Working With Perspex®

PERSPEX
Distribution Ltd

Preparation

The surface protection film can be left in place during fabrication and all marking-out drawn on the film. However, it must be removed before thermoforming although in the case of extruded acrylic, the film may often be left in place provided sheets are only lightly formed and the film is in good condition. Any imperfections in the film can cause marks to be transferred to the thermoformed article. It is therefore, the customer's responsibility to decide whether or not the film should be left in place.

Cleaning

Cleaning of Perspex® is not generally required until after fabrication. However, if a product is to be printed, it may sometimes be advisable to wash the surfaces to be printed with clean, fresh water using a chamois leather or soft cloth. This has the benefit of removing all traces of static charge from the sheet after removal of the film which might otherwise attract dust.

Sawing

Powered saws with blades having alternate teeth bevelled, as for aluminium, are particularly suitable for Perspex®. Band saws, jig saws and fret saws may also be used. The recommended conditions for sawing Perspex® are shown in figure 1a.

Machining

Perspex® is a brittle material.It is therefore, necessary that only light machining cuts are taken and feed rates kept slow. Perspex® will soften if heated above 80°C and heat build-up can cause stress. Therefore, the use of coolants, including water and compressed air in particular is recommended during machining operations.

Perspex® can also be turned on a conventional metalworking centre lathe with cutting speeds to be reduced for an improved quality finish. For turning, HSS tool bits are preferred, kept sharp and ground to zero rake at the top and with 15-20° front rake.

Stress generated by machining can lead to stress-cracking or crazing either immediately or some time after machining. However, stress can usually be reduced, else eliminated in some materials by the gentle heat conditioning process of annealing.which is a gentle heat conditioning process.

While annealing may be required, if machining Perspex® cast to very close tolerances, it may be necessary to normalise the sheet in order to remove the casting stresses from the products manufacture, which would ordinarily have no effect on the behaviour of the product.

By heating the Perspex® above its glass transition temperature, the stresses are relaxed giving rise to uniform shrinkage of approximately 2%. Normalised Perspex® would therefore, be fully stress-relieved.

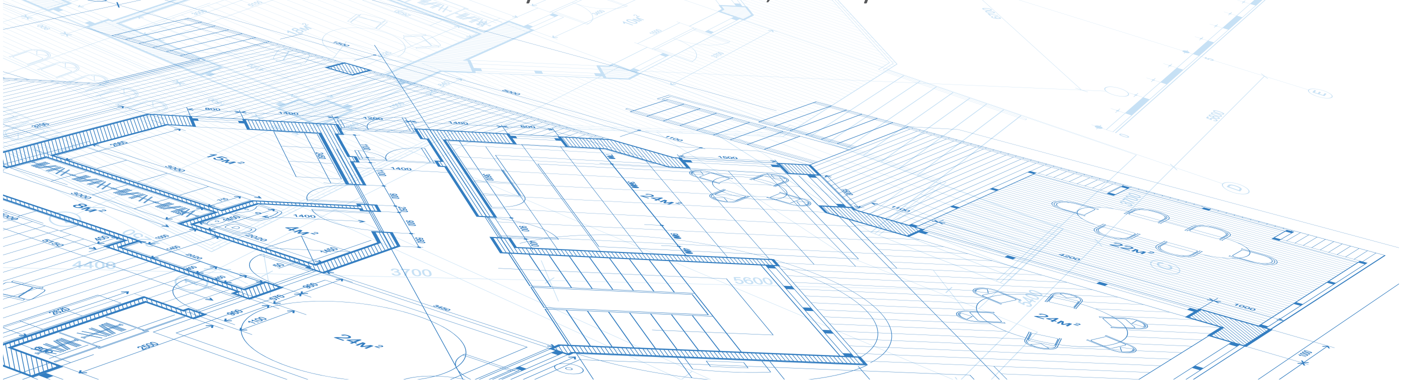
Routing

Fixed head, moving head or portable standard woodworking routers are suitable for Perspex® using the same cutter speeds as for wood. Routing can actually be performed dry but all swarf must be cleared and the cutter kept cool. Compressed air directed onto the cutter and workpiece would be preferred.

For routing, HSS double-edged cutters are preferred, ground and honed with a back clearance angle of about 12° or greater. See figure 1b for cutter speeds.

Scribe - Breaking

Small pieces of Perspex® up to 4mm thick may be conveniently cut in a straight line by deeply scribing one surface several times with



a sharp metal scriber, clamping the sheet with the scribed line uppermost and pressing sharply down over the edge of a bench. Please note, this technique is not suited to extruded.

Laser cutting

Perspex® may be laser cut into complex and intricate shapes. Thicknesses up to 25mm may be cut although some experimentation will be necessary to achieve the optimum quality of finish above 12mm. If bonding up to a laser cut edge it may be necessary to carry out a short annealing cycle to reduce the risk of crazing.

Drilling

Conventional twist drills for use with wood are suitable for use with Perspex® and hole-saws may be used for larger holes greater than 12mm diameter. However, it is advisable to re-grind twist drills to give a zero rake. A small pilot hole should be drilled first to locate the drill and where possible, the work should be supported by a back stop made from either scrap Perspex® or wood to prevent splintering the exit hole.

The use of coolants is recommended for any deep drilling and swarf should be removed at regular intervals.

Screwing and tapping

Standard taps and dies may be used for cutting screw threads in Perspex® with the use of lubricants essential. Wherever possible, coarse threads are preferred as they are less liable to damage. If frequently dismantling, threaded metal inserts would be recommended.

Engraving

Perspex® is easy to engrave using pantographs, CNC engraving machines or laser engravers for very fine detail. Mechanical engraving can actually be performed dry but all swarf must be cleared and the cutter head kept cool. Compressed air directed onto the cutter and workpiece would be preferred.

Cutting tools

To achieve a good finish when cutting, all tools must be kept sharp. Most conventional tools for use with wood or soft metals are suitable for use with Perspex®. Most power tools can also be used and HSS tool bits are suitable to achieve a good finish. For longer-life, tungsten carbide tipped blades and tool bits would be beneficial while for accurate work where a high degree of finish is required, diamond tipped tools would be particularly suitable and the preferred option.

Finishing

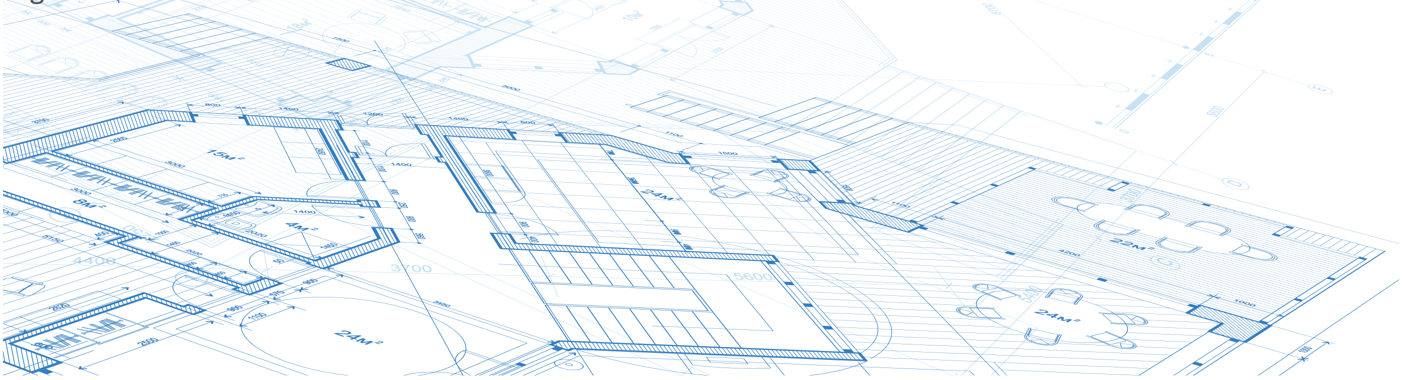
Machining marks can be removed by scraping with a sharp blade set at 90° or sanding then polishing. Bench mounted, portable or belt sanders may be used carried out dry with only light pressure applied. After sanding it will be necessary to anneal the work if bonding or surface decoration is applied.

Polishing

Power buffing with rotating calico mops may be used on the sanded surface with a mild, abrasive buffing soap. Moderate speeds and only light pressure should be applied to prevent overheating.

Diamond polishing can be used for straight edges without the rounded edges produced by buffing and with very little stress.

Flame polishing can be used for thin edges of Perspex® and is fast and effective. Care must be taken not to ignite the surface of the Perspex® and it should be noted that flame polishing can produce highly stressed edges. After flame polishing it will be necessary to anneal the work if bonding or surface decoration is applied.



Working With Perspex®

Thermoforming

To thermoform Perspex® correctly it must be heated uniformly and would require slightly more heating than extruded acrylic. Optimum heating times and temperatures will depend upon a number of factors, including thickness of the sheet, the type of mould being used and the degree of stretching required. Perspex® cast also requires greater force and has a lower elasticity than extruded acrylic. Therefore, Perspex® cast sheet is more suited to thermoforming by mechanical press where more force can be applied than vacuum forming.

Extruded has a lower melt strength than cast sheet, it softens more easily and can be stretched with very little force. For this reason it is more suitable for vacuum forming than cast sheet which requires greater force and has lower elasticity. If overheated extruded will start to extend under its own weight if hung in a vertical heating oven and control of heating time and temperature are critical if oven heating is used.

Heating

When Perspex® sheet is heated to 140° – 170°C it becomes flexible and can be formed into complex shapes by the application of force such as air pressure or mechanical press clamping. If held to that shape and cooled below 90°C it will retain the shape and if re-heated will return to its original flat condition.

As a general rule the preferred thermoforming temperature for Perspex® cast sheet is 170°C and for extruded is 155°C.

When heating extruded IM the sheet may become opaque at the shaping temperature. This is perfectly normal and the clarity will return when the shapings reach room temperature.

Except when local bending, the entire area of acrylic sheets should be uniformly heated within an air circulating oven with accurate temperature control.

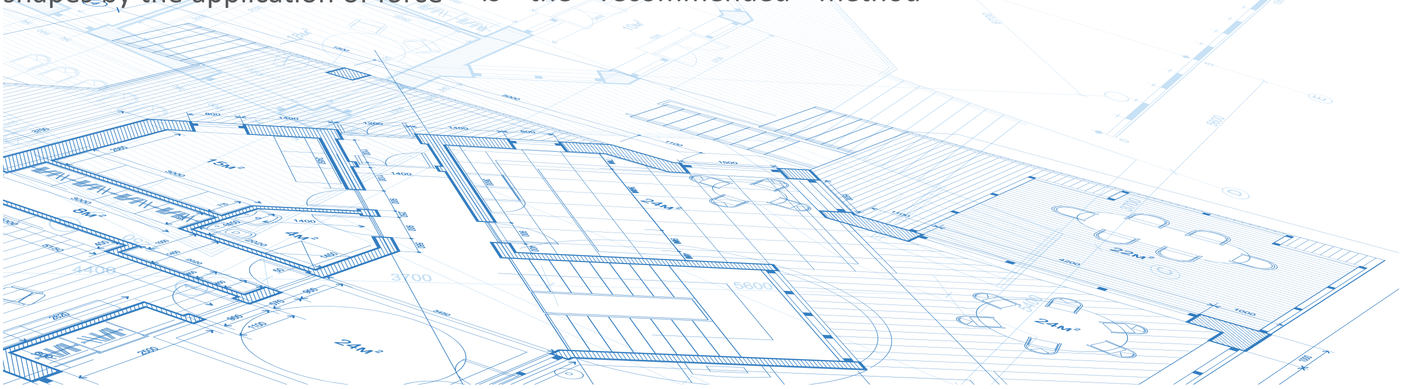
The heating of extruded on a horizontal oven shelf is not recommended because the hot sheet surface marks easily and can stick to the shelf. Infra-red heated vacuum forming machines can overcome these difficulties and are the preferred option for thermoforming extruded.

Perspex® clear and coloured sheets can be laid on clean horizontal shelves but when optical quality is paramount, vertical hanging is the recommended method with suitable hanging clamps to suspend the sheets along their longest dimension. As an alternative to air oven heating, certain infra-red heaters can be used such as those with quartz or ceramic elements. However, these do heat the surface of Perspex® very quickly, so heaters and heated platens must be designed to give uniform heating under controlled conditions to prevent overheating and subsequent degradation of the sheet.

Shrinkage

When Perspex® cast sheet is heated it will shrink, such that on cooling again it will be approximately 2% smaller in both length and breadth with a perceptible increase in thickness. No further shrinkage will occur on reheating but this initial shrinkage should be taken into account when cutting sheets into blanks prior to thermoforming.

When extruded sheet is heated it will exhibit more shrinkage along the direction of extrusion and very little across the direction of extrusion. It is difficult to give precise figures for shrinkage which will depend on the thickness and heating time but as a rule, 2mm sheet would shrink slightly more than 5mm sheet but typically, no more than 5%.



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Cooling

After thermoforming, extruded can be lifted off the mould at a temperature of around 70° - 80°C with Perspex® cast to be kept on the mould until the temperature has reached around 60°C. Uniformity of cooling is important to prevent warpage and stress but mouldings should not be left on the mould too long otherwise they may contract tightly on to the mould and be damaged when lifted off.

Thermoforming of colours

Certain Perspex® colours can change slightly during the heating process, especially if the sheet is overheated. It is important to ensure that the first surface is always the showface as the second surface can be slightly duller after heating. As the sheet is stretched during thermoforming there will be an inevitable thinning and in those areas it may also give rise to a reduction in opacity.

Vacuum forming

Perspex® cast sheet requires higher shaping forces than extruded acrylic and is therefore, less suitable for the low pressure vacuum forming process unless the shapes are quite large and simple in design.

Extruded on the other hand is ideally suited to the vacuum forming process. Due to its lower melt strength, it can be drawn by relatively low vacuum forces, has high extensibility and therefore, high definition within the mould.

Double-sided heating is recommended for all vacuum forming above 2mm thickness. The sheet should be heated carefully and examined regularly until it is ready for shaping. Some trial and error may be needed to reach this stage. The use of "levelling" is advisable by injecting air into the box cavity so supporting the hot sheet during the final heating stages.

If moisture blisters occur when vacuum forming, the extruded sheet should be pre-dried before use, preferably with the surface protection film removed. At least 24 hours drying time may be required at 90 – 95°C.

Moulds

For long production runs and high quality mould detail, cast aluminium moulds cored for water cooling are recommended. A smooth, matt finish is preferred and all dust must be kept clear of the mould surfaces to prevent dust marks, especially when moulding clear sheet. Mould temperatures should be maintained at between 80 – 95°C.

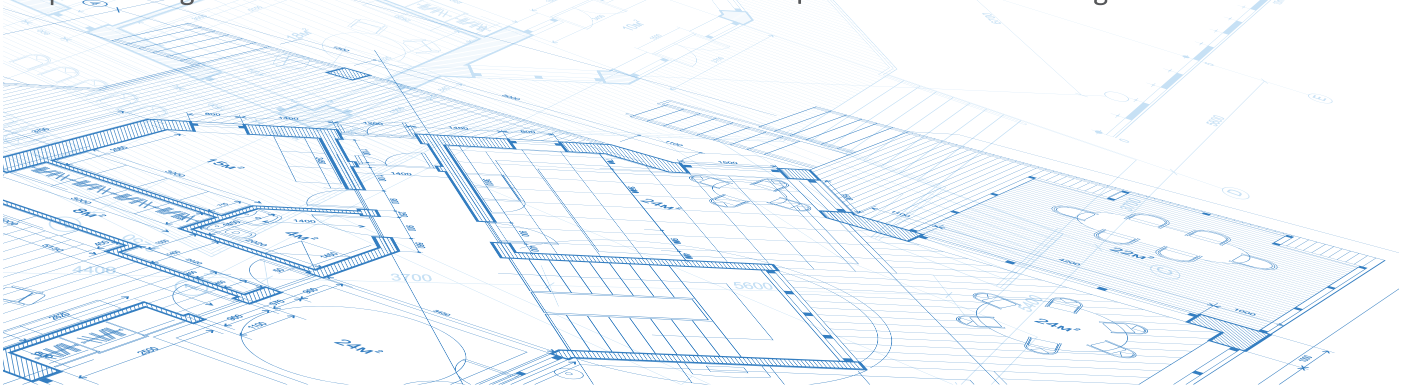
Drape forming

Unaxial bent parts can be achieved by drape forming or simple bending over moulds made out of wood or aluminium and covered with felt. Perspex® sheets should be heated to 140°C with only slight pressure necessary to drape the sheet over the positive mould. The sheet should be placed over the mould immediately after heating and left to cool down at room temperature.

Line bending

Line bending requires that the Perspex® sheets are softened along a narrow line by a strip heater, usually a hot wire. When the shaping temperature is reached, the sheet is bent and clamped or placed in a jig to cool. For sheets thicker than 5mm, double-sided heating is recommended.

For line bending of thick Perspex® cast sheet where a sharp radius is required, it can sometimes be helpful to machine a 'V' groove along the inside face to approximately half the sheet depth. While this will make it easier to bend the sheet at a sharp angle it will inevitably produce a weaker edge.



Stress generated by local line bending can lead to stress-cracking or crazing especially if the sheet is then bonded or decorated. However, stress can usually be reduced, else eliminated by the process of annealing.

General Purpose Cleaning

For all general purpose cleaning, Perspex® should be washed with clean, cold water to which a little detergent has been added. The use of any solvents such as methylated spirits, turpentine, white spirit or any proprietary window cleaning products is neither necessary nor recommended.

The ideal procedure is to polish every one to two weeks using a 100% cotton cloth.

Annealing

The recommended process for annealing Perspex® cast is as follows:

1.Place the components in an air circulating oven at room temperature.

2. Raise the oven temperature at a rate not exceeding 18°C per hour.

3.When the annealing temperature of 90°C is reached, maintain the temperature for:

a.1 hour for up to 3mm thickness
b.2 hours for up to 6mm
c.4 hours for up to 12mm
d.6 hours for up to 20mm

4.Cool to room temperature at a rate not greater than 12°C per hour.

For thermoformed components the annealing temperature should be reduced to within the range of 70 – 85°C.

A rapid annealing cycle which is reliable, especially for thin sheets, is to pre-heat the oven to 80°C, anneal for one hour, then remove the parts from the oven and allow to cool to room temperature.

Normalising

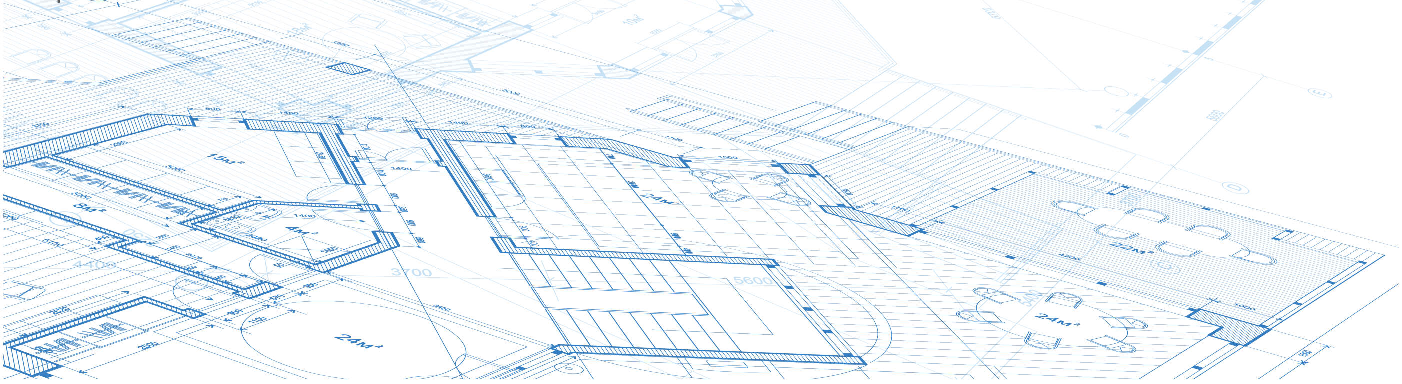
Perspex® contains stresses introduced during the casting process which under normal circumstances have no effect on the behaviour of the finished article. However, if components are being machined to very close tolerances it is advisable to remove these casting stresses by a process called normalising. By heating the PERSPEX® above its glass transition temperature, the stresses are relaxed giving rise to uniform shrinkage of approximately 2%. Normalised Perspex® would therefore, be fully stress-relieved.

The normalising process consists of a closely controlled temperature and time cycle depending on the sheet thickness. The sheet to be normalised is heated to 140°C in an air circulating oven and held there until it has been heated uniformly. It is then allowed to cool down slowly to avoid the reintroduction of thermal stresses.

The cooling rate should be from between 105 – 110°C to room temperature, not greater than 4°C per hour over a minimum cooling time of 21 hours. The maximum allowable differential between the material and ambient temperature at the time of removal from the oven is 7°C.

The treatment conditions for thick sheet and block are especially critical. Refer table 1c for typical normalising cycles for Perspex® cast acrylic.

For further information, please contact your local branch.



Tables

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Figure 1a

Saw Type	Optimum Blade Speed (m/min)	Optimum Saw Pitch: Sheet Thickness	Optimum Saw Pitch: Teeth/cm	Recommendation
Circular Saw carbide tipped	3000	All thicknesses	0.8-1.6	
Bandsaw	1500	Upto 3mm 3-13mm Over 13mm	6-8 4-5 1.5-2	Saw guides as close together as possible to prevent blade twisting
Jig Saw Fret Saw	Non-critical	Upto 6mm	5-6	Allow blade to stop before withdrawing from saw cut

Figure 1b

Cutters	Spindle Speed
6-12mm diameter or less	ca 24000 RPM
> 12mm	ca 18000 RPM

Figure 1c

Thickness (mm)	Cycle heating to: Hour	Cycle heating to: Min.	Holding at 140° C: Hour	Holding at 140° C: Min.	Cooling to 105-110° C: Hour	Cooling to 105-110° C: Min.	Holding at 105-110° C: Hour	Holding at 105-110° C: Min.
3		30		50		30		30
4		30	1	30		30		50
5		30	1	30		30		50
6		30	1	40		30		50
8	1	00	2	15	1	00	1	30
10	1	00	3	00	1	00	1	30
12	1	00	3	45	1	00	1	50
13	1	00	3	45	1	00	1	50
15	1	00	4	15	2	00	2	00
20	1	30	5	30	3	30	3	00
25	1	39	7	00	3	30	3	30
30	1	45	8	30	4	45	4	00
35	2	00	9	45	5	00	5	00
40	2	30	11	15	5	30	5	45

Thickness (mm)	Cycle heating to		Holding at 140° C		Cooling to 105-110° C		Holding at 105-110° C	
	Hour	Min.	Hour	Min.	Hour	Min.	Hour	Min.
45	2	30	12	30	6	30	6	30
50	3	00	14	00	7	00	7	00
55	3	00	15	30	7	00	7	45
60	3	30	16	45	8	30	8	30