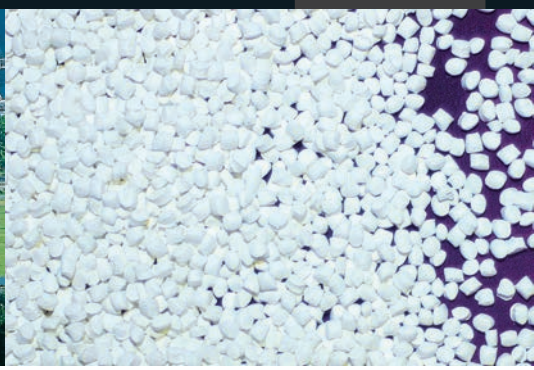
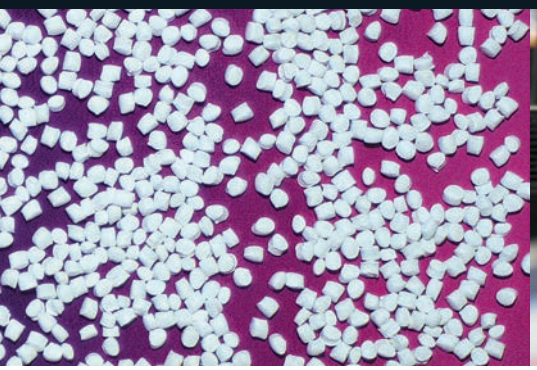
Grivory HT

Enhanced Performance at High Temperatures

GRIVORY®
EMS

Contents





Introduction

Grivory® is the trade name of a group of engineering plastics manufactured and marketed by EMS-GRIVORY. Grivory HT is a semi-crystalline thermoplastic construction material based on polyphthalamide (PPA).

A completely new and specific process for the manufacture, polymerisation and compounding of Grivory HT in Domat/Ems (Switzerland) has been developed by EMS-GRIVORY. Production capacity was adjusted to meet the good demand and EMS-GRIVORY is now one of the most important manufacturers of polyphthalamides in the world and clear market leader in Europe.

Grivory HT is characterised by a high-performance property profile. Technical injection-moulding parts made of this material have impressive dimensional stability, even at high application temperatures. The property profile of Grivory HT overlaps well into the performance range of high-performance plastics. The values of Grivory HT for properties such as stiffness and strength at application temperatures up to 120°C - important for replacement of metals - surpass those of materials such as PPS or PEEK.

The Grivory FWA grades are physiologically harmless and can also be used in sensitive application areas such as in direct contact with drinking water and foodstuffs.

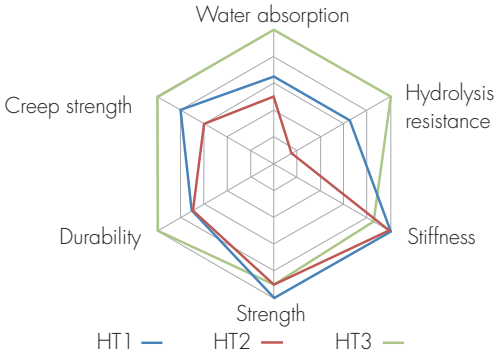
Grivory HT is available as granules for processing using injection-moulding methods on conventionally available equipment and moulds. The different grades of material within this group result from the type and composition of the basic polymers and their modification with reinforcing materials (glass fibre, minerals), stabilisers and processing aids.

Givory HT is used for the efficient manufacture of high-performance technical components which are characterised by:

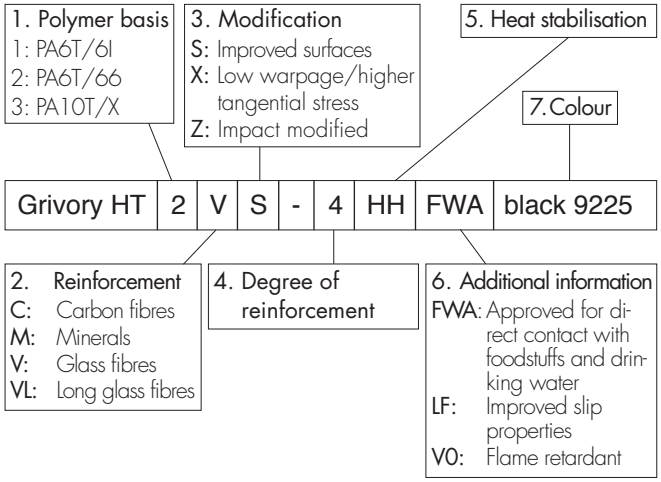
- stiffness and strength at high application temperatures
- property values which are influenced very little by absorption of water
- good dimensional stability and a low tendency to warp
- good resistance to chemicals
- good surface quality
- rational and cost-effective manufacture

Grivory HT grades

- Grivory HT1: PA6T/6I
- Grivory HT2: PA6T/66
- Grivory HT3: PA10T/X



Grivory HT Nomenclature



Characteristics of Grivory HT1 grades

Grivory HT1 grades	Characteristics and properties	Application areas
HTV-3H1 HTV-4H1 HTV-45H1 HTV-5H1 HTV-6H1 HT1V-65H	Injection-moulding grade with 30-65 wt% glass-fibre reinforcement based on polyphthalamide PA 6T/6I. Stiff and strong at high application temperatures. Heat stabilised, dimensionally stable, low water uptake, good resistance to chemicals and automotive media (fuel, oils, brake fluid) even at high temperatures.	Stiff, dimensionally accurate technical parts in mechanical engineering, automotive and electro applications. Functional parts in contact with chemicals and requiring good performance values at high application temperatures.
HT1V-3 FWA HT1V-4 FWA HT1V-5 FWA HT1V-6 FWA	Drinking water approved, heat stabilised injection-moulding grades with 30-60 wt% glass-fibre reinforcement, based on polyphthalamide PA6T/6I. Approved for direct contact with drinking water as per ACS, KTW, W270, WRAS and NSF standards. EU conformity for direct contact with foodstuffs and unlimited FDA approval for contact with all foodstuffs. UL listed.	Stiff, dimensionally accurate technical parts, functional parts in sanitary applications, foodstuff industry applications and domestic appliances in direct contact with drinking water and foodstuffs at high application temperatures.
HT1V-3 HY HT1V-4 HY HT1V-5 HY	Hydrolysis-optimised, heat stabilised injection-moulding grades with 30-50 wt% glass-fibre reinforcement, based on polyphthalamide PA6T/6I. Stiff and strong even at high application temperatures and in direct contact with hot water or automotive coolants.	Stiff, dimensionally accurate technical parts. Hot-water housings and functional components in automotive construction and sanitary and heating system applications.
HTM-4H1	Mineral-reinforced (40 wt%) injection-moulding grade based on polyphthalamide PA6T/6I. Stiff and strong even at high application temperatures. Heat stabilised. Isotropic properties, low warpage, dimensionally stable, low thermal expansion. UL listed.	Stiff, dimensionally accurate parts with good dimensional stability and low thermal expansion. Functional and visible components in automotive applications with electrochemical surface coatings.
HT1V-33X LED white 6861	33 wt% glass-fibre reinforcement on a PA6T/6I basis. High light reflection, good flowability, good strength and stiffness values.	Thin-walled LED reflector housings.
HT1V-33X UV white 6861	33 wt% glass-fibre reinforcement on a PA6T/6I basis. High light reflection, good flowability, good strength and stiffness values, yellowing optimised.	Thin-walled LED reflector housings with reduced yellowing and longer life expectancy.

Characteristics of Grivory HT2 grades

Grivory HT2 grades	Characteristics and properties	Application areas
HT2V-3H HT2V-4H HT2V-45H HT2V-5H HT2V-6H	Injection-moulding grades with 30-60 wt% glass-fibre reinforcement based on polyphthalamide, PA6T/66. Simple to process. Stiff and strong at high application temperatures. Heat stabilised, dimensionally stable, good resistance to chemicals.	Stiff, dimensionally accurate technical parts in mechanical engineering, automotive and electro applications. Functional components in contact with chemicals and requiring good performance values at high application temperatures.
HT2V-3H LF	Material used for sliding bearings, PTFE-modified injection-moulding grade with 30 wt% glass-fibre reinforcement, based on polyphthalamide PA6T/66. Simple to process, stiff and strong at high application temperatures. Little wear, heat stabilised, dimensionally stable, good resistance to chemicals	Stiff, dimensionally accurate bearing components in mechanical engineering, automotive and electro applications. Tribologically stressed functional components (joint sleeves, bearing halves, guide channels, sliders) in contact with chemicals and requiring high performance values at high application temperatures.
HT2C-3X LF black 9833	Material used for sliding bearings, PTFE modified injection-moulding grade with 30 wt% carbon fibre reinforcement based on polyphthalamide, PA6T/66. Maximum stiffness and strength, conductive, very low density.	Bearing components to satisfy highest requirements.
HT2V-3X V0 HT2V-4X V0 HT2V-5X V0	Flame retardant, halogen-free injection-moulding grades with 30-50 wt% glass-fibre reinforcement, based on polyphthalamide PA6T/66. Self-extinguishing (UL 94 V-0). Good flow properties. Stiff and strong at high application temperatures. Light inherent colour, colourable. UL listed.	Self-extinguishing, stiff, dimensionally accurate technical parts in electro applications where the flammability classification of the material (as per UL 94 V-0) is a mandatory prerequisite. Suitable for thermal pulse loading commonly occurring in industrial soldering processes. RoHS: Parts made of these materials conform to the requirements as per RoHS (2002/95/EG and 2011/65/EU, Restriction of Hazardous Substances). WEEE: Parts made of these materials are exempt from the requirements governing "selective recycling" as per guideline 2002/96/EC concerned with disposal of used electro and electronic components
HT2C-3X	Carbon-fibre-reinforced (30 wt%) injection-moulding grade based on polyphthalamide PA6T/66. Very stiff and strong, low density, conductive.	Stiff, light, dimensionally accurate components in mechanical engineering and automotive applications. Tribologically stressed functional components in contact with chemicals and requiring high performance values at high application temperatures.
HT2VZ-15H HT2VZ-33H XE 4099 (HT2VZ-3)	Injection-moulding grades with 15-33 wt% glass-fibre reinforcement based on polyphthalamide, PA6T/66. Easy to process. Stiff, impact resistance and strong at high working temperatures. Heat stabilised, dimensionally stable, good resistance to chemicals.	Stiff, impact resistance, dimensionally accurate technical parts in mechanical engineering, automotive and electro applications. Functional components in contact with chemicals and requiring good performance values at high application temperatures.
XE 4216 (HT2VS-3HH) XE 4217 (HT2VS-45HH)	Injection-moulding grades with 30 resp. 45 wt% glass-fibre reinforcement based on polyphthalamide, PA6T/66 with optimised heat resistance and surface quality.	For components such as turbo-charger air ducts exposed to extremely high thermal stressing.

"Grivory XE..." designates the new, commercialised pilot products during the market introduction phase. The future standard product designation is shown in brackets, example: Grivory XE 4216 (HT2VS-3HH).

Characteristics of Grivory HT3 grades

Grivory HT3 grades	Characteristics and properties	Application areas
XE 4063 (HT3V-30H) XE 4065 (HT3V-50H)	Injection-moulding grades with 30 resp. 50 wt% glass-fibre reinforcement, based on polyphthalamide, PA10T/X. Very good resistance to chemicals and dimensional stability. Made partly from renewable raw materials.	Stiff and strong, dimensionally accurate technical parts in mechanical engineering, automotive and electro applications at high working temperatures.
XE 3996 (HT3V-30) XE 4095 (HT3V-50)	Injection-moulding grades with 30 resp. 50 wt% glass-fibre reinforcement, based on polyphthalamide, PA10T/X. Good flowability, very good resistance to chemicals and dimensional stability. Made partly from renewable raw materials.	Stiff and strong, thin-walled and dimensionally accurate technical parts in mechanical engineering and electro applications at high working temperatures.
XE 4101 (HT3V-40 FWA)	Drinking water approved injection-moulding grade with 40 wt% glass-fibre reinforcement, based on polyphthalamide, PA10T/X. Excellent hydrolysis resistance and dimensional stability. Made partly from renewable raw materials. Approved for direct contact with drinking water as per ACS, KTW, W270, WRAS and NSF directives. EU and FDA conform.	Stiff, dimensionally accurate technical parts, functional parts in sanitary applications, foodstuff industry applications and domestic appliances in direct contact with drinking water and foodstuffs at high application temperatures and requiring hydrolysis resistance.
XE 4102 (HT3C-30)	Carbon-fibre-reinforced (30 wt%) injection-moulding grade based on polyphthalamide PA10T/X66. Very stiff and strong, low density, conductive, very good resistance to chemicals. Made partly of renewable raw materials.	Stiff, light and dimensionally accurate technical parts in mechanical engineering and automotive applications. Tribologically stressed functional components in contact with chemicals and providing a good performance at high application temperatures.
HT3Z LF	Non-reinforced injection-moulding grade, impact resistant, PTFE modified, based on polyphthalamide, PA10T/X. Very good resistance to chemicals and dimensional stability. Made partly of renewable raw materials.	Durable, dimensionally accurate bearing components in mechanical engineering, automotive and electro applications. Tribologically stressed functional components (joint sleeves, bearing halves, guide channels, sliders) in contact with chemicals and requiring high performance values at high application temperatures.
HT3Z	Non-reinforced injection-moulding grade, impact resistant, PA10T/X. Very good resistance to chemicals and dimensional stability. Made partly of renewable raw materials.	Durable, dimensionally accurate bearing components in mechanical engineering, automotive and electro applications in contact with chemicals and requiring high performance values at high application temperatures.

Grivory HT3 grades	**Characteristics and properties**	**Application areas**
XE 4134 (HT3VX-30)	Injection-moulding grade with 30 wt% glass-fibre reinforcement, optimised against warpage, based on polyphthalamide, PA10T/X. Very good resistance to chemicals and dimensional stability. Made partly from renewable raw materials.	Stiff and durable, dimensionally accurate bearing components in mechanical engineering, automotive and electro applications at high operating temperatures. Components exposed to high internal pressure and those with high requirements regarding distortion.
XE 4027 (HT3V-30 V0)	Flame retardant, halogen-free injection-moulding grade with 30 wt% glass-fibre reinforcement, based on polyphthalamide PA10T/X. Self-extinguishing (UL 94 V-0), good flow properties. Stiff and strong at high application temperatures. Light inherent colour, colourable. UL listed including RTI. Optimised against corrosion. Satisfies RoHS regulations and WEEE requirements. Made partly of renewable raw materials.	Self-extinguishing, stiff, dimensionally accurate technical parts in electro applications where a V-0 flammability classification of the material (as per UL 94) is a mandatory prerequisite. Suitable for lead-free SMT reflow soldering e.g. as per JEDEC J-STD-020C.
XE 4120 (HT3V-30 V0 CO)	Flame retardant, halogen-free injection-moulding grades with 30 wt% glass-fibre reinforcement, based on polyphthalamide PA10T/X. Self-extinguishing (UL 94 V-0), good flow properties. Stiff and strong at high application temperatures. UL listed including. Satisfies RoHS regulations and WEEE requirements. Excellent suitability for soldering (SMT reflow soldering), optimised against corrosion.	Self-extinguishing, stiff, dimensionally accurate technical parts in electro applications where the V-0 flammability classification of the material (as per UL 94) is a mandatory prerequisite. Excellent suitability for lead-free SMT reflow soldering e.g. STM plug connectors as per JEDEC J-STD-020C.
XE 4164 (HT3V-30 CO)	Injection-moulding grades with 30 wt% glass-fibre reinforcement, based on polyphthalamide, PA10T/X. Good flowability, very good resistance to chemicals and dimensional stability.	Stiff, light and dimensionally accurate technical parts in electro applications where a HB flammability classification of the material (as per UL 94) is sufficient. Excellent suitability for lead-free SMT reflow soldering e.g. SMT plug connectors as per JEDEC J-STD-020C.
XE 4185 (HT3 V0 CO)	Flame retardant, halogen-free, non-reinforced injection-moulding grades based on polyphthalamide PA10T/X. Self-extinguishing (UL 94 V-0), good flow properties. Good strength values at high application temperatures. UL listed. Satisfies RoHS regulations and WEEE requirements. Excellent suitability for soldering (SMT reflow soldering), optimised against corrosion.	Self-extinguishing, dimensionally accurate and durable technical parts in electro applications where a V-0 flammability classification of the material (as per UL 94) is a mandatory prerequisite. Excellently suited for lead-free SMT reflow soldering e.g. SMT plug connectors as per JEDEC J-STD-020C.

Properties of Grivory HT1 grades

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Mechanical properties				
Tensile E-modulus	1 mm/min	ISO 527	MPa	dry cond.
Tensile stress at break	5 mm/min	ISO 527	MPa	dry cond.
Elongation at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry cond.
Ball indentation hardness		ISO 2039-1	MPa	dry cond.
Thermal properties				
Melt temperature	DSC	ISO 11357	°C	dry
Heat deflection temperature HDT/A	1.8 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.0 MPa	ISO 75	°C	dry
Thermal expansion longitudinal	23 - 55°C	ISO 11359	10^{-6}/K	dry
Thermal expansion transverse	23 - 55°C	ISO 11359	10^{-6}/K	dry
Maximum working temperature	long-term	ISO 2578	°C	dry
Maximum working temperature	short-term	EMS	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index		IEC 60112	-	cond.
Specific volume resistance		IEC 60093	Ω · m	dry cond.
Specific surface resistance		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm³	dry
Flammability (UL 94)		ISO 1210	Rating	-
Water absorption	23°C/saturated	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	longitudinal	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 1874				

	HTV-3H1 black 9205	HTV-4H1 black 9205	HTV-45H1 black 9205	HTV-5H1 black 9205	HTV-6H1 black 9205	HT1V-65H black 9205	HT1V-3 FWA black 9225	HT1V-4 FWA black 9225	HT1V-5 FWA black 9225	HT1V-6 FWA black 9225
	11 000 11 000	14 500 14 000	16 500 16 000	18 000 17 500	23 000 22 500	25 500 25 500	11 000 11 000	14 500 14 000	18 000 17 500	23 000 22 500
	190 170	220 210	235 230	250 240	260 250	280 270	190 170	220 210	250 240	260 250
	2 2	2 2	2 2	2 2	1.5 1.5	1.5 1.5	2 2	2 2	2 2	1.5 1.5
	50 50	70 70	75 75	80 80	75 75	60 60	50 50	70 70	80 80	75 75
	50 50	70 70	75 75	80 80	75 75	60 60	50 50	70 70	80 80	75 75
	7 7	8 8	12 12	11 11	11 11	12 12	7 7	8 8	11 11	11 11
	7 7	8 8	12 12	10 10	10 10	11 11	7 7	8 8	10 10	10 10
	280 270	310 300	325 320	340 340	360 360	420 420	280 270	310 300	340 340	360 360
	325	325	325	325	325	325	325	325	325	325
	>280	>280	>280	>280	>280	>280	>280	>280	>280	>280
	155	200	205	210	215	240	155	200	210	215
	20	15	15	15	15	15	20	15	15	15
	50	50	45	40	40	40	50	50	40	40
	150	150	150	150	150	150	140	140	140	140
	260	260	265	265	270	280	260	260	265	270
	30 30	30 30	30 30	30 30	30 30	30 30	30 30	30 30	30 30	30 30
	575	600	600	600	600	600	575	600	600	600
	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11
	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12
	1.44	1.53	1.59	1.65	1.78	1.85	1.44	1.53	1.65	1.78
	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB
	3.5	3.5	3.3	3.0	3.0	2.8	3.5	3.5	3.0	3.0
	1.8	1.5	1.4	1.3	1.2	1.1	1.8	1.5	1.3	1.2
	0.20	0.10	0.10	0.10	0.10	0.10	0.20	0.10	0.05	0.05
	0.75	0.70	0.65	0.50	0.45	0.40	0.70	0.55	0.45	0.25
	PA6T/6I MH, 12-110, GF30	PA6T/6I MH, 12-140, GF40	PA6T/6I MH, 12-160, GF45	PA6T/6I MH, 12-190, GF50	PA6T/6I MH, 12-220, GF60	PA6T/6I MH, 12-250, GF65	PA6T/6I MH, 12-110, GF30	PA6T/6I MH, 12-140, GF40	PA6T/6I MH, 12-190 GF50	PA6T/6I MH, 12-220, GF60

Properties of Grivory HT1 and HT2 grades

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Mechanical properties				
Tensile E-modulus	1 mm/min	ISO 527	MPa	dry cond.
Tensile stress at break	5 mm/min	ISO 527	MPa	dry cond.
Elongation at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry cond.
Ball indentation hardness		ISO 2039-1	MPa	dry cond.
Thermal properties				
Melt temperature	DSC	ISO 11357	°C	dry
Heat deflection temperature HDT/A	1.8 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.0 MPa	ISO 75	°C	dry
Thermal expansion longitudinal	23 - 55°C	ISO 11359	10^{-6}/K	dry
Thermal expansion transverse	23 - 55°C	ISO 11359	10^{-6}/K	dry
Maximum working temperature	long-term	ISO 2578	°C	dry
Maximum working temperature	short-term	EMS	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index		IEC 60112	-	cond.
Specific volume resistance		IEC 60093	Ω · m	dry cond.
Specific surface resistance		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm³	dry
Flammability (UL 94)		ISO 1210	Rating	-
Water absorption	23°C/saturated	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	longitudinal	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 1874				

Grivory HT1

Grivory HT2

HT1V-3 HY black 9205	HT1V-4 HY black 9205	HT1V-5 HY black 9205	HTM-4H1	HT2V-3H	XE 4216 (HT2VS-3HH)	XE 4217 (HT2VS-45HH)	HT2V-45H
11 000 11 000	14 500 14 000	18 000 17 500	7 500 7 500	11 000 11 000	11 0000 9 600	15 000 13 000	16 000 15 500
190 170	220 210	250 240	105 105	180 165	190 150	230 165	240 215
2 2	2 2	2 2	1.5 1.5	2.0 2.0	2.7 2.7	2.7 2.7	2 2
50 50	70 70	80 80	50 50	45 45	55 65	70 80	75 75
50 50	70 70	80 80	20 25	40 40	45 45	60 60	60 60
7 7	8 8	11 11	5 5	9 9	9 9	11 11	11 11
7 7	8 8	10 10	3 4	9 9	7 7	9 9	10 10
280 270	310 300	340 340	260 260	265 255	260 210	270 250	315 310
325	325	325	325	310	300	300	310
>280	>280	>280	145	280	280	280	>280
155	200	210	115	200	200	200	235
20	15	15	50	20	20	20	15
50	50	40	50	70	80	70	60
150	150	150	140	140	150	150	140
260	260	265	125	260	240	240	265
30 30	30 30	30 30	32 32	38 38	45 45	45 45	38 37
575	600	600	575	600	525	600	600
1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+11 1.0E+11	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10
1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12
1.44	1.53	1.65	1.55	1.42	1.43	1.58	1.56
HB	HB	HB	HB	HB	HB	HB	HB
3.5	3.5	3.0	3.5	5.0	5.4	4.3	4.0
1.8	1.5	1.3	1.5	1.8	2.1	1.7	1.4
0.20	0.10	0.05	0.70	0.15	0.20	0.15	0.10
0.70	0.55	0.60	0.85	0.80	0.90	0.80	0.75
PA6T/6I MH, 14-110, GF30	PA6T/6I MH, 14-140, GF40	PA6T/6I MH, 14-190, GF50	PA6T/6I MH, 12-070, MD40	PA6T/66 MH,14-110, GF30	PA6T/66+X MH, 14-110, GF30	PA6T/66+X MH, 14-110, GF45	PA6T/66 MH,14-160, GF45

Properties of Grivory HT2 grades

Mechanical properties				
Tensile E-modulus	1 mm/min	ISO 527	MPa	dry cond.
Tensile stress at break	5 mm/min	ISO 527	MPa	dry cond.
Elongation at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry cond.
Ball indentation hardness		ISO 2039-1	MPa	dry cond.
Thermal properties				
Melt temperature	DSC	ISO 11357	°C	dry
Heat deflection temperature HDT/A	1.8 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.0 MPa	ISO 75	°C	dry
Thermal expansion longitudinal	23 - 55°C	ISO 11359	10^{-6}/K	dry
Thermal expansion transverse	23 - 55°C	ISO 11359	10^{-6}/K	dry
Maximum working temperature	long-term	ISO 2578	°C	dry
Maximum working temperature	short-term	EMS	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index		IEC 60112	-	cond.
Specific volume resistance		IEC 60093	Ω · m	dry cond.
Specific surface resistance		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm³	dry
Flammability (UL 94)		ISO 1210	Rating	-
Water absorption	23°C/saturated	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	longitudinal	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 1874				

HT2V-5H	HT2V-6H	HT2VZ-15H	HT2VZ-33H	XE 4099 (HT2VZ-30)	HT2V-3H LF	HT2V-3X V0	HT2V-4X V0	HT2V-5X V0	HT2C-3X	HT2C-3X LF
17 500 17 000	20 500 20 000	6000 6000	11000 11000	9000 9000	11 000 11 000	10 500 10 500	13 500 13 500	17 000 17 000	24 500 24 000	24 000 24 000
250 225	260 235	125 100	200 180	160 130	185 160	140 130	150 145	160 155	275 265	240 210
2 2	2 2	3.0 3.5	2.5 2.5	3 3	2 2	2 2	2 2	1.5 1.5	2 2	1.5 2
85 85	80 80	65 55	55 55	85 75	50 50	40 40	45 45	45 45	55 55	40 40
65 65	55 55	45 40	50 45	85 75	45 45	35 35	40 40	40 40	50 50	40 40
11 11	11 11	10 10	10 10	14 14	7 7	7 7	9 9	10 10	8 8	7 7
11 11	11 11	5 5	9 9	10 10	7 6	6 6	9 9	10 10	7 7	5 5
325 325	340 330	175 -	260 240	190 160	270 260	240 230	270 260	295 275	300 290	290 260
310	310	310	310	310	310	310	310	310	310	310
>280	>280	265	>280	275	280	>280	>280	>280	>280	280
240	240	100	200	165	170	190	200	200	245	210
15	20	30	20	20	20	25	15	15	15	10
55	35	75	60	60	70	45	50	50	75	70
140	140	140	140	140	140	140	140	140	140	140
265	265	245	265	255	260	270	270	270	270	240
38 37	38 37	33 32	38 37	34 33	37 37	34 34	34 34	34 34	- -	3 3
600	600	575	600	600	575	600	600	600	-	-
1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	1.0E+10 1.0E+10	<50 <50	<50 <50
1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+12	1.0E+11	1.0E+11	1.0E+11	100	10
1.62	1.73	1.24	1.44	1.36	1.47	1.43	1.53	1.65	1.32	1.40
HB	HB	HB	HB	HB	HB	V0	V0	V0	HB	HB
3.5	3.0	5.5	5.0	4.8	4.5	3.5	3.5	3.0	4.5	4.3
1.2	1.1	2.0	2.0	1.6	2	1.3	1.2	1.0	1.5	1.5
0.10	0.10	0.40	0.10	0.15	0.20	0.10	0.10	0.05	0.05	0.10
0.70	0.70	0.90	0.90	0.90	0.80	0.90	0.80	0.60	0.65	0.30
PA6T/66 MH,14-190, GF50	PA6T/66 MH,14-190, GF60	PA6T/66 MH,12-060, GF15	PA6T/66 MH,14-110, GF33	PA6T/66 MH,12-090, GF30	PA6T/66 MH,12-110, GF30	PA6T/66 MHF,11-120, GF30	PA6T/66 MHF,11-120, GF40	PA6T/66 MHF,11-160, GF50	PA6T/66 MH,14250, CF30	PA6T/66 MHS, 14-250, CF30+Z

Properties of Grivory HT3 grades

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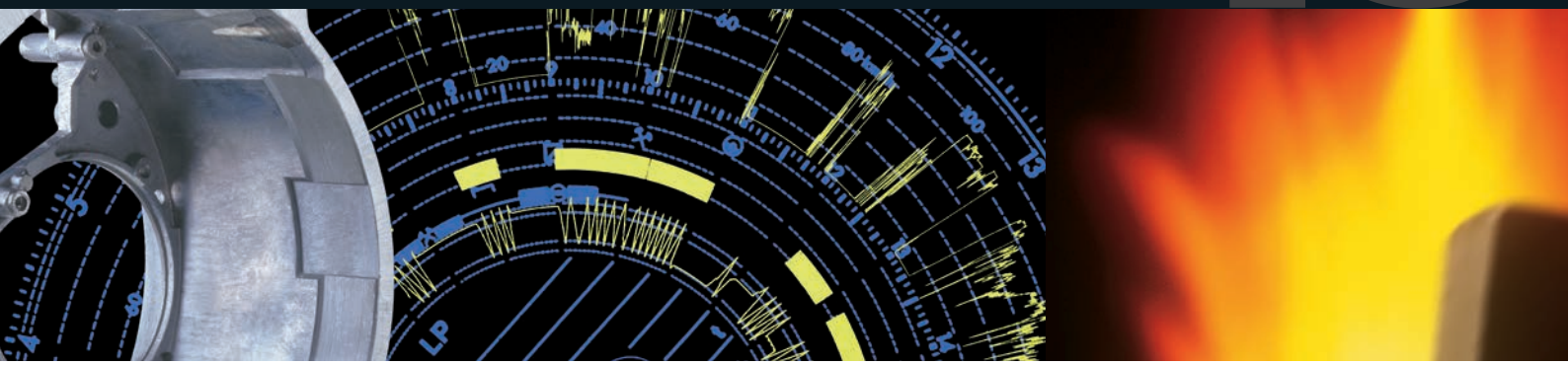
Mechanical properties					XE4063 (HT3V-30H)
Tensile E-modulus	1 mm/min	ISO 527 MPa	MPa	dry cond.	9500 9500
Tensile stress at break	5 mm/min	ISO 527 MPa	MPa	dry cond.	180 165
Elongation at break	5 mm/min	ISO 527 MPa	%	dry cond.	3 3
Impact strength	Charpy, 23°C	ISO 179/2-1eU kJ/m2	kJ/m²	dry cond.	80 70
Impact strength	Charpy, -30°C	ISO 179/2-1eU kJ/m2	kJ/m²	dry cond.	70 60
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA kJ/m2	kJ/m²	dry cond.	10 10
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA kJ/m2	kJ/m²	dry cond.	9 8
Ball indentation hardness		ISO 2039-1	MPa	dry cond.	210 210
Thermal properties					
Melt temperature	DSC	ISO 11357	°C	dry	295
Heat deflection temperature HDT/A	1.8 MPa	ISO 75	°C	dry	260
Heat deflection temperature HDT/C	8.0 MPa	ISO 75	°C	dry	150
Thermal expansion longitudinal	23 - 55°C	ISO 11359	10^{-6}/K	dry	20
Thermal expansion transverse	23 - 55°C	ISO 11359	10^{-6}/K	dry	70
Maximum working temperature	long-term	ISO 2578	°C	dry	150
Maximum working temperature	short-term	EMS	°C	dry	250
Electrical properties					
Dielectric strength		IEC 60243-1	kV/mm	dry cond.	38 37
Comparative tracking index		IEC 60112	-	cond.	600
Specific volume resistance		IEC 60093	Ω · m	dry cond.	10^{10} 10^{10}
Specific surface resistance		IEC 60093	Ω	cond.	10^{11}
General properties					
Density		ISO 1183	g/cm³	dry	1.37
Flammability (UL 94)		ISO 1210	Rating	-	HB
Water absorption	23°C/saturated	ISO 62	%	-	2.4
Moisture absorption	23°C/50% r.h.	ISO 62	%	-	1
Linear mould shrinkage	longitudinal	ISO 294	%	dry	0.5
Linear mould shrinkage	transverse	ISO 294	%	dry	0.8
Product designation as per ISO 1874					PA 10T/X,MH, 14-100, GF30

XE4065 (HT3V-50H)	XE3996 (HT3V-30)	XE4095 HT3V-50)	XE4101 (HT3V-40 FWA)	XE4102 (HT3C-30)	XE4221 (HT3V-30/2)	XE4134 (HT3VX-30)	XE4164 (HT3V-30 CO)	XE4027 (HT3V-30 V0)	XE4120 (HT3V-30 V0 CO)	XE4185 (HT3 V0 CO)	HT3Z LF	HT3Z
16000 16000	9500 9500	17000 16500	13000 13000	23000 23000	9500 9500	10000 10000	10500 10500	10000 10000	11500 11500	3000 3000	2800 2800	2600 2600
230 220	150 150	220 200	190 175	250 250	170 170	145 140	150 150	130 130	150 145	60 60	80 75	80* 80*
2.5 2.5	2 2	2 2	3 2.5	2 2	2.5 2.5	2 1.5	2 2	2 2	2 2	6.5 12	6.5 6.5	6** 6**
90 80	40 40	80 70	85 75	60 60	45 45	30 30	35 35	50 50	55 50	40 35	100 95	kein Bruch kein Bruch
90 80	40 40	75 70	80 70	60 60	45 45	30 30	35 35	50 50	45 45	35 30	95 90	80 50
12 12	7 7	11 11	10 10	8 8	9 9	11 11	10 10	8 8	8 8	5 5	6 6	12 12
12 12	7 7	10 10	9 8	6 6	8 8	11 11	8 8	7 7	6 6	3 3	6 6	12 12
245 245	225 225	280 280	220 220	250 250	205 205	240 240	270 265	235 235	255 255	150 150	140 140	140 140
295	295	295	295	295	265	295	315	295	315	315	295	295
270	260	270	265	270	220	280	275	260	280	130	110	115
225	140	240	190	210	110	165	140	155	155	-	-	-
15	20	15	20	10	20	20	20	20	20	80	80	80
65	65	60	70	80	70	65	70	70	55	80	80	80
150	150	150	150	150	150	150	150	150	150	140	140	140
260	250	260	255	260	210	260	260	250	270	100	100	105
32 31	33 33	32 31	32 31	3 3	35 35	35 35	32 30	33 33	33 33	30 30	33 33	33 33
600	600	600	600	-	600	600	600	600	600	600	400	600
10^{10} 10^{10}	10^{9} 10^{9}	10^{10} 10^{10}	10^{10} 10^{10}	<50 <50	10^{9} 10^{9}	10^{10} 10^{10}	10^{9} 10^{9}	10^{9} 10^{9}	10^{10} 10^{10}	10^{9} 10^{9}	10^{10} 10^{10}	10^{10} 10^{10}
10^{11}	10^{11}	10^{11}	10^{11}	15	10^{10}	10^{11}	10^{10}	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}
1.58	1.38	1.58	1.49	1.26	1.34	1.38	1.4	1.41	1.43	1.18	1.19	1.13
HB	HB	HB	HB	HB	HB	HB	HB	V-0	V-0	V-0	HB	HB
1.7	2	1.7	2	2.5	2	2	3.5	1.5	2.2	4.5	2.9	3.4
0.8	0.8	0.8	0.9	1.2	0.8	0.9	1.6	0.6	1.3	1.7	1.4	1.5
0.5	0.4	0.2	0.5	0.1	0.5	0.2	0.2	0.3	0.2	2	1.75	2
0.9	1.1	0.7	0.9	0.6	0.8	0.7	0.7	1	0.8	2	1.2	1.75
PA 10T/X, MH, 14-160, GF50	PA 10T/X, MH, 14-100, GF30	PA 10T/X, MH, 14-100, GF50	PA 10T/X, MH, 18-120, GF40	PA 10T/X, MH, 18-120, CF30	PA 10T/X, MH, 14-100, GF30	PA 10T/X, MH, 12-100, GF30	PA 10T/X, MHF, 11-100, GF30	PA 10T/X, MHF, 11-100, GF30	PA 10T/X, MHF, 11-100, GF30	PA 10T/X, MHF, 11-030	PA 10T/X, MH, 12-030	PA 10T/X, MH, 12-030

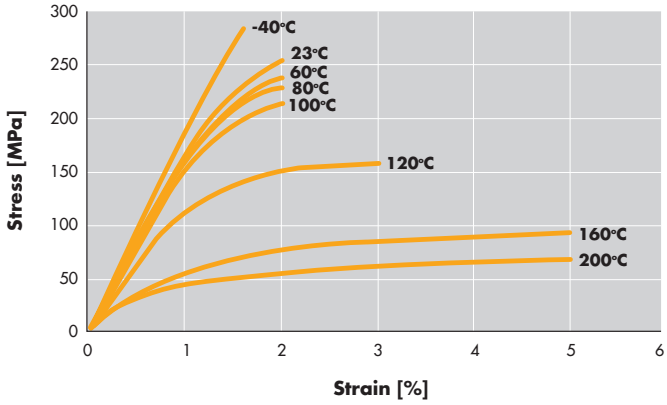
* Tensile stress at yield

** Elongation at yield

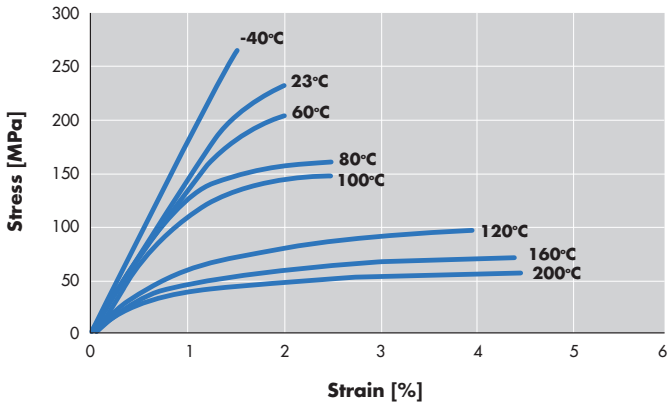
Design data - Short-term behaviour



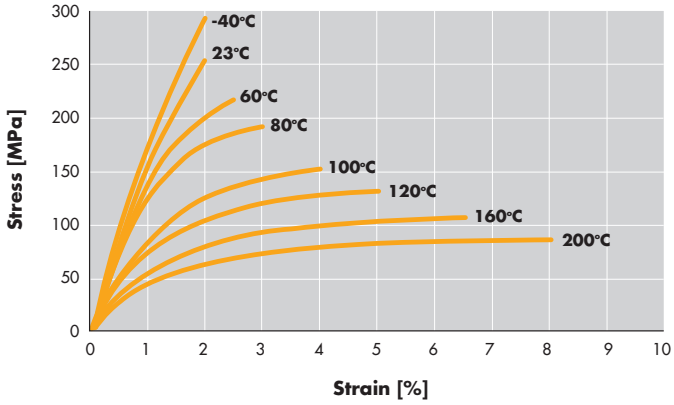
Stress-strain diagram
Grivory HTV-5H1 - dry



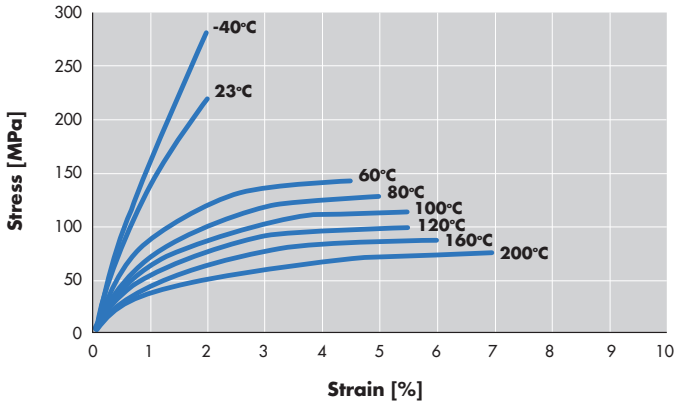
Stress-strain diagram
Grivory HTV-5H1 - conditioned



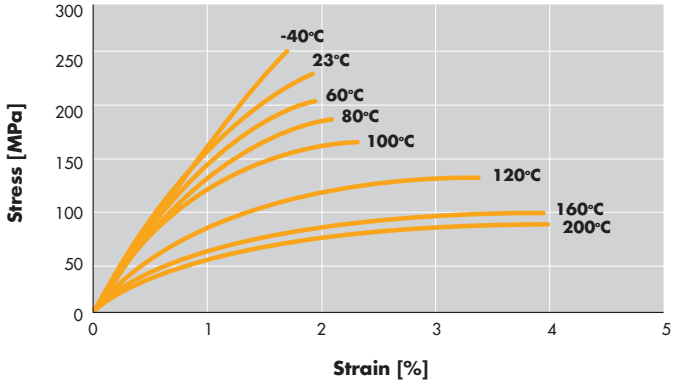
Stress-strain diagram
Grivory HT2V-5H - dry



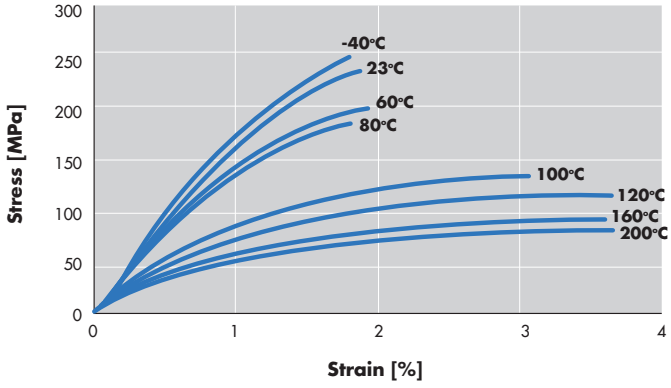
Stress-strain diagram
Grivory HT2V-5H - conditioned



Stress-strain diagram
Grivory XE 4065 (HT3V-50H) - dry

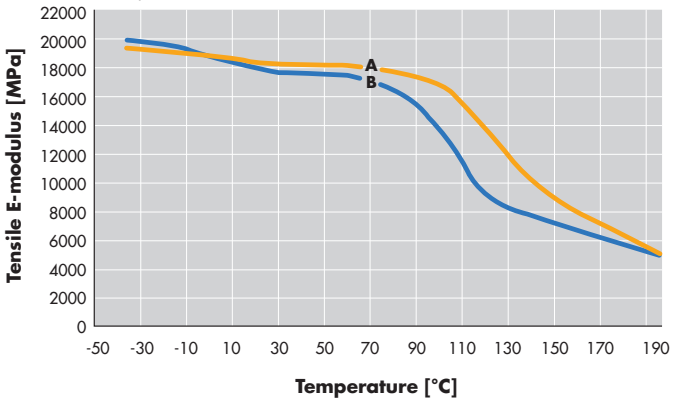


Stress-strain diagram
Grivory XE 4065 (HT3V-50H) - conditioned



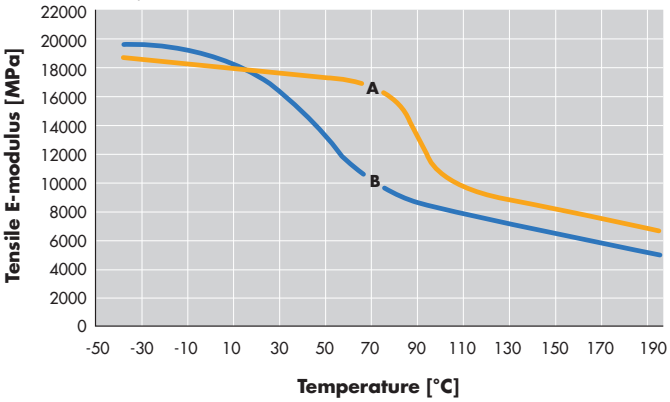
Tensile E-modulus Grivory HTV-5H1

(**A:** dry, **B:** cond.)



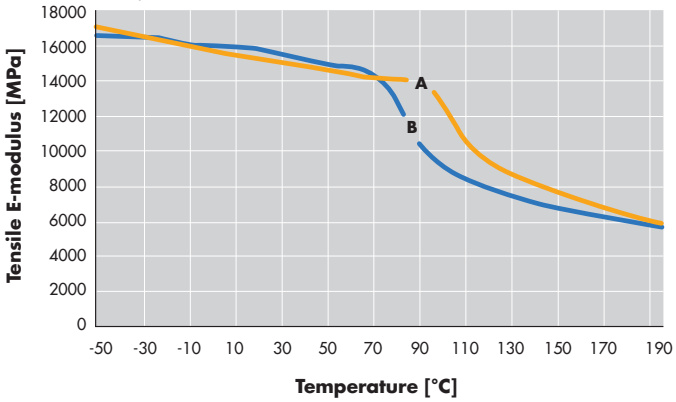
Tensile E-modulus Grivory HT2V-5H

(**A:** dry, **B:** cond.)

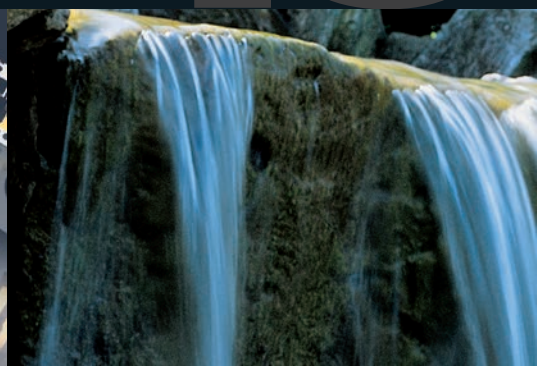


Tensile E-modulus Grivory XE 4065 (HT3V-50H)

(**A:** dry, **B:** cond.)



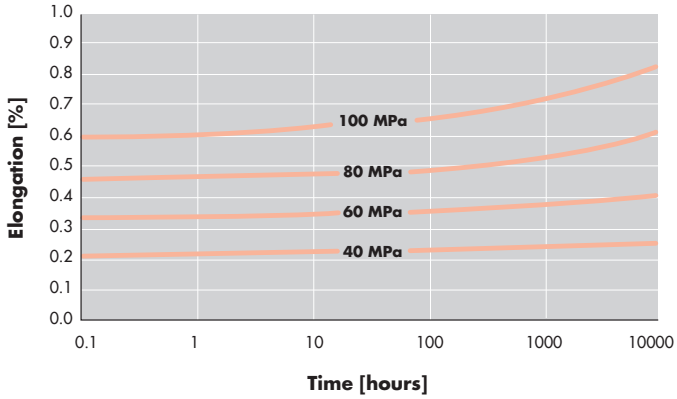
Design data - Long-term behaviour



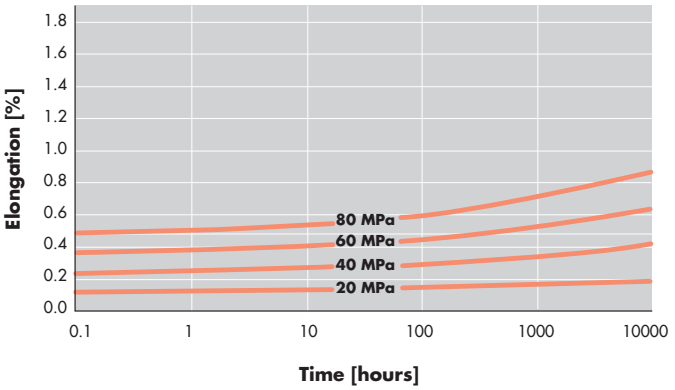
With static, long-term stressing of a material under different mechanical loads, characteristic creep curves can be obtained for plastic materials.

These materials creep as a result of the effects of stress and temperature.

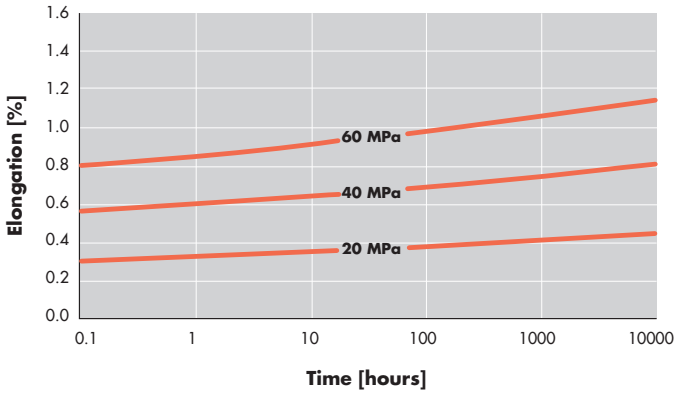
Creep curves Grivory HTV-5H1 at 23°C / 50 % rel. humidity



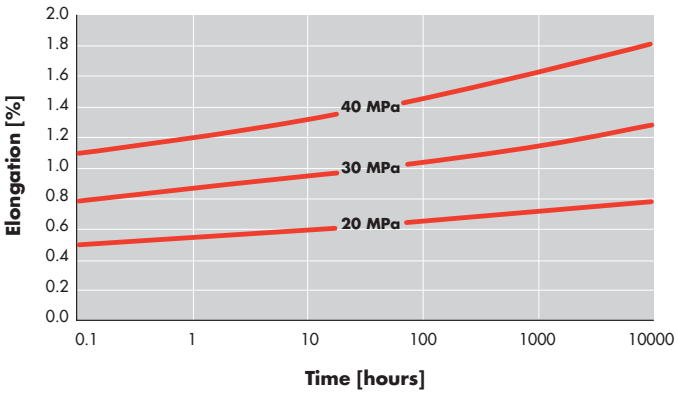
Creep curves Grivory HTV-5H1 at 80°C



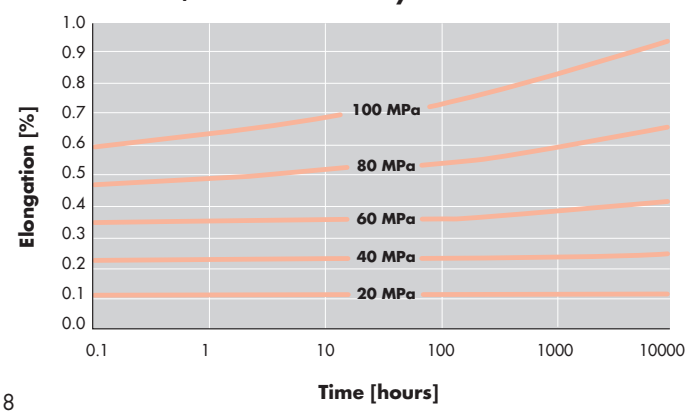
Creep curves Grivory HTV-5H1 at 120°C



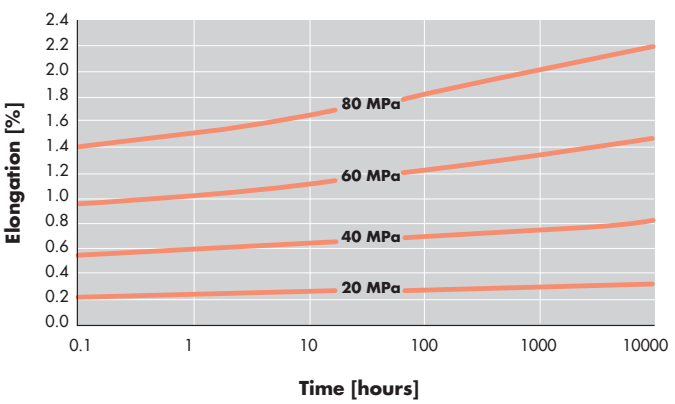
Creep curves Grivory HTV-5H1 at 150°C



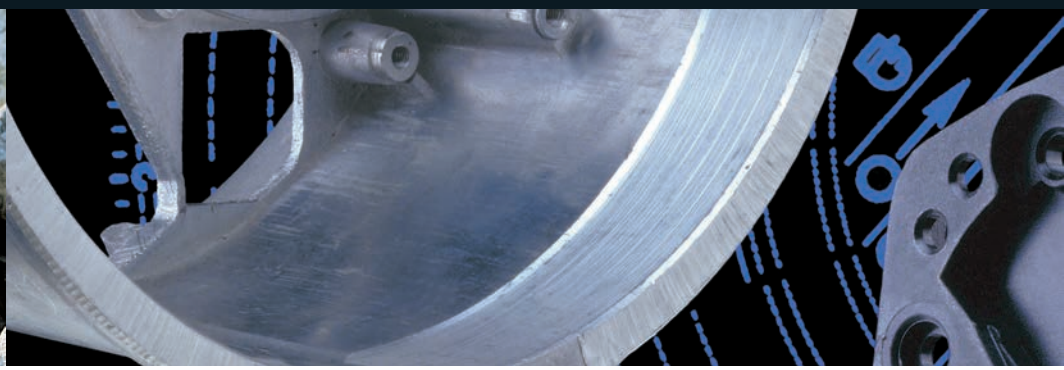
Creep curves Grivory HT2V-5H at 23°C / 50 % rel. humidity



Creep curves Grivory HT2V-5H at 80°C



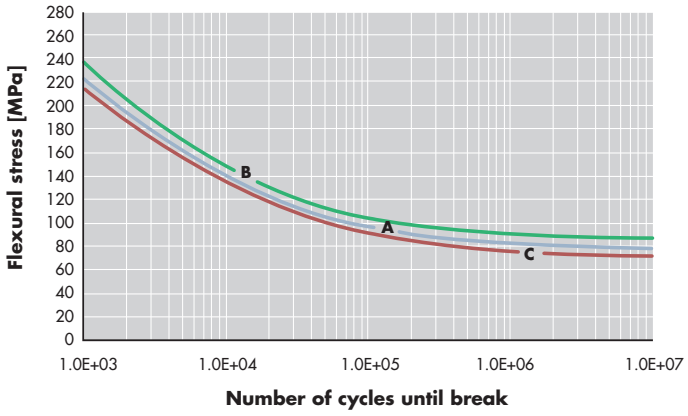
Flexural fatigue strength - Wöhler curves



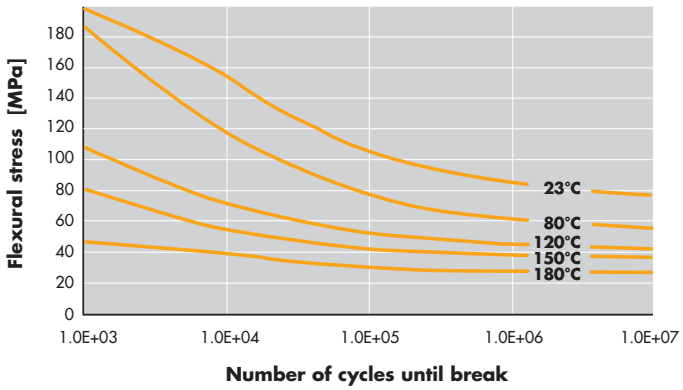
Dynamic long-term stressing may lead to failure of a construction material. Breakage occurs after a certain number of stress cycles depending on the intensity of the mechanical flexural stress.

Comparison Grivory HTV-5H1, Grivory HT2V-5H, Grivory XE 4065 (HT3V-50H), Flexural fatigue strength (Wöhler Curves) at 23°C

A: Grivory HT2V-5H black
B: Grivory HTV-5H1 black
C: Grivory XE 4065 (HT3V-50H)

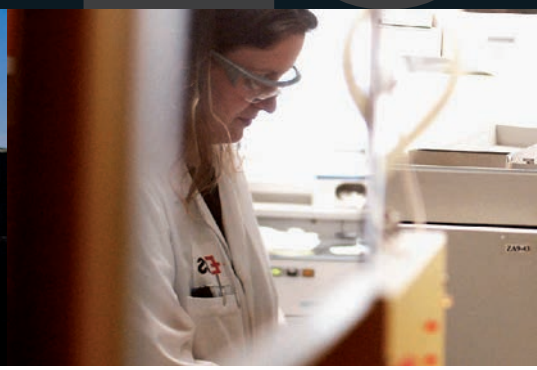


Grivory HTV-6H1 at different temperatures Flexural fatigue strength (Wöhler curves)



As per DIN 53442
Frequency of load cycles (reinforced) = 5 Hz

Resistance to weathering



The influence of UV radiation causes a change in physical and chemical properties of all plastic materials. In particular, the combination of radiation, oxygen in the air, moisture and temperature may lead to a reduction in the working life of construction materials due to chain fission, cross-linking and other oxidative processes.

Resistance to weathering is dependent on the structure of the polymers and the kind of filling used (glass, mineral, carbon black etc.). As the plastic usually suffers mainly from weathering of the surface area, the service life of a component is largely dependent on its thickness.

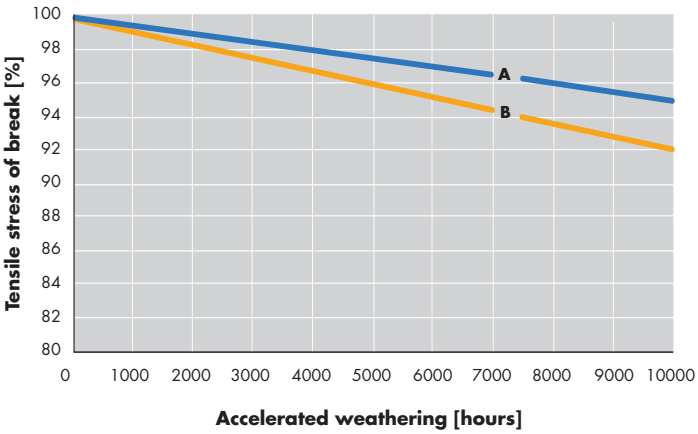
The working life of polyamide parts is determined using both accelerated weathering apparatus (filtered Xenon rays according to ISO 4892-2) and in open-air weathering tests (alpine climate at EMS).

In order to test weathering stability, 4-mm-thick test bars are exposed to accelerated weathering and their stress at break tested by our material testing department after determined periods of time.

Grivory HT exhibits very good resistance to weathering and is suitable for long-term exterior applications. After 10,000 hours of accelerated weathering (acceleration factor 3-4) the stress at break values for HTV-5H1 black 9205 are more than 95% and for Grivory HT2V-5H black 9205, more than 90% of the original figures.

Tensile stress at break of Grivory HT after weathering ISO 4892-2

A: Grivory HTV-5H1 black 9205 **B:** Grivory HT2V-5H black 9233



At raised temperatures, indications of ageing become apparent for all plastic materials. Over time, this ageing has a negative effect on the properties of the material.

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

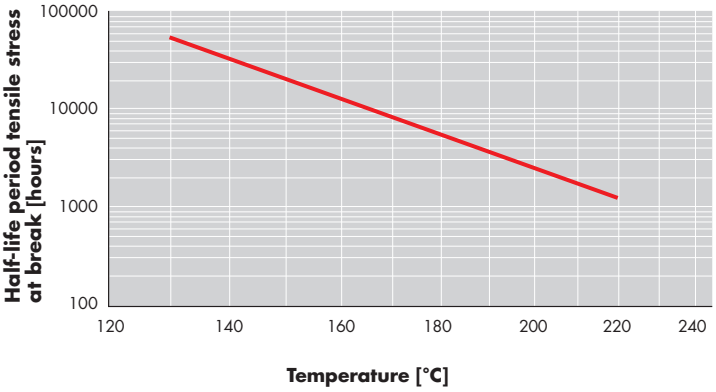
In practice, specification of a temperature-time limit, within which the properties of the thermally stressed plastic material must remain at an acceptable level, is of great importance.

In order to determine these temperature-time limits, extensive testing is carried out in our material testing department. This ensures that Grivory HT can be used successfully, even at high temperatures, through the correct choice of product and grade.

The maximum time or temperature at which the material has a remaining 50% of ultimate tensile strength 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 curve of Grivory HT

Grivory HTV-5H1



Testmethod: ISO 2578
Test samples: ISO 20753 Type A1, tensile bar 4 mm
Criterion: 50 % residual tensile strength

Resistance to chemicals

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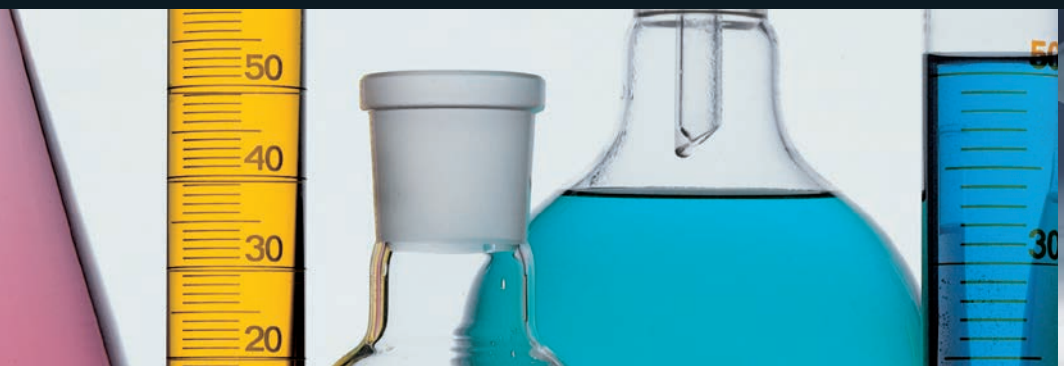
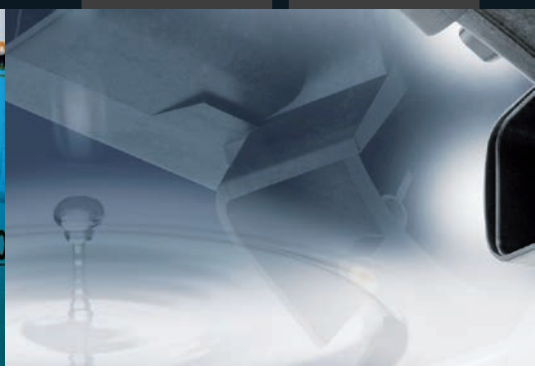




Grivory HT exhibits very good resistance to a variety of chemicals: organic solvents, fuels, oels, fats and alkalis. Strong acids such as sulphuric acid, nitric acid or formic acid cause hydrolytic degradation of all polyamides; Grivory HT, however, has good resistance to diluted acids at room temperature. Aggressive chemicals such as cresol, hexafluorisopropanol or trifluoroacetic acid can cause polyamides to dissolve completely. Glycols and other alcohols as well as water, however, only attack these materials aggressively at high temperatures. The following list refers to resistance at room temperature. Depending on the type of chemical involved, higher temperatures may have an influence on the degree of resistance.

•	Acetic acid, conc.
•••	Acetone
•••	Acrylate adhesives
•••	AdBlue (32.5% urea in water)
•••	Ammonia, 10% aqueous
•••	Amyl acetate
••	Aniline
•••	Antifreeze (ethylene glycol)
•••	Benzene
•	Benzyl alcohol
•••	Biodiesel (e.g. RME, SME, B20)
•	Bromine, bromine water
•••	Butane
•••	Butanol
•••	Calium chloride, satt.
•••	Calcium salts, satt., aqueous
•••	Carbon tetrachloride
o	Chlorine, gaseous
•••	Chlorobenzene
•	Chloroform
•••	Citric acid, conc.
•••	Copper sulphate, satt., copper salts, 10% aqueous
o	Cresol
•••	Crude oil
•••	Diesel fuel
•••	Diethyl ether
•••	Engine oil
•••	E10, E85 (fuels containing ethanol)
•••	Ethanol
•••	Ethylene oxide
•••	Fats, oils and lubricants
o	Fluorine
••	Formaldehyde, formalin, 40% aqueous
••	Formic acid 10% aqueous
o	Formic acid, conc.
•••	Glycerine
••	Halogenated hydrocarbons
•••	Heptane
•••	Hydraulic oil
••	Hydrochloric acid 1%
•	Hydrochloric acid 10%
o	Hydrochloric acid (37%, aqueous)
••	Hydrogenperoxide 2%
•	Hydrogenperoxide 10%
•	Hydrogenperoxide 30%
•••	Hydrogen sulphide, 25% aqueous
••	Iodine tincture, alcholic
•••	Isooctane
•••	Isopropanol
•••	Kerosene
••	Lactic acid conc.
••	Lactic acid conc.
•••	Lubricating oils, grease
•••	Magnesium chloride satt.
•••	Methane
•••	Methanol
•••	Methyl ethyl ketone
••	Methylene chloride
•••	Mineral oil
o	Nitric acid, 65% aqueous
••	Nitrobenzene
o	Oleum
••	Oxalic acid 10% aqueous
•	Ozone
•••	Perchlorethylene
•••	Petrol
•••	Petroleum ether
•	Phenole, aqueous
•	Phosphoric acid 10% aqueous
•••	Potash (potash salts) satt.
•	Potassium permanganate, 1% aqueous
•••	Propane
•••	Pyridine
o	Resorcinol, alcoholic
•••	Salicylic acid (saturated).
•••	Sea water
•••	Silicon oil
•••	Soap solution
•••	Soda lye 50%, aqueous
•••	Soda solution, satt.
•••	Sodium carbonate, 50% aqueous
•••	Sodium salts, aqueous
•	Sodium hypochlorite 5% aqueous
•••	Styrene
•••	Sulphur
••	Sulphur dioxide <5% gaseous
•	Sulphuric acid, 10% aqueous
o	Sulphuric acid, 50% aqueous
••	Tartaric acid, 10% aqueous
•••	Terpentine
•••	Tetralin
•••	Toluol
•••	Transformer oil
••	Trichlorethane
••	Trichlorethylene
•••	Triethanolamine
•••	Uric acid, conc.
••	Vinegar, 9% aqueous
•••	Water
•••	Wine
•••	Xylol
•••	Zinc chloride 50% aqueous

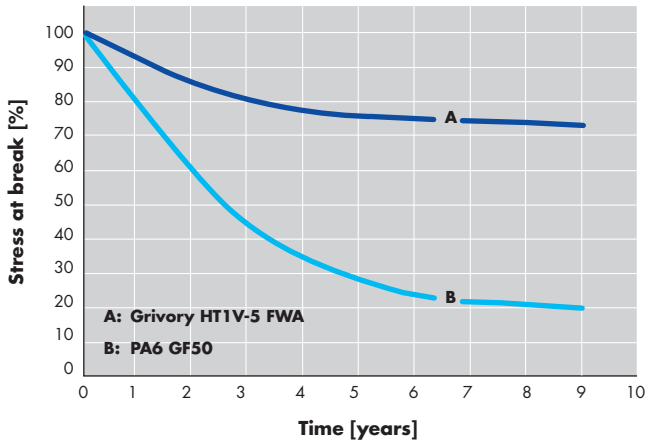
•••	resistant; no or only slight, reversible changes in weight and dimension.
••	limited resistance; appreciable changes in dimension and possible irreversible changes in property values occur after longer periods of exposure. Consultation advisable before use.
•	not resistant - may be used under certain conditions (short exposure time)
o	soluble or already strongly attacked after only a short exposure time
conc.	concentrated

Resistance to hot water and hydrolysis

Even at high temperatures, parts made of Grivory HTV take up less water and this significantly more slowly, than parts made of polyamide 6 (PA6 GF) or polyamide 66 (PA66 GF). Compared to these materials, Grivory HTV shows clearly better resistance to water.

The following graph shows measured values of tensile test pieces (ISO 527, 4x10 mm) made of Grivory HT1V-5 FWA and PA6 GF50 after several years storage in cold water at 23°C. After 9 years storage in water, strength values of parts made of Grivory HT1V-5 FWA are 180 MPa, much higher compared to parts made of glass-fibre reinforced polyamide 6.

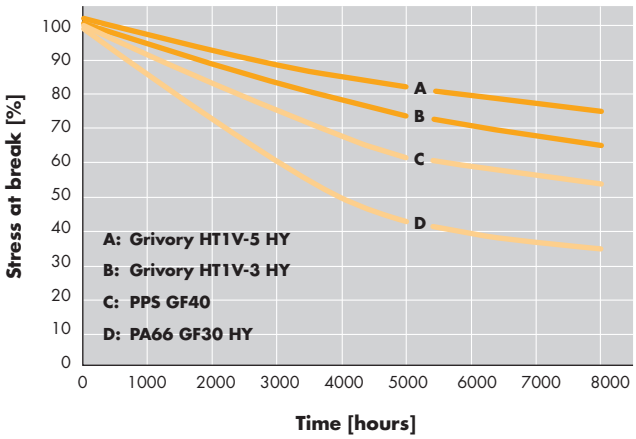
Resistance to cold water, 23°C



The relative initial values (100%) refer to the tensile stress at break of freshly injected, dry parts.

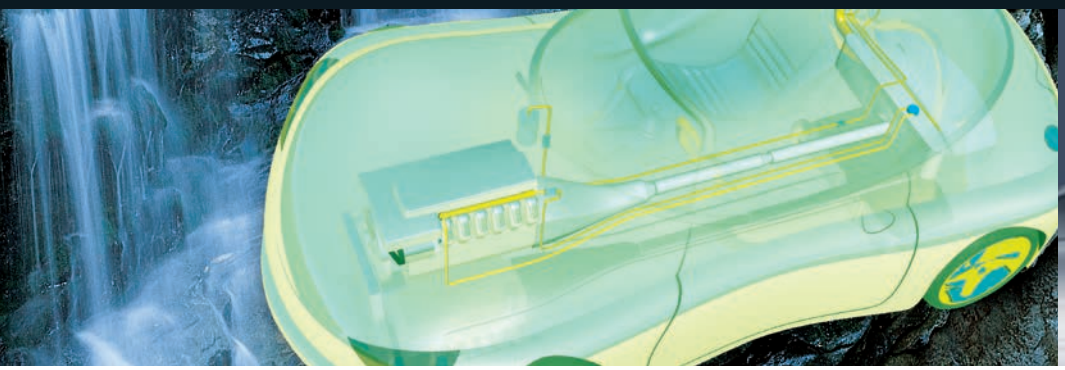
The following graph shows the results of storage of Grivory HT1V-3 HY, HT1V-5 HY, PA66 GF30 (hydrolysis stabilised) and PPS GF40 at 110°C. (Specimens used were tensile bars as per ISO 527, 3x3 mm)

Resistance to hot water, 110°C



The relative initial values (100%) refer to the tensile stress at break of test bars conditioned as per ISO 1110.

Resistance to automotive media



Grivory HT1 and HT2 exhibit excellent resistance to all common automotive media such as coolants, fuels, oils and lubricants.

Both PPA grades are characterised by their resistance to mineral oil products and synthetic oils at high temperatures.

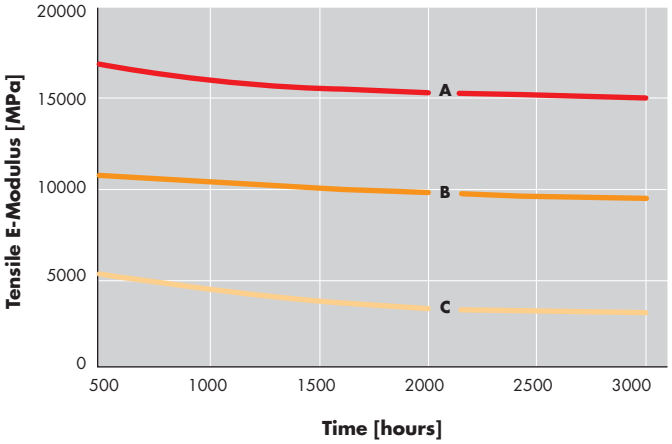
Resistance to coolants

A: Grivory HT1V-5 HY

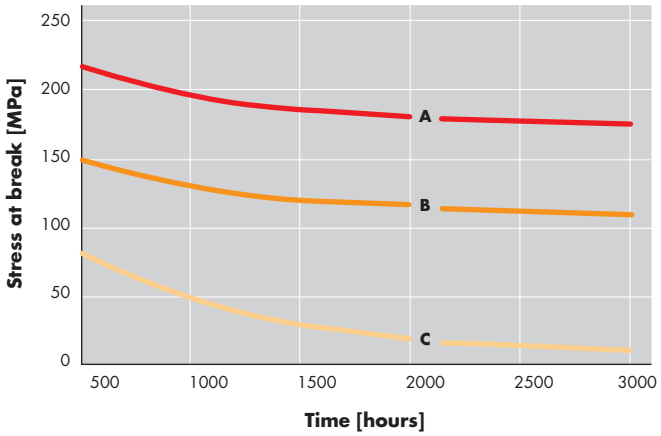
B: Grivory HT1V-3 HY

C: PA66 GF30 HY

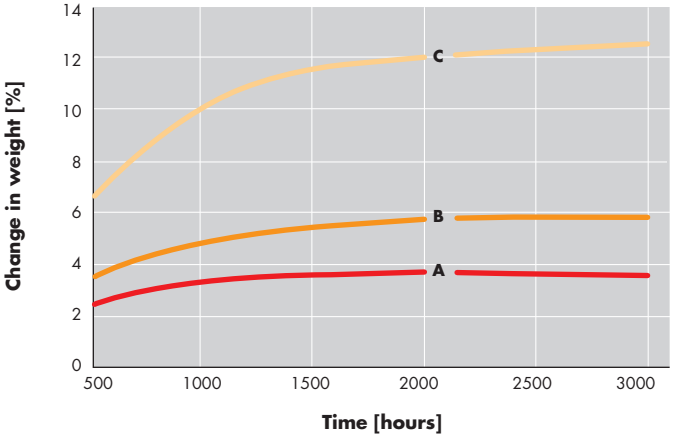
Tensile E-modulus (MPa), ISO 527, after storage in monoethylene glycol/water 1/1 120°C



Tensile stress at break (MPa), ISO 527, after storage in monoethylene glycol/water 1/1 120°C



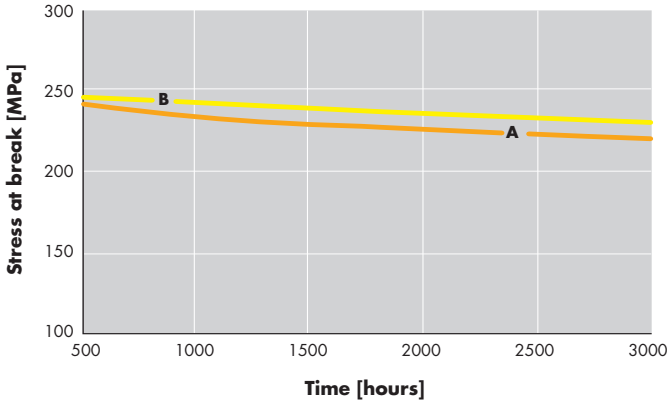
Weight change (%), tensile bars 3x3 mm, after storage in monoethylene glycol/water 1/1 120°C



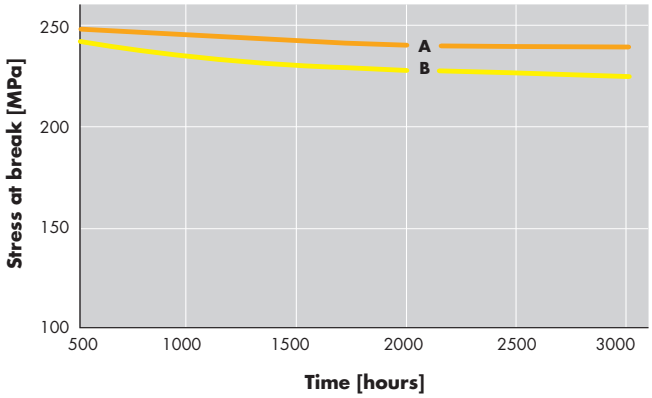
Stress at break [ISO 527] after storage in:

A: Grivory HTV-5H1 black 9205 **B:** Grivory HT2V-5H black 9205

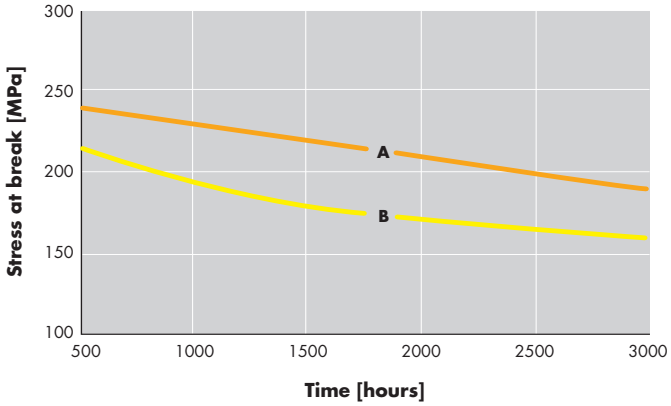
Diesel fuel, 150°C



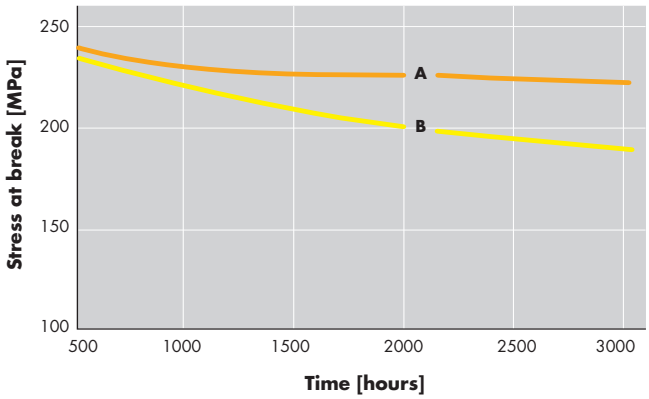
Super petrol (lead-free), 60°C



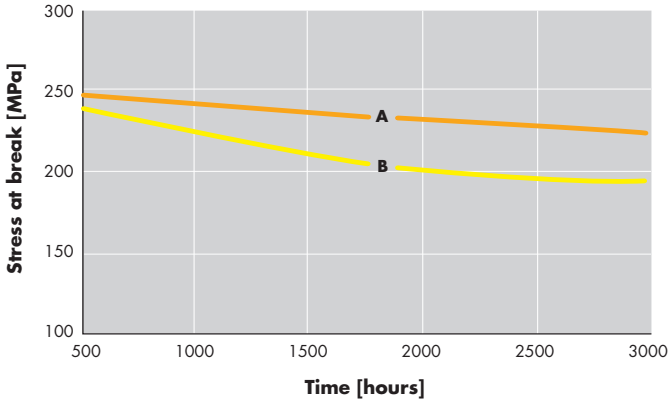
RME, 150°C



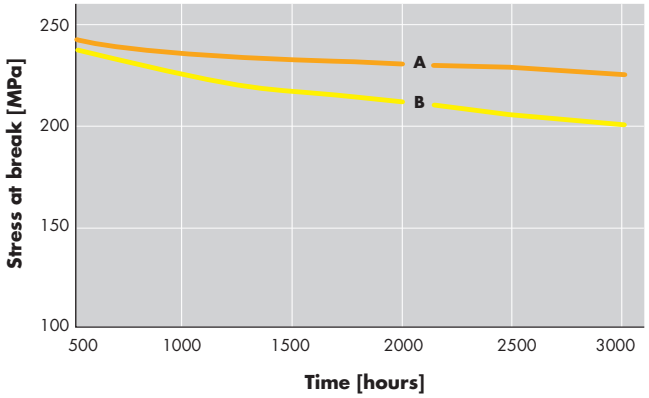
Brake fluid (DOT4), 135°C



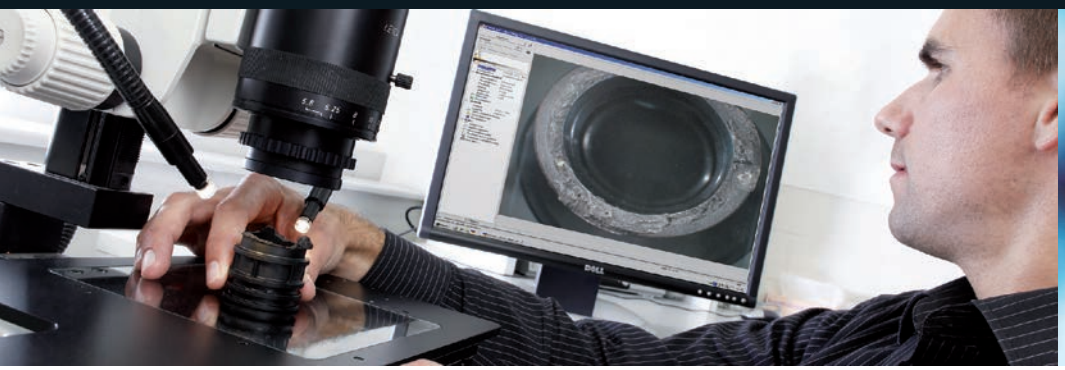
Engine oil SAE 10W40, 135°C



Sulphuric acid (H2SO4, 36%), 23°C



Comparison to other construction materials



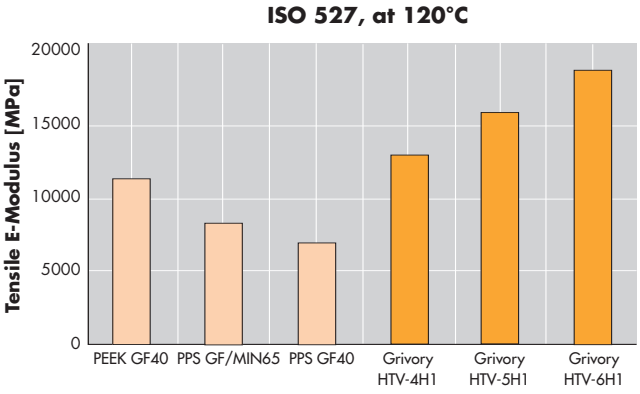
- Thermoplastic materials

Among thermoplastic materials, Grivory HT is positioned in the transition area between high-quality engineering plastics and high-performance plastics.

Fundamentally, the polyphthalamide Grivory HT has the property characteristics of polyamide. Compared to traditional materials based on polyamide (PA6) or polyamide 66 (PA66), Grivory HT is characterised by the fact that its mechanical property values are hardly influenced by the absorption of water typical of all polyamides. Stiffness, strength and heat deflection temperature values remain at a very high level.

- High-performance thermoplastic materials

At high application temperatures, Grivory HT achieves and exceeds the performance of PPS or PEEK with regard to hardness, strength and stiffness. At the same time and also under high temperatures, Grivory HT offers good resistance to a wide range of chemicals, dimensional stability and high strength values even after long-term use. The long-term working temperature for parts made of Grivory HT lies between 140°C and 150°C. Parts made of Grivory HT1 can also resist short-term thermal impulses of up to 300°C.



- Thermosets

Even though processing technologies (thermoset/thermoplastic) are different, quality of the finished products with regard to mechanical-thermal properties can be compared.

Material	Tensile stress at break (MPa)	E-Modulus (MPa)	Heat deflection temperature HDT/A (°C)
Grivory HTV-3H1 (GF30)	170	11000	280
Grivory HTV-6H1 (GF60)	250	21000	290
Melamine formaldehyde	50 – 90	7000 – 9000	155 – 215
Melamine phenol	55 – 85	7000 – 16000	155 – 200
Phenolic resins	35 – 70	8000 – 12000	110 – 250

The thermoplastic Grivory HT has better values for core properties such as stiffness, strength and heat deflection temperature than most thermoset injection-moulding compounds. The advantage of thermosets having less costly raw materials is more than compensated by outlay for post-treatment (deflashing). Another point in the favour of themoplastic Grivory HT is the fact that it can be used as regranulate or recycled without problem.

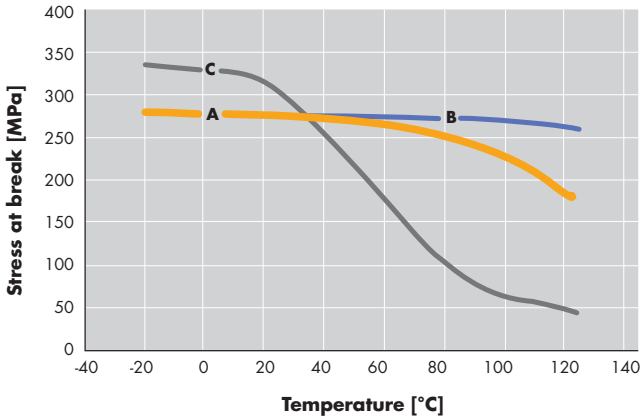
- Die-cast alloys

Grivory HT is excellently suited for the substitution of metal, particularly for parts previously made of die-cast alloys.

When used as a substitute for metal the mechanical-thermal properties of Grivory HT are usually sufficient to ensure reliable working of the part. Parts made of Grivory HT offer significant weight advantages and are resistant to corrosion without post-treatment of surfaces.

Strength of Grivory HT in comparison to die-cast alloys

A: Grivory HT1V-65H, **B:** Aluminium, **C:** Zinc



Using Grivory HT in place of metals allows manufacturing costs to be reduced by 30 – 50 %. Post-treatment processes typical for die-cast alloys - deflashing, coating (colouring) or subsequent cutting of threads - are no longer necessary.

These advantages may already become apparent simply through changes in manufacturing technology due to the use of a different material.

Further, in some cases substantial, cost reductions can be achieved through integration of design. Composite (metal/plastic) parts can be made of one material using Grivory HT, several components of an assembly can be combined, metal inserts (e.g. thread bushing) can sometimes be eliminated.

Approvals

Grivory HT in contact with foodstuffs:
EU: Grivory HT FWA grades satisfy the relevant requirements of the EU directive No. 1935/2004 including its supplements, as well as the requirements of the EU directive no. 10/2011 dated January 14, 2011 including supplements.

USA (FDA): According to the American Food and Drug Administration (FDA), Grivory HT "FWA" grades are approved for repeated direct contact with foodstuffs. Further details for each product can be found in the "Supplier Compliance Statement for Applications in Food Contact".

Grivory HT "FWA" is also approved by NSF/ANSI Standard 51 (Food Equipment Materials) for contact with foodstuffs.

Grivory HT in contact with drinking water
Germany (KTW, W 270): The Grivory HT "FWA" grades have been tested according to KTW recommendations of the German Federal Environmental Agency and are approved for applications in contact with hot drinking water (85°C).
In addition, they also satisfy the requirements of the DVGW worksheet W 270 "Multiplication of micro-organisms on construction materials for drinking water applications - Test and evaluation" governing protection of drinking water from micro-organisms.

France (ACS): have been tested according to AFNOR XP P 41-250 and are approved in France for contact with drinking water ("Attestation de Conformité Sanitaire").

UK (WRAS): Grivory HT "FWA" grades have been tested and certified as approved products by the British Water Regulations Advisory Scheme (WRAS). They are approved for applications in contact with both cold and hot drinking water at temperatures up to 85°C.

USA (NSF 61): The Grivory HT "FWA" grades are certified for hot water applications (82°C) by NSF/AINSI, Standard 61 ("Drinking Water System Components – Health Effects").

Grivory HT FWA grades:
Grivory HT1V-3 FWA natural + Grivory HT1V-3 FWA black 9225
Grivory HT1V-4 FWA natural + Grivory HT1V-4 FWA black 9225
Grivory HT1V-5 FWA natural + Grivory HT1V-5 FWA black 9225
Grivory HT1V-6 FWA natural + Grivory HT1V-6 FWA black 9225
Grivory XE 4101 (HT3V-40 FWA) natural +
Grivory XE 4101 (HT3V-40 FWA) black 9225

Requirements made of plastic materials with regard to their fire behaviour are varied and follow the national regulations of each country and legislation governing the field of application. For electronic applications, an approval from the Underwriters Laboratories (UL approval) for both the plastic material and finished part is required in the USA and in some European countries. The current "Yellow Cards" of the products are also available via internet at: www.ul.com

Flame resistant standard products:
The following Grivory HT products are listed under the reference number EMS-CHEMIE E53898 in the flammability class UL 94 HB:

Grivory HTV-3H1 Grivory HTV-4H1 Grivory HTV-5H1 Grivory HTM-4H1
Grivory HT1V-3 FWA Grivory HT1V-4 FWA Grivory HT1V-5 FWA Grivory HT1V-6 FWA
Grivory HT2V-3H Grivory HT2V-45H Grivory HT2V-5H
XE 4164 (HT3V-30 CO), 30 wt% glass-fibre reinforcement

Flame retardant, self-extinguishing products:
The flame-retardant, glass-fibre reinforced Grivory HT "UL 94 V-0" grades contain no halogens or red phosphorous. They are self-extinguishing and correspond to the classification UL 94 V-0. The "Yellow Cards" show the properties listed by UL and are available via internet at: www.ul.com

The following Grivory HT products are listed under the reference number EMS-CHEMIE E53898 in the flammability class UL 94 V-0:

Grivory HT2V-3X V0,
30 wt% glass-fibre reinforcement

Grivory HT2V-4X V0,
40 wt% glass-fibre reinforcement

Grivory HT2V-5X V0,
50 wt% glass-fibre reinforcement

Grivory XE 4027 (HT3V-30 V0),
30 wt% glass-fibre reinforcement

Grivory XE 4120 (HT3V-30 V0 CO)
30 wt% glass-fibre reinforcement

XE 4185 (HT3-V0 CO), non-reinforced

RoHS: The products Grivory HT2V-3X V0, HT2V-4X V0, HT2V-5X V0, XE 4027, XE 4120 and XE 4185 satisfy the RoHS requirements (2002/95/EG and 2011/65/EU, Restriction of Hazardous Substances).

WEEE: Parts manufactured from Grivory HT2V-3X V0, HT2V-4X V0, HT2V-5X V0, XE 4027, XE 4120, XE 4185 are exempt from requirements concerning "selective recycling" according to the 2002/96/EC and 2011/65/EU governing recycling of old appliances.

FMVSS: All Grivory HT products satisfy the requirements of FMVSS 302 (ISO 3795, DIN 75200). Their burning rates, measured in plate flaming tests, are lower than 100 mm/min at wall thicknesses >1 mm.

Drying and storage

Grivory HT is delivered dried and ready for use in air-tight sacks. Pre-drying is not necessary if it is handled and stored correctly.

Sealed, undamaged sacks can be stored for years if sheltered from the weather. A dry room where sacks are protected from damage is recommended as storage space. Sacks which do become damaged should be resealed air-tight, or the material placed in an air-tight metal container. It is important that material to be used is stored for some days at processing temperature so that condensation does not form on the surface of the granules when the sacks are opened.

The packaging should be opened shortly before processing begins. Material which is in contact with the air for any length of time may reach a critical content of more than 0.1% in the top layer of granules. During long dwell times with granules in the hopper, a hopper heating system or hopper dryer should be used.

Following manufacture, Grivory HT is dried to a content of less than 0.1 % and packed in air-tight sacks. If the packaging is damaged or the material stored in contact with the air for too long, the granules will need to be dried again. An excessive water content may become apparent through bubbles or foam in the melt cake during free ejection or silvery streaking on the surface of the moulded parts.

Drying can be carried out using the following methods:

Desiccant dryer

Temperature:	max. 80°C
Time:	4 - 12 hours
Dew point of the dry air:	-40°C

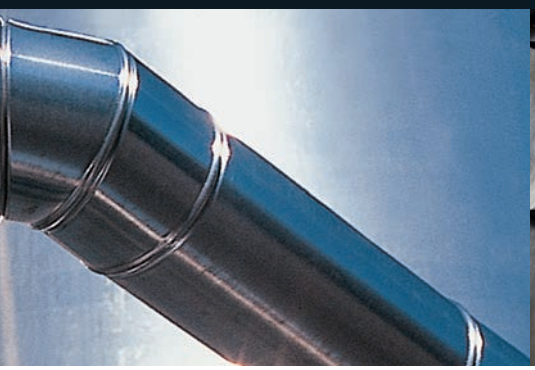
Vacuum oven

Temperature:	max. 100°C
Time:	4 - 12 hours

Circulating air ovens are not recommended as they tend to cause moistening of the granules at a high ambient temperature and with high air humidity.

The drying time is dependent to a great degree on the moisture content. In case of doubt, drying should be carried out for about 12 hours.

Drying temperatures above 80°C in a desiccant dryer can lead to yellowing of light-coloured granules. A higher temperature can be used (100°C) in a vacuum oven with lower partial oxygen pressure.



The processing latitude for Grivory HT1 grades lies between 330° and 350°C; for Grivory HT2 grades between 310°C und 340°C and for Grivory HT3 grades between 300° and 330°C. The recommended processing temperature for each Grivory HT grade is given in the respective data sheet.

Screw

Grivory HT can be processed efficiently using a single-flighted universal three-zone screw equipped with a non-return valve. The effective screw length should be between 18 D and 22 D.
Use of a wear-resistant screw is recommended for the processing of Grivory HT grades with high levels of glass-fibre reinforcement.

Heating

At least three separately regulated heating zones should be able to achieve barrel temperatures of up to 350°C. A separate nozzle heating system is also necessary. The temperature of the barrel flange must also be controllable.

Die

An open die may be used when processing Grivory HT, as such a die allows free flowing of the material and is very long-lasting due to its simple structure. Needle valve nozzles have proved useful if the melt tends to flow out of the die.

Mould design

Design rules typical for thermoplastic materials are also valid for mould design. Basically, all kinds of sprue system can be used for processing Grivory HT. Conventional wear-resistant tool steel, hardened to approx. 56 - 65 HRC, is sufficient for the shaping surfaces of the mould. Additional abrasion protection is recommended for areas with a higher flow speed.

The mould cavity must have large-scale venting, particularly in the vicinity of the joint lines. Additional machined ejectors and venting slits (0.02 mm) must be planned on the mould parting line.
Basically, all sprue and gating systems can be used for processing of Grivory HT grades. As these materials set over a relatively narrow range of temperatures, the sprue must be large enough to compensate for volume reduction during cooling in the holding pressure phase.

Mould temperature

A good heating system combined with a correct mould temperature is a prerequisite for the manufacture of high-quality injection-moulded articles. The mould temperature influences the setting behaviour and the degree of crystallinity of the article and, therefore, the surface quality, shrinkage behaviour, warpage, mass tolerance and level of internal stressing.

Grivory HT1 grades are processed at mould temperatures >=140°C, Grivory HT2 grades at mould temperatures between 100°C and 140°C and Grivory HT3 grades between 110° and 160°C. The required mould wall temperature is dependant on the geometry and wall strength (wall thickness) of the component. As a rule of thumb it can be said that the lower the wall strength of the component, the higher the mould wall temperature should be. Mould wall temperatures of up to 190°C are normal for low wall strengths.

Post treatment

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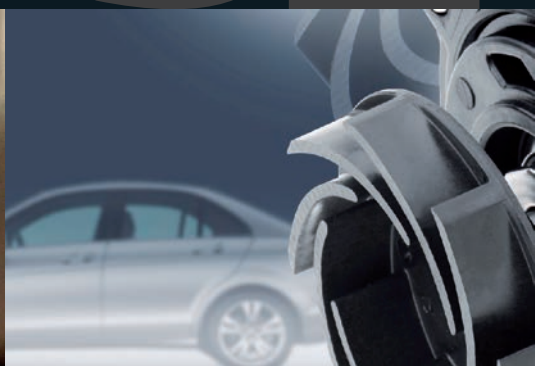


Bonding

The most common reaction adhesives are:

Single-component systems:
- Cyano acrylate or methacrylate adhesives are well suited for bonding Grivory HT to metal.

Two-component systems:
- Epoxy resin adhesives with a long pot life (curing time) are suitable for use on large bonding areas and can be used to fill gaps.

Kinds of pre-treatment:
- Degreasing: use of organic solvents such as acetone, for example
- Mechanical removal: brushing, grinding, sand blasting
- Electro-chemical: Corona discharge, low-pressure plasma
- Thermal: flaming
- Chemical: treatment with caustic substances or primers. Suitable systems are available from adhesive manufacturers.

Our customer advice department will be happy to supply you with further information regarding choice of adhesive and suppliers.

Welding

Good welding results can be achieved for all highly reinforced Grivory HT grades using friction welding methods such as ultra-sonic and vibration welding. During design work the maximum possible size of joint area should be planned for parts to be welded. During welding, the contact pressure must be selected and adjusted according to the type of material and the geometry of the parts being welded. This pressure may lie between 1 MPa and 3 MPa.

Injection, infra-red and hot-plate welding methods can only be used in a limited way to weld Grivory HT.

Screw fastening

Parts made of Grivory HT can be fastened well with self-tapping screws. Metrical threads can be integrated directly into the finished components.

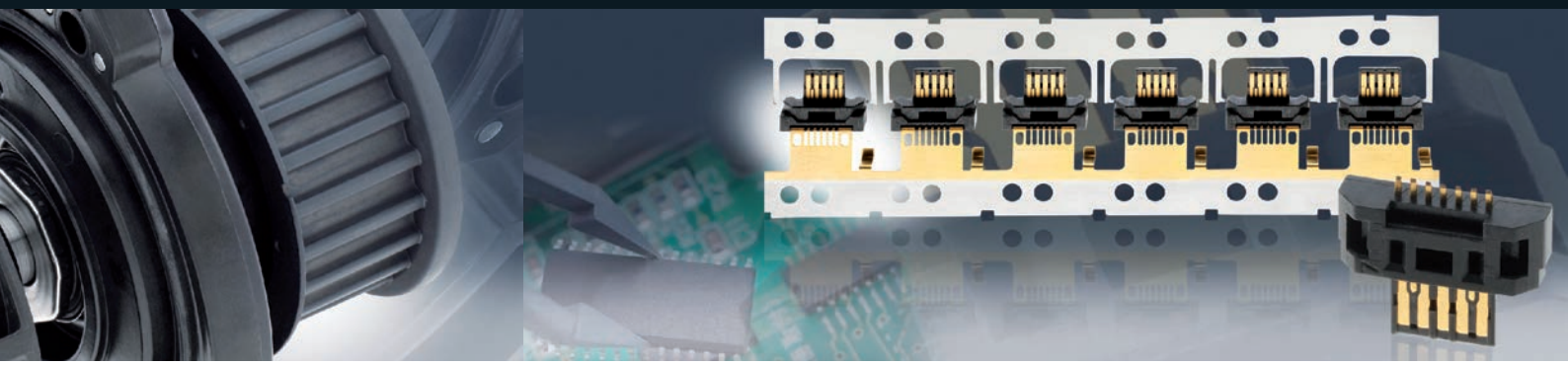
Painting

Grivory HT can be painted with different kinds of paint without impairing the mechanical properties. Single and two-component paints are suitable.

Pre-treatment: Refer to “Bonding”.

Laser printing

Grivory HT grades can be modified for inscribing with laser-printing by the addition of special pigments such as black 9219 LW or masterbatches.



Machining

For economical reasons, it should be ensured that the design of a component makes machining unnecessary. If machining is used to make prototypes, it should be remembered that the properties will not necessarily be identical to those of an injection-moulded component.

	Method				
	Unit	Turning	Milling	Sawing	Drilling
Clearance angle	degrees	5-10	3-15	15-30	5-10
Rake angle	degrees	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
Tip	degrees	-	-	-	90-120
Circular pitch	mm	-	2-8	-	-

Use of carbide-tipped tools is recommended due to the large amount of reinforcing material in reinforced Grivory HT grades.

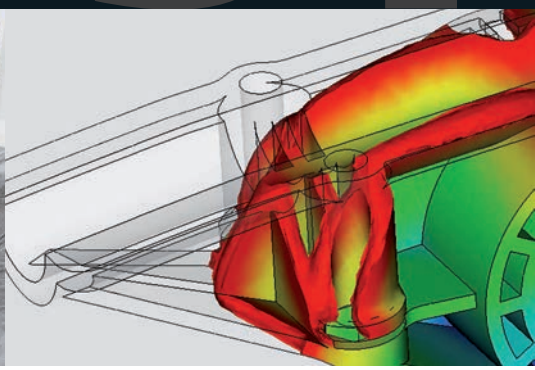
Use of reclaimed material

Being a thermoplastic material, it is possible to reprocess faulty parts made of Grivory HT and recycle a certain amount of reclaimed material during the injection-moulding process. The following points should, however, be taken into consideration:

- Water already absorbed
- Dust content and grain size distribution
- Pollution from other polymers, dust, oil etc.
- Quantity ratio, percentage added to original material
- Changes in colour
- Changes of the mechanical properties

Particular care must be taken by the operator during addition of the reclaimed material.

Customer services and technical support



We provide advice and support for our customers, starting from the development right through to serial production of a part. We also offer quality, reliability and technical support as part of our customer services.

- We create an optimal material recommendation for your application.
- Our customer service centre is equipped with modern injection-moulding machinery and extruders to find solutions to problems which may arise.
- The high quality of our materials is constantly subjected to tests and quality assurance in order to provide you with high-performance products.
- Our up-to-date testing laboratories are at your disposal for testing of mechanical, thermal, electrical and chemical properties.

CAE

Using computer-aided simulation calculation systems, the application development department of EMS-GRIVORY is capable of providing customers with optimal mould design support. The CAE systems used allow the moulded parts to be designed using Finite Element (FE) programmes. The filling process is then described by rheological simulation.

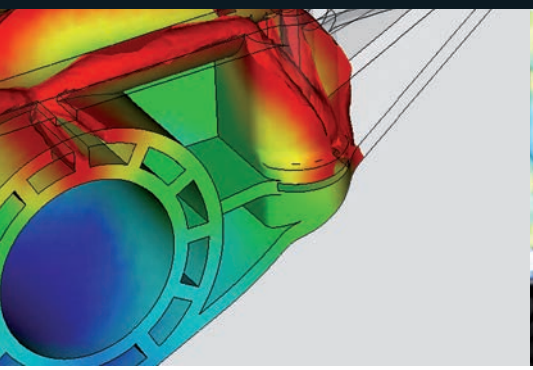
An FE analysis provides information about mechanical loading and stresses on the moulded part. Based on this calculated stress distribution, specific modifications can be implemented and tested directly with a new FE calculation.

As soon as satisfactory structural properties have been achieved using FE analysis, a rheological simulation can be used to evaluate the optimal sprue position and to provide qualitative statements about fibre alignment, shrinkage and warpage of the parts.

Through use of modern FE and rheological simulation tools, the EMS-GRIVORY team of experts is able to provide customers with optimal mould design support using virtual 3D data.

Prototype moulds and Selective Laser Sintering (SLS)

Quick realisation and rapid implementation of a good idea is the key to success. With construction of prototype moulds, EMS-GRIVORY helps minimise the risk, save valuable time and reduce costs. Prototypes of moulded parts can also be optimised through use of FE analysis and rheological simulation. The prototype moulds can then be used to manufacture a small series of moulded parts at minimum expense, thus allowing practical tests to be carried out before the serial production is started. This preparation work reduces outlay and helps avoid expensive modifications to manufacturing moulds.



The Business Unit EMS-GRIVORY has state of the art equipped laboratories at its disposal in the material testing and quality control departments.

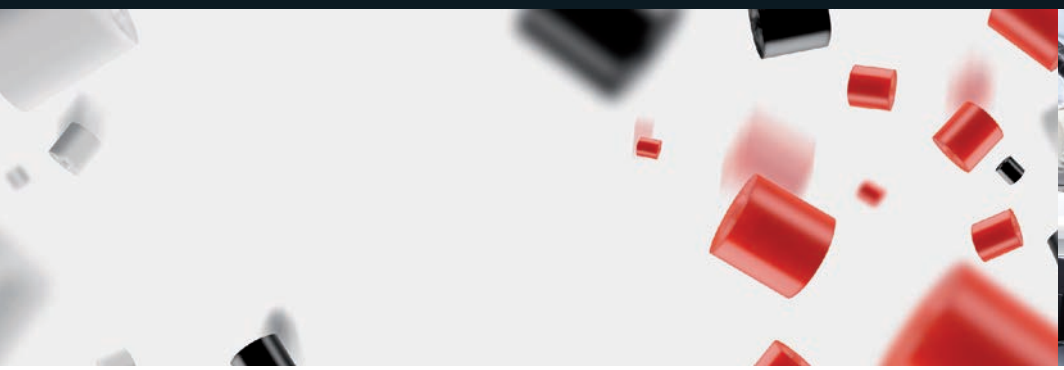
Our equipment infrastructure allows us not only to determine the conventional mechanical, thermal and electrical properties of our construction materials for data sheets and homologation, but also to carry out research and development work and to support application development work with practical tests.

- The mechanical testing laboratory is equipped with universal testing machines, impact testing apparatus (both automated and instrumented pendulum) as well as servo-hydraulic and dynamic mechanical test equipment.
- The rheology laboratory of material testing is capable of providing key material data necessary for simulation of injection-moulding processes.
- Tests to determine the resistance to chemicals, heat and weathering provide us with information about application possibilities for our materials under extreme conditions.
- Chemical and processing-technical tests allow us to check the quality of our products and to ensure consistent quality levels.
- Our analytics laboratories can carry out analysis over the whole spectrum of modern analysis methods such as, for example, chromatography, infrared spectroscopy, x-ray fluorescence, emissions spectroscopy, CHNS analysis, electro-microsco-py/ EDX, TOC, DSC and TGA.

We can also help customers with specific questions. In order to provide support in monitoring of fatigue behaviour of our products, flexural bending or flexural stress tests can be carried out and Wöhler curves drawn up over a wide range of temperatures In addition, we also have special equipment at our disposal such as a hot water circulation unit for testing the working life under practical conditions of plastic parts through which water flows, sterilisation equipment and many others.

With these services we offer our customers active support in the choice of material and material development as well as with design and testing.

CAMPUS / EMS Material Database



CAMPUS stands for Computer Aided Material Preselection by Uniformed Standards.

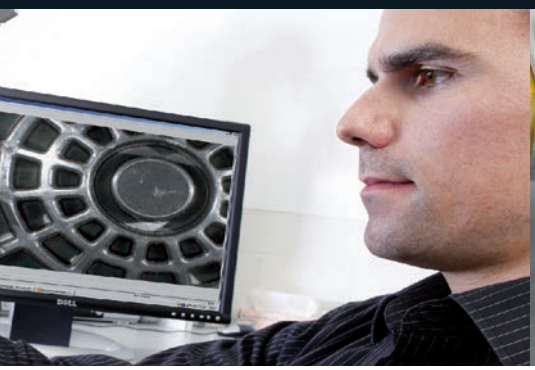
The data bank contains a chosen selection of expressive test results which accurately describe the property profile of a material. Test bars from which the test data is obtained, are manufactured under standardised injection conditions. Determination of the characteristic figures is carried out according to the standards ISO 10350 and ISO 11403.

EMS-GRIVORY has worked actively on the formation of the CAMPUS data bank since 1989. At the moment, our test laboratories have characterised around 300 construction materials according to the CAMPUS profile with regard to physical, chemical and process-technical properties. These are available both in table form (mechanical, thermal, rheological and electrical property values) and in graph form (stress-strain curves, creep curves, shear loss modulus, viscosity and pvT).

Material descriptions, resis-tance to chemicals, typical applications and process-ing notes supplement the product profile.

The **EMS Material Database** makes it possible to carry out a simple, quick product search for numerical property values or features, markets and approvals. A technical data sheet and safety data sheet is available for each product.

Simple access to the EMS Material Database and CAMPUS is possible on our homepage **www.ems-grivory.com**.



The world wide production sites of EMS-GRIVORY follow the rules of our common quality management system based on the international standards ISO 9001:2008 and ISO/TS 16949:2009. They are certified by the Swiss Association for Quality & Management Systems (SQS).

The regulations of ISO/TS 16949 were compiled by the international automotive industry and, compared to ISO 9001 which is applied globally, these requirements are more far-reaching and stricter.

Our management system is process-oriented towards the primary goal of customer satisfaction. Our efforts are concentrated on conformance with quality requirements and appropriate use of resources.

The quality planning cycle starts with market research and ends with customer services. In the intermediate development phase, research and manufacturing teams face particularly challenging tasks. Development projects are tackled by interdepartmental teams working according to processes of simultaneous engineering, where team members are not limited to thinking and acting solely within the categories of their own departments, but work towards a mutual objective. During this work, up-to-date technologies (such as statistical experimental design) and preventive methods (such as failure mode and effect analysis) play a central role. The guiding principle of project management is to avoid faults before solving them.

Statistical process control is used to monitor and improve our manufacturing processes. The accuracy of our equipment is monitored in measurement system analyses.

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

Our quality management system serves first and foremost our customers, with main focus placed on their actual requirements and not on burocratical processes.

Delivery form

Grivory is delivered as dry, cylindrical granules packed in moisture-tight sacks.

Pre-drying is not necessary if the sacks remain unopened and undamaged. A wide variety of Grivory grades are available from stock in the colours natural and black.

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

Recycling of packaging material

The disposal markings on our packaging materials provide a criterion for sorting and ensure segregated disposal.

In some European countries EMS-GRIVORY pays a disposal charge e.g. with RIGK for return of empty containers free of charge.

Grivory Link

Further information can be found on our homepage:

www.emsgrivory.com

EMS-GRIVORY products

Grivory HT

Enhanced performance at high temperatures

Grivory® is the trade name for a group of engineering plastic materials. Grivory HT, manufactured and sold by EMS-GRIVORY, is a construction material based on polyphthalamide (copolyamide PA6T6I, PA6T/66, PA10T/X).

Grivory GV

The proven material for metal replacement

Grivory® GV is the trade name for a group of engineering plastic materials manufactured and sold by EMS-GRIVORY. Grivory GV is based on a combination of semi-crystalline and partially aromatic polyamide. Grivory is available in granulate form for processing using injection-moulding methods.

Grilon

Premium polyamide

Grilon® is the trade name for engineering plastics from EMS-GRIVORY based on polyamide 6, polyamide 66 and polyamide 66/6 alloys. The construction materials in this product family are semi-crystalline polyamides and 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 polyamides for highest requirements

The trade name Grilamid TR designates transparent polyamides manufactured by EMS-GRIVORY. Grilamid TR grades are transparent, thermoplastically processable polyamides based on alliphatic and cycloaliphatic components.

Disclaimer

The information contained in this publication is based on our present knowledge and experience. The given figures and data are guidance values and do not represent binding material specifications. No warranties of any kind, either express or implied, including warranties of merchantability or fitness for a particular purpose, are given regarding products, design, data and information. The customer is not released from his obligation to investigate the products fitness and the suitability for the intended application, compliance with legal requirements and intellectual property rights. We reserve the right to change the information at any time and without prior notice. The information in this publication is not to be considered a contractual obligation and any liability whatsoever is expressly declined. For further questions about our products please contact our experts. Note: EMS-GRIVORY cannot assess possible future health risks which may result from direct contact of its products with blood or tissue. For this reason, EMS-GRIVORY cannot promote medical applications which involve long-term contact of plastic with blood or tissue.

Domat/Ems, September 2013

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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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