Fabrication Guide

Makrolon® polycarbonate sheet
## Contents

### Fabricating
- Sawing ........................................... 4
- Routing ......................................... 5
- Shearing ........................................ 5
- Laser Cutting ................................... 5
- Die Cutting ...................................... 6
- Drilling .......................................... 6

### Forming
- Brake Bending ................................. 7
- Cold Bending ................................. 7
- Thermoforming ............................... 7
- Predrying ....................................... 7
- Forming Equipment ........................... 7
- Heaters ......................................... 7
- Heating Cycle ................................. 8
- Shading or Screening ....................... 8
- Troubleshooting ............................... 9
- Molds ........................................... 10
- Mold Design .................................... 10
- Free Blown Billow Forming of Dome .... 12
- Free Drawn Vacuum Dome Forming ...... 12
- Registration Forming ...................... 12
- Drape Forming ................................. 13
- Strip Heating .................................. 13

### Bonding/Fastening
- Mechanical Fastening ...................... 14
- Solvent Bonding ............................... 14
- Transfer Tape Bonding ..................... 15
- Welding ......................................... 15

### Finishing
- Sanding .......................................... 16
- Jointing-Planing .............................. 16
- Solvent Polishing ............................ 16
- Hot Stamping .................................. 16
- Screen Printing ............................... 16
- Painting ......................................... 17
- Paint and Ink .................................. 17

### Glazing Information
- Installation Guidelines and Procedures 18
- Cleaning and Maintenance .................. 19

### Product Selector
- Product Features .............................. 20
- Competitive Offsets .......................... 20
- Warranties ..................................... 21

### Technical Information
- Physical Properties ......................... 22
- Environmental Resistance .................. 23
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 6000-8000 ft/min. Blades for cutting 3/32” and thicker material should have 3-5 teeth per inch. 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.

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
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 1/4” to 1/2” 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.

BAND SAW BLADE DESIGN

1-8 teeth per inch

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

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 .001” 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 Makrolon® Polycarbonate Sheet in gauges up to .080” thick is normally achieved utilizing the following steps.

Steel rule dies mounted in a press provide good results. The shear strength of Makrolon Polycarbonate Sheet is 10,000 psi which is appropriate for die cutting methods.

Calculating the required press tonnage to cut Makrolon Polycarbonate Sheet:

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

- \(F\) = Required force in tonnage of the press
- \(P\) = 10,000 psi (shear strength of Makrolon Polycarbonate Sheet)
- \(A\) = The sectional area to be cut

Example: Die cut 12” x 20” x .030” thick rectangle

Total length of cut = 20” + 20” + 12” + 12” = 64”

Shear area = Total length x thickness (.030”)

or 64” x .030” = 1.92 in²

Required force = \(P = 10,000 \text{ psi}\)

\[
F = \frac{P \times A}{2,000} = \frac{10,000 \text{ psi} \times 1.92 \text{ in²}}{2,000 \text{ lbs.}} = 9.6
\]

Press tonnage (PT.) = 9.6

Use 3 PT. (.042”) 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 Makrolon Polycarbonate Sheet (above .060”).

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.

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**DRILLING**

Makrolon 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.

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**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
Forming

**BRAKE BENDING**
Makrolon® Polycarbonate Sheet can be brake bent to 90° angles in gauges ≤ .100”. 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 ≥ .118”.

**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 x 100).

**COLD BEND RADII**

<table>
<thead>
<tr>
<th>Sheet Thickness (T)</th>
<th>Minimum Radius (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8”</td>
<td>12.5”</td>
</tr>
<tr>
<td>3/16”</td>
<td>18.7”</td>
</tr>
<tr>
<td>1/4”</td>
<td>25.0”</td>
</tr>
</tbody>
</table>

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 250°F, 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 250°F 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 20 in. 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 .177”. For thicknesses above .177”, 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 350°F to 360°F. 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 12” x 12” x .060” sheet will sag approximately 1”. A 36” x 36” x .177” sheet may sag 4”-6” 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 .177” gauge can be heated from one side. Above .177” 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

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

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### Thermoforming Machines:

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

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

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

### Drying Ovens:

- **Grieve Corporation**
  - Address: 500 Hart Road, Round Lake, IL 60073
  - Tel: (847) 546-8225
  - Website: [www.grieve.corp.com](http://www.grieve.corp.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 smooths out from extended use.

When constructing the mold, mold shrinkage should be a design consideration. Shrinkage for Makrolon Polycarbonate Sheet is .005”-.007”. The heating/cooling cycle and the type of vacuum forming equipment will also influence results.

MOLD SHRINKAGE

<table>
<thead>
<tr>
<th>Material</th>
<th>Heat Transfer Rate Factor</th>
<th>K Value btu/hr/ft²/°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>6190</td>
<td>130</td>
</tr>
<tr>
<td>Steel</td>
<td>1238</td>
<td>26</td>
</tr>
<tr>
<td>Aluminum filled epoxy</td>
<td>24-47</td>
<td>.52-.87</td>
</tr>
<tr>
<td>Plaster of Paris</td>
<td>8.29</td>
<td>.17</td>
</tr>
<tr>
<td>Epoxy</td>
<td>6.24</td>
<td>.13</td>
</tr>
<tr>
<td>Wood (maple)</td>
<td>4.48</td>
<td>.09</td>
</tr>
</tbody>
</table>

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 1/64”-1/32” 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 thermo-forming runs, Makrolon Polycarbonate Sheet could stick to the mold. It is recommended that the mold temperature not exceed 260°F.

FORMING GUIDELINES

<table>
<thead>
<tr>
<th>Sheet Temperature:</th>
<th>Typical: 340°F-380°F</th>
<th>Optimum: 350°F-360°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mold Temperature:</td>
<td>210°F-260°F</td>
<td></td>
</tr>
</tbody>
</table>
1. Thinning of material in deep-mold cavities can be overcome by use of plug assists designed for fast penetration.

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

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

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

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

6. 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 (240°F-260°F).
- Predry Makrolon Polycarbonate Sheet in air circulating oven at 250°F. (See page 7 for recommended drying times.)
- Place Makrolon Polycarbonate Sheet in clamping frame of thermoforming machine.
- Heat sheet until uniform sag occurs (340°F-380°F).
- 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 (340°F-380°F).
- 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**

- Heat Source
- Clamp Frame
- Air Box
- Air Inlet
- Makrolon® Polycarbonate Sheet
- Sag
- Microswitch
- Electric Eye
- Air Pressure

**DRAWN DOME FORMING**

- Heater
- Clamp Frame
- Vacuum Box
- Vacuum Line
- Sag
- Electric Eye
- Apply Vacuum
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:
- 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 1/8") can be grooved with a 1/16" radius to allow sharper bends.

Strip heating or line bending is commonly used for producing localized angular bends in polycarbonate. Generally, predrying is not required for material thicknesses of .118” or less.

PROCEDURE:
- Predrying Makrolon Polycarbonate Sheet may not be necessary.
- Bring to forming temperature of about 300°F-320°F in the oven.
- Remove parts and immediately place over a male mold covered with felt.
- Apply pressure until cool.

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 1") 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

HEAT BENDING DEVICE

Nichrome resistance wire (or Calrod type heater)

3/4” Transite approx. 6” wide

Milled groove to accept Nichrome wire (approximately 1/16"-1/8” below surface of Makrolon® Polycarbonate Sheet). Do not allow wire to contact sheet directly.

Rheostat for temp. control

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.crlclark.com

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

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.
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.
Finishing

**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. 1/64” 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 375°F; dwell time 2-3 seconds at 60 psi.

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 naptha 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.
INSTALLATION GUIDELINES

Makrolon® Polycarbonate Sheet may be installed using wet or dry glazing systems. However, Bayer MaterialScience 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 24'' x 24''), the thermal and load movements in larger sheet sizes require high performance, low modulus elastomers such as silicones.

RECOMMENDED SEALANTS, GASKETS, AND TAPES

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

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
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®

Expansion Allowances

As a general guideline, glazing systems should be designed to allow 1/16” per foot of length and width as the expansion in the sash.

### EXPANSION ALLOWANCES–EDGE ENGAGEMENTS

<table>
<thead>
<tr>
<th>Sheet Size</th>
<th>24”x24”</th>
<th>24”x36”</th>
<th>36”x48”</th>
<th>48”x60”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansion Allowance</td>
<td>1/8”x1/8”</td>
<td>1/8”x3/16”</td>
<td>3/16”x1/4”</td>
<td>1/4”x5/16”</td>
</tr>
<tr>
<td>Edge Engagement</td>
<td>3/8”</td>
<td>1/2”</td>
<td>9/16”</td>
<td>3/4”</td>
</tr>
<tr>
<td>Rabbet Depth</td>
<td>1/2”</td>
<td>11/16”</td>
<td>13/16”</td>
<td>1-1/16”</td>
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</tbody>
</table>

### COMPARATIVE EXPANSION RATES

<table>
<thead>
<tr>
<th>Material</th>
<th>in/in °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>.000050</td>
</tr>
<tr>
<td>Makrolon® Polycarbonate Sheet</td>
<td>.0000375</td>
</tr>
<tr>
<td>Aluminum</td>
<td>.0000129</td>
</tr>
<tr>
<td>Steel</td>
<td>.000063</td>
</tr>
<tr>
<td>Acrylic</td>
<td>.0000410</td>
</tr>
</tbody>
</table>

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
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 AND ENERGY TRANSMITTANCE

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Visible</th>
<th>Solar Energy</th>
<th>Visible</th>
<th>Solar Energy</th>
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<tbody>
<tr>
<td>3/32&quot;</td>
<td>87%</td>
<td>90%</td>
<td>50%</td>
<td>58%</td>
</tr>
<tr>
<td>1/8&quot;</td>
<td>86%</td>
<td>89%</td>
<td>50%</td>
<td>58%</td>
</tr>
<tr>
<td>3/16&quot;</td>
<td>84%</td>
<td>88%</td>
<td>50%</td>
<td>58%</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>82%</td>
<td>86%</td>
<td>50%</td>
<td>58%</td>
</tr>
</tbody>
</table>
## Technical information

### TYPICAL Makrolon® GP POLYCARBONATE SHEET PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Makrolon</th>
<th>Units</th>
<th>Test Method</th>
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</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.2</td>
<td></td>
<td>ASTM D-792</td>
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<tr>
<td>Water Absorption 24 hrs.</td>
<td>0.15</td>
<td>%</td>
<td>ASTM D-570</td>
</tr>
<tr>
<td>Refractive Index</td>
<td>1.586</td>
<td></td>
<td>ASTM D-542</td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength, Yield, .125˝</td>
<td>9,000</td>
<td>psi</td>
<td>ASTM D-638</td>
</tr>
<tr>
<td>Tensile Strength, Ultimate</td>
<td>9,500</td>
<td>psi</td>
<td>ASTM D-638</td>
</tr>
<tr>
<td>Tensile Modulus</td>
<td>345,000</td>
<td>psi</td>
<td>ASTM D-638</td>
</tr>
<tr>
<td>Shear Strength</td>
<td>6,000</td>
<td>psi</td>
<td>ASTM D-732</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>12,500</td>
<td>psi</td>
<td>ASTM D-695</td>
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<tr>
<td>Flexural Strength at 5% Strain</td>
<td>13,500</td>
<td>psi</td>
<td>ASTM D-790</td>
</tr>
<tr>
<td>Flexural Modulus .125˝</td>
<td>345,000</td>
<td>psi</td>
<td>ASTM D-790</td>
</tr>
<tr>
<td>Izod Impact Notched .125˝</td>
<td>12-16</td>
<td>ft.lb/in of notch</td>
<td>ASTM D-256</td>
</tr>
<tr>
<td>Rockwell Hardness</td>
<td>118</td>
<td>R Scale</td>
<td>ASTM D-785</td>
</tr>
<tr>
<td>Gardner Impact 1/2” Diameter Dart .125˝</td>
<td>&gt;320</td>
<td>in.lbs</td>
<td>ASTM D-5420</td>
</tr>
<tr>
<td>Instrumented Impact .125˝</td>
<td>&gt;45</td>
<td>ft.lbs</td>
<td>ASTM D-3763</td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat Deflection Temperature 264 psi</td>
<td>270</td>
<td>°F</td>
<td>ASTM D-648</td>
</tr>
<tr>
<td>Heat Deflection Temperature 68 psi</td>
<td>280</td>
<td>°F</td>
<td>ASTM D-648</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion 3.75 x 10⁻⁶</td>
<td>in/in/°F</td>
<td></td>
<td>ASTM D-696</td>
</tr>
<tr>
<td>Coefficient of Thermal Conductivity</td>
<td>1.35</td>
<td>BTU/hr/ft²/°F</td>
<td>ASTM D-177</td>
</tr>
<tr>
<td>Smoke Density</td>
<td>68</td>
<td></td>
<td>ASTM D-2843</td>
</tr>
<tr>
<td>Shading Coefficient Clear .125˝</td>
<td>1.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shading Coefficient Gray/Bronze .125˝</td>
<td>.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shading Coefficient Dark Gray .125˝</td>
<td>.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brittleness Temperature</td>
<td>-200</td>
<td>°F</td>
<td>ASTM D-746</td>
</tr>
<tr>
<td><strong>Flammability</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal Burn, AEB .125˝</td>
<td>&lt;1</td>
<td>in</td>
<td>ASTM D-635</td>
</tr>
<tr>
<td>Horizontal Burn, ATB .125˝</td>
<td>&lt;1</td>
<td>min</td>
<td>ASTM D-635</td>
</tr>
<tr>
<td>Self Ignition Temperature</td>
<td>1070</td>
<td>°F</td>
<td>ASTM D-1929</td>
</tr>
<tr>
<td>Flash Ignition Temperature</td>
<td>800</td>
<td>°F</td>
<td>ASTM D-1929</td>
</tr>
<tr>
<td>UL 94 Clear ≥ .060”</td>
<td>V-2</td>
<td>-</td>
<td>UL 94</td>
</tr>
<tr>
<td>UL 94 Clear ≥ .250”</td>
<td>V-0</td>
<td>-</td>
<td>UL 94</td>
</tr>
<tr>
<td><strong>Optical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmittance Clear .125˝</td>
<td>&gt;88</td>
<td>%</td>
<td>ASTM D-1003</td>
</tr>
<tr>
<td>Haze Clear .125˝</td>
<td>&lt;1</td>
<td>%</td>
<td>ASTM D-1003</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dielectric Constant 10 Hz</td>
<td>2.96</td>
<td>-</td>
<td>ASTM D-150</td>
</tr>
<tr>
<td>Dielectric Constant 60 Hz</td>
<td>3.17</td>
<td>-</td>
<td>ASTM D-150</td>
</tr>
<tr>
<td>Volume Resistivity 8.2 x 10¹⁶</td>
<td>ohm-cm</td>
<td></td>
<td>ASTM D-257</td>
</tr>
<tr>
<td>Dissipation Factor 60 Hz</td>
<td>0.0009</td>
<td>-</td>
<td>ASTM D-150</td>
</tr>
<tr>
<td>Dissipation Factor 1 MHz</td>
<td>0.010</td>
<td>-</td>
<td>ASTM D-150</td>
</tr>
<tr>
<td>Arc Resistance Stainless Steel Strip Electrodes</td>
<td>10-11</td>
<td>sec</td>
<td>ASTM D-495</td>
</tr>
<tr>
<td>Tungsten Electrodes</td>
<td>120</td>
<td>sec</td>
<td>ASTM D-495</td>
</tr>
</tbody>
</table>

**COMPETITIVE EDGE**

Bayer MaterialScience 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.

Bayer MaterialScience 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.materialscience.bayer.com.

**Makrolon® POLYCARBONATE SHEET COMBUSTIBILITY**

Although the least combustible glazing material, Polycarbonate Sheet will ignite when exposed to an ignition source over 800°F.
Environmental resistance of Makrotron® polycarbonate sheet

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

<table>
<thead>
<tr>
<th>CHEMICALS:</th>
<th>Makrotron® POLYCARBONATE SHEET IS RESISTANT TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amyl Alcohol</td>
<td>Chromic Acid (20%)</td>
</tr>
<tr>
<td>Aluminum Chloride</td>
<td>Citric Acid (40%)</td>
</tr>
<tr>
<td>Aluminum Sulfate</td>
<td>Copper Chloride</td>
</tr>
<tr>
<td>Ammonium Chloride</td>
<td>Copper Sulfate</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>Formic Acid (10%)</td>
</tr>
<tr>
<td>Ammonium Sulfate</td>
<td>Formalin (30%)</td>
</tr>
<tr>
<td>Antimony Trichloride</td>
<td>Glycerine</td>
</tr>
<tr>
<td>Arsenic Acid</td>
<td>Heptane</td>
</tr>
<tr>
<td>Butyl Alcohol</td>
<td>Hydrochloric Acid (10%)</td>
</tr>
<tr>
<td>Calcium Nitrate</td>
<td>Hydrogen Peroxide (30%)</td>
</tr>
<tr>
<td>Chlorinated Lime Paste</td>
<td>Hydrofluoric Acid (10%)</td>
</tr>
<tr>
<td>Chrome Alum</td>
<td>Isopropanol</td>
</tr>
<tr>
<td>Lactic Acid (20%)</td>
<td>Magnesium Chloride</td>
</tr>
<tr>
<td>Magnesium Chloride</td>
<td>Magnesium Sulfate</td>
</tr>
<tr>
<td>Manganese Sulfate</td>
<td>Mercuric Chloride</td>
</tr>
<tr>
<td>Nickel Sulfate</td>
<td>Nitric Acid (10%)</td>
</tr>
<tr>
<td>Nitric Acid (20%)</td>
<td>Nitric Acid (20%)</td>
</tr>
<tr>
<td>Oleic Acid</td>
<td>Oxalic acid</td>
</tr>
<tr>
<td>Pentane</td>
<td>Phosphoric Acid (10%)</td>
</tr>
<tr>
<td>Potassium Bromate</td>
<td>Sodium Chloride</td>
</tr>
<tr>
<td>Potassium Bromide</td>
<td>Sodium Hypochlorite</td>
</tr>
<tr>
<td>Potassium Nitrate</td>
<td>Sodium Sulfate</td>
</tr>
<tr>
<td>Potassium Perchlorate</td>
<td>Stannous Chloride</td>
</tr>
<tr>
<td>Potassium Persulfate</td>
<td>Sulfur</td>
</tr>
<tr>
<td>Sulfuric Acid (10)*</td>
<td>Sulfuric Acid (50%)</td>
</tr>
<tr>
<td>Sodium Nitrate</td>
<td>Sodium Bicarbonate</td>
</tr>
<tr>
<td>Sodium Bisulfate</td>
<td>Sodium Carbonate</td>
</tr>
<tr>
<td>Sodium Sulfate</td>
<td></td>
</tr>
</tbody>
</table>

* Sulfuric Acid at 1% attacks polycarbonate sheet

COMMON HOUSEHOLD MATERIALS Makrotron® POLYCARBONATE IS RESISTANT TO:

<table>
<thead>
<tr>
<th>CHEMICALS:</th>
<th>Makrotron® POLYCARBONATE IS RESISTANT TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borax</td>
<td>Joy Liquid Detergent</td>
</tr>
<tr>
<td>Cocoa</td>
<td>Insulating Tape</td>
</tr>
<tr>
<td>Cement</td>
<td>Linseed Oil</td>
</tr>
<tr>
<td>Chocolate</td>
<td>Liquor</td>
</tr>
<tr>
<td>Cod Liver Oil</td>
<td>Milk</td>
</tr>
<tr>
<td>Cognac</td>
<td>Mineral Water</td>
</tr>
<tr>
<td>Coffee</td>
<td>Mustard</td>
</tr>
<tr>
<td>Detergents</td>
<td>Olive Oil</td>
</tr>
<tr>
<td>Fish Oil</td>
<td>Onions</td>
</tr>
<tr>
<td>Fruit Syrup</td>
<td>Orange Juice</td>
</tr>
<tr>
<td>Grapefruit Juice</td>
<td>Paraffin Oil</td>
</tr>
<tr>
<td>Gypsum</td>
<td>Rapseed Oil</td>
</tr>
<tr>
<td>Rum</td>
<td>Salad Oil</td>
</tr>
<tr>
<td>Salt Solution (10%)</td>
<td>Table Vinegar</td>
</tr>
<tr>
<td>Soap (Soft/Hard)</td>
<td>Tomato Juice</td>
</tr>
<tr>
<td>Tincture of Iodine (5%)</td>
<td>Water</td>
</tr>
<tr>
<td>Vinegar</td>
<td>Washing Soap</td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Vodka</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
</tr>
<tr>
<td>Antifreeze</td>
<td>Hydrochloric Acid (conc.)</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>Milk or Lime (CaOH)</td>
</tr>
<tr>
<td>Cyclohexanol</td>
<td>Nitric Acid (conc.)</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>Sulfuric Acid (conc.)</td>
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Makrotron® POLYCARBONATE SHEET IS NOT RESISTANT TO:

<table>
<thead>
<tr>
<th>CHEMICALS:</th>
<th>Makrotron® POLYCARBONATE SHEET IS NOT RESISTANT TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>Benzyl Alcohol</td>
</tr>
<tr>
<td>Acetic Acid (conc.,)</td>
<td>Brake Fluid</td>
</tr>
<tr>
<td>Acetone</td>
<td>Bromobenzene</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>Butylic Acid</td>
</tr>
<tr>
<td>Ammonium Fluoride</td>
<td>Carbon Tetrachloride</td>
</tr>
<tr>
<td>Ammonium Hydroxide</td>
<td>Carbon Disulfide</td>
</tr>
<tr>
<td>Ammonium Sulfide</td>
<td>Caustic Potash Sol. (5%)</td>
</tr>
<tr>
<td>Benzene</td>
<td>Caustic Soda Sol. (5%)</td>
</tr>
<tr>
<td>Benzoic Acid</td>
<td>Chloride</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>Formic Acid (conc.)</td>
</tr>
<tr>
<td>Chlorothene</td>
<td>Freon (refrigerant/polyellant)</td>
</tr>
<tr>
<td>Cutting Oils</td>
<td>Gasoline</td>
</tr>
<tr>
<td>Cyclo Hexanone</td>
<td>Lacquer Thinner</td>
</tr>
<tr>
<td>Cyclohexene</td>
<td>Methyl Alcohol</td>
</tr>
<tr>
<td>Dimethyl Formamide</td>
<td>Nitrobenzene</td>
</tr>
<tr>
<td>Ethane Tetrachloride</td>
<td>Nitrocellulose Lacquer</td>
</tr>
<tr>
<td>Ethylamine</td>
<td>Ozone</td>
</tr>
<tr>
<td>Ethyl Ether</td>
<td>Phenol</td>
</tr>
<tr>
<td>Ethylene Chlorohydrin</td>
<td>Phosphorus Hydroxy</td>
</tr>
<tr>
<td>Phosphorus Trichloride</td>
<td>Proplonic Acid</td>
</tr>
<tr>
<td>Proplonic Acid</td>
<td></td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td></td>
</tr>
<tr>
<td>Sodium Sulfate</td>
<td></td>
</tr>
<tr>
<td>Sodium Sulfide</td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td></td>
</tr>
<tr>
<td>Sodium Nitrate</td>
<td></td>
</tr>
<tr>
<td>Tetrahydroxalane</td>
<td></td>
</tr>
<tr>
<td>Thiophene</td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td></td>
</tr>
<tr>
<td>Turpentine</td>
<td></td>
</tr>
<tr>
<td>Xylene</td>
<td></td>
</tr>
</tbody>
</table>

Makrotron® POLYCARBONATE SHEET IS DISSOLVED BY:

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

EFFECTS OF MOISTURE ON Makrotron® POLYCARBONATE SHEET:

Makrotron Polycarbonate Sheet has good resistance to water up to approximately 150°F. Above this temperature, the effect of moisture is time-temperature related. Exposing Makrotron 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.
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 .220” 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.

**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 Bayer MaterialScience sheet product please call: 800/254-1707, or visit our web site at www.materialscience.bayer.com.
The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations are beyond our control. Therefore, it is imperative that you test our products, technical assistance and information to determine to your own satisfaction whether our products, technical assistance and information are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by us. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale which are available upon request. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information. Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with any claim of any patent relative to any material or its use. No license is implied or in fact granted under the claims of any patent.

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