CHEMCAST®

The all purpose cell-cast acrylic sheet

GENERAL PURPOSE

Technical Manual

CELL CAST ACRYLIC SHEET GENERAL PURPOSE

UNIGEL

CHEMCAST®

The all purpose cell-cast acrylic sheet

ISO 9001
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Certification

INDEX

Storage and Handling

Protection

PLASTIGLAS offers three different types of protection according to your production needs, for protection and ease of handling:

Antistatic Film (PMT)
Less resistant than paper, this protection is made of transparent plastic film applied to both sides of the sheet to protect it from possible damage during shipping, handling, storage, and machining.

Kraft Paper (PCH /PJ)
Applied to both sides of the sheet to protect it from possible damages during shipping, handling, storage, and transformation.
Its high resistance makes it recommendable for long transformation processes. It also can be marked with marker, pencil, or grease pencil.

Thermoformable Film (PT)
Transparent thermoformable plastic protection applied to one side of the sheet. Ideal for manufacturing thermoformed products with high depth (bathtubs), resists shipping, handling, storage, and transformation similar to EVA films. Recommended for use in gas ovens with forced air circulation and temperatures between 180º to 200ºC.

Storage

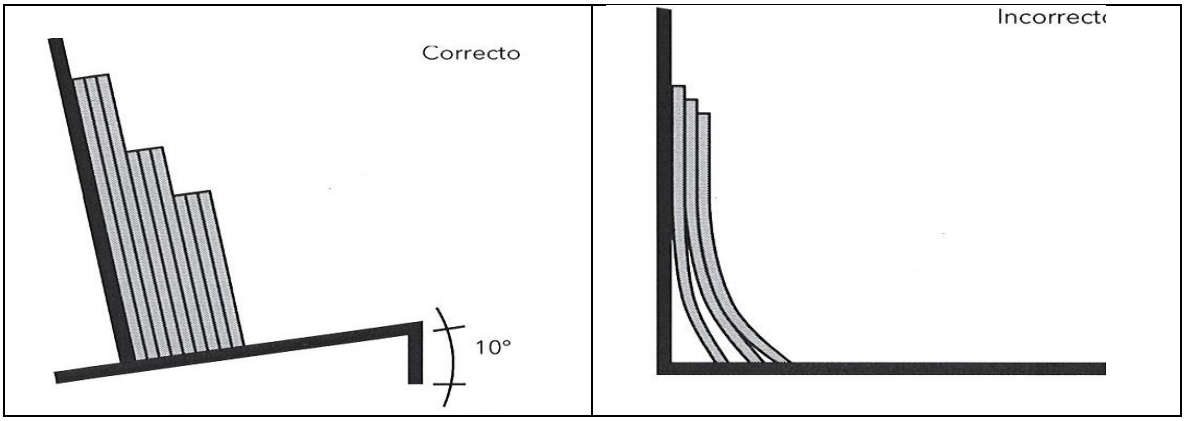
Because it is a thermoplastic material, CHEMCAST acrylic sheet can become deformed before or after the different transformation processes if stored near heat sources. Avoid storing it near radiators, hot containers, furnaces, or steam lines.

Likewise, CHEMCAST acrylic sheet is eroded by some solvents. keep vapors from coming in to contact with the sheets.

CHEMCAST acrylic sheet is a slow combustion material and does not present any special fire risk.
Store in a vertical position in stands with a slight incline of approximately 10°, and a base no greater than 25 cm. This way the faces of the CHEMCAST acrylic sheet will be supported across the entire surface, preventing deformation and facilitating handling as shown in the illustration below.

Store your acrylic sheets on a vertical A-frame with a slight inclination.

Acrylic sheets stored in completely vertical position will tend to deform or warp.



Cleaning

CHEMCAST acrylic sheet can be thoroughly and easily cleaned using a solution of water and 1% mild detergent or soap. Apply to a clean and dry cloth or chamois for satisfactory removal of grease and oil. Use isopropyl alcohol, naphtha, or hexane only in extreme cases.

Be sure not to use glass cleaners and organic solvents such as acetone, thinner, benzene, carbon tetrachloride, or toluene, as they erode the surface of the sheet.

To avoid attracting dust due to electrostatic charges on the sheet, always clean with a damp cloth or with products made for such purposes, such as PLASTIGLAS antistatic glaze.

When surface scratches appear on the material, use PLASTIGLAS polisher applied to the surface of the sheet with a clean and dry cloth or chamois. Wait about 10 to 20 seconds before removing it and then return the shine with PLASTIGLAS antistatic glaze.

General Recommendations

CHEMCAST acrylic sheet can be machined just like wood or soft metals such as copper or brass. CHEMCAST acrylic sheet can even be swaged, sheared, and stamped with no problem. When performing any such machining operations, keep in mind the following:

Tools must be well sharpened, free of slag. Likewise, they should steadily supported to prevent shattering. Swarf or dust produced during machining must be removed from the surface of the CHEMCAST acrylic sheet to keep them from making marks.

Hard tools with tungsten carbide teeth are preferable as they keep their edge for longer period of time and produce finer finishes.

It is very important to keep tools and materials clean in order to obtain satisfactory results. Work surfaces should be cleaned and free of dust and swarf to prevent scratching of the surface of the material during different transformation processes.

Reducing Friction Heating

Friction heating due to cutting and machining operations must be reduced to a minimum as produced. This is essential in order to reduce thermal stress at the area of the sheet being machined, which could result in subsequent cracking. That is why cutting tool edges must be in good conditions, according to recommended specifications.

Cooling

Because CHEMCAST acrylic sheet has a lower thermal conductivity than metals, it will tend to soften under excess heat. Consequently, the cutting equipment, tool, and feed rate must be selected. Air, water, oil, or special liquid cooling are effective ways to prevent overheating.

Thin gage (1.5 mm to a maximum of 10 mm) sheets do not require cooling during the cutting process.

Cutting

CHEMCAST acrylic sheet can be cut in many ways using manual or electric tools (such as those used in wood-cutting). Selection will depend on the type of work and production to be manufactured.

Thin sheets can be cut very much like glass (there are special blades and cutters in the market for cutting plastics, laminate sheets, etc.). When making a scoring cut, place the material on a flat surface supported by a straightedge. You will need to run the edge of the blade along several times and cut through approximately 1/3 of the thickness of the material. Hold the sheet firmly to check that the line drawn on the material is above the cut. Press the overhanging part downward to detach it.

Scrape the edges avoid sharp angles. The use of gloves is recommended. Do not make cuts too long and do not use this method for longer than 6.0 mm.

Always make the incision following a ruler or with a straightedge.

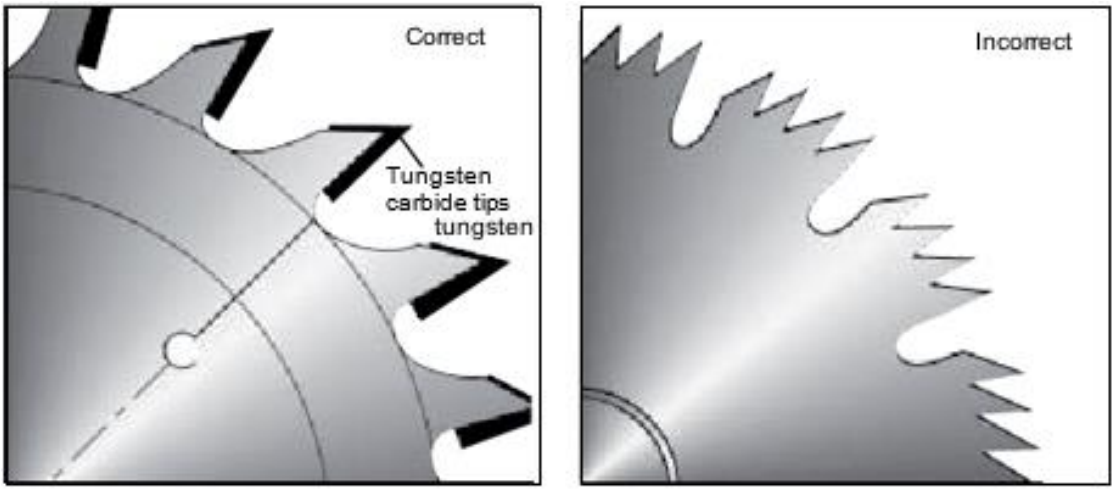
Place the sheet on a straight edge, hold it well and then detach it.

Cutting with Circular Saw

The circular saw should have straight teeth to promote cooling and avoid softening the material. Tungsten carbide teeth provide an excellent cut and last longest between filings. Cut feed should be slow to keep material from heating or shattering. The saw must be operated at relatively high speeds. Prior to cutting make sure it has reached top speed.

The thicker the gage of the material to be cut, the greater the saw diameter should be and fewer teeth per centimeter (minimum two teeth per inch).
When using a circular saw, hold the sheet steady and feed with even pressure and speed to prevent shattering.

Disk specifications

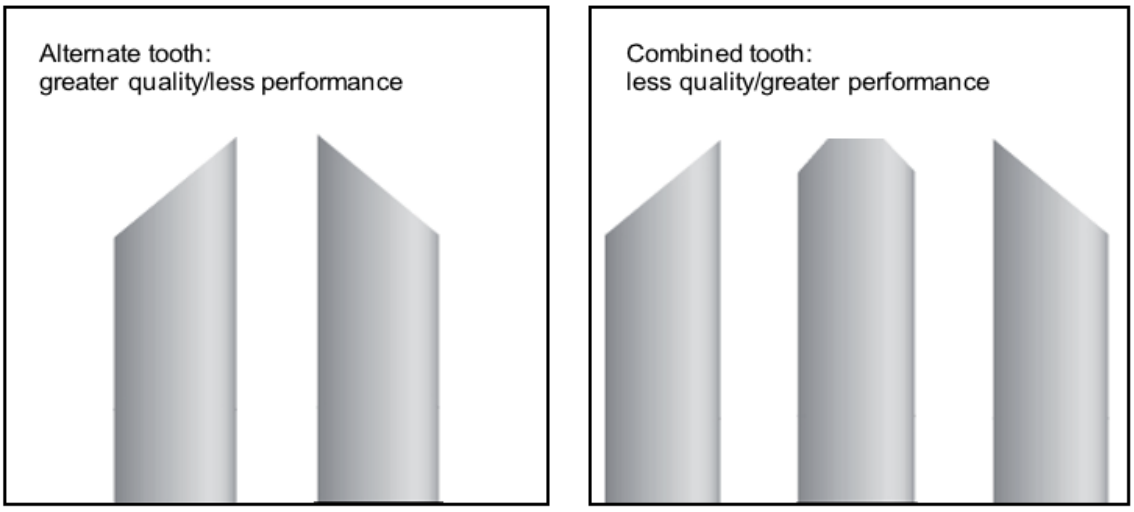


Do not use combination blade

Once disk size and teeth type and number have been selected according to the number of sheets to be cut and material gage, to prolong the useful life of the tools and obtain high quality, even cuts, it is recommended that the disk on table saws whose cutting blade is mounted below the table stick out approximately 1/8 to 1/2 an inch above the pieces to be cut. This adjustment will let the disk obtain even cuts with shallow marks, not to mention reducing friction heating and the thermal stress in the IMPACT area being machined to a minimum, thereby eliminating subsequent cracking due for this reason.

For bucksaws such as miter and bench saws, the disk should stick out 1/32 an inch below the material. This adjustment will also result in even, high-quality cuts and reduce friction heating to a minimum.

Tooth characteristics



SPECIFICATION FOR CUTTING WITH BUZZ SAW, MITER, OR RADIAL SAW						
DISK	ACRYLIC SHEET (gage in mm.)					
	1.5- 2	3-4	5 - 10	12- 15	18- 21	25- 32
Diameter (")	8	10	10	12	12	12 - 14
Gage (")	3/32	1/8	1/8	1/8	1/8	5/32
Teeth	96	82 - 96	82 - 96	82 - 96	48 - 52	48 - 52

Teeth with tungsten carbide tips tooth with face straight to center, combined, or alternate.

Cutting with Buzz Saw

The band saw is the right machine for making curved cuts on flat sheets and for re-threading formed pieces. The use of a band saw with variable speed up to 5,000 feet/min. and minimum throat depth of 10 inches is recommended.

It is a good idea to use a metal-cutting band or a special band for plastics. It will also be necessary to adjust the guide to be as close to the material as possible to prevent shattering along the cut line and reduce saw vibration to the minimum.

SPECIFICATION FOR CUTTING BAND					
BAND / ENGINE	ACRYLIC SHEET (gage in mm.)				
	1.5- 2	3-4	5 - 10	12- 15	18- 21
Minimum width (")	3/16	3/16	1/4	3/8	3/8
X Teeth (")	18	14	10	8	8
H.P.	1	1.5	1.5	1.5 - 2	2
R.P.M	from 2500 to 3500 3533500				

Cutting with Other Equipment

There now exist cutting methods that do not produce burrs. These methods are very efficient as the material does not undergo friction heating and the cut surface does not need operations such as edging or sandpapering.

Laser

Laser cutting has been used by some industrial sectors for several years now. Its main features are:

- High precision cut
- Manufacturing flexibility
- Cost reduction

One advantage of the laser cutting system is versatility of application. In addition to direct employment in cutting acrylic sheets, it can be used for processing many other types of materials.
A laser device can be used to cut, weld, and hew surfaces of up to 30 mm thick thanks to the fact that the laser's energy is concentrated at a single point and heat generation can be limited to a minimal area, avoiding heat deformation and structural changes to the material. Cuts are fine with exact edges, which is highly useful for pieces of acrylic with intricate forms. Drill holes can be made as small as 0.1 mm in diameter at a velocity of up to 150,000 holes per hours.

Water Jet

The abrasive water jet system eliminates many problems associated with conventional cutting machinery and operations. By concentrating a very fine stream of water at high pressure and great speeds, high water pressure is created, capable of cutting a piece of titanium alloy up to 10 inches thick.
Using a combination of highly pressurized water and abrasive materials such as silica powder, the water cut can cut any material without producing heat and leaving an exceptional finish on the surface of the cut.
Advantages offered by this cutting system for acrylic include eliminating distortion due to heat, the ability to perform any angle, and its multi-directional cut type integrated into computer systems allows for any line shape, rendering secondary operations such as sandpapering or polishing unnecessary while reducing waste material because of the highly limited cutting area.

Problem and Solution Guide

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
STORAGE AND HANDLING		
•Sheet deformity	•Storage near heat sources such as radiators, furnaces, and steam lines. •Storage in vertical position with or without rack (improper storage).	•Place away from heat sources. •Relocate storage area. •Store on racks with a base inclined at 10º and no greater than 25 cm.
•Sheet cracking	•Storage near solvent vapor or near places such as painting, printing areas, etc.	•Store in horizontal position. •Place away from solvents of any kind. •Relocate storage area.
CUTTER (blade for plastic)		
•Cut deviates from incision line.	•Shallow groove.	•Deepen incision by approximately 1/3 material gage. •Position a metallic ruler beneath the material and push down.
CUT		
•Cut not squared	• Buffer or guide out of adjustment. • (Radial or miter) saw out of adjustment.	•Align guide to disk. •Check and/or align disk to bench or arm.
•Splintering of edges	•Dull disk •Inadequate disk •Disk vibration •Low speed •Cut too shallow •Piece improperly fastened	•Sharpen disk and/or change broken or dull tungsten carbide tips •Change to specified disk. •Tighten nuts on motor´s arrow •Change to larger plates. •Check and/or modify RPM. •Adjust cut depth. •Fasten piece better.

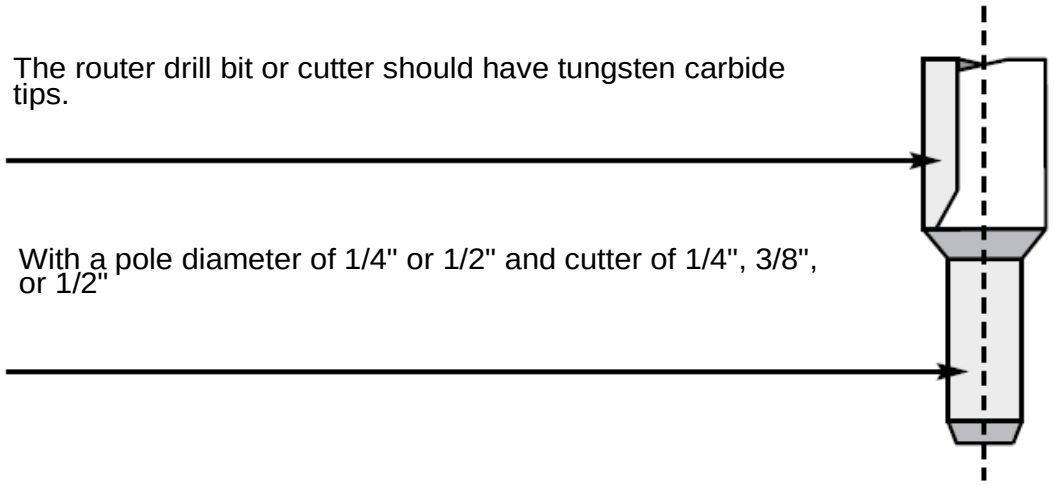
DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
CUT		
•Softened material	•Inadequate disk •High speed	•Change to a specified disk •Change to specified speed specified •Check and/or modify RPM
•Overheating (material and engine)	•Fast cutting speed •Material gage too thick	•Reduce feed rate feed •Shallower cut in steps •Cool with water or coolant liquids
•Jammed disk	•Low-power engine (HP) •Disk diameter too small •Material gage too thick	•Change engine with one with higher power (HP) according to specifications. •Change to disk with larger diameter. •Shallower cuts or less number of pieces.
•Jagged cut	•Buffer or guide out of adjustment •Saw out of adjustment	•Align buffer to disk to disk. •Align disk to bench or arm.
BAND SAW		
•Irregular cut	•Band tension •Inadequate band •Buffers need adjustment	•Adjust band tension •Change to specified band. •Adjust buffers.
•Band jammed	•Low speed •Low engine power (HP) •Inadequate band	•Change to a recommended speed. •Change to higher HP engine as recommended. •Change to specified band.
•Limited radial cut	•Band width greater than curve radius	•Check radial cut table and change band accordingly.

BAND SAW		
•Shattering of material	•Inadequate band •Dull band •Buffers out of adjustment	•Change to specified band. •Change to new band. •Adjust buffers.
•Slow cut	•Dull band •Inadequate band •Low speed	•Change to new band. •Change to recommended band. •Increase speed.

Machining

Routing

The CHEMCAST acrylic sheet can be cut with a portable or fixed (electric or pneumatic) router. An electric router of at least 1.5 HP at 20,000 to 30,000 rpm is recommended. Use drill bits or cutters with tungsten carbide tips and a minimum diameter of 1/4" o 3/8". Ideally 1/2" to keep the vibration caused by the high speeds from breaking the material. This method provides a very even cut and serves to both shape as well as make large-diameter holes. You can use the router fixed to a table or with a copy guide for pieces with more complex designs.



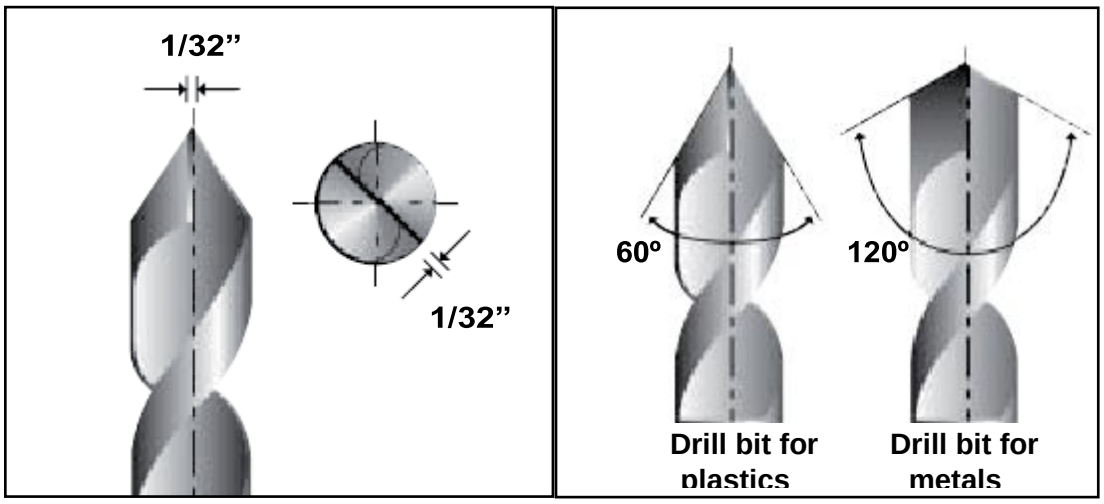
Drilling

Any type of portable or column drill can be used to drill CHEMCAST acrylic sheet. A column drill is ideal because it provides better control and greater precision. With a little care, the right technique, and a properly sharpened drill bit, you can get good results from an ordinary manual drill.

A high-speed drill bit for steel can be used, but it is recommended to modify it to prevent fractures in your material. This modification can be made by sharpening small surfaces on both edges of the drill bit with medium or fine grade emery. These surfaces must be parallel to the drill bit length with a gage of 1/32" and an incline angle between 60° and 80°.

For a better finish within the drill, use a slow spiral drill bit with polished channels, which will clean the drill of drill cuttings without damaging or burning the walls. If the drill bit is

correctly sharpened and used at the right speed, two continuous drill cuttings will come out of the drill hole. When you need to make drill holes with a diameter greater than 19 mm (3/4"), it is recommended to use saw-drill bits with an inner hollow or extension drill bits at a low speed.



Manual Threading

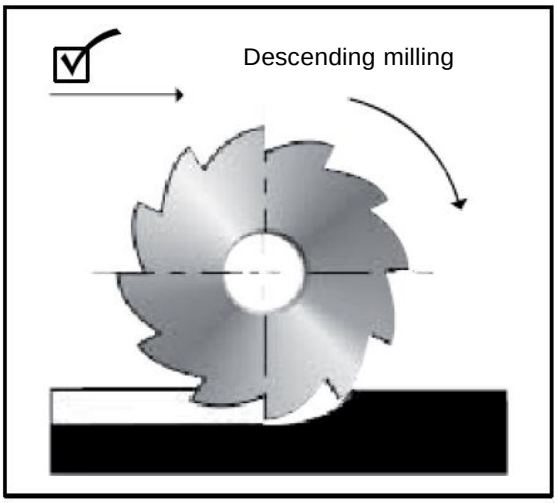
Male Threading:
A round bar can threaded with a jackbit. It is important that the diameter of the bar be slightly greater than the diameter of the jackbit.
Female Threading:
For this type of machining you will need to drill a hole slightly smaller than the diameter of the tap.

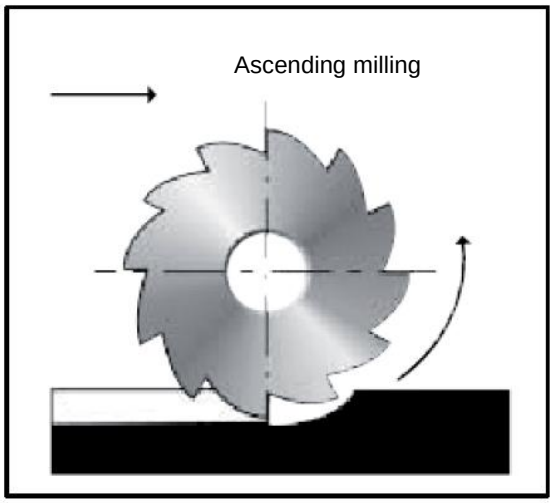
General Considerations:
The threading process involves the danger of causing cracking. The tap or threading machine should return to remove drill cuttings.
To reduce the internal stress of the piece during and after threading, you will need to use oil or a soapy water solution during the process.
Due to the fact that the material undergoes contractions and dilations, there must be a tolerance in the piece's adjustment with its counterpart in order to avoid pieces breaking.

Milling

A milling machine for metals is recommended. High-speed steel or molybdenum or vanadium carbon steel are great cutting tool materials.

When spinning the milling machine, a downward direction is better than upward. Downward milling provides advantages such as longer cutting tool life and drill cuttings that come loose easier. The end of the cutter should be selected according to the form of the material to be processed.





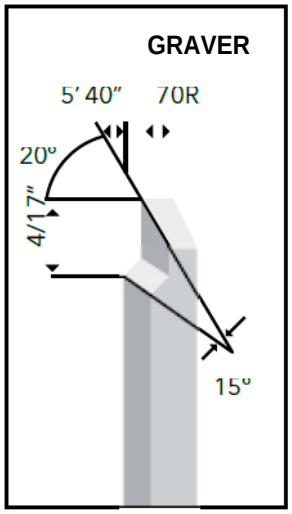
OPERATING CONDITIONS

- Cutting speed: 600-800 m/min
- Cutting depth: 1 mm or less
- Feed rate: 90 mm/min

Turning

A wood or metal lathe can be used. Cutting tool should be made of high-speed steel or carbon steel. When the material is mounted on the chuck, handle it with a cloth or chamois to keep from scratching the piece.

The cutting tool should be positioned in the center or slightly below the center of the piece. If the cut is very deep and the feed rate high, the surface will crack and the tool will cause splintering and vibration. When a very fine finish is needed, the feed rate should be between 33 to 66 feet/min. It is important that the tool have an adequate edge to achieve a fine finish.



OPERATING CONDITIONS		
	Rough finish	Fine finish
Cutting angle	0-3º	0-3º
Relief angle	10-20º	10-20º
Cut angle	60-80º	60-80º
Cutting speed	100-200 m/min	15-60 m/min
Feed rate	1-2 mm/min	.01-.03 mm/min
Depth of cut	3-5 mm	.01-.07 mm

When cutting CHEMCAST acrylic sheet, regardless of the technique used, the edges will be rough, which is not recommendable for joining with another sheet or for finishing the piece. It is necessary to level off these edges by applying different techniques depending on the desired finish, one of them being sandpapering.

Engraving

To engrave CHEMCAST acrylic sheet you can use a variable speed (5000 to 20,000 rpm) electric or pneumatic motor-tool. There is a wide range of cutting millers to create different effects. This equipment is generally used for engraving artistic pieces.

Edging

The aim of this operation is to eliminate the mark left during cutting. You can do this with an electric edging machine for wood and a cutter with tungsten carbide tips, a manual electric edging machine, or manually with a blade.

Sandpapering

Before polishing the CHEMCAST acrylic sheet it must be sandpapered until the finish is even and matte. Sandpapering quality will depend on the type of sandpaper used. The finer the grain, the finer the finish. If the work has caused deep marks on the surface of the sheet, sandpaper with medium grain sandpaper between No. 180 and 320, to continue with fine sandpaper, preferably lubricated with water, No. 400 to 600 until the surface is even, matte, and completely free of any marking. This can be performed by hand or using mechanical or electrical equipment.

Manual Sandpapering

To sandpaper by hand, techniques similar to woodwork are used, only more carefully. Use a wood or rubber chock to perform the sandpapering.
When eliminating marks, be sure to sandpaper an area larger than the mark to avoid distortions or a stained appearance. Use circular movements, pressing lightly and preferably lubricating with water.
As you work with CHEMCAST acrylic sheet, you will gain sufficient experience to determine the sandpapering needs for each case.

Sandpapering with Mechanical Equipment

Commercial mechanical sandpaper machines can be used to work with CHEMCAST acrylic sheet. Perform the operation as if working with wood, but using less pressure and speed.

Of course, you will need to change the sandpaper type depending on the job to be performed, always lubricating with water, especially with fine sandpaper of the grades recommended above.

Polishing

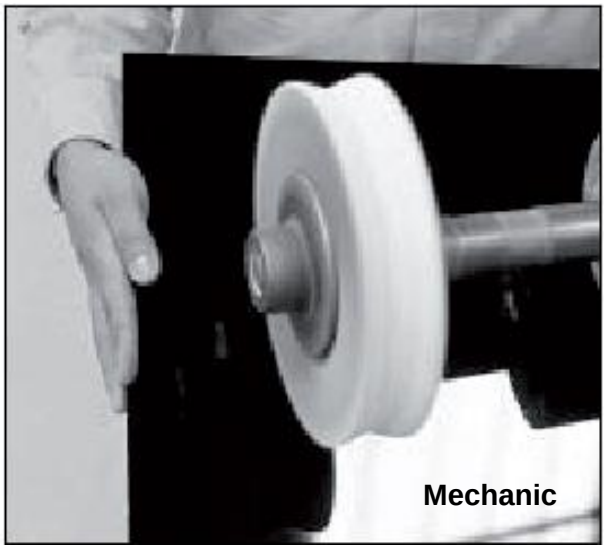
To restore shine to the CHEMCAST acrylic sheet at edges and surface, you can use an electric or pneumatic polisher. Manual polishing is also possible.

Hand Polishing

Apply automotive silicone or paste wax to your CHEMCAST acrylic sheet with a white chamois, leaving a thin, even coat. Next, rub repeatedly with the chamois. Finally, clean with another damp white chamois (do not apply to printed areas in order not to damage them).

Mechanical Polishing

You can use 3 to 5 HP motors with polishing wheels fitted with soft chamois disks joined to form a wheel of approximately 2.5 to 7.5 cm thick (1" to 3") having a diameter of 15 to 30 cm. (8" to 12"). You can also use electrical or pneumatic portable tools fitted with chamois disks. A speed between 1000 and 1800 rpm is recommended. Never use rotors that have been used to polish metal as the metallic swarf scratches the acrylic.



The CHEMCAST acrylic sheet can be polished using a solvent-free commercial polisher, paste wax, or automotive silicone. First apply the polisher to the chamois wheel. Move the piece from one side of the wheel to the other until the surface is evenly smooth and shiny. Be careful, do not apply too much pressure and keep the piece moving in order to keep the sheet from overheating, which could cause burns or disfiguring.

Glazing

For safety reasons, it is important not to begin polishing near the top edge of the sheet. The wheel can easily catch it and throw the piece out of your hands, launching it some distance, or right at you. Always start polishing approximately one third of the way down from the top edge of the sheet and keep the piece moving from one side to another until reaching the bottom edge. Then turn the sheet over and repeat the process. The use of gloves and safety goggles is recommended.

This method is used when you need to glaze areas that the polisher cannot. It is a quick, clean, easy operation that saves time and money. You can use the following equipment:

- Oxygen-acetylene
- Oxygen-butane
- Oxygen-propane
- Chromatographic hydrogen-oxygen

It is important that the flame reach a temperature of 1200° to 1300° centigrade. Use jewelry or dental cutting nozzles. Application speed is approximately 4 m / min in proportion to 2 kg of oxygen per 1 kg of gas.

Edges are susceptible to crazing if there is an immediate contact with chemicals after this process. It is necessary to let the material cool down completely.

Problem and Solution Guide

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
MACHINING		
•Splintering of edges	•Inadequate drill bit •Blunt drill bit •Cut in direction of edge	•Change to tungsten carbide drill bit •Sharpen and/or change tips of tungsten carbide •Correct direction
•Vibration in piece and in the router	•Router improperly attached to base •Drill bit not tight enough •Material gage too thick	•Tighten router to base •Correct tightness •Shallower cut
•Softened material •Cut with copy guide and offset template	•Inadequate drill bit •Blunt drill bit •Cut in direction of edge •Drill bit eccentric to guide	•Change specified drill bit •Sharpen and/or change tungsten carbide tips •Correct direction •Adjust centers
DRILLING		
•Splintering of material upon entrance and/or exit	•Inadequate drill bit attack angle •Inadequately sharpened •Drill bit diameter too wide	•Modify attack angle to 60 or 80º •Modify to double edge 1/32” •Change to extension or hollow bit
•Cracking or softening of material	•Overheating	•Cool with water or liquids refrigerants
MALE AND FEMALE THREADING		
•Rough, cracked sides •Thread fillets not carved out	•Blunt taps •Small drill hole •Dull bearings (threading machine) •Drill hole too large •Inadequate diameter/thread ratio	•Change taps •Drill larger hole •Clean bearings/generously lubricate •Repeat the piece / increase thread diameter •Check ratio tables

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
MILLING		
•Softening of material	•Inadequately milled •High speed	•Check bit type, change if necessary •Correct speed
•Shattering	•Blunt mill bit •Cut against grain	•Sharpen and/or change bit •Change to parallel cut
TURNING		
•Softening of material	•High speed	•Modify speed
•Shattering and/or vibration	•Blunt graver •High feed rate •Cut too deep	•Sharpen and/or change graver •Reduce feed rate •Reduce cut depth
SANDPAPERING		
•Edge has saw or router mark	•Needs sandpapering	•Sandpaper more and/or increase pressure
•Warped edge	•Poor sandpapering technique	•Do not balance hand (For manual operations)
•Warped edges	•Greater pressure at ends of piece edge	•Balance out pressure on center and toward the corners
•Sandpapering coarse at edge	•Sandpaper too coarse	•Change to finer sandpaper
•Edge has been sandpapered, resulting in inclination, with no parallels between edges	•Greater pressure to one side	•Balance out pressure on center and toward the corners

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
•Distortion of surface	•Excess pressure	•Reduce pressure
•Edges burnt and/or warped	•Insufficient paste •Inadequate rotors •Poorly applied glazing technique •Flame too close to material •Slow application speed •Poor mixture of gases	•Add more paste •Change to specified rotors •Improve technique •Change to mechanical polishing •Retreat from flame •Apply flame at velocity of 4 m / min. •Regulate flame at high temperature
•Subsequent cracking	•Paste or polisher has solvent residue	•Change to specified pastes •Clean rotors
•Overheating	•Static piece •Excess pressure	•Moving piece •Reduce pressure
•Yellowing	•Poor mixture of gases	•Regulate flame at high temperature
•Pieces melted together	•Pressure between pieces	•Leave space between pieces

Thermoforming
General Recommendations

Thermoforming the CHEMCAST acrylic sheet is the simplest and most common process for transforming it. Because it is a thermoplastic material it softens and can be easily handled and take any shape when heated at the right temperature and time. When it cools it recovers its rigidity and keeps the shape it was given.

The cost of the equipment and molds is relatively low and two-dimensional or three-dimensional forms can be obtained be means of a wide variety of processes.

1) Characteristics of the finished product will be determined in the forming process.
2) The material should be evenly heated to the point of softening and formed before it cools below its molding temperature.
3) Acrylic should cool slowly and uniformly while in the mold at room temperature. Consider the same time the material was in the furnace in order to prevent possible deformities in the formed piece.
4) The formed piece should cool before being painted.
5) Piece design should take into account shrinking of 2% on both sides and a 4% increase in gage and contraction of 0.6 to 1% when cooling.

Forming cycles and temperatures

The softening temperature of the CHEMCAST acrylic sheet is within the range of: 160° to 180° centigrade.

- Low temperatures produce internal stresses such as cracking or fissures.
- High temperatures create bubbles and mold marks.

There is formula for determining how long to keep an acrylic sheet in a gas furnace with forced air circulation:

2.1 x G (mm) = T (minutes) where:

2.1 = Factor
G = Gage of material in mm
T = Time in minutes

Heating Equipment

1. Gas furnace with forced air circulation

- Provides uniform heat and constant temperature with minimal risk of overheating the acrylic sheet.
- Use electric fans to force the hot air to circulate across the acrylic sheet at a speed of approximately 150 ft/min and devices and devices or deflectors to distribute the air toward all parts of the furnace.
- Gas furnaces require heat exchangers to prevent soot accumulation due to gas flow, as well as controls to interrupt the passage of gas if necessary. Electric furnaces can be heated using groups of 1000-watt electric resistances. If using a furnace with capacity of 100 m3, it will use approximately 25,000 watts of power, half of which will be used to compensate the loss of heat to leaks, insulation transmission, and due to use of doors.
- We suggest using 2" insulation and that the furnace doors be as narrow as possible for maximum reduction of temperature loss.
- Use automatic devices for strict temperature control between 0° and 250°C.
- In order to obtain more uniform heating of the sheet it's important that it is hung vertically. This can be achieved by using a system that affixes the material lengthwise with hasps or channels with springs that run by means of skidders that slide over closet rails.

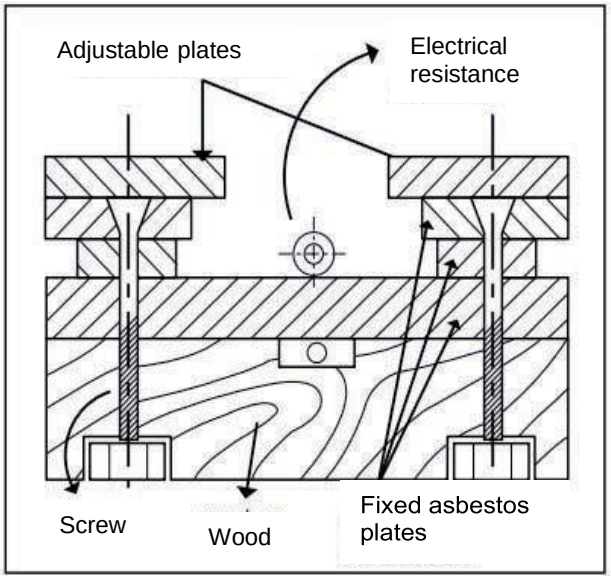
2. Infrared Heating Furnaces

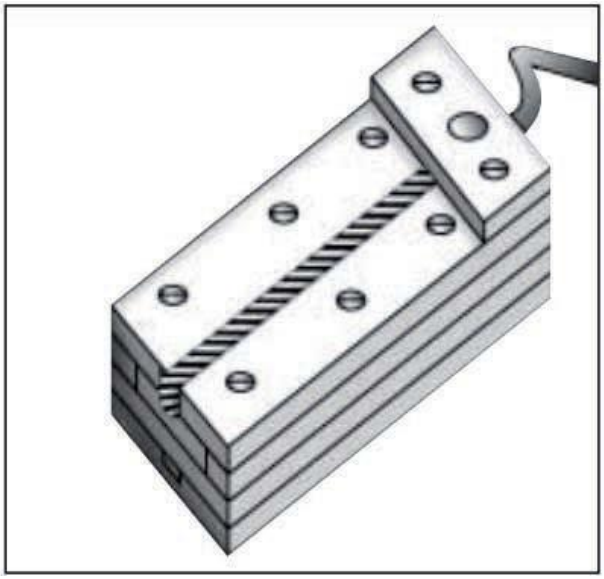
- Commonly used in automatic thermoforming machines, heating the sheet by means of radiation at a velocity of 3 to 10 times greater than in an air circulation furnace, providing greatly reduced time cycles when the temperature is extremely critical and it is harder to obtain uniform heating of the material.
- Infrared heat is absorbed by the exposed surface of the acrylic to quickly reach temperatures above 180°C, in order to then be transmitted to the center of the material by slow temperature conduction.
- Infrared radiation heating can be obtained using tubular metal elements, electric spiral (spring) resistances, or grouping infrared lamps. To achieve more uniform heating, you can use metallic net or screen mounted between the heating elements and the material to act as a heat diffuser. Likewise, place the top infrared heating plate approximately 30 cm from the material and the lower plate approximately 50 cm away.
- To regulate entrance of energy to the equipment, it is recommended to use devices such as variable transformers or percentage meters to help control the temperature.

3. Linear resistance heating units

A resistance units can only be used to form bends on a straight line, for which it is necessary to have a spring-type (No. 20) or shielded (approx. 1 Kw x 1.2 m) resistance unit. Linear resistance units are made of wire enclosed in ceramic Pyrex tubes. Do not let the material touch the tube in order to prevent marks on the surface. A space of 6 mm is recommended between the tube and the material for uniform heating of thin material.

When using this procedure to heat material with a gage greater than 3 mm, place resistance units on both sides of the material.





It is easy to make a heating device with a linear resistance unit.

Thermoforming Techniques

1. Two-dimensional Thermoforming

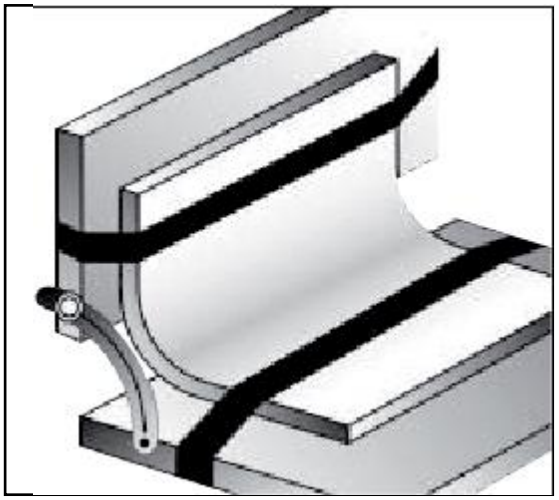
Two-dimensional thermoforming is a bending process that can be achieved by two methods:

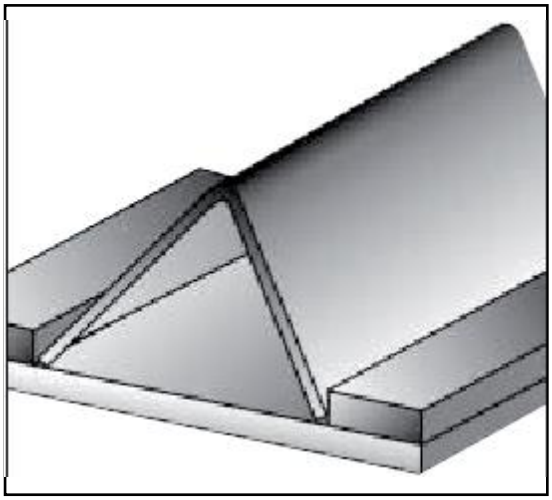
Bending by linear heating

Place the CHEMCAST acrylic sheet to be heated over a linear resistance, bending to the desired angle. To proceed to bending, remove the protection (paper or plastic film) from the bend line (the rest may be left in place to protect the areas you won't be working with). Place the sheet over the supports with the line to be bent directly over the heat line, bending along the heated side. Heating time will vary according to sheet gage. To bend a CHEMCAST acrylic sheet with gage greater than 4 mm it is recommended to heat it on both side to obtain an adequate bend. Heat the sheet until it begins to soften

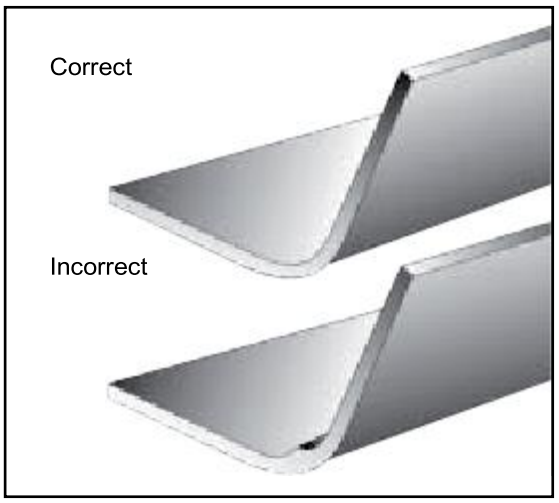
in the bend area. Do not try to bend the sheet before it is well heated or when it is partially cool as this can lead to irregular, folded corners or cracking.

Heat carefully. Irregular heating can cause arching on the bend line. This is sometimes hard to avoid, especially with pieces with a length greater than 60 cm. Arching can be reduced by fastening the recently formed material with clamps or a template until it cools. Templates can be made of wood and may be fixed or adjustable. Use light cotton gloves when handling the hot sheet to protect your hands.

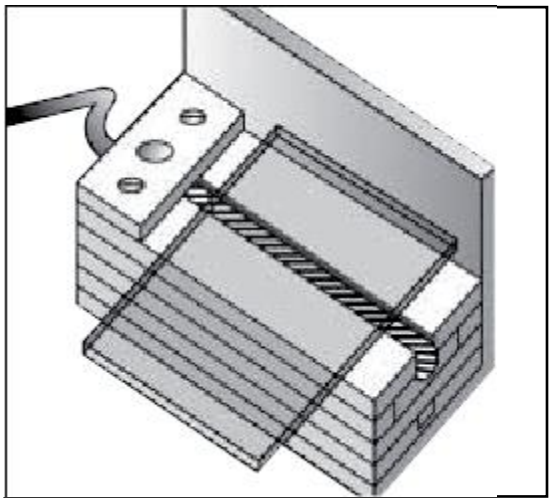




Use fixed or adjustable templates to hold the piece at the desired angle.



With proper heating you'll get clean, shiny corners.



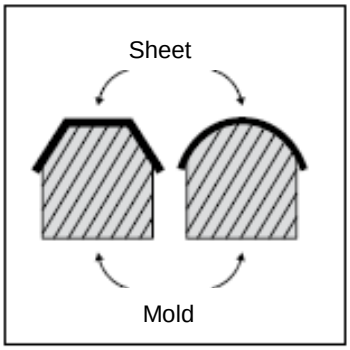
Place the sheet over the supports with the line to be bent directly over the heat line, the material shouldn't touch the walls of the resistance in order to avoid marks.

Cold Forming.
The CHEMCAST acrylic sheet can be cold formed on curved frames, as long as the curve radius is greater than 180 times the gage of the material used. Formula: R (radius) = 180 X G (gage en mm.)

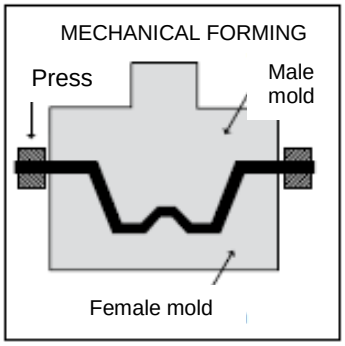
2. Three-dimensional Thermoforming (with Molds)

3D forming procedures generally require the use of vacuums, pressurized air, mechanical equipment, or a combination of these to thermoform the CHEMCAST acrylic sheet to the desired shape. Some of these techniques are described below:

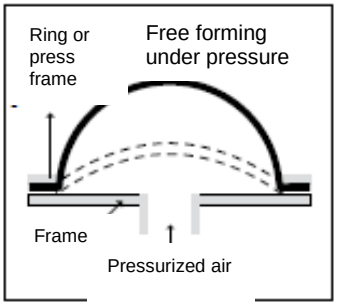
Free or Gravity forming.
This is the simplest of all the methods due to the fact that the sheet, once softened, is placed over the mold and takes on the shape due to its own weight. The edges of the material can be fastened to the mold to prevent undulations that tend to form during cooling



Mechanical Forming with Male and Female Mold.
The CHEMCAST acrylic sheet can be formed by pressing the softened material between female and male molds to produce pieces with very precise dimensions. This procedure requires molds to have an excellent finish in order to reduce the possibility of marks to the absolute minimum.
The CHEMCAST acrylic sheet can be formed like a sheet of metal--by pressing the hot material you can obtain pieces with precise dimensions and a desired texture.



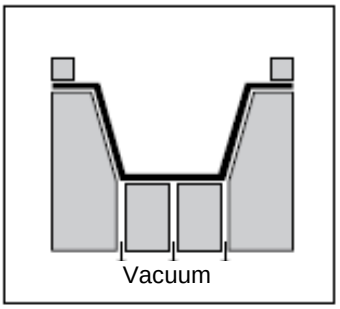
Free forming under pressure or air vacuum.
Pieces requiring optical clarity such as domes, airplane windows, helicopter cabins, etc. can be formed without a mold, just by stretching the acrylic. The shape of the finished piece will be given by the shape and size of the ring affixing it to the frame and by the height given by the vacuum or pressure. However, these shapes are limited to freely formed bubbles or spherical contours.
A vacuum is preferred for free forming. For pressure greater than one atmosphere air blowing or pressure will have to be used. The shape of the piece will be



given by the shape and size of the ring affixing it to the frame Vacuum and Pressure Shaping Female Mold.

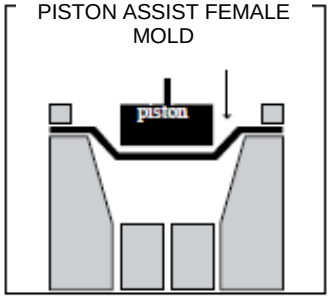
This procedure allows you to form pieces over molds whose form requires greater precision than that obtained by vacuum. This way you obtain pieces with good detail definition and closed dimensional tolerances. However, high pressures will cause marks from the mold on the piece. If high pressures are required, the molds should be metal, epoxy resins, or other materials that withstand high pressures without becoming deformed. It is imperative that the molds have a good finish in order to obtain quality pieces.

VACUUM FEMALE MOLD



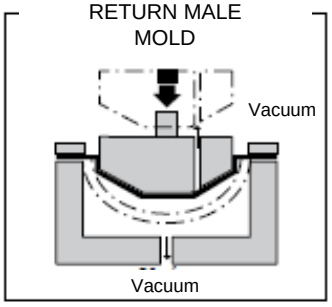
Pressure forming with piston assist female mold.
The piston-assist technique is used to reduce thinning in the bottom of formed pieces. The piston stretches the material before pressure is applied. Piston speed of 1 to 3.5 m/min, more than 6 m/min damages the material on initial contact.
Molding pressure 2.8 kg/cm2.

PRESSURE WITH PISTON ASSIST FEMALE MOLD



Vacuum forming with return and male mold.
This method is valuable for forming pieces requiring uniform thickness in walls and as little molding marks as possible. The softened sheet is stretched in a vacuum glass box until it reaches the depth necessary to fit the mold. Once the mold has penetrated, the vacuum is gradually released so that the acrylic returns to its original shape, coming up against the mold and conforming to it. More defined shapes can be achieved if vacuum is applied to the mold on return.

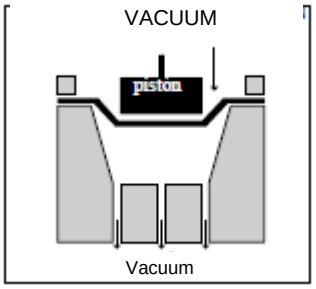
VACUUM FORMING WITH RETURN MALE MOLD



This method provides uniform thickness to the walls of the piece and minimal molding marks. Pressure forming with piston assist, female mold and vacuum

This is the most sophisticated method of all as it combines almost all of the above mentioned methods, it is generally used for very deep thermoforms where more controlled gages are required and when there is a risk of rupture due to excessively deep molding

PRESSURE WITH PISTON ASSIST FEMALE MOLD AND VACUUM



Thermoforming Equipment

Thermoforming equipment consists of the following basic elements:

Heating unit

- Gas furnace with air recirculation
- Infrared radiation heating furnace

Mechanical equipment

- 2000 kg/cm2 min. hydraulic press
- Air pressure 7 kg/cm2, minimum 3/4"-diameter pipes
- 0.05 m3 / min vacuum, 1-3"-diameter pipes, 0.5 to 3 m3 tanks storing 600 to 710 mm of Hg (24" to 28" Hg).

Accessories

- Metal frames
- Hoses
- Bases for fastening material
- Clamps
- Ball valves

Problem and Solution Guide

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
TWO-DIMENSIONAL THERMOFORMING (linear bend)		
•Bubbles in bend area	•Overheating of the piece	•Reduce temperature and/or time
•Wrinkles in bend area	•Piece too cold	•Increase temperature and/or time
•Arching in bend area	•Overheating of the piece	•Reduce temperature and/or time
THREE-DIMENSIONAL THERMOFORMING (with molds)		
•Bubbling or blistering in sheet	•Heating too fast	• Reduce temperature and/or furnace time
•Incomplete forms and details	•Uneven heating •Insufficient heating of sheet •Insufficient vacuum	•Check and fix furnace •Increase temperature or heating time •Greater tank and vacuum pump capacity
•Change of sheet color	•Excessive heat •Sheet too thin	•Reduce temperature or heating time •Increase sheet gage
•Excessive warping or buckling of sheet	•Sheet too hot	•Reduce temperature and/or heating time
•Cooling mark on formed piece	•Sheet too hot	•Reduce temperature and/or heating time •Reduce mold temperature
•Small wrinkles or irregular marks	•Sheet too hot •Vacuum drill holes too large	•Reduce furnace temperature •Fill and drill at a smaller diameter
•Variation in sheet buckling	•Uneven sheet temperature	•Check and/or fix furnace

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
THREE-DIMENSIONAL THERMOFORMING (with molds)		
•Wrinkles during forming	•Excessive heating of sheet •Insufficient vacuum	•Reduce furnace temperature •Check and/or correct vacuum system
•Shiny lines or areas	•Sheet overheated •Trapped air between material and mold	•Reduce heating time •Sand-blast mold surface
•Poor surface appearance of piece	•Insufficient vacuum •Sheet dirty	•Increase number of vacuum orifices •Clean sheet
•Excessive distortion or post-shrinking after removing mold	•Mold removed too soon	•Extend cooling cycle •Use fans
•Excessive thinning of wall thickness of the piece	•Inadequate thermoforming technique •Sheet too thin	•Use another thermoforming technique •Increase material gage
•Twists in the pieces	•Piece not properly cooled •Insufficient mold temperature	•Adjust cooling cycle •Increase mold temperature
•Shrink marks at corners	•Mold surface too smooth •Insufficient vacuum	•Sand-blast mold surface •Check and/or correct vacuum system
•Uneven prestretching of the bubble	•Low temperature •Uneven sheet gage	•Increase temperature •Longer heating time at lower temperature
•Corners have thin gage on deep formations	•Inadequate mold heating •Uneven heating of sheet	•Increase mold temperature •Check and/or correct furnace operation

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
THREE-DIMENSIONAL THERMOFORMING (with molds)		
•Piece sticks to mechanical assist	•Insufficient escape angle •Lower assist temperature	•Increase escape angle •Increase temperature
•Piece sticks to mold	•High temperature of piece •Insufficient escape angle	•Reduce temperature •Increase escape angle
•Corners of piece shatter once in use	•Inadequate piece design •Concentration of stress on the piece	•Redesign piece •Increase mold radii

Binding Techniques

The CHEMCAST acrylic sheet can be glued with solvents and adhesives, creating strong, lasting, transparent joints. The strength and appearance of the joint will depend on how carefully and skillfully it is made. Practice on small pieces. The more experience you have, the better finish you'll obtain.

Preparing the Surface

It is better that the surfaces are not forced to join. It's easier to work when they are flat or straight. Areas of the sheet that make up the original surface do not need additional preparation, nor do those made with a clean saw cut. But if the area to be joined has imperfections it will be necessary to sand it or give it another finish until it is flat, smooth, and square. Do not polish the sides to be joined as this will round the surface and reduce the contact area and the joint can crack. Always remove the protective paper or film from the area to be joined. It is a good idea to protect the surface near the area to be glued with adhesive tape resistant to the solvent or adhesive. Press it well so that solvent or adhesive won't run beneath it. Remove the tape after the joint has been made. Use solvents such as methylene chloride, ethylene dichloride, trichloroethylene, chloroform, ether, or acetone.

Some precautions when working with solvents:

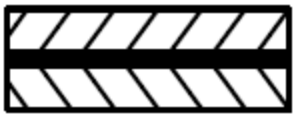
- Always work in a well-ventilated area
- Do not smoke. Solvents are flammable and highly volatile.
- Protect your skin from direct contact (use of safety goggles is recommended)

TYPES OF ADHESIVES		
TYPE	**EXAMPLE**	**CHARACTERISTICS**
Solvents	Methylene Chloride Chloroform Acetones Toluene	Low-viscosity liquids that melt with the acrylic in a short time. Fast evaporating, quick binding.
Solvent Cements	•The same solvents + acrylic swarf •AD-CRYL extra	Can provide viscosity needed to fill holes. Relatively fast binding.
Polymerizable Adhesives	•AD-CRYL III •PG-PLUS	The same raw material as the acrylic. The only ones stable when exposed. Form very resistant joints.

Types of Joint

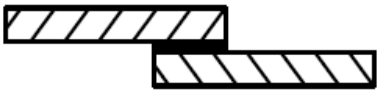
Joints like those used in wood can be made. These joints can be made mechanically or by gluing with adhesives. Below are the most common joint types:

Sandwich



Overlap

Traslape

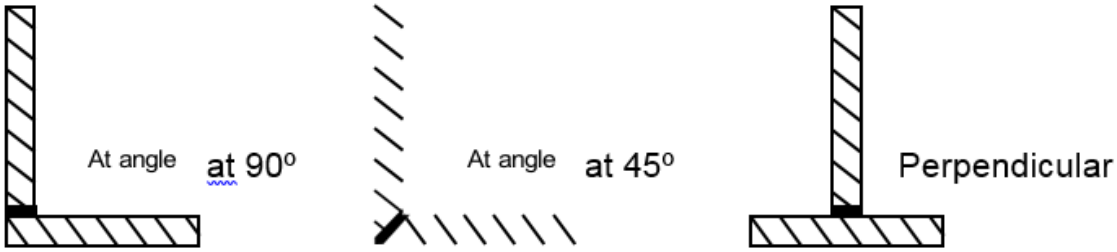


"V"

Straight or "bone"

Mortar

Polymerizable adhesive is recommended for these types of joints.



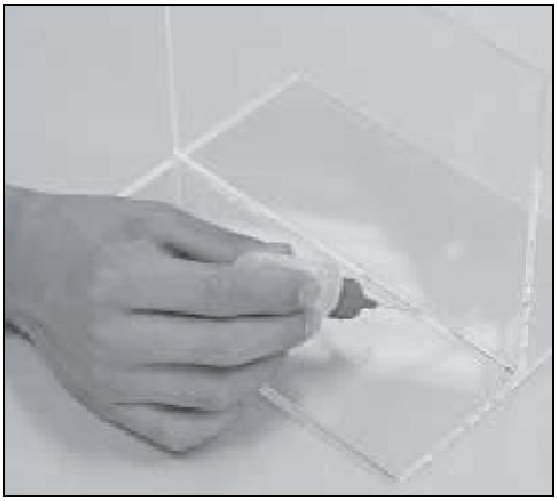
Binding Methods

There are binding methods for any adhesive of the groups mentioned above, depending on the type of joint, piece shape, and volume to be produced, and stress resistance. The main methods are:

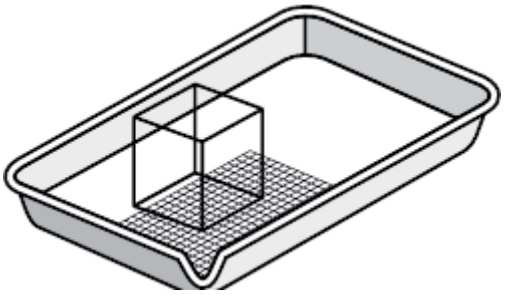
- Capillarity
- Submersion or soaking
- Polymerizable Adhesives Techniques

Capillarity

The action of a low-viscosity adhesive or solvent as it flows between the bound surfaces.
The surfaces to be joined should set correctly. Using a hypodermic needle, dropper, or narrow nozzle and container, apply the adhesive or solvent to one end, which will cover the entire area to be glued.



Once the low-viscosity (or edge) adhesive or solvent has been applied, it will flow by capillarity.



In the submersion method the material should not rest directly on the bottom of the tray.

Submersion or Soaking

Submerge the edge of one of the pieces to be joined directly in the solvent for 3 to 5 minutes. Use a shallow aluminum, stainless steel, galvanized steel, glass, or polyethylene trey to submerge the acrylic.

Place a metal mesh inside the tray to keep the edge of your sheet from touching the bottom of the tray. Keep the tray level and pour enough solvent in it just to evenly cover the metal mesh. Next, carefully place the edge to be glued inside the tray until it rests on the mesh. Hold it with a support or with your hands as it soaks.

The part making contact will swell and slightly dissolve, making the joint possible. Remove the piece and allow the excess to run off. Place it on the part to be glued and keep the parts in firm contact until the solvent evaporates or the joint is firm.

The CHEMCAST acrylic sheet should steep in the solvent for 1 to 4 minutes, depending on sheet gage, solvent type, and bond strength required.

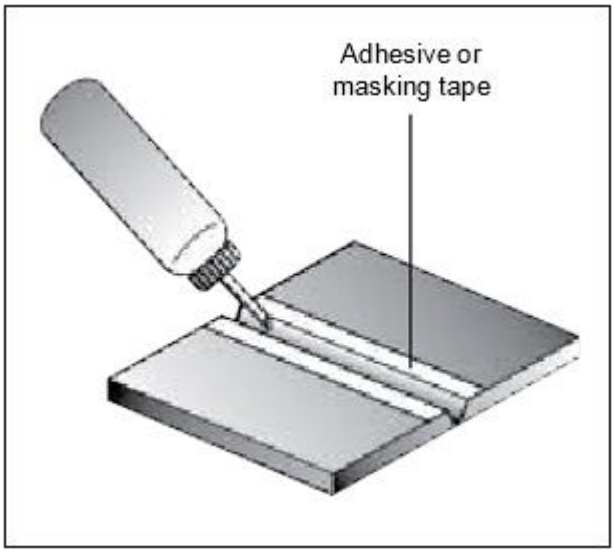
Soaking (submersion) time should be enough so that the edge of the sheet swells. Let the excess solvent run off, holding the piece at an incline.

Next, quickly but carefully, place the soaked piece in the exact spot on the other piece where it is to be joined. Keep the pieces joined without pressing for about 30 seconds, enough to allow the solvent to act on the surface of the other piece and then evaporate. When the pieces are joined, keep them in firm contact, holding them still 5 to 15 minutes.

Polymerizable Adhesives

This method is used when the above cannot be used due to the parts not setting correctly or for difficult areas to be glued. First place adhesive tape around the area to protect it. Apply the adhesive directly to the gluing area with a narrow nozzle until filled.

Remove protective paper from the area to be joined and carefully apply the adhesive with a brush, spatula, or narrow nozzle. Place adhesive or masking tape around the area to be glued to protect it. It can be removed after about 5 minutes, when the adhesive is still fresh. Carefully place adhesive on one side of the joint and then joint the pieces keeping them motionless for at least 10 minutes.



Use adhesive tape to cover the part where the adhesive should not touch

Other Binding Techniques

Thanks to technological development, there are currently highly revolutionary methods for joining pieces of acrylic. Below are two very versatile techniques:

- Hot air gun for plastics:

Now thermoplastics such as acrylic, PVC, polyethylene, and polystyrene, among others, can be easily soldered or glued, separated or bent, with a hot air gun.

Depending on the application, the tool adjusts electronically to provide different temperatures, speeds, and coupling of different nozzles.

The tools has a blower that produce between 50 and 230 liters of air per minute at temperatures between 1° and 700°C, depending on the size of the nozzle that is coupled. Because it is possible to finely adjust the tool, it can be used for soldering the most difficult thermoplastics.

With no nozzle, the gun provides a large amount of air for heating, separating, bending, or accelerating reactions. There are a wide variety of nozzles and accessories that adapt to this manual tool in a matter of seconds.

- Ultrasound

This is an clean, quick, efficient assembly, joining, or processing method for rigid thermoplastic parts and films.

Several ultrasound assembly techniques are used by all sectors of the industry to join plastic with plastic and plastic to metallic parts or other non-plastic materials as well as for inserting elements by replacing or excluding the use of solvents, adhesives, mechanical fasteners and other products.

A high electric energy frequency is supplied to a converter (a component that converts electric energy to a mechanical vibratory energy at ultrasound frequencies). The vibratory energy produced by the converter is then transmitted through a modulated amplitude device called "booster to the horn" (sonotrode). This acoustic instrument transfers the vibratory energy directly to the parts to be joined. The vibrations pass along the piece being worked on toward the joint area, where friction converts the vibratory energy into heat that melts the plastic. When this melted state is achieved, the vibration stops. Pressure is briefly kept on the pieces while the fused parts solidify to create strong molecular bond between them. Cycles are normally less than one second and the joint takes on the appearance of the material of the piece.

	ACRYLIC BINDING vs. OTHER MATERIALS									
	1	2	3	4	5	6	7	8	9	10
ACRYLIC	X	X	X	X	X	X	X	X	X	X
FOAMED PVC	X			X		X	X		X	X
POLYSTYRENE	X	X	X	X		X	X			X
ALUMINUM			X	X	X	X	X			X
IRON			X	X	X	X	X			X
WOOD			X		X	X	X			X

1. Solvents
2. Solvent cements
3. Polimerizables
4. Cyanoacrylates (Crazy Kola LokaMR / Crazy Glue)
5. Epoxies
6. Films
7. Adhesive tapes
8. Ultrasound
9. Hot air welding
10. Mechanical fasteners (bolts and screws)

Problem and Solution Guide

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
BINDING		
•Cracking of piece	•Polished or glazed surface or edges •Over-catalyzed polymerizable adhesive	•Do not polish or glaze •Check and correct formulation
•Bubbled (trapped air) in edges	•Edge with cutting mark •Inadequate solvent •Insufficient binding technique	•Set edge with router •Change to another type of adhesive •Practice technique
•Bubbles between binding surfaces	•Low pressure •Inadequate adhesive •Insufficient binding technique	•Increase pressure •Change to another type of adhesive •Change technique
•Haze or cloudiness	•Contact with solvent vapors •Grease or silicon on surface •Humidity	•Reduce contact time •Clean with water and soap or hexane •Dry surface
•Yellowing of joint	•Over-catalyzed polymerizable adhesive	•Check and correct formulation
•Binding undone or delaminating	•Grease or silicon on surface •Inadequate adhesive •Insufficient binding time	•Clean with water and hexane soap •Change adhesive •Increase time
•Poor resistance to mechanical stress	•Inadequate adhesive •Inadequate joint type •Inadequate polymerizable adhesive	•Change adhesive •Change joint type •Change adhesive
•Incomplete curing (Gel)	•Deficient catalyzing	•Check and correct formulation

Finishes

CHEMCAST acrylic sheet can be given different finishes including air gun painting, silkscreen process, metalizing, etc.

Spraying

This most common painting method uses an air gun. The CHEMCAST acrylic sheet can be painted with one or more colors, using common techniques such as masking or templates. Enamels and lacquers can be used. Acrylic versions are preferable as they are perfectly compatible with the acrylic. Avoid those containing solvents (acetone, toluol, or thinner).
To obtain a better finish with the air gun, it's best to apply several light layers rather than a single application of thick paint. Masking film (latex) is particularly useful when several colors are to be applied. Carefully follow manufacturer instructions when using thinner, in correct use excess quantities can cause serious defects to the surface of the acrylic.

Silk Screening

This method is used for designs requiring several colors or when the graphics have a certain complexity or when exact repetition of a design is required at low cost. Silkscreen equipment basically consists of a base frame, hinged bar, a screen, and a screed board.
Templates are often made with photographic stencils. As for inks, it's important to use acrylic- or epoxy-based inks. Solvent-based inks can also be used provided no binding will be taking place. If laminate or binding is to be implemented, the use of acrylic- or epoxy-based inks is recommended. Let the ink dry for a period of 24 hours and apply the adhesive to the acrylic that has not been printed.

Metalizing

Acrylic can be metalized using high vacuum and aluminum or titanium particles. This type of finish is generally outsourced as it is a very delicate process and the machinery is very expensive.
The finish is similar to a mirror, but can be metalized in a wide range of colors.

Shading

This finish can be achieved through different methods. The first consists of sanding the piece with water sandpaper. The finer the sandpaper, the more even the finish will be. Sandpaper no. 400 or 600 is recommended. Note that two different texture types are possible depending on whether you sand dry or wet. The second method consists of submerging the piece in solvents or strong acids. Though solvents are preferred because there is much less risk involved in handling them. The use of methylene chloride, toluene, or similar solvents is recommended. The degree of texture obtained by the acrylic is in proportion to the time the piece is left in contact with the solvent.

Sand Blasting

Sand blasting consists of forcing very fine sand through a nozzle at extremely high air pressure. A sand blaster is perfect for shading acrylic pieces. The texture is very even and both complete pieces as well as specific areas can be shaded using maskants. There are two types of sand blaster. The traditional sand blaster works only with air, while wet sand blasters use water.

Hot Stamping

Hot stamping is a technique that can be used to provide an excellent, high-quality finish on acrylic pieces. It is primarily used in prints such as key rings, domino pieces, mixers, and other publicity items. Manual machinery is typically employed. Only an engraved metal stamp is needed (the greater the relief on the stamp, the deeper the stamping). The stamping can be made by pressing down while applying heat to the stamp and the piece to be stamped. Can be printed with basic and metallic colors.

Problem and Solution Guide

DEFECT	POSSIBLE CAUSE	SUGGESTED SOLUTION
SPRAY (AIR GUN)		
•Cracking	•Use of solvent-based paints •Cleaning with solvents	•Change to acrylic- or epoxy-based paints •Clean with soapy water solution
•Sagging	•Diluted or watered down paint	•More homogenous mixture
•Scaling (poor anchoring to substrate)	•Drying too fast •Dirty surface needs degreasing •Thin layer	•Reduce solvent •Clean surface with adequate chemical agents
SILK SCREENING		
•Cracking	•Use of solvent-based inks •Clean with solvents	•Change to acrylic- or epoxy-based inks •Clean with soapy water solution
•Runny ink	•Mesh saturated or too wide •Diluted ink	•Clean or change to finer mesh •Denser mixture
•Scaling (poor anchoring to substrate)	•Dirty surface needs degreasing •Ink not suitable for acrylic	•Clean surface with adequate chemical agents •Change ink
•Sagging	•Paint too watery	•Thicken paint

IMPORTANT: PLASTIGLAS de México S.A. de C.V. does not assume any liability for the suggestions and information provided in this manual, which are based on information we consider to be true and accurate and is offered on good faith, but with no guarantee given that conditions of product use and transformation are not under our control.

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