# INSTRUCTION OPTIONS

POLYCASA® PS

## CONTENT

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## 1 INTRODUCTION

The manufacture of plastic articles from POLYCASA® PS sheet normally involves secondary fabrication operations, including sawing, drilling, bending, decorating, and assembling. This guide covers the properties and characteristics of POLYCASA® PS that need to be taken into account if secondary operations are to be performed successfully.

## 2 STORING AND HANDLING

The originally packed plastic sheets should neither be stored outside nor be exposed to great variations of weather and/or temperature. When storing under conditions with substantial variation of temperature and humidity, flat shape distortion (corrugation) of the sheet can happen, even when stored flat and stacked.

Polyethylene film protects sheets against dirt, mechanical load and scratches. It is recommended to leave the protective PE film in place until final processing.

Our standard PE protective film (without glue) is not designed for long-term open-air exposure/protection - it has only moderate UV- and heat-resistance. If sheet is stored outside, without protection, the protective foil should be removed 4 weeks after film application latest, as there is a risk of brittleness and difficult removal of the degraded PE film. This could lead to the damage of the sheet surface. If sheet is stored inside under normal stable storage conditions, it is recommended to remove the film 6 months after film application latest.

The special products PS are masked with special films. Details regarding suitability and processing properties can be taken from the referring technical data sheets, which can be obtained from technical customer service.

PS standard products could be protected with self-adhesive foil on demand. It has to be considered that there is always a risk that the film could be difficult to remove and leave glue residues on the sheet surface after removal depending on storage conditions. POLYCASA is unable to give a recommendation in how long time the sheet can be safely stored with self-adhesive film.

Customers are recommended to carry out own trials. POLYCASA cannot take any responsibility for problems caused by self-adhesive film.

Differences in temperature and moisture-content between top- and bottom-side of sheet or between different sheet areas can cause different dimension changes inside the sheet. This can result in waviness of the sheet after a short time. It is recommended to store the sheet under constant temperature and humidity conditions on a flat surface.

# 3 FABRICATING

## 3.1 Machining guidelines

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

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

Since plastics are poor heat conductors, the heat generated by machining operations must be absorbed by the tool or carried away by coolant. A jet of air directed on the cutting edge aids in cooling the tool and in removing chips.

Plain water or soapy water is sometimes used for cooling unless the trim scrap is to be reused.

## 3.2 Milling

Sheet manufactured from POLYCASA® PS can be machined with standard high-speed milling cutters for metal, provided they have sharp edges and adequate clearance at the heel.

## 3.3 Drilling

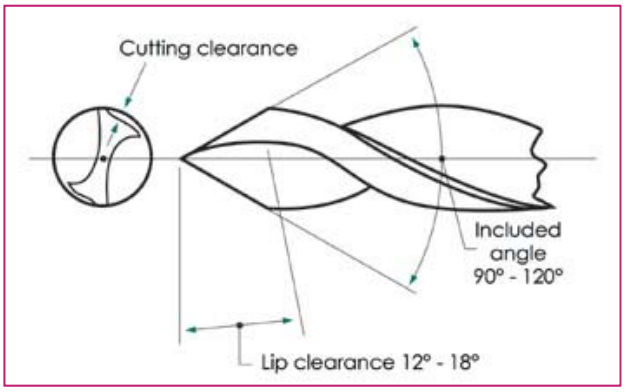


**Figure 1**

**Suggested drill-point design for drilling plastic sheet**

Drills designed especially for plastics are available, and their use is suggested. Standard twist drills for wood or metal can be used; however they require slower speeds and feed rates to produce a clean hole. Twist drills for plastics should have 2 flutes, a point with an included angle of 60° to 90°, and a lip clearance of 12° to 18°, as shown in figure 1.

Wide, highly polished flutes are desirable since they expel the chips with low friction and thus tend to avoid overheating and consequent gumming. Drills should be backed out often to free chips, especially when drilling deep holes.

Peripheral speeds of twist drills for plastics ordinarily range from 30 to 61 m per minute.

The rate of drill feed into the plastic sheet generally varies from 0.25 to 0.63 mm per revolution.

NOTE:

When drilling, be sure to hold or clamp the part securely to prevent it from cracking or slipping and presenting a safety hazard to the operator.

## 3.4 Sawing

Following types of sawing operations can be used to saw thermoplastic materials: band saw, circular saw and jigsaw as well as hand operated saws.

It is recommended that new or well-sharpened tools are used. At very high cutting speeds, the saw blade should be cooled with water or an alternative appropriate cooling emulsion.

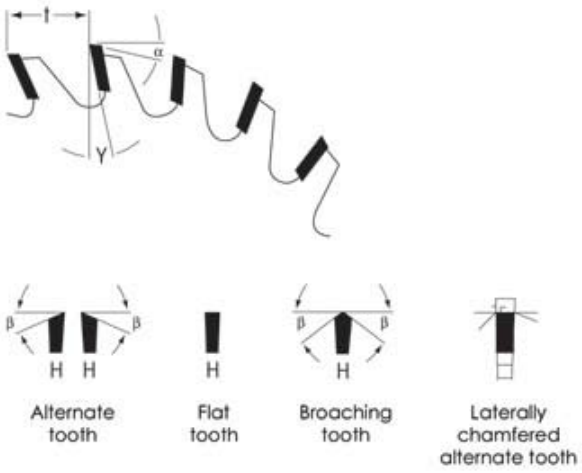


**Figure 2: Example of Saw blades**

**Table 1: Sawing recommendations**

| Type of sawing | Band saw | Circular saw |
|---|---|---|
| Tooth distance | sheet thickness below 3 mm, 1 to 2 mm | 8 to 12 mm |
| | sheet thickness 3 to 12 mm, 2 to 3 mm | 8 to 12 mm |
| Clearance angle α | 30 to 40° | 15° |
| Rake angle ψ | 15° | 10° |
| Tooth angle β | - | 15° |
| Cutting speed | 1200 - 1700 m/min | 2500 - 4000 m/min |
| Feed speed | - | 30 m/min |

## 3.5 Routing

Routers with sharp two-flute straight cutters produce very smooth edges. They are useful for trimming the edges of flat or formed parts, particularly when the part is too large or irregular in shape for a band saw. Portable, overarm, and under-the-table routers work equally well. The plastic sheet should be fed to the router slowly to avoid excessive frictional heating and shattering. The router or plastic sheet, whichever is moving, must be guided with a suitable jig. Compressed air can be used during the routing operation to cool the bit and aid in chip removal.

# 4 FORMING

## 4.1 Thermoforming

There are a number of different thermoforming techniques that can, under well-controlled conditions, be used to form POLYCASA® PS sheet, once heated, into the shape of a mould by mechanical, air pressure, or vacuum forces. Both male (plug) and female (cavity) moulds are used.

Tooling can range from low cost plaster moulds to expensive water cooled steel moulds but cast aluminium is more commonly used. Other materials including wood, gypsum, and epoxy can also be used.

Forming processes to be discussed include straight vacuum, drape, matched mould, pressure-bubble plug-assist, plug-assist pressure, vacuum snap-back, pressure-bubble vacuum snap-back, trapped-sheet contact-pressure, free, and mechanical.

In the event that during the heating up of POLYCASA® PS small bubbles appear, this is due to the fact that the sheets have absorbed moisture during storage.

In this case, the sheets must be pre dried before they are worked on.

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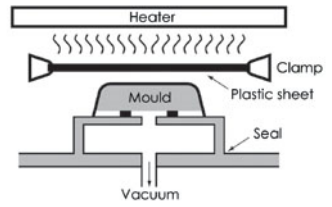
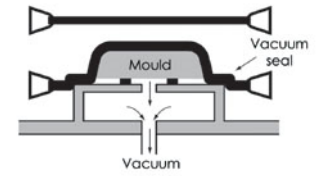
## 4.2 Straight vacuum forming

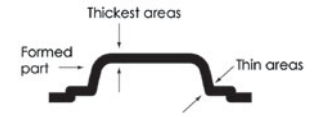
Vacuum forming is the most versatile and widely used forming process. The equipment costs less and is simpler to operate than most pressure or mechanical techniques. In straight vacuum forming, POLYCASA® PS is clamped in a frame and heated. When the hot sheet is in an elastic state, it is placed over the female mould cavity. The air is then removed from the cavity by vacuum and atmospheric pressure then forces the hot sheet against the contours of the mould. When the POLYCASA® PS sheet has cooled sufficiently, the formed part can be removed. Thinning at the upper edges of the part usually occurs with relatively deep moulds. The hot sheet being drawn to the centre of the mould first causes thinning. Sheeting at the edges of the mould must stretch the most and thus becomes the thinnest portion of the formed item. Straight vacuum forming is normally limited to simple, shallow designs. **See figure 3**




(A) Clamped, heated plastic can be pulled over the mould, or the mould can be forced into the sheet.




(B) Once the sheet has formed a seal around the mould, a vacuum is drawn to pull tightly against the mould surface.

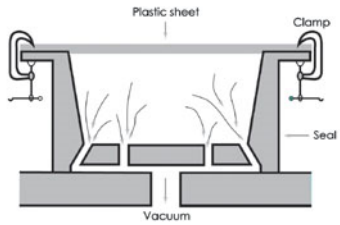



(C) Final wall thickness distribution in the moulded part.

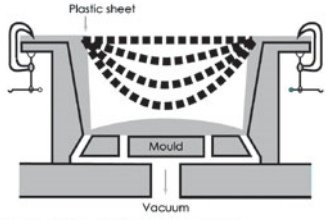
## 4.3 Drape forming

Drape forming is similar to straight vacuum forming except that after the POLYCASA® PS sheet is framed and heated, it is mechanically stretched, and a pressure differential is then applied to form the sheet over a male mould. In this case, however, the sheet touching the mould is close to its original thickness. It is possible to drape-form items with a depth-to-diameter ratio of approx. 4 to 1; however, the technique is more complex than straight vacuum forming. Male moulds are easier to build and generally cost less than female moulds; however, male moulds are more easily damaged. Drape forming can also be used with gravitational force alone. For multi-cavity forming, female moulds are preferred because they do not require as much spacing as male moulds.

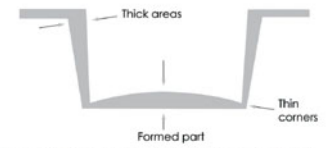
**See figure 4**




(A) A clamped, heated sheet is forced down into the mould by air pressure after a vacuum is drawn in the mould.




(B) Plastic sheet cools as it contacts the mould.




(C) Areas of the sheet that touch the mould are the thinnest.

## 4.4 Matched-mould forming

Matched-mould forming is similar to compression moulding in that heated POLYCASA® PS sheet is trapped between male and female dies made of wood, plaster, epoxy or some other material.

Although they cost more, water-cooled matched moulds produce more accurate parts with close tolerances.

## 4.5 Pressure-bubble plug-assist vacuum forming

The pressure-bubble plug-assist vacuum forming technique can be used when POLYCASA® PS sheet is to be formed into deep articles that must have good thickness uniformity. The sheet is placed in a frame and heated, and controlled air pressure is used to create a bubble. When the bubble has been stretched to a predetermined height, the male plug-assist (normally heated) is lowered to force the stretched sheet into the cavity.

Plug speed and shape can be varied for improved material distribution; however, the plug is made as large as possible so that the plastic material is stretched close to the shape of the finished product. The plug should penetrate 75 to 85% of the mould cavity depth. Air pressure is then applied from the plug side while a vacuum assist is being drawn on the cavity. The female mould must be vented to allow the escape of trapped air.

## 4.6 Plug-assist pressure forming

Plug-assist pressure forming is similar to plug-assist vacuum forming in that a plug forces the hot POLYCASA® PS sheet into a female cavity.

Air pressure applied from the plug then forces the plastic sheet against the walls of the mould. Plug design and plug speed can be varied to optimize material distribution.

## 4.7 Plug-assist vacuum forming

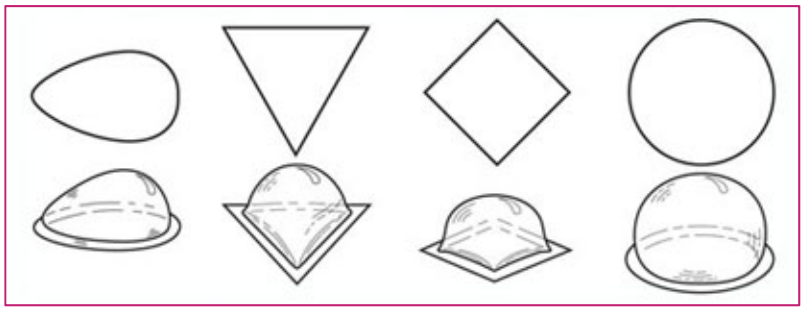
Corner or periphery thinning of cup- or box-shaped articles can be prevented by use of a plug-assist to mechanically stretch and pull additional plastic material into the female cavity. The plug should be 10 to 20% smaller than the mould and should be heated to just under the forming temperature of the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

Plug-assist vacuum forming and plug-assist pressure forming (see previous section) 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.

## 4.8 Free forming

In free forming, air pressures of about 2.76 MPa can be used to blow a hot POLYCASA® PS sheet through the silhouette of a female mold. Air pressure causes the sheet to form a smooth bubble-shaped article such as used in skylight panels or window well covers. Since only air touches each side of the pad, there will be no mark-off unless a stop is used to form a special contour in the bubble.

Figure 5: Examples of free-form shapes that can be obtained with openings



# 5 ASSEMBLY

POLYCASA® PS sheet can be fabricated into a variety of shapes and articles with solvent, cement (a polymer dissolved in a solvent), or adhesive bonds. In general, when the surfaces to be joined are irregular, cement is preferred over a solvent.

Solvents and cements are not the best choice when bonding POLYCASA® PS sheet to other thermoplastics. Adhesives, including cyanoacrylates, two-part acrylics and hot melts, are more effective when bonding POLYCASA® PS to dissimilar plastics and can be used to bond POLYCASA® PS to itself.

## 5.1 Assembly guidelines

The following guidelines should be observed when bonding POLYCASA® PS sheeting:

- The sheet edges must be clean and free from contamination.
- The surfaces must be smooth and accurately aligned.
- A solvent or cement must be sufficiently active to soften the mating surfaces for some flow to occur when pressure is applied.
- When using solvents in POLYCASA® PS sheet assembly, 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 acetic acid to the solvent or use of a slower curing cement-type bond is suggested.
- Fixture pressure must be maintained to prevent movement of the joint until it is solid.
- Good ventilation is required when working with solvents. Exposure levels must be controlled according to OSHA guidelines.

## 5.2 Bonding techniques: solvents, cements and adhesives

Small articles with flat surfaces can be joined by placing the pieces together and applying the appropriate bonding agent (solvent, cement, or adhesive). Care should be taken to ensure that the joints are uniformly coated; a solvent can be effectively applied with a needle applicator. The assembly should be clamped into position until the bond is set. When larger articles are to be solvent bonded, it is best to immerse the joining surfaces in a solvent bath until the material is softened and then clamp them into position until the bond has set. A constant level of solvent immersion should be maintained in a shallow pan with a support pad, screens, and other means to ensure part-to-part uniformity.

Several solvents, cements, and adhesives provide strong bonds with good clarity when used in POLYCASA® PS sheeting fabrication operations:

| Material | Bond Type |
|---|---|
| Methyl Ethyl Ketone (MEK) | Solvent |
| Methylene Chloride | Solvent |
| Mixture of PS in a 50/50 mixture toluene/MEK (300 g PS/1000 g mixture) | Solvent |
| Super Glue Cyanoacrylate | Adhesive |

## 5.3 Mechanical fastening

POLYCASA® PS sheet can be fabricated with mechanical fasteners into attractive joints.

The diameter of the holes should be oversized to allow movement of the assembly caused by thermal expansion. Screws and rivets provide permanent assembly. Standard nuts, bolts, and machine screws are used in many instances, in addition, special screws and rivets specially designed for use with plastics are available. Springs, clips, and nuts are low cost, rapid, mechanical fasteners. Hinges, knobs, catches and dowels are some other devices used in mechanical assemblies.

# 6 FINISHING

## 6.1 Sanding

POLYCASA® PS sheet is best sanded wet to avoid the frictional heat build-up that is characteristic of dry sanding techniques. If water coolants are used, the abrasive lasts longer and the cutting action increased. Progressively finer abrasives are used: for example, rough sanding with 80-grit silicon-carbide would be followed by finer sanding with 280-grit silicon-carbide, wet or dry. The final sanding may be with 400 or 600-grit sandpaper. After the sanding is finished and the abrasives removed, additional finishing operations may be required.

## 6.2 Joining

A standard woodworking jointer-planer will produce an accurately aligned and good quality finished edge on POLYCASA® PS sheeting. Carbide or high speed blades, which have a longer life, will provide a uniform finish as well.

## 6.3 Filing

When many thermoplastics, including POLYCASA® PS, are filed, a light powder that tends to clog some files is produced. Therefore, aluminum Type A, shear-tooth, or other files that have coarse, single-cut teeth with an angle of 45° are preferred.

## 6.4 Solvent polishing

The appearance of saw-cut edges can be improved by first sanding and then solvent polishing with MEK or methylene dichloride. It may be necessary to add a slow drying component such as diacetone alcohol to prevent humidity blush after drying.

NOTE: When using solvents, proper ventilation of the area is essential. Follow all precautions listed on the Material Safety Data sheet supplied with the solvent being used.

## 7 PRINTING

POLYCASA® PS sheeting can be printed with conventional equipment; however, the ink does not penetrate a plastic as it does with paper and cloth and is therefore subject to damage by abrasion. This can be minimized by applying a light coat of clear lacquer over the printing.

There are a number of different methods used when printing on plastics including letterpress, letter flex, dry offset, offset lithography, rotogravure, stenciling, and a commonly used silk screen process.

In silk screening, the ink is spread on a fine metallic or fabric screen onto the product, and a squeegee is used to force the ink through the screen on the sheet.

Since each application may require a different type of ink, it is suggested that an ink manufacturer be consulted for recommendations.

## 8 VERTICAL GLAZING

In order to determine the required dimensions for POLYCASA® PS sheets, fixed on all sides, the following factors are to be taken into consideration:

- Coefficient of thermal expansion

80 x $10^{-6}$ corresponding to 0.08 mm per m length and a 1°C change of temperature.

- Inside width of the frame

The frames can be made of plastic, wood or metal. It is highly recommended that the frame rebate consist of relatively dense material. For a defined edge length, the frame must be larger and this according to the amounts indicated below:

| Edge length | Addition |
|---|---|
| 500 mm | 3.0 mm |
| 1000 mm | 5.0 mm |
| 1500 mm | 7.0 mm |
| 2000 mm | 10.0 mm |
| 3000 mm | 15.0 mm |

- Depth of rebate

The rebate should be approx. 25 mm deep.

- Length/width ratio

The figures take a length/width ratio of 1:1.5 up to 1: 3 into account.

Important when glazing with POLYCASA® PS sheets:

- Care is to be taken when installing for adequate free space due to thermal expansion.
- The edging tape must not stick to the POLYCASA® PS sheets. Rubber and plastic profiles without plasticizers can be used for the edging tape.
- The sealing medium must have permanent elasticity, suitable materials being polysulphides and silicon rubbers in a neutral composition.

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## 8.1 Curving capabilities

- All curves with radius between 450 mm and 570 mm
- Maximum sheet height: 1950 mm
- Maximum sheet width: 1000 mm
- Maximum sheet thickness: 5 mm
- Minimum sheet thickness: 2 mm
- Tolerances on Radius: ± 15 mm / Length + width: ± 1 mm/m

Other materials, shapes, radius, thickness and dimensions must be tested prior to ordering.

NOTE: Two control tools for the radius (i.e. a curved profile where the sheet will be mounted in) must be sent to POLYCASA® prior to the first order.

## 8.2 Thermal insulation

POLYCASA® PS sheets used in indoor glazing applications results in considerable energy cost savings by preventing excessive heat loss in winter and blocking heat entry in the summer.

The heat loss factor, normally referred to as the U-value, of POLYCASA® PS is significantly lower than for glass at the same thickness. Some examples of the heat insulation performance of POLYCASA® PS in single and double glazing systems are given below and compared with glass.

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Advantages of POLYCASA® PS to glass

**At the same thickness:**

- **Improvement of the U-value (former K-value)**
- **Weight saving**

**SINGLE GLAZING:**

- Improvement U-value:

| | |
|---|---|
| Glass 5 mm: | U-value = 5.74 W/m² °C |
| POLYCASA® PS 5 mm: | U-value = 5.01 W/m² °C |
| | Δ = 0.73 W/m² °C = 12.7% |

- Weight saving:

| | |
|---|---|
| Glass 5 mm: | 12.5 kg/m² |
| POLYCASA® PS 5 mm: | 5.25 kg/m² |
| | Δ = 7.25 kg = 58% |

**DOUBLE GLAZING:**

- Improvement U-value:

| | |
|---|---|
| 2 x glass 4 mm with air gap 5 mm: | U-value = 3.57 W/m² °C |
| 2 x POLYCASA® PS 4 mm with air gap 5 mm: | U-value = 3.15 W/m² °C |
| | Δ = 0.42 W/m² °C = 11.8% |

- Weight saving:

| | |
|---|---|
| 2 x glass 4 mm: | 20 kg/m² |
| 2 x POLYCASA® PS 4 mm: | 8.4 kg/m² |
| | Δ = 11.6 kg/m² = 58% |

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**At the same U-value:**

- **Weight saving**
- **Volume saving**

**SINGLE GLAZING:**

| | |
|---|---|
| Glass 10 mm: | U-value = 5.60 W/m²°C |
| POLYCASA® PS 2 mm: | U-value = 5.50 W/m²°C |

- Weight saving:

| | |
|---|---|
| Glass 10 mm: | 25.00 kg/m² |
| POLYCASA® PS 2 mm: | 2.10 kg/m² |
| | Δ = 22.9 kg/m² = 91.6% |

- Volume saving: Δ = 8 mm

**DOUBLE GLAZING:**

| | |
|---|---|
| 2 x glass 5 mm with 15 mm air gap: | U-value = 3.05 W/m²°C |
| 2 x POLYCASA® PS 3 mm with 10 mm air gap: | U-value = 2.99 W/m²°C |

- Weight saving:

| | |
|---|---|
| Glass 2 x 5 mm: | 25.0 kg/m² |
| POLYCASA® PS 2 x 3 mm: | 6.3 kg/m² |
| | Δ = 18.7 kg/m² = 74.8% |

- Volume saving:

| | |
|---|---|
| Glass 2 x 5 + 15: | 25 mm |
| POLYCASA® PS 2 x 3 + 10: | 16 mm |
| | Δ = 9 mm |

U-values / U-values for customer specific glazing systems can be provided upon request.

For more information contact one of the sales offices of Polycasa.

## 9 CONCLUDING REMARKS

For more details on further processing methods, please contact our technical customer service.

NOTE: Our technical recommendations are without legal obligation.

The information given in this brochure is based on our knowledge and experience to date. It does not release the user from the obligation of carrying out their own tests and trials, in view of the many factors that may affect processing and application; neither do they imply any legally binding assurance of certain properties or of suitability for a specific purpose. It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislation are observed. Technical data of our products are typical ones; measured values are subject to production variation.