TRANSPARENT PRODUCTS

Technical Manual

Transparent PETG sheets

Griphen™ Frost

arla

All information herein described is valid for both Griphen™ and Griphen™ UV, unless stated otherwise.

CONTENTS OF THIS MANUAL

Chemical Resistance

Griphen™ Frost shows a good resistance to a number of chemicals. The overall chemical resistance is however dependent upon the following parameters:

· temperature (resistance decreases with higher temperatures)
· stress level (best resistance is with flat sheet, clamped in a frame)
· chemical concentration (mostly in water, from some ppm to pure)
· exposure time (from fumes over drips to continuous contact)

Following information is meant as a guideline. As to the above influences, it is recommended to perform own testing according to the final application.

Do not hesitate to contact us in case of questions regarding the chemical compatibility of Griphen™ Frost.
In case you want Arla Plast to perform compatibility testing, the product and its MSDS, together with indications on above parameters are required.

In general, Griphen™ Frost shows a good chemical resistance for various chemicals such as dilute solution of acids, salts and aliphatic hydrocarbons, but it is significantly affected by aromatic hydrocarbons and ketones. All tests are performed on flat sheet, immersed in the reagent at room temperature

Reagent				
Acetic Acid	5%	+	a	1
Acetic Acid	10%	0	b	1
Acetic Acid	conc.	-	a	1
Aceton		-	a	1
Aceton		-	b	2
Ammonium Hydroxide	conc.	-	a	1
Ammonium Hydroxide	10%	-	ab	1
Antifreeze, Automotive				
Ethylen Glycol Type		+	a	1
Benzene		-	ab	1
Brake Fluid, DOT3		+	a	1
Brake Fluid, off		0	a	1
Carbon Tetrachloride		-	a	1
Chromic Acid	40%	+	a	1
Citric Acid	10%	+	ab	1
Cottonseed Oil		+	a	1
Deionized Water		+	a	1
Detergent, Alconox (0,25%)		+	a	1
Di(2-Ethylhexyl) Phthalate		+	a	1
Dibutyl Sebacate		+	a	1
Diesel Fuel		0	a	1
Dimethyl Formamide		-	a	1
Ethanol	50%	+	b	2
Ethanol	50%	0	a	1
Ethanol	100%	+	ab	1
Ethyl Acetate		-	a	1
Ethylene Dichloride		-	a	1
Gasohol, 10% Ethanol		0	a	1
Gasohol, 10% Methanol		0	a	1

Gasoline, Base for Gasohol	5%	o	a	1
Gasoline, Premium Unleaded	10%	o	a	1
Gasoline, Regular		+	a	1
Gasoline, Regular Unleaded		o	a	1
Gasoline, Regular Unleaded		-	b	1
Grease, Automotive		+	a	1
Hexane		+	a	1
Heptane		-	b	2
Hydrochloric Acid	conc.	-	a	1
Hydrochloric Acid	10%	o	b	1
Hydrogen Peroxide	3%	+	a	1
Hydrogen Peroxide	28%	+	a	1
Isooctane		+	a	1
Kerosene		+	a	1
Lacquer Thinner		-	a	1
Methyl Alcohol		-	a	1
Mineral Oil		+	a	1
Motor Oil		+	ab	1
Nitric Acid	conc.	-	a	1
Nitric Acid	10%	+	a	1
Nitric Acid	40%	o	a	1
Oleic Acid	83%	+	a	1
Olive Oil		+	ab	1
Phenol	5%	-	ab	1
Silicone Spray Lubricant		-	a	1
Soap Solution	1%	+	a	1
Sodium Carbonate	2%	+	a	1
Sodium Carbonate	20%	+	a	1
Sodium Chloride	10%	+	a	1
Sodium Hydroxide	1%	+	a	1
Sodium Hydroxide	10%	o	b	2
Sodium Hydroxide	10%	-	a	1
Sodium Hypochlorite	3,5%	+	a	1
Sulphuric Acid	conc.	-	a	1
Sulphuric Acid	3%	+	ab	1
Sulphuric Acid	30%	o	ab	1
Tapping Oil		+	a	1
Toluene		-	b	2
Toluene		-	a	1
Transformer Oil		+	a	1
Transmission Fluid		+	a	1
Turpentine		+	a	1
Water		+	b	2

Legend:
+ Resistant
o Limited Resistance
- Not Resistant

Test condition:
(1) Stress free, immersion, 23°C, 1 year
(2) Stress free, immersion, 23°C, 30 days

Source:
(a) Eastman
(b) SK chemicals

Fabricating

1 GENERAL

General Guidelines

Griphen™ Frost sheet can be worked with most tools used for machining wood or metal. Tool speeds should be such that the sheet does not melt from frictional heat. In general, the highest speed at which overheating of the tool or plastic does not occur will give the best results.

It is important to keep cutting tools sharp at all times. Hard, wear-resistant tools with greater cutting clearances than those used for cutting metal are suggested. High-speed or carbon-tipped tools are efficient for long runs and provide accuracy and uniformity of finish.

Since plastics are poor heat conductors, the heat generated by machining operations must be absorbed by the tool or carried away by coolant. A jet of air directed on the cutting edge aids in cooling the tool and in removing chips. Plain water or soapy water is sometimes used for cooling unless the trim scrap is to be reused.

Griphen™ Frost surface might whiten locally when stressed in cold state, like cold bending, die cutting, etc. Also surface friction might cause similar discolouration. This effect can be reduced by local heating (hot air or flame), but will be very difficult to delete fully.

2 SAWING

Circular saw

The table saw type is the most frequently used for sawing flat sheet. When sawing thin gauge sheet, decrease saw speed, feed rate and pitch. Keep the gap between blade and table as small as possible.

Ensure that the table is free of particles that may damage the masking and scratch the Griphen™ Frost sheet.

Band saw

Band saws are used to cut out formed parts, or irregular shapes. For a series of the same shape, a supporting calliper can be useful in preventing chipping. Thicker gauges are best sawn with a bigger tooth size.
To achieve a smooth edge, circular saws and routers are preferable to a band saw.

	Band saw	Circular saw
Clearance angle	20 - 40°	10 - 30°
Rake angle	0 - 5°	5 - 15°
Tooth angle	-	15°
Cutting speed (m/min.)	600 - 1.700	1.000 - 4.000
Tooth distance (mm) t (larger for thicker sheet)	1,5 - 3,5	2 - 10

Trouble shooting

Chipping :Increase blade tooth size and saw speed, decrease feed rate.
Gumming: decrease blade tooth size and saw speed, increase feed rate.
Cracks or notches: as for chipping, check clamping.

In all cases, inspect blade sharpness, check blade fence alignment and if needed use air to cool blade. Change of sound or vibration during sawing, is an indication that sharpness and alignment might have changed.

3 ROUTING

Routing is especially recommended for trimming workpieces. Always use routers of at least 750 Watts, and a speed of 18 000 to 25 000 rpm is preferred. Bits should be straight fluted preferably two-fluted, carbide-tipped, or high-speed steel, with a diameter of 4 to 12 mm. Always feed counter rotation-wise up to 1.5 m/min, and cool with compressed air only.

Manufacturers of routers:
Geiss Thermoforming, Max Mayer, Pacer Systems Limited

4 SHEARING, BLANKING, PUNCHING & DIE CUTTING

Griphen™ Frost surface might whiten locally when stressed in cold state, like cold bending, die cutting, etc.
Also surface friction might cause similar discoloration.

Shearing and Punching

Shearing will produce linear straight-edged cuts, while punching and blanking can produce a variety of shapes. These fabrication methods can be used on Griphen™ Frost sheet in 2 mm. For thicker sheet, routing is preferable to above mentioned techniques. It is important to adjust the blade clearance in relationship to the bed knife. A clearance of approx. 0.025 mm is desirable to avoid a rough edge cut. Cracking and chipping can be reduced by heating the sheet to max 45°C; however, some allowance for hole shrinking due to cooling may be necessary.

Die Cutting

This is a technique frequently applied to paper. Griphen™ Frost can be die cut up to 2 mm, with steel rule dies (A ribbon of steel bent to any desired contour and mounted in or around a block of wood). Blades of 0.8-1 mm thickness work well. The steel rule must be sharpened or replaced fairly often.

Symmetric double bevelled blades (15 & 30°) are recommended. For thicknesses above 1.5 mm asymmetric blades should be used. To obtain straight edges, one side bevelled blades under 30° must be used.

Keep the back-up pad (made out of nylon or HDPE high density polyethylene) in good shape and ensure a perfect alignment of the die and the pad to obtain appropriate cuts.
Adequate power in the die press is needed to achieve the desired cut..

The die press tonnage can be calculated using following formula:
F(Tons) = S x t x P/ 10 000

S = Shear strength = 33 (Mpa)
t = thickness in mm
P = Perimeter of cut in mm

Manufacturers of shearing, punching & die cutting machines:
Sandt AG

5 DRILLING

Drills designed for plastics are recommended, but standard twist drills for metal will do the job as long as they have not been used on metals before, though they require slower speeds and feed rates to produce a clean hole.
For deep holes, in the edges of thicker gauge sheet for example, cool with compressed air and frequently back out the drill to free chips and prevent melting of them. Never use cutting oils. Like other transparent plastics.

Griphen™ Frost is a notch-sensitive material and cutting threads develop stress points that can create stress crazing or cracking. Always keep a distance from the edge, minimum 1.5 times the diameter of the hole. Be sure drilled holes are smooth with no evidence of cracks or roughness, which can cause breakage when fastening.

Do not use countersunk screws with Griphen™ Frost sheet. (see mechanical fastening)

Clearance angle	5 - 15°
Rake angle	0 - 5°
Top angle	110 - 130°
Helix angle	30°
Cutting speed	30 - 60 m/min.
Feed	0,1 – 0,6 mm/rev

6 TAPPING

Be aware that tapping will create notches in the part, which might decrease local impact resistance and stress resistance.

Conventional 4-flute taps can be used for cutting internal threads in plastic sheet when a close fit is required. Such taps, however, have a tendency to generate considerable heat during the tapping operation. A high-speed, 2-flute tap will offer longer life and greater tapping speed than a conventional tap, and provide clearance for chip discharge. In order to obtain uniform thread, flutes should be ground so that both edges cut simultaneously.

Cutting edges should be 85° from the centre line, giving a rake of minus 5° on the front face of the lands so that the tap will not bind in the hole when it is backed out. It is desirable to have some relief on the sides of threads.

7 MILLING

Standard high-speed milling cutters for metal achieve best results, provided they are sharp (not been used on metal before) when applied on.

Typical parameters are 500 rpm and feed 0.25 mm/rev.

8 LASER CUTTING

Lasers can be used to cut Griphen™ Frost, giving clear edges up to 5 mm thickness. The result of the cut depends on the installation and its parameters. Preliminary cutting-tests are recommended. . Laser power and travel speed must be optimised to minimise ‘whitening’ of the Griphen™ Frost sheet while cutting.

Fumes coming off during
cutting might smell unpleasant and therefore it is recommended to use appropriate exhaust systems.

Do not to induce stress into freshly laser cut sheet (e.g. cold brake forming), as breakage might occur.

Therefore it is recommended to anneal the sheet (max 50 °C) or stock it for some time (min 1 week) prior to that specific forming technique.

Forming

1| Cold forming
- · Cold curving
- · Cold bending & brake forming

2| Thermoforming
- · Hot line bending
- · Drape forming
- · Vacuum forming

3| Trouble shooting

1 COLD FORMING

Griphen™ Frost surface might whiten locally when stressed in cold state, like cold bending, die cutting, etc.
Also surface friction might cause similar discoloration. This effect can be reduced by local heating (hot air or flame), but will be very difficult to delete fully.

Cold curving

Griphen™ Frost can be cold curved with a minimum radius of 175 times the gauge thickness for outdoor applications, and 125 times the thickness for indoor applications (Note that when exposed to UV radiation Griphen™ Frost will age similar to PETG sheet). When smaller radii are needed thermoforming is the solution.

Cold bending & brake forming

Due to surface whitening on the bend zone, this technique is not recommended for esthetical reasons.
The alternative is hot line bending.

2 THERMOFORMING

Griphen™ Frost sheet retains its matt surface even when formed with higher draw ratios.
Surface friction has to be reduced to a minimum to avoid local surface whitening. In some cases this whitening can be reduced by locally heating the area with hot air or by means of a flame.

Griphen™ Frost sheet does not need to be pre-dried and can be thermoformed at low temperature (110-155°C). Sheet temperatures over 160°C may cause blistering and damage the sheet.

The adhesive masking on the Griphen™ Frost sheet has to be removed prior to any thermoforming technique.
Take care while heating the sheet. Heating too fast will result in heat accumulating at the sheet surface and degrade it. Because of its low specific heat, Griphen™ Frost sheet requires only a little energy to be formed.
The most appropriate heaters are infra red heaters. Contact heating and high-frequency heating are not suitable.
Halogen heaters only are suitable for coloured sheet.

Hot line bending

The Hot Line Bending equipment is a simple IR- or electrical resistance heater, bending-calliper coated with fabric and a clamping device.
To keep the finished part protected, the masking can be removed locally on the bend zone alone. Perform a preliminary test to find out the correct heating time.
The heating time depends on the power of the IR heaters. With one side heating, it takes about 2 min to make a 3 mm sheet weak enough to bend. Thicker sheet need to be heated from both sides. If not available, turn periodically during the heating cycle. Always bend the sheet with the last heated side forming the outside radius.

When Griphen™ Frost softens, remove from heating source, bend, place into calliper and clamp.
Cool slowly to prevent distortion. Keep the part close to the heating device to make it cool down evenly. Once the part is at about 75 °C, it can be placed in a fixing device and cool down in the air.

Manufacturers of hot line bending machines:
R Clarke & Company Ltd, EFC, Shannon BV

Drape forming

Uni-axial bent parts can be achieved by drape forming. The mould can be made out of wood or aluminium covered with felt. Slight pressure (with soft gloves or cloth, e.g. linen) is sufficient to drape the Griphen™ Frost sheet over a positive mould.

Remove standard masking before putting into an IR oven to be heated. Preferably the sheet should be clamped in a frame, as placing it on a bed might mark the sheet. The sheet temperature should be about 130°C to achieve easy forming. Place sheet on the mould immediately after heating; therefore minimise distance between mould and oven. Cool in surrounding air, but take care for drafts which could cause distortion of, and stress in the finished parts.

Note that as the sheet is not framed during the process it will shrink during the heating process (for thin sheet up to 6% in extrusion direction).

Vacuum forming

Griphen™ Frost sheet retains its matt surface even when formed with higher draw ratios.
Surface friction has to be reduced to a minimum to avoid local surface whitening. In some cases this whitening can be reduced by locally heating the area with hot air or by means of a flame.

Because of its perfect flow properties, Griphen™ Frost sheet, allows you to make the most complex finished parts. Draw ratios of 4:1 can be achieved. Standard available vacuum forming machines, preferably with a sandwich heating system, can be used to forem. Griphen™ Frost requires a minimum vacuum of 500 mm Hg (0,66 atm or 0,066 MPa), but higher vacuum is preferred.

Moulds

Depending on series to be produced and the required finish of the parts, one can use different mould materials. Be aware that the mould material affects both cooling time and finish of the formed parts.

Design moulds with such roundings that the Griphen™ Frost can slip over; however, friction can cause local whitening. For a good evacuation of air, it is important to make an optimum number holes in the right places. Inadequately placed holes might cause optical defects on the formed parts. This may occur especially on parts with large flat surfaces. A mould temperature of 50-55°C gives best results. To achieve a perfect optical finish, it is recommended to use temperature-controlled moulds.

Negative and positive mouldings

Negative moulds result in finished parts with a thin bottom and thick walls, whilst positive moulds result in parts with a thick bottom and thin walls. Depending on the application, either a positive or a negative mould should be built. For better external finish use negative moulds which show more detail.

Heating

Remove standard protection masking prior to thermoforming, and blow off the sheet and mould with ionised pressurised air.

When clamped on 2 sides only (e.g. in automatic feeders) be informed that the free side might shrink (see drape forming). Therefore 4 side clamping is preferred. If a heating profile is available, it is recommended to adjust it as such that when pre-blown, the sheet forms the same shape as the mould. That way the best thickness spread is obtained.

Griphen™ Frost sheet requires only 155°C to form even the most complex structures. One side heating is not recommended for sheets of 3 mm and above. To prevent surface degradation, avoid fast heating. The sheet can only absorb part of the IR radiation and accumulation of heat will damage the sheet and embrittle the formed part.

Cooling the formed part

Cool with compressed air; possibly with water mist (avoid droplets as they might cause marking). Let the part stiffen sufficiently and take it from the mould. Shrinkage of Griphen™ Frost is about 0.4%.

Using positive
moulds, shrinkage might cause removal problems. Take care to remove before the part shrinks on the mould. Do not cool too fast, because the generated stresses may result in cracking. If necessary, post-forming relaxation can be done at 65-75°C.

Take care when stacking formed parts, as surface friction can cause local whitening.

Manufacturers of vacuum forming machines:
Adolf Illig Maschinenbau GmbH & Co KG, Brown Machinery LLC, Formech Ltd, Jürgen Schönwolff, Maschinenfabrik Georg Geiss, Meaf Machines BV, Meico srl – T.S.T., Kiefel GmbH, Reichel GmbH, Shelley Thermoformers International Ltd.

Free Forming

These techniques are utilized in forming dome shapes. Free blown billow forming uses air pressure while free drawing uses a vacuum.

The sheet is heated until a sag is formed. An optical switch and/or a micro-switch are coupled with the pressure (vacuum).The initial pressure (vacuum) is high (2,8 MPa or more) and is lowered towards the end of the forming cycle. The pressure (vacuum) is held until the sheet temperature reaches 75°C and the forming is able to be removed. Here will be no mark-off as no moulds are used, but dirt or oil in compressed air may cause marks on the sheet.

Plug-assist vacuum forming

Corner or periphery thinning of box-shaped articles can be prevented by use of a plug-assist to mechanically stretch and pull additional plastic material into the female cavity. The plug should be 10 to 20 % smaller than the mould and should be heated to ca 110-130°C. Once the plug has forced the hot sheet into the mould cavity, air is drawn from the mould to form the part.

Other methods

Other thermofoming methods are combinations of above mentioned ones.
Plug-assist vacuum forming and plug-assist pressure allow deep drawing and permit shorter cooling cycles and good wall thickness control. Both processes require close temperature control and are more complex than straight vacuum forming. High pressure forming (HPF) and Twin sheet forming (TSF) are two advanced methods which for small to average series can compete with injection moulding and blow moulding.

High Pressure Forming

Using a negative mould, the atmospheric air pressure that spreads the softened sheet over the mould, is increased by pressurised air up to 1 N/mm^2 (10 Kgf/cm2).

Twin Sheet Forming

Two heated sheets are brought between two negative moulds. Air pressure in between those sheet is applied while the circumference of the sheet is clamped. An alternative technique forms the upper and lower part separately, and both parts are brought together, the circumference is reheated to obtain fusion of both parts. This technique creates hollow shapes, to obtain light parts with high structural stiffness.

3 TROUBLESHOOTING

Problem	Possible cause	Solution	HLB	DF	VF	FF
Crazed or weak parts	sheet too hot	reduce heating			✓	✓
	mould too cold	increase mould temperature			✓	
	part removed too late	shorten cooling cycle			✓	
	vacuum rate too fast	restrict vacuum			✓	
	sharp edges	round corners			✓	
	sheet surface too small	use bigger sheet			✓	
Webbing	uneven heating	check for hot spots or shade spots			✓	
	mould spacing too small	min. spacing = 2 x depth			✓	
	vacuum rate too fast	restrict vacuum			✓	
	sheet surface too big	clamp-mould spacing < 50 mm			✓	
Reduced or incomplete details	too small vacuum	check for leaks			✓	
		add vacuum holes			✓	
	sheet temperature too low	increase heating			✓	
Part sticks on to mould	mould too hot	reduce mould temperature			✓	
	part removed too late	remove earlier			✓	
	draft angle too small	draft angle should be> 6°			✓	
Mark-off	mould surface too smooth	Sand surfaces			✓	
	sheet temperature too high	reduce heating time	✓	✓		
	edges: masking came off	cut sheet with unprinted masking up		✓		
	vacuum holes at the wrong place	redesign vacuum holes			✓	
Surface defects	vacuum holes at the wrong place	redesign vacuum holes			✓	
	dust on mould or sheet	clean with compressed air		✓	✓	
Unequal parts	mould/clamp too cold	increase pre-heating			✓	
	uneven heating/cooling	check for drafts, check heater	✓			
	part removed too late	remove part sooner			✓	
Brittle parts	overheated parts	decrease heating power	✓	✓	✓	✓
Cracks or breakage	stresses too high	heat slower on wider area	✓			
Bubbles in the sheet	too much heat	reduce heating	✓		✓	✓
	moisture	pre-dry	✓	✓	✓	✓

Bonding and fastening

1 SOLVENT BONDING

Use extreme caution when working with solvents: they may be toxic or contain carcinogens. Adequate ventilation is essential. Obtain Safety Data Sheets from the solvent manufacturer.

This technique has been used for years to make displays from acrylic sheet, but can also be used to construct three-dimensional shapes with Griphen™ Frost sheet. To bond small pieces, one can use a hypodermic needle and making sure that the solvent flows throughout the area to be cemented.

Edge dipping is another method used to assemble two flat parts under a 90° angle. The edge of the sheet which is to be bonded, is dipped in the solvent until it becomes soft. Then it is put on the flat sheet under slight pressure. The jointed articles can be safely placed on a table to dry after the solvent has been applied. Special care should be taken that no air bubbles are left after curing. Both methods depend on smooth edge preparation, pressure and curing.

Applicable solvents	Boiling point
Methylene dichloride	40,5 °C
Acetone	56,5 °C
Chloroform	61,1 °C
Tetrahydrofurane (THF)	66 °C
Methyl ethyl ketone (MEK)	79.7°C
Trichloroethylene	87,0°C
Cyclohexanone	155,0°C

When using solvents it is advisable that the work area be climate controlled with low humidity to minimise joint ‘whitening’. If this is not possible, the addition of 10 % glacial acetic acid (boiling point 116.5 °C) to the solvent or use of a slower curing cement-type bond is suggested. Solvents with a low boiling point, may cause whitening or insufficient softening of the treated surface which results in improper joints.

To prevent early evaporation, use mixtures of the above mentioned solvents or dissolve Griphen™ Frost chips in one of them to increase boiling point.

Mixture suggestions :
- 42% MEK, 42% Trichloroethylene and 16% Methylene dichloride
- 85% Methylene dichloride, 12% Trichloroethylene and 3% MEK

When using a solvent in which 8% of Griphen™ Frost chips have been dissolved, the curing time is longer, allowing you to adjust the position of the two parts to be bonded, and preventing them from whitening.

To obtain above mentioned solvents contact local chemist or drugstore, or check for specialty chemicals suppliers like www.brenntag.com

2 ADHESIVE BONDING

When working with adhesives, the usual safety and health precautions should be taken and eventual special instructions from the adhesive manufacturer should be observed.

A lot of commercial adhesives have proven their effectiveness for bonding GRIPHEN™FROST. Types, which can be used, are Akrifix™118, Extrufix™, Ruderer™118. Adhesives on polyurethane or acrylic basis give good results. Take into account that stresses in the sheet or parts in combination with solvents or adhesives may cause cracking. For optimum gluing results remove the surface locally. Cut and finish the surfaces to be bonded carefully.

A good alternative is a 2 component polyurethane adhesive, which exists in a clear transparent grade.

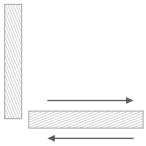
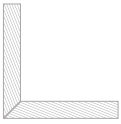
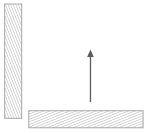
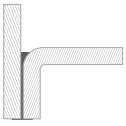
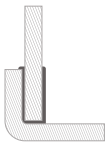
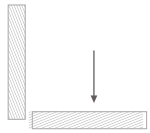
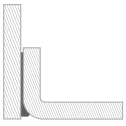
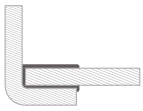
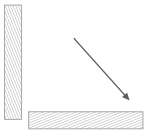
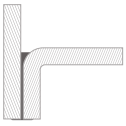
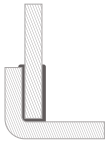
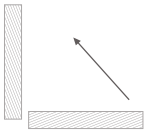
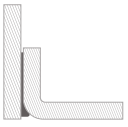
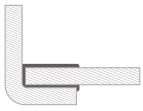
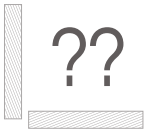
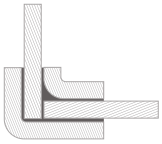
Manufacturers of adhesives:

Agomet Klebstoffe GmbH, Bostik Findley B.V., Engineering Chemicals BV, Kömmerling Chemische Fabrik KG, Loctite Corporation, Lord Corporation (Europe) Ltd., Meco GmbH, National Starch & Chemical NV, Bison International bv, Permabond, Rectavit NV, Ruderer GmbH, UHU GmbH, Vantico

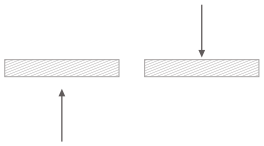
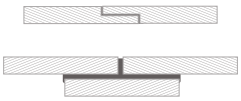
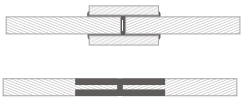
3 RECOMMENDED BONDING DESIGNS

Joint design, often overlooked, should be such that the bonding area carries the load equally, with the major stresses in tension or shear thereby minimising cleavage and peel stresses. The lap joint is the most frequently encountered joint type when working with relatively thin gauge materials.

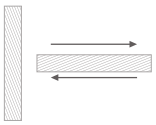
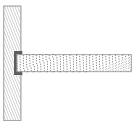
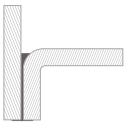
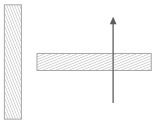
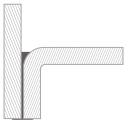
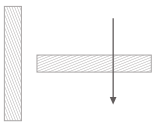
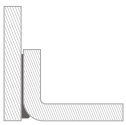
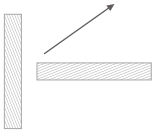
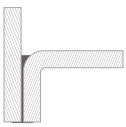
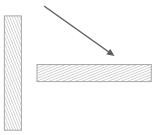
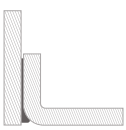
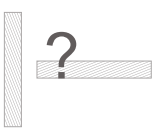
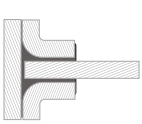
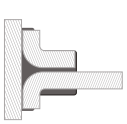
Angular connection

Direction of forces	Recommended construction	
		
		
		
		
		
		

Flat connection

Direction of forces	Recommended construction	
		
		
		

T-shape connection

Direction of forces	Recommended construction	
		
		
		
		
		
		

4 TAPE BONDING

Due to its specific matte surface, tape bonding might not give the right results.
Double sided self adhesive tapes, transparent and mostly on an acrylic basis, can be used to make quick fastenings. These tapes are elastic and stick to different materials. They can be quite useful in bonding thin sheet materials to other plastics, glass or metals.
Use following procedure to make proper bondings:
· Bend along the part for more than tape width.
· Clean this zone with a 50% Isopropyl alcohol - water solution.
· Pressing with wooden roller evacuates trapped air and improves strength.

Manufacturers of bonding tapes:
3M Company, MACtac Europe S.A., Scapa Tapes

5 MECHANICAL FASTENING

Due to its high impact resistance, all types of mechanical fastening can be applied, depending on thickness of the Griphen™ sheet up to 1.5 mm, it can be nailed, stapled or riveted. These kinds of fastening are not recommended for industrial applications.

The best way to fasten Griphen™ is to use screws with a cylindrical head. Never use screws with chamfered heads. They cause stress cracking. Drill holes 0.5 mm larger than the screw. Screws of plastic can always be used. When using metal screws or bolts, use plastic washers (nylon). Metal thumbscrews can be used without washers.

Use galvanised types only.
Never use glue to tighten bolts.
No more than 2 extra twists after turning firm by hand.
Mechanical fastening will produce a stronger part than solvent bonded parts and allows for easier disassembly and cleaning.

6 WELDING

While mechanical fastening and solvent bonding are the most often recommended methods of joining Griphen™ Frost, another alternative is welding.

Ultrasonic welding and spin welding have both proven to be appropriate. High frequency welding is not suited. Contact manufacturers of ultrasonic welding equipment for recommendations on section and joint design.

Manufacturers of ultrasonic welding equipment:
Branson Ultrasonics Corp, Pfaff AG

Also possible is hot air welding, using a welding rod made of PETG or if not available locally also a strip cut from a 3 or 4 mm Griphen™ Frost sheet will work well.

Manufacturers of hot air welding equipment:
Pfaff AG

Finishing

1 Sanding
2 Polishing
3 Decorating

1 SANDING

The sheet edges can be sanded using both wet and dry systems. Dry sanding can result in gumming as frictional heat build-up is created. Wet sanding gives a smooth finish. In both cases, further finishing in order to restore the gloss will be necessary.

Example : start with 80-grit paper and end with 400 or 600-grit.

2 POLISHING

Polishing is a time consuming activity and should only be applied for smaller series and parts made out of thick gauge sheet. The edges can be polished by different techniques. Keep in mind the specific colour of Griphen™: a glass clear edge will rarely be achieved.

Mechanical polishing

After grinding, surfaces of Griphen™ Frost sheet can be polished in order to obtain a better surface finish. Burnish wheels of cloth or fleece and felt polishing bands, together with a suitable polishing wax, give good results. Keep surface temperature low, in order to a later appearance of fine cracks. Suppliers of mechanical polishing tools:

Suppliers of mechanical polishing tools:
3M, EFC (US)

Diamond polishing

Griphen™ Frost sheet can be diamond polished resulting in an excellent surface quality that does not need further treatment. No pre-grinding step is required, as per step up to 0.5 mm can be removed.

Suppliers of Diamond polishing tools:
Shannon B.V., EFC (US)

Flame polishing

Use a standard propane - or butane torch or a hot nitrogen welder. It is very important to control the distance between the sheet and the heat source. Without proper control, surface whitening or material flow of the Griphen™ Frost might occur.

nstead of a torch, an electrical hot air device can be used.
As with Acrylics, flame polishing Griphen™ Frost sheet can cause long-term edge cracking. However, with continued practice and by using proper techniques, excellent results can be achieved.

Solvent polishing

The appearance of saw-cut edges can be improved by first sanding them. For smoother, glossy edges, consider solvent polishing with MEK or methylene dichloride. To prevent humidity blush after drying, add a small amount of a slow-drying component such as diacetone alcohol.

Use extreme caution when working with solvents. Adequate ventilation is essential. Follow precautions Safety Data Sheets from the solvent manufacturer.

3 DECORATING

Flat sheets can be screen printed, tampon printed, hot stamped or decorated with self adhesive films. Vacuum formed parts can be tampon printed or hot stamped.
Other techniques are (spray) painting, laser marking, sand blasting, ...

Hot stamping

Griphen™ Frost sheet or formed parts made out of Griphen™ Frost are easily decorated by hot stamping. Decoration can be done on single pieces (vertical stamping or roll-on stamping) upto continuous pieces. Special types can be thermoformed. Typical conditions are:

Die temperature: 190 °C
Pressure: 0.4 N/mm2
Dwell time: 2-3 seconds

Hot stamping foil / tools manufacturers:
Leonhard Kurz GmbH & Co, John T Marshall Ltd

Screen printing

Griphen™ Frost sheet can be printed with conventional printing equipment. In general, printing inks which are compatible with thermoplastic oriented polyesters (PET) work well. Since the ink does not penetrate GRIPHEN™ FROST as it does with paper or fabric, it is subject to abrasion. This problem can be minimised by applying a clear top lacquer over the printing.

All standard Griphen™ Frost sheets have an adhesive polyethylene masking. It is very important to ensure the sheet is clean and free from dust and dirt prior to screening. Use ionized air to remove dust.
Be careful not to exceed 65°C during the cure process.

In case of questions, please consult your ink supplier.
Apollo colours Ltd, Coates Screen Inks GmbH, Coates Screen inks Ltd, Diegel GmbH, Marabuwerke GmbH & Co, Pröll KG, Ruco Druckfarben, Sericol International, Unico NV

Cleaning

Griphen™ Frost sheet may be cleaned by using a clean soft sponge and washing with lukewarm water containing a mild soap or a slightly acidic, neutral or slightly alkaline detergent. Then rinse thoroughly with clean water and dry with chamois leather or a moist sponge. A subsequent anti-static treatment is recommended. Fresh paint splashes, grease, smeared glazing compounds, etc. can be removed before drying by rubbing lightly with isopropyl alcohol on a soft cloth followed by a thorough wash and rinse as described above. Rust stains can be removed with a 10% oxalic acid solution.

Do not use abrasive or highly alkaline cleaners, acetone, benzene, leaded gasoline or carbon tetrachloride on Griphen™ Frost sheet.

Never scrape with razor-blades or other sharp instruments. Having good electrical insulating properties,Griphen™ Frost sheet is subject to electric static charge and dust attraction. Treatment with an anti-static agent keeps the sheet free from static charge and dust over prolonged periods.

There are some commercially available products which act simultaneously as cleaning agent and anti-static agent. Before commencing certain operations on Griphen™ Frost sheet such as painting, screen printing or thermoforming, it is recommended that dust particles be blown off first, using an ionised air gun. Dusting with a regular air gun or a cloth only moves the particles rather than removing them.

Material Properties

Property	Unit	Value	Standard
Physical Properties			
Density	g/cm^3	1.27	ISO 1183
Light transmission (Light source D65, thickness 3 mm)	%	-	ASTM D1003
Refractive index		1.57	ISO 489
Moisture absorption 24 hours, 23°C, immersion	%	0.2	ISO 62
Mechanical Properties			
Tensile strength at yield	N/mm^2	53	ISO 527
Elongation at yield (at break)	%	40	ISO 527
Modulus of elasticity	N/mm^2	2200	ISO 527
Charpy unnotched impact strength +23°C	kJ/m^2	NB	ISO 179/2D
Izod notched impact strength +23°C	kJ/m^2	11,5	ISO 180/1A
Izod notched impact strength -30°C	kJ/m^2	4,4	ISO 180/1A
Rockwell hardness		R115	ISO 2039-2
Thermal Properties			
Linear coefficient of thermal expansion (23-40°C)	$10^{-6} x\ K^{-1}$	51	ASTM D696
Heat deflection temperature, HDT A (1,80 N/mm^2)	°C	68	ISO 75
Heat deflection temperature, HDT B (0,45 N/mm^2)	°C	72	ISO 75
Thermal conductivity λ	W/m K	0,19	DIN 52612
Fire Properties			
Fire classification according to UL94	Class	HB	UL 94
National fire standards			See below(°)
Oxygen Index	%	25	ASTMD2863-77
Electrical Properties			
Volume resistivity, dry	Ω x cm	10^{16}	IEC 60093
Surface resistivity, dry	Ω	10^{15}	IEC 60093
Dielectric strength, dry (1 mm)	kV/mm	30	IEC 60243
Dielectric constant, dry 1 MHz		2,4	IEC 60250
Dissipation factor (tan δ), dry 1MHz		0,02	IEC 60250

(°) A list of products that have been tested to national fire standards and their respective classification is presented at www.arlaplast.se.
For latest information contact our technical support.

Usefull addresses

3M Europe
Hermeslaan 7
B-1831 Diegem
Tel. +32-2-722 45 00
Fax +32-2-722 45 11
innovation@mmm.com
www.3m.com

Adolf Illig Maschinenbau GmbH & Co KG
Robert Boschstrasse 10
D-74081 Heilbronn
Tel. +49-7131-50 50
Fax +49-7131-50 53 03
info@illig.de
www.illig.de

Apollo colours Ltd
127 Nathan way
West Thamesmead business park
UK-SE28 0AB London
Tel. +44-20-88 54 00 17
Fax +44-20-83 16 69 56
London@apollocolours.co.uk
www.apollocolours.co.uk

Bostik Findley B.V.
Postbus 303
NL-5201 AH 's-Hertogenbosch
De Voerman 8
NL-5215 MH 's-Hertogenbosch
Tel. +31-73-624 42 44
Fax +31-73-624 43 44
info@bostikfindley.nl
www.bostikfindley.nl

Branson ultrasonics
Applied Technologies Group
41 Eagle Rd.
Danbury, CT 06813-1961
Tel. +1-203-796 04 00
Fax +1-203-796 98 38
info@bransonultrasonics.com
www.branson-plasticsjoin.com

Brown Machinery LLC
330 N. Ross Street
Beaverton
USA-48612 MI
Tel. +1-989-435 77 41
Fax +1-989-435 28 21
102557.2203@compuserve.com
www.brown-machine.com

Coates Screen Inks GmbH
Wiederholdplatz 1
D-90459 Nürnberg
Tel. +49-911-64 220
Fax. +49-911-64 222 00
info@coates.de
www.coates.com

Coates Screen inks Ltd
Cray avenue
St. Mary Cray
Orpington
UK-BR5 3TT Kent
Tel. +44-1689-89 96 66
Fax +44-1689-87 82 62
Coates.screen@coates.com
www.coates.com

C.R Clarke & Company Ltd
Betws Industrial Park
Soundry Rd
UK-SA18 2LS Carmarthenshire
Tel. +44/1269 590 530
Fax +44/1269 590 540
sales@crclarke.co.uk
www.crclarke.co.uk

Diegel GmbH
Ernst-Diegel-Straße 1
D-36 291 Alsfeld
Tel. +49-6631 78 50
Fax +49-6631 78 585
info@diegel.de
http://www.diegel.de

Dymax Europe GmbH
Trakehner Strasse 3
D-60441 Frankfurt am Main
Tel.+49-6971-65 20 58
Fax+49-6971-65 38 30
dymaxinfo@dymax.de
www.dymax.com

Edge Finisher Company
16 Stony Hill Road,
USA-06801 Bethel CT
Tel. +1-800-625-5863
Fax +1-203-796-7924
info@edgefinisher.com
www.edgefinisher.com

Engineering Chemicals BV
Van Andelstraat 7
NL-4650 AB Steenbergen
Tel. ++31-1675-669 84
Fax ++31-1675-611 18
e-chem@e-chem.nl
www.e-chem.nl

Formech Ltd.
Unit 4
Thrales end farm/lane
Harpenden
UK-AL5 3NS Hertfordshire
Tel +44-1582-46 97 97
Fax +44-1582-46 96 46
sales@formech.com
www.formech.com

Geiss Thermofoming
Industriestrasse 2
D-96 143 Sesslach
Tel.+49-95-69 92 21 0
Fax+49-95-69 92 21 20
mail@geiss-ttt.com
www.geiss-ttt.com

Haubold Technik
Industriestraße 8
D-69 509 Mörlenbach
Tel. +49-6209-88 19
Fax +49-6209-53 53
Haubold-tgw@t-online.de
www.haubold-technik.de

Henkel Loctite Corporation
Adresses: see website
Email: see website
www.loctite-europe.com

John T Marshall Ltd
Canonbury Works
Dove Road, Essex Road
UK-N1 3LY London
Tel. +44-20-7226 7957
Fax +44-20-7704 9885
sales@johntmarshall.co.uk
www.johntmarshall.co.uk

Jürgen Schönwolff
Reparaturtechnik, Apparatebau
Solterbergstraße 30
D-32602 Vlotho
Tel. +49-5228-549
Fax +49-5228-74 56
info@schoenwolff.de
www.schoenwolff.de

Kiefel GmbH
Industriestraße 17-19
D-83 395 Freilassing
Tel. +49-8654-78 0
Fax +49-8654-78 490
w.eglseer@kiefel.de
www.kiefel.de

Kömmerling Chemische Fabrik KG
Adresses : see website
Email: see website
www.kömmerling.de

Leonhard Kurz GmbH & Co
Schwabacher Straße 482
D-90 709 Fürth/Bay
Tel. +49-911-714 10
Fax +49-911-714 13 57
sales@kurz.de
www.kurz.de

Lord Corporation (Europe) Ltd.
Chemical Products Division
Stretford Motorway Estate
Barton Dock Road, Stretford
UK-M32 0ZH Manchester
Tel. +44-161-8658048
Fax +44-161-8650096
infoadhesives@lord.com
www.lordadhesives.com

MACtac Europe S.A.
Boulevard Kennedy
B-7060 Soignies
Tel. +32-67-34 62 11
Fax +32-67-33 05 74
mactac.europe@bemis.com
www.mactac-europe.com

Max Mayer
Maschinenbau GmbH - Werk I
Postfach 80 13
Flurstraße 34
D-89 218 Neu-Ulm
Tel. +49-730 88 130
Fax +49-730 88 133 10
centrale@maka.com
www.maka.com

Marabuwerke GmbH & Co
Aspergestraße 4
D-71 730 Tamm
Tel. +49-7141 6910
Fax +49-7141 691147
info@marabu.de
www.marabu.de

Meaf Machines BV
Industrieweg 10
Postbus 98
NL-4401 LB Yerseke
Tel. +31/113 57 14 95
Fax +31/113 57 12 56
office@meaf.nl
www.meaf.nl/sitemap

Meco GmbH
Radolfzellerstraße 56
D-78473 Allensbach
Tel. +49-7533-16 11
Fax +49-7533-44 35
service@meco-online.de
www.meco-online.de

Meico srl – T.S.T.
Via della Giardina 8
I-20052 Monza (MI)
Tel. +39/39 27061
Fax +39/39 2706235
sales@meico.it
www.meico.it

National Starch & Chemical
Adresses : see website
Email: see website
www.nationalstarch.com

Pacer Systems Limited
Gauntley Street
UK-NG7 5HF Nottingham
Tel. +44-1159-88 77 770
Fax +44-1159-88 77 88
Support@pacersystems.co.uk
www.pacersystems.co.uk

Bison international
Dr. A.F. Philipsstraat 9
NL-4462 EW Goes
Tel. +31-113-24 82 48
Fax +31-113-23 20 77
info@bison.boltongroup.nl
www.bison.net

Permabond
Woodside Road, Eastleigh
UK-SO50 4EX Hants
Tel. +44-2380-629 628
Fax +44-2380-629 629
helpline.asia@permabond.com
www.permabond.com

Pfaff AG
Postfach 3020
Königstraße 154
D-67 653 Kaiserslautern
Tel. +49-631 2000
Fax +49-631 17202
info@pfaff-industrial.com
www.pfaff-industrial.com

Polar-Mohr
Maschinenvertriebsgesellschaft GmbH&Co.KG
Hattersheimer Straße 25
D-65719 Hofheim
Tel. +49-6192-204-0
Fax +49-6192-22193
polar@polar-mohr.com
www.polar-mohr.de

Pröll KG
Treuchtlinger Straße 29
D-91 781 Weißenburg i. Bay.
Tel. +49-91419060
Fax +49-914190649
wug@proell.de
www.proell.de

Rectavit NV
Anton Catriestraat 39
B-9031 Drongen
Tel. +32-92-26 89 41
Fax +32-92-27 52 49
info@rectavit.be
www.rectavit.be

Reichel GmbH
Mühle 1
D-55 270 Bubenheim
Tel. +49/6130 92030
Fax +49/6130 920322
info@reibu.de
www.reibu.de

Ruco Druckfarben
Lorsbacher straße 28
D-65 817 Eppstein
Tel. +49-6198 30 40
Fax +49-6198 32 288
info@ruco-inks.com
www.ruco.de

Ruderer
Harthauser Strasse 2
D-85604 Zorneding
Tel. +49-8106-24 210
Fax +49-8106-298 96
info@ruderer.de
www.ruderer.de

Sandt AG
Lemberger Straße 82
D-66 932 Pirmasens
Tel. +49-6331-71 30
Fax +49-6331-71 31 43
www.schoen-sandt.de

Scapa Tapes Europe
Holland Street
Denton
UK-M34 3GH Manchester
Tel. +44-1613-36 44 33
Fax +44-1613-35 01 04
www.scapa.com

Sericol International
Pysons Road
Broadstairs
UK-CT10 2LE Kent
Tel. +44/1843 866668
Fax +44/1843 872122
sales@sericol.co.uk
www.sericol.co.uk

Shannon BV
Turfschipper 11-13
NL-2292 JC Wateringen
Tel. +31/174 225 240
Fax +31/174 225 249
info@shannon.nl
www.shannon.nl

Shelley Thermoformers International Ltd.
Stonehill
Stukeley Meadows Industrial Estate
UK-PE29 6DR Huntingdon, Cambridgeshire
Tel. +44-1480-45 36 51
Fax +44-1480-521 13
mbarson@cannon-shelley.co.uk
www.cannon.com

UHU GmbH & Co. KG
Herrmannstrasse 7
D-77815 Bühl/Baden
Tel. +49-7223-28 40
info@uhu.de
www.uhu.de

Unico NV
Essenestraat 20
B-1740 Ternat
Tel. +32-2-582 16 90
Fax +32-2-582 52 40
labo@unico.be
www.unico.be

Vantico
Adresses: see website
Email: see website
www.adhesives.vantico.com