

Technical Manual

Transparent polycarbonate sheets

POLYCARBONATE CLEAR range

POLYCARBONATE COLOURED range

POLYCARBONATE SAPHIR[®] range

All information herein described is valid for:
POLYCARBONATE CLEAR, POLYCARBONATE COLOURED and
POLYCARBONATE SAPHIR grades, unless stated otherwise.

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Storage, handling, and protection

Storage

POLYCARBONATE CLEAR sheet should be stored and protected from atmospheric influences like sun, rain, and heat by storing them inside. Heat and moisture can cause problems.

POLYCARBONATE CLEAR sheets of the same length should be stacked together horizontally and in such a way that the longest sheet is at the bottom of the stack in order to avoid unsupported overhangs.

Do not stack sheets or pallets where they can be walked on or driven into.

Handling

POLYCARBONATE CLEAR sheet should be handled with care to prevent damage and scratching. Each sheet is protected with a Polyethylene protection film to minimise this risk.

The masking film protects the sheet surface against scratches and should be removed only just prior to the actual installation, or shortly after.

Protection

POLYCARBONATE CLEAR sheets are normally delivered with protective masking on both surfaces. Top side printed with brand name and Arla Plast logo and bottom side with a non-printed masking. Depending on the product or the requirements, these maskings can be static or with glue, formable or not, transparent, or coloured. When the sheets are to be heated (thermoforming, hot bending, etc.) it is recommended to remove the printed masking or the masking with glue.

Masking, even thermoformable ones should not be exposed to temperatures or timing exceeding normal forming cycle times and temperatures. It is always advisable to do preliminary testing.

POLYCARBONATE CLEAR sheets are delivered in a standard packaging as general protection against transport and handling damage. Special packaging like for thermoformers is available on request.

Site safety

During the installation of POLYCARBONATE CLEAR sheet all necessary arrangements should be taken to ensure safe working conditions in line with the regulation in force. Never walk on the sheet during installation or maintenance. Use appropriate boards, placed on the purlins, to support the weight.

Chemical resistance

POLYCARBONATE SAPHIR is our polycarbonate (PC) sheet range with a silicon based hard coat. The coating gives a high protection against abrasion and an improved chemical resistance compared to standard polycarbonate. For short term contact (droplets, accidental fumes) its surface is resistant to most chemicals. For longer exposure or exposure to liquids please refer to the chemical compatibility of POLYCARBONATE CLEAR.

POLYCARBONATE CLEAR and POLYCARBONATE COLOURED will have identical chemical compatibility as their UV protected grades POLYCARBONATE CLEAR UV and POLYCARBONATE COLOURED UV.

POLYCARBONATE CLEAR shows a good resistance to several 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 POLYCARBONATE CLEAR.

In case you want Arla Plast AB to perform compatibility testing, the product and its SDS, together with indications on above parameters are required.

In general, POLYCARBONATE CLEAR 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.

The various chemicals were tested according to our standard chemical resistance test procedure. Polycarbonate strips are exposed to the chemicals during a certain period at induced stress levels and temperatures, to check the suitability of POLYCARBONATE CLEAR for use with the tested chemicals. Test results are based on visual observations and physical testing of the strips before and after the exposure to the chemical when needed. The data published in this manual are correct to the best of our knowledge and the knowledge of resin suppliers. If there is any question of the validity of the data, actual testing before using is recommended.

Following are some general guidelines on the chemical resistance of POLYCARBONATE CLEAR sheet.

Acids:

POLYCARBONATE CLEAR in general has a good resistance against diluted inorganic and organic acids. With acids in concentrated form care must be taken.

Bases:

POLYCARBONATE CLEAR will be chemically attacked ranging from partial to complete destruction of the polycarbonate by long-term contact with alkali and alkaline salts. Though the hydraulic stability of POLYCARBONATE CLEAR is limited; it is successfully used in continuous contact with water up to 50°C and can also be used for applications where regular sterilization up to 120°C is required.

Salt solutions:

POLYCARBONATE CLEAR has a good resistance at room temperature to solutions of neutral and acid salts.

Alcohols and glycols:

In general compatibility with POLYCARBONATE CLEAR is good when using alcohols, except for methanol; however, high temperatures in combination with high stress levels should be avoided.

Ethers:

Most ethers can be used with POLYCARBONATE CLEAR in stressless condition for short contact, e.g., dip treatment.

Aromatic, halogenated, per chlorinated hydrocarbons:

POLYCARBONATE CLEAR will be affected by most of these chemicals. It is readily dissolved by certain halogenated solvents, such as Methylene chloride, 1,2 dichloroethane are the most common choice for solvent cementing and casting. Plasticization and crystallization can result from contact with aromatic and per chlorinated hydrocarbons.

Aliphatic hydrocarbons:

POLYCARBONATE CLEAR shows good compatibility with many aliphatic hydrocarbons.

Esters:

Most esters will affect POLYCARBONATE CLEAR resulting in plasticization and crystallization.

Ketones:

Depending on the ketone type these chemicals will dissolve and degrade POLYCARBONATE CLEAR even with short time contacts.

Oils and greases:

Mineral oils without aromatic and naphthenic components are harmless to POLYCARBONATE CLEAR. However, some mineral oils and greases may contain additives and dopes which can attack POLYCARBONATE CLEAR.

Many synthetic oils and greases do attack POLYCARBONATE CLEAR.

Silicone oils do not attack POLYCARBONATE CLEAR in most cases. However, with these lubricants also some exceptions have been found.

Fabricating

- 1 General**
- 2 Sawing**
- 3 Routing**
- 4 Shearing, blanking, punching & die cutting**
- 5 Drilling**
- 6 Tapping**
- 7 Milling**
- 8 Laser cutting**

1 General

General guidelines

POLYCARBONATE CLEAR 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. Allow for sufficient clearance so that only the cutting edge contacts the material.

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. Note however that POLYCARBONATE CLEAR is not compatible with most coolants and cutting oils, therefore we suggest a jet of compressed air directed on the cutting edge aiding the cooling of the tool and removal of chips. Plain water without additives or soapy water is sometimes used for cooling unless the trim scrap is to be reused.

POLYCARBONATE CLEAR sheet is provided with polyethylene masking on both sides to avoid damage to the polished surfaces during transport and processing.

The protective masking should be left on the sheet during machining and subsequent installation. However, remove the masking immediately after installation. Failure to do so could make removal at a later stage extremely difficult: exposure to sunlight, surface erosion, humidity and temperature changes will degrade and embrittle the polyethylene masking.

2 Sawing

Circular saw

The table saw is the most used type for sawing flat sheet. Sawing thinner gauges (below 2 mm) may display a cracked edge due to vibration of the sheet. This can mostly be solved by sawing stacks of ± 16 mm using a thicker sheet or strip (3 mm) beneath as a support (use either POLYCARBONATE CLEAR, MDF, PVC foam or material of similar rigidity). When sawing thin gauge sheet, decrease saw speed, feed rate and pitch. Keep the gap between blade and table as small as possible. Carbide-tipped circular saws with alternate bevel are preferred.

Ensure that the table is free of particles that may damage the masking and scratch the POLYCARBONATE CLEAR sheet. For sawing single sheet thinner than 2 mm, shearing is preferred to sawing.

Band saw

Band saws are used to cut out formed parts and 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.)	600-1.000	1.000-3.000
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/or alignment might have changed.

3 Routing

Routing is especially recommended for trimming work pieces. 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](#)

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4 Shearing, blanking, punching & die cutting

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 POLYCARBONATE CLEAR sheet up to 3 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 90°C; however, some allowance for hole shrinking due to cooling may be necessary. Stack shearing of POLYCARBONATE CLEAR sheet is not recommended, but when done use clamping bar covered with industrial felt and allow a peel cut of 0,5 mm for better quality.

Die cutting

This is a technique frequently applied to paper. POLYCARBONATE CLEAR can be die cut up to 3 mm with no risk, 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.

As for punching, allowance for shrinkage of the holes is necessary (up to 5%) if a thermal treatment follows the machining of the sheet. The tendency towards shrinkage decreases with increasing thickness and hole diameter. Symmetric double beveled blades (15 & 30°) are recommended. For thicknesses above 1,5 mm asymmetric blades should be used. To obtain straight edges, one side beveled blades under 30° must be used.

Keep the back-up pad, made out of polyamide (PA) or high-density polyethylene (HDPE), 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:

$$F(\text{Tons}) = \sigma \times t \times P / 10\,000$$

σ = Shear strength = 40 (MPa)

t = thickness in mm

P = Perimeter of cut in mm

Manufacturers of shearing, punching & die cutting machines:

[Sandt AG, Polar Mohr](#)

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, POLYCARBONATE CLEAR is a notch-sensitive material and cutting threads develop stress points that can create stress crazing or cracking.

For large holes, commercially available clock cutters can be used. 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, to avoid breakage when fastening. It is recommended not to use countersunk screws/bolts with POLYCARBONATE CLEAR sheet. (see mechanical fastening).

Clearance angle	5-15°
Rake angle	0-5°
Top angle	110-130°
Helix angle	30°
Cutting speed	15-60m/min.
Feed	0,1-0,3 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, tend 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.

To obtain uniform thread, flutes should be ground so that both edges cut simultaneously. Cutting edges should be 85° from the centreline, 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 the best results, provided they are sharp (not been used on metal before) when applied on.

Cutting speeds between 100 and 500 m per minute and feed between 0,1 and 0,5 mm per revolution. Typical parameters are 500 rpm and feed of 0,25 mm/rev.

8 Laser cutting

Lasers can be used to cut POLYCARBONATE CLEAR, giving undiscoloured edges up to 1.5 mm thickness. Thicker gauges will show a light brown to dark brown burnt edge; the result of the cut depends on the installation and its parameters. Preliminary cutting-tests are recommended. Laser power and travel speed must be optimized to minimize 'whitening' of the POLYCARBONATE CLEAR sheet while cutting. Fumes coming off during cutting might smell unpleasant and therefore it is recommended to use appropriate evacuation systems, preferably with active carbon filtering.

Do not induce stress into freshly laser cut sheet (e.g., cold forming), as breakage might occur. Therefore, it is recommended to anneal the sheet (max 125 °C) or stock it for some time (min 1 week) prior to the brake forming. A 2 mm POLYCARBONATE CLEAR sheet absorbs about 50 % of the capacity of a CO2 laser.

Excimer-Lasers also perform very well with POLYCARBONATE CLEAR, but only a few types are available for industrial use.

Nd-YAG lasers are not effective, because of the transparency of POLYCARBONATE CLEAR for wavelengths in the visible range, unless wavelength doubling is used (NIR).

Typical settings for POLYCARBONATE CLEAR, somewhat depending on the colour, are 200 W, 24 sec.

Forming

1 Cold forming

- Cold curving
- Cold bending & brake forming

2 Thermoforming

- Hot line bending
- Drape forming
- Vacuum forming

3 Annealing

4 Trouble shooting

All techniques mentioned in this chapter are applicable to all ARLA PLAST AB polycarbonate sheet grades, with exception of POLYCARBONATE SAPHIR® range of sheet, which can be used for flat glazing only. It's hard and scratch resistant surface does not allow for any forming techniques.

Maskings, even thermoformable ones, should not be exposed to temperatures or times exceeding normal forming cycle times and temperatures. It is always advisable to do preliminary testing.

Our POLYCARBONATE CLEAR sheets are delivered in a standard packaging as general protection against transport and handling damage. Special packaging especially developed for thermoformers is available on request.

1 Cold forming

Cold curving

POLYCARBONATE CLEAR can be cold curved with a minimum radius of 175 times the thickness for outdoor applications, and 125 times the thickness for indoor applications. When smaller radii are needed, thermoforming or drape forming is the solution.

Cold bending & brake forming

Brake forming can be done on standard sheet metal down acting brakes, but preferably on hydraulic table folding machines (rotary action), especially for thicker sheet.

When brake forming POLYCARBONATE CLEAR sheet over 6 mm on table folding machines (or over 2 mm on down acting presses), stress levels are too high, and failure can occur. The maximum angle which can be formed depends on the sheet thickness and is limited by the internal stresses due to the forming. Preferably, the forming should be done parallel to the extrusion direction (production number is printed in extrusion direction). Note that several properties including chemical resistance and impact resistance will decrease due to the increased internal tensions. Annealing can reduce these residual stress levels (see below).

Due to relaxation immediately following the bending, an over-bend of approximately 25° is required. If possible, allow the sheet to relax for a few days after bending before assembling it.

In general, hot line bending is preferable to brake forming.

Manufacturers of cold bending & brake forming presses (both rotary and down acting):

[R Clarke & Company Ltd, Haubold Technik, Jürgen Schönwolff, Reichel GmbH.](#)

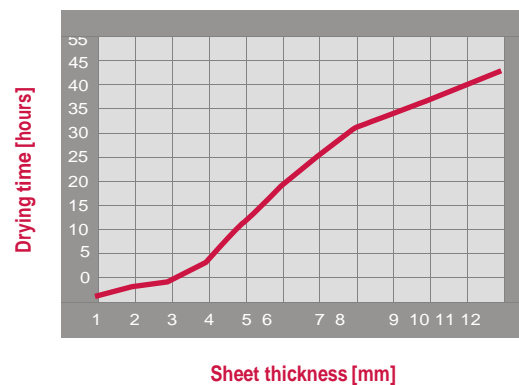
2 Thermoforming

Pre-drying

Despite the very low moisture absorption which contributes to the good dimensional stability of POLYCARBONATE CLEAR sheet, thorough pre-drying of sheet stock is essential for all thermoforming techniques in which the sheet temperature will rise above 160°C. Failure to do so will probably result in moisture blisters.

The recommended procedure is to use an air circulating oven set at 120-125°C. A desiccating type of oven is recommended. After removal of the protective masking the sheet should be suspended (on drilled holes), put upright or laid flat on racks in the oven. Make sure that the sheets are arranged 20-30 mm apart so that the air can circulate freely between them.

Note that it is also possible to pre-dry with the masking on, but drying time is longer. In that case it is recommended that temperature should not exceed 70°C to avoid sticking problems, and that only masking without printing is used (printing – even inkjet, can result in ghosting on the finished product).



When it is required that forming should be done with the masking on the sheet, please contact us for latest information regarding thermoformable masking.

The minimum drying time depends not only on the sheet thickness, but mainly on the moist content. A simple test can be done to obtain optimum drying time: place a part of the dried sheet into an oven at 180°C for 10 minutes.

If bubbles appear, the sheet is not fully dried, and the process needs to be maintained. As soon as no bubbles appear no more, optimum drying time is set.

Pre-dried sheet should, if possible, be left in the oven until immediately before forming to save heating power and heating time on the thermoforming machine. Fully dried sheets taken out of the oven and cooled down to room-temperature may be used within a period of 1 hour up to a maximum of 10 hours (depending on the relative humidity and temperature of the workshop) without the necessity of pre-drying them again.

When preparing a blank for a thermoformed POLYCARBONATE CLEAR part, remember that the sheet shrinks the first time it is heated above the glass transition temperature (about 148°C). Shrinkage up to a maximum of 20% (for thin sheet) can be expected, unless the sheet is clamped in a frame.

Before starting the heating and thermoforming operation, the POLYCARBONATE CLEAR sheet should be cleaned by means of an anti-static cleaning agent or an ionised air gun. This is necessary to avoid marks on, or even imbedding of dirt or dust particles in, the final article.

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Take care while heating the sheet. Heating too fast will result in heat accumulating at the sheet surface and degrading it. The most appropriate heaters are infra-red heaters. Contact heating and high-frequency heating are not suitable.

Halogen heaters are only suitable for coloured sheets.

Hot line bending (HLB)

The Hot line bending equipment is a simple IR- or electrical resistance heater, bending-calliper coated with fabric and a clamping device. It is preferred to remove the masking, as forming occurs at 150-160 °C, but to keep the finished part protected, remove the masking locally but avoid cutting the sheet surface. In some cases, the masking can stay on the sheet during the entire process. Perform a preliminary test to find out the correct heating time.

For sheets up to 2 mm pre-drying normally is not needed. If bubbles occur on the edges, place some insulating material against the edges to avoid overheating them. If bubbles still occur, it might be needed to pre-dry. If inner angles are smaller than 45° the masking should be removed on the inner side.

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 sheets 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 POLYCARBONATE CLEAR 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 and reduce tensions. Once the part is at about 145°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 (DF)

Uni-axial or slightly curved 3D bent parts can be achieved by drape forming. The mould, preferably pre- heated to 80-100°C - can be made from wood, aluminium or resin covered with felt. Slight pressure (with soft gloves or cloth, e.g., linen) is sufficient to drape the POLYCARBONATE CLEAR sheet over a positive mould. An alternative method is to place the flat sheet on the mould, foreseen with a load to push the sheet in place when getting soft. Then place mould and sheets in an oven.

Remove standard masking before putting it into an IR oven to be heated. Preferably the sheet should be clamped in a frame or hung, as placing it on a bed might mark the sheet. The sheet temperature should be about 170°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.

In most cases it is not needed to pre-dry the sheet for the drape forming process. Note that, as the sheet is not framed during the process, it will shrink during the heating process (sheet up to 5 mm can shrink up to 20% in extrusion direction). This can be fine-tuned during extrusion.

Vacuum forming (VF)

Because of its good flow properties, POLYCARBONATE CLEAR sheet, allows you to make complex finished parts.

Draw ratios of 3:1 can be achieved. Standard available vacuum forming machines, preferably with a sandwich heating system can be used to form POLYCARBONATE CLEAR sheet.

POLYCARBONATE CLEAR requires a minimum vacuum of 500 mm Hg (=0,66 atm = 0,066 MPa), but higher vacuum is preferred.

Moulds

For long production runs and/or when optical quality is required, use temperature controlled (120 - 130°C) aluminium or steel tools. For prototypes or limited production work, tools made of plaster, hardwood, reinforced epoxy or polyester resins may be used. Be aware that the mould material affects both cooling time and finish of the formed parts. It is also preferred that the mould roughness (Ra value) is situated between 1 to 1.4. Allow for moulding shrinkage of 0.8 to 1%.

For good evacuation of air, it is important to make an optimum number of holes in the right locations. If that is not the case, optical defects like little pores or craters could be formed. This may occur especially on parts with large flat surfaces. To avoid venting marks on the final moulding, these vent holes should not have diameters larger than 0.5 - 0.8 mm. Back drilling with larger drills is suggested to speed up air evacuation.

Design moulds with such rounding (minimum equal to sheet thickness) that the POLYCARBONATE CLEAR can slip over without risk for thinning and webbing. A good release of the moulding can be obtained by providing a draft angle of minimum 4 to 6°.

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.

Understand that POLYCARBONATE CLEAR reproduces every detail, badly finished moulds included. This can be reduced by either refinishing the mould or by reducing the mould temperature and/or the sheet surface temperature.

Heating

Remove standard protection masking prior to thermoforming and blow off the sheet with ionised pressurised air. When clamped on 2 sides only (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.

It is also recommended that the systems used to support and clamp the edges of the sheet should also be heated, to avoid significant heat losses during heating as well as uneven cooling which could result in internal stresses or edge warping. To improve the thickness gradient the sheet can be blown or mechanically pre-formed by means of a plug.

POLYCARBONATE CLEAR sheet requires between 175 and 210°C to form most structures. It is recommended to supply minimum 30kW/m² as heating power, but if present power is not sufficient, it might help to insulate the process with heat- reflecting material. 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. The necessary heating time, proportional to the sheet thickness, must be determined during preliminary tests on the thermoforming machine.

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. POLYCARBONATE CLEAR sheet cools rapidly, and because of this it requires rapid forming. At the same time, however, its high heat deflection temperature under load enables short cooling cycles to be achieved. The mouldings can be removed from the mould with little risk of deformation as soon as they have cooled down to about 135°C. Mould shrinkage of POLYCARBONATE CLEAR is about 0,8%. Using positive moulds, this 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, annealing can be done.

Manufacturers of vacuum forming machines:

[Adolf Illig Maschinenbau GmbH & Co KG, Brown Machinery LLC, Formech Ltd, Jürgen Schönwölf, Maschinenfabrik Georg Geiss, Meaf Machines BV, Meico srl – T.S.T., Kiefel GmbH, Reichel GmbH, Shelley Thermoformers International Ltd.](#)

Free Forming (FF)

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 135°C and the forming can 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. 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. The plug should be 10 to 20 % smaller than the mould and should be heated to ca 170-180°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 thermoforming methods are combinations of above-mentioned ones. 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 (HPF)

Using a negative mould, the atmospheric air pressure that spreads the softened sheet over the mould, is increased by pressurised air up to 1 MPa.

Twin Sheet Forming (TSF)

Two heated sheets are brought between two negative moulds. Air pressure in between these sheets 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 Annealing

Whenever possible, use the optimum processing conditions to minimize the creation of internal stresses. Parts with too high internal stress levels should be annealed to avoid failure in service. This can be done by heating the parts evenly in an air circulating oven up to 120 - 130°C, at which temperature they should be kept for 1 hour for every 3 mm of the part thickness. Then the part should be cooled slowly to room temperature, preferably in the oven with its doors closed.

4 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
- 2 Adhesive bonding
- 3 Recommended bonding designs
- 4 Tape bonding
- 5 Mechanical fastening
- 6 Welding

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 is not applicable on SAPHIR™ because of its enhanced chemical resistance. Routing off the hard coating is an alternative, but local swelling due to solvent attack might alter the properties of the coating.

Furthermore, it is not recommended to use solvent bonding for bonding two different substrates; adhesive bonding is more appropriate here.

Also note that the use of solvents might decrease properties of the substrates.

Solvent bonding has been used for years to make displays from acrylic sheet but can also be used to construct three- dimensional shapes with POLYCARBONATE CLEAR 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.

To eliminate the solvent presence, maintain the article under pressure at 80-90°C for six hours. If the article is to be exposed to higher temperatures or to boiling water for short periods of time, the parts must be kept at 120°C for five hours.

Suitable solvents	Boiling point
Methylene dichloride	40,5 °C
Chloroform	61,1 °C
Tetrahydrofurane (THF)	66,1 °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 minimize joint 'whitening'. If this is not possible, the addition of 10 % glacial (> 99.8%) 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 POLYCARBONATE CLEAR chips (e.g. saw dust) or granules in one of them to increase boiling point.

When using a solvent in which 8% of POLYCARBONATE CLEAR 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.

A thicker solvent based glue will be easier to fill gaps and irregularities, where on the other hand, a more liquid glue can be applied using capillary action.

To obtain above mentioned solvents contact local chemist or drugstore, or check for specialty chemicals suppliers like [brenntag](#).

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.

This technique is not applicable on SAPHIR™ because of its enhanced chemical resistance. Routing off the hard coating is an alternative, but local swelling due to solvent attack might alter the properties of the coating.

Also note that the use of solvents might decrease properties of the substrates.

Adhesive bonding is interesting for gap-filling bonding, which is not possible with the solvent bonding technique. Also, adhesive bonding mostly is more flexible than solvent bonding. A lot of commercial adhesives have proven their effectiveness for bonding POLYCARBONATE CLEAR (to POLYCARBONATE CLEAR or other materials).

In general, one need only consider the first five types of adhesives listed below, as these are suitable for virtually all types of engineering assembly work and, unlike most of the others, they do not generally need sophisticated equipment.

Essentially there are 12 basic adhesive types which cover nearly all requirements.

1-Anaerobics:

Often known as 'sealants' or locking compounds. Mainly acrylic based, they will normally set in the presence of metal and absence of air (atmospheric oxygen). They are generally used to lock or seal and retain all manner of turned or threaded parts and are often used to seal flanges.

2-Cyanoacrylates:

Also based on acrylic resins. Unlike anaerobes, they require surface moisture as the vital catalyst in hardening. Generally, they harden in seconds. Often used for bonding small parts and rubber.

3-Epoxies:

Based on an epoxy resin which is mixed with a hardener. This allows great variety in formulation; their strength is often employed in bonding larger components. Single part epoxies (ESP) - resin and hardener are pre-mixed so they give high performance without mixing by the user.

4-Toughened variants:

Toughened adhesives incorporate low molecular weight rubbers that build in exceptional resistance to peel and impact forces. Most adhesive types (Acrylic-based, epoxy and epoxy single part (ESP)) can be toughened in this way. 'Toughening' reinforces the best features of these adhesives with the unique shock absorption and strength of the rubber matrix.

5-UV adhesives:

These cure under exposure to UV light (some types even to visible light). Due to their extremely fast cure speeds, they can be easily incorporated into high-speed production lines.

6-Hot melts:

A refined form of the earliest adhesive — hot wax. They are used for assembling small, lightly loaded parts for use in less severe environments. However, they are too viscous for use on small parts.

7-Phenolics:

One of the earliest types of structural adhesive. Their use often involves specialized equipment and complex procedures. Nevertheless, they perform well in severe environments.

8-Plastisols:

Based on PVC dispersions. They cure only at elevated temperatures and are generally used only on large scale work or where there is access to a heat source, intended for another purpose.

9-Polyurethanes:

Like epoxies, they offer variety in formulation. However, polyurethanes are difficult to handle and usually require specialized mixing equipment generally used for bad bearing applications in dry conditions — as they are prone to moisture attack. Transparent types suit well for polycarbonate.

10-Rubber adhesives:

Based on a rubber solution, where the solvent evaporates to effect bonding. Not suitable for loaded joints or harsh environments.

11-Tapes:

Adequate for bonding small components but cannot support heavy loads. Some will withstand quite harsh environments.

12-Silicones:

At present, silicones in combination with polycarbonate sheet is mainly used in glazing and building. Such silicones should be of a neutral type. Also, for POLYCARBONATE SAPHIR, adhesion will be sufficient for building applications.

Material to be bonded: Adhesives can bond virtually every material in common engineering use. Nevertheless, it's sensible to avoid materials troubled by weak or loose surface layers, stress cracking, solvent attack, and water migration. Where there is no substitute for untreated aluminium, cadmium, magnesium zinc, flexible PVC, unprepared glass, polyacetals, polyethylene, polypropylene and PTFE, performance may be improved by appropriate techniques.

Adhesives on polyurethane or acrylic (toughened) basis give mainly good results. Consider that stresses in the sheet or parts in combination with solvents or adhesives may cause cracking. Cut and finish the surfaces to be bonded carefully.

Two component polyurethane adhesives, which exist in a clear transparent grade or transparent UV curable, are the best transparent types. Fast curing cyano-acrylics seem transparent, but often cause whitening. On the other hand, they can be used for preliminary fixing while using another glue.

Note that there is no universal glue. Applicable glue type depends on the application: substrates to be bonded, temperature, humidity, UV resistance, fixed load – shocks or vibrations, bonding speed, bonding surface...

Also keep in mind that rigid, hard adhesives might cause part breakage due to crack propagation.

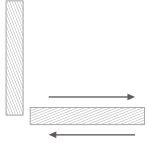
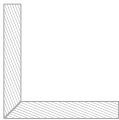
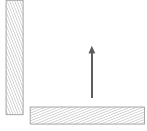
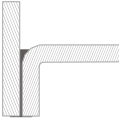
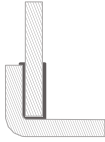
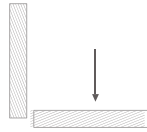
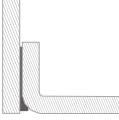
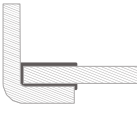
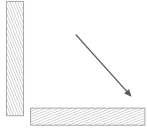
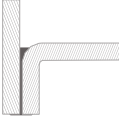
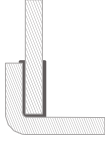
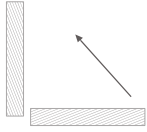

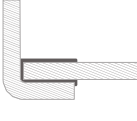


Manufacturers of adhesives:

[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](#)




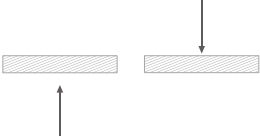



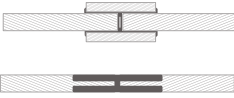
3 Recommended bonding designs

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.

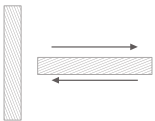
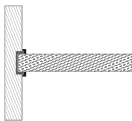
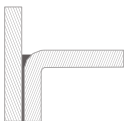
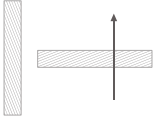
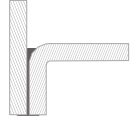
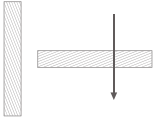
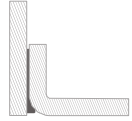
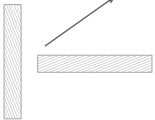
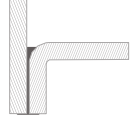
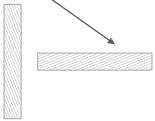

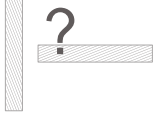

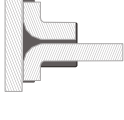
Angular connection

Direction of forces	Recommended construction	
		
		
		
		
		
		

Flat connection

Direction of forces	Recommended construction	
		
		
		

T-shape connection

Direction of forces	Recommended construction	
		
		
		
		
		
		

This information is given in good faith and to the best of our knowledge, but without warranty. Each user of our materials should determine himself the suitability for a specific application, and he is also liable for observing any proprietary or third-party rights. It is always advisable to do preliminary testing. Technical data concerning our products are typical values. Saphir® is a registered trademark of ARLA PLAST AB.

4 Tape bonding

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 bonding:

- 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 POLYCARBONATE CLEAR 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 POLYCARBONATE CLEAR is to use screws with a cylindrical head. Never use screws with chamfered (conical) heads. They cause stress cracking. Drill holes 0,5 mm larger than the screw. The distance between the centre of the hole and the outer edge of the sheet should be at least 2 times the diameter of the hole, with a minimum of 6 mm. The screws should be tightened to a point which still allows the sheet to move under fluctuating temperatures. Screws of plastic can always be used. When using metal screws or bolts, use washers preferably plastic washers (nylon, PE) . Metal thumbscrews can be used without washers, as tensions are limited.

Use galvanized 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.

Special care must be taken to allow for dilatational movement in case of temperature changes during construction or application. For POLYCARBONATE CLEAR count for 3,5 mm per metre.

Solutions are a.o. sleeve holes, flexible fastenings, ... Preferred though is clamping in gasket system (compatible dry systems or plasticizer free neutral types)

Due to the complexity of chemical compatibility, all chemicals which come into contact with polycarbonate should always be tested or approved for polycarbonate.

For sheet products, also sealants, gaskets and the various cleaning media are concerned.

When using glazing compounds, it is essential that the sealant system accepts a certain amount of movement to allow for thermal expansion, without loss of adhesion to the frame or sheet.

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Never use PVC gaskets. Due to the migration of additives from soft PVC, our POLYCARBONATE CLEAR sheet can be chemically affected resulting in surface micro-cracks or even sheet breakage. Compatible Neoprene or EPDM rubbers are recommended.

Specifically for our POLYCARBONATE SAPHIR range: The specific hard coating on POLYCARBONATE SAPHIR sheet makes that POLYCARBONATE SAPHIR surfaces are resistant to many chemicals that under normal circumstances are detrimental to POLYCARBONATE SAPHIR sheet.

Ultrasonic insertion of internally threaded metal bushes can also present a suitable method of fixing POLYCARBONATE CLEAR articles or for attaching metal parts such as hinges, metal standard profiles, etc. to POLYCARBONATE CLEAR sheet. Window machine guards can also be clamped in EPDM rubber profiles, avoiding stress concentrations, and maximising the impact strength of the machine guard.

The required sheet thickness of POLYCARBONATE CLEAR sheet is a function of the size of the sheet and of the load which can be expected.

The dimensions are normally determined by the architect/designer. The load (usually wind- or snow load) must be determined according to local or national regulations in function of the site and the height of the installed glazing. This is usually done by the architect. The recommended rebate depth should be respected. Furthermore, sufficient clearance should be allowed for expansion of the POLYCARBONATE CLEAR sheet after installation. The sealant materials must be chemically compatible with POLYCARBONATE CLEAR and must accept a certain amount of movement of the sheet without loss of adhesion. Rubber gaskets in plasticizer free Chloroprene- or EPDM rubber-based compound give the best results. In most cases a maximum sheet deflection of 50 mm is regarded mainly for aesthetical reasons, or for smaller sizes of 1/25 of the width. In some applications such as sound walls or areas where visibility is low, 80 mm and even higher deflections are allowed.

6 Welding

While mechanical fastening and solvent bonding are the most often recommended methods of joining POLYCARBONATE CLEAR another alternative is welding. However, from an aesthetic point of view, welding is not the preferred assembly technique. Therefore, it is mainly used to assemble opaque sheet products. 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 PC or if not available locally, also a strip cut from a 3 or 4 mm POLYCARBONATE CLEAR sheet will work well. In both cases both the rod and the substrate should be pre-dried to avoid bubble formation. Typical parameters are airflow at 350 - 400°C, measured at 5 mm from the nose and min. 100 mm/min feed in order to avoid material decomposition. Maximum welding zone is 300 mm to avoid severe and excessive internal tensions with risk for breakage. This technique is not suitable for POLYCARBONATE SAPHIR.

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 to restore the gloss will be necessary. In case of abrasive belts with synthetic resin bonding are used (for dry and wet sanding), a belt speed of 20 - 30 m/s and a low contact pressure are recommended.

Example: start with 80-grit paper, continue with grit 200 and end with 400 or 600-grit.

Note that sheet with enhanced UV protection (POLYCARBONATE CLEAR UV and POLYCARBONATE COLOURED UV range), do not have UV protection on the cut edges.

2 Polishing

Note that sheet with enhanced UV protection (POLYCARBONATE CLEAR UV and POLYCARBONATE COLOURED UV range), are protected via coextrusion. Polishing their surface might remove this thin coextruded UV layer locally.

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 POLYCARBONATE CLEAR, as a glass clear edge will rarely be achieved.

Mechanical polishing

After sanding, surfaces of POLYCARBONATE CLEAR 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:

[3M, EFC \(US\)](#)

Diamond polishing

POLYCARBONATE CLEAR 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 POLYCARBONATE CLEAR might occur.

Instead of a torch, an electrical hot air device can be used. Typically, 400-550 °C for 5 seconds moving at 100 mm can be used to remove scratches.

As with Acrylics, flame polishing POLYCARBONATE CLEAR 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 Methylene dichloride. To prevent humidity blush after drying, add a small amount of a slow-drying component such as diacetone alcohol. As to its relatively good chemical resistance, it will be difficult to eliminate all sawing traces using this technique.

Use extreme caution when working with solvents. Adequate ventilation is essential. Follow precautions in the 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 (thin cast films are preferred as they limit bubble formation and are less subject to out gassing). Vacuum formed parts can be tampon printed or hot stamped.

The decoration of POLYCARBONATE SAPHIR sheet is extremely difficult due to the chemical resistant properties of its surface. On request we can offer 1-side hard coated POLYCARBONATE SAPHIR HC LG sheet, or our POLYCARBONATE SAPHIR SPD (see under screen printing).

Other common techniques are (spray) painting, laser marking and sand blasting.

Hot stamping

POLYCARBONATE CLEAR sheet or formed parts made out of POLYCARBONATE CLEAR are easily decorated by hot stamping. Decoration can be done on single pieces (vertical stamping or roll-on stamping) up to continuous pieces. Special types can be thermoformed after application.

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

POLYCARBONATE CLEAR sheet can be printed with conventional printing equipment. In general, printing inks which are compatible with polycarbonate (PC) work well. Since the ink does not penetrate POLYCARBONATE CLEAR as it does with paper or fabric, it is subject to abrasion. This problem can be minimized by reverse printing or by applying a CLEAR top lacquer over the printing.

All standard POLYCARBONATE CLEAR sheets have a static (glue free) polyethylene masking which is easy to remove. To avoid the so-called ghosting effect with metallic paints, it is recommended to print on the side with the non-printed 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.

Our POLYCARBONATE SAPHIR SPD sheet is a polycarbonate sheet screen printed with a special ink and coated with a scratch resistant coating. Contact us for more information.

In case of questions, please consult your ink supplier.

Following printing ink manufacturers have experience with our sheet:

[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

POLYCARBONATE CLEAR 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 POLYCARBONATE CLEAR sheet. Never scrape with razor-blades or other sharp instruments.

Minor scratches can be removed or made less noticeable by polishing with hot air. (see polishing)

Having good electrical insulating properties, POLYCARBONATE CLEAR 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 POLYCARBONATE CLEAR sheet such as painting, screen printing or thermoforming, it is recommended that dust particles be blown off first, using an ionized air gun. Dusting with a regular air gun or a cloth only moves the particles rather than removing them.

The protective coating of the SAPHIR sheet makes it more tolerant towards chemical attacks. Stains from ink, paint and marks from graffiti can be removed with products designed for this purpose (ask the supplier for the right graffiti remover). Always be careful not to scratch the surface of the sheet, and – in case it is not compatible with polycarbonate – to avoid contact with non-coated areas (edges, holes...).

Suitable cleaning solvents for POLYCARBONATE CLEAR at room temperature are water, white spirit, hexane, heptane, Ethyl alcohol, Butyl alcohol, isopropyl alcohol (also known as IPA or Isopropanol).

As far as cleaning in dish washing machines or rinsing devices is concerned, in order to remove bits of food and the remains of meals, care should be taken that the concentration recommended by the manufacturers, mostly 0,1-0,5%, of the normally strongly alkaline pre rinsing solution, is not exceeded. Also the temperature should not rise above 60°C, better still 55°C. The rinsing cycle which follows, when usually weakly acidic or neutral active substances are contained in the water, can be carried out as usual at 80-85°C on account of the very short contact time (less than two minutes).

It is important when cleaning animal breeding cages made of POLYCARBONATE CLEAR that the litter is carefully removed. If an alkaline cleaning material is used, this must be rinsed off completely, as the following conventional sterilisation will otherwise leave dull marks on the surface.

In order to avoid scale deposits the water used in cleaning equipment should be demineralised. If in spite of this lime has formed on the surface of the product it is advisable to remove this, e.g., with dilute acetic acid.

Typical material properties

POLYCARBONATE CLEAR

(for other products see our website)

Property	Value	Unit	Standard
Physical properties			
Density	1,2	g/cm ³	ISO 1183
Refractive index (20 °C)	1,586		ISO 489
Moisture absorption 24 h, 23 °C, 50% RH	0,15	%	ISO 62
Mechanical properties			
Tensile strength at yield (at break)	60 (70)	N/mm ²	ISO 527
Elongation at yield (at break)	6 (110)	%	ISO 527
Elastic modulus	>2300	N/mm ²	ISO 527
Flexural modulus	>2300	N/mm ²	ISO 178
Charpy unnotched impact strength -40 °C	NB	kJ/m ²	ISO 179/1eU
Charpy notched impact strength -30 °C	11	kJ/m ²	ISO 179/1eA
Izod notched impact strength +23 °C	65	kJ/m ²	ISO 180/1A
Izod notched impact strength -30 °C	10	kJ/m ²	ISO 180/1A
Thermal properties			
Coefficient of linear thermal expansion (20-70 °C)	65x10 ⁻⁶	K ⁻¹	ISO 11359-2
Heat deflection temperature, HDT A (1,80 N/mm ²)	132	°C	ISO 75
Heat deflection temperature, HDT B (0,45 N/mm ²)	142	°C	ISO 75
Vicat temperature VST/B 120	149	°C	ISO 306
Vicat temperature VST/B 50	148	°C	ISO 306
Thermal conductivity	0,20	W/m.K	ISO 8302
Electrical properties			
Volume resistivity, dry	>10 ¹⁴	Ω.m	IEC 62631
Surface resistivity, dry	10 ¹⁶	Ω	IEC 62631
Dielectric strength, dry	30	kV/mm	IEC 60243
Dielectric constant, dry 50 Hz	3		IEC 62631
Dielectric constant, dry 1 MHz	2,9		IEC 62631
Dissipation factor (tan δ), dry 50 Hz	0,001		IEC 62631
Dissipation factor (tan δ), dry 1 MHz	0,01		IEC 62631

All properties are polycarbonate properties. (°) A list of products that have been tested to national fire standards and their respective classification is presented at www.arlaplast.com. For latest information contact us at technicalsupport@arlaplast.com.

Useful 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 5303
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 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@bostik.nl
www.bostik.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
sales@brown-machine.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.de

Sun chemicals EUROPE
Wexham Springs
Framewood Rd.
Slough, SL3 6PJ
United Kingdom
Tel.: + 44-203 139 0000
Fax.: + 44-203 139 0001
www.sunchemical.com

C.R Clarke & Company
Ltd Betws Industrial Park
Sundry 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>

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

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

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

Edge Finisher Company
 16 Stony Hill Road,
 USA-06801 Bethel CT
 Tel. +1- 203-792-8622
 Fax +1-203-796-7924
info@edgefinisher.com
www.edgefinisher.com

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

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

Colourfoil Ltd.
 3 Brewery Fields,
 Church Street,
 Great Baddow,
 Chelmsford,
 UK - Essex, CM2 7LE.
 Tel: +44 1245 807 858
 Fax: +44 844 562 4059
www.colourfoil.co.uk

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

Jürgen Schönwolff
 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.koemmerling.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

Meco GmbH

Radolfzellerstraße 56

D-78473 Allensbach

Tel. +49-7533-16 11

Fax +49-7533-44 35

www.mecostat.com

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

AXYZ International -

Nottingham

Unit i5a Cowlairs

UK - Nottingham, NG5 9RA

Tel: 44-115 975 8100

Fax: 44-115 979 4600_

www.axyz.com

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

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

Permabond
 Permabond
 Wessex Business Park,
 Wessex Way, Colden,
 Common, Hampshire, UK
 SO21 1WP
 Tel. +44-1962 711661
 Fax: +44-1962 711662
info.europe@permabond.com
www.permabond.com

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

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

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

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

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

Pröll KG
 Treuchtlinger Straße 29
 D-91 781 Weißenburg i. Bay.
 Tel. +49-91419060
 Fax +49-914190649
wug@proell.de
www.proell.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
Temat
Tel. +32-2-582 16 90
Fax +32-2-582 52 40
labo@unico.be
www.unico.be

Huntsman
Adresses: see website
www.huntsman.com