Grilon

Premium polyamide

GRILON®
EMS

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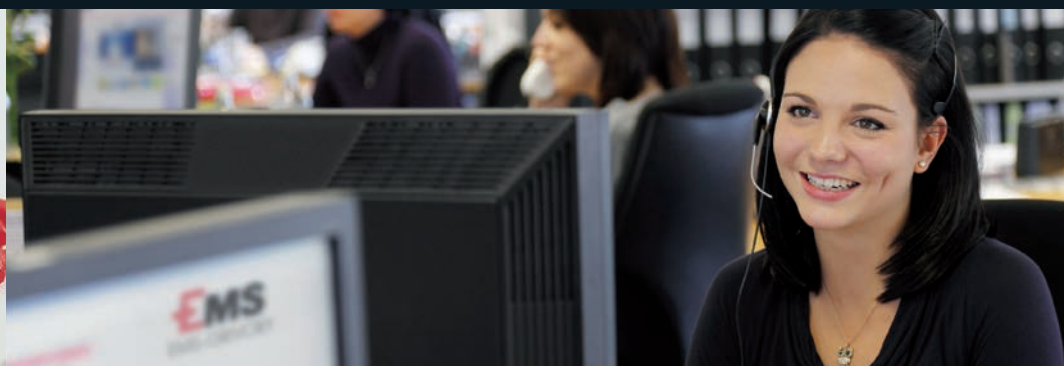


Grilon® is the brand name for engineering plastics based on polyamide 6 and polyamide 66 and manufactured by EMS-GRIVORY.

With the manufacture of special polyamide 6 + polyamide 66 alloys, EMS-GRIVORY has succeeded in further improving the already outstanding properties of Grilon.

The products in this group are semi-crystalline polyamide materials characterised by the following properties:

- high strength and stiffness
- high impact strength
- high heat deflection temperature
- good abrasion and surface slip (friction) properties
- resistance to many chemicals
- good electrical properties
- economic processing

Grilon is perfectly suited for processing using injection moulding, extrusion and extrusion blow-moulding methods.

Due to their excellent properties, these materials can be used in a wide variety of application segments such as the automotive industry, electrical / electronic technology, sport and leisure as well as in mechanical engineering.

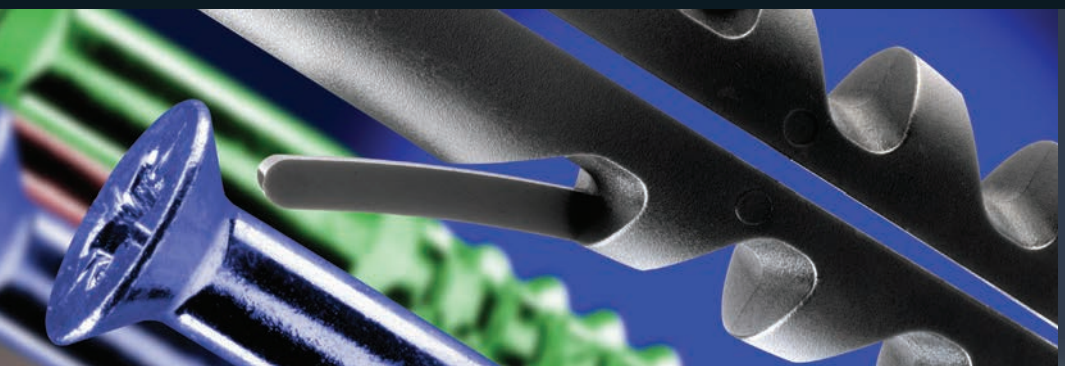
The various Grilon grades differ from each other according to the type and composition of the basic polymers as well as their modification with stabilisers, processing aids and reinforcing materials (minerals, glass, carbon and steel fibres).

Grade families

Grilon A	66
Grilon B	6
Grilon TS	66 + 6

EMS-GRIVORY – Your partner for tailor-made solutions

Grilon – nomenclature



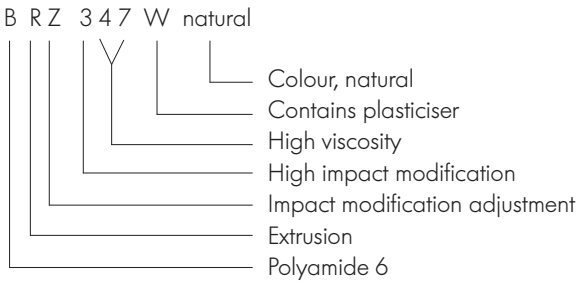
Extrusion

Block 1	A B TS	polyamide 66 polyamide 6 PA66 + PA6 alloy
Block 2	S Z R F EB BM BT MB	standard injection moulding grade impact-modified extrusion/raw film quality extrusion blow-moulding grade barrier polyamide alloy masterbatch
Block 3	1.. 2.. 3.. .23 .34, .40 .47, .50	slight impact modification impact-modified high impact modification low viscosity higher viscosity high viscosity
Block 4	S H UV VO FR HM W EC LF FA LW ELX X	improved surface quality specially heat stabilised UV stabilised self-extinguishing as per UL 94 flame-retardant adhesion-modified containing plasticiser electrically conductive low sliding friction suitable for foodstuffs suitable for laser marking and lettering elastomer special modification

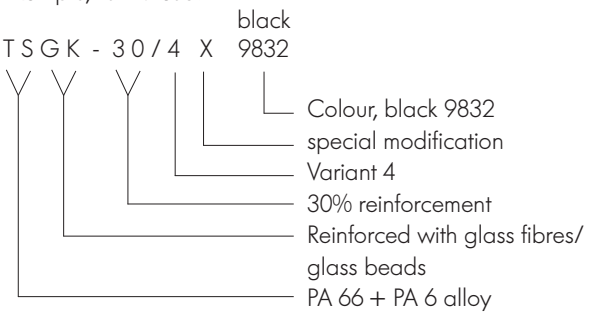
Injection moulding

Block 1	A B TS	polyamide 66 polyamide 6 PA66 + PA6 alloy
Block 2	G K M C GM GK EB ..Z GL	reinforced with glass fibres reinforced with glass beads reinforced with minerals reinforced with carbon fibres reinforced with glass fibres/minerals reinforced with glass fibres/glass beads extrusion blow-moulding grade impact modification adjustments reinforced with glass fibres/long fibre
Block 3	10 to 60	10 to 60% reinforcement
Block 4	S H UV VO FR HM W EC LF FA LW ELX X	improved surface quality specially heat stabilised UV stabilised self-extinguishing as per UL 94 flame-retardant adhesion-modified heat ageing stability electrically conductive low sliding friction suitable for foodstuffs suitable for laser marking and lettering elastomer special modification

Example, non-reinforced:



Example, reinforced:



Electrical / electronics technology

Examples	Suitable grades
Airbag connector	Grilon BG-30/2
Automatic fuse, isolating switch	Grilon BS V0, Grilon TS V0
Battery holder	Grilon TSM-30
Battery switch	Grilon BGM-65 X V0
Cable clamps	Grilon BG-30S, Grilon BG-50S
Cable support, aircraft	Grilon BS V0
Cable support, power lines	Grilon TSG-50/4
Cable sheathing	Grilon R 50 H NZ, Grilon BRZ 347 W
Cable ties	Grilon TSS, Grilon TSZ 1, Grilon TS V0
Carbon brush holder	Grilon TSG-30/4, Grilon TSG-50/4, Grilon BG-40 HM
CEE plug	Grilon TSZ 3
Circuit board holder	Grilon BS/2, Grilon AS/2
Coil formers (electric motors)	Grilon TSM-30, Grilon TS V0, Grilon AS/2
Computer plug	Grilon TS V0
Corrugated pipe fittings	Grilon BS V0, Grilon TS V0
Door isolation switch	Grilon AG-25 HM
Electrical plug	Grilon AS V0, Grilon BS V0, Grilon TS V0, Grilon BG-30 S, Grilon AS/2, Grilon BS/2, Grilon BZ 1/2, Grilon BZ 3
Electrical socket	Grilon TS FR
Handles, power tools	Grilon BG-40 HM
Housing components, controls	Grilon BG-30 S
Housing components (power tools)	Grilon BG-30 S, Grilon BG-30, Grilon BG-50 S, Grilon BG-40 HM, Grilon TSG-30, Grilon BGZ-30/2, Grilon BZ 1/2, Grilon BGK-30X
Micro-motor housing	Grilon BK-30, Grilon BK-50, Grilon TSM-30
Plug connectors for rail vehicles	Grilon BGM-65 X V0, Grilon BS V0
Radio housing (military)	Grilon BGZ-30/2
Relay chassis	Grilon BGM-65 X V0, Grilon BGK-30 X, Grilon TSGK-30 X
Switch, functional parts	Grilon TSG-30/4, Grilon BG-50 S, Grilon BT 40 Z
Switch housing	Grilon BG-40 HM, Grilon TS V0, Grilon TSG-30 FR
Terminal blocks	Grilon AS V0, Grilon TS V0
Transformer housing	Grilon TSGK-30 X
Vacuum cleaner nozzle	Grilon BZ 1/2
Warning lamp (socket)	Grilon BT 40 Z

Application examples

Automotive and transport

Examples	Suitable grades
Acoustic insulation	Grilon BRZ 323 ELX
Aerial housing	Grilon TSZ 1
Aerial motor housing	Grilon TSM-30
Airbag clips	Grilon TSZ 3
Airbag components	Grilon BG-30 S
Air-filter housing, truck	Grilon BG-30 S
Air intake components (flexible)	Grilon ELX 40 H NZ, Grilon ELX 50 H NZ
Air intake components (stiff)	Grilon TSK-30/4, Grilon EB 50 H, Grilon EB 50 H DZ, Grilon R 50 H NZ, Grilon EBV-15H, Grilon EBV-2H, Grilon EBVZ-15H, Grilon RVZ-15H.1
Air intakes	Grilon BG-30, Grilon TSG-30/4
Bearing bushes	Grilon TSC-20/4 EC
Bellows, sliding roof	Grilon BG-30 HM, Grilon BG-40 HM
Bicycle brake lever	Grilon BG-30 S, Grilon BG-50 S, Grilon BGZ-30/2, Grilon BGZ-50/2
Bicycle carrier components	Grilon BZ 3
Bicycle fasteners	Grilon BS
Bicycle gearing components	Grilon BGZ-30/2
Bicycle pedal clip	Grilon BS/2
Bicycle shoes / soles	Grilon BG-30 S
Bowden cables	Grilon AZ 3/2
Bracket for air intake	Grilon BGZ-30/2
Bracket for motorbike control cable	Grilon TSGZ-30
Brake fluid container	Grilon BS/2
Cable ducts	Grilon TSZ 1
Cable holders	Grilon BG-30 S, Grilon BG-50 S, Grilon TSG-30/4
Car headlight levelling sensor	Grilon BG-50 H, Grilon BG-50 HM
Chain links, ski-slope grooming machine	Grilon AZ 3/2
Clutch ring	Grilon AG-25 HM
Connectors, central locking	Grilon BT 40 Z
Control joystick (excavator)	Grilon BG-50 HM
Cooling circuit connectors	Grilon BG-50 H
Cover for middle arm rest	Grilon TSGK-30 X
Cup holder	Grilon BG-15 HM
Door handle escutchion	Grilon TSS
Engine cover	Grilon BGM-40 X, Grilon TSM-30
Engine stabiliser bar	Grilon TSC-20/4 EC
Fan blades (shield)	Grilon TSGZ-50, TSZ 1
Fastening clips	Grilon TSS, Grilon BZ 1, Grilon TSZ 1, Grilon AS V0
Filler neck	Grilon BRZ 347 W, Grilon ELX 50 H NZ
Fuel tank cap	Grilon TSG-30, Grilon BG-25 S
Gear sensors	Grilon BG-50 H

Automotive and transport

Examples	Suitable grades
Glove compartment handle	Grilon BG-15 S, Grilon BG-30 S
Headrest guide	Grilon TSZ 1
Hinge, convertible roof	Grilon BT 40 Z
Hydraulic oil container for power steering	Grilon BS/2, Grilon BG-15 S, Grilon TSG-30
Indicator lamp housing	Grilon BT 40 Z
Indicator lever	Grilon BG-15 S, Grilon BG-50 S
Injection rail	Grilon BGZ-30/2, Grilon BGZ-30
Inner layer of freon lines	Grilon BZ 3/2
Inner layer of fuel lines	Grilon BRZ 247 W, Grilon BRZ 347 W
Interior mirror control housing	Grilon TSS
Interior trim	Grilon BG-30
Jack retainer	Grilon BG-30 S
Loudspeaker grill	Grilon TSS
Mobile phone console	Grilon TSZ 1
Motorbike handlebar grips	Grilon BG-15 S
Mud guard / bumper supports	Grilon TSG-30/4
Oil dipstick	Grilon BGZ-30/2, TSGZ-30
Oil filler pipe	Grilon TSG-30/4, Grilon R 50 H NZ, Grilon EBV-15H
Pipe sheathing	Grilon ELX 50 H NZ
Plunger, vacuum container	Grilon TSZ 1
Pressure sensor	Grilon BZ 3/2
Radiator cap	Grilon TSG-30/4
Radiator grille	Grilon BGM-40 X
Rear bumper stop	Grilon BGZ-30
Rear seat lock housing	Grilon BS
Rear view mirror holder	Grilon TSG-50/4
Release lever, rear seat	Grilon BG-15 S
Seat belt guide / bracket	Grilon TSZ 1
Seat belt holder	Grilon BG-15 HM
Seat lever	Grilon BG-30 S
Steering column lock housing	Grilon BG-30 S
Stone chip protection	Grilon BS/2
Tank cap	Grilon TSM-30
Taxi-meter housing	Grilon TSGZ-30
Toothed belt cover	Grilon TSM-30
Truck foot rest (cabin step)	Grilon TSS/4
Turbo charger pipe (flexible)	Grilon ELX 50 H NZ
Turbo charger pipe (stiff)	Grilon EBV-15H, Grilon EBV-2H, Grilon RVZ-15H.1
Under-bonnet electronic housing	Grilon BG-40 HM, Grilon BG-30 S

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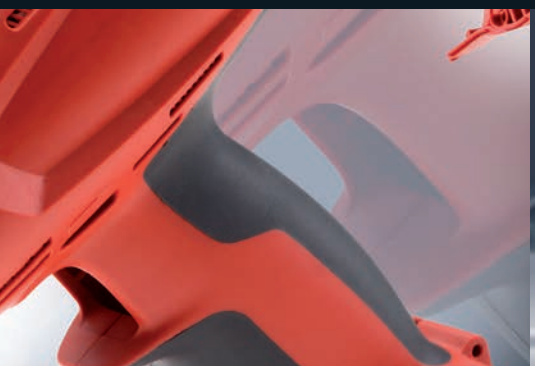
Automotive and transport

Examples	Suitable grades
Underfloor cover, fuel line	Grilon BS
Release handle, rear window	Grilon BG-40 HM
Release handle, seats	Grilon BZ 3
Fuel vent flap	Grilon TSM-30
Fuel vent line	Grilon BRZ 340 H
Fuel vent screw	Grilon B -50 S
Vulcanisation mandrel for rubber hoses	Grilon BRZ 247 W
Door mirror housing (painted)	Grilon BG-30 S
2-component gearshift	Grilon BG-40 HM
2-component gearshift grommet/boot	Grilon BG-30 HM

Mechanical engineering

Examples	Suitable grades
Blade holder for lawnmower	Grilon AZ 3/2
Gear wheels	Grilon BS/2, Grilon BK-50
Gear wheels (clocks)	Grilon TSG-30
Corrugated pipe guides	Grilon TSS/4 LF 20
Fastening plate for rubber retainers (gas mask)	Grilon BR 40 W
Pneumatic lines	Grilon BRZ 334 H, Grilon BRZ 247 W, Grilon BRZ 347 W
Screwdriver handles	Grilon BZ 1
Sliding sleeves	Grilon TSS/4 LF 2, Grilon TSS/4 LF 20
Sliding rollers	Grilon TSS/4
Steering ring	Grilon TSC-30/4 EC
Thread guide for spinning machines	Grilon TSC-30/4 EC
Tool handles	Grilon BGZ-30/2, Grilon BGZ-50/2, Grilon BG-50 S
Conveyor belts	Grilon BR 40 W, Grilon BRZ 323 ELX
Turning blades for newspaper machines	Grilon TSC-30/4 EC
Wheel hub (lawnmower)	Grilon TSGZ-15



Construction, sanitary fittings

Examples	Suitable grades
Edge cutter for roll of string	Grilon TSGZ-15
Escalator trim	Grilon BT 40 Z
Extrusion profiles	Grilon BZ 3/2
Filter bowl	Grilon BGZ-30/2
Flowmeters	Grilon BS
Furniture fittings	Grilon BZ 3/2, Grilon BG-30, Grilon BG-25 S, Grilon BG-50 S, Grilon BK-30, Grilon BS, Grilon BS/2, Grilon AS
Gas bottle valve caps	Grilon BZ 3/2, Grilon AZ 3
Lever for gas fittings	Grilon TSG-50/4
Manometer housing	Grilon TSG-30/4, Grilon BGZ-30/2
Wall plugs / dowels	Grilon BZ 1, Grilon BZ 1/2
Water tap caps	Grilon BS

Sport & optics

Examples	Suitable grades
Blade holder for ice skates	Grilon AZ 3/2
Bowling skittle	Grilon BZ 3
Damping elements for tennis and squash racquets	Grilon AZ 3/2
Fishing reel spool	Grilon BK-30
Floats (fishing)	Grilon BS 23
Gun chassis	Grilon BGZ-30/2, Grilon BG-15 HM
Handles for pocket knives	Grilon BT 40 Z
Intermediate plate for ice stock stones	Grilon BGZ-30
Model car parts	Grilon BS/2, Grilon BZ 1/2, Grilon BGZ-30/2
Parts for inline and roller skates	Grilon BGZ-15
Parts for rubber dinghies	Grilon BS/2, Grilon AS
Ski binding components	Grilon BZ 3/2, Grilon BGZ-50/2
Ski boot spoiler	Grilon AZ 3
Soles for sports shoes	Grilon BR 40 W
Surfboard fin	Grilon BG-50 S
Tripod components	Grilon BZ 1

Application examples

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Household & optics

Examples	Suitable grades
Base plate for bread slicer	Grilon BK-30
Blade guide for cutter	Grilon BS
Canister grips	Grilon BG-30 S
Carrying handles for plastic boxes	Grilon BG-50 S
Chair and suitcase rollers	Grilon BS, Grilon BZ 3/2
Chair backrest	Grilon BS, Grilon BS/2
Coffee machine components	Grilon BG-30 S, Grilon BG-30
Cooking utensils	Grilon BS, Grilon AS
Dishwasher casing	Grilon BG-30
Domestic appliance components	Grilon BG-30, Grilon BK-30
Floating level controller	Grilon BG-50 S
Foot mats	Grilon BRZ 323 ELX
Knife handles	Grilon BG-25 S, Grilon BK-30, Grilon BT 40 Z
Nutcrackers	Grilon TSG-50
Pen caps	Grilon BZ 1/2
Rolling pin	Grilon BK-50
Safety glasses	Grilon BZ 3/2, Grilon BT 40 Z
Security ties	Grilon BZ 1/2
Spectacle frames	Grilon AS, Grilon BT 40 Z
Spider for office chair	Grilon BG-30 S
Suitcase lock	Grilon AZ 3
Tin opener	Grilon TSG-30, Grilon TSG-50

Miscellaneous

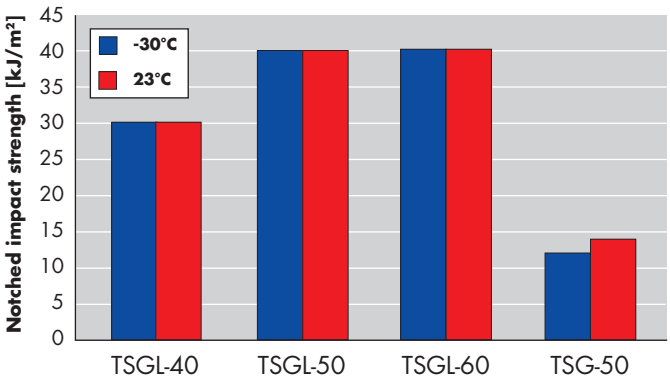
Examples	Suitable grades
Badges	Grilon TSZ 1
Containers for agrochemicals	Grilon BFZ 3
Dental filling preparation device	Grilon BG-40 HM
Ear tags	Grilon BS 23, Grilon BS/2, Grilon BZ 1, Grilon BZ 3/2
Parts for milking machines	Grilon BS, Grilon BT 40 Z
Pneumatic dispatch system covers	Grilon AZ 3
Protective packaging frames	Grilon TSG-50/4
Scarecrows	Grilon BGZ-30/2
Shell for fireman's helmet	Grilon AZ 3

Grilon reinforced with long glass fibres – a new product group

Grilon TSGL

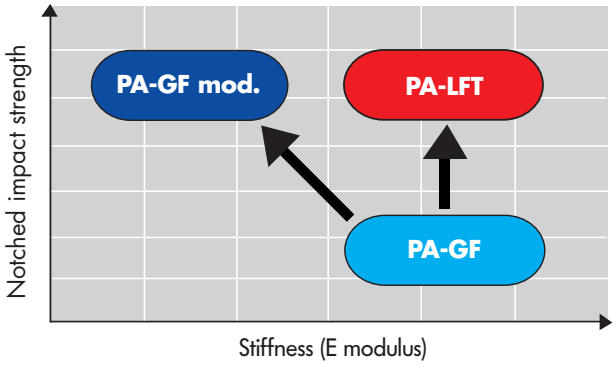
Grilon TSGL is a group of materials where the polyamide matrix is reinforced with long glass fibres. These materials exhibit the same special properties as those of Grilon TSG materials reinforced with short glass fibres such as, easy processing, high stiffness and good resistance to chemicals. In addition, they exhibit significantly improved notched impact strength and creep tendency due to reinforcement with long glass fibres. The properties remain at a high level even after moisture absorption and at increased temperatures.

Notched impact strength of TSG long fibre products



Compared to TSG materials reinforced with short glass fibres such as Grilon TSG-50, TSGL products have a notched impact strength which is approximately 2.5 times higher. This can be attributed to the internal fibre skeleton (three-dimensional glass fibre network) of the component which is revealed when the component is reduced to ash (see picture).

What is particularly remarkable is, that the increase in notched impact strength does not result in any loss in stiffness. This is not possible in the case of conventional impact-modified products because their elastomer components absorb energy which always leads to a loss in stiffness.



Grilon TSGL reinforced with long glass fibres also exhibits an excellent heat deflection temperature. Compared to Grilon TSG, the heat deflection temperature in accordance with ISO 75C (8 MPa) is 30°C to 40°C higher.

The fibre-felt structure increases the resistance to cracking. Compared to materials reinforced with short glass fibres, the propagation of cracks is substantially reduced. As a result, a test plate in an impact penetration test is not fragmented but instead just shows a hinge fracture (see diagram).

	Modification	PA 6	PA 66	PA 66+6	Page
Injection moulding	Non-reinforced	●	●	●	14/15
	Non-reinforced, impact-modified	●	●	●	16/17
	Reinforced with glass fibres	●	●	●	18 – 21
	Reinforced with glass fibres, impact-modified	●	●	●	22/23
	Reinforced with glass fibres, adhesion-modified	●	●		22/23
	Reinforced with glass beads, minerals, hybrid	●		●	24/25
	Self-extinguishing	●	●	●	26/27
	Sliding bearing materials, conductive	●		●	28/29
	LFT, reinforced with long fibres			●	30/31
Extrusion	Flexible grades	●			32/33
	Extrusion blow-moulding materials	●			34/35

Properties
Injection moulding, non-reinforced

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	50 mm/min	ISO 527	MPa	dry cond.
Yield strain	50 mm/min	ISO 527	%	dry cond.
Stress at break	50 mm/min	ISO 527	MPa	dry cond.
Strain at break	50 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	
Water absorption	23°C/sat.	ISO 62	%	
Moisture absorption	23°C/50% r.h.	ISO 62	%	
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	Grilon BS 23	Grilon BS	Grilon BS/2	Grilon BR 40	Grilon AS/2	Grilon TSS	Grilon TSS/4
	3300	3000	3300	3300	3700	2700	3000
	1300	1000	1100	900	1700	750	1100
	-	90	90	90	95	70	80
	-	40	45	40	60	40	50
	-	4	3	4	4	4	5
	-	15	15	25	12	15	15
	85	60	70	60	80	45	55
	-	55	55	55	50	60	50
	4.5	15	5	10	10	25	15
	> 50	> 50	> 50	> 50	> 50	> 50	> 50
	120	no break	no break	no break	no break	no break	no break
	no break	no break	no break	no break	no break	no break	no break
	100	no break	no break	no break	no break	no break	no break
	45	no break	no break	no break	no break	no break	no break
	4.5	5	4	6	4	8	6
	20	30	20	35	12	35	40
	4.5	5	4	7	4	6	6
	3	4	3	4	4	7	5
	-	120	140	140	150	135	145
	-	55	60	60	85	45	65
	222	222	222	222	260	260	260
	60	60	55	55	75	55	65
	185	175	170	170	225	140	220
	-	-	-	-	-	-	-
	0.7	0.8	0.7	0.7	0.5	0.8	0.7
	0.9	0.8	1.0	1.0	1.0	1.2	0.8
	80–100	70–90	70–90	80–100	80–100	80–100	80–100
	160	180	180	180	220	200	220
	24	30	30	30	29	26	28
	22	27	28	28	27	25	26
	600	600	600	600	600	600	600
	10^{12}	10^{11}	10^{12}	10^{12}	10^{12}	10^{11}	10^{12}
	10^{11}	10^{9}	10^{11}	10^{11}	10^{11}	10^{9}	10^{11}
	10^{12}	10^{11}	10^{12}	10^{12}	10^{12}	10^{10}	10^{12}
	1.14	1.13	1.14	1.14	1.14	1.14	1.13
	V - 2	HB	HB	HB	HB	HB	HB
	9	9	9	9	8	9	8
	3	3	3	3	2	3	2.5
	0.80	1.00	0.80	0.95	0.75	1.15	1.25
	1.05	1.30	0.95	1.05	1.20	1.30	1.45
	PA6, MR, 12-030 N	PA6, MHR, 14-030 N	PA6, MR, 18-030 N	PA6, GHR, 27-030 N	PA66, MR, 14-040 N	PA66+PA6, MHR, 14-030 N	PA66+PA6, MHR, 14-030 N

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

Properties
Injection moulding, non-reinforced, impact-modified

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	50 mm/min	ISO 527	MPa	dry cond.
Yield strain	50 mm/min	ISO 527	%	dry cond.
Stress at break	50 mm/min	ISO 527	MPa	dry cond.
Strain at break	50 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.
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Ball indentation hardness		ISO 2039-1	MPa	dry cond.
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Melt temperature	DSC	ISO 11357	°C	dry
Heat deflection temperature HDT/A	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	10^{-4}/K	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	10^{-4}/K	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm³	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	
Water absorption	23°C/sat.	ISO 62	%	
Moisture absorption	23°C/50% r.h.	ISO 62	%	
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	Grilon BZ 1	Grilon BZ 1/2	Grilon BZ 3	Grilon BZ 3/2	Grilon BT 40 Z	Grilon AZ 3	Grilon AZ 3/2	Grilon TSZ 1	Grilon TSZ 3
	2400	2700	1800	1800	2400	1800	1700	2400	1600
	900	900	600	600	1600	700	700	750	550
	65	65	45	50	70	45	45	65	40
	40	35	25	25	50	30	-	35	-
	4	4	5	4	6	5	5	4	5
	15	15	15	15	7	15	-	20	-
	45	45	45	40	50	45	45	40	40
	55	55	40	40	45	40	35▲	60	30▲
	25	> 50	> 50	> 50	15	45	> 50	25	> 50
	> 50	> 50	> 50	> 50	> 50	> 50	> 50	> 50	> 50
	no break	no break	no break	no break	no break	no break	no break	no break	no break
	no break	no break	no break	no break	no break	no break	no break	no break	no break
	no break	no break	no break	no break	no break	no break	no break	no break	no break
	no break	no break	no break	no break	no break	no break	no break	no break	no break
	10	10	60	65	15	90	90	11	70
	30	25	110	115	20	no break	120	45	no break
	8	6	15	15	10	20	20	10	15
	5	6	15	15	12	20	20	8	15
	110	120	95	95	120	95	95	125	
	50	55	40	40	80	45	55	45	
	222	222	222	222	222	260	260	260	260
	55	55	50	50	105	65	65	55	55
	160	160	135	130	135	180	170	160	140
	-	-	-	-	-	-	-	-	-
	0.9	0.9	1.3	1.3	0.7	1.2	1.5	1.2	1.2
	1.2	1.2	1.5	1.5	1.0	1.3	1.5	1.5	1.5
	80–100	80–100	80–100	80–100	80–100	90–110	90–110	80–100	80–100
	180	180	180	180	130	220	220	180	180
	33	40	31	42	37	29	29	31	34
	30	35	28	39	34	28	27	27	30
	600	600	600	600	600	600	600	600	600
	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}
	10^{10}	10^{11}	10^{10}	10^{11}	10^{11}	10^{10}	10^{11}	10^{10}	10^{10}
	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{11}	10^{11}
	1.10	1.10	1.06	1.06	1.06	1.07	1.07	1.12	1.07
	HB	HB	HB	HB	HB	HB	HB	HB	HB
	9	9	9	9	6	8	8	8.5	7
	3	3	3	3	2.5	2	2	2.5	2.3
	1.10	0.85	1.30	1.10	0.70	1.60	1.60	1.25	1.65
	1.35	1.35	1.50	1.45	0.90	1.80	1.80	1.35	1.80
	PA6-HI, MR, 14-020 N	PA6-HI, MHR, 18-030 N	PA6-HI, MHR, 14-020 N	PA6-HI, MHR, 14-030 N	PA6-HI+PA12/X, MHR, 18-032 N	PA66-HI, MHR, 14-020 N	PA66-HI, MHR, 14-020 N	PA66+PA6-HI, MHR, 14-020 N	PA66+PA6-HI, MHR, 14-020 N

The "conditioned" test values were determined using test specimens stored in accordance with ISO 1110
▲ Stress at 50% elongation

Properties
Injection moulding, reinforced with glass fibres

Mechanical properties					Grilon BG-15 S
Tensile E modulus	1 mm/min	ISO 527	MPa	dry	6700
				cond.	3400
Yield stress	5 mm/min	ISO 527	MPa	dry	-
				cond.	-
Yield strain	5 mm/min	ISO 527	%	dry	-
				cond.	-
Stress at break	5 mm/min	ISO 527	MPa	dry	140
				cond.	75
Strain at break	5 mm/min	ISO 527	%	dry	4
				cond.	15
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry	45
				cond.	85
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry	40
				cond.	45
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry	5
				cond.	10
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry	4
				cond.	5
Ball indentation hardness		ISO 2039-1	MPa	dry	170
				cond.	80
Thermal properties					
Melt temperature	DSC	ISO 11357	°C	dry	222
Heat deflection temperature HDT/A	1.80 MPa	ISO 75	°C	dry	195
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry	-
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry	60
Thermal expansion coefficient, long.	23–55°C	ISO 11359	10^{-4}/K	dry	0.5
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	10^{-4}/K	dry	1.2
Max. working temperature	long-term	ISO 2578	°C	dry	100–120
Max. working temperature	short-term	ISO 2578	°C	dry	200
Electrical properties					
Dielectric strength		IEC 60243-1	kV/mm	dry	40
				cond.	37
Comparative tracking index	CTI	IEC 60112		cond.	500
Specific volume resistivity		IEC 60093	Ω · m	dry	10^{12}
				cond.	10^{10}
Specific surface resistivity		IEC 60093	Ω	cond.	10^{12}
General properties					
Density		ISO 1183	g/cm³	dry	1.23
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-	HB
Water absorption	23°C/sat.	ISO 62	%	-	8
Moisture absorption	23°C/50% r.h.	ISO 62	%	-	2.5
Linear mould shrinkage	long.	ISO 294	%	dry	0.15
Linear mould shrinkage	transverse	ISO 294	%	dry	0.60
Product designation as per ISO 16396					PA6, MHR, 14-070,GF15

Grilon BG-25 S	Grilon BG-30 S	Grilon BG-30	Grilon BG-30/2	Grilon BG-50 S	Grilon BG-50 H	Grilon AG-30	Grilon TSG-30	Grilon TSG-30/4	Grilon TSG-50	Grilon TSG-50/4
8500	9500	10000	9500	17500	17500	10500	9700	9700	16500	17500
4800	6000	6500	6500	11500	11500	7000	6000	6000	10000	12500
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
165	185	190	185	245	245	195	175	190	240	250
90	125	110	125	165	165	130	120	125	150	170
4	4	3.5	5	3	3	3	3	3	3	2.5
10	10	6.5	10	6	6	6	6	8	5	4.5
85	85	85	75	90	90	65	75	70	90	80
85	90	95	90	95	95	85	85	80	100	85
70	70	70	65	85	85	55	65	60	80	70
70	70	70	70	90	90	50	65	60	90	80
10	11	12	11	15	15	10	13	10	15	14
20	20	20	20	25	25	15	20	12	20	20
8	8	9	8	11	11	9	10	7	11	12
9	9	9	9	12	12	9	10	6	12	12
185	210	210	210	270	270	230	210	210	270	280
90	100	100	100	155	155	130	110	110	160	160
222	222	222	222	222	222	260	260	260	260	260
205	205	200	205	210	210	260	220	235	220	250
-	-	-	-	-	-	-	-	-	-	-
125	135	135	135	170	170	160	155	155	165	200
0.25	0.2	0.3	0.2	0.15	0.15	0.2	0.2	0.2	0.15	0.15
0.8	1.1	1.1	1.1	1	1	1	1.1	1	1	0.9
100–120	100–120	100–120	100–120	100–120	130–150	100–120	100–120	100–120	100–120	100–120
200	200	200	200	200	200	230	220	230	220	230
40	40	34	40	40	36	38	25	25	31	27
37	37	31	37	37	33	35	24	21	31	22
500	500	550	500	575	475	550	600	475	600	600
10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{11}	10^{12}
10^{11}	10^{11}	10^{10}	10^{11}	10^{11}	10^{11}	10^{11}	10^{10}	10^{11}	10^{9}	10^{11}
10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	10^{11}	10^{12}	10^{10}	10^{12}
1.31	1.35	1.35	1.35	1.58	1.58	1.35	1.34	1.35	1.56	1.55
HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB
7	7	7	7	5	5	5	6.5	5	6	5
2	2	2	2	1.5	1.5	1.5	2	2	1.5	1.5
0.10	0.10	0.10	0.10	0.05	0.05	0.15	0.10	0.15	0.05	0.05
0.60	0.55	0.55	0.55	0.50	0.50	0.70	0.65	0.60	0.30	0.35
PA6, MHR, 14-090,GF25	PA6, MHR, 14-090,GF30	PA6, MHR, 14-100 N,GF30	PA6, MH, 18-080 N,GF30	PA6, MH, 14-190,GF50	PA6, MH, 14-190,GF50	PA66, MHR, 14-100 N,GF30	PA66+PA6, MHR, 14-100 N,GF30	PA66+PA6, MHR, 14-100 N,GF30	PA66+PA6, MHR, 14-160 N,GF50	PA66+PA6, MHR, 14-190 N,GF50

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

Properties
Injection moulding, reinforced with glass fibres

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	5 mm/min	ISO 527	MPa	dry cond.
Yield strain	5 mm/min	ISO 527	%	dry cond.
Stress at break	5 mm/min	ISO 527	MPa	dry cond.
Strain at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	
Water absorption	23°C/sat.	ISO 62	%	
Moisture absorption	23°C/50% r.h.	ISO 62	%	
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	Grilon BG-30 FC	Grilon BG-50 FC	Grilon BG-60 FC	Grilon TSG-15/4 W	Grilon TSG-30/4 W	Grilon TSG-35/4 W	Grilon TSG-50/4 W	Grilon TSG-60/4 W
	10000	17200	19000	5600	9700	11000	16000	20000
	6200	11500	13500	3100	6000	7500	12000	13000
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	180	240	245	120	190	190	230	242
	100	155	160	70	125	130	150	159
	2.5	3	3.2	2.5	3	3	2.5	2.2
	7	6	3.4	14	8	6	5.0	3.6
	60	90	91	35	70	75	90	86
	80	95	96	95	80	85	90	91
	55	85	90	30	60	60	90	86
	55	90	90	33	60	70	80	76
	11	15	16	4	10	10	14	13
	15	25	26	6	13	13	18	18
	9	11	11	3	7	8	13	11.5
	9	12	12	3	6	8	12	11
	230	-	273	200	210	220	270	317
	110	-	156	95	110	115	150	198
	222	222	223	260	260	260	260	265
	210	215	215	220	235	240	250	245
	-	-	-	-	-	-	-	-
	160	180	190	60	155	175	215	210
	0.2	-	0.14	0.3	0.20	0.20	0.15	0.13
	1.1	-	1.0	0.8	0.70	0.70	0.90	0.87
	110–130	100–120	130–150	130–150	130–150	130–150	130–150	130–150
	200	200	200	230	230	230	230	230
	40	-	36	25	25	26	27	-
	37	-	33	21	21	21	22	-
	500	-	475	475	475	500	525	-
	10^{12}	-	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	-
	10^{11}	-	10^{10}	10^{11}	10^{11}	10^{11}	10^{11}	-
	10^{12}	-	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	-
	1.35	1.58	1.69	1.20	1.35	1.40	1.55	1.72
	HB	HB	HB	HB	HB	HB	HB	HB
	7	5	4.2	6	5	5	5	5
	2	1.5	1.1	2.5	2	2	1.5	1.2
	0.10	0.05	0.05	0.35	0.15	0.10	0.05	0.10
	0.55	0.50	0.50	0.55	0.60	0.50	0.35	0.35
	PA6, MHR, 12-190 N,GF30	PA6, MHR, 12-190 N,GF50	PA6, MHR, 10-190 N,GF60	PA66+PA6, MHR,14-060 N,GF15	PA66+PA6, MHR,14-100 N,GF30	PA66+PA6, MHR,14-110 N,GF35	PA66+PA6, MHR,14-160 N,GF50	PA66+PA6, MHR,14-160 N,GF60

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

Properties – injection moulding reinforced with glass fibres, impact-modified, adhesion-modified

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	5 mm/min	ISO 527	MPa	dry cond.
Yield strain	5 mm/min	ISO 527	%	dry cond.
Stress at break	5 mm/min	ISO 527	MPa	dry cond.
Strain at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-
Water absorption	23°C/sat.	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

Grilon BGZ-15	Grilon BGZ-30/2	Grilon BGZ-30	Grilon BGZ-50/2	Grilon TSGZ-15	Grilon TSGZ-30	Grilon BG-15 HM	Grilon BG-30 HM	Grilon BG-40 HM	Grilon BG-50 HM	Grilon AG-25 HM
5400	8500	8700	16000	5600	9000	5500	8700	12000	14000	6400
2900	5500	5200	10000	2900	5400	3800	6500	8500	10000	4900
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-
120	150	150	230	110	180	105	140	150	175	85
70	105	100	150	65	90	70	95	130	125	70
4	4	5	3	4	4	4	3	3	3	2
8	8	9	6	10	8	10	5	5	5	3
70	80	100	95	75	80	55	60	70	40	35
80	95	120	130	90	90	60	60	70	45	35
60	80	80	90	60	80	60	50	65	40	35
70	85	85	95	70	80	60	45	65	25	30
13	15	20	15	12	15	10	12	15	12	8
20	25	30	25	17	25	12	14	20	16	9
7	11	17	11	5	10	5	9	12	10	7
7	12	25	12	5	10	5	9	12	10	6
145	170	170	280	160	180	150	180	200	210	165
70	85	90	170	75	95	90	120	130	140	95
222	222	222	222	260	260	222	222	222	222	260
190	200	200	210	215	215	160	170	195	200	155
-	-	-	-	-	-	-	-	-	-	-
60	85	85	165	60	100	65	95	130	140	80
0.4	0.2	0.3	0.15	0.2	0.2	0.2	0.3	0.15	0.2	0.4
1	1.2	1	1	1.1	1.1	1.3	1.1	1	1.2	0.9
100–120	100–120	100–120	100–120	100–120	100–120	90–110	90–110	90–110	90–110	90–110
180	180	180	180	200	200	180	180	180	180	220
35	41	35	41	30	34	38	40	41	40	27
32	38	32	38	27	30	32	38	38	38	26
500	550	500	550	600	600	600	600	550	600	600
10^{12}	10^{12}	10^{12}	10^{12}	10^{11}	10^{11}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}
10^{10}	10^{11}	10^{11}	10^{11}	10^{9}	10^{9}	10^{11}	10^{11}	10^{11}	10^{11}	10^{11}
10^{12}	10^{12}	10^{12}	10^{12}	10^{10}	10^{10}	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}
1.19	1.34	1.31	1.57	1.2	1.33	1.14	1.26	1.36	1.49	1.17
HB	HB	HB	HB	HB	HB	HB	HB	HB	HB	HB
7	7	7	5	8	7	5.5	5	5	3.5	2.5
2	2	2	1.5	3	2.5	2	1	1.5	1	1
0.20	0.10	0.10	0.05	0.15	0.05	0.15	0.10	0.10	0.05	0.15
0.70	0.60	0.50	0.35	0.65	0.50	0.50	0.30	0.40	0.25	0.45
PA6-HI, MHR, 14-050,GF15	PA6-HI, MH, 18-080,GF30	PA6-HI, MHR, 14-090 N,GF30	PA6-HI, MHL, 18-160,GF50	PA66+PA6HI, MHR, 14-060 N,GF15	PA66+PA6HI, MHR, 14-190 N,GF30	PA6-HI, MH, 18-050 N,GF15	PA6-HI, MH, 18-090,GF30	PA6-HI, MH, 18-120,GF40	PA6-HI, MH, 18-140,GF50	PA66-HI, MHR, 14-060,GF25

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

Properties
Injection moulding reinforced (glass beads, minerals, hybrid)

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	5 mm/min	ISO 527	MPa	dry cond.
Yield strain	5 mm/min	ISO 527	%	dry cond.
Stress at break	5 mm/min	ISO 527	MPa	dry cond.
Strain at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-
Water absorption	23°C/sat.	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	Grilon BK-30	Grilon BK-50	Grilon BGK-30 X	Grilon BGM-40 X	Grilon TSK-30/4	Grilon TSM-30	Grilon TSGK-30 X
	4200	6100	7000	10000	4100	5800	8500
	1500	1700	3800	5000	1800	2300	5000
	-	95	-	-	-	-	-
	-	45	-	-	-	-	-
	-	4	-	-	-	-	-
	-	8	-	-	-	-	-
	70	80	140	120	75	75	155
	35	40	80	55	45	45	85
	5	10	3	2.5	10	3	3
	> 50	30	7	6	35	15	10
	40	60	65	40	30	45	50
	> 100	-	75	50	85	> 100	75
	30	35	50	35	25	35	45
	30	-	50	45	25	35	45
	4	4	8	5	4	5	8
	10	4	15	7	8	7	13
	3	3	6	3	2	5	7
	3	3	6	3	3	3	7
	-	225	-	220	175	170	200
	-	90	-	115	85	90	100
	222	222	222	222	260	260	260
	70	95	185	195	70	110	215
	190	-	-	-	–	-	-
	-	45	140	90	50	70	80
	0.9	0.7	0.35	0.3	0.8	0.8	0.6
	0.9	0.7	0.7	0.8	0.8	0.8	0.8
	100–120	100–120	100–120	100–120	100–120	100–120	100–120
	180	180	180	180	220	220	220
	31	36	29	35	27	27	24
	29	29	23	32	25	27	23
	500	450	400	525	500	525	425
	10^{12}	10^{11}	10^{12}	10^{12}	10^{12}	10^{11}	10^{12}
	10^{11}	10^{9}	10^{10}	10^{10}	10^{11}	10^{9}	10^{10}
	10^{12}	10^{10}	10^{12}	10^{12}	10^{12}	10^{10}	10^{11}
	1.34	1.55	1.34	1.44	1.35	1.37	1.34
	HB	HB	HB	HB	HB	HB	HB
	8	5	7	7	5	6.5	7.5
	2	1.5	2	2	2	2	2
	0.95	0.70	0.10	0.25	0.90	0.75	0.10
	1.00	0.75	0.50	0.55	0.95	0.85	0.65
	PA6, MHR, 14-040, GB30	PA6, MHR, 18-060, GB50	PA6, MHR, 14-070 N, (GF+GB)30X	PA6, MHR, 14-100 N,(GF+MD)40X	PA66+PA6, MHR, 14-040 N, GB30	PA66+PA6, MHR, 14-040 N, MD30	PA66+PA6, MHR, 14-080 N, (GF+GB)30X

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

Properties
Injection moulding, self-extinguishing

Mechanical properties					Grilon BS V0
Tensile E modulus	1 mm/min	ISO 527	MPa	dry	3700
				cond.	1200
Yield stress	50 mm/min	ISO 527	MPa	dry	90
				cond.	45
Yield strain	50 mm/min	ISO 527	%	dry	3
				cond.	15
Stress at break	50 mm/min	ISO 527	MPa	dry	70
				cond.	55
Strain at break	50 mm/min	ISO 527	%	dry	4
				cond.	> 50
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m²	dry	> 100
				cond.	> 100
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m²	dry	80
				cond.	90
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m²	dry	3
				cond.	15
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m²	dry	3
				cond.	3
Ball indentation hardness		ISO 2039-1	MPa	dry	150
				cond.	60
Thermal properties					
Melt temperature	DSC	ISO 11357	°C	dry	222
Heat deflection temperature HDT/A	1.80 MPa	ISO 75	°C	dry	70
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry	170
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry	-
Thermal expansion coefficient, long.	23–55°C	ISO 11359	10^{-4}/K	dry	0.7
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	10^{-4}/K	dry	0.9
Max. working temperature	long-term	ISO 2578	°C	dry	100–120
Max. working temperature	short-term	ISO 2578	°C	dry	180
Electrical properties					
Dielectric strength		IEC 60243-1	kV/mm	dry	32
				cond.	29
Comparative tracking index	CTI	IEC 60112		cond.	575
Specific volume resistivity		IEC 60093	Ω · m	dry	10^{12}
				cond.	10^{11}
Specific surface resistivity		IEC 60093	Ω	cond.	10^{12}
General properties					
Density		ISO 1183	g/cm³	dry	1.16
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating		-/V - 0/V - 0
Oxygen index		ISO 4589-2	%		≥ 32
Glow wire flammability index (GWFI)	1 mm	DIN EN 60695-2-12	°C		960
	3 mm	DIN EN 60695-2-12	°C		960
Water absorption	23°C/sat.	ISO 62	%		8
Moisture absorption	23°C/50% r.h.	ISO 62	%		2.5
Linear mould shrinkage	long.	ISO 294	%	dry	0.85
Linear mould shrinkage	transverse	ISO 294	%	dry	0.90
Product designation as per ISO 16396					PA6, MFHR, 14-040 N

Grilon BS V0 X	Grilon BGM-65 X V0	Grilon AS V0	Grilon TS FR	Grilon TS V0	Grilon TS V0 X	Grilon TSG-20/4 FR X	Grilon TSG-30/4 FR X	Grilon TSG-30/4 V0	Grilon TSM-30/4 V0
3500	11500	3900	3300	3600	3800	4500	6500	10500	7000
1200	7100	2000	1200	1600	1300	2000	3000	6500	3000
85	-	90	85	85	80	-	-	-	-
40	-	55	50	50	40	-	-	–	-
4.0	-	4	4	4	4	-	-	-	-
25	-	12	15	15	25	-	-	-	-
70	120•	80	65	75	75	70•	85•	150•	75•
50	90•	50	50	50	50	45•	55•	90•	45•
10	1•	9	20	10	9	10•	8•	2.5•	2.5•
> 50	3•	> 50	> 50	> 50	> 50	> 50•	20•	4.5•	10•
> 100	25	65	> 100	75	90	40	55	65	25
> 100	25	> 100	> 100	> 100	> 100	> 100	90	70	50
> 100	15	> 100	> 100	70	75	40	50	60	25
> 100	15	> 100	80	> 100	> 100	45	60	60	20
5.5	3	4	10	4	4	4	5	9.5	3
15	3	8	20	15	9	8.5	9	14	3.5
5	3	3	10	3	3.5	3.5	4	9	2.5
3.5	3	3	5	3	3	3	3.5	8.5	2
190	285	155	170	-	190	200	220	255	250
70	95	85	65	-	75	90	110	130	120
222	222	260	260	260	260	260	260	260	260
70	160	75	60	70	75	100	170	235	150
195	-	225	205	210	200	55	60	165	60
-	75	-	-	-	-	-	-	-	-
0.7	0.3	0.6	0.7	0.7	0.7	-	-	-	0.7
0.9	0.6	0.9	0.9	0.9	0.9	-	-	-	0.7
90–110	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120
160	180	220	200	200	200	200	220	220	220
-	33	31	29	28	-	-	-	-	
-	29	28	28	26	-	-	-	-	
600	500	600	575	600	600	600	600	600	550
10^{12}	10^{12}	10^{12}	10^{11}	10^{11}	10^{12}	10^{11}	10^{11}	10^{10}	10^{11}
10^{11}	10^{11}	10^{11}	10^{9}	10^{9}	10^{11}	10^{9}	10^{9}	10^{10}	10^{9}
10^{12}	10^{12}	10^{12}	10^{10}	10^{10}	10^{12}	10^{10}	10^{10}	10^{10}	10^{10}
1.18	1.69	1.16	1.15	1.16	1.19	1.29	1.38	1.39	1.38
V - 0	-/V - 2/V - 0	-/V - 0/V - 0	V-2/V-2/V-2	V-0/V-0/V-0	V - 0	V - 2	V - 2	V - 0	V - 0
-	~ 65	≥ 32	-	≥ 32	-	-	-	-	-
960	960	960	960	960	960	960	960	960	960
775	960	960	960	960	775	-	-	775	-
7.5	5	7	8	8	7	6	5	4	4
2.8	1.5	2	2.5	2.5	2.5	2	2	1.5	1.5
0.65	0.25	0.95	0.70	0.70	0.65	0.55	0.35	0.20	0.60
0.70	0.55	1.10	0.75	0.75	0.70	0.70	0.55	0.65	0.85
PA6, MFHR, 14-040 N	PA6, MFHR, 14110, (MD+GF) 5X	PA66, MFHR, 14-040 N	PA66+PA6, MFHR, 14-030 N	PA66+PA6, MFHR, 14-040 N	PA66+PA6, MFHR, 14-040 N	PA66+PA6, MFHR, 14040 N, GF20, FR (40)	PA66+PA6, MFHR, 14070 N, GF30, FR (40)	PA66+PA6, MFHR, 14110 N, GF30, FR (40)	PA66+PA6, MFHR, 14070 N, MD30, FR (40)

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

• Testing speed 5 mm/min

Properties
Injection moulding, reinforced (sliding bearing materials, conductive)

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	50 mm/min	ISO 527	MPa	dry cond.
Yield strain	50 mm/min	ISO 527	%	dry cond.
Stress at break	50 mm/min	ISO 527	MPa	dry cond.
Strain at break	50 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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	10^{-4}/K	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	10^{-4}/K	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm³	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-
Water absorption	23°C/sat.	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	Grilon BS EC	Grilon TSS/4 LF 2	Grilon TSS/4 LF 20	Grilon TSC-10/4 EC	Grilon TSC-20/4 EC	Grilon TSC-30/4 EC	Grilon TSC-40/4 EC
	3000	3300	2700	9200	16000	23000	26000
	1000	1400	1200	6500	10000	15000	17000
	70	90	60	-	-	-	-
	40	50	35	-	-	-	-
	5	5	4	-	-	-	-
	35	15	10	-	-	-	-
	50	70	65	170•	230•	250•	260•
	50	40	40	120•	160•	180•	200•
	20	12	15	3•	3•	2.5•	2•
	> 50	> 50	> 50	7•	6•	5•	4•
	75	> 100	> 100	50	65	60	60
	> 100	> 100	> 100	80	90	85	85
	45	> 100	45	40	60	60	50
	50	> 100	55	40	60	70	50
	5	4	4	5	8	10	10
	8	20	8	12	15	16	16
	3	4	4	4	5	7	7
	3	4	4	4	5	7	7
	130	140	140	200	240	265	280
	60	65	60	110	150	180	185
	222	260	260	260	260	260	260
	60	85	85	240	240	240	240
	165	220	220	-	-	-	-
	-	-	65	110	185	185	185
	0.4	0.6	0.8	0.2	0.2	0.1	0.1
	0.5	0.9	0.9	1	0.9	0.8	0.7
	80–100	80–100	80–100	100–120	100–120	100–120	100–120
	180	200	200	230	230	230	230
	8	27	27	6	-	-	-
	5	25	25	6	-	-	-
	–	475	475	-	-	-	-
	10^6	10^{12}	10^{12}	10^6	10^4	1000	100
	10^6	10^{11}	10^{10}	10^6	10^4	1000	100
	10^7	10^{11}	10^{11}	10^7	10^5	1000	100
	1.22	1.16	1.28	1.18	1.22	1.26	1.31
	HB	HB	HB	HB	HB	HB	HB
	9	7	5	5	5	5	5
	3	2.5	2	1.5	1.5	1.5	1.5
	0.90	0.90	0.90	0.05	0.05	0.05	0.05
	1.10	1	1	0.65	0.30	0.25	0.20
	PA6, MHRZ, 14-030 N, X	PA66+PA6, MHRS, 14-030 N, Z2	PA66+PA6, MHRS, 14-030 N, Z20	PA66+PA6, MHRS, 14-090 N, CF10	PA66+PA6, MHRS, 14-160 N, CF20	PA66+PA6, MHRS, 14-220 N, CF30	PA66+PA6, MHRS, 14-250 N, CF40

The "conditioned" test values were determined using test specimens stored in accordance with ISO 1110
• Testing speed 5 mm/min

Properties
Injection moulding, reinforced with long fibres

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	5 mm/min	ISO 527	MPa	dry cond.
Yield strain	5 mm/min	ISO 527	%	dry cond.
Stress at break	5 mm/min	ISO 527	MPa	dry cond.
Strain at break	5 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112		cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-
Water absorption	23°C/sat.	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

		Grilon TSGL-40/4 FA	Grilon TSGL-40/4	Grilon TSGL-50/4	Grilon TSGL-60/4
		13500	13000	17400	22000
		10000	9500	12500	16500
		-	-	-	-
		-	-	-	-
		-	-	-	-
		-	-	-	-
		220	230	265	280
		160	165	185	205
		2.1	2.5	2.3	2.1
		2.5	2.8	2.6	2.3
		75	80	100	110
		80	85	105	115
		60	65	95	105
		55	60	75	95
		25	30	40	40
		30	35	45	45
		25	30	40	40
		30	35	45	45
		280	275	310	340
		185	180	200	230
		260	260	260	250
		250	250	250	255
		225	220	230	235
		-	0.20	0.20	0.20
		-	0.60	0.50	0.40
		-	120–130	120–130	120–130
		-	220	220	220
		-	29	29	28
		-	24	24	24
		-	600	600	600
		-	10^{11}	10^{10}	10^{10}
		-	10^{10}	10^{10}	10^{10}
		-	10^{12}	10^{13}	10^{13}
		1.45	1.45	1.55	1.68
		HB	HB	HB	HB
		5.0	5.0	4.5	4.0
		1.8	1.8	1.5	1.2
		-	0.15	0.10	0.10
		-	0.4	0.3	0.20
		PA66+PA6, MH, 14-140 N, GF40	PA66+PA6, MH, 14-140 N, GF40	PA66+PA6, MH, 14-190, GF50	PA66+PA6, MH, 14-230, GF60

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

Properties
Extrusion, flexible, highly heat-resistant

Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry / cond.
Yield stress	50 mm/min	ISO 527	MPa	dry / cond.
Yield strain	50 mm/min	ISO 527	%	dry / cond.
Stress at break	50 mm/min	ISO 527	MPa	dry / cond.
Strain at break	50 mm/min	ISO 527	%	dry / cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry / cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry / cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry / cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry / cond.
Comparative tracking index	CTI	IEC 60112	-	cond.
Specific volume resistivity		IEC 60093	Ω · m	dry / cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-
Water absorption	23°C/sat.	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	flexible					high heat resistance	
	Grilon BRZ 334 H	**Grilon BR 40 W**	**Grilon BRZ 340 H**	**Grilon BRZ 247 W**	**Grilon BRZ 347 W**	**Grilon EBGM-20 HX**	**Grilon EBGM-30 HX**
	950	1300	2800	650	600	6300	9500
	300	500	700	380	350	3300	5500
	-	40	70	-	-	-	-
	-	30	35	-	-	-	-
	-	35	4	-	-	-	-
	-	40	15	-	-	-	-
	40▲	40	40	30▲	30▲	105	155
	20▲	60	45	25▲	25▲	55	90
	> 50	> 50	40	> 50	> 50	3	3
	> 50	> 50	> 50	> 50	> 50	7	6
	no break	no break	no break	no break	no break	50	70
	no break	no break	no break	no break	no break	65	70
	no break	no break	no break	no break	no break	50	65
	no break	no break	no break	no break	no break	50	65
	100	15	13	120	110	8	10
	no break	no break	> 125	no break	no break	10	11
	85	3	11	7	15	5	7
	85	3	7	10	15	5	7
	90	55	130	35	35	150	210
	30	30	45	25	25	75	105
	222	222	222	215	215	260	260
	45	45	55	40	40	195	225
	55	110	130	75	80	-	-
	-	-	-	-	-	65	155
	1.2	1.1	0.9	1.4	1.5	0.3	0.2
	1.4	1.6	1.2	1.5	1.6	1.0	0.8
	100–120	80–100	100–120	80–100	80–100	-	130–150
	180	180	180	170	170	-	230
	26	31	40	31	-	40	38
	22	28	35	29	-	30	34
	600	450	600	500	600	550	500
	10^{11}	10^{11}	10^{12}	10^{12}	10^{12}	10^{10}	10^{10}
	10^{8}	10^{10}	10^{11}	10^{11}	10^{11}	10^{9}	10^{9}
	10^{9}	10^{10}	10^{12}	10^{12}	10^{12}	10^{10}	10^{12}
	1.00	1.12	1.10	1.12	1.07	1.24	1.37
	HB	HB	HB	HB	HB	HB	HB
	5	8	9	8	8	8	5.5
	1.5	2.5	3	2.5	2.5	3	2
	-	-	-	-	-	0.40	0.205
	-	-	-	-	-	0.70	0.80
	PA6-HI, GHR, 24-040 N	PA6-P, 24-010	PA6-HI, GHR, 27-020 N	PA6-HIP, GH, 32-007	PA6-HIP, GHL, 32-005	PA6+PA66-HI, 22-060, GF15	PA66+PA6, MH, 14-100, GF30

The "conditioned" test values were determined using test specimens stored in accordance with ISO 1110
▲ Stress at 50% elongation

Properties
Extrusion blow-moulding materials

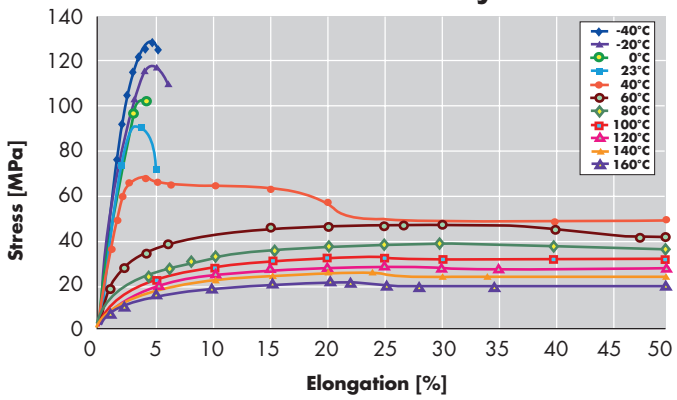
Mechanical properties				
Tensile E modulus	1 mm/min	ISO 527	MPa	dry cond.
Yield stress	50 mm/min	ISO 527	MPa	dry cond.
Yield strain	50 mm/min	ISO 527	%	dry cond.
Stress at break	50 mm/min	ISO 527	MPa	dry cond.
Strain at break	50 mm/min	ISO 527	%	dry cond.
Impact strength	Charpy, 23°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Impact strength	Charpy, -30°C	ISO 179/2-1eU	kJ/m^2	dry cond.
Notched impact strength	Charpy, 23°C	ISO 179/2-1eA	kJ/m^2	dry cond.
Notched impact strength	Charpy, -30°C	ISO 179/2-1eA	kJ/m^2	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	1.80 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/B	0.45 MPa	ISO 75	°C	dry
Heat deflection temperature HDT/C	8.00 MPa	ISO 75	°C	dry
Thermal expansion coefficient, long.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Thermal expansion coefficient, trans.	23–55°C	ISO 11359	$10^{-4}/K$	dry
Max. working temperature	long-term	ISO 2578	°C	dry
Max. working temperature	short-term	ISO 2578	°C	dry
Electrical properties				
Dielectric strength		IEC 60243-1	kV/mm	dry cond.
Comparative tracking index	CTI	IEC 60112	-	cond.
Specific volume resistivity		IEC 60093	Ω · m	dry cond.
Specific surface resistivity		IEC 60093	Ω	cond.
General properties				
Density		ISO 1183	g/cm^3	dry
Flammability (UL 94)	0.8 mm	IEC 60695-11-10	Rating	-
Water absorption	23°C/sat.	ISO 62	%	-
Moisture absorption	23°C/50% r.h.	ISO 62	%	-
Linear mould shrinkage	long.	ISO 294	%	dry
Linear mould shrinkage	transverse	ISO 294	%	dry
Product designation as per ISO 16396				

	Grilon EB 50 H	Grilon EB 50 H DZ	Grilon EB 50 H NZ	Grilon EBV-15H	Grilon EBVZ-15H	Grilon RVZ-15H.1	Grilon EBV-2H	Grilon ELX 40 H NZ	Grilon ELX 50 H NZ
	2800	2300	1800	5600	5500	5500	6500	550	220
	800	700	600	2700	2500	2400	3500	250	150
	75	60	50	-	100	-	-	18	-
	40	35	-	-	60	-	-	-	-
	4	4	5	-	3	-	-	15	-
	20	20	-	-	10	-	-	-	-
	50	50	45	110•	100•	95•	120•	21▲	16▲
	50	45	25▲	65•	60•	60•	70•	16▲	12▲
	50	50	> 50	5•	5•	6•	4•	> 50	> 50
	> 50	> 50	> 50	25•	30•	25•	15•	> 50	> 50
	no break	no break	no break	80	85	90	80	no break	no break
	no break	no break	no break	> 100	> 100	> 100	> 100	no break	no break
	no break	no break	no break	80	85	90	85	no break	no break
	no break	no break	no break	80	85	90	90	no break	no break
	11	70	95	15	20	20	15	no break	no break
	> 125	> 125	no break	30	35	35	30	no break	no break
	10	20	25	6	8	9	6	25	110
	9	20	25	8	8	9	8	25	no break
	135	100	90	145	140	140	180	26	17
	55	40	30	70	65	65	80	16	11
	222	222	222	222	222	222	222	210	210
	55	50	45	165	165	160	190	45	35
	140	90	105	-	-	-	-	60	50
	-	-	-	50	50	50	65	-	-
	0.9	1.2	1.3	0.5	0.4	0.35	0.3	1.6	1.6
	1.2	1.4	1.4	1.2	1.2	1.2	1.2	1.7	1.7
	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120	100–120
	180	180	180	180	180	180	180	180	180
	28	27	-	26	-	40	30	28	29
	24	24	-	22	-	37	27	26	30
	425	425	475	325	-	600	-	600	575
	10^{11}	10^{11}	10^{12}	10^{11}	10^{11}	10^{12}	10^{11}	10^{9}	10^{9}
	10^{9}	10^{9}	10^{11}	10^{9}	10^{9}	10^{11}	10^{9}	10^{8}	10^{8}
	10^{10}	10^{10}	10^{12}	10^{10}	10^{10}	10^{12}	10^{10}	10^{10}	10^{10}
	1.11	1.1	1.07	1.21	1.2	1.19	1.25	1.03	1.01
	HB	HB	HB	HB	HB	HB	HB	HB	HB
	9	9	9	8	8	8	8	6.5	6.5
	3	3	3	2.5	2.5	2.5	2.5	2	2
	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
	PA6-HI, BH, 34-030	PA6-HI, BH, 34-020	PA6-HI, GH, 34-020	PA6-HI, BH, 27-060, GF15	PA6-HI, GH, 27-050, GF15	PA6-HI, BH, 27-050, GF15	PA6-HI, BH, 27-050, GF20	PA6 / X-HI, BGH, 32-005	PA6 / X-HI, BGH, 32-002

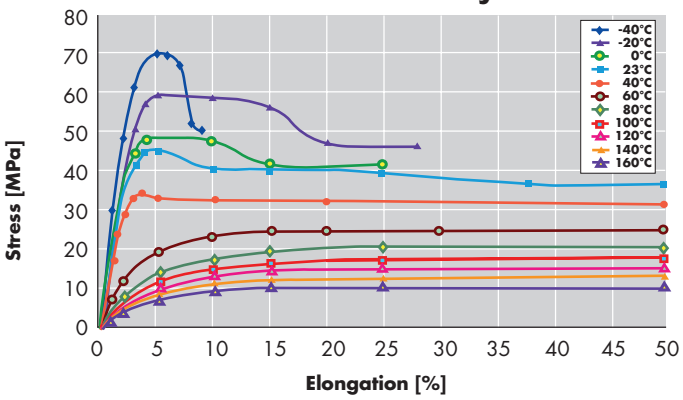
The "conditioned" test values were determined using test specimens stored in accordance with ISO 1110
▲ Stress at 50% elongation • Testing speed 5 mm/min

Mechanical properties as a function of temperature

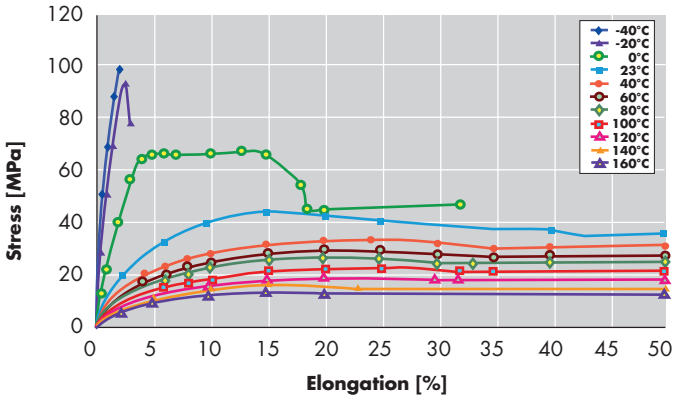
Tensile test Grilon BS/2 – dry



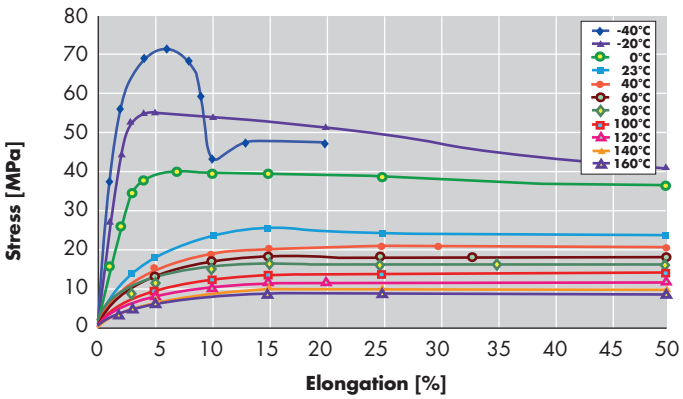
Tensile test Grilon BZ 3 – dry



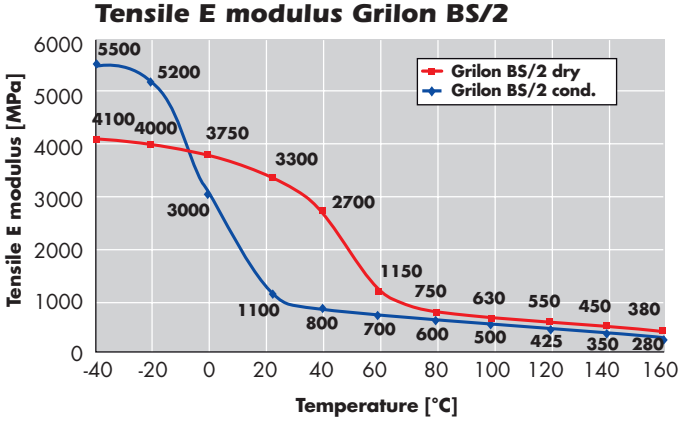
Tensile test Grilon BS/2 – cond.



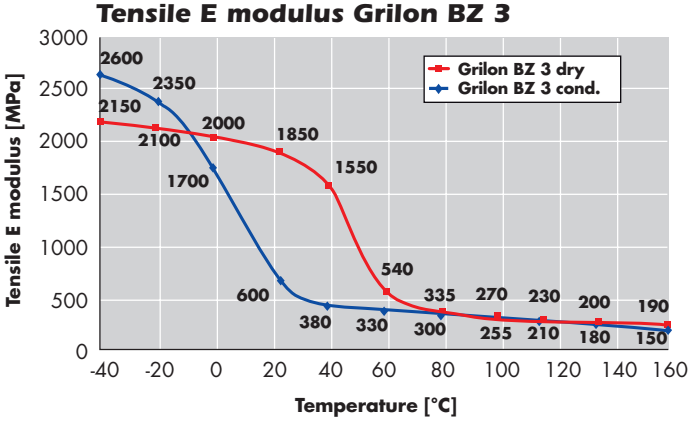
Tensile test Grilon BZ 3 – cond.



Tensile E modulus Grilon BS/2

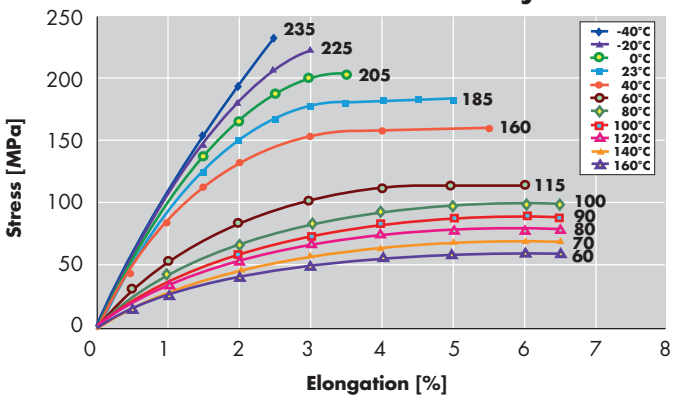


Tensile E modulus Grilon BZ 3

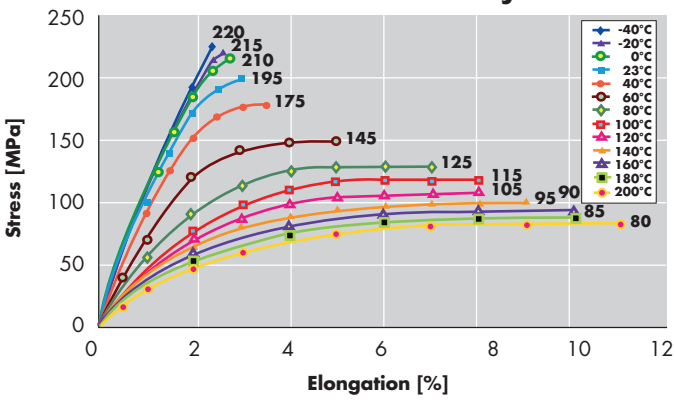


Mechanical properties as a function of temperature

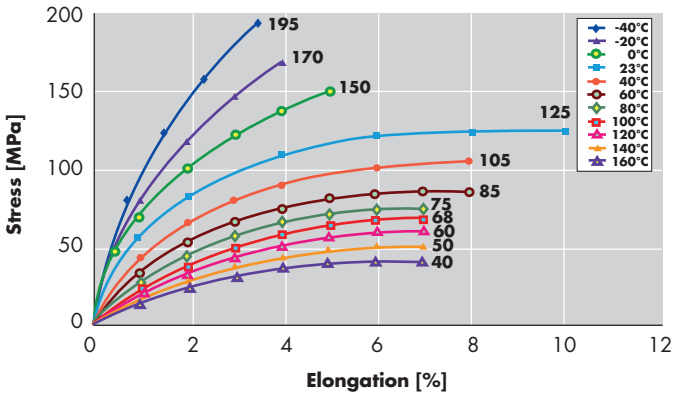
Tensile test Grilon BG-30 S – dry



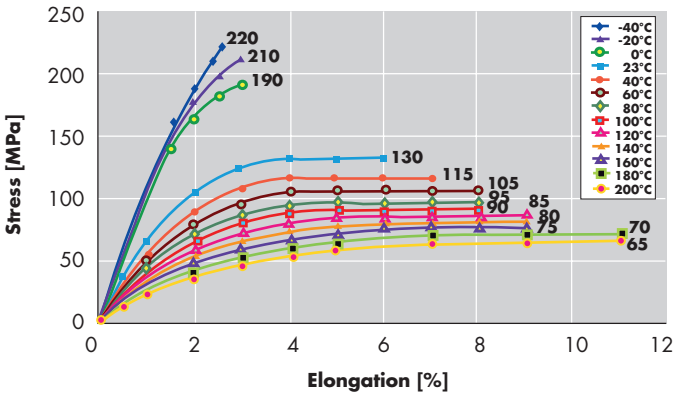
Tensile test Grilon AG-30 – dry



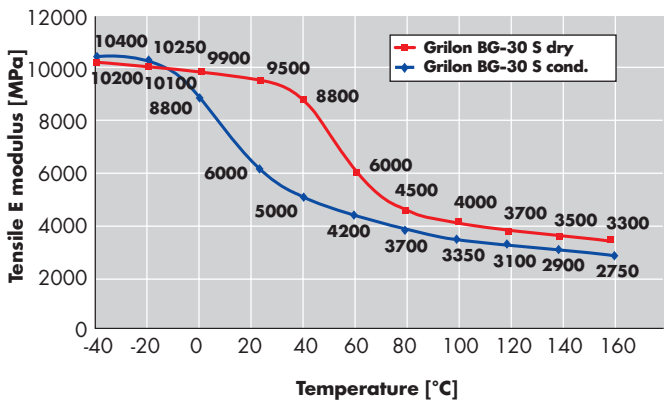
Tensile test Grilon BG-30 S – cond.



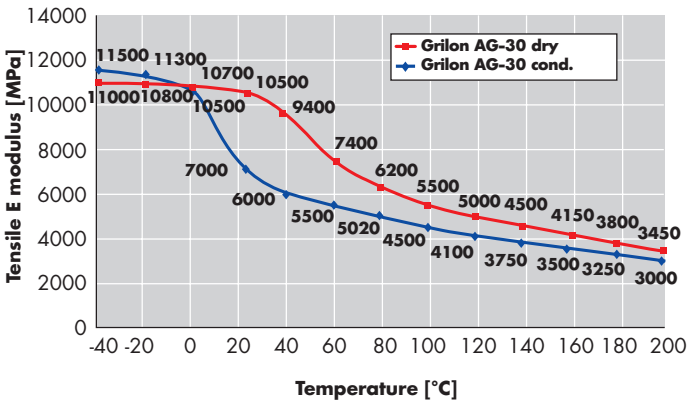
Tensile test Grilon AG-30 – cond.



Tensile E modulus Grilon BG-30 S



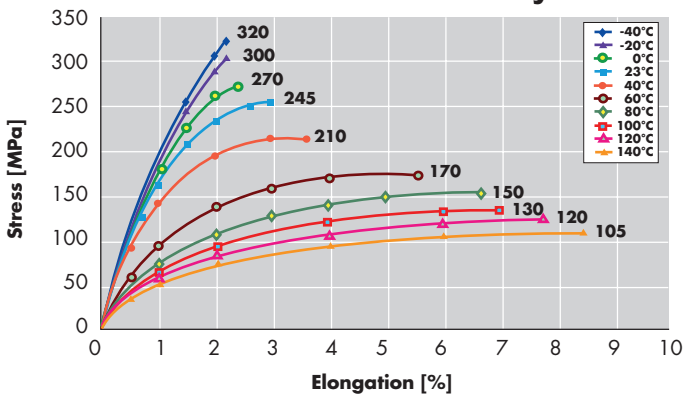
Tensile E modulus Grilon AG-30



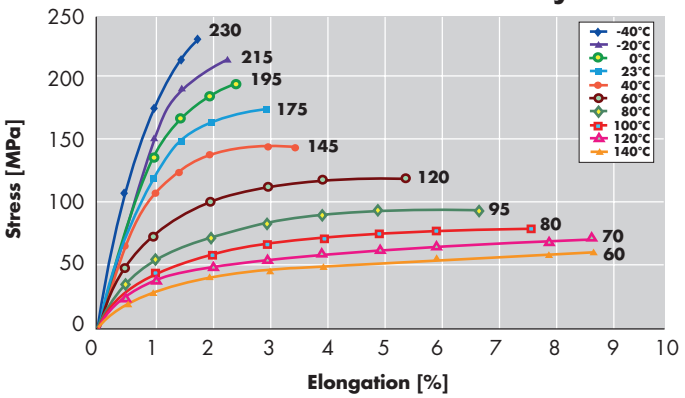
Design data – short-term behaviour

Mechanical properties as a function of temperature

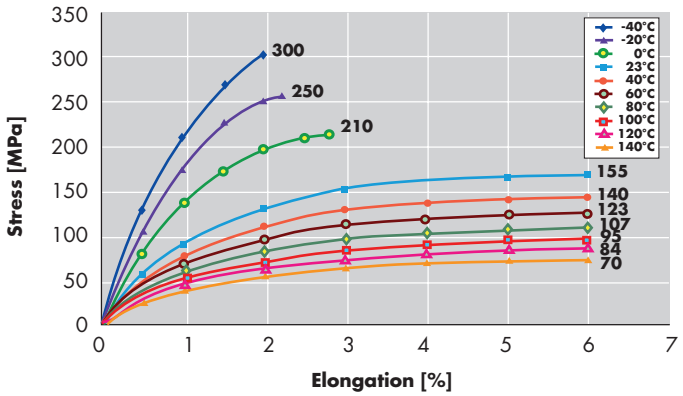
Tensile test Grilon BG-50 H – dry



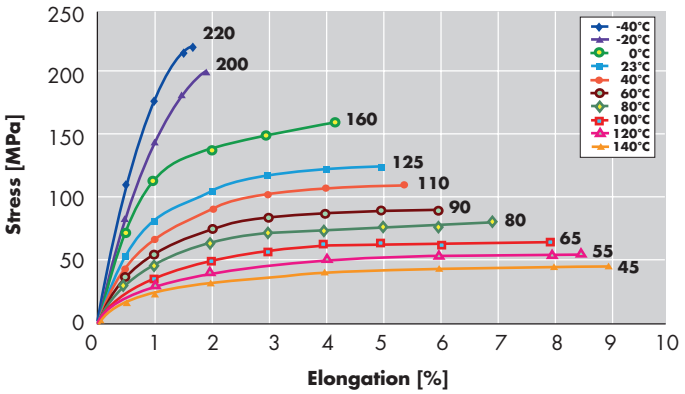
Tensile test Grilon BG-50 HM – dry



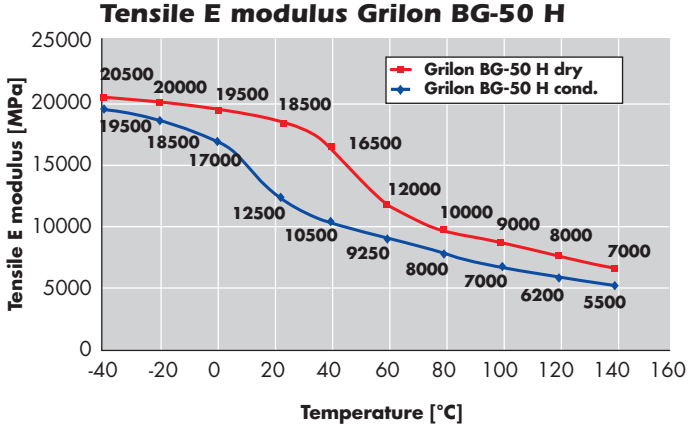
Tensile test Grilon BG-50 H – cond.



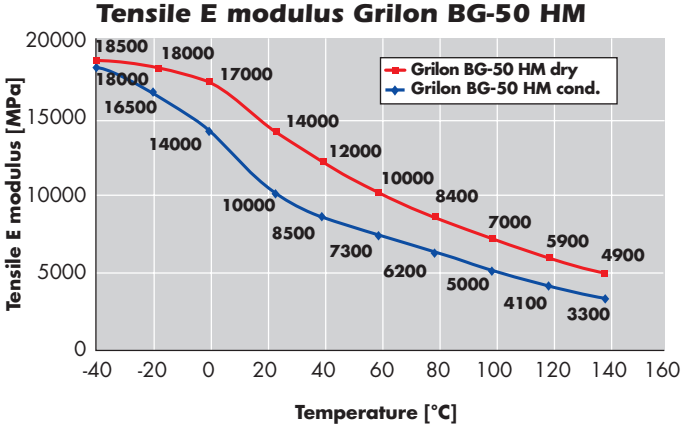
Tensile test Grilon BG-50 HM – cond.



Tensile E modulus Grilon BG-50 H

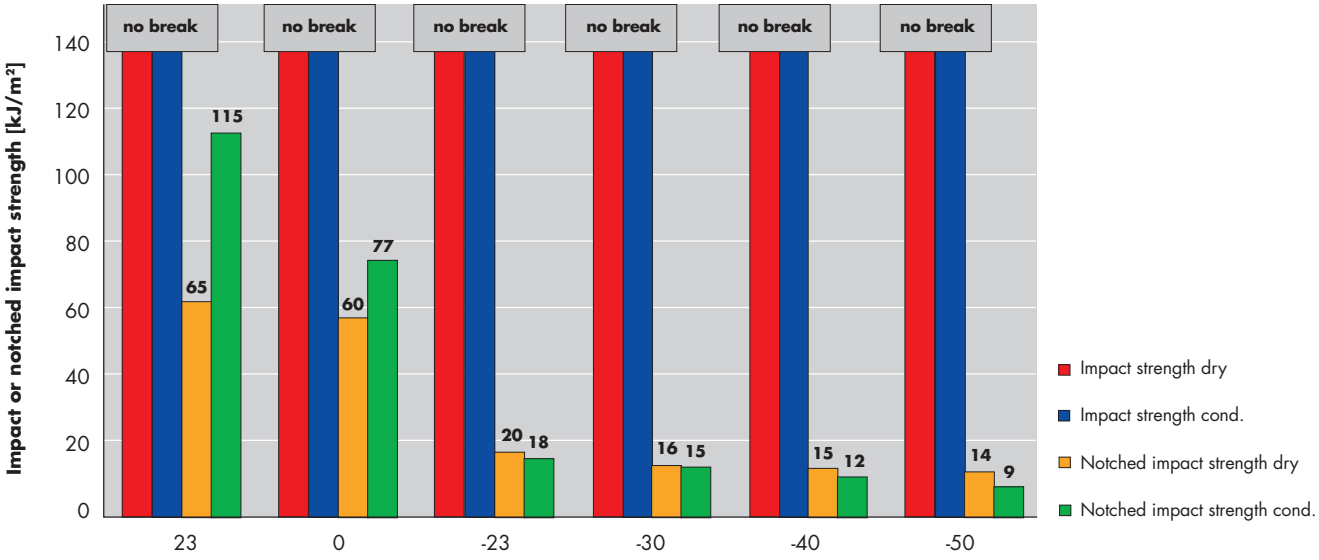


Tensile E modulus Grilon BG-50 HM

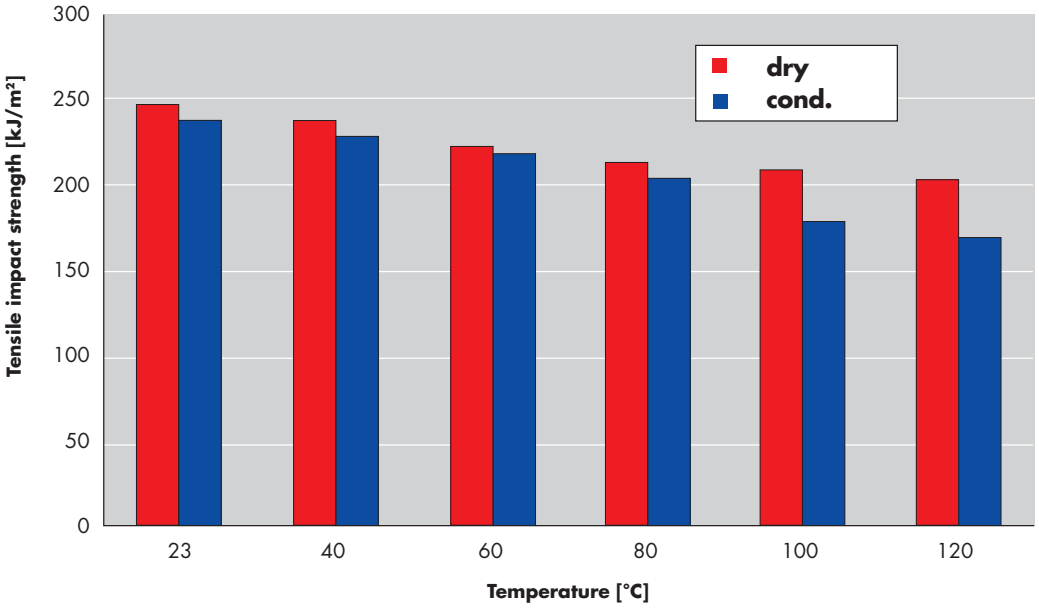


Mechanical properties as a function of temperature

Impact and notched impact strength Grilon BZ 3/2, ISO 179/2-1



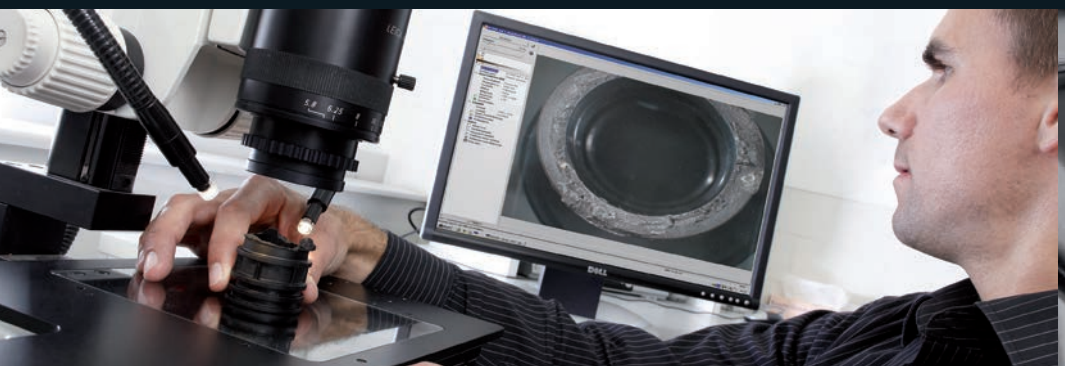
Tensile impact strength Grilon BGZ-50/2



As per ISO 8256

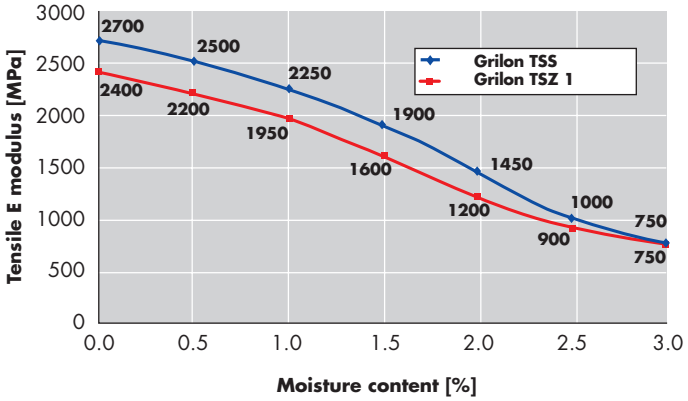
Test specimens:	10x1 mm
Test speed:	6.4 m/s
Starting length:	48.0 mm

Design data – short-term behaviour

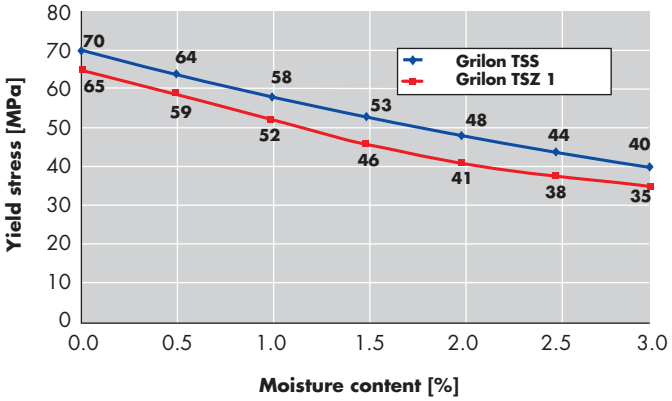


Mechanical properties as a function of moisture content

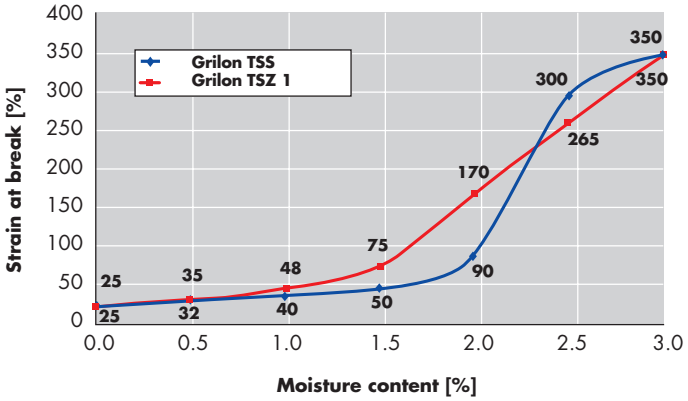
Tensile E modulus Grilon TSS, Grilon TSZ 1



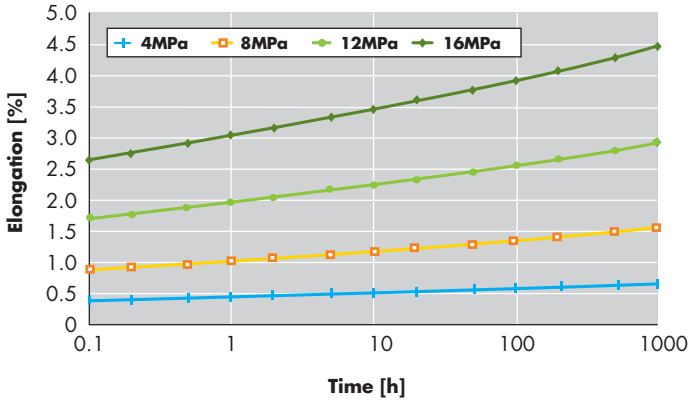
Yield stress Grilon TSS, Grilon TSZ 1



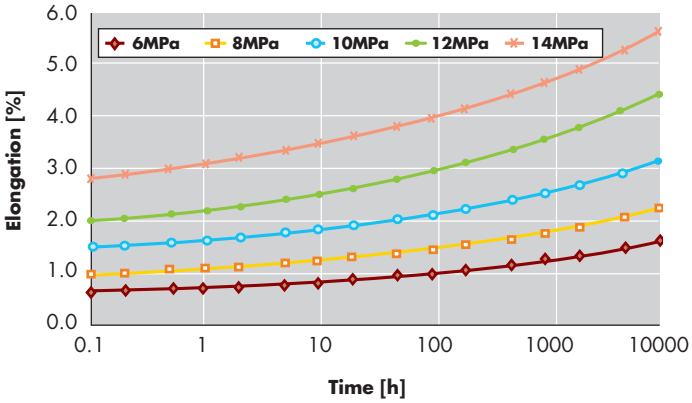
Strain at break Grilon TSS, Grilon TSZ 1



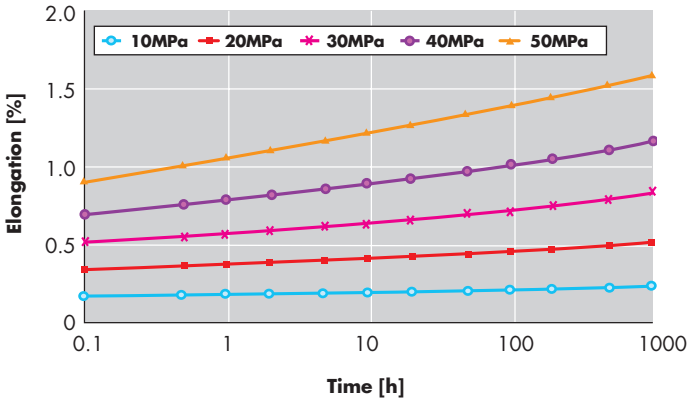
Creep curves Grilon BS/2 at 23°C / 50% r.h.



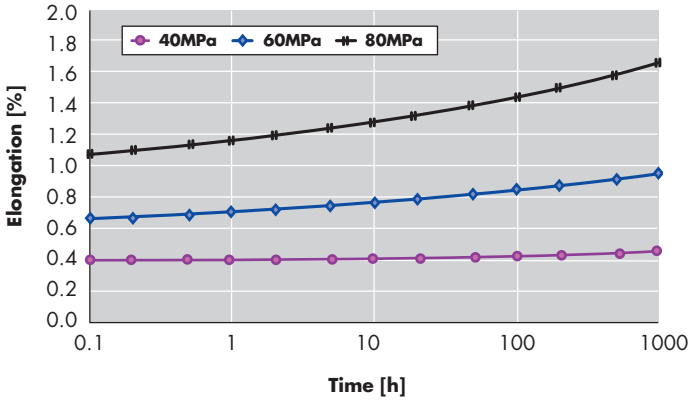
Creep curves Grilon BZ 1/2 at 23°C / 50% r.h.



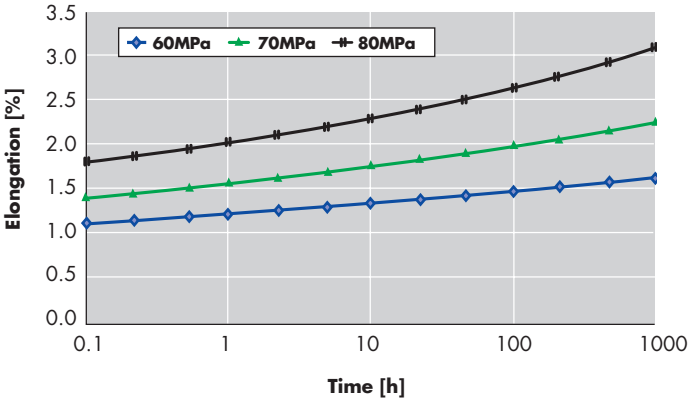
Creep curves Grilon BG-30 S at 23°C / 50% r.h.



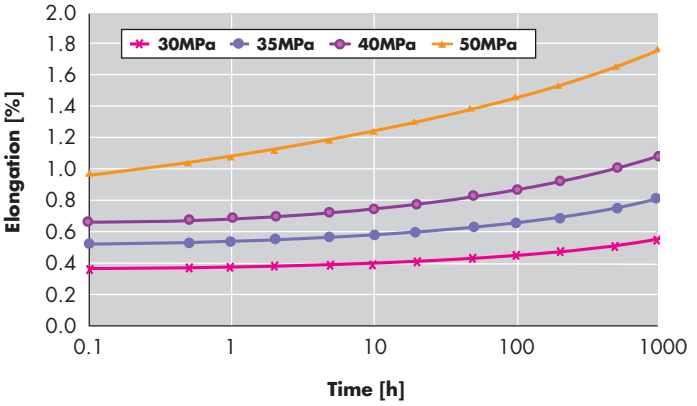
Creep curves Grilon BG-50 H at 23°C / 50% r.h.



Creep curves Grilon BG-50 H at 120°C



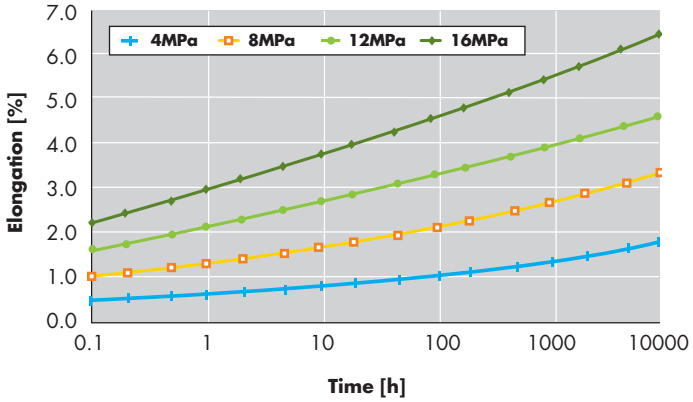
Creep curves Grilon BGM-65 X V0 at 23°C / 50% r.h.



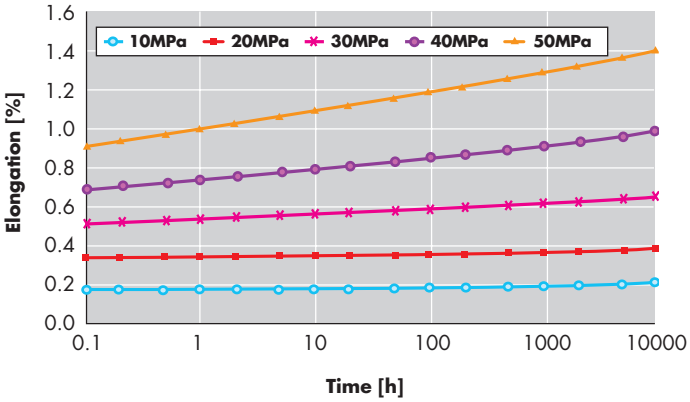
Design data – long-term behaviour

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

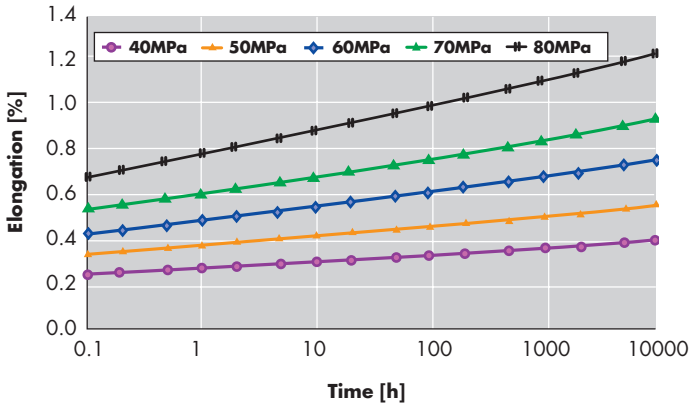
Creep curves Grilon TSS at 23°C / 50% r.h.

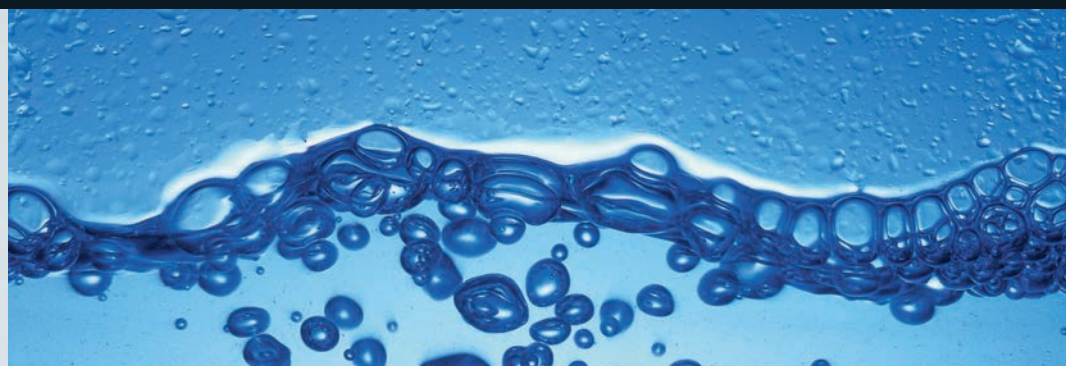


Creep curves Grilon TSG-30/4 at 23°C / 50% r.h.



Creep curves Grilon TSG-50/4 at 23°C / 50% r.h.





Grilon is very resistant to a large number of chemicals. These include organic solvents, petrols, oils, fats and alkalis.
Strong acids, such as sulphuric acid, nitric acid or formic acid, cause swelling and rapid hydrolytic degradation of all Grilon grades. However, Grilon products have short-term resistance to diluted organic acids at room temperatures.

Some aggressive chemicals, such as cresol, hexafluorisopropanol, methanolic calcium chloride solution or trifluoroacetic acid, can dissolve polyamides completely. Glycols, various other acids and water only attack the material chemically at higher temperatures.

o	Acetic acid, conc.
●●●	Acetone
●●●	Ammonia, 10% aqueous
●●●	Amyl acetate
●●	Aniline
●●	Antifreeze (glycol)
●●●	Benzene
●	Benzyl alcohol
●	Bromine
●●●	Butane
●●●	Butanol
●●●	Carbon tetrachloride
●●●	Caustic potash 50%
o	Chlorine
o	Chlorine dioxide
●●●	Chlorobenzene
●	Chloroform
●●	Citric acid, conc.
●●●	Copper sulphate, 10% aqueous
o	Cresol
●●●	Crude oil
●●●	Diesel fuel
●●●	Diethyl ether
●●●	Engine oil
●●●	Ethanol
●●●	Ethylene oxide
●●●	Fats (lipids)
o	Fluorine
●	Formaldehyde
●	Formic acid, 10% aqueous
o	Formic acid, conc.
●●●	Freon liquid F12
●	Freon liquid F22
●●●	Glycerine
●●●	Heptane
●●●	Hydraulic oil
●	Hydrochloric acid 1%
o	Hydrochloric acid, conc.
●	Hydrogen peroxide 2%
●	Hydrogen peroxide 10%
o	Hydrogen peroxide 30%
●●●	Hydrogen sulphide <5% gaseous
o	Iodine tincture, alcoholic
●●●	Isooctane
●●●	Isopropanol
●●●	Kerosene
●●	Lactic acid, aqueous
●●●	Magnesium chloride, 10% aqueous
●●●	Methane
●●●	Methanol
●●	Methylene chloride
●●●	Methyl ethyl ketone
●●●	Mineral oil
o	Nitric acid, conc.
●●	Nitrobenzene
o	Oleum
●●	Oxalic acid, 10% aqueous
●	Ozone
●●●	Perchloroethylene
●●●	Petrol
●●●	Petroleum ether
●	Phenol
●	Phosphoric acid, 10% aqueous
●●●	Potash (potassium carbonate), sat.
o	Potassium permanganate 5%
●●●	Propane
●●●	Pyridine
o	Resorcinol
●●●	Salicylic acid
●●●	Sea water
●●●	Silicone oil
●●●	Soap suds
●●●	Soda, sat. (sodium carbonate)
●●●	Sodium chloride, saturated
●	Sodium hypochlorite, 5% aqueous
●●●	Sulphur
●●	Sulphur dioxide <5% gaseous
●	Sulphuric acid 1%
o	Sulphuric acid, conc.
●●●	Styrene
●●	Tartaric acid, aqueous
●●●	Tetralin
●●●	Toluene
●●●	Transformer oil
●●	Trichloroethane
●●	Trichlorethylene
●●●	Turpentine
●●●	Urea, 20% aqueous
●●	Uric acid, aqueous
●●	Vinegar
●●●	Water
●●●	Wine
●●●	Xylol
●●	Zinc chloride, 50% aqueous

●●●	resistant, only minor, reversible changes in dimensions
●●	limited resistance; significant change in dimensions 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

Resistance to weathering

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 fission, crosslinking and other oxidative processes, resulting in a reduction of the working life of the material.

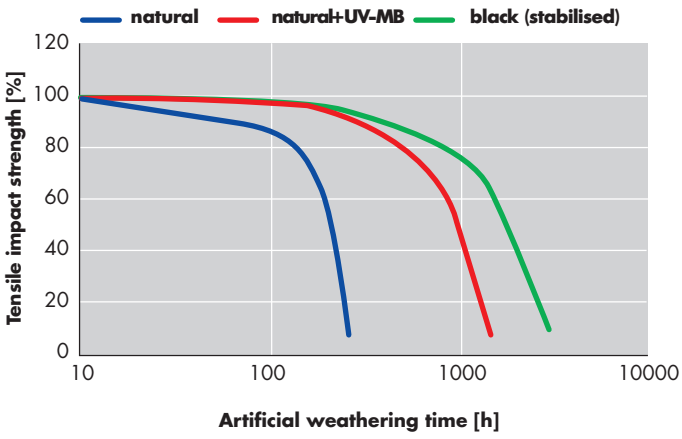
Resistance to weathering is dependent on the structure of the polymers, on their additives and type of reinforcement (glass, mineral, carbon black, colour pigments, etc.). The effects of weathering are observed mainly on the surface of the material, so that the serviceability of a component is very dependent on its thickness.

The working life of polyamide components is determined using accelerated weathering tests. Our material testing department uses 1-mm-thick testing bars exposed on a long-term basis to an aggressive atmosphere with xenon lamp radiation, water spray cycles and temperatures of 65°C.

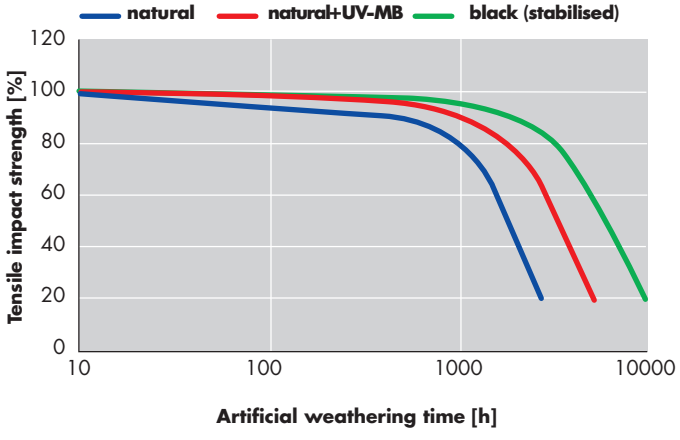
Along with impact strength, test criteria include changes in gloss and colour. In order to obtain test results under practical conditions, outdoor weathering tests are also carried out. The alpine climate at EMS, with an annual global radiation energy of 4.8 GJ/m^2, also allows for realistic correlation with conditions in other climates.

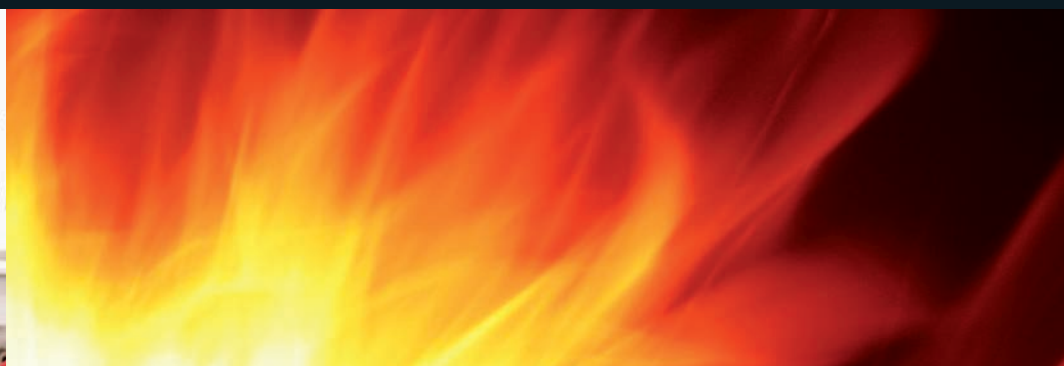
Grilon products are suitable for outdoor applications. The weathering resistance of non-reinforced and reinforced Grilon grades can be improved on a long-term basis by the addition of small amounts of the specially developed UV masterbatch Grilon MB 3427 AUV. The addition of suitable amounts of carbon black (Grilon MB 9295 AC) also significantly improves weathering stability so that a service life of well above 10 years can be achieved.

Resistance to weathering of Grilon AS, BS, TS



Resistance to weathering of Grilon AG-30, BG-30, TSG-30





At elevated temperatures, ageing phenomena occur for 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.

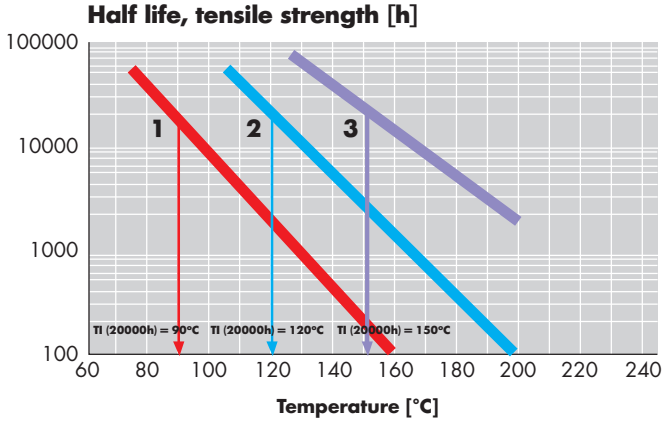
In practice, specification of a temperature-time limit, within which the properties of the thermally stressed plastic material remain at an acceptable level, is of great importance.

Extensive testing has been carried out to determine these temperature-time limits. The correct choice of material and grade then ensures that Grilon products can be used successfully, even at consistently high temperatures.

The maximum time or temperature at which the material has 50% of its tensile strength remaining compared to the original value, can be read from the data presented in an Arrhenius plot. The intersection with the 20,000 hour line gives the temperature index TI20,000. This index is the measurement for the long-term working temperature of a material.

The resistance to heat ageing of non-reinforced and reinforced Grilon grades can be further improved by the addition of small amounts of the heat masterbatch Grilon MB 3388 AH. In this way, the long-term working temperatures can be increased by 10°C – 20°C.

Resistance to heat ageing Arrhenius plots for Grilon non-reinforced and reinforced



Curve 1 = AS, BS, TSS
Curve 2 = AG-30, BG-30, TSG-30
Curve 3 = BG-50 H

Approvals

Grilon in contact with foodstuffs

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 Grilon grades satisfies the requirements of these EU 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. The global migration value for PA6 and PA66 in this case is 60 mg/kg of foodstuff. In the case of PA6, there is also a specific migration threshold value for caprolactam of 15 mg/kg of foodstuff. In the case of PA66, a specific migration value of 2.4 mg/kg of foodstuff applies for hexamethylene diamine.

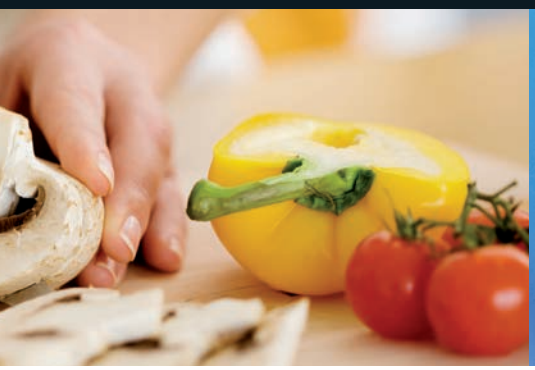
USA

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) issued by the Food and Drug Administration (FDA). Relevant in this regard are Sections 21 CFR 177.1500 (6) for PA6, 21 CFR 177.1500 (1) for PA66 as well as additional paragraphs for the additives.

The following products satisfy requirements for repeated contact with foodstuffs, i.e. short-term contact with constantly new amounts of foodstuffs, in both the EU and the USA:

Grilon BS/1 FA natural
Grilon BG-30 S FA natural
Grilon BG-30 S FA black 9840
Grilon TSS/2 FA natural
Grilon TSS/2 FA black 9840
Grilon TSG-15 FA natural
Grilon TSG-15/4 FA black 9840
Grilon TSG-25/4 FA natural
Grilon TSG-25/4 FA black 9840
Grilon TSG-30/4 FA natural
Grilon TSG-30/4 FA black 9840
Grilon TSG-50 FA natural
Grilon TSG-50 FA black 9833
Grilon TSG-50/4 FA black 9840
Grilon TSGL-40/4 FA black 9840

This list is not necessarily exhaustive. Please contact our sales representatives for more information regarding the suitability of our individual Grilon grades for use in contact with foodstuffs.



Grilon in contact with drinking water
If taps and fittings are to be used in drinking water systems, the taps themselves and, in some cases, the material of which they are made, must be approved for use according to the regulations of the respective countries.

The following requirements must be satisfied:

Germany:
KTW – Federal Environmental Agency guideline on plastics in drinking water
DVGW (German Technical and Scientific Association for Gas and Water) Code of Practice W 270

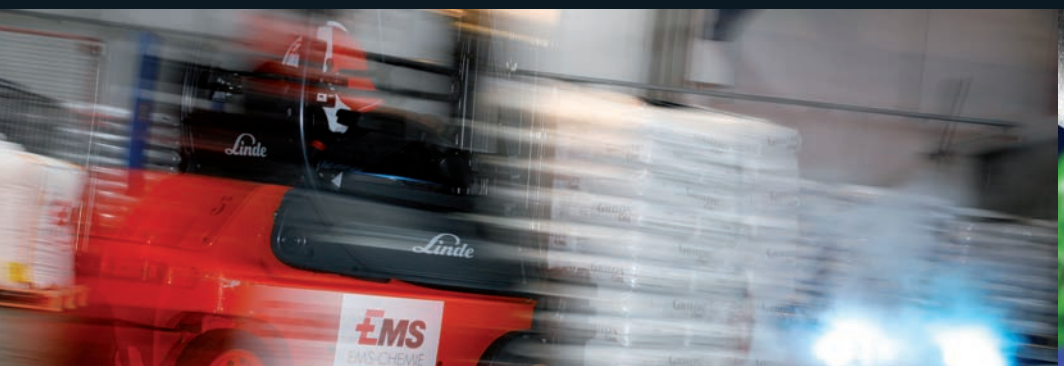
France:
ACS (Attestation de Conformité Sanitaire)

Great Britain:
WRAS (Water Regulations Advisory Scheme)

USA:
NSF 61– NSF International, ANSI/NSF Standard 61 "Drinking Water System Components – Health Effects, System Components"

Please contact our sales representatives for more information regarding the suitability for use of our individual Grilon grades in contact with drinking water.

Storage and drying



Storage

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. If the sacks become damaged, the material must be transferred immediately to a sealable metal container.

However, it is important – particularly during the winter months – that the material to be used is stored for a few days in the processing area in order to ensure that the temperature of the granules reaches the relevant room temperature. This prevents the formation of condensation on the surface of the granules when the sack is opened.

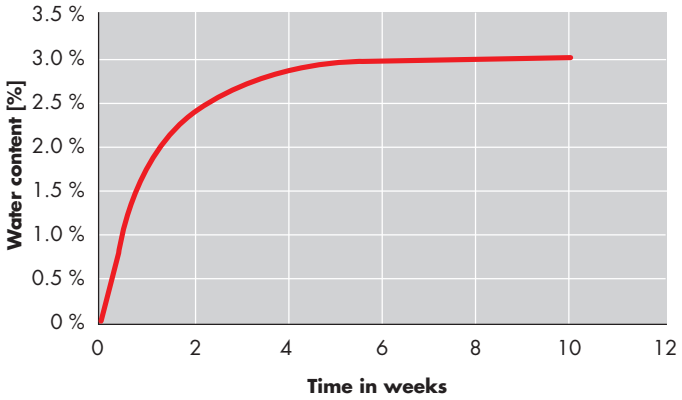
When packaging is opened, the material must be transferred immediately to a feed hopper or dryer. If only a partial amount is to be used from an opened sack, the remaining material should be placed in a resealable metal container with as little air space as possible.

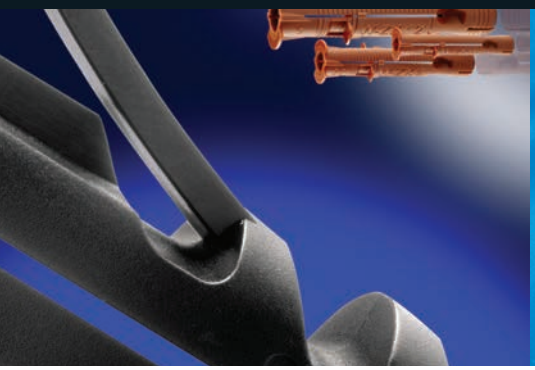
Moisture absorption

Grilon is delivered ready for use. Pre-drying to reduce the moisture content is not necessary.

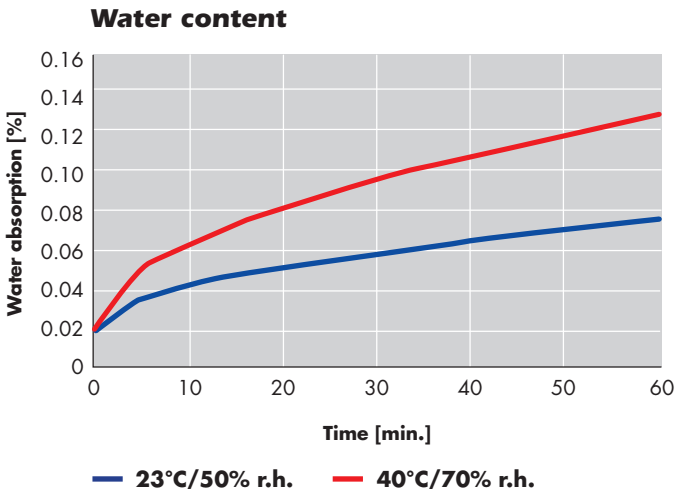
Since polyamides are hygroscopic by nature, the material absorbs water as soon as it is exposed to air humidity. This is the case if sacks are damaged or left open for too long. Excessively long dwell times in open feed hoppers may also result in an increased moisture content of the material.

Water absorption of polyamide 6 at 23°C and an air humidity of 50%





Water absorption of the top layer of granules for PA6 exposed to surrounding air at different temperatures and air humidity levels:



Drying

If the granules have absorbed moisture for any of the previously mentioned reasons, they must be dried.
Air circulating ovens are not suitable for polyamides. The granules can be dried using one of the options below:

Dry air dryer

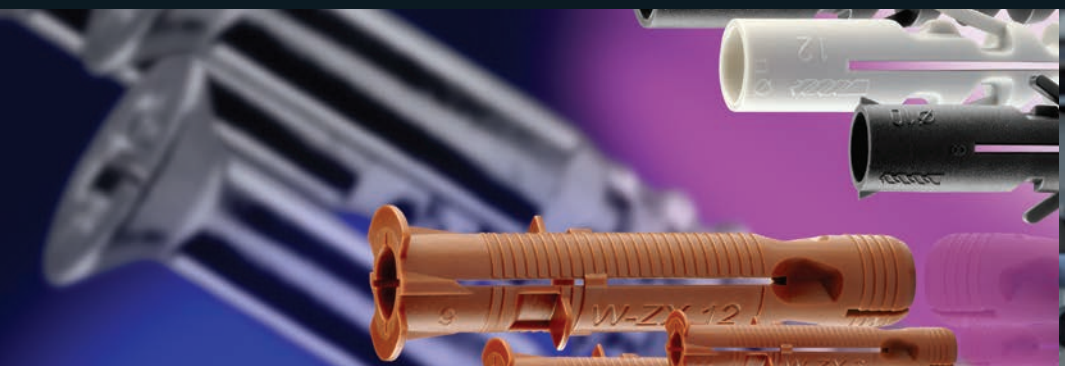
This kind of drying system is widely available. Polyamides should be dried in air at a maximum temperature of 80°C (60°C for low-melting copolyamides). In order to achieve a sufficient level of drying, the drying media (air, inert gas) should have a dew point lower than -25°C.

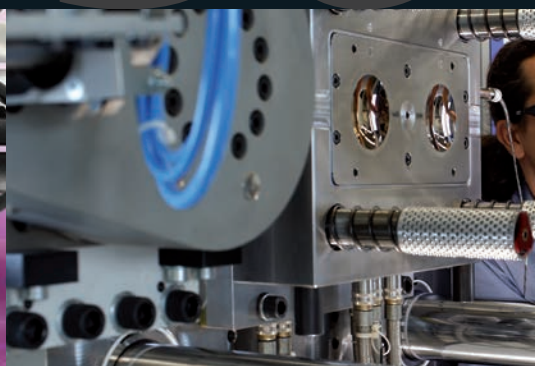
In the case of a moderately increased moisture content, drying times of 4 to 12 hours are sufficient. The necessary time for granules saturated with moisture may be up to 25 hours.

When using an inert gas such as nitrogen, the drying temperature can be raised to 100°C (90°C for low-melting copolyamides). The drying time required for granules saturated with moisture is then approximately 12 hours. At this temperature, correspondingly shorter drying times also apply for granules with a slightly increased moisture content. Towards the end of the drying time, the temperature should be reduced to 70°C. The granules must be allowed sufficient time to cool from 100°C to approx. 70°C to 80°C before they are removed from the dryer.

Vacuum dryer

When using a vacuum dryer, drying can be carried out at a temperature of 100°C (90°C for low-melting copolyamides). An absolute air pressure of less than 200 mbar should be maintained. Granules saturated with moisture should be dried for around 12 hours. When using this system, the temperature should also be reduced to 70°C to 80°C towards the end of the drying period before the granules are removed from the dryer.





Cylinder temperature settings for the plasticising unit lie between 260°C and 310°C for reinforced Grilon grades, and between 240°C and 300°C for non-reinforced grades. In general, flameproof materials have a smaller processing window. The recommended processing temperatures for each Grilon grade are given in the respective data sheets.

Screw

Grilon can be processed efficiently using a single-flight universal three-zone screw. The effective screw length should be between 18 D and 22 D. Use of a non-return valve is always recommended in order to prevent the melt flowing back into the screw flight. Use of a wear-resistant screw is recommended for the processing of Grilon grades with glass-fibre reinforcement.

Nozzle

An open nozzle may be used when processing Grilon because a nozzle of this type allows free flowing and is very long lasting due to its simple structure. However, needle valve nozzles have proved useful if the melt still tends to flow out of the nozzle.

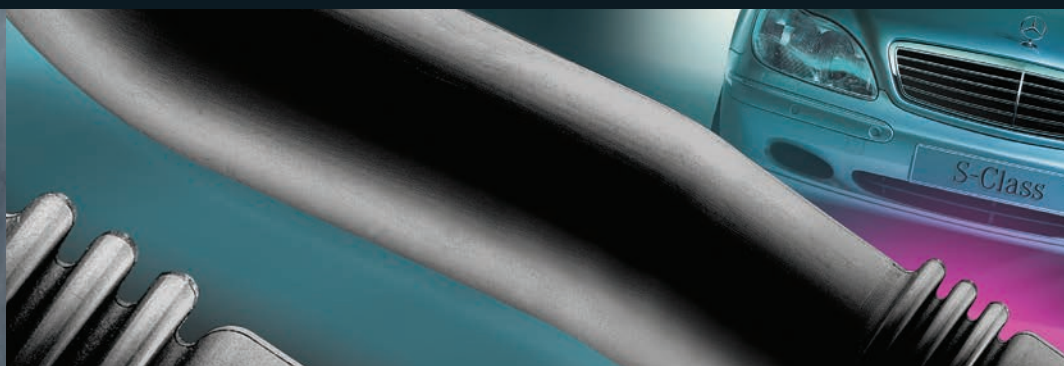
Mould design

Design rules typical for thermoplastics are valid for mould design. Basically, all kinds of sprue systems can be used to process Grilon. Because Grilon grades have a relatively freezing temperature range, the sprue must be adequately dimensioned to prevent premature solidification and to ensure that cavities can be filled easily.

Mould temperature

As a rule, Grilon is processed with a mould temperature of 80°C. In order to improve the surface quality, particularly with reinforced grades, a higher mould temperature of 100°C to 120°C has proved suitable.

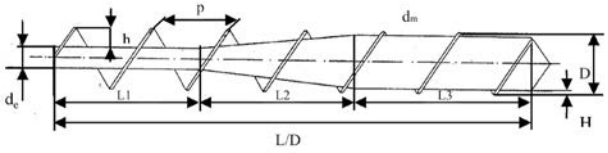
A good temperature control system combined with the correct temperature in the mould is a prerequisite for the manufacture of high-quality injection-moulded parts. The mould temperature influences the setting behaviour and the degree of crystallinity and thus the associated surface quality, shrinkage,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



Extruder

Screw geometry

The following 3-zone geometry, used in combination with a cylinder having a smooth feed zone, has proved suitable as the basic layout for processing Grilon materials:



Compression ratio c =	$\frac{D2 - de^2}{D2 - dm^2}$
Guidelines for the compression ratio: low viscosity grades and copolyamides: c = 3 – 3.8 medium to high viscosity grades: c = 2.7 – 3.5	

Recommended zone lengths taking the total plasticising length 25 x D as an example:

L / D = 25	L1	L2	L3
high and medium viscosity	8–10	4–7	8–11
low viscosity and copolyamides	9–12	3–6	8–11

If mixing segments are used, these must be positioned near or in front of the screw tip. The use of shear elements is not recommended. Barrier screws may exhibit lower compression ratios due to the screw compression.

Feed zone geometry

Polyamide 6 granules are relatively hard in comparison to other polymers such as polyolefins. The higher the temperature, the more significant this difference becomes. Whereas polyolefins may behave like "plasticine" at a given point in the feed zone, PA 6 granules are still "unyielding" and hard. Correspondingly cylinders having a smooth feed zone have proved suitable for use with Grilon materials.

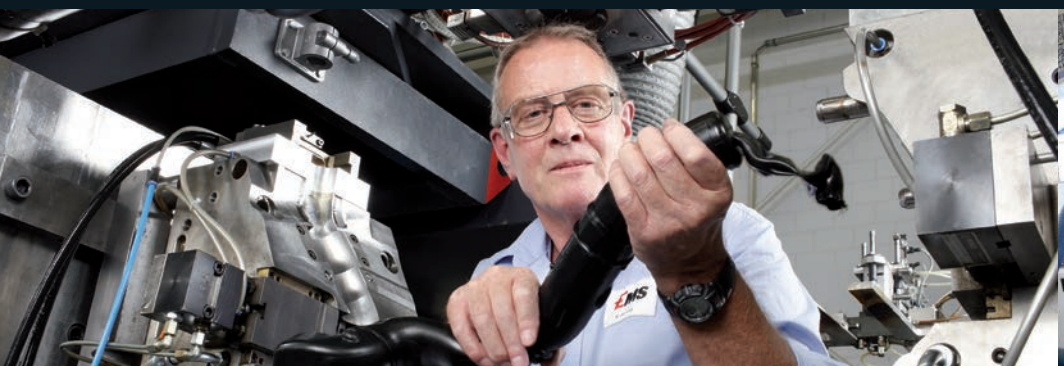
Grooved feed zones can be recommended if:

- they have a groove geometry suitable for polyamides
- the screw geometry of the grooved bush geometry segment is configured for polyamides

Groove profiles should be linear, sawtooth or step shaped up to a maximum groove depth of 0.5 mm for extruders with a 60 mm screw diameter.

When used with Grilon grades, feed bushes with deep grooves, typical for use with polyolefins, cause an enormous increase in torque. This may lead to an approximate 3x higher input power requirement compared to cylindrical, smooth feed zones under the same processing conditions. In order to prevent stalling of the screw, it may be necessary to heat the feed zone with oil to temperatures above 150°C and to carry out the startup procedure gradually.

Use of grooved bushes only increases the specific output performance for PA6 very slightly unlike for polyolefins.



Pipes and parison

The manufacture of pipes and tubes from polyamide materials is carried out using longitudinally moulded-on pipe extrusion heads. Either centre-fed dies (Fig. 1) or spiral mandrel dies (Fig. 2) can be used as extrusion heads. When using a spiral "spider" mandrel die, flow marking and flow lines can be avoided by minimising the profile and number of mandrel supports.

The design of the pipe extrusion head makes a significant contribution to smoothly running extrusion at high speeds and the properties of the extruded pipe such as cold impact strength, burst pressure, long-term compression set and the optical quality of the pipes. Mandrel supports with a streamlined cross-section have proved suitable.

Die dimensions

Die land and haul-off ratio also have a decisive influence on the quality of the extruded pipes. A die land which is too short can lead to significant expansion of the melt on exit which makes subsequent calibration of the pipes very difficult or which does not completely remove flow lines caused by mandrel supports. When processing Grilon materials, we recommend a die land length of 25x the die gap width for a centre-fed die and a minimum of 10 mm for a spiral mandrel die.
The haul-off ratio influences important pipe properties such as cold impact strength, strain at break and resistance to chemicals. The draw-down ratio is of particular importance because it influences the lead into the calibration as well as the stretching of the melt.

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

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

Recommendations for Grilon: Draw-down ratio 1:1.03, haul-off ratio depending on take-off speed: 1.4 – 2.0. The higher the take-off speed, the lower a haul-off ratio can be selected.

Calibration

The conventional calibration method using a vacuum tank with tube or plate calibrating is well suited for Grilon materials. In general, short calibration dies should be used in order to avoid high calibration friction values and rapid solidification. The surface of the calibration channel should be sand-blasted. An effective and uniform lubricating water film should be present at the feed entry.
The calibration shrinkage allowance for Grilon in a vacuum calibrator is dependent on the take-off speed and ranges from 4% to 10% for very high extrusion speeds. High vacuum values should be avoided in order to prevent impairment of the mechanical properties through processing. A vacuum of 100 mbar is sufficient for stable calibration behaviour of high-quality pipes.

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

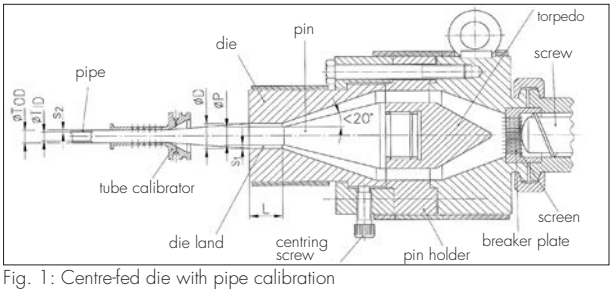


Fig. 1: Centre-fed die with pipe calibration

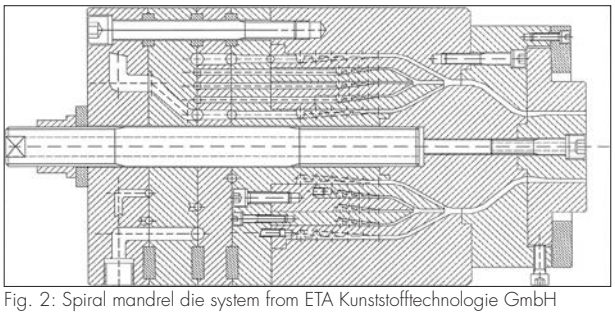
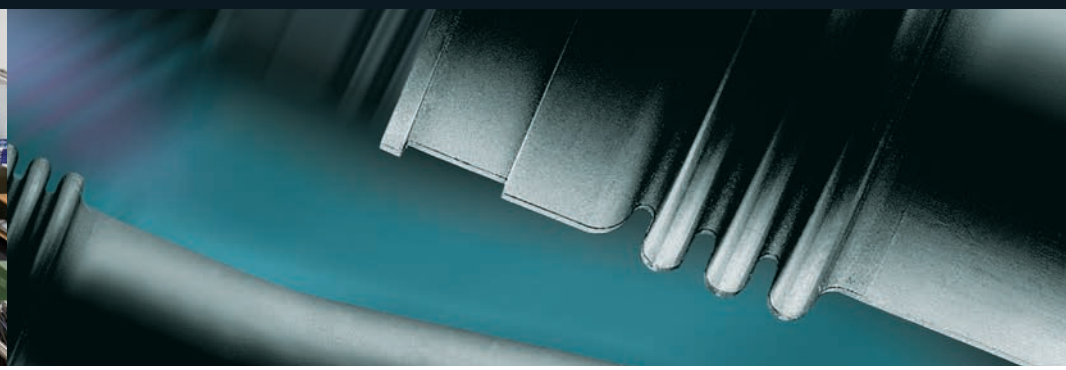


Fig. 2: Spiral mandrel die system from ETA Kunststofftechnologie GmbH



Extrusion blow-moulding dies

As described in the paragraph regarding pipe extrusion, along with centre-fed dies, spiral "spider leg" mandrel dies may also be used. However, spider-leg mandrel supports may cause a longitudinal orientation of the fibres in grades containing glass-fibre reinforcement, resulting in weak spots in the finished part. This can be prevented by staggering the position of the die legs.

When using melt accumulators, FIFO (first-in first-out) dies should be selected in order to avoid extremely long melt dwell times.

Nozzles

The die and core geometries used must ensure sufficient levels of compression (sufficiently convergent flow-channel cross-section for the whole wall thickness control range). This ensures efficiency of wall-thickness control even when the die orifice is opened wide.

Parison swelling

Parison swelling with Grilon materials is generally much smaller than when using polyolefins. General recommendations regarding when to use a larger die compared to those used for processing polyethylene and polypropylene cannot be given because the various Grilon grades differ greatly in this respect. Along with the melt temperature and the shear rates created, the nozzle geometry has a decisive influence.

Parison swelling increases with small diameter nozzles and high output rates. Accordingly, parison swelling can decrease if large nozzles and a relatively slow output rate are used.

Blow ratio

The blow ratio to be selected is dependent on the shape of the finished article – if it is rounded with a nearly even longitudinal cross-section or if it has sharp edges and corners.

possible blow-up ratio	simple part geometry	unfavorable part geometry
non-reinforced Grilon grades	up to ~ 6 : 1	up to ~ 4 : 1
reinforced Grilon grades	up to ~ 4 : 1	up to ~ 2 : 1

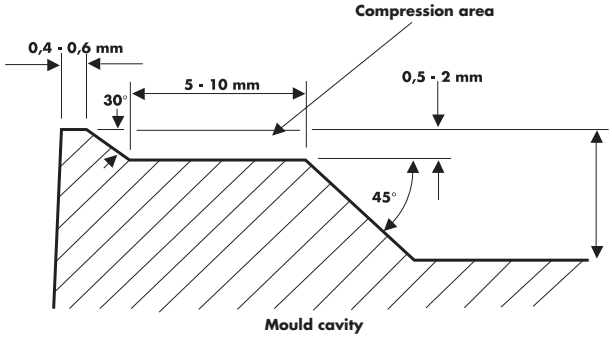
Mould

It is recommended that corrosion-resistant steel grades such as 1.2316, 1.4122 and 1.2083 be used for mould cavities, outer die rings, calibrating mandrels and pinch-off seams. Today, moulds can also be manufactured from surface-hardened aluminium.

Venting slits can be milled to a depth of 0.1 mm and a width of 25 mm in the mould parting surfaces. Vents drilled in the mould cavity side should have a dia-meter of up to 0.3 mm. It is also possible to use sintered metal plates for mould venting.

Geometry of pinch-off seams

When using Grilon materials, the compressed area must be sufficiently dimensioned in order to achieve high pinch-off weld strengths of the finished parts.

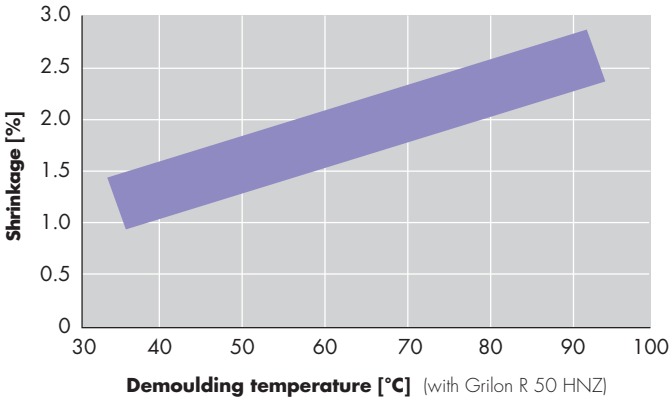


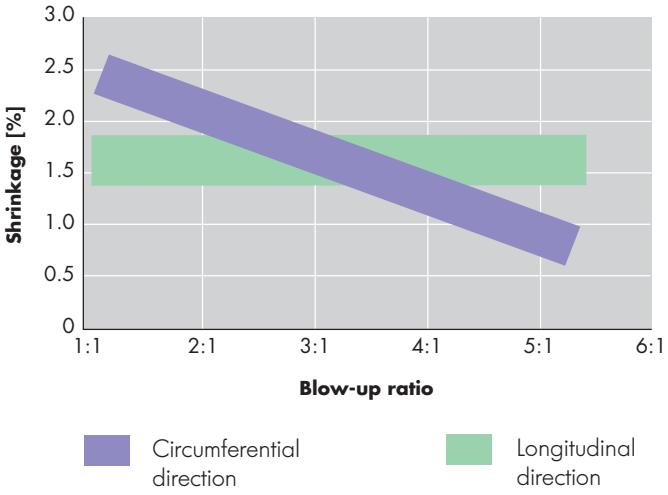
Clamping force

Relatively high nip forces of 1400 N/cm to 2200 N/cm are necessary when processing Grilon materials.

Shrinkage

The following two diagrams show the general dependency of shrinkage. The higher the temperature of a finished article when it is removed from the mould, the greater the shrinkage can be expected to be. Peripheral shrinkage is also influenced by the blow ratio.





Shrinkage values vary significantly according to the Grilon grade being used, the geometry of the part being made, its wall thicknesses and the processing conditions. It is therefore difficult to specify exact shrinkage values.

When experience with the type of material and geometry is limited, moulds should be designed slightly smaller in order to achieve the correct shrinkage allowances later through secondary finishing.

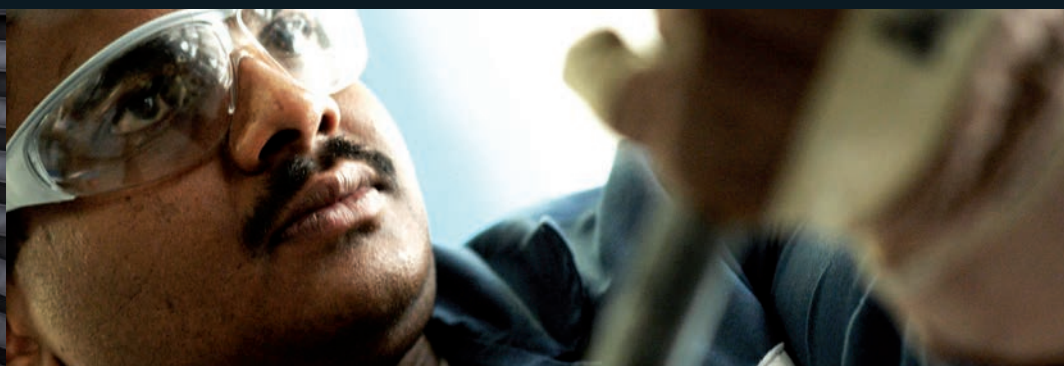
Mould temperatures

Mould temperatures of between 40°C and 80°C are recommended for Grilon grades.

Using reclaimed material

When used correctly (low or correct moisture content, short dwell times of the melt), up to 50% reclaimed material can be mixed with new material without this having noticeable negative effects on the finished articles.

Stable process control, i.e. fewest possible parameter changes in comparison to pure new material, is greatly dependent on the size, shape and uniformity of the pieces of reclaimed material used.



Bonding
Grilon's excellent resistance to chemicals makes it a difficult material to bond. However, with careful choice of adhesive and the correct process technology, good results for adhesion and diffusion bonds can be obtained, so that engineering joints are possible.

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

The most common reaction adhesives:

Single-component systems

- Cyanacrylate or methacrylate adhesives, particularly well suited for bonding Grilon to metal, moulded 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 to activate the bond surfaces.

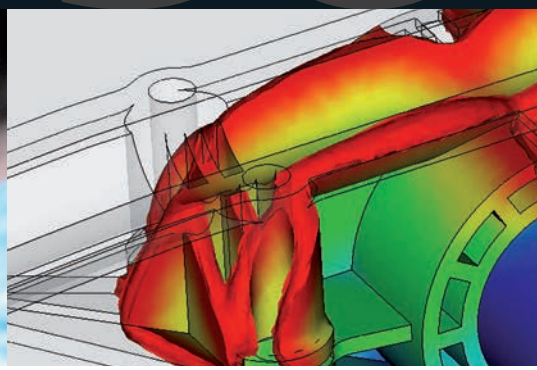
Types of pre-treatment

- Degreasing: use of organic solvents, e.g. acetone
- Mechanical abrasion: brushing, grinding, sandblasting
- Electro-chemical: corona discharge, low pressure plasma
- Thermal: flaming
- Chemical: treatment with corrosive substances; adhesive manufacturers offer suitable primer systems

The choice of suitable adhesive must be made separately for every application because, in addition to the material to be bonded, the joint geometry, the bonding gap and the 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 solid bonds can be obtained for shaped parts made of Grilon using heated element welding, ultrasonic welding, infrared 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 processes are suitable for embedding threaded metal inserts as well as for riveting and beading.



Painting
Due to its excellent resistance to most solvents, Grilon 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 suitable.

Pre-treatment
Special pre-treatment of Grilon 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 shaped parts made of Grilon.

Laser marking and lettering
Various Grilon grades can be modified to be suitable for laser marking and printing if required.

Reusing reclaimed material
The following points should be observed:

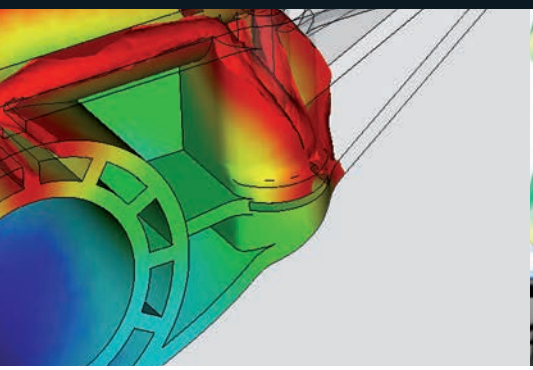
- Water absorption: moisture content
- Grinding: dust content, maximum particle size
- Contamination by other polymers, dust, oil, etc.
- Proportion: percentage addition to original material
- Changes in colour
- Changes in mechanical properties

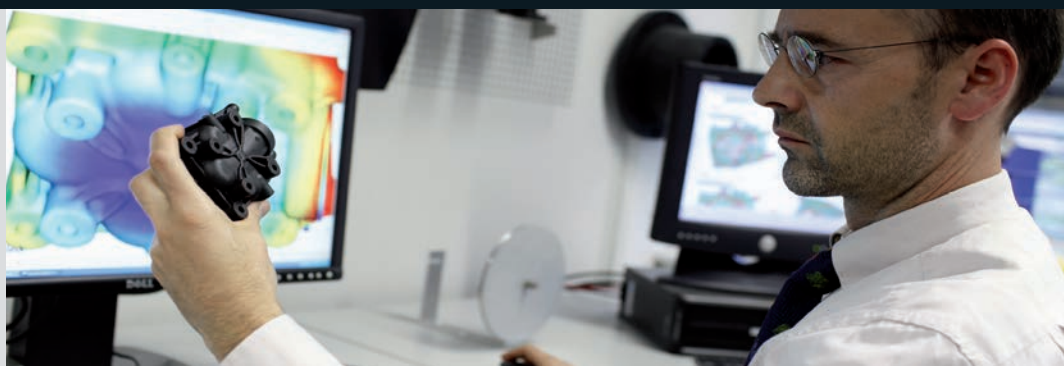
Machining
It should be borne in mind that, for economical reasons, parts should be designed so as to make machining unnecessary. If machining is used to make prototypes, it should be remembered that the properties are not necessarily identical to those of an injection-moulded part.

Methods of pre-treatment are given in the chapter "Bonding".

	Method				
	Unit	Turning	Milling	Sawing	Drilling
Clearance angle	o	5–10	3–15	15–30	5–10
Rake angle	o	2-10	5-15	3-6	6-15
Sectional 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	o	-	-	-	90–120
Circular pitch	mm	-	2–8	-	-

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





We provide 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 processing 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.

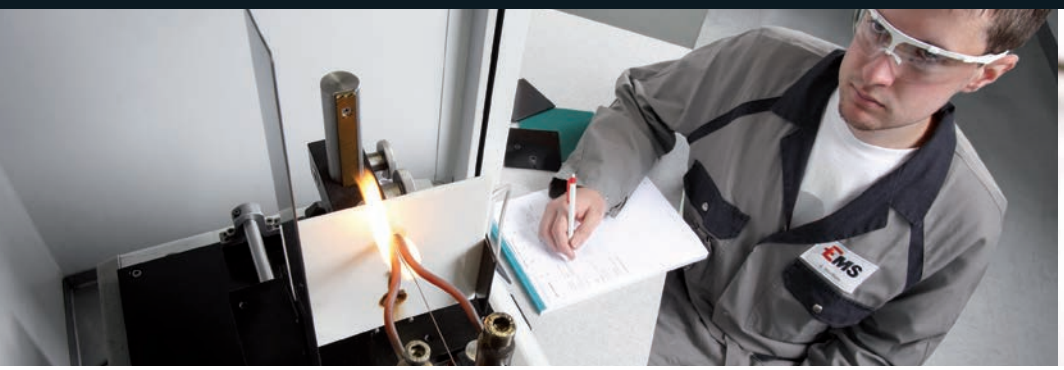
We support you by manufacturing a small series of prototypes for the first practical tests.

In our application development centre, we can also sample metal die-casting tools directly, after small, reversible modifications.

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

With these prototypes you can gain first 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 pneumatic flexural strength apparatus and a dynamic compression-tension machine available for testing the dynamic short-term and long-term stress behaviour of Grilon materials.

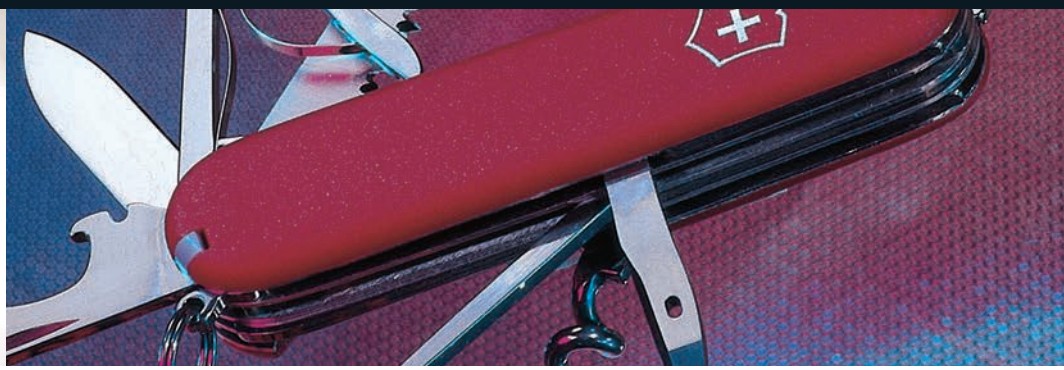
- The rheological laboratory of our materials testing department is capable of supplying characteristic property data for materials necessary for the simulation of injection-moulding processes.

- Laboratory tests carried out to examine resistance to chemicals, heat and weathering 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 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-elongation, creep, shear/loss module, viscosity, pvT).

Material descriptions, chemical resistance information, typical applications and processing information supplement the product profile.

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

The very extensive "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, but 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

The international EMS-GRIVORY production sites all 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.

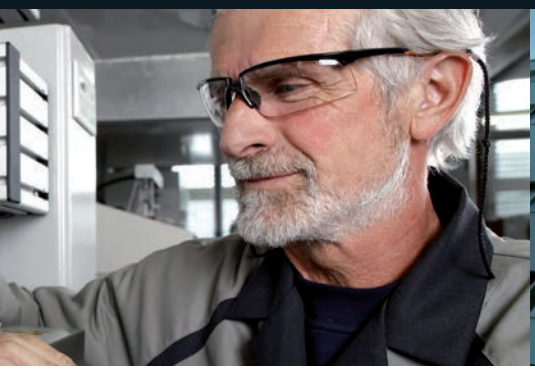
The quality planning cycle begins with market research and ends with customer service. In the intermediate development phase, research and manufacturing face particular challenges.

Development projects are handled by inter-departmental teams working according to the principles of "simultaneous 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. Modern 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 cycloaliphatic units.

Delivery form

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

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

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

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

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

Grilon 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, May 2011

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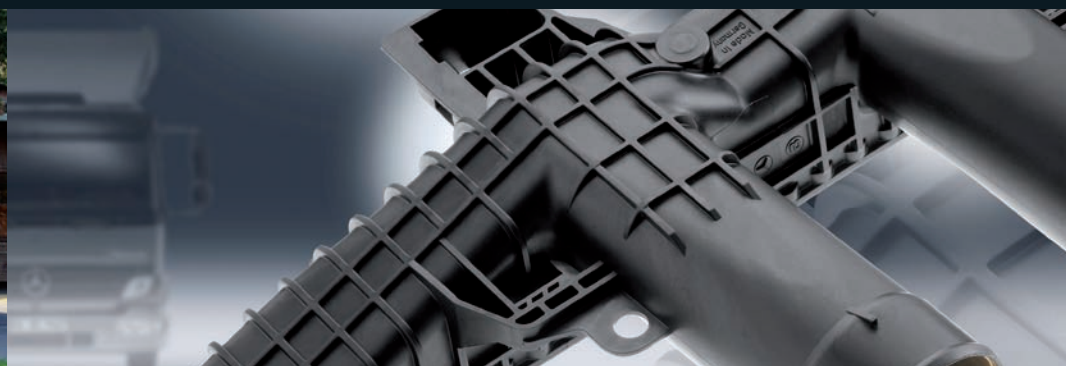

EMS-GRIVORY worldwide
www.emsgrivory.com

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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