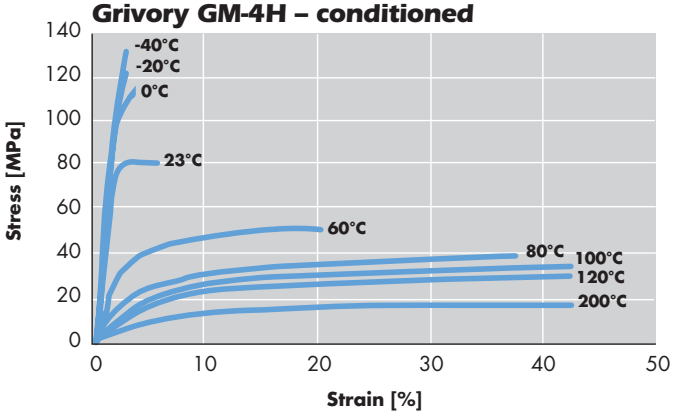
Stress-strain diagram
Grivory GC-4H – conditioned

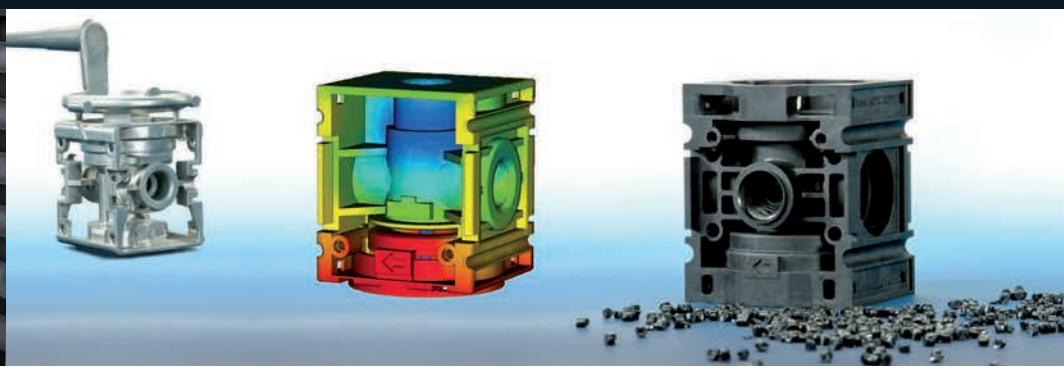


Stress-strain diagram
Grivory GM-4H – dry



Stress-strain diagram
Grivory GM-4H – conditioned

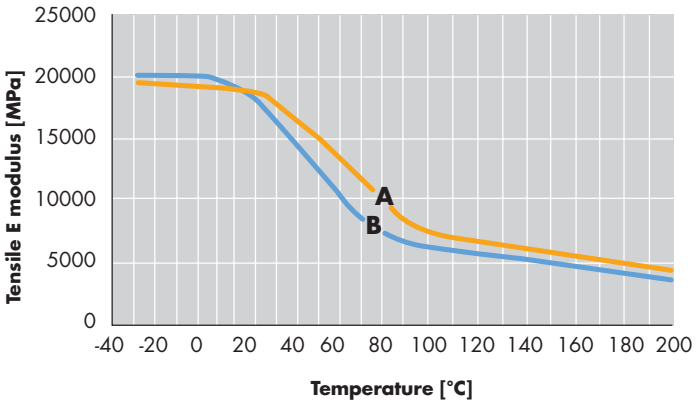




Mechanical properties as a function of temperature

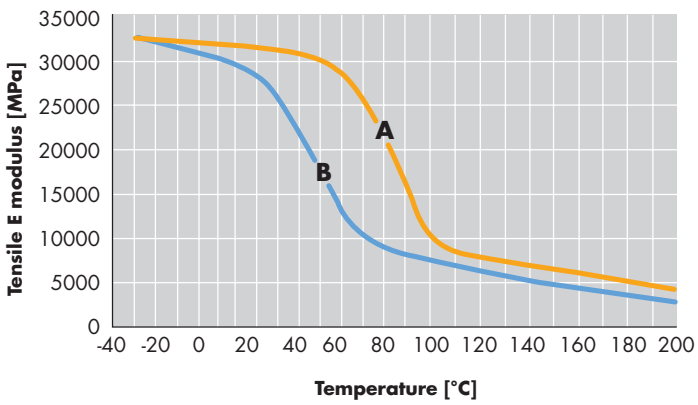
Tensile E modulus Grivory GV-5H

A: dry, **B:** conditioned



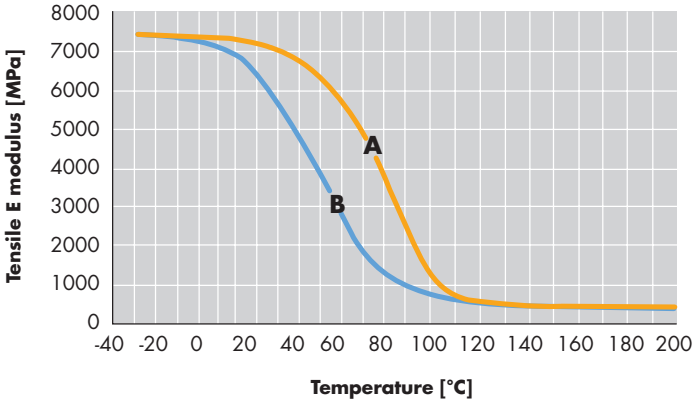
Tensile E modulus Grivory GC-4H

A: dry, **B:** conditioned



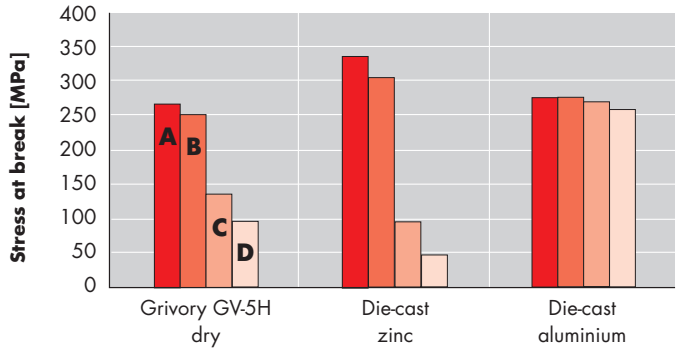
Tensile E modulus Grivory GM-4H

A: dry, **B:** conditioned



Grivory shows similar strength values to those of die-cast alloys

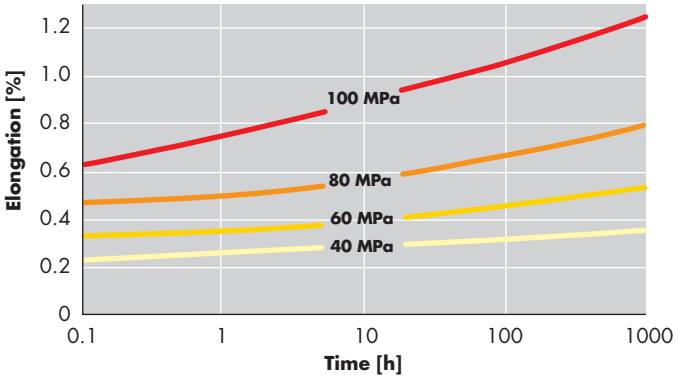
A: -20°C, **B:** 23°C, **C:** 80°C, **D:** 130°C



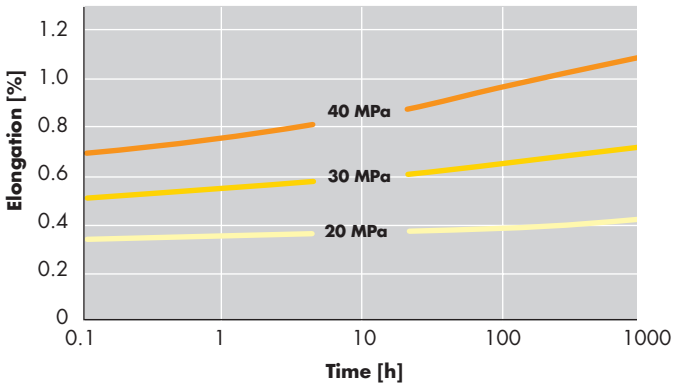
Design data – long-term behaviour

The long-term static stress of a material under different mechanical loads, characteristic time-elongation (creep) curves for each plastic material can be plotted. The creep is a function of stress and temperature.

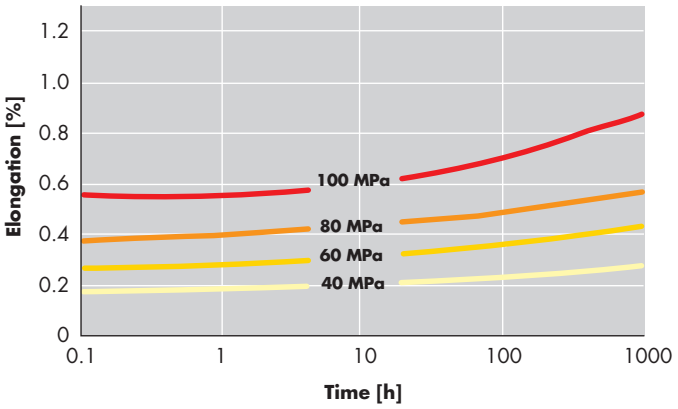
Creep curves for Grivory GV-5H at 23°C/50% r.h.



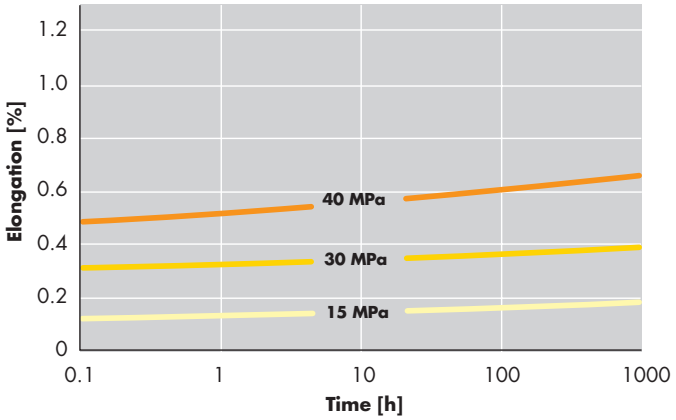
Creep curves for Grivory GV-5H at 80°C



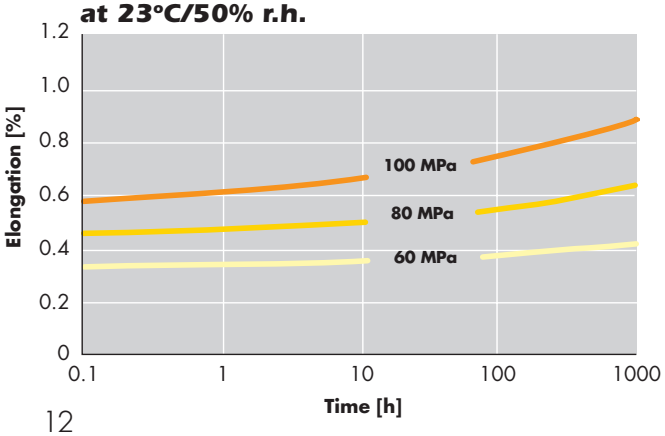
Creep curves for Grivory GV-6H at 23°C/50% r.h.



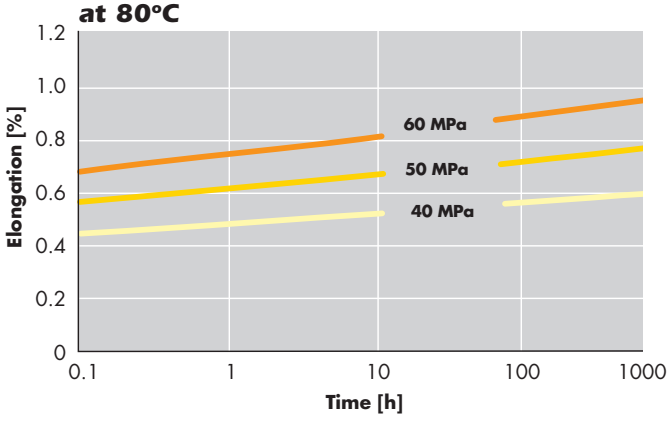
Creep curves for Grivory GV-6H at 80°C

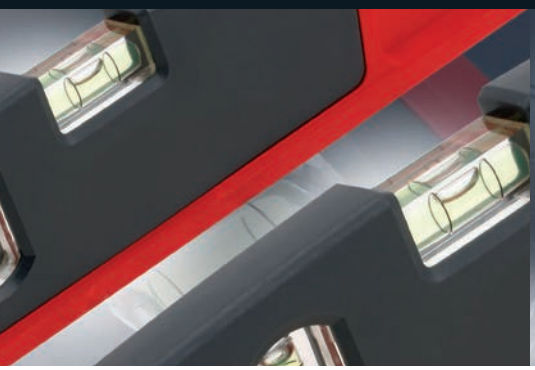


Creep curves for Grivory GVX-5H at 23°C/50% r.h.

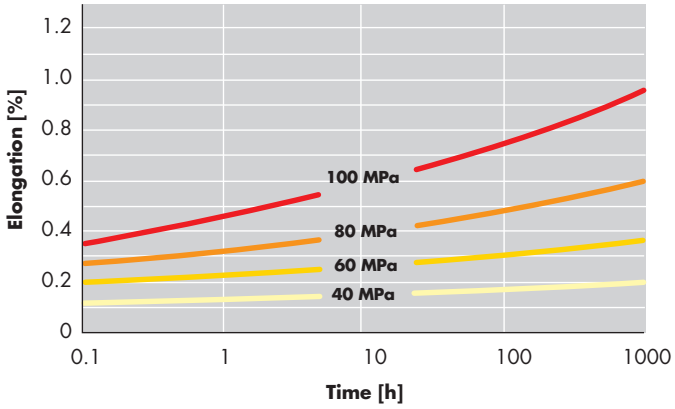


Creep curves for Grivory GVX-5H at 80°C

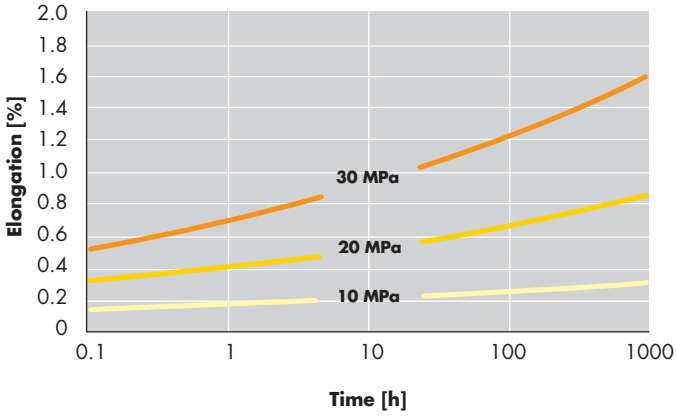




Creep curves for Grivory GC-4H at 23°C/50% r.h.



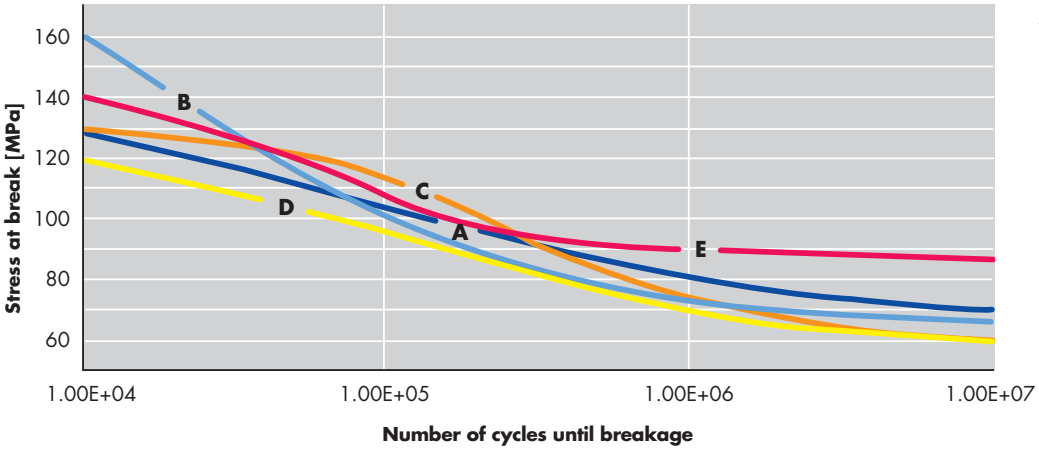
Creep curves for Grivory GM-4H at 23°C/50% r.h.



Flexural fatigue strength

Dynamic, long-term stress may lead to failure of a material. Depending on the level of cyclic mechanical stress, breakage occurs after a certain number of load cycles.

Flexural fatigue strength (Wöhler curves) as per DIN 52442 at 23°C Frequency 8 Hz



A: Grivory GV-5H cond.
B: Grivory GC-4H cond.
C: PA GF50 cond.
D: PA12 GF50 cond.
E: GVL-5H cond.

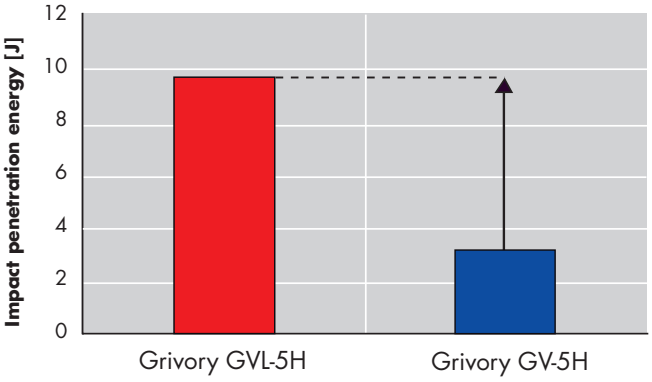
Special reinforcement materials

EMS-GRIVORY offers special materials with enhanced properties and characteristics compared to the standard grades of Grivory GV.

Grivory GVL

Grivory GVL is a group of materials in which the partially aromatic polyamide matrix has been reinforced with long glass fibres. This allows the characteristic properties of Grivory GV to be maintained, e.g. high stiffness and strength after moisture absorption, good resistance to chemicals and dimensional stability as well as very low warpage. However, Grivory GVL nevertheless exhibits the capacity to absorb much higher energy levels in the case of impact stress. This is demonstrated significantly in the case of the impact penetration test in accordance with DIN 53373. Compared to Grivory GV-5H, Grivory GVL-5H exhibits a three times higher energy absorption.

Impact penetration energy DIN 53373/23°C

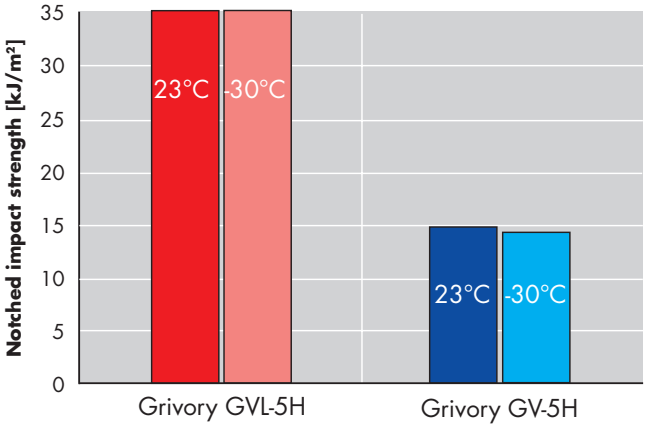


This can be attributed to the structure of the long glass fibres in the component. Unlike short glass fibres, the long glass fibres form a 3-D fibre-felt structure in the component. This becomes visible when a component of this type is pyrolised.

The fibre-felt structure increases the resistance to cracking and prevents cracks from spreading much more effectively than materials reinforced with short glass fibres. In an impact penetration test, the test plate is not punctured. Instead it shows an area with hinge fractures.

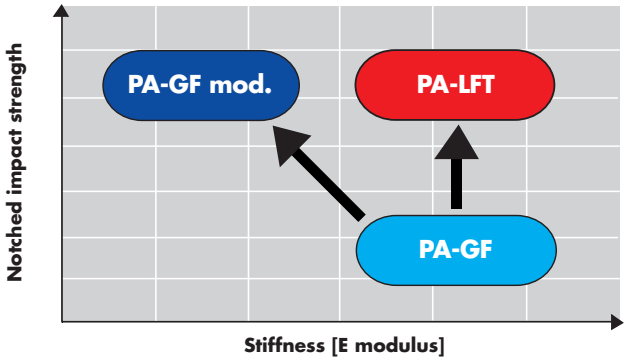
This improved energy absorption is also exhibited at lower temperatures down to -30°C. This is shown in the following notched impact strength diagram as per ISO 179/2.

Notched impact strength Charpy, ISO 179/2, dry



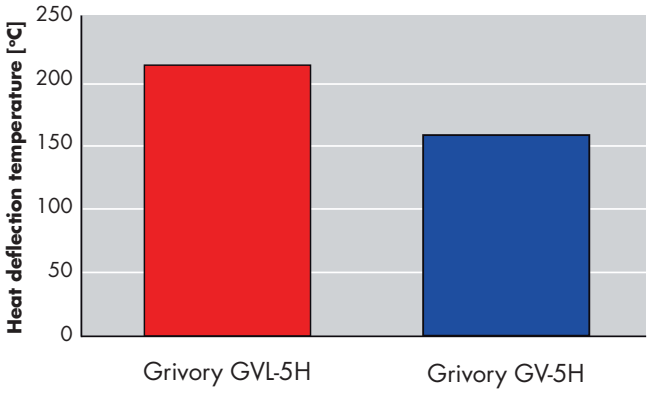
The notched impact strength can be increased without any loss in the stiffness of the material. This is not possible with conventionally reinforced polyamides with impact modification where the energy absorbing elastomer components always lead to a loss in stiffness.

Combined stiffness / toughness



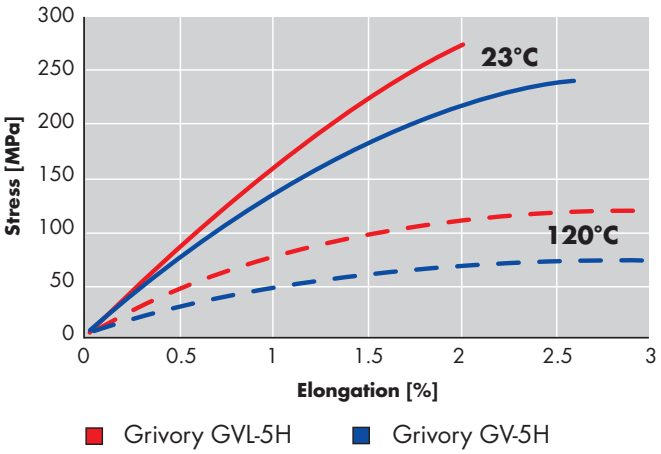
Grivory GVL exhibits an excellent heat deflection temperature. Compared to Grivory GV, for Grivory GVL the HTD/C as per ISO 75 is higher by 50°C.

Heat deflection temperature
ISO 75 HDT/C (8 MPa)



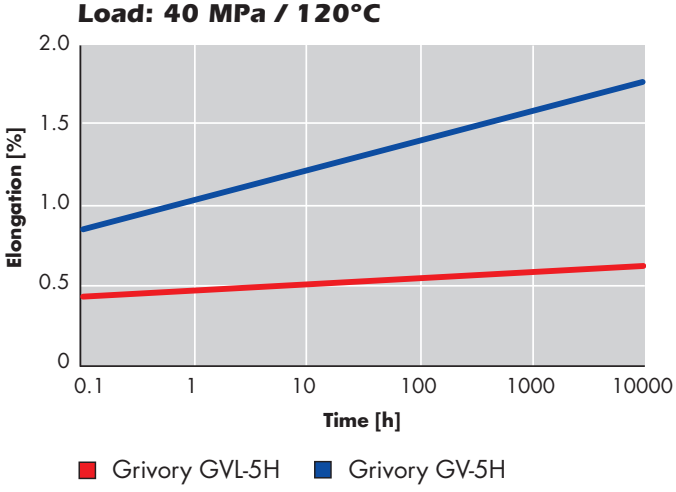
The three-dimensional fibre-felt structure gives the matrix additional stability. This results in enhanced mechanical performance, especially at higher temperatures. This improved performance is clearly visible in the stress-elongation diagram as per ISO 527.

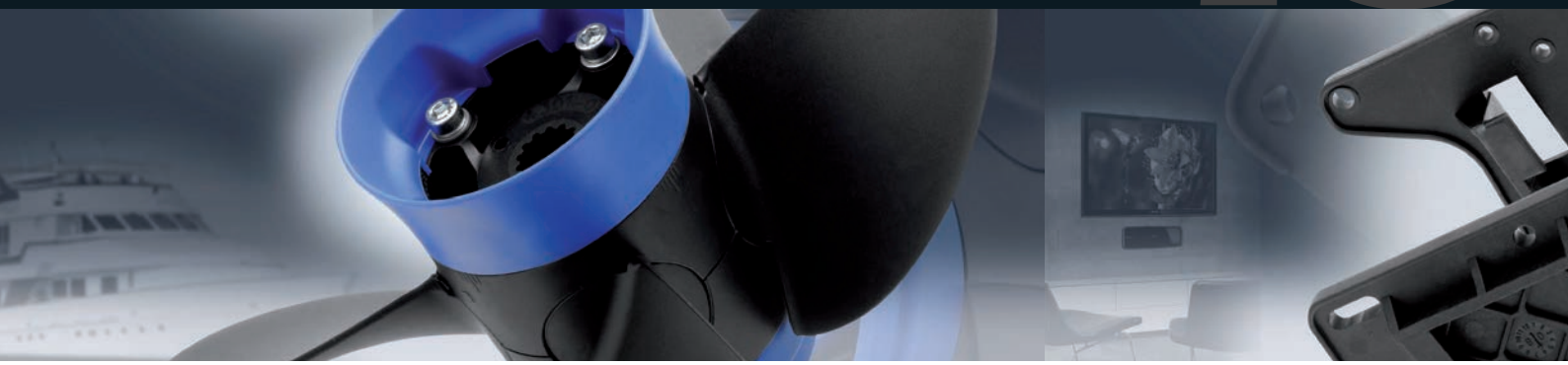
Stress-elongation diagram



Under constant load conditions, Grivory GVL exhibits a greatly reduced creep tendency compared to products reinforced with short fibres. At higher temperatures, this difference is significant. After 10,000 hours with a load of 40 MPa and at a temperature of 120°C, Grivory GVL-5H creeps by only 0.25%.

Creep behaviour
Load: 40 MPa / 120°C





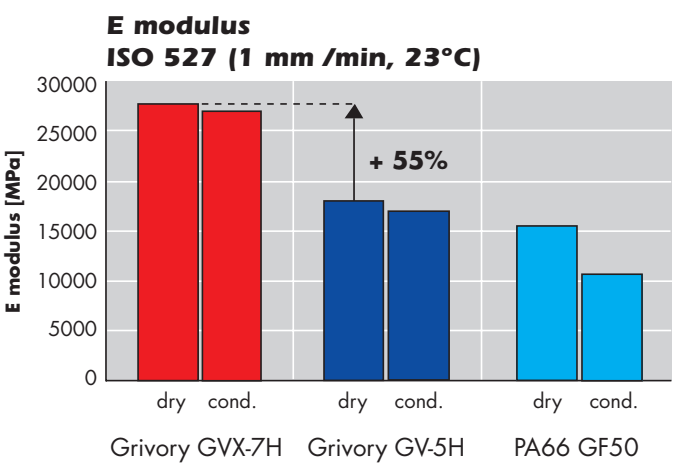
In a component, moulded from conventional short glass fibre reinforced material the fibres orientate themselves in the flow direction of the melt. This orientation of the glass fibres can result in warpage of the component. The fibre-felt structure in components made of Grivory GVL results in improved isotropic distribution of the glass fibres, and the tendency of the component to warp is therefore reduced.

Also due to the fibre-felt structure, components made of Grivory GVL exhibit greatly improved fatigue behaviour under dynamic loading than grades reinforced with short glass fibres.

With Grivory GVL, surfaces with comparable quality to that of Grivory GV can be achieved. Grivory GVL can be recycled and is also easy to process. The materials in this group, with their enhanced properties, are used in the automobile, mechanical engineering, electrical/electronics sectors as well as the sports and leisure industry.

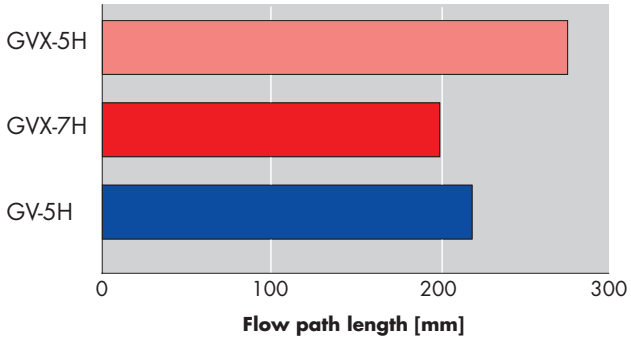
Grivory GVX

Grivory GVX is a material group in which the matrix and reinforcement material have been optimised for maximum stiffness and strength. In addition, the Grivory GVX products exhibit exceptionally good flow properties. As a result of the significant improvement in mechanical performance, the areas of application for metal replacement are being continually expanded.
Grivory GVX-7H achieves an E modulus of 28,000 MPa. After conditioning, this stiffness remains virtually unaltered at 27,500 MPa. After moisture absorption, conventional polyamides lose approximately 35% of their dry as moulded stiffness.



Grivory GVX-7H exhibits an E-modulus which is up to 55% higher than that of Grivory GV-5H. This is a valid comparison since Grivory GVX-7H has comparable flow properties and can therefore be processed similarly to Grivory GV with 50% glass fibre reinforcement. Surface quality and warpage are also best in class, making Grivory GVX products ideal for high-quality metal replacement and, in particular, for very stiff, thin-walled, complex components with long flow paths.

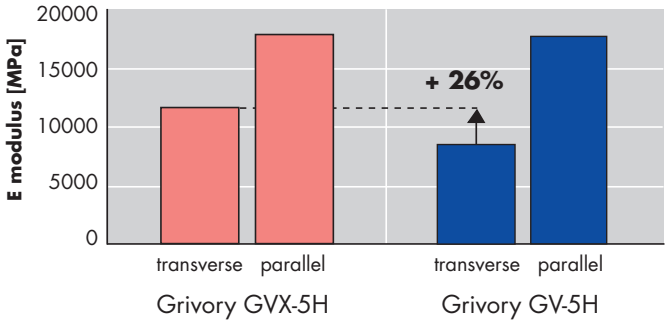
Flow path length
(wall thickness 1.5 mm, width 10 mm)



Nominal pressure:	1'000 bar
Mould temperature:	100°C
Melt temperature:	300°C

Compared to polyamides with conventional glass fibre reinforcement, Grivory GVX grades have a significantly higher strength in the transverse direction to flow. This is particularly beneficial for components with internal pressure loads, because in these parts high stresses often occur transverse to the fibre orientation.

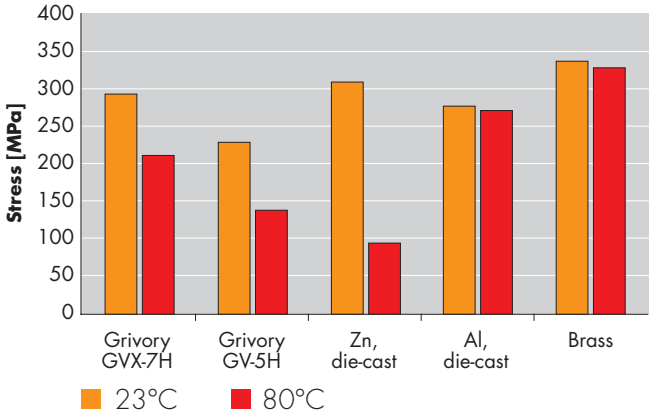
E modulus
ISO 527 (1 mm /min, 23°C)

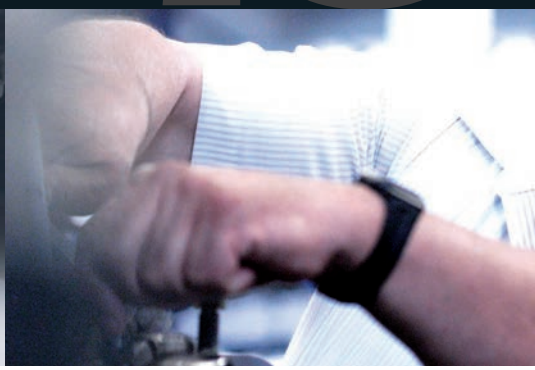


The advantages of Grivory GVX compared to die-cast metals are, above all, lower density, ease of processing, system integration and more efficient manufacturing with reduced post treatment and up to 40% cost savings.

With a tensile strength of almost 300 MPa, Grivory GVX is at the forefront of thermoplastic materials. Grivory GVX holds its own in direct comparison with die-cast metals and is vastly superior to die-cast zinc at higher temperatures, for example. When combined with a design suited to plastic, structural strength which is comparable to that of metal components can be achieved.

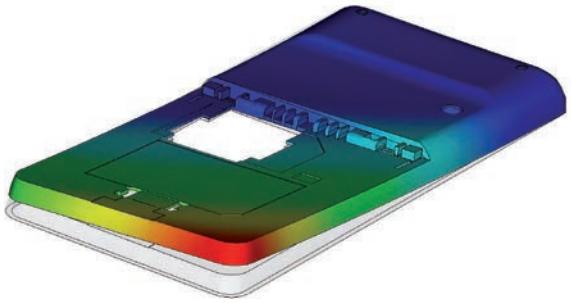
Breaking strength
ISO 527





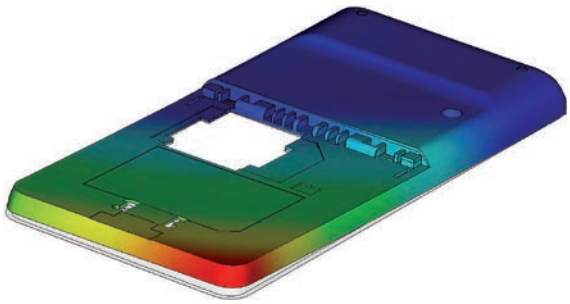
Warpage occurs with all reinforced plastics. Depending on the component, different shrinkage in the direction of, and transverse to, the orientation of the fibres, results in deformation. With their optimised glass fibre reinforcement, Grivory GVX grades exhibit a significantly reduced tendency to warpage. Compared to standard materials with high levels of reinforcement, shrinkage transverse to the orientation of the fibres has been reduced by 25%. This results in components with much less warpage.

Mobile phone cover with warpage (A)



A Moldflow analysis clearly demonstrates the difference between the warping of Grivory GVX (B) and a conventional product with the same glass fibre content (A). The low degree of warpage is not just theoretical. Test parts and a large number of serial applications provide impressive evidence of the low warpage of Grivory GVX.

Mobile phone cover, reduced warpage with GVX (B)



Exposure to UV radiation causes changes in the physical and chemical properties of all plastics, including polyamides. In particular, a combination of radiation, oxygen in the air, moisture and temperature can lead to chain scission, crosslinking and other oxidative processes, resulting in a reduction of the working life of the material. Resistance to weathering is dependent on the structure of the polymer and the additives (glass, mineral, carbon black, etc.). The effects of weathering are observed mainly on the surface of the material, so that the serviceability of a component is very dependent on its thickness.

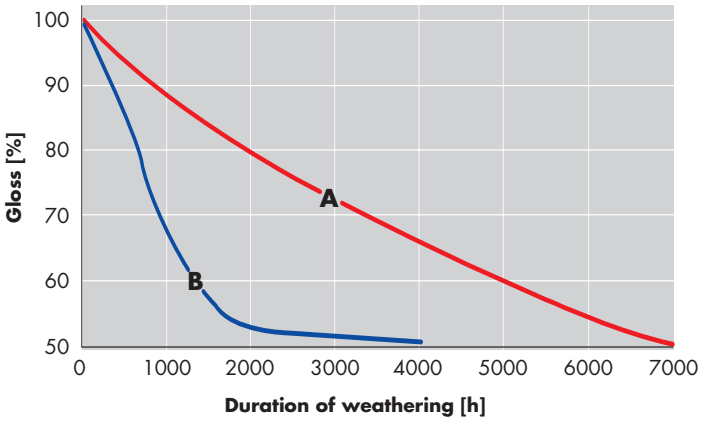
Grivory GV exhibits good resistance to weathering and is therefore well suited for many outdoor applications.

Grivory HL products have an optimised UV stabiliser system. This makes them also suitable for use in applications under extreme climatic conditions, in particular those involving high UV exposure.

The working life of polyamide parts is determined both in accelerated weathering test equipment (filtered xenon-arc light according to ISO 4892-2) and in outdoor weathering tests (alpine climate at EMS).

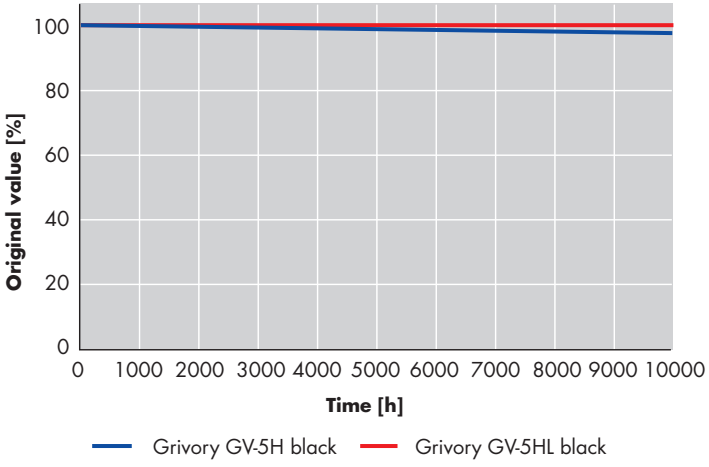
In order to test weathering stability, 1-mm-thick test bars are exposed to weathering in our material testing department and their tensile impact strength is tested after set periods of time. After 10,000 hours of accelerated weathering, the impact strength values of black Grivory GV products retain more than 80% of their original values; in the case of Grivory GV-5HL black, the figure is 95%. It goes without saying that, thick walled parts have a much longer working life in practical use.

Grivory GV gloss after artificial weathering
A: Grivory GV-5HL black,
B: Grivory GV-4H, GV-5H, GV-6H black



Test method: ISO 4892-2
Test specimens: Tensile bars, 1 mm
Criterion: Gloss (60) in % of the original value

Tensile impact strength after weathering



2,100 hours are the equivalent of approximately 1 year of outdoor weathering in the alpine climate at EMS.

Test method: ISO 4892-2
Test specimens: Tensile bars, 1 mm
Criterion: Tensile impact strength in % of the original value SRG 01/01

Resistance to heat ageing

At elevated temperatures, ageing phenomena occur in all plastic materials. Over time, these phenomena have a negative effect on the properties of the material.

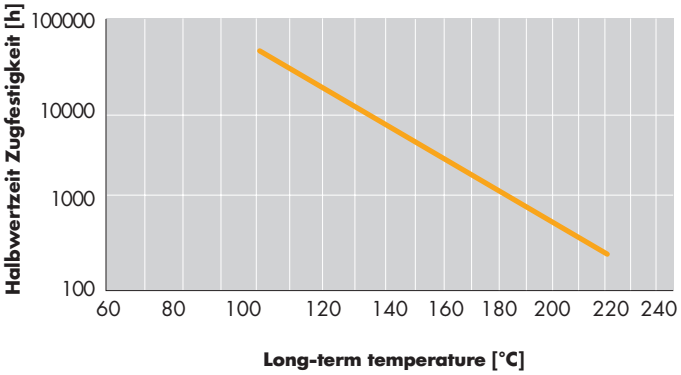
These processes are of a chemical nature, such as oxidation reactions, but may also be caused by physical phenomena such as post-crystallisation or changes in morphology.

In practice, specification of a temperature-time limit, within which the properties of the thermally stressed plastic material remain at an acceptable level, is of great importance.

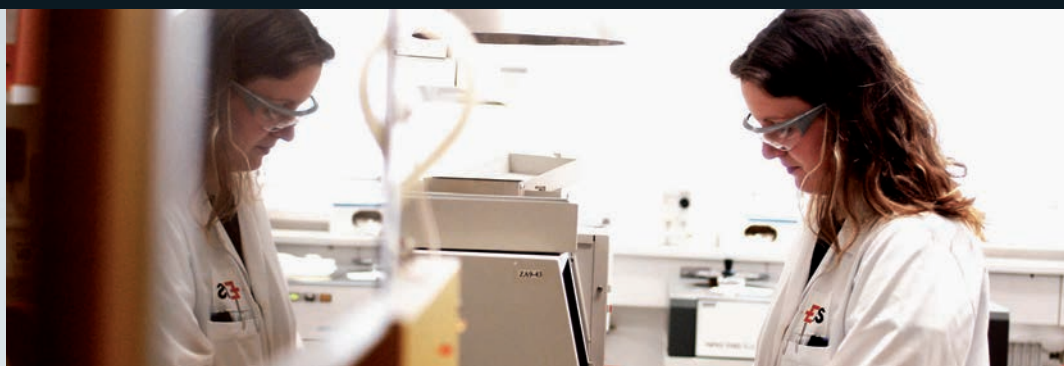
Extensive testing of the temperature-time limits has been carried out, resulting in the development of optimal formulations which guarantee the successful use of Grivory GV grades, even at high temperatures.

The time or temperature at which the material has 50% of the ultimate tensile strength remaining compared to the original value can be read from the data presented in an Arrhenius curve (scale: log [t]/[1/T].

Resistance to heat ageing
Arrhenius diagram for
Grivory GV-4H, GV-5H, GV-6H



Test method:	ISO 2578
Test specimens:	ISO 3167 Type A, tensile bars 4 mm
Criterion:	50% reduction in tensile strength



Grivory GV is generally resistant to a wide variety of organic solvents and alkalis. Fuels, oils and fats also have no effect on Grivory GV.

Strong acids cause relatively rapid hydrolytic degradation of all polyamides; Grivory GV is resistant to dilute organic acids when in contact with them for a short time.

•	Acetic acid
••	Acetone
•••	Aluminium salts
•••	Ammonia
•••	Amyl acetate
••	Aniline
••	Antifreeze
•••	Benzene
•	Benzyl alcohol
•	Bromine
•••	Butane
••	Butanol
••	Calcium chloride, saturated
•••	Carbon tetrachloride
•••	Caustic potash, 50% solution
o	Chlorine
•••	Chlorobenzene
•	Chloroform
••	Citric acid
•••	Copper sulphate
o	Cresol
•••	Crude oil
•••	Diesel
•••	Diethyl ether
•••	Engine oil
••	Ethanol
•••	Ethylene oxide
•••	Fats
o	Fluorine
•	Formaldehyde
o	Formic acid conc.
•••	Freon F12, liquid
•	Freon F22, liquid
•••	Glycerine
•••	Heptane
•••	Hydraulic oil
•	Hydrochloric acid 1%
o	Hydrochloric acid 10%
•	Hydrogen peroxide 20%
•••	Hydrogen sulphide
o	Iodine tincture, alcoholic
•••	Isooctane
•••	Kerosene
•	Lactic acid
••	Magnesium chloride, saturated
•••	Methane
••	Methanol
•••	Mineral oil

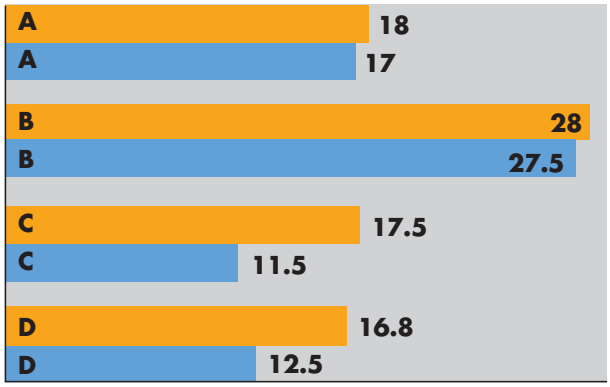
Polyamides are dissolved completely by some aggressive chemicals such as concentrated mineral acids, phenols and methanolic calcium chloride solution as well as highly halogenated acetic acid. At elevated temperatures, glycols and various other acids also attack the material aggressively.

o	Nitric acid
••	Nitrobenzene
o	Oleum
••	Oxalic acid
•	Ozone
•••	Perchloroethylene
•••	Petrol
•••	Petroleum ether
•	Phenol
•••	Potassium carbonate, saturated
o	Potassium permanganate 5%
•••	Propane
•••	Pyridine
o	Resorcinol
•••	Salicylic acid
•••	Sea water
•••	Silicone oil
•••	Soap suds
•••	Sodium carbonate, saturated
•••	Sodium chloride, saturated
•••	Sodium sulphate, saturated
•••	Styrene
•••	Sulphur
•	Sulphuric acid 10%
o	Sulphuric acid, concentrated
••	Tartaric acid
•••	Tetralin
•••	Toluene
•••	Transformer oil
••	Trichloroethane
••	Trichloroethylene
•••	Turpentine
•••	Urea
••	Uric acid
••	Vinegar
•••	Water (23°C)
•••	Wine
•••	Xylol
••	Zinc chloride

•••	resistant, only minor, reversible changes in dimension
••	limited resistance; significant change in dimension after longer periods of time
•	not resistant; may still be used under certain conditions
o	soluble or strongly attacked within a short period of time

Comparison with other materials

Thermoplastics E modulus [MPa x 1000]



A: Grivory GV-5H dry, cond.
B: GVX-7H dry, cond.
C: PA66 GF50 dry, cond.
D: PA6 GF50 dry, cond.

Grivory GV is positioned in the range of high quality engineering plastics. As a rule, Grivory GV has the characteristic properties of polyamides. In direct comparison with traditional materials based on polyamide 6 (PA6) or polyamide 66 (PA66), Grivory GV is characterised by the fact that, unlike most polyamides, its mechanical properties are hardly affected by the absorption of moisture. Stiffness and strength values remain at a high level.

Thermosets

Even though processing technology (thermoset / thermoplastic) is different, the quality of the finished products with regard to mechanical thermal properties may be compared.

Material	Breaking strength [MPa]	E modulus [MPa]	Heat deflection temperature HDT/A [°C]
Grivory GV	145–260	8200–22000	230–235
Grivory GVL	240–290	14300–22500	255
Grivory GVX	250–300	18000–28000	245–250
Melamin formaldehyde	50–90	7000–9000	155–215
Melamin phenol	55–85	7000–16000	155–200
Phenolic resins	35–70	8000–12000	110–250

Grivory GV thermoplastic has better values for core properties such as stiffness, strength and heat deflection temperature than most thermosets. In terms of the electrical characteristics, Grivory, being insensitive to moisture, achieves the good insulation values of thermosets.

The advantage of less costly raw materials for thermosets is often more than offset by the longer cycle times and the outlay for post treatment (deflashing). Another point in favour of the thermoplastic Grivory GV is the fact that it can be recycled or reprocessed without problem.

Die-cast alloys

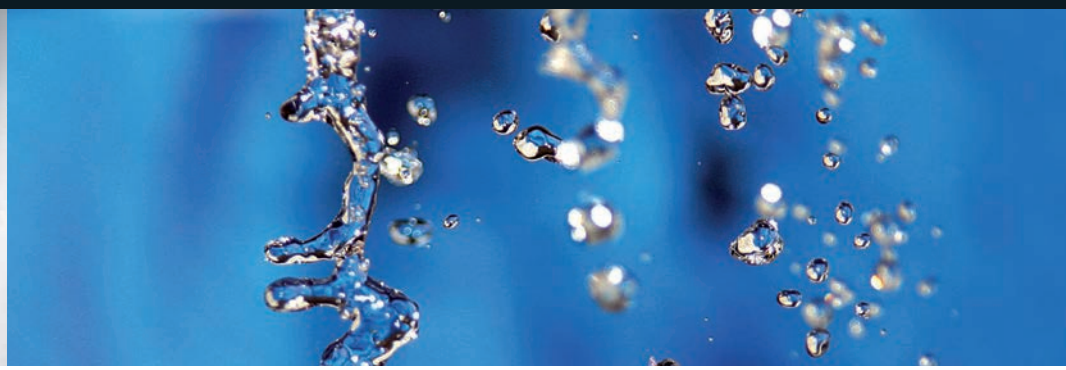
Grivory GV is ideally suited for the replacement of metal, particularly for parts previously made of die-cast alloys.

There are two reasons for this success:
The mechanical thermal properties of Grivory GV are often fit for purpose to ensure reliable working as a metal replacement material. An important role is also played by the weight advantage of parts made of Grivory GV and their resistance to corrosion.

Manufacturing costs can be reduced by up to 50% through replacement of metals. The post treatment processes typical for die-cast alloys – deflashing, coating (paint) or subsequent thread cutting – are no longer necessary.

Further and often substantial cost savings can also be achieved through greater functional integration in the part. Composite parts (metal/plastic) can often be replaced by just one material – Grivory GV. Similarly, subassemblies comprising a number of parts can be manufactured as a single injection moulded component ready for serial production. Metal inserts (bushing, threaded inserts) can often be eliminated.

Grivory GV in contact with foodstuffs and drinking water



EU

In Directive 2002/72/EC and its supplements, the European Union has stipulated the conditions to be fulfilled by polymers in contact with foodstuffs. The polymer matrix of the Grivory grades satisfies the requirements of these guidelines for contact with foodstuffs. These EU directives have largely been accepted by the EU countries and Switzerland and incorporated in national legislation. The national legislation can sometimes go beyond the requirements of the EU directives.

Materials may only be used if the additives they contain (lubrication agents, etc.) are also approved. The end products must also fulfil requirements with regard to the migration limit, i.e. the amount of a substance migrating from the material into the foodstuff.

USA

Products made of polyamides which are marketed in the USA and which involve contact with foodstuffs must satisfy the guidelines within the Code of Federal Regulations (CFR) as issued by the Food and Drug Administration (FDA). Relevant sections are Sections 21 CFR 177.1500 (6) for PA6, 21 CFR 177.1500 (1) for PA66 as well as additional paragraphs for the additives.

Product	EU	FDA	NSF 51
GV-2 FWA	approved	approved	not listed
GV-4 FWA	approved	approved	not listed
GV-5 FWA	approved	approved	not listed
GV-6 FWA	approved	approved	not listed

Germany

DVGW (German Technical and Scientific Association for Gas and Water) KTW (plastics in drinking water) recommendations of the Federal Health Agency, DVGW Code of Practice W 270 "Microbial Enhancement on Materials to Come into Contact with Drinking Water – Testing and Assessment".

France

(ACS - Attestation de Conformité Sanitaire)

UK

(WRAS - Water Regulations Advisory Scheme)

USA

(NSF 61- NSF International Standard 61 "Drinking Water System Components – Health Effects")

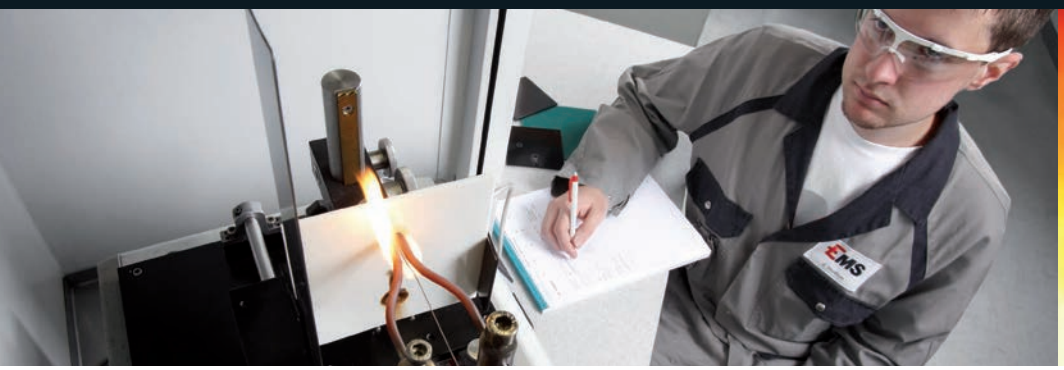
All Grivory GV grades also satisfy the requirements of the following EU directives and regulations:

Regulation (EC) No. 2037/2000 (ozone depleting substances), Regulation (EC) No. 1895/2005 (BADGE, BFDGE, NOGE), Directives 76/769/EEC (substances classified as carcinogens and toxic to reproduction), 94/62/EC (packaging), 2000/53/EC (ELV, directive on end-of-life vehicles), 2002/16/EC (epoxy derivatives), 2002/61/EC (azo colourants), 2002/95/EC and 2002/96/EC (RoHS and WEEE, electrical equipment), 2003/11/EC (PBDE), 2003/53 (nonylphenol), 2005/69/EC (PAH), 2005/80/EC (CMR), 2005/84/EC (phthalates), 2006/122/EC (PFOS, PFOA).

Further certifications are available on request.

Product	KTW	ACS	WRAS	NSF 61
GV-2 FWA	23°C	approved	23°C	23°C
GV-4 FWA	23°C	approved	23°C	23°C
GV-5 FWA	23°C	approved	23°C	23°C
GV-6 FWA	23°C	approved	23°C	23°C

Behaviour in fire



Standard products, low flammability
The following Grivory GV grades in all colours are listed by UL in flammability class UL 94 HB under the reference number EMS-CHEMIE E 53898:

Grivory GV-2H
Grivory GV-4H
Grivory GV-5H
Grivory GV-6H

Grivory GVS-5H
Grivory GVX-7H
Grivory GM-4H
Grivory GC-4H
Grivory G355 NZ
Grivory G4V-5H
Grivory GVN-35H

Flame-retardant, self-extinguishing products
The flame-retardant Grivory GV "V0" grades, reinforced with glass fibres, are free from both halogens and red phosphorus. They are self-extinguishing and are classified in accordance with UL 94 V0. The "Yellow Cards" contain the UL-listed properties. The Yellow Cards for listed products are available over the Internet under reference number EMS-CHEMIE E 53898:

Grivory GV-3H V0
30 per cent by weight glass fibre reinforcement

Grivory GV-4H V0
40 per cent by weight glass fibre reinforcement

Grivory GVX-5H V0
50 per cent by weight special glass fibre reinforcement

Grivory GVX-5H FR
50 per cent by weight special glass fibre reinforcement V0 up to 3.2 mm

RoHS: the products Grivory GV-3H V0 and Grivory GV-4H V0 satisfy the requirements of RoHS (2002/95/EC, Restriction of Hazardous Substances).

WEEE (waste electrical and electronic equipment): The "selective utilisation" requirement as per guideline 2002/96/EC on waste electrical and electronic equipment does not apply to parts made from Grivory GV-3H V0 and Grivory GV-4H V0.

FMVSS (Federal Motor Vehicle Safety Standards): All Grivory GV products satisfy the requirements of FMVSS 302 (ISO 3795, DIN 752000). Burning rates determined in a plate flaming test are below 100 mm/min. for wall thicknesses > 1 mm.

Grivory GV is delivered ready dried in airtight sealed packaging. Further drying is not necessary provided that the product is stored correctly. However, if sacks are damaged as a result of incorrect storage, Grivory GV must be dried again before use. Drying can be carried out in a vacuum oven or a dry air dryer.

Properly sealed, undamaged sacks can be stored for years if sheltered from the weather. Storage is recommended in a dry room in such a way that sacks are also protected from damage. Sacks which do become damaged should be hermetically resealed immediately. Alternatively, it is better to transfer the material to a metal, airtight container. It is important that the material to be used is stored for approximately 1 day in the processing area in order to ensure that the temperature of the granules reaches room temperature. This is particularly important during winter as it prevents the formation of condensation on the surface of the granules when the sack is opened.

The packaging should be opened shortly before processing begins. If the top layer of granules is in contact with the air for any length of time it may reach a critical water content of ≥ 0.1%. Where long dwell times with granules in the hopper are unavoidable, a hopper heating system or hopper dryer should be used.

Circulating air ovens are not recommended for drying as – they can cause a higher moisture level of the granules where ambient temperature and humidity are high.

Type of dryer	Drying temperature	Drying time
Dry air dryer	max. 80°C	4–12 hours
Vacuum oven	max. 100°C	4–12 hours

The drying time is very dependent on the moisture content. In case of doubt, drying should be carried out for about 12 hours. For dry air dryers, temperatures in excess of 80°C can result in yellowing of natural or light coloured granules.

Processing – injection moulding

The processing melt temperature range for reinforced Grivory grades lies between 280°C and 300°C. The recommended processing temperature for each Grivory GV grade is given in the data sheets.

It is possible to work at the upper limit of the recommended melt temperature (max. 310°C) for parts with long flow distances and low wall thicknesses.

Screw geometry

Grivory GV can be processed without problem using a conventional universal three-zone screw with a non-return valve. The effective screw length should be between 18 D and 22 D.

A non-return valve is necessary in order to prevent the melt flowing back along the screw flight during injection and the holding pressure phases.

Nozzle

An open nozzle may be used when processing Grivory GV. A nozzle of this type allows free flowing and is very long lasting due to its simple structure. However, hydraulically controlled needle valve nozzles may prove useful if the melt tends to flow out of the nozzle.

Mould design

Design rules typical for thermoplastics are valid for mould design. Basically, all kinds of sprue system can be used for the processing of Grivory GV. Since polyamides solidity relatively quickly, the sprue runner must be large enough to compensate for shrinkage during cooling in the holding pressure phase.

Mould temperature

As a rule, Grivory GV is processed with a mould temperature of 80°C to 120°C. Mould temperatures of around 120°C should be used to achieve best surface quality and parts which satisfy the requirements for highest hardness and strength.

A good heating system combined with the correct mould temperature is a prerequisite for the manufacture of high quality injection-moulded parts. The mould temperature influences the freezing behaviour and the degree of crystallinity and thus the associated surface quality, shrinkage, warpage, dimensional tolerances and level of internal stress.

Bonding
Grivory GV is one of those materials which are difficult to bond with adhesives due to their excellent resistance to chemicals. However, strong and reliable adhesive bonds can be achieved with a careful choice of adhesive and suitable process technology.

Solvent adhesives based on phenol (resorcinol, cresol) as well as reaction adhesives (single or two-component systems) are particularly suitable for adhesive bonding of Grivory.

The most common reactive adhesives:

Single-component systems:
- cyanacrylate adhesives; methacrylate adhesives; particularly well suited for bonding Grivory to metal and for parts with a small surface area, very quick setting

Two-component systems:
- polyurethane adhesives
- epoxy resin adhesives; longer pot life (hardening time), gap filling, large bonding areas

A significant improvement in bond quality can be achieved through pre-treatment.

Type of pre-treatment:
- degreasing: use of organic solvents, e.g. acetone
- mechanical abrasion: brushing, grinding, sandblasting
- electrochemical: corona discharge, low-pressure plasma
- thermal: flaming
- chemical: treatment with caustic substances; adhesive manufacturers offer suitable primer systems

The choice of a suitable adhesive must be made separately for every application because, in addition to the material to be bonded, the joint geometry, bonding gap and surface quality all have a major impact on the resultant bond. Our application development centre will be happy to supply you with further information regarding the choice of adhesive and suppliers.

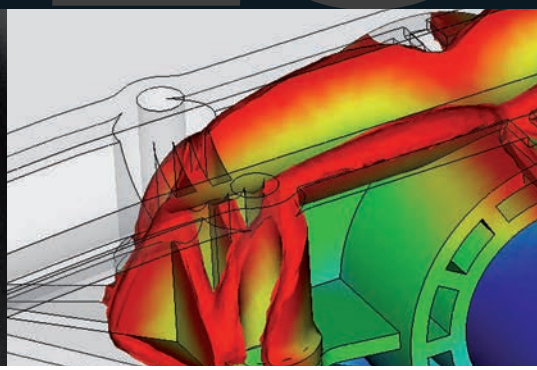
Welding
Very good welds can be obtained for moulded parts made of Grivory GV using heated element welding, ultrasonic welding, spin welding, laser welding and vibration welding technology.

The best results in the weld zone are achieved using ultrasonic welding, which makes this method particularly suitable for use with small components. Ultrasonic welding can be used for embedding threaded metal inserts as well as for riveting and beading.

Vibration welding offers more freedom for the combination of different thermoplastic materials. This includes, for example, the option of welding amorphous materials to semi-crystalline ones. In particular, the bonding of glass fibre reinforced Grivory with amorphous, transparent Grivory GTR 45 opens up interesting possibilities for construction engineers.

Screw fastening
Parts made of Grivory can be fastened effectively with self-tapping screws. Threads can be integrated directly into the component.

Machining
Use of reclaimed material



Painting
Due to its excellent resistance to most solvents, Grivory GV can be painted with one or several coats of different kinds of paint to achieve a good cover without impairing the mechanical properties. Single and two-component paints with their solvent content adjusted to suit the material to be painted are most suitable.

Pre-treatment
Special pre-treatment of Grivory GV is normally not necessary, although certain additives such as lubricants may make painting more difficult. In these cases, improved paint adhesion can be achieved by pre-treating moulded parts made of Grivory GV.
Methods of pre-treatment are given in the section "Bonding".

Metal plating
Parts made of Grivory may also be metal plated by vacuum or, following the necessary pre-treatment, by galvanic processes. Excellent surface finishes can be achieved for both reinforced and non-reinforced grades.

General
Please contact our application development centre for further information regarding post treatment of Grivory.

Use of reclaimed material
Faulty parts can be reprocessed and recycled.

The following points should be observed:

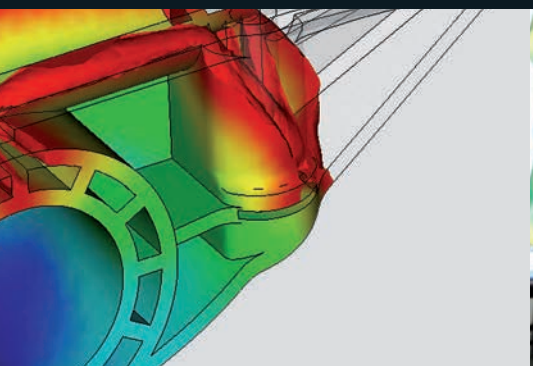
- Water absorption: moisture content
- Milling: dust content, maximum particle size
- Contamination by other polymers, dust, oil, etc.
- Proportion: percentage addition to original material
- Changes in colour
- Changes to mechanical properties

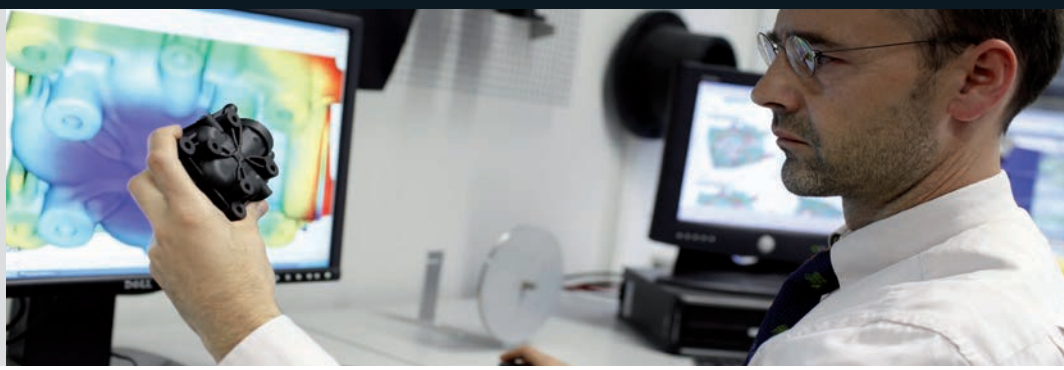
Machining
It should be borne in mind that, for economical reasons, parts should be designed in order to make machining unnecessary. If machining is used to make prototypes, it should be remembered that the properties are not necessarily identical to those of an injection-moulded part.

	Method				
	Unit	Turning	Milling	Sawing	Drilling
Clearance angle	–	5–10	3–15	15–30	5–10
Rake angle	–	2–10	5–15	3–6	6–15
Cutting speed	m/min	200–400	300–800	200–500	50–120
Rate of feed	mm/U	0.1–0.5	0.1–0.5	-	0.1–0.5
Point angle	-	-	-	-	90–120
Circular pitch	mm	-	2–8	-	-

Due to the high degree of reinforcement of Grivory GV, GM and GC grades, the use of carbide-tipped tools is recommended.

Laser marking and lettering
Grivory GV and GM grades can be modified to be suitable for laser marking and lettering if required.





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

- We draw up and discuss with you a range of designs for your applications in order to find an optimum solution from both a technical and an economic viewpoint.
- As a material specialist, we will provide you with a material recommendation that "fits". We do this by comparing and analysing possible materials, thereby ensuring that we recommend the material which is best suited to your application.
- We also provide support in identifying and carrying out tests suited to your application. Our modern laboratories can offer a wide and varied range of mechanical, thermal, chemical and electrical tests.
- Are you experiencing problems with material sampling or the start of production? With our applications engineering know-how, we can offer you expert advice for process and mould optimisation, and our Technical Customer Services department can also provide on-site support.

CAE

Using computer-aided engineering systems, EMS-GRIVORY application development centre are able to offer our customers a wide range of support services in this sector. CAE systems used include the Moldflow program modules FLOW, COOL and WARP for the simulation of injection moulding processes as well as the finite element (FE) programs NX-Nastron and ANSYS for mechanical part design and layout. Rheological simulation enables the optimum positioning of the gate to be determined before manufacturing of the mould is begun. These programs are also useful when changes to existing moulds are necessary because they provide an extremely efficient way of finding a solution. The variety of calculations which can be made ranges from simple flow pattern simulations, taking into consideration the influence of the cooling system, to qualitative statements about shrink behaviour and the warping of shaped parts. Part design using FE analysis provides information about highly stressed areas. This allows weak points in the design to be identified and corresponding modifications to be made. Through the use of both the NX-Nastron and CATIA 3D CAD systems, in combination with the Parasolid, IGES and STEP interfaces, EMS-GRIVORY is able to use the customer's own 3D CAD data directly as the basis for CAE simulations.

Prototypes

The key to success is rapid realisation and quick implementation of a good idea! EMS-GRIVORY helps to reduce the effort involved in the manufacture of prototypes, thereby saving valuable time and reducing costs.

We provide support with the manufacture of small series of prototypes for the first practical tests.

In our application development centre, we can also produce samples from metal die-casting tools directly, with small, reversible modifications.

Within the shortest possible period of time, we therefore offer you the opportunity to test initial prototypes without the need to construct an injection mould in advance.

With these prototypes you can gain initial practical experience and incorporate this knowledge into subsequent project phases, thereby eliminating the need to carry out expensive modifications to manufacturing moulds shortly before serial production.

Using our test laboratories

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

Our instrument infrastructure allows us not only to determine the standard mechanical, thermal and electrical properties of our materials for use in data sheets and approvals, but also to provide practical support for research and development work, application development and for our customers.

- Our mechanical testing laboratory is equipped with modern tensile testing machines, automated impact testing apparatus and devices to determine the creep behaviour of plastic materials in air and liquid media. We also have a pneumatic flexural strength apparatus and a dynamic compression-tension machine available for testing the dynamic short-term and long-term stress behaviour of Grivory materials.

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

- Laboratory tests are carried out to examine the resis-tance to chemicals, heat and weathering and provide important information about the use of our materials in applications involving extreme conditions.

- Chemical and process-engineering tests ensure that the high quality levels of our products can be properly monitored and the consistent nature of properties is guaranteed.

In addition, our materials testing department can make use of a variety of additional equipment such as an EMS-P test unit (determination of the permeability of fuel-system components to petrol), a petrol circulation unit (testing of the working life of plastic petrol lines under extreme conditions), a hot air threshold pressure test (for testing of parts made using extrusion blow-moulding processes) and many more.

With these services, we can offer our customers active support in the choice and development of materials as well as component design and testing of finished parts.

CAMPUS
stands for **C**omputer **A**ided **M**aterial **P**reselection by **U**niformed **S**tandards.

The database 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. Testing is carried out according to the international standards ISO 10350 and ISO 11403.

EMS-GRIVORY has taken an active part in the creation of the CAMPUS database since 1989. Currently, our testing laboratories have characterised more than 170 materials according to the CAMPUS profile regarding physical, chemical and process-engineering properties. These are shown in both tabular form (mechanical, thermal rheological and electrical property values) and graphical form (stress-strain, creep, insertion/loss module, viscosity, pvT).
Material descriptions, chemical resistance information, typical applications and processing information supplement the product profile.

The database programme and CAMPUS data can be downloaded from our website (www.emsgrivory.com).

The very comprehensive "EMS Material Database" is also available at the EMS-GRIVORY website. This facility not only enables you to quickly download technical and safety data sheets, it also allows you to compare products directly, carry out a simple search by product designations or polymer groups, or conduct a more advanced search for specific properties, product features, applications or specific authority approvals.

Quality standards

All EMS-GRIVORY production sites throughout the world work in accordance with the same quality management system based on standards ISO 9001:2008 and ISO/TS 16949:2009. They are certified by the Swiss Association for Quality and Management Systems (Schweizerische Vereinigung für Qualitäts- und Management-Systeme, SQS). Compared to ISO 9001 which is found worldwide, ISO/TS 16949, which was developed by the automotive industry, contains further-reaching and more stringent requirements.

Our management system is process oriented. Our ultimate aim is customer satisfaction. Our efforts are concentrated on conformance with quality requirements and the 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 inter-departmental teams working according to the principles of "simulta-neous engineering". The team members do not think and act solely within the confines of their own departments but instead strive to attain a common goal. Mo-dern technology (such as statistical test design) and preventive methods (such as failure, probability and effect analysis) play a central role. The guiding principle of project management is "avoiding mistakes instead of correcting them".

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

Continual improvement of products, services and productivity is the subject of official improvement programmes to which all of our employees are fully committed.

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

Product lines

Grivory HT
Enhanced performance at high temperatures.

Grivory® is the brand name of a group of engineering plastics. Grivory HT is a material based on polyphthalamide (copolyamide PA6T/6I, PA6T/66, PA10T/X), manufactured and marketed by EMS-GRIVORY.

Grivory GV
The proven material for metal replacement.

Grivory® GV is the brand name of a group of engineering plastics manufactured and marketed by EMS-GRIVORY. The materials in this group are based on semi-crystalline polyamides with some partially aromatic content. Grivory GV is available in granular form for processing using injection moulding methods

Grilon
Premium polyamide

Grilon® is the EMS-GRIVORY brand name for engineering plastics based on polyamide 6, polyamide 66 and polyamide 66/6 alloys. The products in this group are semi-crystalline polyamide materials which are characterised by many groundbreaking properties.

Grilamid
Technical polymer for highest demands.

Grilamid® is the brand name given by EMS-GRIVORY to its polyamide 12 products. These engineering plastics have been successfully tried and tested for more than 30 years in a wide variety of challenging applications.

Grilamid TR
Transparent polyamide for highest demands.

Grilamid TR® is the brand name given by EMS-GRIVORY to its transparent polyamides. Grilamid TR grades are transparent polyamides for processing using thermoplastic methods and based on aliphatic and cyclo-aliphatic units.

Delivery form

Grivory GV is delivered as dry granules, packaged in moisture-proof sacks of 25 kg each.

Pre-drying of material from unopened and undamaged sacks is not necessary.

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 typespecific disposal.

In some European countries, EMS-GRIVORY pays disposal fees in advance, e.g. in cooperation with the RIGK scheme in Germany where empty packaging containers can be returned free of charge.

Grivory link
For further information, please visit our website:

www.emsgrivory.com

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

Please note: EMS-GRIVORY cannot assess any possible future health risks which could be caused by the long-term contact of our products with blood or tissue. For this reason, EMS-GRIVORY cannot promote medical applications involving long-term contact of plastic with blood or tissue.

Domat/Ems, October 2014

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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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EMS-GRIVORY

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