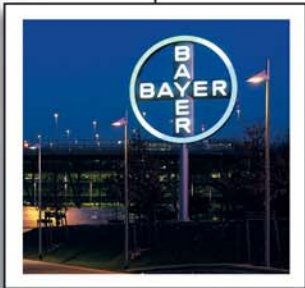
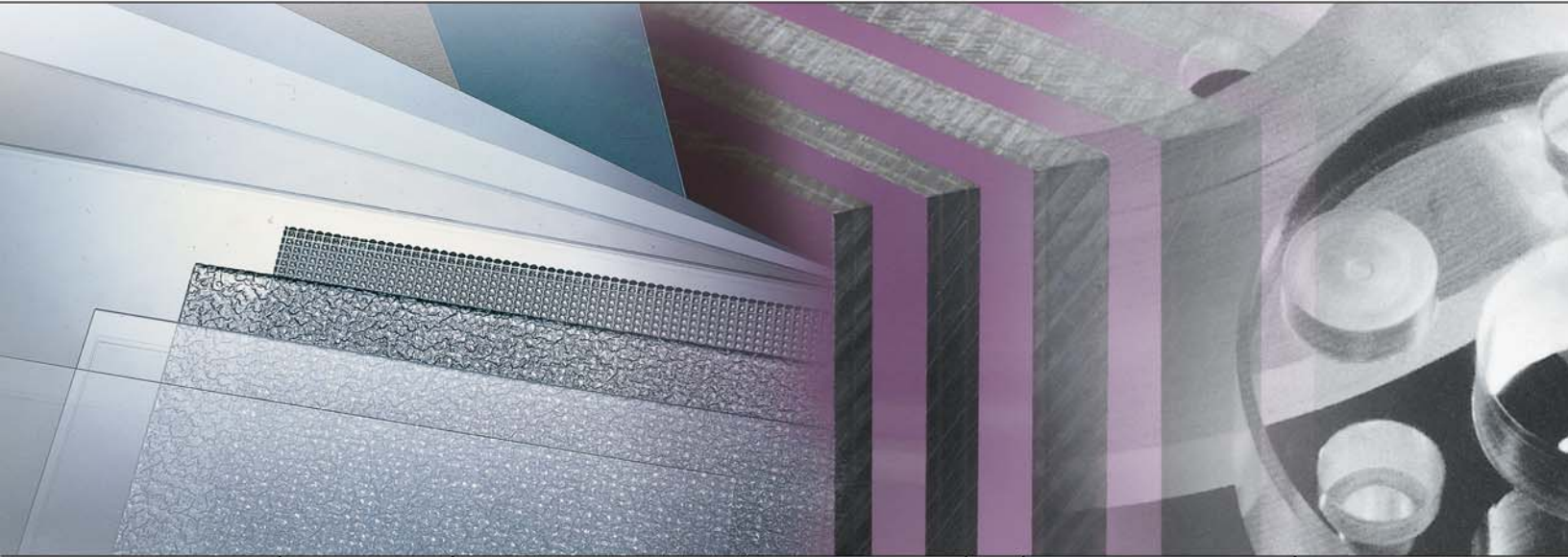


# MAKROLON®

P O L Y C A R B O N A T E   S H E E T



**...Clearly the Right Choice**  
Fabrication Guide

**Sheffield Plastics**  
A Bayer MaterialScience LLC Business

# None Tougher—None Clearer MAKROLON® Polycarbonate Sheet...

## “Made with MAK” for Quality and Excellence

Produced from Bayer Corporation’s MAKROLON polycarbonate resins, Sheffield’s MAKROLON Polycarbonate Sheet meets or exceeds the performance characteristics of any directly competitive product on the market today. Combining innovation with a desire for excellence and state-of-the-art manufacturing, Sheffield Plastics produces a wide range of polycarbonate sheet products that are unsurpassed for clarity and toughness. With outstanding forming, fabrication, and performance characteristics, “None Tougher, None Clearer” MAKROLON Polycarbonate Sheet can be easily fabricated into products that last. When you need clarity, toughness, and endurance, be sure you choose “Made with MAK.”

In addition to supplying quality products, leading technology, and industry leading technical support, Sheffield Plastics takes pride in having the highest rated distribution network in the industry. The Sheffield Plastics team is comprised of our local distributors backed by Sheffield manufacturing and product support personnel. When your application requires additional assistance, please contact our team of dedicated professionals who are always ready to assist you at **800-254-1707**.

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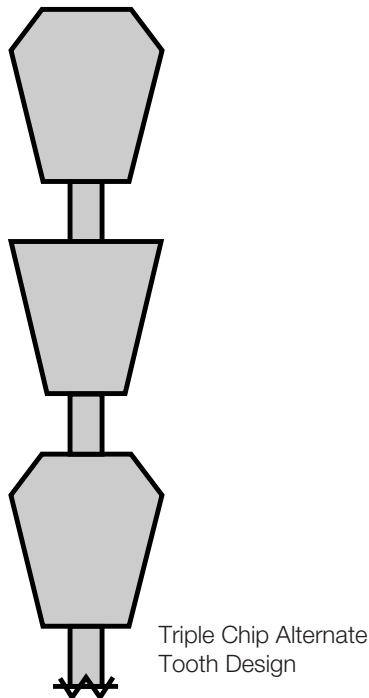
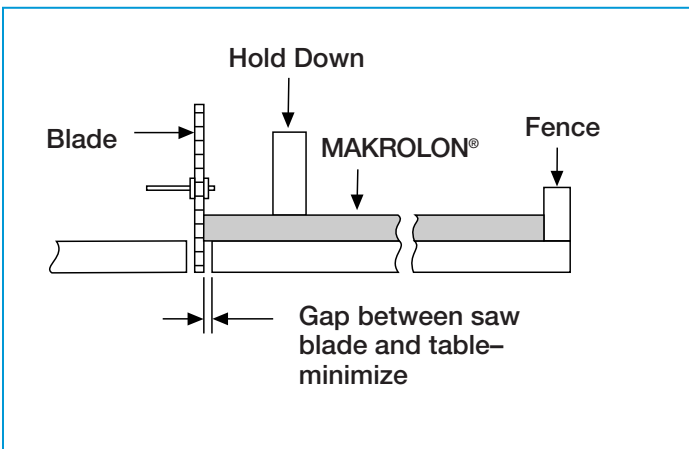
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## CIRCULAR SAWS

A circular saw blade with carbide teeth utilizing the “triple chip” tooth design is the preferred method of cutting MAKROLON® Polycarbonate Sheet. Table or overhead panel saws are normally used.

Circular saws should be run in the speed range of 1829-2438 m/min. Blades for cutting 2.86 cm and thicker material should have 3-5 teeth per 2.54 cm. The hook or rake angle should be 10°-15°. When sawing thin-gauge MAKROLON Polycarbonate Sheet, it is important to have a good supporting edge on the saw table with minimal gap between the saw blade and table supporting edge. Be sure tabletops are smooth and free from projections that might scratch or mar MAKROLON Polycarbonate Sheet.



Triple Chip Alternate Tooth Design

## CIRCULAR SAW TROUBLESHOOTING

**PROBLEM:** Melting or Gummed Edges

**SUGGESTED SOLUTIONS:**

1. Increase blade tooth size
2. Reduce saw speed
3. Increase feed rate
4. Use air to cool blade
5. Use blade lubricant compatible with MAKROLON Polycarbonate Sheet
6. Inspect blade for sharpness
7. Check blade-fence alignment
8. Reduce number of sheets in stack

**PROBLEM:** Chipping

**SUGGESTED SOLUTIONS:**

1. Decrease blade tooth size
2. Increase saw size
3. Provide better clamping and/or support for sheet stack
4. Reduce feed rate
5. Check blade and arbor for wobble
6. Inspect blade for sharpness



### Router Bit Suppliers:

Dino Saw Company  
340 Power Ave.  
Hudson, NY 12534  
Tel: (518) 828-9942  
www.dinosaw.com

Onsrud Cutter  
800 Liberty Drive  
Libertyville, IL 60048  
Tel: (800) 234-1560  
www.onsrud.com

Boshco Inc.  
144-A Rangeway Road  
North Billerica, MA 01862  
Tel: (978) 667-1911  
www.boshco.com

### Saw Blade Suppliers:

Forrest Manufacturing  
457 River Road  
Clifton, NJ 07014  
Tel: (800) 733-7111  
www.forrestmanufacturing.com

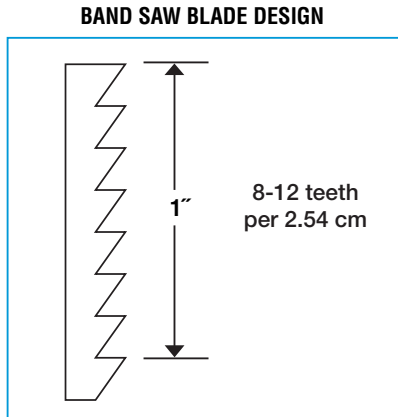
General Saw Corp.  
2518 Andalusia Blvd.  
Cape Coral, FL 33909  
Tel: (800) 772-3691  
www.generalsaw.com

Dino Saw Company  
340 Power Ave.  
Hudson, NY 12534  
Tel: (518) 828-9942  
www.dinosaw.com

FTM, Inc.  
6160 Cobblestone Rd.  
Placerville, CA 95667  
Tel: (530) 626-1986  
www.thefabricatorssource.com

## BAND SAWS

Band saws are useful for trimming formed parts or irregular shapes. Band saws should be run at 762-914 m/min and have 8-12 teeth per 2.54 cm. Coarser (larger tooth) blades perform better with thicker gauge MAKROLON® Polycarbonate Sheet. Proper support of the part to be trimmed is important because vibration may induce cracking if the cut is not smooth. Sanding the edge smooth after cutting is recommended.



## BAND SAW TROUBLESHOOTING

**PROBLEM:** Melting or Gummed Edges

**SUGGESTED SOLUTIONS:**

1. Increase tooth size
2. Reduce saw speed
3. Use air to cool blade
4. Check blade sharpness

**PROBLEM:** Chipping

**SUGGESTED SOLUTIONS:**

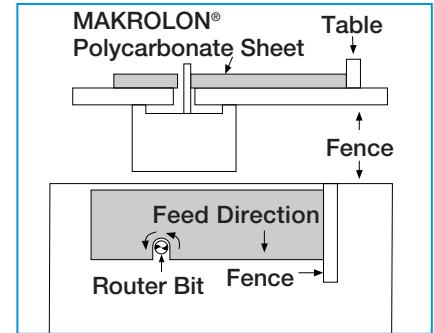
1. Decrease tooth size
2. Slow down stock feed rate
3. Provide better clamping and/or support to eliminate vibration
4. Check blade sharpness

## ROUTING

Routing produces a smooth edge on MAKROLON Polycarbonate Sheet and may also be used to cut curved or irregular shapes. Routers with a speed of 20,000 to 25,000 rpm are preferred. Use straight (fluted 2 or 3) carbide-tipped or high-speed steel router bits. Bits should be .635 cm to 1.27 cm diameter for best results. Use a router with at least 1 H.P. motor.

Special care must be used when routing—Use proper guarding and eye protection. Stock feed rates must be monitored closely. Feeding MAKROLON Polycarbonate Sheet at excessive rates can cause vibration and cracking.

It is important to feed the sheet against the rotation of the router bit and to provide a fence for sizing when making straight cuts.

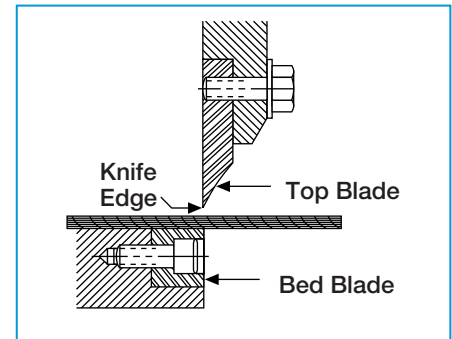


## LASER CUTTING

MAKROLON Polycarbonate Sheet can be cut using industrial cutting lasers. Edges may become amber or brown when laser cutting. For information on laser cutting equipment and part cutting services, contact the manufacturer of your equipment or the suppliers listed on this page.

## SHEARING

MAKROLON Polycarbonate Sheet may be sheared using a conventional sheet metal power shear. It is important to adjust the top blade clearance in relationship to the bed blade. A clearance of .003 cm is desirable to avoid a rough edge cut. Shear single sheets only.



### Laser Cutting Equipment Supplier:

Preco Laser Systems  
500 Laser Drive  
Somerset, WI 54025  
Tel: (715) 247-3285  
www.precolaser.com

### Laser Cut Parts:

Laser Engineering Inc.  
444 North York Road  
Elmhurst, IL 60126  
Tel: (630) 530-0500  
www.laserengineering.com

Preco Laser Systems  
500 Laser Drive  
Somerset, WI 54025  
Tel: (715) 247-3285  
www.precolaser.com

## DIE CUTTING

Die cutting MAKROLOLON® Polycarbonate Sheet in gauges up to .203 cm thick is normally achieved utilizing the following steps.

Steel rule dies mounted in a press provide good results. The shear strength of MAKROLOLON Polycarbonate Sheet is 517,149 torr which is appropriate for die cutting methods.

Calculating the required press tonnage to cut MAKROLOLON Polycarbonate Sheet:

$$F = \frac{P \times A}{2,000}$$

F= Required force in tonnage of the press  
 P=517,149 torr (shear strength of MAKROLOLON Polycarbonate Sheet)

A=The sectional area to be cut

Example:

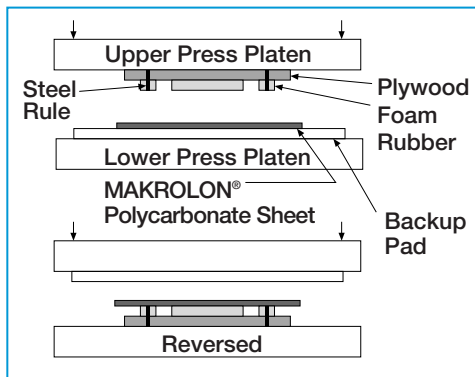
Die cut 30.48 cm x 50.80 cm x .076 cm thick rectangle  
 Total length of cut =  
 50.80 cm + 50.80 cm + 30.48 cm + 30.48 cm = 162.56 cm  
 Shear area = Total length x thickness (.076 cm)  
 or 162.56 cm x .076 cm = 4.877 cm<sup>2</sup>  
 Required force = P = 517,149 torr

$$F = \frac{P \times A}{2,000} = \frac{517,149 \text{ torr} \times 4.877 \text{ cm}^2}{2,000} = 9.6$$

Press tonnage (PT.) = 9.6

Use 3 PT. (.107 cm) thick steel to fabricate steel rule die. Flush or center bevel ground rule provides a clean cut. Facet ground steel rule is used to cut thicker gauge MAKROLOLON Polycarbonate Sheet (above .152 cm).

Be sure platens are parallel and that the backup pad is in good condition. Backup pads can be made from a wide variety of materials such as nylon, HDPE, etc.

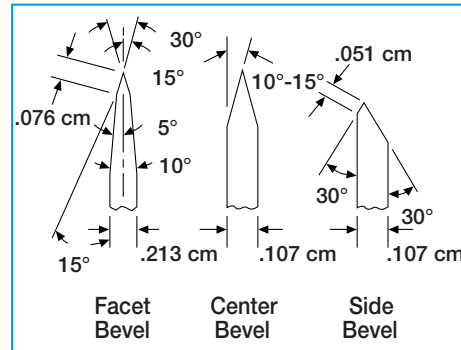


## DRILLING

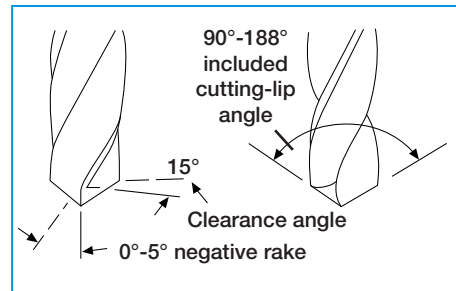
MAKROLOLON Polycarbonate Sheet is easily drilled using ordinary high-speed steel drill bits.

Regulate pressure and speed until a continuous spiraling chip is observed. Use air or water as a coolant if required. Using cutting oils may cause crazing. Be extremely careful if using taps or self-tapping screws; tapping creates notches that can result in stress cracks because polycarbonate is a notch-sensitive material, like most clear plastics. Recommended drill speed is 350-1750 rpm.

### CROSS SECTION - BLADE GRINDS



### DRILL BIT DESIGN



Hole Dia.	Drill Speed (RPM)
.318 cm	1750
.635 cm	1000-1500
1.27 cm	350-500

### Die Cutting Equipment Suppliers:

National Steel Rule Die Co.  
 3580 Lightner Boulevard  
 Vandalia, OH 45377  
 Tel: (937) 667-8407  
 www.zedindustries.com

Atlas Die, Inc.  
 2000 Middlebury Street  
 Elkhart, IN 46516  
 Tel: (574) 295-0050  
 www.atlasdie.com

### Specialty Drill Bit Suppliers:

Craftics, Inc.  
 PO Box 91930  
 Albuquerque, NM 87199  
 Tel: (505) 338-0005  
 www.craftics.com

FTM, Inc.  
 6160 Cobblestone Road  
 Placerville, CA 95667  
 Tel: (530) 626-1986  
 www.thefabricatorssource.com

## BRAKE BENDING

MAKROLON® Polycarbonate Sheet can be brake bent to 90° angles in gauges ≤ 254 cm. Attempts at bending heavier gauges can result in cracks or breakage at the time of bending or later due to high levels of stress in the bend area. For this reason strip heat bending is recommended on all gauges ≥ .300 cm.

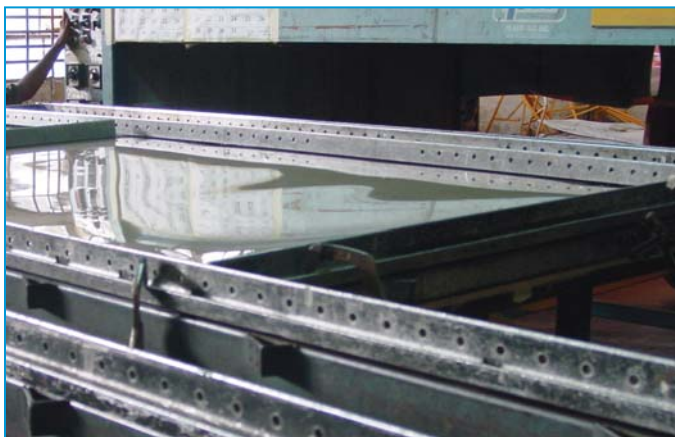
## COLD BENDING

MAKROLON® GP and MAKROLON® SL Polycarbonate Sheets may be cold-bent with the minimum radius based upon the sheet thickness. As a guideline, the material can be radiused to 100 times the thickness: (R=T x100).

## COLD BEND RADII

Sheet Thickness (T)	Minimum Radius (R)
.318 cm	31.75 cm
.476 cm	47.50 cm
.635 cm	63.50 cm

Note: MAKROLON® AR Polycarbonate Sheet is recommended for flat glazing only.



## DRYING TIME (HOURS)

THICKNESS	121°C	82°C
.236 cm	4	8
.300 cm	6	14
.381 cm	8	20
.500 cm	12	30
.600 cm	24	50

Note: MAKROLON® AR Polycarbonate Sheet is recommended for flat glazing only.

## THERMOFORMING

MAKROLON Polycarbonate Sheet can be thermoformed on standard equipment. Vacuum forming, free blown forming, and line bending are the most extensively used processes.

While most standard forming techniques can be used, critical process modifications specific to polycarbonate are necessary to ensure uniform and repeatable formed parts.

## PREDRYING MAKROLON® POLYCARBONATE SHEET

MAKROLON Polycarbonate Sheet must be dried before thermoforming because polycarbonate absorbs moisture at a high rate. Trapped moisture forms vapor above 121°C, and the vapor expansion creates bubbles in the sheet.

Sheets of MAKROLON Polycarbonate sheet should be placed in a dehumidifying air circulating oven for predrying. Temperature should be 121°C and monitored with controls. Recommended predrying time periods are shown below. Be cautious. Polycarbonate sheet begins absorbing moisture immediately upon removal from the predrying oven. The rate of absorption is dependent upon the ambient dew point. For this reason, it is crucial to transfer the sheet directly to the forming machine as quickly as possible.

## FORMING EQUIPMENT

The thermoforming machine should be capable of generating and maintaining a vacuum of 50.8 cm. Hg pressure throughout the thermoforming cycle.

Vacuum forming machines with infrared heating elements perform well for MAKROLON Polycarbonate Sheet forming. Rotary and shuttle designs with automatic or semi-automatic controls are most suitable. Key features of this type for equipment are timer control accuracy, uniform heating sources, and sufficient vacuum power. Single-sided heating has proven effective for MAKROLON Polycarbonate Sheet in gauges up to .500 cm. For thicknesses above .500 cm, it is recommended that dual-sided heating ovens be used for effective radiation penetration.

## HEATERS

Infrared cal rod, coiled nichrome or ceramic heating elements provide the best heating sources. Gas-fired heaters or convection ovens are not normally used with polycarbonate. Uniform heating of the sheet is critical. Radiation absorption graphs for polycarbonate are available. These graphs help match the emissivity of the heating element with the sheet for the most efficient heat penetration.

### HEATING CYCLE

Heating MAKROLON® Polycarbonate Sheet for vacuum forming requires heat penetration to achieve a 177°C to 182°C. The heat required will be higher for more complex shapes. When MAKROLON Polycarbonate Sheet reaches forming temperature, uniform “sag” occurs. The amount of sag depends on the size and thickness of the sheet. A 30.48 cm x 30.48 cm x .152 cm sheet will sag approximately 2.54 cm. A 91.44 cm x 91.44 cm x .50 cm sheet may sag 10.16 cm-15.24 cm at the center. Once uniform temperature has been achieved, timers can accurately reproduce the condition, and part-to-part consistency can be maintained.

### PROCEDURE:

- Sheet thicknesses up to .500 cm gauge can be heated from one side. Above .500 cm gauge, two-sided heating is normally required to significantly enhance productivity.
- Heat source is removed and heated sheet is forced over or into mold where vacuum is applied.

### HELPFUL HINT:

- MAKROLON Polycarbonate Sheet “sets up” very quickly compared to other thermoplastics and can be removed from the mold in a short period of time.

#### Caution:

MAKROLON Polycarbonate Sheet remains quite hot during this cycle and care must be observed when handling finished parts.

- Throughout the vacuum forming process, it is imperative that dust and dirt be controlled. MAKROLON Polycarbonate Sheet has a static charge that attracts foreign particles which can create surface imperfections. Molds also attract dust particles and should be cleaned to avoid creating surface defects.

### SHADING OR SCREENING

Shading is often used to balance out hot spots in an oven for uniform temperature. Shading may also be used to control the sag of MAKROLON Polycarbonate Sheet during heating.

### PROCEDURE:

- Use heavy-duty metal screening to shade the major portion of the clamped sheet, leaving several inches along the edges unshaded to compensate for cooler areas.
- Screens can be installed permanently or placed loosely above the sheet, depending on how much shading is required.

### HELPFUL HINTS:

- Use slow heating. This is particularly important with heavier gauges in order to prevent gradient heating.
- Allow heat to reach uniformity at the center of the sheet.
- The heating rate may be reduced by lowering the heat intensity or by moving the sheet farther away from the heaters.



# Thermoforming Troubleshooting



PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
Bubbles or blisters	Too much moisture in sheet	- Predry sheet for longer time period - Check predry oven temperature
Pinholes or surface marks	Vacuum holes too large	- Use smaller diameter vacuum holes
Mark off	Mold surface too smooth	- Vapor hone or use extra fine emery cloth to lightly abrade mold surface
	Mold surface too rough	- Preheat mold
Sheet pulls out of damping frame during forming	Sheet too cold to form	- Heat sheet for longer time period
Non-uniform sag	Uneven heating	- Check heaters - Screen "hot" areas
Incomplete part formation detail	Sheet too cold	- Heat sheet for longer time period
	Inadequate vacuum	- Check vacuum system for leakage - Increase vacuum
Webbing	Sheet too hot	- Reduce heating cycle
	Improper mold spacing	- Redesign mold
		- Use mechanical assist/bridging



## Thermoforming Machines:

Brown Machine  
Division John Brown Plastics  
330 North Ross Street  
Beaverton, MI 48612  
Tel: (517) 435-7741  
[www.brownmachine.com](http://www.brownmachine.com)

Plasti-Vac, Inc.  
214 Dalton Avenue  
P.O. Box 5543  
Charlotte, NC 28206  
Tel: (800) 438-4139  
[www.pvi-plastivac.com](http://www.pvi-plastivac.com)

Plastic Thermoforming Systems  
The Shuman Company  
3232 South Boulevard  
Charlotte, NC 28209  
Tel: (704) 525-9980  
[www.shuman.biz](http://www.shuman.biz)

## Drying Ovens:

Grieve Corporation  
500 Hart Road  
Round Lake, IL 60073  
Tel: (847) 546-8225  
[www.grievcorp.com](http://www.grievcorp.com)



## MOLDS

In general, male molds are more suitable for vacuum forming. However, other factors such as part size, finish, and shape dictate mold design. Choice of mold materials should be determined by considering the length of the production run. For optimum cost-effectiveness, use the least expensive material that will take the entire run.

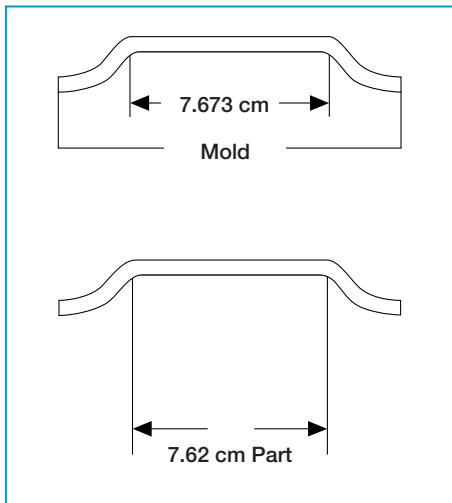
It is evident that thermal transfer is much more efficient with aluminum than wood. Wood, however, can be utilized for short-run projects.

MAKROLON® Polycarbonate Sheet reproduces mold surface finish accurately, even to the point of replicating wood grain in a smooth wood mold.

Sometimes it is desirable to reduce the polish on a steel or aluminum mold by utilizing a vapor hone or bead blast. This is due to the fact that if the mold surface is too smooth, air entrapment can occur creating "mark off." For best results, use fine hand sanding on the surfaces. Sanding provides tiny channels for air evacuation to prevent air entrapment. This may have to be repeated on long production runs, as the sanded finish smoothes out from extended use.

When constructing the mold, mold shrinkage should be a design consideration. Shrinkage for MAKROLON Polycarbonate Sheet is .013 cm-.018 cm. The heating/cooling cycle and the type of vacuum forming equipment will also influence results.

### MOLD SHRINKAGE



## MOLD MATERIALS AND MOLD DESIGN

MAKROLON Polycarbonate Sheet allows the use of a variety of mold materials: wood, filled and unfilled polyesters, epoxies, and metals.

Molds for vacuum forming need to take only 724 torr, so there is little wear on the tooling with low pressure of the material against the mold surface.

## TYPICAL MOLD MATERIALS THERMAL CONDUCTIVITY PROPERTIES

Material	Heat Transfer Rate Factor	K Value btu/hr/sf/ft
Aluminum	6190	130
Steel	1238	26
Aluminum filled epoxy	24-47	.52-.87
Plaster of Paris	8.29	.17
Epoxy	6.24	.13
Wood (maple)	4.48	.09

## MOLD DESIGN

Draft Angles: Minimum 5°-7° or greater for ease of part removal from the mold.

Radii and Fillets: Use generous radii wherever possible for more uniform walls and greater rigidity. On female tooling, use permanent corner fillets.

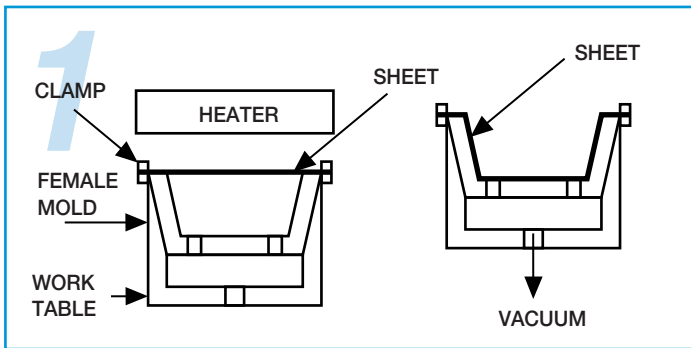
Vacuum Holes: In order to form the sheet as rapidly as possible, use sufficient holes for fast evacuation of air from between the sheet and the mold. In female molds, use air evacuation holes at all deep draw areas, especially around the mold perimeter where the sheet will be drawn last.

## HELPFUL HINTS:

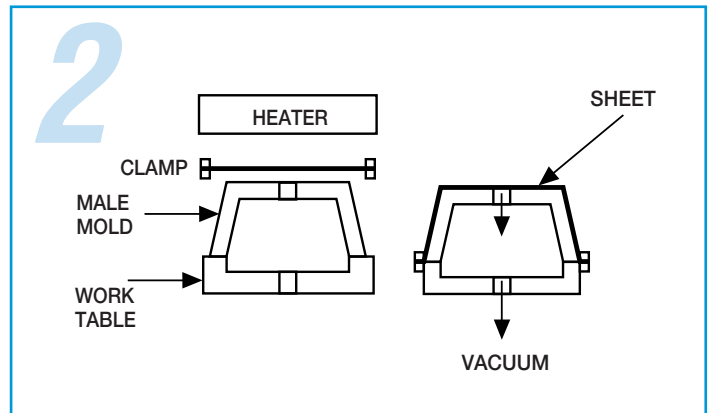
- Keep the diameter of the holes small (approximately .040 cm-.080 cm diameter) to avoid marking on the sheet. Long, thin slots may be designed for air evacuation in female tooling.
- Use vapor honed or fine sanded finishes.
- Avoid sharp corners to minimize stress.
- Avoid highly polished surfaces that can cause mark off.
- Always preheat mold. Cold molds can create surface defects and/or warped parts.
- If mold temperature becomes too high during thermoforming runs, MAKROLON Polycarbonate Sheet could stick to the mold. It is recommended that the mold temperature not exceed 127°C.

## FORMING GUIDELINES

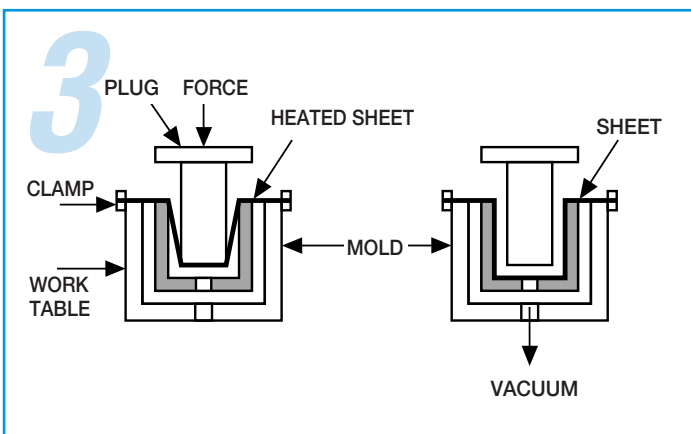
Sheet Temperature:  
 Typical: 171°C-193°C  
 Optimum: 177°C-182°C  
 Mold Temperature: 99°C-127°C



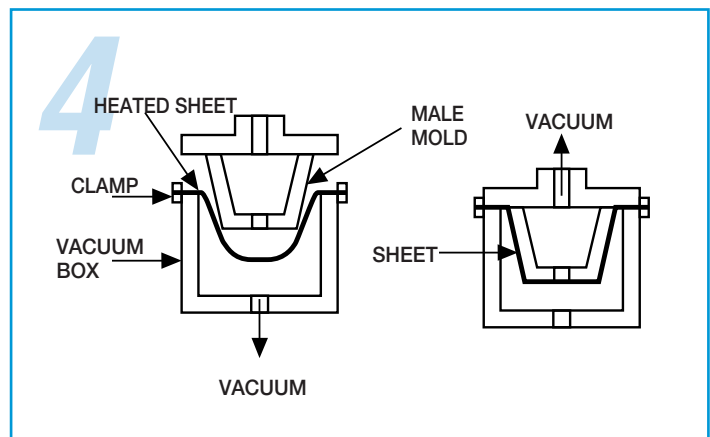
Straight vacuum forming in a female mold is recommended for low-profile parts where deep draw is not a requirement.



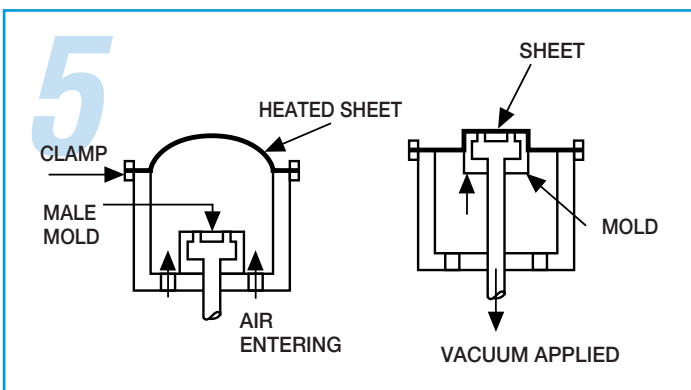
Drape forming over a male mold usually results in better material distribution and depth-to-diameter draw ratios.



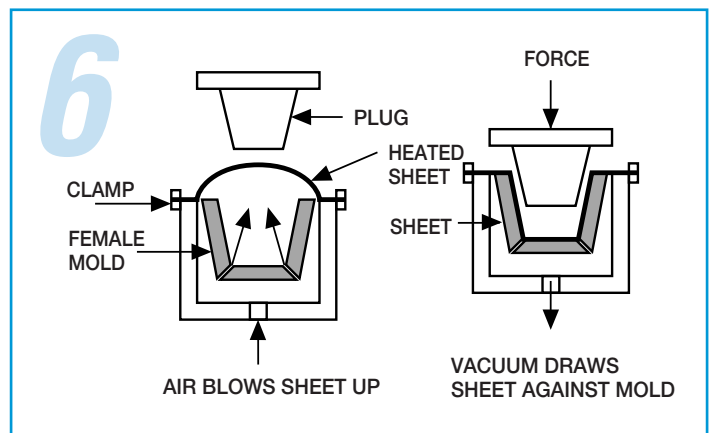
Thinning of material in deep-mold cavities can be overcome by use of plug assists designed for fast penetration.



Vacuum forming with snap-back can reduce starting sheet size, aid material distribution, and minimize chill marks.



Air-slip forming is similar to vacuum snap-back except that heated sheet is billowed up and mold rises to meet it.



Forming with billow plug is often used to produce thin-wall items with depth-to-diameter draw ratios up to 1.5:1.

## FREE BLOWN BILLOW FORMING OF DOME

This process is utilized for forming dome shapes from MAKROLON® Polycarbonate Sheet. The procedures and equipment are the same as vacuum forming with the exception of the mold. Billow forming can be done with positive air pressure (free blown) or negative pressure (vacuum).

### PROCEDURE:

- Preheat all clamps and tooling (116°C-127°C).
- Predry MAKROLON Polycarbonate Sheet in circulating oven at 121°C. (See page 7 for recommended drying times.)
- Place MAKROLON Polycarbonate Sheet in clamping frame of thermoforming machine.
- Heat sheet until uniform sag occurs (171°C-193°C).
- Remove heat source.
- Lower pressure box to seal air supply pressure.
- Apply air pressure. Initial air pressure is high, and as dome is created, air pressure is reduced.
- When overall height is achieved, maintain positive air pressure until part cools.
- Be sure air source is properly filtered and uniformly dispersed for even formation of dome.
- Utilize electric eye designs or microswitches to assure consistent product.
- When dome reaches electric eye, set height. The eye controls air pressure through a solenoid valve to control cooling.
- Remove and trim.

## FREE DRAWN VACUUM DOME FORMING

Follow steps involved in vacuum thermoforming, including predrying.

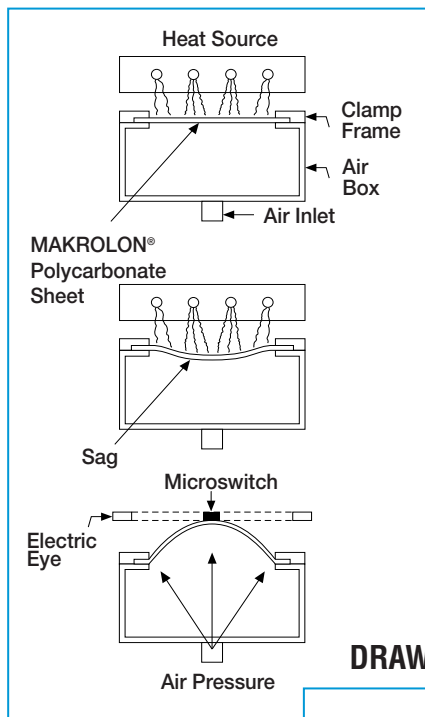
### PROCEDURE:

- Place sheet in clamping frame of thermoforming machine.
- Heat sheet until uniform sag occurs (171°C-193°C).
- Remove heat source.
- Apply vacuum seal box and apply vacuum pressure.
- Use electric eye or microswitch to assure consistency of depth of dome.
- Retain small amount of vacuum pressure until dome sets up.
- Remove and trim.

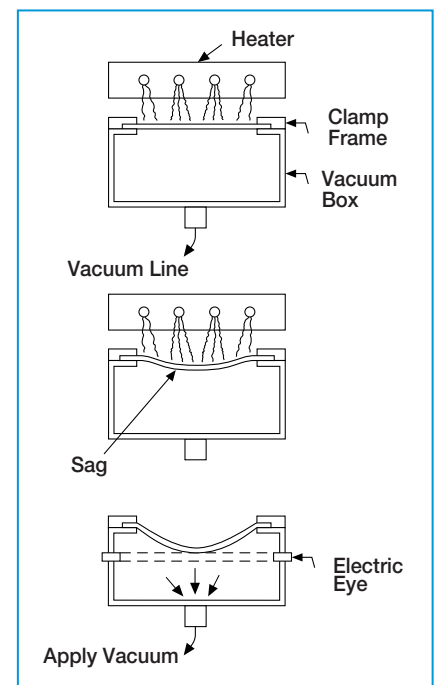
## REGISTRATION FORMING

MAKROLON Polycarbonate Sheet is suitable for registration vacuum forming. Because the material is extruded, it is important to orient the sheet so that each part is screened and formed in the same direction each time. Material should be specially ordered for this application. Dimensional stability tests indicate MAKROLON Polycarbonate Sheet in free form releases stress about 2-4% in the direction of extrusion and 1% across the extrusion web.

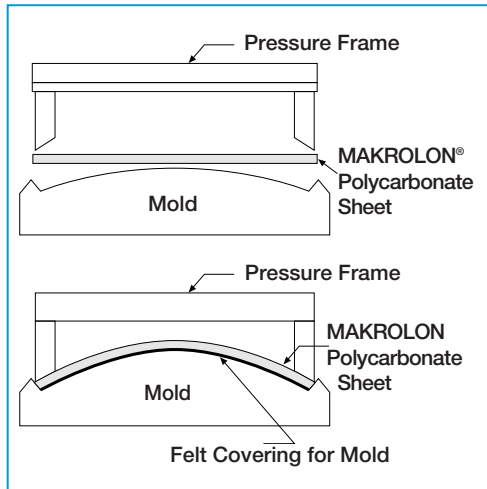
### BLOWN DOME FORMING



### DRAWN DOME FORMING



## DRAPE FORMING



## DRAPE FORMING

Simple contours can be achieved by drape forming MAKROLON® Polycarbonate Sheet. This method can be utilized to manufacture a part requiring a simple radius of curvature. Mold material can be wood, fiberglass or aluminum covered with felt.

### PROCEDURE:

- Predrying MAKROLON Polycarbonate Sheet may not be necessary.
- Bring to forming temperature of about 149°C-160°C in the oven.
- Remove parts and immediately place over a male mold covered with felt.
- Apply pressure until cool.

## STRIP HEATING MAKROLON® POLYCARBONATE SHEET

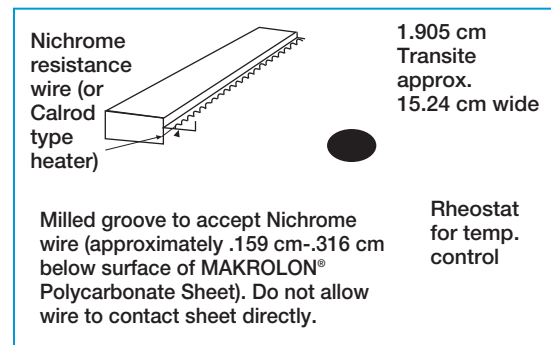
Strip heating or line bending is commonly used for producing localized angular bends in polycarbonate. Generally, predrying is not required for material thicknesses of .300 cm or less.

### PROCEDURE:

- Remove protective masking in bend area.
- Regulate nichrome heat source to 171°C-185°C maximum.
- Place sheet over heat source at bend area.
- Allow heat to soften material—time depends on gauge.
- Remove sheet and make desired bend on wood or heavy fabric-covered aluminum fixture.
- Bend immediately—polycarbonate sets up quickly.
- Allow sheet to cool in fixture.
- Some bends may require a degree of overbending to achieve desired angle after sheet sets up. Strip heating works best for relatively short parts—wide parts may warp.

- Avoid bending short tabs on wide parts; warping may occur.
- For thicker gauge sheet, use two-sided heating. (Repeated turning with one-side heating may also achieve sufficient heat penetration.)
- Thicker gauge sheet (above .316 cm) can be grooved with a .159 cm radius to allow sharper bends.

## HEAT BENDING DEVICE



## STRIP HEATING TROUBLESHOOTING

**PROBLEM:** Bubbles in bent area  
**POSSIBLE CAUSE:** Too much heat  
**SUGGESTED SOLUTION:** Reduce temperature

**PROBLEM:** Warpage  
**POSSIBLE CAUSE:** Part too wide for heat bending  
**SUGGESTED SOLUTION:** Heat from both sides to provide more uniform heat penetration

**PROBLEM:** Heating not uniform  
**SUGGESTED SOLUTION:** Check for air drafts which may affect uniform cooling

**PROBLEM:** Cooling not uniform  
**SUGGESTED SOLUTION:** Do not try to bend short (under 2.54 cm) sections

**PROBLEM:** Mark off  
**POSSIBLE CAUSE:** Heater is contacting plastic. Transite is too hot. Masking is not removed over sufficient area where heat is being applied  
**SUGGESTED SOLUTION:** Lower heat source

### Strip Heaters:

FTM Inc.  
 6160 Cobblestone Road  
 Placerville, CA 95667  
 Tel: (530) 626-1986  
 www.thefabricatorssource.com

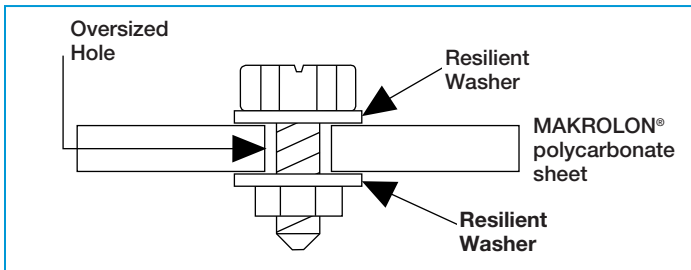
C.R. Clark & Co.  
 1272 Aquila Loop  
 Celebration, FL 34747  
 Tel: (800) 676-7133  
 www.crclark.com

Craftics, Inc.  
 PO Box 91930  
 Albuquerque, NM 87199  
 Tel: (505) 338-0005  
 www.craftics.com

## MECHANICAL FASTENING

Aluminum rivets and machine screws may be used to join MAKROLON® Polycarbonate Sheet to other materials by utilizing proper attachment methods.

Drill oversized holes and use washers to distribute and cushion localized stress. Be sure to consider differentials in expansion factors for dissimilar materials. Be sure drilled holes are smooth and free from cracks.



## SOLVENT BONDING

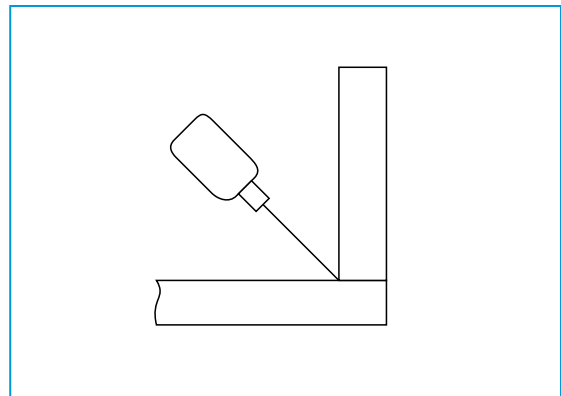
Many applications for MAKROLON Polycarbonate Sheet involve fabrication of sheets to construct three-dimensional shapes. The most popular method is to solvent bond. MAKROLON Polycarbonate Sheet solvent bonding can be achieved using methods employed in fabricating other thermoplastics such as acrylic. The two most common methods are needle type applicator capillary action and edge dipping. Both methods rely on smooth edge preparation, pressure, and curing.

It should be noted that solvent bonding will significantly reduce the strength of polycarbonate.

### PROCEDURE:

- Smaller items with flat surfaces can be bonded by placing the pieces together and applying the solvent along the edges using a needle applicator or hypodermic syringe. Make sure the solvent flows along the entire joint.
- For bonding larger items, immerse the surfaces to be joined in the solvent until the material is softened.
- Clamp them in position and hold until the bond is set.

## NEEDLE APPLICATOR



### HELPFUL HINTS:

- Edges must be clean and free from dirt.
- Surfaces should be smooth and properly aligned.
- Apply even pressure to reduce bubbles in the bond area.

### TECHNIQUES TO REDUCE WHITENING:

1. Fabricate in a climate-controlled area with low relative humidity.
2. The addition of 10% glacial acetic acid in the solvent reduces whitening.
3. Thickening the solvent with polycarbonate resin or sawdust promotes slower curing and reduces whitening.
4. Joint cure time is somewhat longer than acrylic. Be sure to retain fixture pressure until the joint is solid.

Note: Use extreme caution when working with solvents. Adequate ventilation is essential. Control exposure levels according to OSHA guidelines. Obtain Material Safety Data Sheets from the solvent manufacturer.

### Adhesive Suppliers:

Industrial Polychemical  
Weld-On Adhesives  
17109 South Main Street  
Gardena, CA 90247  
Tel: (800) 421-2677  
www.ipscorp.com

Pacer Tech Industrial  
9420 Santa Anita Ave.  
Rancho Cucamonga, CA 91730  
Tel: (800) 538-3091  
www.supergluecorporation.com

Hartel Enterprises  
12970 Branford St., Suite F  
Pacoima, CA 91331  
Tel: (818) 767-0861

Lord Corp.  
2000 West Grandview Blvd.  
Erie, PA 16514  
Tel: (814) 868-3611  
www.lord.com

Dow-Corning Corporation  
3901 South Saginaw  
Midland, MI 48640  
Tel: (989) 496-4000  
www.dowcorning.com

General Electric Company  
260 Hudson River Road  
Waterford, NY 12188  
Tel: (518) 237-3330  
www.gesilicones.com

Ciba Specialty Chemicals Performance Polymers  
4917 Dawn Avenue  
East Lansing, MI 48823  
Tel: (800) 367-8793  
www.loctite.com

## MAKROLON® POLYCARBONATE SHEET ADHESIVE GUIDE

ADHESIVE	JOINS MAKROLON SHEET TO	COMMENTS	COLOR	1-OR 2-PART SYSTEM	APPLICATION METHOD	SETUP TIME	CURE TIME	SUPPLIER
Methylene Chloride	MAKROLON Polycarbonate Sheet Acrylic	- Clear Solvent - High tensile strength products - Low-impact resistance	Clear	One	Flow	20 sec.	48 hrs @ 24°C	Chemical Supply House
Weld-On Series	MAKROLON Polycarbonate Sheet Butyrate	- Various viscosities offering quick bonds	Clear	One	Flow	1 min.	24 hrs.	IPS/Weld-On
Urethane	Virtually Anything	- Clear, flexible high-impact bond - Excellent peel strength - Excellent shear strength	Clear	Two	Flow	8 hrs. @ 24°C	5 hrs. @ 66°C or 7 days @ 24°C	Hartel Enterprises, Inc. Formulated Systems Group
RTV Silicone	Metal/Plastic/Wood	- Excellent heat resistance - Good thermal expansion	Various Colors	One	Tubes, Caulkers	60 min. @ 24°C	24 hrs.	Dow-Corning GE Silicones

### TRANSFER TAPE BONDING

Achieving a strong edge bond using solvents on thin-gauge thermoplastics is extremely difficult due to the reduced size of the bond area. Structural bonding of thin-gauge MAKROLON® Polycarbonate Sheet can be accomplished, however, by utilizing acrylic-based transfer tapes along with slight design modifications.

#### PROCEDURE:

- Bend a small return on the appropriate part to be fastened approximately the width of the transfer tape.
- Clean tape contact areas with 50/50 isopropyl alcohol-water mixture.
- Apply transfer tape to the return.
- Remove tape masking and press the part into place.

#### HELPFUL HINTS:

- Rolling the bonded area with a small wood or rubber roller improves bond strength.
- A nonstick slip sheet is useful for proper positioning of large or hard to handle parts.
- Peel strength of long, lineal bonded areas can be increased with the addition of a mechanical fastener at both ends of the bond.

### WELDING

While mechanical fastening and solvent bonding are the most often recommended methods for joining plastics, another alternative is welding. Ultrasonic, radio frequency, and spin welding have proven to be appropriate. Contact manufacturers of ultrasonic welding equipment for recommendations on section and joint design.

#### Transfer Tape Suppliers:

3M/Industrial Specialties Division  
3M Center, Bldg. 220-7E-01  
St. Paul, MN 55144-1000  
Tel: (800) 227-5085  
[www.3m.com/us/mfg\\_industrial/adhesives/](http://www.3m.com/us/mfg_industrial/adhesives/)

St. Gobain Performance Plastics  
1 Sealant Park  
Granville, NY 12832  
Tel: (518) 642-2200  
[www.nortonfoam.com](http://www.nortonfoam.com)

#### Ultrasonic Welding Equipment:

Branson Ultrasonics Corp.  
41 Eagle Road, Suite 1  
Danbury, CT 06813-1961  
Tel: (203) 796-0400  
[www.bransonultrasonics.com](http://www.bransonultrasonics.com)

## SANDING

MAKROLON® Polycarbonate Sheet can be sanded using both wet and dry techniques. Gumming can result from dry sanding. Wet sanding produces a smooth finish. In both instances, the part will require further finishing in order to restore its high gloss.

MAKROLON Polycarbonate Sheet can also be buffed using a 2-wheel system. The first wheel uses a buffing compound to remove shallow scratches. The second buffing wheel is used for restoring the gloss.

## JOINTING-PLANING

A standard woodworking jointer-planer is an excellent edge finishing machine for MAKROLON Polycarbonate Sheet. Blades must be carbide or high-speed steel. Avoid removal of too much stock on each pass. .040 cm or less stock removal normally yields the cleanest edge. Trying to remove too much material results in a rough edge or cracking of the sheet.

If smoother edges are required, wet sanding with fine grit sandpaper is recommended.

## SOLVENT POLISHING

In order to improve the look of saw-cut edges, begin by sanding the edges smooth. For smoother, glossy edges, consider solvent polishing with MEK or methylene dichloride. To prevent humidity blush after drying, it may be necessary to add a small amount of a slow-drying component such as diacetone alcohol or glacial acetic acid. Since MAKROLON Polycarbonate Sheet has such good chemical resistance properties, keep in mind that solvent polishing cannot be expected to totally eliminate sand marks from the sheet edge.

Note: Use extreme caution when working with solvents. Adequate ventilation is essential. Control exposure levels according to OSHA guidelines. Obtain Material Safety Data Sheets from the solvent manufacturer.



## HOT STAMPING

MAKROLON Polycarbonate Sheet is easily decorated by hot stamping. Normal operating conditions are: head (die) temperatures 191°C; dwell time 2-3 seconds at 3102 torr.

Contact foil manufacturer for recommended application guidelines.



## SCREEN PRINTING

Standard silk screening equipment with screens of varying mesh 8x-16x regulating the amount of ink coverage on MAKROLON Polycarbonate Sheet provides excellent sign product.

As with all thermoplastics, MAKROLON Polycarbonate Sheet must be clean and free from surface residuals prior to screening. Many screeners use a prerinse of 50% water and 50% isopropyl alcohol to clean the surface of MAKROLON Polycarbonate Sheet. Be sure to use soft nonabrasive cloths when cleaning to avoid scratching MAKROLON Polycarbonate Sheet. Ionized air also provides a good method for removing lint and dust.

After screening, separate sheets on a drying rack until ink is completely dry. DO NOT pack sheets for shipment until inks are dry.

UV cure inks can be used with heavy gauge MAKROLON Polycarbonate Sheet, but intense or prolonged UV may have a damaging effect on thin gauges. It is not recommended for MAKROLON Polycarbonate Sheet under .060 gauge as some loss of physical properties occurs.

## PAINTING

Many paint systems are available for MAKROLON® Polycarbonate Sheet. As with screen printing it is important that the surface of the MAKROLON Polycarbonate Sheet be clean and free from surface residuals prior to painting. Many painters use a mixture of 50% water and 50% isopropyl alcohol to clean the surface of the sheet. Be sure to dry thoroughly prior to painting. Use a soft nonabrasive cloth or sponge to avoid scratching MAKROLON Polycarbonate Sheet. Conventional spray, spray masked, roller coat and brush are common application methods.

Avoid using paints containing toluene, xylene or solvents that will craze MAKROLON Polycarbonate Sheet. Be careful when using the paper masking for the design. Sharp knives can notch MAKROLON Polycarbonate Sheet and allow crazing to occur. Be sure not to allow razor knives to penetrate the MAKROLON Polycarbonate Sheet when cutting through masking paper.

A number of companies market paint systems for MAKROLON Polycarbonate Sheet and provide technical advice on application.

## PAINT AND INK REMOVAL

Use caution when removing overspray or drips. Be sure that the solvent will not attack and craze polycarbonate. Isopropyl alcohol, VM&P naphtha or similar solvents have been successfully used. Be sure to rinse with clear water after solvent application. Do not use scrapers, blades, knives, etc., as they will scratch MAKROLON Polycarbonate Sheet. Always test a small area and observe possible attack before subjecting large sheet to solvent.

## NOTES ON MAKROLON® AR POLYCARBONATE SHEET

Coated sides of MAKROLON AR Polycarbonate Sheet cannot be painted because of the abrasion-resistant coating. However, sheet that is only coated on one-side (MAKROLON AR-1 Polycarbonate Sheet) can be reverse screened on the uncoated side using standard painting techniques for polycarbonate. This material is an excellent choice for durable graphics applications in high traffic areas.



### Hot Stamping Foil Suppliers:

Transfer Print Foils, Inc.  
9 Cotters Lane  
East Brunswick, NJ 08816  
Tel: (908) 238-1800  
(800) 235-3645  
hmt.com/holography.TPF

Foilmark  
40 Melville Park Road  
Melville, NY 11747  
Tel: (800) 645-9177  
www.foilmark.com

Crown Roll Leaf, Inc.  
91 Illinois Ave.  
Paterson, NJ 07503  
Tel: (800) 631-3831  
www.crownrolleef.com

### Screen Print Ink Supplier:

NazDar  
1087 N. Northbranch Street  
Chicago, IL 60622  
Tel: (800) 736-7636  
www.nazdar.com

### Paint Suppliers:

Spraylat Corporation  
716 South Columbus Avenue  
Mt. Vernon, NY 10550  
Tel: (914) 699-3030  
(800) 336-1936  
www.spraylat.com

Red Spot Paint & Varnish Co., Inc.  
1107 E. Louisiana Street  
Evansville, IN 47711  
Tel: (800) 457-3544  
www.redspot.com

Mathews Paint Company  
8201 100 Street  
Pleasant Prairie, WI 53158  
Tel: (800) 323-6593  
www.mathewspaint.com



## INSTALLATION GUIDELINES

MAKROLON® Polycarbonate Sheet may be installed using wet or dry glazing systems. However, Sheffield warns against the use of PVC gasketing. The material may also be used for double-glazing or over-glazing applications for added insulation and security. Maintain adequate separation between the glazing panels to prevent touching during high humidity and/or high heat conditions.

## INSTALLATION PROCEDURES

1. Clean sash and prime if necessary. For replacement glazing, make sure all old sealant and projections are removed. Rabbet should be free of burrs and of the proper depth to allow for expansion of the MAKROLON Polycarbonate Sheet glazing panel.
2. Carefully measure the sash opening. Determine the appropriate edge engagement and expansion allowance from Table (on next page). Cut MAKROLON Polycarbonate Sheet to the exact size required, making sure cut edges are smooth and free of chips and notches.
3. Glaze MAKROLON Polycarbonate Sheet with the proper compatible sealant. While smaller lites allow for the use of nonhardening oil-based and acrylic-latex caulks (up to 61 cm x 61 cm), the thermal and load movements in larger sheet sizes require high performance, low modulus elastomers such as silicones.



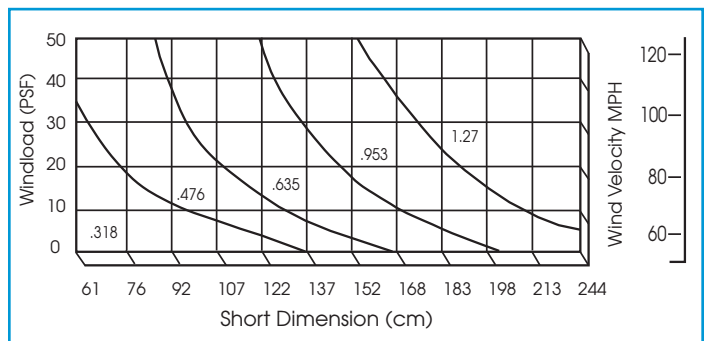
## RECOMMENDED SEALANTS, GASKETS, AND TAPES

Product Type	Product Name	Manufacturer
Silicone	Dow 795 Dow 999 Trademate®	Dow-Corning Corp Midland, MI (517) 496-4000
Silicone	Silpruf® Construction 1200®	General Electric Co. Waterford, NY (800) 255-8886
Silicone	Spectrem	Tremco Columbus, OH (800) 321-7906
Gasket	EPDM (60,70D)	Tremco Columbus, OH (800) 321-6357
Tape	440	Tremco Beechwood, OH (800) 321-7906
Gasket/Tape	Norrene® Foam V-2100 Urethane	Norton Company Granville, NY (518) 642-2200
Butyl Tape	Isocryl 5600	Schnee-Morehead Irving, TX (214) 438-9111

Many other glazing materials are commercially available which are compatible with MAKROLON Polycarbonate Sheet. Please contact those manufacturers for their recommended products.

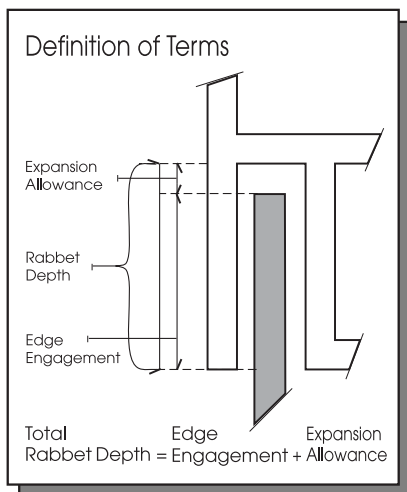
Trademate is a registered trademark of Dow-Corning Corp.  
Silpruf is a registered trademark of General Electric Company  
Norrene is a registered trademark of Norton Company

## WIND LOAD PERFORMANCE



## EXPANSION ALLOWANCES—EDGE ENGAGEMENTS

Sheet Size (cm)	61x61	61x91	91x122	122x152
Expansion Allowance (cm)	.318x.318	.318x.476	.476x.635	.635x.794
Edge Engagement (cm)	.953	1.27	1.429	1.905
Rabbit Depth (cm)	1.27	1.746	2.064	1.699



## EXPANSION ALLOWANCES

As a general guideline, glazing systems should be designed to allow .159 cm per meter of length and width as the expansion in the sash.

## COMPARATIVE EXPANSION RATES

Material	cm/cm °C
Glass	.0000127
MAKROLON® Polycarbonate Sheet	.0000953
Aluminum	.0000328
Steel	.0000160
Acrylic	.0001041

## CLEANING AND MAINTENANCE

Thoroughly rinse with warm water using a soft cloth or sponge. Wash with mild soap or detergent and rinse thoroughly with clean water. To prevent water spots, thoroughly dry the glazing with a chamois or moist sponge. Do not use abrasive cleaners. Avoid cleaning in direct sunlight to prevent streaking.

## COMPATIBLE CLEANERS

The following cleaning agents are compatible with MAKROLON Polycarbonate Sheet products when used according to the manufacturer's recommendations:

- Formula 409®
- Top Job, Joy®
- Palmolive Liquid®
- Windex D with Ammonia D®

Formula 409 is a registered trademark of Clorox Company  
 Top Job and Joy are registered trademarks of Proctor & Gamble  
 Palmolive is a registered trademark of Colgate Palmolive  
 Windex D is a registered trademark of Drackett Products Company



Product Features	MAKROLON® GP	MAKROLON® SN	MAKROLON® AR	MAKROLON® SL (SunLife)	MAKROLON® FI	Privacy Patterns	MAKROLON® CG	MAKROLON® HYGARD®
Superior Impact Strength	★	★	★	★	★	★	★	★
Enhanced UV Resistance			★	★			★	★
Forced Entry Protection (UL 972)	★	N/A	★	★	★	★	★	★
Enhanced Abrasion Resistance			★				★	★
Thermoformable	★	★		★	★	★		
Cold-Formable	★	★		★	★	★		
Patterned Sheet	★	†				★		
Flame Inhibiting					★			
Bullet Resistant (UL 752)								★
Physical Attack Resistant			★				★	★

†MAKROLON® SN Polycarbonate Sheet is available with a matte finish.  
MAKROLON® SL Polycarbonate Sheet is UL 48 Certified

## COMPETITIVE OFF-SETS

MAKROLON® Grade	Description	GE Grade	AtoHaas Grade
MAKROLON® GP	General purpose grade for fabrication and glazing	LEXAN® 9030, 9034 DL 4630, DL 4634	TUFFAK® A
MAKROLON® GP Matte	Matte texture for privacy glazing	N/A	N/A
MAKROLON® GP Pebble	Pebble patterns for privacy glazing	LEXAN 90318 P.A.G.	TUFFAK A P-66
MAKROLON® FD	FDA compliant material	LEXAN 9440	TUFFAK T
MAKROLON® FI	Flame inhibiting grade	LEXAN 9600	N/A
MAKROLON® FI	Flame inhibiting	LEXAN 1200	TUFFAK FI-8
MAKROLON® SL	Thermoformable enhanced UV resistance	LEXAN SG 100	TUFFAK XL
MAKROLON® AR	Abrasion & UV resistance	LEXAN MarGard	TUFFAK CM-2
MAKROLON® CG 375	Physical attack resistant	LEXGARD® MPC 375	N/A
MAKROLON® CG 500	Physical attack resistant	LEXGARD MPC 500	N/A
MAKROLON® CG 750	Physical attack resistant	LEXGARD RC 750	N/A
MAKROLON HYGARD® 750	Bullet resistant	LEXGARD MP 750	N/A
MAKROLON HYGARD® 1000	Bullet/physical attack resistant	LEXGARD MP 1000	N/A
MAKROLON HYGARD® 1250	Bullet/physical attack resistant	LEXGARD SP 1250	N/A
MAKROLON® WG	Window Grade—high impact strength	Westlake Zelux	N/A
MAKROLON® TG	Optically clear, enhanced abrasion & UV resistance	LEXAN FRA460, FRA236	N/A

Lexan and Lexgard are registered trademarks of General Electric Corp.  
Tuffak is a registered trademark of AtoHaas.

## LIGHT AND ENERGY TRANSMITTANCE

By allowing up to 90% of solar energy and 88% of visible light through, clear MAKROLON Polycarbonate Sheet is an excellent glazing material for applications designed to maximize solar gain. In areas of solar intensity where higher shading or privacy is required, tinted materials may be used.

## Light Transmission (Initial)

Gauge	Clear		Bronze or Gray	
	Visible	Solar Energy	Visible	Solar Energy
.238 cm	87%	90%	50%	58%
.318 cm	86%	89%	50%	58%
.476 cm	84%	88%	50%	58%
.635 cm	82%	86%	50%	58%

## TYPICAL MAKROLON® GP POLYCARBONATE SHEET PROPERTIES

Property	MAKROLON	Units	Test Method
<b>General</b>			
Specific gravity	1.2	-	ASTM D-792
Water Absorption 24 hrs.	0.15	%	ASTM D-570
Refractive Index	1.586	-	ASTM D-542
<b>Mechanical</b>			
Tensile Strength, Yield, .318 cm	9,000	torr	ASTM D-638
Tensile Strength, Ultimate	9,500	torr	ASTM D-638
Tensile Modulus	345,000	torr	ASTM D-638
Shear Strength	6,000	torr	ASTM D-732
Compressive Strength	12,500	torr	ASTM D-695
Flexural Strength at 5% Strain	13,500	torr	ASTM D-790
Flexural Modulus .318 cm	345,000	torr	ASTM D-790
Izod Impact Notched .318 cm	12-16	m.kg/cm of notch	ASTM D-256
Rockwell Hardness	118	R Scale	ASTM D-785
Gardner Impact 1.27 cm Diameter Dart .318 cm	>320	cm.kg	ASTM D-5420
Instrumented Impact .318 cm	>45	m.kg	ASTM D-3763
<b>Thermal</b>			
Heat Deflection Temperature 13653 torr	270	°C	ASTM D-648
Heat Deflection Temperature 3517 torr	280	°C	ASTM D-648
Coefficient of Thermal Expansion	3.75 x 10 <sup>-5</sup>	cm/cm/°C	ASTM D-696
Coefficient of Thermal Conductivity	1.35	BTU/hr/m <sup>2</sup> /°C	ASTM D-177
Smoke Density	68	-	ASTM D-2843
Shading Coefficient Clear .318 cm	1.02	-	ASHRAE
Shading Coefficient Gray/Bronze .318 cm	.70	-	ASHRAE
Shading Coefficient Dark Gray .318 cm	.58	-	ASHRAE
Brittle Temperature	-200	°C	ASTM D-746
<b>Flammability</b>			
Horizontal Burn, AEB .318 cm	<1	cm	ASTM D-635
Horizontal Burn, ATB .318 cm	<1	min	ASTM D-635
Self Ignition Temperature	1070	°C	ASTM D-1929
Flash Ignition Temperature	800	°C	ASTM D-1929
UL 94 Clear ≥ .152 cm	V-2	-	UL 94
UL 94 Clear ≥ .635 cm	V-0	-	UL 94
<b>Optical</b>			
Transmittance Clear .318 cm	>88	%	ASTM D-1003
Haze Clear .318 cm	<1	%	ASTM D-1003
<b>Electrical</b>			
Dielectric Constant 10 Hz	2.96	-	ASTM D-150
Dielectric Constant 60 Hz	3.17	-	ASTM D-150
Volume Resistivity	8.2 x 10 <sup>16</sup>	ohm-cm	ASTM D-257
Dissipation Factor 60 Hz	0.0009	-	ASTM D-150
Dissipation Factor 1 MHz	0.010	-	ASTM D-150
<b>Arc Resistance</b>			
Stainless Steel Strip Electrodes	10-11	sec	ASTM D-495
Tungsten Electrodes	120	sec	ASTM D-495

### COMPETITIVE EDGE

Sheffield Plastics sets rigid raw material requirements for its polycarbonate resins supplied by Bayer Corporation. These materials, coupled with state-of-the-art production and quality control technology, assure that the physical properties of MAKROLON Polycarbonate Sheet will meet or exceed any directly competitive product on the market today. When it's "Made with Mak", you really have a competitive edge.

Sheffield Plastics will not be responsible for the use of this information relative to actual application. Users must make their own determination of its suitability for their specific use. No warranty is made for the fitness of any product, and nothing herein waives any of the seller's conditions of sale.

### DOCUMENTATION AND TECHNICAL SUPPORT

Specific product information, warranty details, and further information regarding proper fabrication and/or use of materials can be received by contacting your local MAKROLON Polycarbonate Sheet distributor or by visiting us at [www.sheffieldplastics.com](http://www.sheffieldplastics.com).

### MAKROLON® POLYCARBONATE SHEET COMBUSTIBILITY

Although the least combustible glazing material, Polycarbonate Sheet will ignite when exposed to an ignition source over 427°C.

# Environmental Resistance of **MAKROLON®** Polycarbonate Sheet

## MAKROLON® POLYCARBONATE SHEET IS RESISTANT AT 70°F AND 0% STRAIN TO:

### CHEMICALS:

Amyl Alcohol	Chromic Acid (20%)	Lactic Acid (20%)	Potassium Bromate	Sodium Chloride
Aluminum Chloride	Citric Acid (40%)	Magnesium Chloride	Potassium Bromide	Sodium Hypochlorite
Aluminum Sulfate	Copper Chloride	Magnesium Sulfate	Potassium Nitrate	Sodium Sulfate
Ammonium Chloride	Copper Sulfate	Manganese Sulfate	Potassium Perchlorate	Stannous Chloride
Ammonium Nitrate	Formic Acid (10%)	Mercuric Chloride	Potassium Permanganate	Sulfur
Ammonium Sulfate	Formalin (30%)	Nickel Sulfate	Potassium Persulfate	Sulfuric Acid (10%)*
Antimony Trichloride	Glycerine	Nitric Acid (10%)	Potassium Sulfate	Sulfuric Acid (50%)
Arsenic Acid	Heptane	Nitric Acid (20%)	Silicone Oil	Tartaric Acid (30%)
Butyl Alcohol	Hydrochloric Acid (10%)	Oleic Acid	Silver Nitrate	Zinc Chloride
Calcium Nitrate	Hydrogen Peroxide (30%)	Oxalic acid	Sodium Bicarbonate	Zinc Sulfate
Chlorinated Lime Paste	Hydrofluoric Acid (10%)	Pentane	Sodium Bisulfate	
Chrome Alum	Isopropanol	Phosphoric Acid (10%)	Sodium Carbonate	

\*Sulfuric Acid at 1% attacks polycarbonate sheet

## COMMON HOUSEHOLD MATERIALS **MAKROLON®** POLYCARBONATE IS RESISTANT TO:

### CHEMICALS:

Borax	Joy Liquid Detergent	Rum
Cocoa	Insulating Tape	Salad Oil
Cement	Linseed Oil	Salt Solution (10%)
Chocolate	Liquor	Soap (Soft/Hard)
Cod Liver Oil	Milk	Table Vinegar
Cognac	Mineral Water	Tincture of Iodine (5%)
Coffee	Mustard	Tomato Juice
Detergents	Olive Oil	Vodka
Fish Oil	Onions	Washing Soap
Fruit Syrup	Orange Juice	Water
Grapefruit Juice	Paraffin Oil	Wine
Gypsum	Rapeseed Oil	

## PETROLEUM PRODUCTS **MAKROLON®** POLYCARBONATE SHEET IS RESISTANT TO:

Compressor Oil	Spindle Oil
Diesel Oil	Transformer Oil
Kerosene	Vacuum Pump Oil
Refined Oil	

Note: Elevated temperature and/or strain significantly alters resistance to industrial petroleum products.

## LIMITED RESISTANCE AT 70°F AND 0% STRAIN TO:

Antifreeze	Hydrochloric Acid (conc.)
Calcium Chloride	Milk or Lime (CaOH)
Cyclohexanol	Nitric Acid (conc.)
Ethylene Glycol	Sulfuric Acid (conc.)

## MAKROLON® POLYCARBONATE SHEET IS NOT RESISTANT TO:

### CHEMICALS:

Acetaldehyde	Benzyl Alcohol	Chlorobenzene	Formic Acid (conc.)	Phosphorus Trichloride
Acetic Acid (conc.)	Brake Fluid	Chloroethene	Freon (refrigerant/propellant)	Propionic Acid
Acetone	Bromobenzene	Cutting Oils	Gasoline	Sodium Sulfide
Acrylonitrile	Butylic Acid	Cyclo Hexanone	Lacquer Thinner	Sodium Hydroxide
Ammonia	Carbon Tetrachloride	Cyclohexene	Methyl Alcohol	Sodium Nitrate
Ammonium Fluoride	Carbon Disulfide	Dimethyl Formamide	Nitrobenzene	Tetrahydronaphthalene
Ammonium Hydroxide	Carbolic Acid	Ethane Tetrachloride	Nitrocellulose Lacquer	Thiophene
Ammonium Sulfide	Caustic Potash Sol. (5%)	Ethylamine	Ozone	Toluene
Benzene	Caustic Soda Sol. (5%)	Ethyl Ether	Phenol	Turpentine
Benzoic Acid	Chloride	Ethylene Chlorohydrin	Phosphorus Hydroxy	Xylene

## MAKROLON® POLYCARBONATE SHEET IS DISSOLVED BY:

Chloroform, Cresol, Dioxane, Ethylene Dichloride, Methylene Chloride, Pyridine

## EFFECTS OF MOISTURE ON **MAKROLON®** POLYCARBONATE SHEET:

MAKROLON Polycarbonate Sheet has good resistance to water up to approximately 66°C. Above this temperature, the effect of moisture is time-temperature related. Exposing MAKROLON

Polycarbonate Sheet to repeated steam cleaning or dishwashing can create hydraulic crazing. The result can be a clouding of the surface and ultimately a loss of physical strength properties.

# “Made with MAK”, None Tougher, None Clearer MAKROLON® Polycarbonate Sheet...

## BROAD RANGE OF PRODUCTS FOR THE MOST DEMANDING APPLICATIONS

From lofty barrel vault skylights exposed to extreme sunlight to street level signs that require resistance to graffiti and vandalism...from precision machined parts to the simple toughness of domed playground windows, there is a MAKROLON® Polycarbonate Sheet product that's right for your application.

### MAKROLON® GP Polycarbonate Sheet

is UV-stabilized and incorporates both economy and high performance in every sheet. One attribute that sets it apart from the competition is the UL 94 VO rating on gauges .559 cm and greater, making it cost effective in a wide range of industrial and design applications.

### MAKROLON® SL Polycarbonate Sheet

is enhanced, UV resistance polycarbonate sheet that offers exceptional weatherability. Superior impact strength and formability makes this product an ideal choice for exterior factory/plant glazing; guards used in outdoor equipment; or other applications requiring increased weatherability and UV resistance.

### MAKROLON® AR Polycarbonate Sheet

offers UV resistance, glass-like surface hardness, high impact strength, and excellent chemical resistance, making it an outstanding choice for flat, noncurved machine guards.

### MAKROLON HYGARD® LAMINATES

offer unsurpassed protection from ballistic and physical attack in bullet resistant and containment glazing applications.



For detailed product or limited warranty information on any Sheffield Plastics sheet product please call: **800/254-1707**, or visit our web site at [www.sheffieldplastics.com](http://www.sheffieldplastics.com).

**MAKROLON®**  
**Polycarbonate Sheet is:**  
**“Clearly the Right Choice”**  
**for Any Application**

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