ALTUGLAS®
BY ARKEMA

CAST & EXTRUDED SHEET

Technical Brochure

Contents


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Introduction

THE ALTUGLAS® BRAND NAME

Altuglas® is the Arkema registered trade name for PMMA (polymethylmethacrylate) products.

Altuglas® is available in many forms:

- cast and extruded sheets
- sanitaryware sheets
- resins
- adhesives and auxiliary products

GENERAL PROPERTIES OF ALTUGLAS®

Brief summary of properties:

Altuglas® is a rigid, transparent, thermoplastic material. Naturally colourless and exceptionally clear, it can also be tinted for an almost infinite range of colours. The light transmission and diffusion parameters can be varied on request.

It is inert to many corrosive chemicals and is the plastic material of choice for outdoor use (resistant to UV and general weathering).

A wide variety of industrial, craft and artistic processes can be used to machine and shape Altuglas® sheets.

THE RANGE

The products described in this technical brochure are referred to as:

- ALTUGLAS® CN, for cast sheet
- ALTUGLAS® EX, for extruded sheet

Sheets are available in a wide range of formats, thicknesses, colours and surface finishes. Detailed information on the various combinations, as well as delivery conditions, are given in the Altuglas® Product Catalogue.

Sheets manufactured by Altuglas International meet the following standards:

- ALTUGLAS® CN: ISO 7823.1 - 2003
- ALTUGLAS® EX: ISO 7823.2 - 2003

APPLICATIONS

Altuglas® CN and EX sheets are used in numerous applications:

- **signs and signboards:** illuminated panels, 3D lettering, indicator panels…
- **POS advertising:** display stands, testers, notice-boards…
- **interior design:** shop-fitting, furniture, glazing…
- **architectural fittings:** street furniture, safety fittings, acoustic screens, skylights…
- **sanitaryware**[1], bathtubs, shower trays…
- **transport:** deflectors, sun visors, registration plates, ship hatches and portholes…
- **industry:** machine guards, dials, precision parts…
- **medical:** cribs, incubators…

Many specialist applications can be added to this list, such as, swimming pool shelters and barriers, etc.

[1] Applications such as baths, shower trays and basins require the use of a special Altuglas® CS sheet (also known as cast sanitaryware sheet).

Properties of Altuglas®

Table of specifications

MAIN CHARACTERISTICS	TEST METHOD			INDICATIVE VALUES				
				UNITS	ALTUGLAS® CN		ALTUGLAS® EX	
	ISO	NF	Others		Thickness mm	Value	Thickness mm	Value
GENERAL PROPERTIES								
Water absorption, 24 hrs	62	T 51002	DIN 53495	%	4	0,30	4	0,30
Water absorption, 8 days	62	T 51002	DIN 53495	%	4	0,50	4	0,50
Water absorption, max. (total immersion, 1200 hrs)			Internal	%	3	1,75	3	1,75
Density	1183	T 51063	DIN 53479			1,19		1,19
MECHANICAL PROPERTIES								
Poisson ratio to 20°C						0,39		0,39
Tensile strength to 23°C	527	T 51034	DIN 53455					
Stress at break	-2/1A/5			MPa	4	76	4	74
Modulus of elasticity				MPa	4	3300	4	3300
Elongation at break				%	4	6	4	5
Tensile strength to -20°C	527	T 51304	DIN 53455					
Stress at break	-2/1A/5			MPa	4	102		
Elongation at break				%	4	5		
Tensile strength to 80°C	527	T51304	DIN 53455					
Stress at break	-2/1A/5			MPa	4	24		
Elongation at break				%	4	22		
Tensile strength to 23°C	178*	T51001	DIN 53452					
Stress at break				MPa	4	130	4	120
Modulus of elasticity				%	4	3250	4	3250
Charpy impact strength (un-notched)	179/2D	T 51035	DIN 53453	Kj/m^2	4	12	4	10
Izod impact strength (notched)	180/1A		ASTM D256A	Kj/m^2	4	1,4	4	1,3
Hardness, Rockwell Scale M	2039		ASTM D785			100		95
Hardeness, Shore Scale D	868	T 51109				60-70		80
Compressive strength	684	T 51101	DIN 53454	MPa	4	130	4	110
Shear strength - dynamic modulus			DIN 53445	MPa		1700		1700
OPTICAL PROPERTIES								
Light transmittance	T 51068	DIN 5036						
3 mm thick				%	3	92	3	92
3 mm thick				%	5	92	5	92
8 mm thick				%			8	92
10 mm thick				%	10	92		
Refractive index	T 51064	DIN 53491				1,492		1,492

NB: The standards quoted are not always strictly equivalent. We have given the average values of our laboratory tests, as an indicator only.
*Speed: 1mm/min.

WARRANTY: The information given in this literature is based on the findings of our research and experience. It is intended as a general guide to the use of our products and must not be considered as a binding specification. Altuglas International may in no way be held liable for this information, including in the case of third party rights infringement.

MAIN CHARACTERISTICS	TEST METHOD			INDICATIVE VALUES				
				UNITS	ALTUGLAS® CN		ALTUGLAS® EX	
	ISO	NF	Others		Thickness mm	Value	Thickness mm	Value
ELECTRICAL PROPERTIES								
Dielectric strength		C 26225	DIN 53481	KV/mm		20 to 25		20 to 25
Transverse resistivity		C 26215	DIN 53482	Ohm.cm		$> 10^{15}$		$> 10^{15}$
Dielectric constant		C 26230	DIN 53483					
to 50 Hz						3,7		3,7
to 0,1 MHz						2,6		2,6
THERMAL PROPERTIES								
Cœfficient of linear expansion	EN 2155-1	T 51251	DIN 52328	mm/m/°C		0,065		0,065
Thermal conductivity			DIN 52612	W/m/°C		0,17		0,19
Specific heat			ASTM C 351	J/g/°C		1,32		1,32
Insulation coefficient K			DIN 4701					
3 mm thick				$W/m^2/°C$	3	5,4	3	5,4
5 mm thick				$W/m^2/°C$	5	5,1	5	5,1
10 mm thick				$W/m^2/°C$	10	4,5	10	4,5
Vicat softening point B 50 conditioned samples	306	T 51021	DIN 53460	°C		115		105
Heat distortion temperature under load, 1,80 N/mm^2 conditioned samples	75/A	T 51005	DIN 53461	°C		109		102
Max. continuous service temperature				°C		85		80
Forming oven temperature				°C		130-190		140-175
Max. heating temperature				°C		200		180
Max. linear shrinkage ofter heating, thickness ≥ 3 mm				%		2		3
Max. linear shrinkage ofter heating, thickness < 3 mm				%		2		6
Max. superficial temperature under infrared			°C		220		210	
FLAMMABILITY								
Self-ignition temperature				°C		approx.450		approx.450
Euroclass classification			EN 13501			E		E
Flame resistance (Radiant heat sources)		P 92501			3	M4		M4
Melt behaviour when burning		P 92505			3	non-drip		drips
Flame resistance			DIN 4102			B2		B2
Flame resistance			BS 476 Pt.7			class 3		class 4
Flame resistance			UL 94			HB		HB
Oxygen index			ASTM 2863 77	%		18		18
Chlorine content				%		0		0
Nitrogen content				%		< 0,02		< 0,02

Properties of Altuglas®

Other properties

OPTICAL PROPERTIES

Altuglas® is inherently extremely transparent. Altuglas® CN and Altuglas® EX have a light transmission index of 92 % for a thickness of 3 mm (DIN 5036 standard).
The transmission curves provided by Altuglas International are measured between 370 nm and 740 nm.

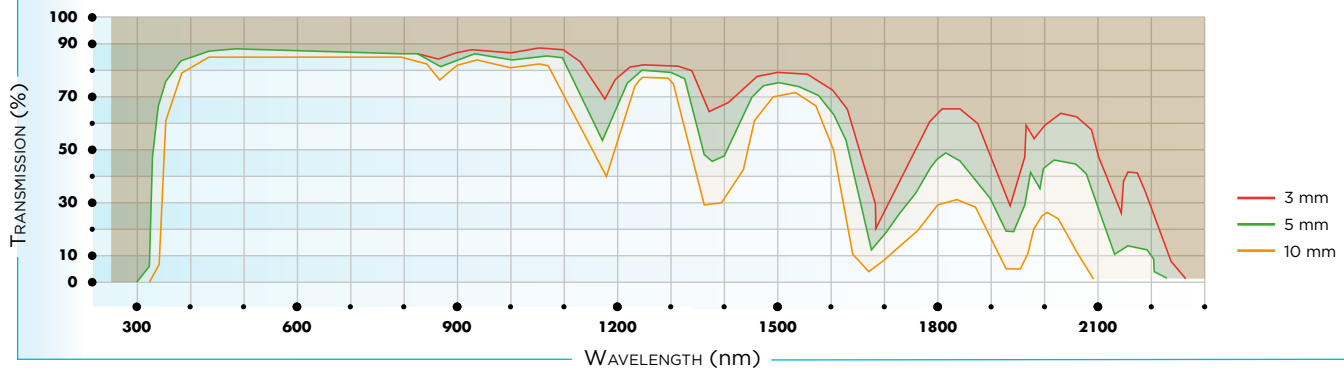
The Altuglas® range includes qualities with specific optical properties. These reduce or increase the transmission of certain wavelengths.

- Altuglas® CN IR
- Altuglas® CN UV Block
- Altuglas® CN Inactinic

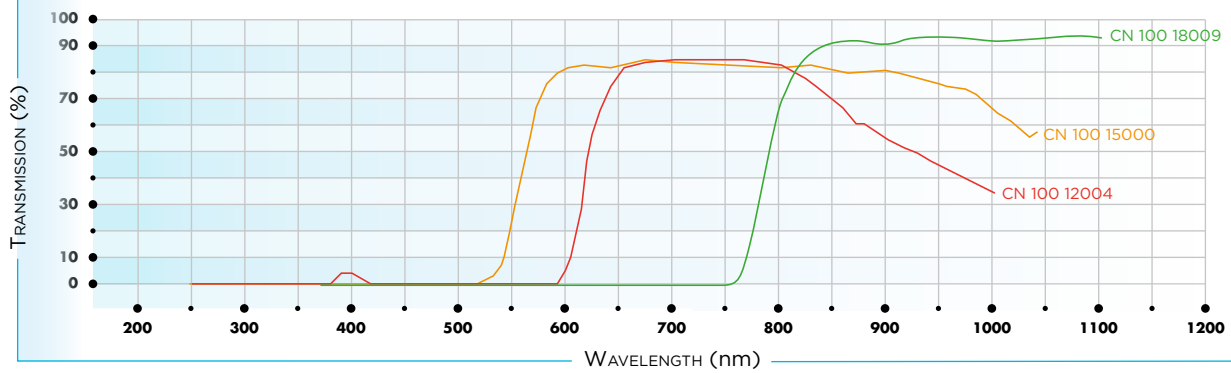
TABLEAU DE SYNTHÈSE

Product name	Reference	Application	Characteristics (LT in % - Wavelength in nanometres)
Altuglas® CN UV Block	141 10000	Artwork protection in museums	- Filters out UV waves - LT < 1 % from 200 to 370 nm
Altuglas® CN IR	100 18009	Infrared detection systems (remote controls, cameras, etc)	- Filters out visible wavelengths and transmits near-infrared
Altuglas® CN Inactinic	100 12004 100 15000	Glazed Panels for photo labs	- Filters white light to make it harmless to photographic film - LT < 5 % from 250 to 570 nm

Light Transmission Curve for clear Altuglas® CN

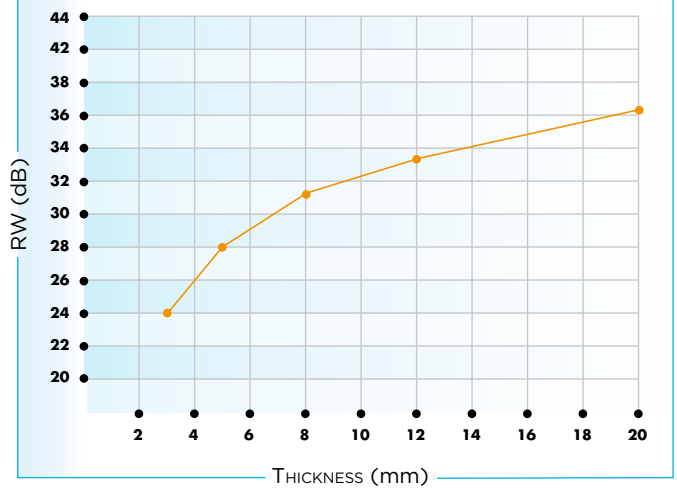


Light Transmission Curve for CN 100 12004 - CN 100 15000 - CN 100 18009



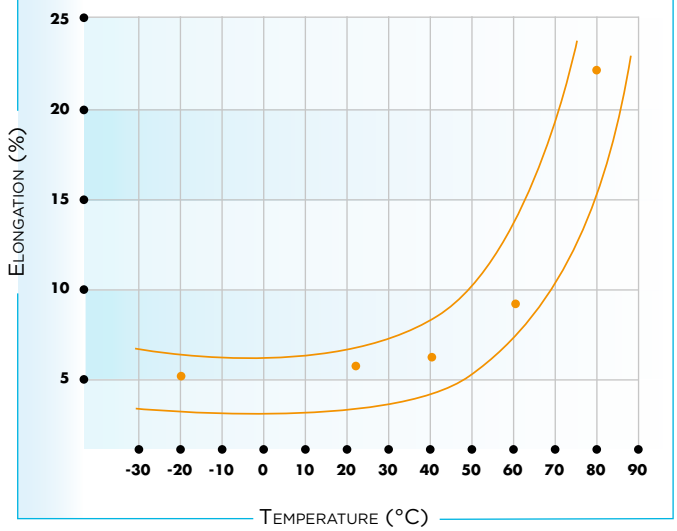
ACOUSTIC PROPERTIES

Acoustic attenuation index Rw as a function of thickness

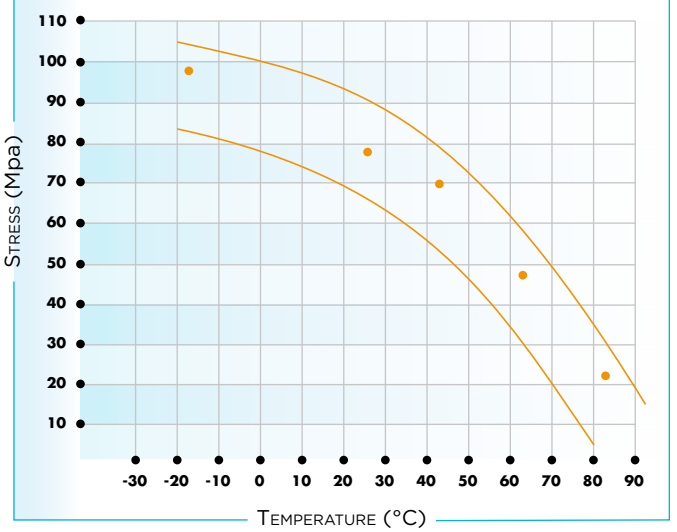


MECHANICAL PROPERTIES

Variation of elongation at break under traction, as a function of temperature from - 20 to + 80°C



Variation in tensile strength, as a function of temperature from -20 to + 80°C



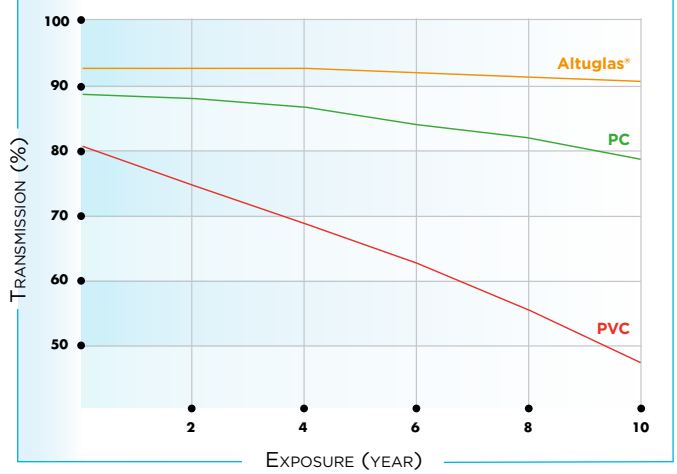
Measurements as specified by the ISO 140 standard and in accordance with C.S.T.B. report No 32 468 dated September 1991.

RESISTANCE TO NATURAL AGEING

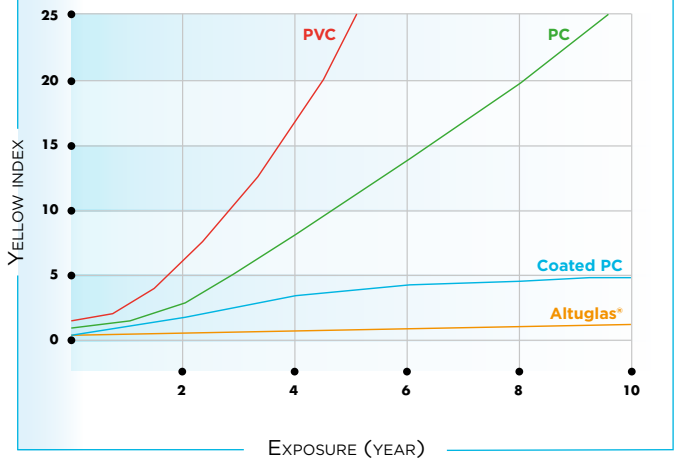
The values apply to a Central European climate.

Altuglas® CN and Altuglas® EX have similar physical properties.
Both have the same excellent resistance to natural ageing.

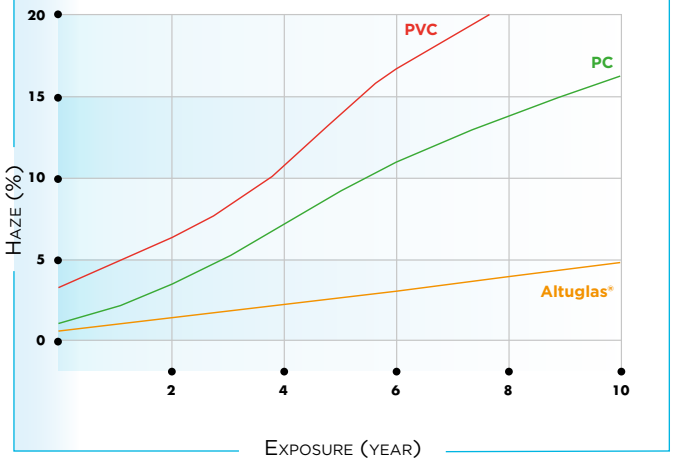
Variation in light transmission as a function of exposure to weathering



Variation in the yellow index as a function of exposure to weathering



Variation in haze as a function of exposure to weathering



Properties of Altuglas®

Altuglas® CN and Altuglas® EX

SIMILARITIES

Altuglas® CN and Altuglas® EX have similar physical properties.

Both have the same excellent resistance to natural ageing.

The main differences lie in their thermal and chemical properties and some of the ways they are processed.

DIFFERENCES

There are intrinsic behavioural differences between these two materials, which must be taken into account in order to obtain high-quality products.

Thickness range

Altuglas® CN is available in an almost unlimited range of thicknesses, starting from 2 mm.

Altuglas® EX is available in thicknesses from 2 to 20 mm.

Dimensional variations

The Altuglas® CN manufacturing process leads to slight variations in the thickness of sheets, whereas the thickness of Altuglas® EX sheet varies very little, if at all.

Altuglas® CN has an isotropic response to temperature, with a maximum shrinkage of 2 % in all directions.

The extrusion process applied to Altuglas® EX leads to variable shrinkage, depending on thickness and direction.

In the extrusion direction:

- maximum of 3 % for thicknesses of 3 mm and over
- maximum of 6 % for thicknesses under 3 mm

Transversally:

- maximum of 1 % for thicknesses above 3 mm
- maximum of 2 % for thicknesses under 3 mm

Thermal stability and viscosity

The average molar mass of Altuglas® CN is much higher than Altuglas® EX (3,000,000 compared with 150,000), with much longer molecular chains. This gives it better thermal stability and better resistance to crazing when exposed to solvents. The thermoforming range is also wider. Altuglas® CN can be reworked hot, which is not possible with extruded sheets.

Altuglas® EX has a much lower viscosity when hot, which makes it more ductile than Altuglas® CN. It can therefore be used for more intricate shapes during complex forming.

Optical properties

Altuglas® CN has unrivalled surface properties and optical purity.

SAME FIELD OF APPLICATION

Common applications

Experience has shown that Altuglas® CN and Altuglas® EX can be interchanged freely. The choice of one product rather than the other will be dictated not only by intrinsic differences in their characteristics, but also by the associated conditions, tools and manufacturing costs.

RECYCLING POSSIBILITIES

Processing off-cuts

Off-cuts from either cast or extruded sheets can be reprocessed without causing any special environmental problems.

Altuglas® is an easily recyclable material.

Possible recycling methods are:

- Altuglas® EX waste can be ground and then re-used through injection or extrusion
- Altuglas® CN waste can be subjected to a «cracking» process. This allows recovery of the original monomer (methylmethacrylate).

If recycling is impossible, off-cuts can be incinerated.

Working with Altuglas®

General

STORAGE OF SHEETS

SAFETY

Edges of sheets may be sharp.
It is recommended that gloves be worn for protection during handling.

Sheets must be stored in a dry place. It is advisable to place a polyethylene cover over the stack when a sheet is removed, to reduce moisture absorption. In fact the absorption of moisture generates waves and/or bending of the PMMA sheets.

It is recommended that sheets of Altuglas® be stored horizontally on their original delivery pallets, and that the pallets be placed on horizontal storage shelves. It is strongly recommended that pallets should not be stacked, which carries the risk of creating internal tensions and spoiling the flatness of the sheets.

If a vertical storage method is adopted, it is preferable that Altuglas® sheets be leant against solid supports inclined at approximately 80°, to avoid any bending.

It is strongly recommended to avoid a storage period longer than 6 months.

Flatness of the sheets could be altered if sheets are stored and/or transported in a humid environment.

PROTECTIVE FILM

Protective film

Both faces of Altuglas® CN and EX sheets are protected by polyethylene film. The top-face film carries the identification marks. With the exception of certain products for which special information is available (e.g. Altuglas® Silver Star), the top face is to be regarded as the working surface.

It is strongly recommended to avoid outdoor storage. Protective films and adhesives could be damaged by UV rays, making them difficult to remove.

Identification marks and traceability

Altuglas® sheets have at least two longitudinal markings, a few centimetres from the two edges. The markings indicate the name of the product, Altuglas® CN or Altuglas® EX, followed by the product code, colour code, thickness in millimetres and batch number.

If cutting is done and for traceability reasons, it is recommended to note the batch number.

This marking provides traceability for all our production batches.

When to remove the film

It is preferable to leave the protective film in position throughout machining, to keep the sheet surface in perfect condition.

Special precautions for thermoforming:

Altuglas® CN: The protective film must be removed before heating and thermoforming.

Altuglas® EX: This precaution is unnecessary for Altuglas® EX, provided the following conditions are observed:

- the film must be totally free from surface faults (holes, scoring, bubbles, etc), which could mark the part
- the film must not touch the oven trays

MACHINING

SAFETY

The various machining processes that are possible with Altuglas® sheets may result in the ejection of large quantities of hard, sharp swarf. It is recommended that goggles be worn during such operations.

In terms of hardness, Altuglas® lies between wood and iron, and is quite close to aluminium or light alloys. It can be machined (cut, milled, turned or drilled) using machine tools designed for working wood or metal.

Recommendations for machining

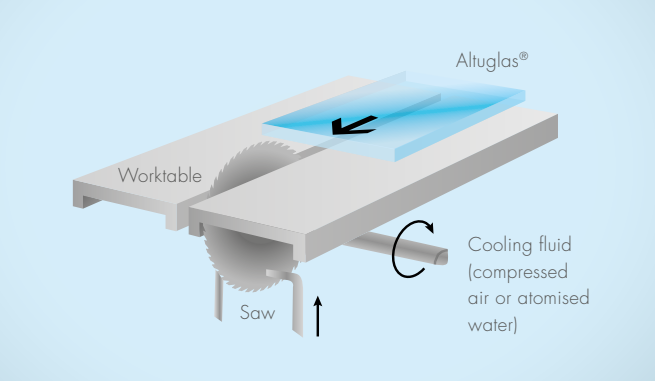
Excessively fast machining causes local overheating, generating internal stresses which must subsequently be relieved by annealing (see page 28). Otherwise, sooner or later, these stresses will cause fine surface crazing, which may spread under the effects of solvents or stress (for example, during bonding or painting).

The material will not overheat during machining if the following general guidelines are followed:

- keep tools really sharp
- ensure efficient removal of swarf
- spray with water containing 2 % of cutting oil («soluble» oil), or use a small jet of compressed air, or spray atomised water directly at the cutting position

Altuglas® EX is more sensitive to overheating than Altuglas® CN.

During machining, parts must be clamped properly to avoid any vibration. This recommendation is particularly important when the sheets are thin. Strong vibration may result in unattractive edges and broken corners.



CUTTING AND OTHER MACHINING

When a sheet is being cut, the blade entry and exit stages are the most critical.

Altuglas® CN can be cut with very simple tools such as a hacksaw. However, this is not recommended: it is a long and delicate operation that cannot provide a very good finish. This method of cutting is strongly discouraged for Altuglas® EX.

A number of industrial cutting methods are suitable for Altuglas®.

Circular saws are normally used for straight cuts, with bandsaws or router cutters for other shapes. Other more sophisticated methods such as lasers or water jets give excellent results.

Altuglas® can be machined using numerous other processes such as drilling, turning, milling or sanding.

THERMOFORMING

Altuglas® is a very versatile, transparent thermoplastic. Parts with very complicated shapes can be created by thermoforming. Products obtained in this way retain all the original properties of the material: transparency, resistance to UV and mechanical strength, special surface aspects (Ex: Altuglas® Dual satin).

OTHER PROCESSES

Altuglas® may be bonded. Using Special Care Adhesive P10 polymerizing adhesive, the strength of the bonded joint can be close to that of the original material.

The most frequently used methods for decorating Altuglas® are screen-printing, spraying or applying coloured self-adhesive vinyl films.

New lighting technologies such as LEDs (light-emitting diodes) are opening up further possibilities.

Working with Altuglas®

Straight cutting and cutting shapes

CUTTING ALONG A GROOVE

SAFETY

Each time Altuglas® sheets are worked, it is strongly recommended that gloves, protective glasses and sound protection be worn during operations.

This technique is not generally recommended, as the edges of the cut are irregular and require subsequent sanding. The technique can only be used for sheets with a thickness of 3 mm or less, over lengths of less than 400 mm.

The groove can be made using a cutter with a sickleshaped blade. Repeat the grooving several times. Use the edge of a table to break along the groove. Goggles and gloves must be worn for protection.

BANDSAW

This type of saw is generally used to cut curves. However, it can also be used for straight cuts on thick sheets.

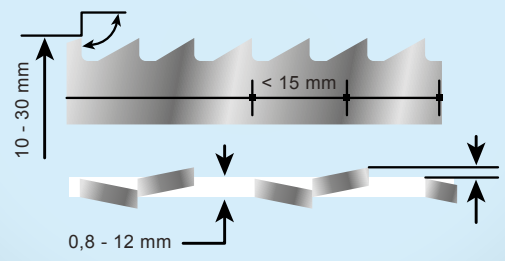
It never gives a clean edge and lengthy finishing operations are necessary if a polished edge is required.

Woodworking machines with a linear cutting speed of 15 to 25 m/sec can be used.

This type of blade does not allow really clean cutting and requires a large amount of finishing work. It is used mainly for cutting rough shapes prior to forming, or cutting around formed parts prior to finishing.

Any woodworking machinery with a linear speed of between 15 and 25 m/sec may be used.

Example of a steel bandsaw with set teeth



JIGSAW

This method of cutting has little to recommend it, in view of the low quality of cut achieved.

Settings: medium cutting speed, with no swing. Medium advance speed. The saw must be in motion before cutting starts. Hold the base of the saw firmly against the sheet and minimise vibration of the sheet as far as possible.

RECOMMENDED SPEED FOR DIFFERENT SAW DIAMETERS

Saw diameter (mm)	Rotation speed (rpm)
150	6400
200	4800
250	3800
300	3200
350	2800
400	2400

CIRCULAR SAW

Circular saws give a straight, accurate cut. This is the most frequently used technique. When cut, Altuglas® sheets have a clean surface.

Two types of blade are usually used:

- carbide-tipped blades are recommended for industrial use, for cutting piles of sheets
- high-speed steel blades are usually used to cut single sheets

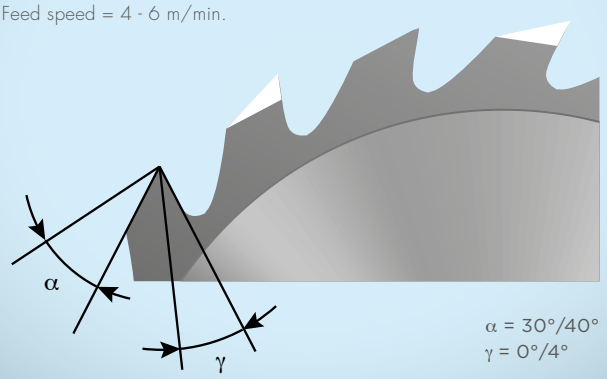
The teeth are radial (the cutting edges are aligned with the centre) and are backed-off to form an angle of 45° at the tip.

The teeth are not set but the saw must have a rake of approx. 0.2 % on each face.

Pitch: 2 to 5 teeth per cm, depending on the Altuglas® being cut. Cooling by a jet of compressed air or water is recommended.

Cardibe-tipped blade with straight or set trapezoidal teeth (tooth pitch: 1 cm)

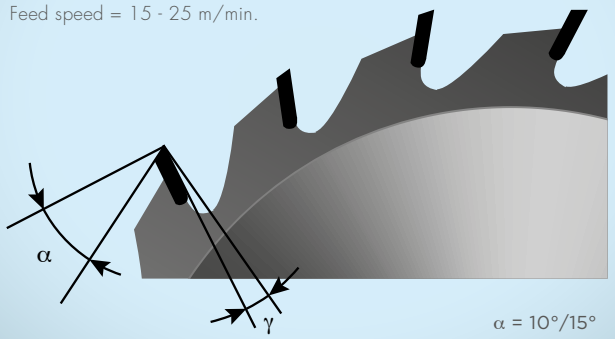
Circumferential speed = 3000 m/min.
Feed speed = 4 - 6 m/min.



α = 30°/40°
γ = 0°/4°

HSS or SHSS or trapezoidal blade (tooth pitch: 1 cm)

Circumferential speed = 3000 m/min.
Feed speed = 15 - 25 m/min.



α = 10°/15°
γ = 0°/-5°

MILLING

Milling can be used to obtain complex shapes with a clean, polished machine finish.

It is advisable to use plain cylindrical milling cutters with two or more cutting edges, preferably those that are one-piece carbide-tipped.

High speed and super-high speed steel tools will deliver results of equal quality.

The rotation speed must be between 10,000 and 30,000 rpm, depending on the diameter and number of cutting edges used, and compressed air cooling may be helpful.

Milling can be used for several operations such as:

- cutting through
- engraving
- finishing edges

A polished finish can be obtained in a single operation if diamond-tipped tools are used.

Annealing is generally recommended (see page 28).

LASER CUTTING

This process offers many advantages:

- it allows most shapes to be produced extremely accurately
- it minimises off-cuts
- it gives an excellent edge-finish, generally requiring little or no final polishing. Differences in the quality of the cut will be due to the laser source and power, cutting speed, and thickness and pigmentation of the Altuglas®.

Laser cutting causes high internal stresses close to the cutting edges, which mean there must be no contact with solvents (adhesives, harsh cleaning products, etc). Annealing will reduce the risks of crazing (see page 28). However, it is inadvisable to use adhesives in conjunction with laser cutting.

WATER-JET CUTTING

This process offers similar advantages to laser cutting, except for the edges which are not glossy in appearance. An additional advantage is that there are no internal stresses near the cut edge. Contact with solvents is permissible, including adhesives.

Working with Altuglas®

Other forms of machining

DRILLING MACHINES AND BITS

Drilling can be carried out with fixed or portable drilling machines, fitted with high speed, super-high speed or carbide-tipped steel drills for light metal, specially ground for Altuglas®.

«Drill File» conical bits may also be used.

It is recommended that the edge of the drill be ground parallel to its centre line, to suit the special characteristics of Altuglas®.

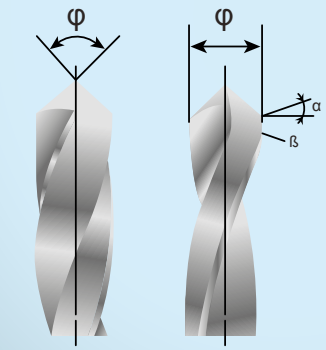
METHOD

When drilling deep holes, the bit should be withdrawn frequently to help eject swarf and minimise heating that may damage the material. The use of carbide-tipped drills under lubrication is recommended, to obtain a high-grade finish on the sides of the holes.

HSS, SHSS or carbide-tipped drills

α = 3°/8°
φ = 60°/90°

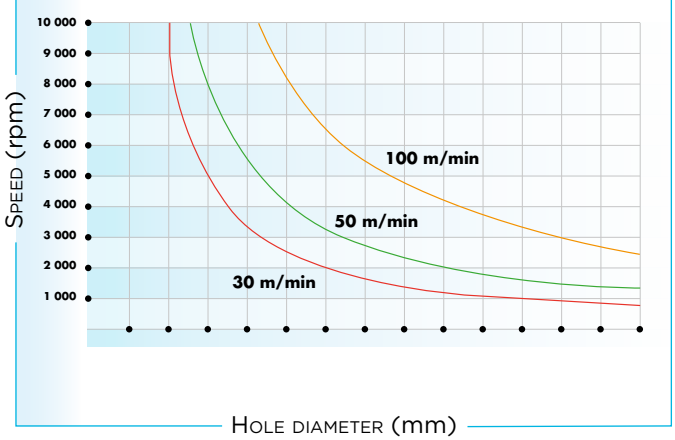
α = 0°/4°
ß = 12°/16°



«Drill-File» conical bit

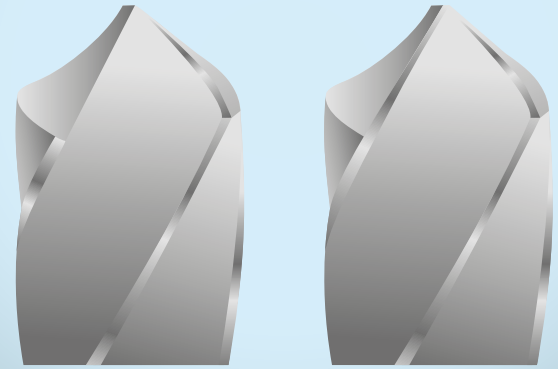
Circumferential speed = 30 - 50 m/min.
Feed speed = 0,05 - 0,1 mm/rev.

Bit rotation speed as a function of hole diameter

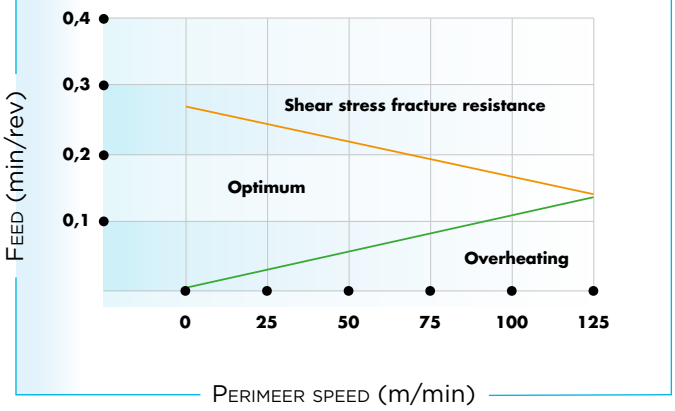


Standard drill

A drill specially designed for PMMA



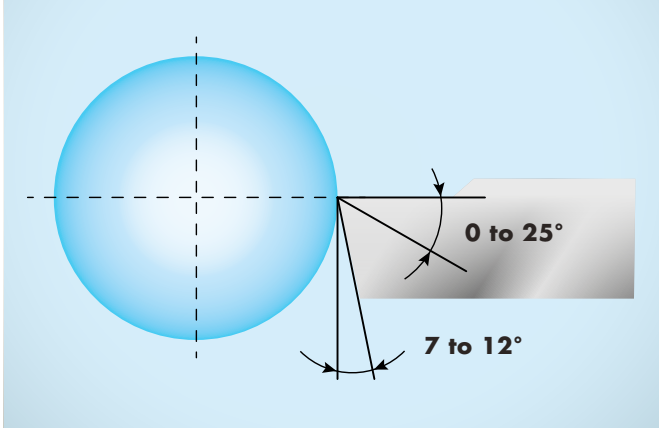
Optimim feed speed as a function of bit rotation speed



TURNING

Altuglas® can be turned in the same way as light metals, using ordinary tools, at the highest possible rotation speed and a low feed speed. In this case the material must be cooled by means of pure water, or a mixture of water and 2 % cutting oil.

Foret spécialement conçu pour Altuglas®



ENGRAVING

This can be carried out using a variety of processes:

- **milling:** engraving by milling is generally carried out on digitally controlled machine-tools
- **laser:** it is possible to engrave within a sheet, in 3 dimensions

SANDING

Sanding is required to finish the edges of coarsely cut sheets. Wet carborundum paper is used, either by hand or on a disc or belt sanding machine. For the latter, the recommended belt speed is 10 m/s. A water spray should preferably be applied during sanding, to minimise overheating of the material.

It is preferable to proceed in stages, using in turn:

- a coarse-grain abrasive paper (e.g. 60)
- a medium-grain abrasive paper (e.g. 220)
- a fine-grain abrasive paper (e.g. 500)

Sanding can be a very similar process to polishing, when the abrasives used are extremely fine.

It is preferable to use underwater sanding (simultaneous lubrication and cooling). The successive use of grain sizes 1500, 2400, 4000, 8000 and 12000 allows an almost perfect surface finish to be obtained. A final polishing operation with Special Care Polish 1 and 2 allows the original surface polish to be fully restored. For further information, see the instructions provided with the kit.

ABRASIVE POLISHING

After sanding, the material may be polished to restore its original surface gloss. This can be carried out by hand or using mechanical processes.

Machine polishing

Some edge-milling machines use diamond tools and give a polished finish directly. Edges can also be polished with a felt-belt polisher or a disc polisher, fitted with cotton or flannel buffs, using a polishing paste that is compatible with Altuglas®. Flat surfaces are polished using portable disc polishers, fitted with felt or sheepskin buffs soaked in Special Care Polish.

Hand polishing

This is carried out using non-woven suede cloth or felt, together with a polishing agent. Use Polish N°1, alone or with Special Care N° 2, depending on the degree of polish required.

After polishing, Special Care Cleaner can be used to remove any finger or handling marks. This improves the gloss and reduces static somewhat, which slows down the accumulation of dust and reduces the frequency of cleaning.

FLAME POLISHING

Using this technique, the machined edges of Altuglas® CN are exposed to a high-temperature flame over a restricted area. Passing the flame quickly over the area to be treated melts it, but does not burn it. As it cools, the melted material forms a perfectly smooth surface. If the machining has been carried out with tools that leave clean edges, the flame allows a polished, glossy surface to be obtained. Otherwise, the edge must first be sanded.

Flame polishing is a very fast technique, but requires certain precautions.

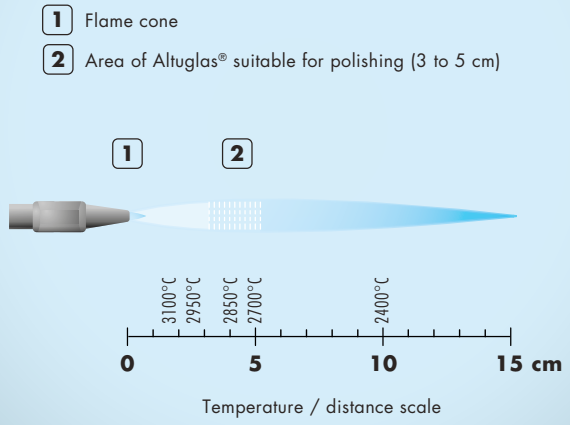
The surfaces being polished must be completely clean and free of any contamination. In particular, avoid touching the surface with fingers.

The technique is for use only with clear or transparent coloured parts. A test must be carried out before using it on diffusing or coloured sheets.

An oxyacetylene torch is often used, with a flame temperature between 2,700 and 2,900°C. The flame must be adjusted to contain excess oxygen (an oxidizing flame).

Lastly, this method causes very high stresses in the material, which must be relieved by annealing (see page 28) before painting, screen-printing or bonding.

Flame polishing with an oxyacetylene torch



Working with Altuglas®

Thermoforming

SAFETY

In some of the forming processes described below, hot sheet is stretched by vacuum or air pressure, with one face still exposed to the atmosphere. Although highly unlikely, the sudden failure of a sheet during forming could be dangerous for staff nearby. Guards must be provided to prevent the ejection of particles, which could be quite sharp.

PRELIMINARY INFORMATION

Thermoforming involves three steps: heating, forming and cooling.

An initial stoving (pre-heating) stage may be necessary, to eliminate moisture from the sheet.

When heated to a suitable temperature (depending on the specific type), Altuglas® becomes soft and rubbery. It can then be given a wide variety of shapes using suitable moulds. Cooling then restores its initial rigidity, while retaining the given shape.

Differences between Altuglas® CN and Altuglas® EX

If a piece of Altuglas® CN does not take up exactly the required shape, it can be reheated and corrected or reused. This can only be done with Altuglas® EX if it has not been stretched.

Thermoforming and protective film

For Altuglas® CN: it is essential to remove the protective film before heating and thermoforming.

For Altuglas® EX: it is not necessary to remove the protective film, provided that the following precautions are observed:

- the film must be totally free from surface faults (pinholes, scratches or bubbles, etc), which could result in marks on the part
- the film must not touch the oven trays

STOVING (PRE-HEATING)

The stoving stage removes internal moisture from the sheets. The sheets are placed in a ventilated oven, at a temperature between 75° and 80°C, for a period of 1 to 2 hours per mm thickness.

The sheets should preferably be separated from one another, in order to facilitate circulation of hot air and rapid evacuation of moisture from the sheets.

HEATING EQUIPMENT

After stoving (if necessary), sheets may be heated using one of two industrial processes:

Circulating hot-air oven

This is the only acceptable heating method for parts requiring good optical properties. The temperature can be accurately controlled and Altuglas® CN sheets can be kept hot while awaiting thermoforming. Altuglas® EX sheets require a shorter heating time and oven waiting time must be kept to a minimum. Altuglas® EX also cools faster than Altuglas® CN.

Infrared heating

This method of heating has low thermal inertia and warm-up time is therefore short.

- when used for thermoforming, it offers high productivity, automated operation and low labour costs. However, the investment is high.
- when used only for stoving (pre-heating), the cost is low but temperature control is more difficult and heating must be done in two stages for thicknesses ≥5 mm

HEATING METHOD

Heating times and temperatures

The temperature and heating time vary, depending on the type of Altuglas® sheet and heating method used.

SUMMARY TABLE OF HEATING CONDITIONS FOR SHEETS

Heating temperature	Altuglas® CN	Altuglas® EX
Minimum temperature (°C)	130	140
Maximum temperature (°C)	200	180
Recommended range (°C)	165 - 190	160 - 175
Heating times by type of equipment	**Altuglas® CN**	**Altuglas® EX**
Oven (min./mm)	3 - 4	2,5 - 3
Infrared panels		
1 panel (sec./mm)	40 - 50	35 - 45
2 panels (sec./mm)	25 - 30	20 - 25

Two main differences in response to heating

SHRINKAGE

When heated for the first time, Altuglas® sheets shrink and allowance must be made for this in determining the dimensions of blanks.

Altuglas® CN is isotropic: it shrinks by a maximum of 2 % in all directions.

With Altuglas® EX, the extrusion process causes variable shrinkage, depending on the thickness and length/width orientation of the sheets relative to the direction of extrusion.

In the extrusion direction:

- maximum of 3 % for thicknesses ≥ 3 mm
- maximum of 6 % for thicknesses < 3 mm

In the transverse direction:

- maximum of 1 %

These differences in shrinkage mean Altuglas® EX sheets must be clamped to a frame during the heating stage, to avoid distortion of their flat surfaces.

UNIFORM HEATING

Altuglas® CN will withstand temperature differences of 10 to 15°C within a given sheet, without any effect on the final quality.

Altuglas® EX must be heated very uniformly: any difference exceeding 5°C may lead to considerable internal stress.

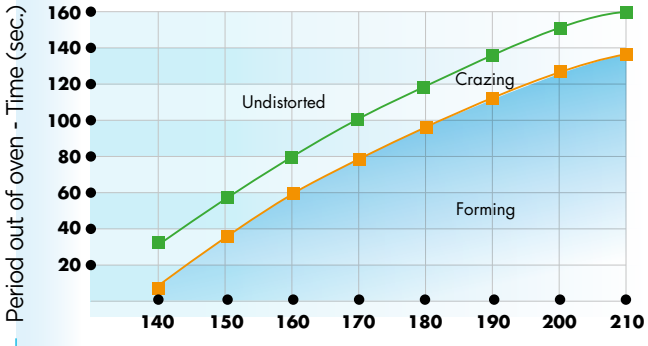
Other differences in response to heating, and precautions:

In a horizontal oven, Altuglas® EX tends to adhere to metal surfaces. It is therefore advisable to provide suitable protective coverings (fluorinated coatings, Tefloncoated fabric or fluorinated sprays) for metal surfaces such as the floor or sides of the oven.

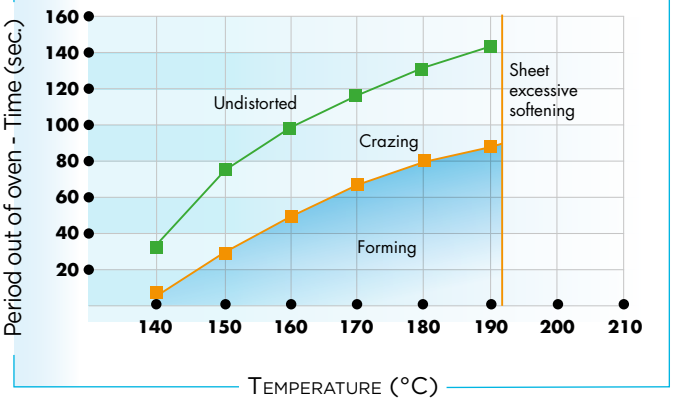
Altuglas® EX sheet tends to creep. The elongation can cause tearing if the temperature exceeds 175°C or even 170°C, and if the heating is prolonged; this type of oven must not be used to heat large extruded sheets.

The heating time and temperature vary with the type of product, the temperature conditions and the complexity of the part being formed. The prime factor in the quality of the part is the time that elapses between removing the hot sheets from the oven (or switching off infrared heating) and forming. The diagrams show the maximum waiting times before forming, in relation to heating temperature, for Altuglas® CN and EX sheets.

3 mm Altuglas® CN forming range



3 mm Altuglas® EX forming range



DIFFERENCES DUE TO THERMOFORMING

Even when heated to the maximum recommended temperature (190°-200°C), high pressure must be applied to Altuglas® CN to cause deformation. However, the pressure must be applied gradually: too sudden pressure could cause failure.

Altuglas® EX, on the other hand, can be thermoformed more easily where there are numerous details and sharp changes.

Altuglas® Easyforming offers improved thermoforming capability relative to Altuglas® CN (better accuracy of shapes).

Altuglas® EI Extruded Impact has even better qualities: better accuracy of shapes and greater strength during mould-stripping, machining and subsequent handling. In addition, the rise temperature faster than extruded standard and therefore offers a better productivity.

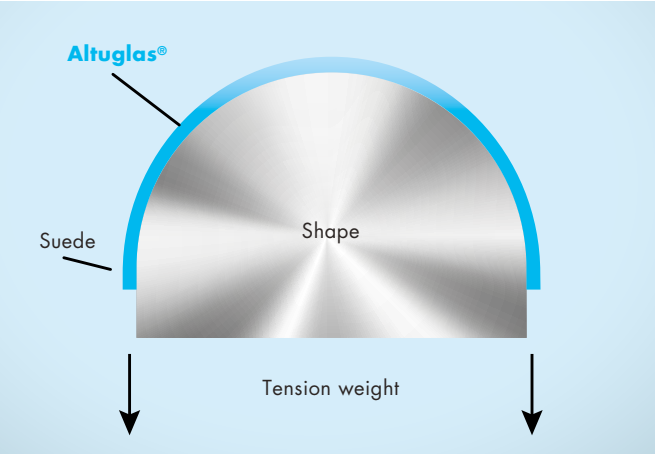
PRODUCTION OF MOULDS

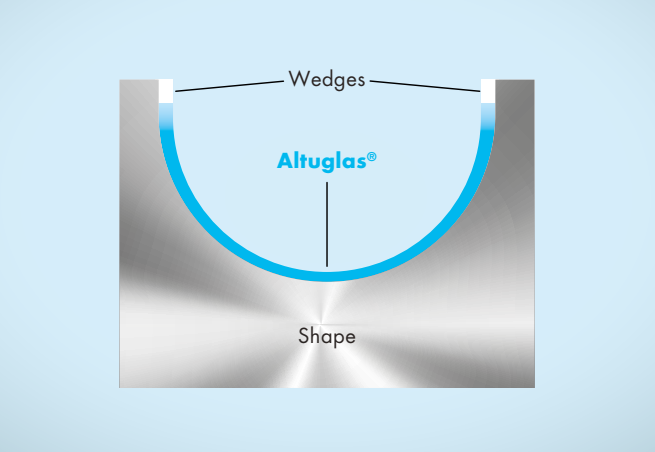
Moulds, and where necessary dies, can be made from a range of materials such as wood, aluminium or steel, and reinforced or pre-stressed polyester or epoxy resins.

To minimize stresses during forming, it is advisable to heat (or better still regulate the temperature of moulds) the dies and clamping frame at approximately 80°C for Altuglas® CN and 70°C for Altuglas® EX.

SIMPLE FORMING OF DEVELOPABLE SURFACES

Allows for known shrinkage, to make sure that the finished part is not smaller than required (note the difference between Altuglas® CN and EX). The heated sheet is simply placed over the shape and held in position with suedette to avoid surface defects. Ensure gradual cooling, away from draughts.





DETERMINING THICKNESS AFTER STRETCH THERMOFORMING

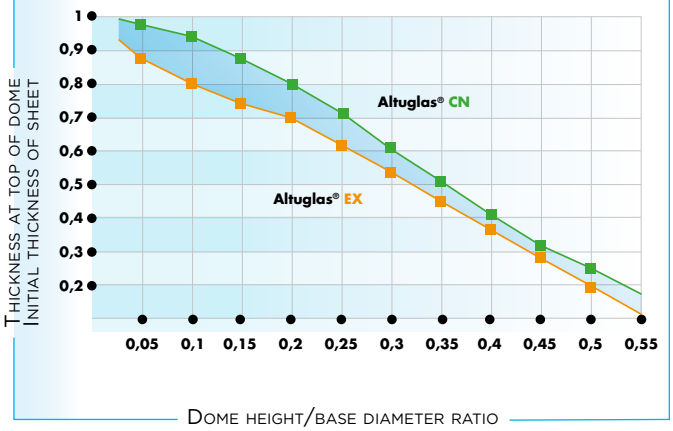
Unlike the forming process described above, one consequence of stretch thermoforming is that there are differences in thickness within the same piece.

The diagram (right) shows a cross-section of a dome produced by unrestrained vacuum- or blow-moulding. Due to stretching of the sheet, the final thickness at the top of the dome is considerably less than the initial thickness.

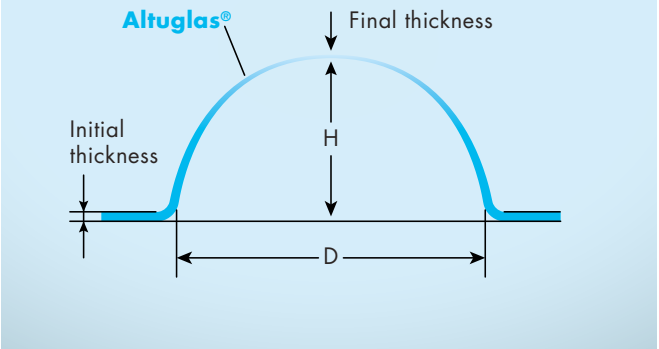
The curves below show the relation between reduction in thickness and degree of stretching for Altuglas® CN and EX. The reduction in thickness is shown as the ratio between final and initial thickness.

The degree of deformation is shown on the axes by the ratio between height and diameter. The curves, shown as a guide only, remain true for domes with a square base.

Table showing Altuglas® elongation during unrestrained blow or vacuum moulding variations in thinning with deformation



Thinning at the top of a dome formed by unrestrained vacuum- or blow-moulding



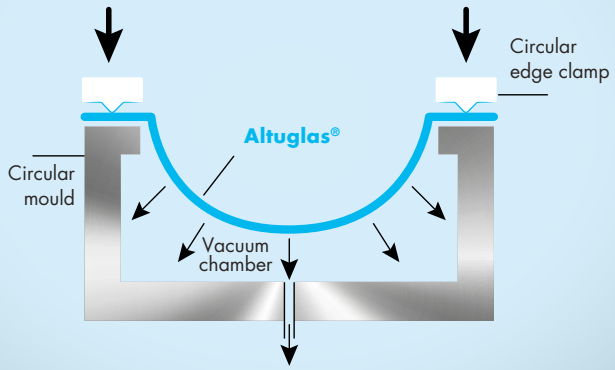
Stretching of Altuglas® sheet by unrestrained vacuum- or blow-moulding.

Change in degree of thinning as a function of degree of deformation.

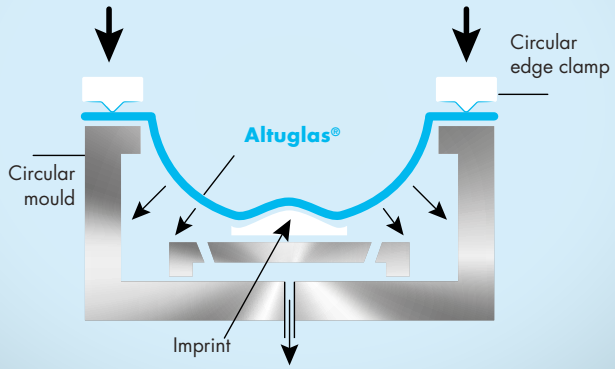
THERMOFORMING BY UNRESTRAINED VACUUM-MOULDING

For perfectly symmetrical forms similar to a spherical or ovoid dome, the mould need only be a frame or a perforated disk, placed on a vacuum tank. The curved part is not then exposed to any contact or friction and there is no risk of marking. When combined with certain «tricks of the trade», this technique can be used to produce complex forms such as those described below.

Thermoforming by unrestrained vacuum-moulding



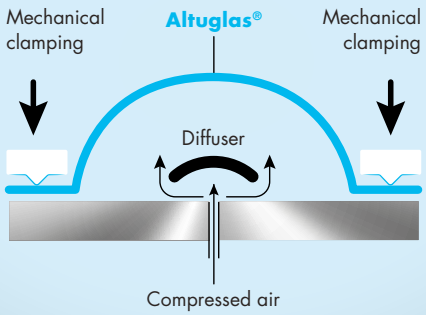
Thermoforming by unrestrained vacuum-moulding with a base imprint



THERMOFORMING BY UNRESTRAINED BLOW-MOULDING

This very simple system consists of a plate with a compressed air inlet, protected by a diffuser to avoid blasting cold air on to the hot Altuglas®. A seal is formed by locking the sheet against the plate, using a ring or frame and a clamp.

Unrestrained blow-moulding with diffuser



THERMOFORMING BY RESTRAINED VACUUM-MOULDING

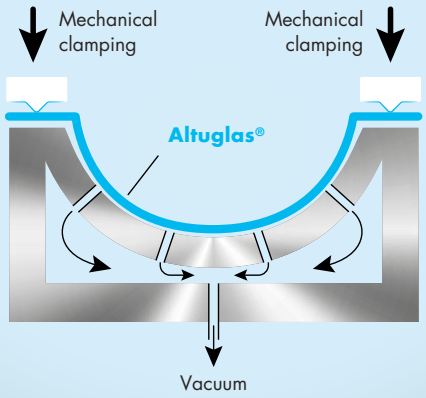
A concave mould is used, with the external shape of the required finished part. After heating, a sheet of Altuglas® is quickly fixed in an air-tight manner to the edge of the mould, using a ring and suitably shaped frame. Air is then pumped from the mould and the sheet takes up the shape.

THERMOFORMING BY RESTRAINED BLOW-MOULDING

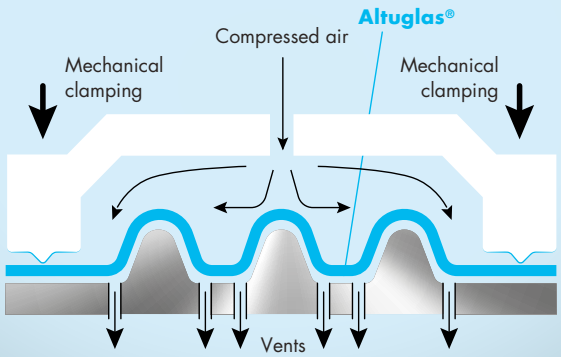
The pressures involved mean the moulds must be very rigid, generally of metal, hardwood or epoxy resin. Vents must be provided at the extremities of the moulds, to allow air to escape.

The Altuglas® sheet must be tightly clamped to ensure good sealing and prevent slippage. The mould may be lightly lubricated, for example with paraffin wax or silicone- based oils, to obtain even drawing and facilitate mould-stripping.

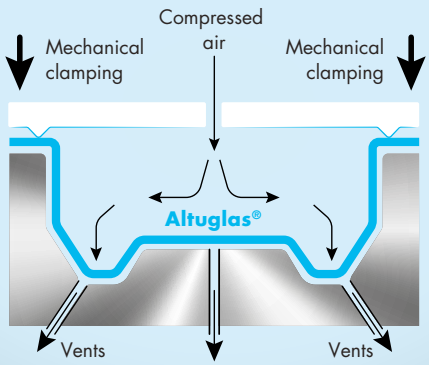
Vacuum moulding



Blow-moulding pieces for an advertising panel in a female mould



Blow-moulding a tray in a female mould



THERMOFORMING BY PRESSING WITH A PUNCH

A punch shaped like the inside of the part is lowered to deform the hot Altuglas® at low pressure (see diagram 1).

If required, a female mould section may still be used to form a die and accentuate the relief. This process, using a mould and punch, has the drawback of marking both faces of the part. Therefore, it is rarely used (see diagram 2).

The punch need not be solid: it may be hollow, simply a frame representing the corners of the part to be formed. The remainder of the surface is then formed by contraction of the Altuglas® as it cools (see diagram 3).

Diagram 1: forming by simple pressing

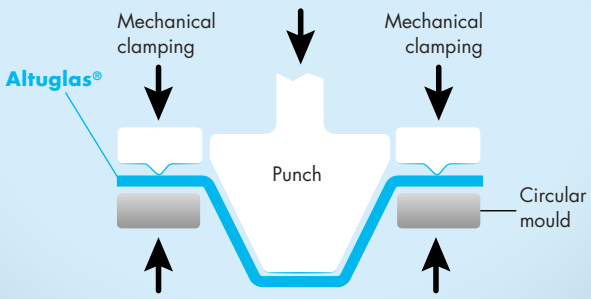


Diagram 2: forming by pressing with a punch and die

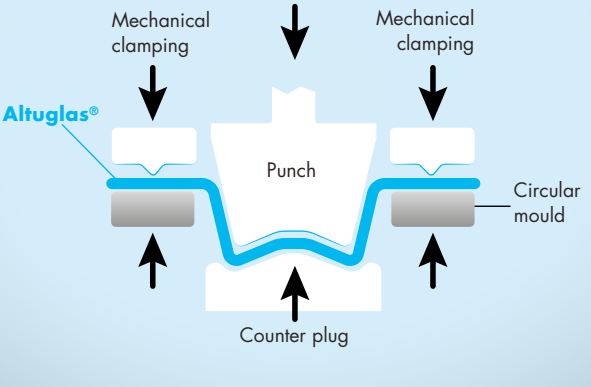
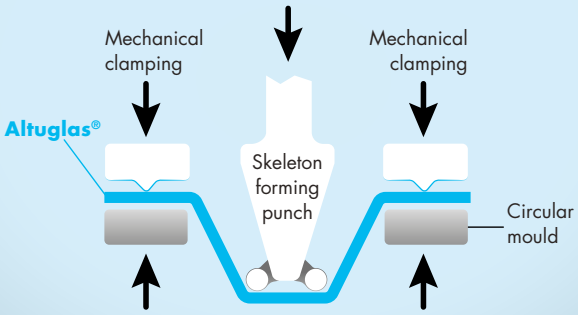


Diagram 3: forming by pressing with a skeleton punch

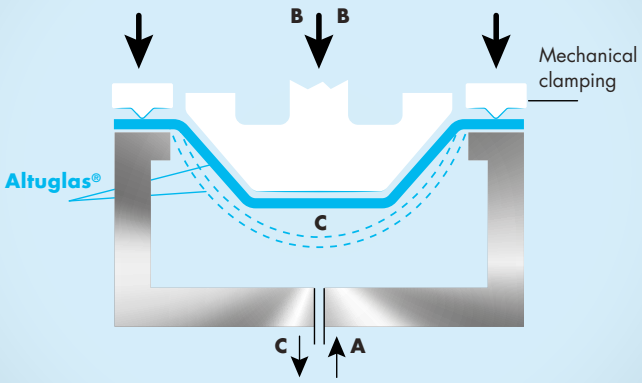


COMBINED THERMOFORMING METHODS: BLOW/VACUUM-MOULDING AND PRESSING

Vacuum-drawing with elastic return against a plug (vacuum/snap-back)

This process is mainly used with Altuglas® CN, which has a memory effect. It consists of first drawing it into a vacuum tank, beyond the shape to be produced. A plug is then lowered into the vacuum-formed shape. The vacuum is released and the Altuglas® CN contracts elastically to fit the plug (see diagram 1).

Diagram 1: forming by vacuum-drawing and moulding

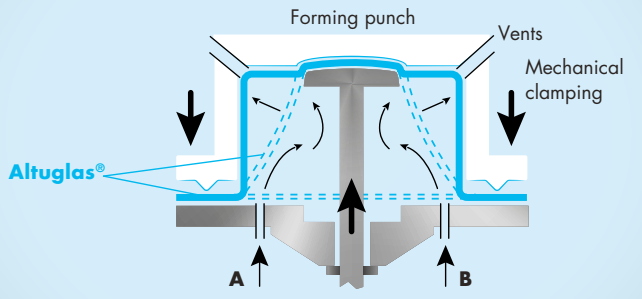


A 1st phase: forming a dome by vacuum
B 2nd phase: mould is lowered into cavity formed
C 3rd phase: the Altuglas® is pressed against the mould

Pressing and blow-moulding

A punch first presses the hot sheet to the bottom of the mould. It is then forced against the walls of the mould by air pressure (see diagram 2).

Diagram 2: forming by pressing and blow-moulding



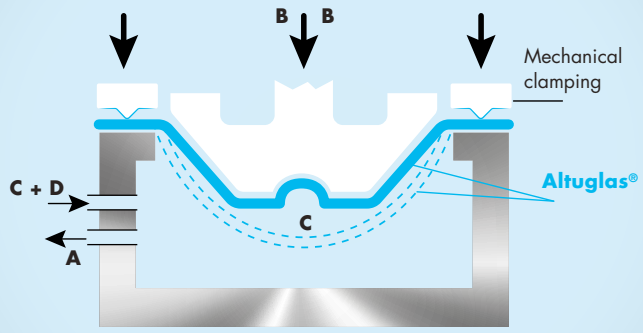
A 1st phase: punch is raised
B 2nd phase: compressed air fed in

Vacuum-drawing and blow-moulding

The same tank is used first to apply a vacuum and then pressure. The vacuum is used to obtain maximum deformation, after which a plug is lowered into the vacuumformed shape. The vacuum is then released and the sheet contracts elastically to fit the form of the plug.

Finally, compressed air is used to force the sheet against all parts of the plug, including any cavities. Due to the elastic memory effect already mentioned, this process is mainly used with Altuglas® CN (see diagram 3).

Diagram 3: forming by vacuum-drawing and blow-moulding



A 1st phase: forming a dome by vacuum
B 2nd phase: mould is lowered into cavity formed
C 3rd phase: the Altuglas® is pressed against the mould
D 4th phase: compressed air fed in

BENDING

If the part to be produced requires only straightforward bends between flat surfaces, it is preferable not to heat the entire sheet, to ensure that the perfect flatness is preserved.

The technique is to heat the Altuglas® locally along the length of the bender, using one or more straight electrical heating elements.

The heating element may, for example, be a nickel/chromium wire held taut by a spring or counterweight and heated by a low voltage supply (24 or 48 volts).

Recommended procedure

- Heat the material to a temperature at which bending can be carried out with the least possible force, as a guide 150° to 170°C. A single unit containing a heating wire and two water boxes is generally sufficient for sheets up to 5 mm thick. For thicker sheets, use two symmetrical systems, placed one on each side of the sheet.
- heat a zone that is at least as wide as the sheet is thick. The width of the zone for a right-angle bend is roughly 5 times the thickness.
- machine a V-groove for acute bend angles and thick sheet

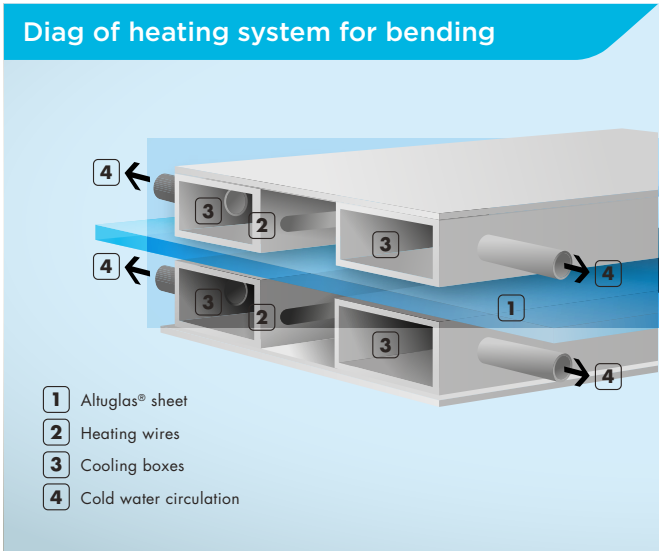
Precautions

A number of precautions must be taken to limit stress in the bend zone:

- apply intense heating to the bend zone only
- use suitable heating units; the best can be adjusted to control the width of the zone to be heated. The zone adjacent to the heated zone must be kept at a temperature of about 70°C for extruded sheets and 80°C for cast sheets, to minimize stresses due to temperature differences.
- avoid excessive thermal shock when bending the material, specifically by using wooden guides

Despite these precautions, bending leaves high internal stresses. Once again, the product must be annealed before being placed in contact with solvents or used in demanding conditions (see page 28).

Diag of heating system for bending



Working with Altuglas®

Guidelines and errors to avoid

AVOIDING ERRORS

Certain basic processing errors must be avoided to obtain the best results:

The part may crack or tear if:

- a part is too hot or too cold
- drawing is done too quickly, especially with Altuglas® CN
- the mould is too cold, or has angles that are too sharp
- the air jet is too forceful or poorly diffused

Optical distortion may occur due to:

- defects in the surface of the mould
- contact between the sheet and mould at high temperature, before forming, especially for Altuglas® EX
- heating above 190°C for Altuglas® CN and 170°C for Altuglas® EX
- too hot a mould
- a poorly diffused jet of air

PRECAUTIONS DURING COOLING

To retain the required form without distortion, the part must be left in the mould until it has cooled to around 70°C.

Cooling must be as long and uniform as possible, to minimise residual internal stress.

Parts formed from Altuglas® EX must be annealed to relieve internal stress before any solvents, paints, printing inks or adhesive films are applied.

ANNEALING

Stress-relieving of machined and formed parts

If the parts have not been properly machined or have been thermoformed under unsuitable conditions, it is preferable that they be annealed in an air circulation oven before contact with solvents, adhesives, ink or paint. This operation is designed to relieve internal stresses caused by machining or forming. It is essential for extruded sheets. Internal stresses can cause crazing in contact with these products.

Annealing times and temperatures

For a given thickness, flat pieces produced from cast or extruded Altuglas® sheet require the same annealing time. Only the temperature changes:

- Altuglas® CN: 85°C
- Altuglas® EX: 75°C

The annealing time is given by the following formula:
Annealing time (hours) = 2 + [0.225 x thickness (mm)].

When annealing bent or thermoformed parts, the temperatures must be reduced by 10°C to avoid unwanted distortion:

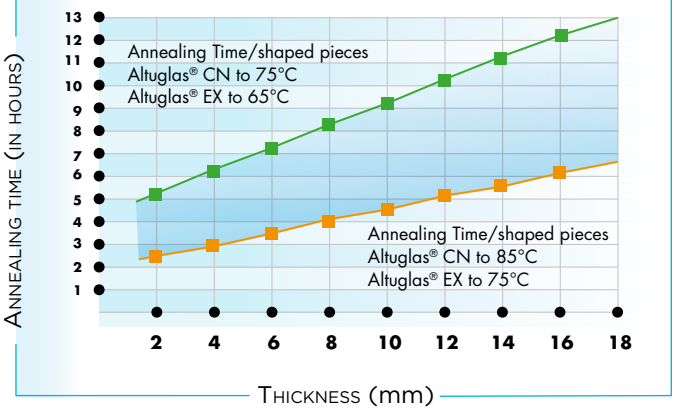
- Altuglas® CN: 75°C
- Altuglas® EX: 65°C

The annealing time for formed parts is given by the following formula:
Annealing time (hours) = 4 + [0.450 x thickness (in mm)].

The graph of the two formulae, below, enables the annealing time for a given thickness to be read at a glance.

It is important to allow the parts to cool naturally in the oven, to avoid fresh stresses due to thermal shock.

Annealing time as a function of temperature for various sheet thicknesses



Assembly

GENERAL INFORMATION

Altuglas®, either in the original flat sheets, or curved by cold or hot bending or thermoforming, is often mounted in a rigid frame. Regardless of whether it is affixed to a rigid frame or inserted in framing sections, certain basic precautions must be taken to avoid breakage or unwanted distortion in the long term.

Incompatibility with other materials

Altuglas® must not be placed in contact with incompatible plastic materials such as plasticized P.V.C. or silicone sealing compounds containing acetic acid or acetates.

Recommended contact products are: Teflon®, Dutral®, EPDM rubber, neoprene, butyl, polyethylene (PE), polypropylene (PP) and neutral silicone. When the nature of the product is unknown, ask the supplier about its compatibility with Altuglas®.

DIMENSIONAL VARIATION AND EXPANSION GAPS

Altuglas® has a coefficient of expansion roughly 10 times that of metals normally used for frames. Consequently, the sheet must be cut to dimensions which leave sufficient space for expansion. This applies just as much to the length and width of the sheet as to the diameters of fixing holes.

In addition, EPDM-type seals (compatible with Altuglas®) are frequently force-fitted between Altuglas® sheet and a rebate in the metal frame. In such an installation, ensure that there is sufficient elasticity to allow the Altuglas® to expand or contract freely. Moreover, with Altuglas® CN, allowance must be made for possible differences in thickness within a given sheet.

Finally, where the sheet is fixed by screws, the following guidelines are recommended:

- the drilling diameter should be substantially greater than the diameter of the screw thread
- the hole must be protected from the screw threads by a plug made of compatible material (PE type)
- insulating EPDM rubber or teflon washers should be used when screwing
- take care not to over-tighten the screw

SELECTING THE SHEET THICKNESS

The Altuglas® sheet must be thick enough to stay rigid when exposed to forces such as wind pressure or snow that may be anticipated in the site area.

COLD BENDING

Altuglas® CN, Altuglas® EX and Altuglas® EI sheets are ideally suited to cold bending. This allows them to be installed in curved rebates. However, the bends must not be sharper than a certain minimum curve radius, to avoid high permanent stress, which would eventually cause crazing or even breaks.

The minimum bend radii (Rmin) are calculated as a function of sheet thickness. The coefficients given vary according to the type of sheet:

Product name	Cœfficient
Altuglas® CN Rmin (mm)	330 x thickness in mm
Altuglas® EX Rmin (mm)	330 x thickness in mm
Altuglas® EI 25 Rmin (mm)	220 x thickness in mm
Altuglas® EI 50 Rmin (mm)	200 x thickness in mm

Installation

BONDING

Bonding is the creation of a PMMA joint between the parts being assembled. The glues are either a solution of PMMA in a solvent, most of which evaporates during curing, or polymerisation in situ to form PMMA. This second process effectively forms continuous Altuglas® between the adjacent parts.

In either case, the first step is to apply either the volatile solvent-based glues, or the monomer solvent for polymerizing glues, to both the faces to be bonded.

However, before any bonding, it is essential to apply an annealing heat-treatment, to relieve any internal stresses left by machining or forming (see page 28).

It is also advisable, once the glue has dried and hardened at room temperature, to carry out another heat treatment for 2 to 5 hours at approx. 60°C, to improve the quality of the joint.

Various types of glues

The specific composition and uses are set out in the Technical Data and Safety Data for each Special Care adhesive.

Contact glues (Special Care Adhesive S)

These are solutions of generally small quantities of PMMA in a solvent, or may even be pure solvent. The setting time is the time required for the solvent to evaporate, but complete evaporation seldom occurs.

Polymerizing glue (Special Care Adhesive P)

Catalysts are added to these fairly viscous solutions of polymethylmethacrylate and methylmethacrylate just before use, to polymerize the monomer. The material in the joint is therefore similar to Altuglas®. The setting time is the time required for the polymerization reaction to take place.

Glue strength

Under ideal conditions, the strength of the joint, measured by a tensile test for example, is within the following range:

- contact glues: 25 to 35 % of the strength of the original adjacent material
- polymerizing glues: 60 to 75 % of the strength of the original adjacent material

WELDING

Welding involves placing the two parts to be joined in contact and then causing them to soften considerably in the contact area. Although many methods are available (hot gas, heating bars, induction, radiation, ultrasonics), this technique can only be applied to Altuglas® EX.

Another method is to use a filler rod and melt the material. It then becomes possible to weld Altuglas® CN.

However, the operation leaves high internal stress and an annealing heat-treatment is essential (see page 28).

Under optimum conditions, the strength of the welded joints varies from 10 to 40 % of that of the original adjacent material.

Finishing & maintenance

DECORATIVE FINISHES

The most frequently used methods of decorating Altuglas® are screen-printing, hot transfer, paint spraying or application of coloured vinyl films. The method chosen will depend on various parameters:

- economic factors (number of parts to be produced, investment cost)
- the shape of the part
- the number of colours to be applied
- the expected life, etc

New technologies are offering new possibilities:

- laser engraving in three dimensions
- illuminated panels with electronic programming of three-colour LEDs (RGB)

Screenprinting

Screen-printing is generally known for its bright colours and long-term stability, and allows parts to be thermoformed after decoration. However, the surfaces must be perfectly flat. There are two types of screen-printing:

- process using solvent-based inks
- process using inks that can be polymerised under UV

The process using UV inks is increasingly used with Altuglas®. When used with Altuglas® sheets, this technology has certain advantages:

- new technical possibilities
- improved working conditions (absence of solvents)
- faster production cycles

The technology of UV inks is evolving rapidly. It is therefore preferable to contact the ink suppliers.

It is recommended to screenprint the inside face in order to avoid any printed being transferred from the upper-face protective film. We recommend to clean the surface before screenprinting.

Paint

Paint can be sprayed on to surfaces after forming and allows quicker drying.

Adhesive films

Special Care must be taken in preparing the surface and applying self-adhesive vinyl film. Subsequent thermoforming is not possible. The absence of gas loss from Altuglas® sheet ensures that the appearance and adhesion will be maintained in the long term. However, it is important to check first that the films are wholly compatible with Altuglas®.

Illuminated decoration

The light diffusion and transmission characteristics of Altuglas® make it the material of choice.

Speciality products such as Altuglas® Elit are designed for tangential illumination. Light comes from light sources located around the edges. Altuglas® Elit diffuses this light evenly over the whole surface. This allows the construction of illuminated surfaces that are very compact. Altuglas® Elit sheets can be curved, thus allowing the creation of complex shapes.

Altuglas® Dual Satin allows optimum diffusion of light via its two matt surfaces, together with an almost infinite range of colours.

Combining new lighting technologies such as LEDs with Altuglas® sheets provides new design opportunities with a minimum of technical constraints.

FINISHING

Before packing and wrapping pieces made of Altuglas® CN or EX, Altuglas® Cleaner can be applied to remove finger and handling marks. This improves the shine and reduces static, which slows down the accumulation of dust.

However, if the parts have accidental scratch marks, they should first be polished using Altuglas® Polish and a soft cloth or polisher.

MAINTENANCE AND CLEANING

All the previous recommendations also apply to maintenance.

In many cases, cleaning only amounts to washing with clean water and a soft cloth, chamois leather or sponge.

Never rub the dry surface of Altuglas®.

The use of solvents such as methylated spirits, turpentine, white spirit or window cleaning products is to be discouraged.

Resistance to chemicals

Altuglas® provides good resistance to water, alkalis and aqueous solutions of inorganic salts. However, Altuglas® is attacked by certain dilute acids, such as hydrocyanic and hydrofluoric acids, and concentrated sulphuric, nitric or chromic acids.

There are three categories of solvents:

- highly active solvents: chlorinated hydrocarbons
- moderately active solvents: aromatics, aldehydes, ketones and esters (acetates)
- slow solvents: alcohols

		REACTION OF ALTUGLAS® TO					
	%	ALTUGLAS® CN	ALTUGLAS® EX		%	ALTUGLAS® CN	ALTUGLAS® EX
ACIDS							
Acetic Acid	10	NA	LA	Lactic Acid	20	NA	NA
Acetic Acid	100	SA	SA	Nitric Acid	10	NA	
Butyric Acid	Concentr.	SA	SA	Nitric Acid	Concentr.	SA	
Chromic Acid	10	NA		Oxalic Acid	Saturated	NA	NA
Chromic Acid	Saturated	SA	SA	Peracetic Acid		SA	SA
Citric Acid	Saturated	NA	NA	Phosphoric Acid	10	NA	NA
Formic Acid	10	NA	NA	Phosphoric Acid	95	SA	SA
Formic Acid concent	90	SA	SA	Sulfuric Acid	10	NA	NA
Hydrochloric Acid	10	NA	NA	Sulfuric Acid	30	LA	LA
Hydrochloric Acid	Concentr.	NA		Sulfuric Acid	90	SA	SA
Hydrofluoric Acid		SA	SA	Tartaric Acid	Saturated	NA	NA
ALCOHOLS							
Amyl Alcohols	Pure	SA	SA	Methyl Alcohol	10	NA	NA
Benzyl Alcohol	Pure	SA	SA	Methyl Alcohol	50	LA	LA
Butyl Alcohol	Pure	SA	SA	Methyl Alcohol	Pure	SA	SA
Ethyl Alcohol	30	LA	SA	Propyl Alcohol	10	LA	LA
Ethyl Alcohol anhydrous	Pure	SA	SA	Propyl Alcohol	50	SA	SA
Ethyl Alcohol Br. contact	10	NA	NA				
BASES							
Caustic Potash	10	NA	LA	Caustic Soda	50	SA	SA
Caustic Potash	50	SA	SA	Sodium Carbonate	Saturated	NA	NA
Caustic Soda	10	NA	LA				
GASES							
Acetylene		NA	NA	Ozone		NA	NA
Butane		NA	NA	Propane		NA	NA
Carbonic Gases		NA	NA	Sulphur Dioxide		NA	NA
Hydrogen		NA	NA	Sulfuric Anhydride		SA	SA
Oxygen		NA	NA				
OILS AND GREASY PRODUCTS							
Butyl Stearate		NA		Mineral Oils		NA	NA
Coconut Oil		NA	LA	Parafin		NA	NA
Lanoline		NA	NA	Sodium Oleate		NA	LA
Lockeed Oil		SA	SA				
FOOD PRODUCTS							
Fruits Juices		NA	NA	Vinegar		NA	NA
Milk		NA	NA	Wine		NA	NA
Olive Oil		NA	NA				

NA - No Attack / LA - Limited Attack / SA - Severe Attack

The following table indicates the resistance of Altuglas® CN and EX to various fluids at room temperature, for various periods of up to 1 year or more.

The tests were only carried out on colourless sheets. The results are considered satisfactory if the test pieces show no obvious changes such as swelling, dissolved areas, crazing, splitting or embrittlement. Slight discolouration may occur without being considered a flaw.

VARIOUS CORROSIVE SUBSTANCES

	%	ALTUGLAS® CN	ALTUGLAS® EX		%	ALTUGLAS® CN	ALTUGLAS® EX
PHENOLS							
Cresol		SA	SA	Phenol		SA	SA
Metacresol		SA	SA				
DISINFECTANTS AND CLEANING AGENTS							
Ammonia Solution	Density 0,88	NA	NA	Hydrogen Peroxide	40 volumes	NA	NA
Ammonia Solution	Concentr.	SA	SA	Hydrogen Peroxide	90 volumes	SA	SA
Bleach	10° Chlorine	NA	NA	Mercurochrome		NA	NA
Bleach	48° Chlorine	SA	SA	Tincture of Iodine		SA	SA
Formaldehyde	40	NA	NA				
MINERAL SALTS IN SOLUTION							
Alun (Saturated Solution)		NA	NA	Mercuric Chloride	10	SA	SA
Ammonium Chloride	Saturated	NA	NA	Potassium Bichromate	10	NA	NA
Ammonium Nitrate		NA	NA	Potassium Chloride	Saturated		NA
Calcium Chloride	Saturated	NA	NA	Potassium Iodide		NA	NA
Calcium Hypochloride		NA	NA	Potassium Permanganate	10	NA	NA
Chlorine Water	2	LA	LA	Sea Water		NA	NA
Copper Sulphate		SA	SA	Sodium Bichromate	10	NA	NA
Ferric Chloride	10		NA	Sodium Bisulphate	10	NA	NA
Iron Perchloride		SA	SA	Sodium Chloride		NA	NA
Iron Sulphate		NA	NA	Sodium Metaphosphate		NA	NA
SOLVENTS AND MISCELLANEOUS							
Acetaldehyde	100	SA	SA	Ethylene Sulphate		SA	SA
Acetic Anhydride		LA	LA	Freon		SA	SA
Acetone		SA	SA	Gasoil		LA	LA
Aniline		SA	SA	Glycerine		NA	NA
Benzene		SA	SA	Mercury		NA	NA
Benzaldehyde		SA	SA	Methylene Chloride		SA	SA
Butyl Acetate		SA	SA	Methylethylketone		SA	SA
Butyle Phtalate		LA	LA	Naphtalene		LA	LA
Chloroform		SA	SA	Nonyl Phthalate		LA	LA
Cyclohexane		SA	SA	Petrol Standard		LA	LA
Dichloroethane		SA	SA	Petrol Super 100 Oct.		SA	SA
Diethylene Glycol		NA	NA	Pyraline		SA	SA
Dioctyl Phthalate		LA	LA	Turpentine		NA	NA
Dioxane		NA	NA	Toluene		SA	SA
Ethylamine		SA	SA	Trichlorethane		SA	SA
Ethyl Acetate		SA	SA	Trichlorethylene		SA	SA
Ethyl Chloride		SA	SA	Tricresyl Phosphate		SA	SA
Ethyl Ether		SA	SA	Xylene		SA	SA
Ethylene Glycol		NA	NA	White Spirit < 3% Aromatics		NA	NA

Guarantee

Clear Altuglas® CN and EX sheets of any thickness retain virtually all their characteristics after 10 years' exposure to weathering.

The Altuglas® guarantee covers light transmission, rigidity and tensile strength.

The exact terms of the guarantee are given in the «10-Year Guarantee» document.

Technical information contained in this brochure is based on our own laboratory tests.

Technical specifications for our products are given as a guide and are subject to modification.

We accept no liability in regard to our product descriptions or the fitness of a product for a particular purpose, or for any direct or consequential loss or damage caused.

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Altuglas International, a global integrated leader in PMMA is heavily involved in the technical plastic sector – from MMA monomer to PMMA acrylic glass – creating and manufacturing innovative products to suit customers' needs worldwide. Its 920 highly committed staff make their contribution daily in our three businesses (MMA, sheet and PMMA resins). Its four great brand names are references: Altuglas®, Plexiglas® (Americas), Oroglas®, Solarkote®.

www.altuglasint.com
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