ShinkoLite™
The art of performing beauty

SHINKOLITE™ ACRYLIC SHEET

Fabrication guide

MITSUBISHI CHEMICAL GROUP
MITSUBISHI CHEMICAL CORPORATION

ShinkoLite™
The art of performing beauty

Contents

About Shinkolite™

Shinkolite™ is a high quality acrylic sheet that combines exceptional aesthetics with unique performance characteristics making it the designer's choice in a wide variety of growing applications. Superior weatherability, extra large size options and performance with light make it ideal for outdoor use in construction, signage, street furniture and more. Its beauty, colors and effects, easy processing and exceptional optical clarity benefit interior schemes, while its excellent light transmission and diffusion properties make it a dream to work with for many applications, including those in retail display, lighting and technology industries.

As a business that is passionate about playing our part in creating a sustainable future, we are always pleased to discuss new challenges, new ideas and new sectors where our range of **Shinkolite**™ products can add value.

Machining

Shinkolite™ has excellent machinability and can be processed in the same manner as wood and metal. Care must be taken with the following points to ensure excellent results in the finished item.

(a) Minimize friction heat during machining
Shinkolite™ has low thermal conductivity and is likely to accumulate friction-generated heat during machining, which may result in thermal strains or burn marks. To prevent heat generation, it is essential to set the correct conditions both in terms of the blade and the particular machining process. Cooling the sheet with compressed air and soluble cutting oil with rust-preventing properties has proven effective.

(b) Ensure tools are sharp and used correctly
Tools must be sharp in order to obtain excellent results in the finished item. It is also important to use a slightly negative rake angle of zero degrees and a sufficient clearance angle.

ShinkoLite
The art of performing beauty

Cutting

Shinkolite™ acrylic sheets may be machined using a variety of different techniques, including:

- **Saw cutting**
  Circular saw
  Band saw
  Fret saw
  Marker cutting
  Jigsaw cutting
- **Laser beam cutting**
- **Drilling**
- **Routing**

Following are our recommendations for using a circular saw.

Circular saw

Saw blade

Outer diameter:	150-355mm
Width of cutting edge:	2.6-3.0mm
Number of cutting teeth:	2.5-3.0 pieces/25.4mm*
Height of blade:	Sheet thickness +5-10mm

(*Thick sheet – use a thick blade. Thin sheet – use a thin blade).

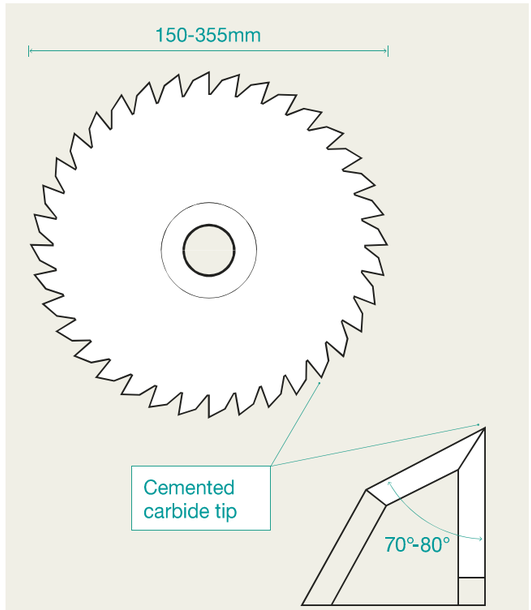
Cutting conditions

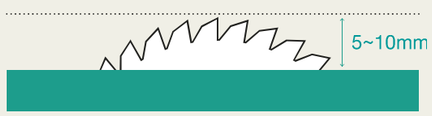
Revolutions:	3,000-5,000rpm
Feed speed:	3-10m/min*
Stack cutting:	20mm or less (admirable)

(*Hign feed speed may result in chipping. Low feed speed may result in burning).

Please note:

★ The blade must be ultra sharp to achieve a professional, high quality finish
★ Keep the gap for the saw line narrow
★ Hold the sheet firmly





Height of blade is equal to the sheet thickness plus 5~10mm

Defect	Cause	Solution
Burning	Blade touches the sheet too frequently	- Decrease revolutions - Increase the feed speed
	Too many sheets in the stack for processing	- Reduce the number of sheets stacked on top of one another - Recommend no more than a total depth of 20mm
	Poor blade quality	- Renew blade to ensure it is sharp - Use a suitable blade for the task
	Not enough heat removal	- Blow air to the cutting area
Chipping	Too much cutting area per cut	- Increase blade revolutions - Decrease the blade speed
	Poor blade quality	- Renew blade to ensure it is sharp - Use a suitable blade for the task
	Sheet touches the base of the blade instead of its teeth	- Control the height of the blade 5-10mm above the surface of the Shinkolite™ sheet
	Vibration of sheet in the cutting area	- Protect the acrylic surface being cut by covering with additional acrylic sheet material

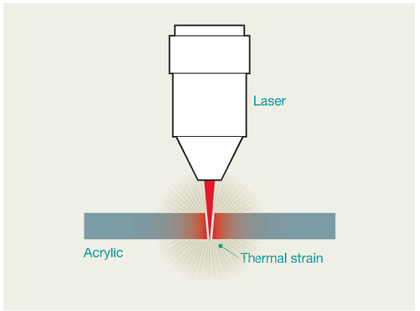
ShinkoLite
The art of performing beauty

Laser beam cutting

Improvements in laser beam equipment technology have led to a rise in the popularity of laser processing. Acrylic gives superior results for laser cutting compared to other plastic materials. In particular, the high heat resistance of Shinkolite™ means it does not burn easily during processing and it is easy to achieve a beautifully clean and smooth cut edge.

Trouble shooting

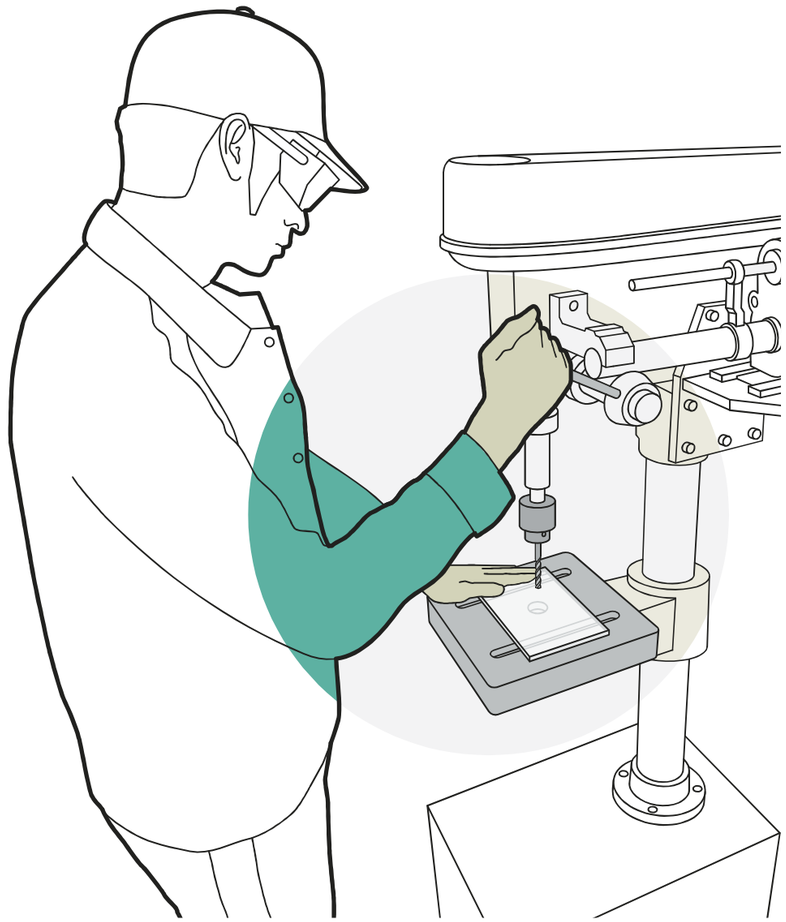
Defect	Cause	Solution
Hazy surface	Polymer vaporization due to high heat	Correct vacuuming Ensure there is good air flow in the processing space
Burr	Resin melts due to high heat	Increasing cutting speed
Cracking	Strain due to high cutting heat	Remove the strain by annealing



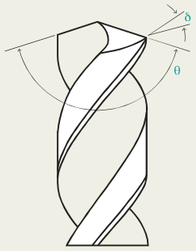
Drilling

Any ordinary device for drilling soft metal may be used. However, heating the sheet may cause fusion and result in a poor drilling surface due to Shinkolite™ having a lower thermal conductivity than metals. Therefore, it is recommended to use the drill manually, sliding the drill bit in and out of the hole occasionally, thereby eliminating sawdust. The cutting angle should be more obtuse and the clearance angle should be larger when compared to drilling metals.

The use of a cutting lubricant or soapy water as a coolant will help form a rake angle of zero degrees, resulting in neatly finished holes without any distortion. A high-helix drill for light metal provides holes with a better surface finish in comparison to a straight shank twist drill.



Drill shape



Rake angle: 0 deg
Cutting angle (θ): 120-140 deg
Clearance angle (δ): 10-20 deg
Feed speed: 60-300mm/min

Drill diameter	Revolution rpm
2mm	2,000-4,000
6mm	1,000-2,000
13mm	500-1,000

Please note:

- ★ Take care of frictional heat
- ★ Use the drill manually and slide it in and out of the hole occasionally to eliminate sawdust and reduce heat generated
- ★ Use a coolant, choose either air, cutting lubricant* or soapy water
- ★ Wash with water after drilling to avoid cracking

*Cutting lubricant: water-soluble lubricant has no detrimental affect on acrylic sheet (use a liquid mix: cutting lubricant 5 : water 95)

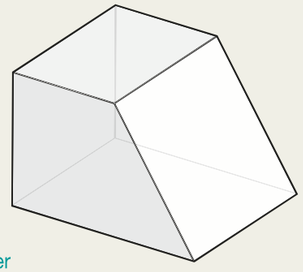
ShinkoLite
The art of performing beauty

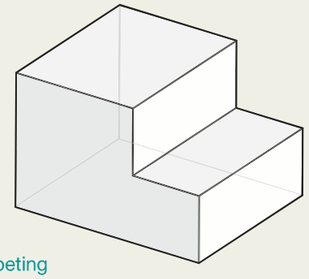
Routing

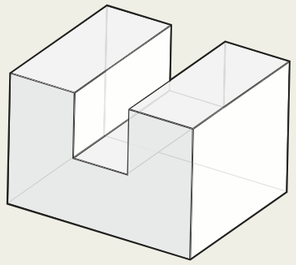
Routing is used to trim, hollow out, create grooves that are curved or angled, and to give a curved edge to molded articles. Hand routers are used for processing heavy goods and large-sized sheets. Generally, a high-performance router machine integrated within an NC unit is used. Cutter blades come in many shapes. Generally, the faster the cutting speed, the fewer number of blades are required.

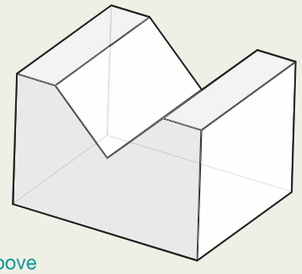
Blade shape revolutions
Rake angle 0°, clearance angle 10 to12°
Blade diameter of 12mm or more, revolutions of around 15,000rpm
Blade diameter of 12mm or less, revolutions of around 24,000rpm
Feed speed 1000~2000mm/min

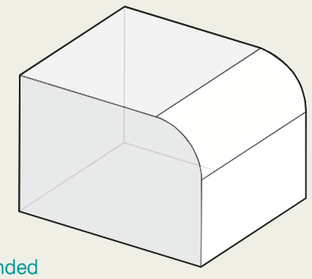
Examples of shapes created by routing


Chamfer


Rabbeting


Dado


V-Groove


Rounded

The thickness tolerance of Shinkolite™ makes it easy to use a router to create a high quality finish for all kinds of intricate shapes and designs.

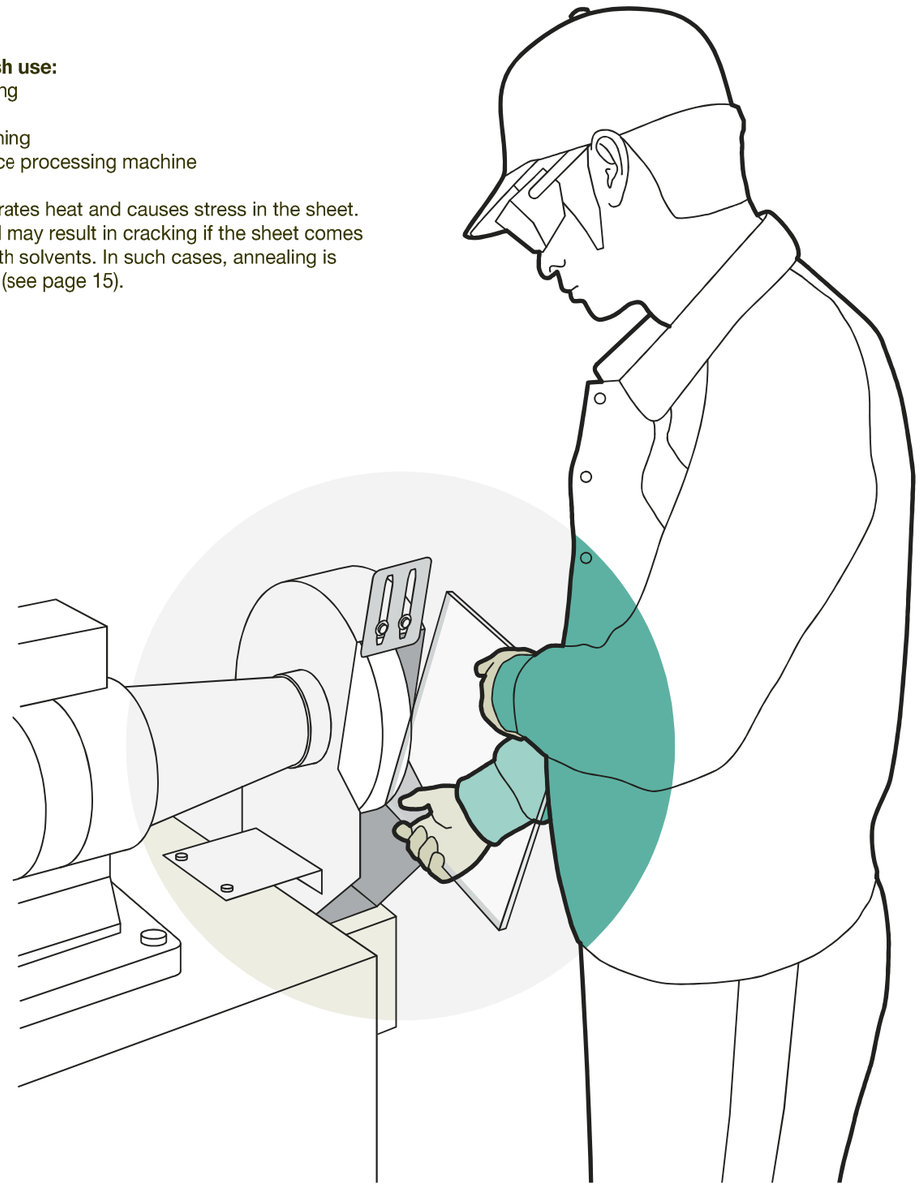
Polishing

For a rough finish use:
- Sandpaper
- Belt grinder
- Plane
- Motor-driven plane

For a medium-smooth finish use:
- Scraping
- Sanding

For a fine finish use:
- Hand finishing
- Buffing
- Flame polishing
- Mirror surface processing machine

Polishing generates heat and causes stress in the sheet. These stressed may result in cracking if the sheet comes into contact with solvents. In such cases, annealing is recommended (see page 15).

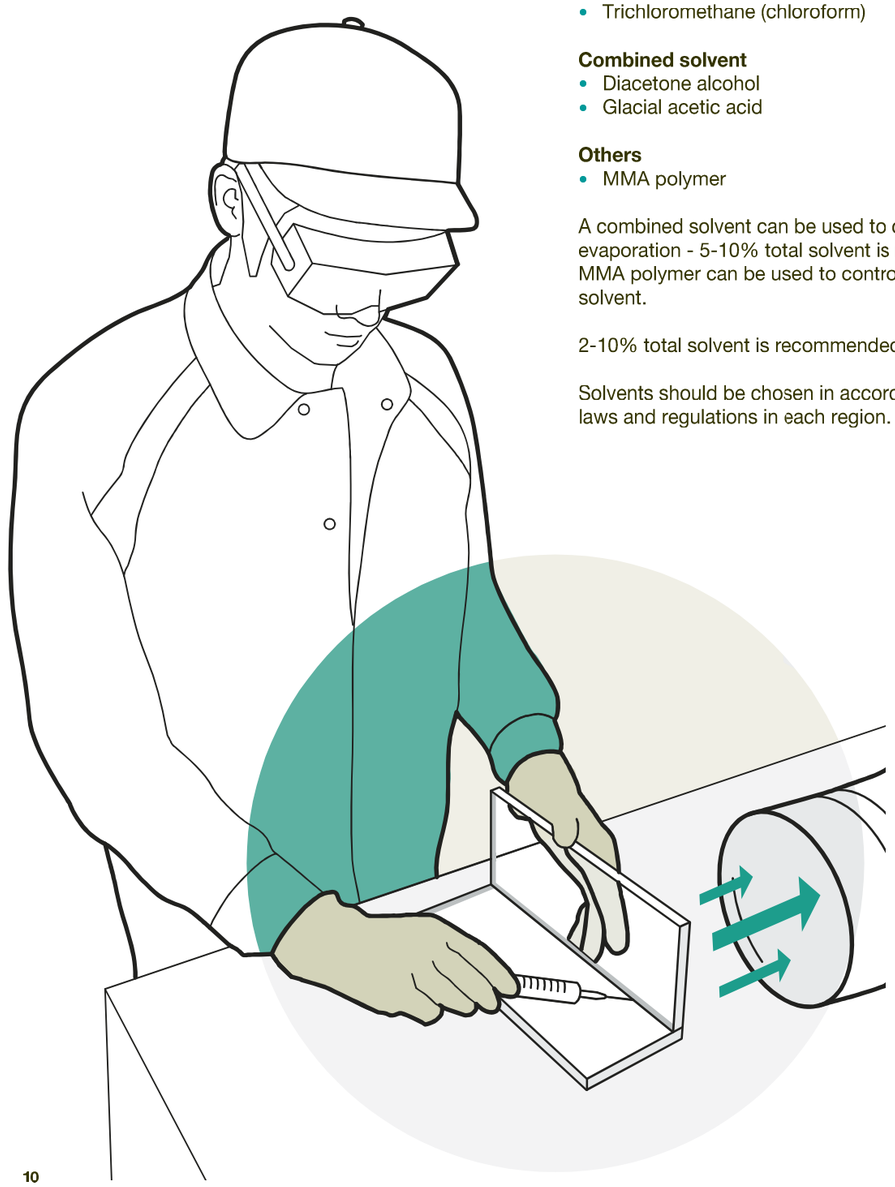


ShinkoLite
The art of performing beauty

Cementing

It is easy to cement Shinkolite™ surfaces together using one of the following methods:
- solvent
- thermo polymerization
- UV polymerization

One of the simplest methods of cementing acrylic sheet is by using a solvent, which works by vaporization (see next column for explanation).



First, apply solvent to the Shinkolite™ surface. Next, press the surface to which it is to be joined firmly in position. After a short time the solvent will vaporize and adhesion will be complete.

In order to get good results both in terms of visual appearance and in terms of the strength of the join, it is important to follow each element of the cementing process methodically and with due care.

Main solvent
- Dichloromethane
- 1,2-Dichloroethane
- Trichloromethane (chloroform)

Combined solvent
- Diacetone alcohol
- Glacial acetic acid

Others
- MMA polymer

A combined solvent can be used to control the speed of evaporation - 5-10% total solvent is recommended. MMA polymer can be used to control the viscosity of the solvent.

2-10% total solvent is recommended.

Solvents should be chosen in accordance with the national laws and regulations in each region.

Troubleshooting

Defect	Cause	Solution
Crazing, Cracking	Water (moisture) absorption	Be careful with storage conditions of Shinkolite™
		Ensure the Shinkolite™ is dry
	Local stress from thermoforming	Avoid forming at low temperature
		Cool slowly after forming
		Annealing
	Stress from frictional heat in machining	Checking the blade
		Cool during machining
		Check machining conditions
		Annealing
	Stress from outer load	Prevent excess loading
		Prevent excess stress
	Stocking or cementing condition	Avoid exposing Shinkolite™ to solvent vapor
		Check air ventilation conditions
		Avoid cementing at low temperature
		Dry off completely before packing
		Evaporate solvent vapor completely using air-gun or similar
Whitening phenomenon	When Shinkolite™ is cemented under high humidity any excess solvent squeezed out onto surface may cause whitening The surface of Shinkolite™ is cooled quickly as the solvent evaporates. At this time moisture in the air causes condensation, which may lead to the sheet whitening	To slow down the speed of evaporation, add a small amount of high boiling point, water-soluble solvent (eg. glacial acetic acid)
Bubble	Finish of cemented surface is poor	Finish the cemented surface more carefully
	Holding pressure is deficient or holding pressure uniformity is poor	Holding pressure must be 0.01-0.04 MPa
	Drying period is deficient	Dry completely
	Solvent composition is poor	Select solvent composition according to atmospheric temperature, cement area, and method of cementing

ShinkoLite
The art of performing beauty

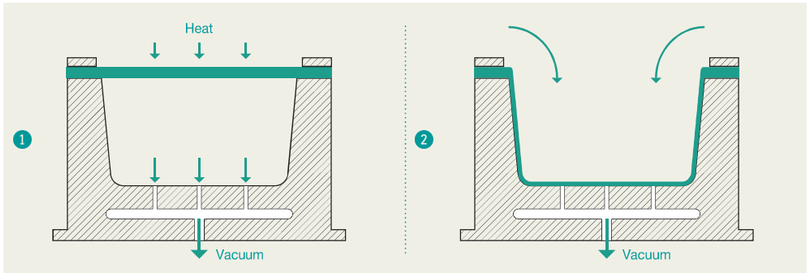
Thermoforming

Shinkolite™ is a thermoplastic resin, which softens when heated allowing you to mold it into any desired shape. Various forming methods may be used depending on the desired shape, including simple right angles and complex curved surfaces.

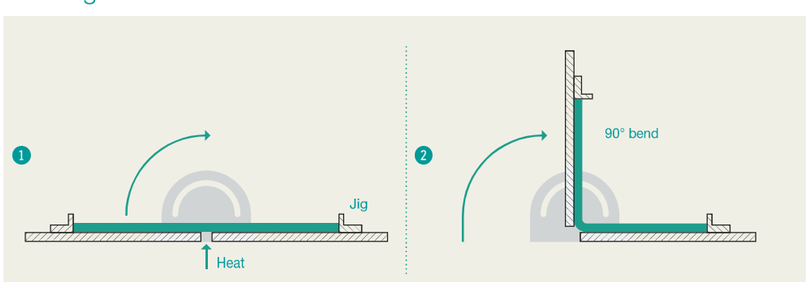
Heating
It is generally best to form a sheet within a temperature range of 140-170°C. Shinkolite™ can be formed at approx. 5-10°C lower temperature compared with conventional glass cell cast acrylic sheet.
Sheet temperature can be controlled by either changing the heater temperature setting and/or by adjusting the time taken to heat the sheets.

Examples of suitable heaters:
- Air convection furnace
- Circulating hot air furnace
- IR furnace
- Localized heater

Vacuum forming



Bending

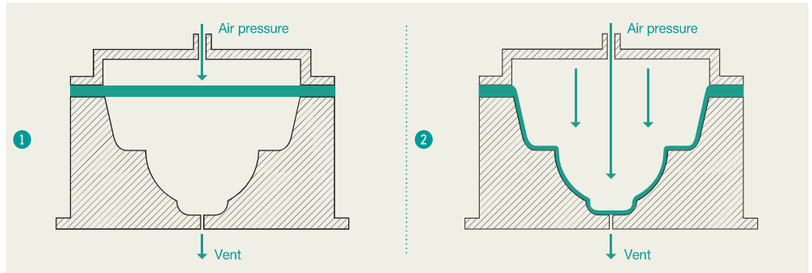


Forming method

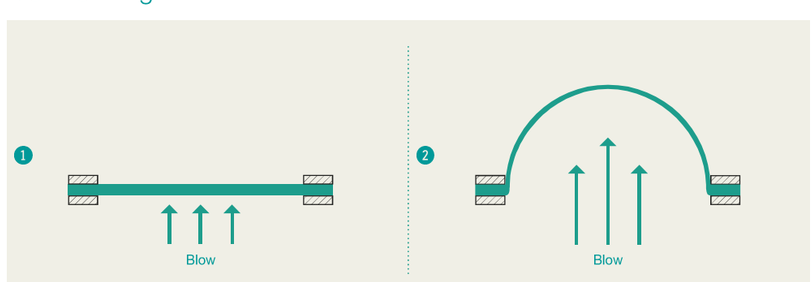
Thermal processing of Shinkolite™ includes bending, simple curve forming, pressing, vacuum forming, free blowing, and pressure forming.

- Bending
- Pressure forming
- Vacuum forming
- Blow forming

Pressure forming



Blow forming



ShinkoLite
The art of performing beauty

Potential defects during heat forming and possible solutions

Defect	Cause	Solution
Warpage and distortion of formed product	- Insufficient heating - Insufficient cooling (high temperature at mold release) - Rapid cooling - 2% Shrinkage distortion inherent in the sheet, shrinkage distortion due to stretching and shrinkage in vertical direction)	- Form under appropriate temperature conditions and cool down as guided - Release from mold at 60-80°C - Remove from mold when cold - Change cooling method: clamp heating from infrared ray – entire heating by heating furnace - Design the mold for greater rigidity
Break / tear (at forming)	- Insufficient heating (break) - Excessive heating (tear) - Inappropriate mold shape	- Form under appropriate temperature conditions - Use appropriate design for the mold - Examine the forming method
Break / tear (at mold release)	- Fast mold release - Insufficient mold draft angle - Excessive cooling	- Adjust mold release speed: Negative mold $\frac{3}{100} \sim \frac{5}{100}$ - Draft angle: Positive mold $\frac{1}{100} \sim \frac{2}{100}$ - Mold release 60-80°C
Mold marks	- Mold surface condition - Forming pressure - Resin temperature - Foreign object, such as small pieces of debris	- Use mold design that has less contact areas - Cover with soft flannel or velvet - Form at low temperature - Prevent attachment of foreign objects - Use heat protection film
Foam formation	- Excessive heating	- Handle materials carefully (do not allow moisture absorption) - Thoroughly pre-dry first - Avoid excessive heating
Cooling line (chilled line, drag line)	- Contact with mold	- Increase the mold temperature - Use low heat conductive materials for the mold - Examine the forming method (try to test whether using blower at same time will work or not)
Shape defect (insufficient forming)	- Air leakage - Insufficient depressurization, insufficient pressure - Insufficient heating - Defect in vacuum hole	- Check the air leakage at the mold and surrounding area - Check vacuum pump and power - Perform process using appropriate forming conditions - Use appropriate vacuum hole diameter and correct number of holes

Take care

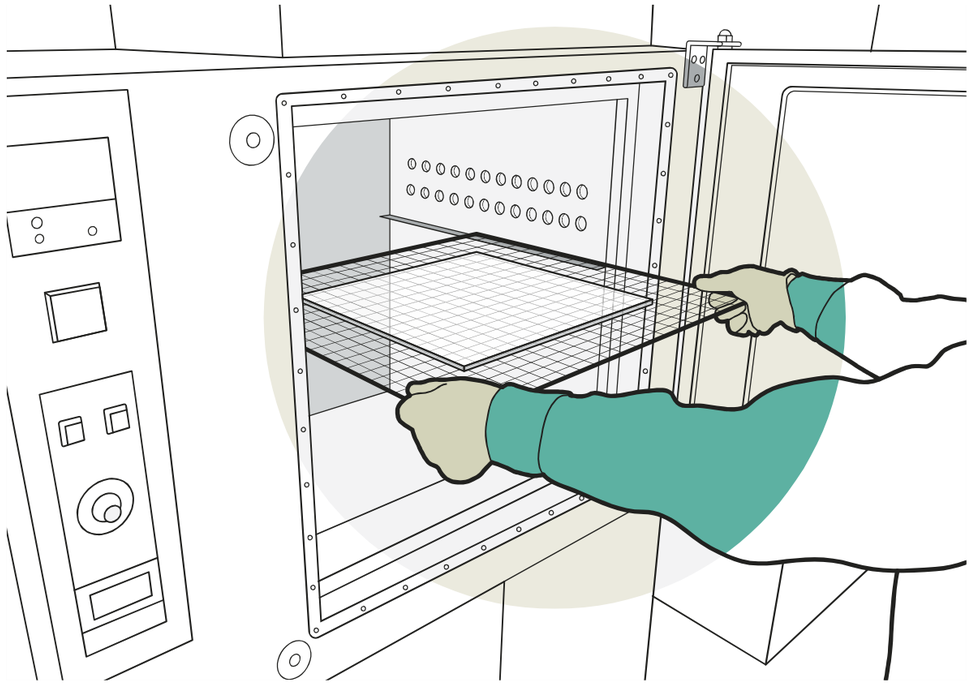
Annealing

Each processing technique generates heat. If this heat is not carefully reduced during processing, the sheet comes under stress, which can cause defects such as cracking or crazing. Annealing is recommended in order to avoid defects occurring.

Annealing method:

1 Keep the sheet in the oven at 60-80°C for 6-8 hours.*
2 Cool slowly. Turn the oven off and wait until the temperature drops to room temperature.

*Oven temperature and time in the oven should be adjusted according to the level of stress in the sheet.



ShinkoLite
The art of performing beauty

Take care

Shinkolite™ is a thermoplastic sheet and requires caution to avoid mechanical, chemical and/or thermal damage during handling and storage as detailed below:

1 Exposure to heat
Shinkolite™ tends to distort when heated over 100°C. It should be stored in an area where the ambient temperature does not exceed 80°C.

2 Mechanical damage
Shinkolite™ has relatively high surface hardness, comparable to aluminum. However, care should be taken not to scratch the surface during handling. Both surfaces of Shinkolite™ are protected with masking film or paper. It is recommended not to remove the masking until necessary to prevent the accumulation of dust and/or accidental surface scratching.

3 Accumulation of dust
When Shinkolite™ is wiped firmly with a dry cloth it can create static electricity. In this state the sheet attracts dust particles in the air, which can cause scratches on general cleaning or wiping. Wiping lightly with a cloth moistened with an antistatic agent or methanol with an antistatic agent included is recommended.

4 Thermal expansion
Shinkolite™ has a fairly large coefficient of thermal expansion. Thermal dimensional changes should be taken into account in processing and storing it. For example, an increase or decrease by 10°C in the sheet temperature causes 0.7mm of linear expansion or shrinkage per 1,000mm in the length of the sheet.

5 Water absorption
Humidity also causes dimensional changes in Shinkolite™. Though these changes are not as great as those caused by thermal variations, the humidity conditions should be carefully watched. If excessive, water absorption leads to bubbling during thermoforming or crazing after printing or painting. It is therefore recommended that storage and working areas should be air-conditioned. Shinkolite™ packaging film/paper are made from special vapor protection material. In order to avoid moisture, it is recommended to re-cover the sheets with the used package once opened.

6 Solvent attack
If Shinkolite™ comes under attack by organic solvents micro cracks may appear in the sheet surface. Avoid storing Shinkolite™ in areas, where it may be exposed to solvent vapors.

7 Combustion characteristics
Shinkolite™ has an ignition temperature of 400°C and is not highly flammable, however, it burns when exposed to a naked flame.

8 Storage positioning
Shinkolite™ can be placed either horizontally or vertically when stored. The sheet can warp depending on the way it is stored. Either of the following is recommended:
a) Stand Shinkolite™ on a rack with its base inclined at a 10-degree angle (see Figure 01). Place the sheets tightly next to each other - it is recommended to keep the total thickness of a number of sheets standing together under 30cm.
b) Stack the sheets flat. Where sheets of different sizes are stacked, avoid an overhang and ensure the smaller size sheets are always placed on top of the larger ones (see Figure 02). The total height of a stack should not exceed 50cm. A stack consisting of the same size of sheets is much preferred.

Figure 01

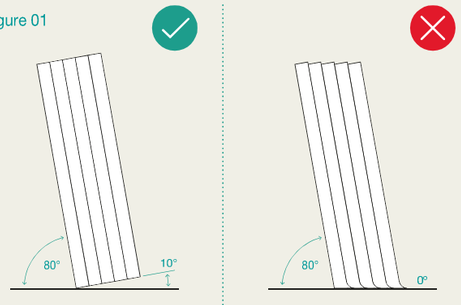
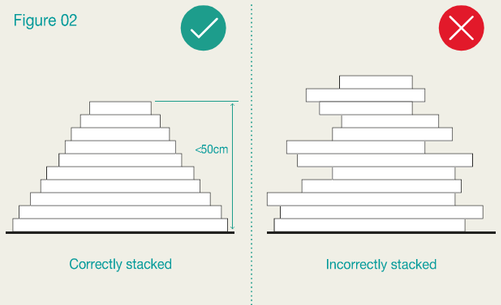


Figure 02



Comparison with other transparent plastics

	PMMA	PC	PVC (rigid)
Optical clarity	Excellent	Good	Medium
Weather resistance	Excellent	Medium	Medium
Scratch resistance	Excellent	Medium	Medium
Processability	Excellent	Good	Excellent
Tensile strength	Excellent	Excellent	Good
Impact strength	Good	Excellent	Good
Thermal	Good	Excellent	Medium

Comparison with other acrylic sheets

	Glass cell cast sheet	Continuous cast sheet	Extruded sheet
Thickness tolerance	Medium	Excellent	Excellent
Appearance	Good	Excellent	Medium
Contamination	Medium	Excellent	Medium (carbide)
Small-batch production	Excellent	Good	Medium
Dimension change on heating	1-2% (no anisotropy)	1-2% (no anisotropy)	1-15% (anisotropic)

Acrylic sheet processability

	Glass cell cast sheet	Continuous cast sheet	Extruded sheet
Cutting (circular saw)	Excellent	Excellent	Medium - Good
Cutting (router)	Excellent	Excellent	Medium - Good
Drilling	Excellent	Excellent	Medium - Good
Polishing (buffing)	Excellent	Excellent	Medium - Good
Polishing (flame)	Good	Excellent	Excellent
Vacuum forming	Good	Good - Excellent	Medium - Good
Press forming	Good	Good - Excellent	Medium - Good
Free blow forming	Good	Excellent	Good
Bending	Good	Excellent	Good - Excellent
Cementing (solvent adhesion)	Good	Good - Excellent	Excellent
Cementing (polymerized adhesion)	Excellent	Excellent	Good
Screen printing	Good	Excellent	Excellent

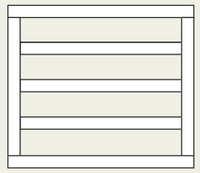
ShinkoLite™
The art of performing beauty

Benefits of Shinkolite™

Shinkolite™ enables easy fabrication due to its high consistency uniform thickness.

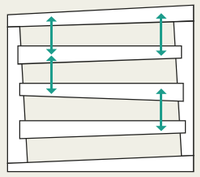
1 Assembly

Shinkolite™ acrylic sheet



Good uniformity

Cell cast acrylic sheet



Lack of uniformity

2 Forming

Shinkolite™ acrylic sheet

Before

After

Cell cast acrylic sheet

Before

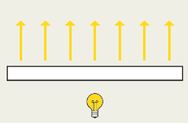
After

Extruded acrylic sheet

Applying heat to extruded acrylic sheet in the forming process causes it to become anisotropic, which leads to poor quality results in the finished product.

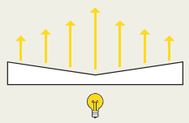
3 Lighting

Shinkolite™ acrylic sheet



Good thickness uniformity ensures excellent brightness uniformity.

Cell cast acrylic sheet



Poor thickness uniformity results in poor brightness uniformity.