

ACRYLIC SHEET

Fabrication Manual

Plexiglas®

ALTUGLAS
INTERNATIONAL
ARKEMA GROUP

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INTRODUCTION

General Health and Safety Precautions

Care must be taken whenever fabricating or thermoforming any thermoplastic, including Plexiglas® acrylic sheet. The heat of thermoforming, cutting, machining, finishing, annealing, or otherwise processing Plexiglas® acrylic sheet may result in the release of vapors or gases, including methyl methacrylate (MMA) monomer. Additionally, cementing Plexiglas® acrylic sheet introduces other vapors related to the formulation of the adhesives. However, thermoforming Plexiglas® acrylic sheet, in accordance with recommended techniques at recommended temperatures and with adequate ventilation, should not result in harmful concentrations of vapors or gases in the workplace.

Concentration Levels and Ventilation Standards

High concentrations of MMA vapors can cause eye and respiratory irritation, headache and nausea. The American Conference of Governmental Industrial Hygienists (ACGIH) Air Contaminant Standard for MMA places the maximum permissible exposure level at a time weighted average (TWA) of 50 ppm.

It is always good practice to provide local exhaust ventilation as close to the point of possible generation of vapors as practical. Suggestions for the design of exhaust ventilation systems are provided in *Industrial Ventilation Manual of Recommended Practice (2004)*, published by the ACGIH, and American National Standards Institute *Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI/AHAZ9.2-2001*.

Special Precautions

Each of the segments in this manual contains a section on any special hazards or precautions related to the process and materials under discussion. Fabricators and other users of Plexiglas® acrylic sheet are advised to read all of these Health and Safety Precautions sections carefully, to become thoroughly familiar with the properties of these materials, and to take all actions recommended for the safe use and processing of the products. Material Safety Data Sheets should be available from the manufacturer for these purposes.

General Fabrication Considerations

Most fabrication and forming techniques for Plexiglas® MC acrylic sheet are similar to those used for Plexiglas® G cell-cast acrylic sheet, although there are some slight differences, which are noted in the appropriate sections.

In order to maximize the beneficial features of each of the sheet products, certain fabrication techniques may differ in working with Plexiglas® G acrylic sheet and Plexiglas® MC acrylic sheet. If questions arise after trying the suggested techniques, please contact the Altuglas International Polymer Technology Center at 800-217-3258 or one of the Sales Offices listed on the back of this manual.

CUTTING PLEXIGLAS®

ACRYLIC SHEET

Health and Safety Precautions

Cutting Plexiglas® acrylic sheet may cause localized heating, resulting in the release of methyl methacrylate (MMA) monomer vapor, and may also generate some polymer dust. See Concentration Levels and Ventilation Standards, page 3. Any dust produced by the cutting of Plexiglas® acrylic sheet is considered “nuisance” dust. The OSHA PEL/TWA for nuisance dusts is 15 mg/m³ total dust, and 5 mg/m³ respirable dust. The ACGIH TLV/TWA for particles (insoluble or poorly soluble) not otherwise specified is 10 mg/m³ inhalable particulate and 3 mg/m³ respirable particulate. Worker exposure to dust can be controlled with adequate ventilation, vacuum dust removal at the point of generation, or the use of suitable protective breathing devices.

Cutting

Plexiglas® acrylic sheet may be cut by sawing or routing with power equipment saws or by scribing and breaking. Scribing is limited to straight cuts in thin pieces of Plexiglas® acrylic sheet, 0.236 inches or less, and is practical for use by the craftsman who has no power tools when cutting small quantities of sheet material. Sawing and routing may be used for straight and curved cuts on any thickness of material. Keep masking intact during fabrication to protect the surfaces and provide lubrication.

Plexiglas® acrylic sheet is a combustible thermoplastic material. Observe fire precautions appropriate for comparable forms of wood and paper products.

The kind of cutting to be done on Plexiglas® acrylic sheet should determine the type of sawing equipment to be used. Circular blade saws are limited to straight cuts; scroll and sabre saws for rough cutting small-radius curves in thin Plexiglas® acrylic sheet; band saws for rough cutting larger-radius curves or for making rough straight cuts in thick Plexiglas® acrylic sheet. Routers and woodworking shapers are used for cutting and trimming the edges of flat and formed parts of any configuration and provide the best overall fabricated edge.

Circular Blade Saws

There are several types of circular blade saws suitable for cutting Plexiglas® acrylic sheet. Table saws vary in size from small, light-duty models to large, heavy-production models and are generally used for cutting Plexiglas® acrylic sheet to close dimensions. The size of table saw most commonly used is a medium-duty model with an arbor of $\frac{5}{8}$ to 1 inch diameter and powered by a 1.5 to 5hp motor. Special fixtures are often used to hold the work steady for accurate cutting.

Radial saws and swing saws move while the work is held stationary and are generally used to make angle cuts and cross cuts in narrow pieces of Plexiglas® acrylic sheet. The length of cut of a radial saw is limited to about 24 inches.

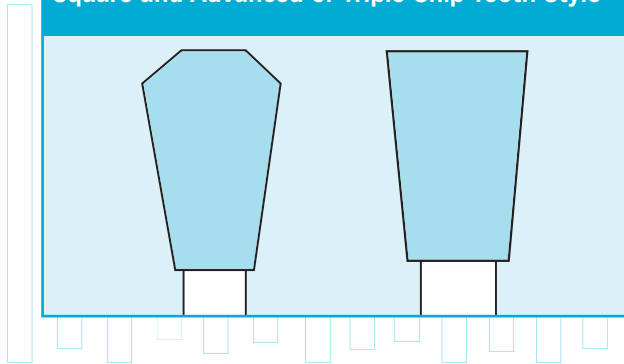
Panel saws are of two types. The first has the saw blade and motor mounted above the material to be cut. The work is placed on the table against a fence and the saw is fed through the work. The second type has the saw blade and motor mounted below the material to be cut with a combination saw guard and hold-down bar. The blade extends through the table high enough to cut through the material. This type of panel saw is usually set so that the saw blade must be retracted before the saw guard and hold-down bar can be released. These saws are available with either horizontal or vertical tables. The vertical saws offer advantages in that less floor space is needed; large sheets of Plexiglas® acrylic sheet may be placed on the saw more easily; and there is less danger of scratching unmasked sheets of Plexiglas® acrylic sheet.

Circular saws should have motors with sufficient power. A 10-inch-diameter saw should be powered by approximately a 2 hp motor; a 14-inch-diameter saw, by approximately a 5 hp motor. Blades are normally driven direct and run at a motor speed of 3,450 rpm. Saws should be equipped with heavy-duty, production-type fences, be well-guarded and have sawdust-removal systems. Kick-plate switches and electromechanical or frictionless electronic motor brakes should be provided for safety purposes.

Programmable horizontal and vertical panel saws with a movable fence can be used to cut Plexiglas® acrylic sheet to size in high-production operations.

FIGURE 1

Square and Advanced or Triple-Chip-Tooth Style



Saw blades should be equipped with carbide-tipped teeth of the triple-chip style. This tooth style is also called square and advance and is illustrated in Figure 1. Triple-chip-style teeth are designed so that alternate teeth start and finish the cut. The slight chamfering of the square tooth corners minimizes chipping. Carbide-tipped blades give cuts of superior quality, cut faster, and require fewer blade changes because of dulling. However, such blades must be returned to the factory for resharpener.

For best results with Plexiglas® MC acrylic sheet, circular saw blades should be the largest diameter possible and contain 60 carbide-tipped teeth with a triple-chip-tooth design. Teeth should be shaped with a 5° to 10° positive rake angle and have sharp cutting edges with adequate clearance.

To obtain the optimum cut from carbide-tipped blades, the saw and stabilizer discs must fit the arbor closely with a clearance of about 0.001 inch, and must run true. Loose bearings, bent arbors, or misaligned or burred stabilizers will vibrate and cause cuts of poor quality and shorten blade life. For maximum service life, carbide-tipped blades used for cutting Plexiglas® acrylic sheet should not be used to cut any dissimilar materials.

To minimize blade wobble, which results in the generation of heat and possible melting of the plastic, the use of a single- or double-mounted, precision-ground, hardened-steel stiffener with a diameter 4 inches less than the saw blade and a blade with additional radial/side tooth clearance is highly recommended. Table 1A lists specifics on the recommended carbide-tipped circular saw blades.

Where the quantity of the Plexiglas® acrylic sheet to be cut does not warrant the purchase of carbide-tipped blades,

Carbide-Tipped Circular Saw Blade Recommendations

Material Thickness	Type Saw	Diameter (Inches)	No. of Teeth	Rake Angle	Plate Thickness (Inches)	Kerf Width (Inches)	Additional Information
.030"-.080" Solid	Table (Hand Feed)	8	80	0°	.095	.075	.052" rim thickness, 2" rim .054" rim thickness, 2" rim .060" rim thickness, 2" rim
		10	80	0°	.095	.080	
		12	80	0°	.095	.085	
.100"-.177" Solid	Table (Hand Feed)	8	80	5°-10°	.072	.100	
		10	80	5°-10°	.072	.100	
		12	80	5°-10°	.090	.125	
		14	80	5°-10°	.105	.145	
.236"-.944" Solid	Table (Hand Feed)	8	60	5°-10°	.090	.125	
		10	60	5°-10°	.090	.125	
		12	60	5°-10°	.090	.125	
		14	60	5°-10°	.105	.145	
1.5"-2" Solid	Table (Hand Feed)	12	60	5°-10°	.105	.145	
		14	60	5°-10°	.125	.170	
		16	60	5°-10°	.135	.180	
.236"-.944" Stacked	Radial or Panel (Power Feed)	8	60	5°-10°	.090	.125	
		10	60	5°-10°	.090	.125	
		12	60	5°-10°	.105	.145	
		14	60	5°-10°	.105	.145	
1.5"-2.0" Stacked Plexiglas® G	Radial or Panel (Power Feed)	14	60	5°-10°	.125	.170	
		16	60	5°-10°	.135	.180	
		18	60	5°-10°	.135	.180	

General: All teeth to be tipped with Premium No. 2 carbide, ground to a triple-chip style with additional side clearance and slight corner level on square tooth.

TABLE 1A

High-Speed Steel Circular Saw Blade Recommendations

Thickness To Be Cut	Blade Thickness	Teeth Per Inch	Type Blade
.030"-.080"	$\frac{1}{16}$ "- $\frac{3}{32}$ "	8-14	Hollow Ground
.098"-.150"	$\frac{3}{32}$ "- $\frac{3}{8}$ "	6-8	Hollow Ground
.177"-.354"	$\frac{3}{32}$ "- $\frac{1}{8}$ "	5-6	Spring Set or Hollow Ground
.472"-.708"	$\frac{1}{8}$ "	3-4	Spring Set or Swaged
.944"-2.000"	$\frac{1}{8}$ "- $\frac{5}{32}$ "	3-3 $\frac{1}{2}$	Spring Set or Swaged

TABLE 1B

Notes: Recommendations are for hand-fed operations (3"-4"/sec.). The number of teeth can be increased proportionately to the feed rate for automatic feed operations, short of overloading the motor.

high-speed steel blades designed to cut Plexiglas® acrylic sheet may be used instead. These blades are made of alloy steel and are tempered to permit filing. The teeth should have a positive rake angle of 0° to 10° and should be of uniform height and shape. When cutting 0.150 inches or thinner sheet, the blade should be hollow ground rather than set. Teeth of uneven height will cause chipping of the Plexiglas® acrylic sheet and will place undue cutting strains on a few teeth. This may cause the saw blade to crack. The saw blades should be machine filed or ground.

For cutting very small quantities of Plexiglas® acrylic sheet, standard hollow ground, fine-tooth blades used for cross cutting wood or ply-tooth blades may be used. Table 1B lists the recommended high-speed steel circular saw blade information for cutting various thicknesses of Plexiglas® acrylic sheet.

Circular Blade Saw Operation

To minimize both chipping and overheating tendencies, circular saw blades should protrude approximately $\frac{1}{2}$ inch more than the thickness of the Plexiglas® acrylic sheet. The work must be held firmly against the fence, which must be parallel to the saw blade.

Several sheets of Plexiglas® acrylic sheet can be cut at one time by stacking one on top of another. Suitably designed holding fixtures must be used when stacks of sheets are to be cut to close tolerances.

When unmasked sheets of Plexiglas® acrylic sheet are cut, it is necessary to take care to avoid scratching the surface of the sheet. Working surfaces should be covered with some soft material such as medium-density felt. The surface should be kept free of dirt and chips.

Sawdust and chips remaining on the surface of the Plexiglas® acrylic sheet after cutting may be removed by blowing with compressed air. Wiping the surface of the sheet with a damp

cloth will remove sawdust that clings to the material because of static electricity. The damp cloth will also dissipate the static charge.

When cutting Plexiglas® acrylic sheet on a table saw, a cutting board should be used for cutting stacked/clamped material or making a cut not parallel to another edge (angle cut). Figure 2 shows a suitable cutting board. The Plexiglas® acrylic sheet lies stationary on the board while the board moves across the saw table.

When cutting stacked Plexiglas® acrylic sheet to final dimensions with a panel saw, hold-down clamps should be used when feasible. This procedure will also help reduce chipping. The manual feed rate should be 3 to 4 inches per second (15 to 20 feet per minute) and should be uniform. The saw should be allowed to cut freely while maintaining the rated speed of the motor. Coolants are not required for most sawing operations, although, if exceptionally smooth cuts in thick sheet are needed, a fine spray mist of detergent in water or 10 percent soluble oil, compatible with Plexiglas® acrylic sheet, in water can be directed against the saw blade.

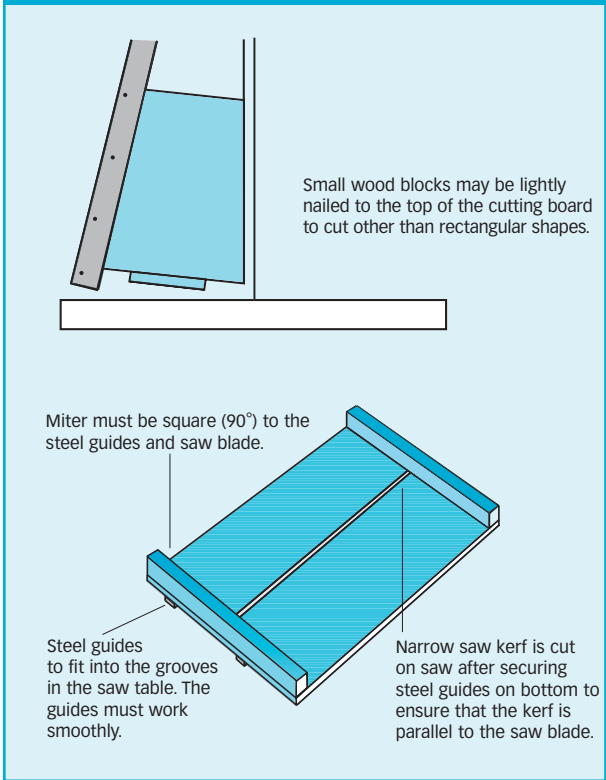
Typical Circular Saw Cutting Problems and Possible Corrections

Chipping	Burning
1. Slow Feed Rate	1. Increase Feed Rate
2. Decrease Blade Penetration	2. Increase Blade Penetration
3. Support Material Continuously (Narrow Saw Slot)	3. Ensure Fence Is Parallel to Blade
4. Provide Hold Down	4. Use Blade Stiffener
5. Increase Tooth Rake Angle	5. Decrease Tooth Rake Angle
6. Ensure Teeth Are of Uniform Height	6. Ensure Blade Has Been Properly Sharpened
	7. Use Blade With Greater Side Clearance

TABLE 2

FIGURE 2

Cutting Board for PLEXIGLAS® Acrylic Sheet



For Plexiglas® MC acrylic sheet, circular saws should operate at speeds of approximately 3,450 rpm and the material feed rate should be about 4 inches per second. The saw blade should be set at a height only slightly greater than the thickness of the material being cut, to ensure a smooth, chip-free edge on either single or stacked cutting of sheets. Elimination of gumming or welding of the sheets during stack cutting can be reduced by

applying compressed air or an approved liquid coolant to the saw blade and material to reduce heat buildup.

Clamp the stack if possible. Make sure that the saw arbor runs true and the blade plate is flat to prevent rubbing. Some fabricators with special cutting problems have found it helpful to purchase a circular saw blade with additional clearance behind the teeth, such as the “no melt” blade from Forrest Manufacturing Co., Inc., in Clifton, NJ (1-800-733-7111). With this blade, increase the feed rate up to 6 inches/second, and increase the height of blade above the plastic sheet, short of developing chipping of the sheet. Stabilizing discs are recommended to minimize saw blades from wobbling and developing heat.

Table 2 (shown on page 6) summarizes some circular saw cutting problems, with some possible corrections.

Band Saws

Band saws should be used when curves are cut in flat sheets or when formed parts are rough trimmed. They are also used for making straight cuts in thick pieces of Plexiglas® acrylic sheet. For production work, large saws with a 30- to 36-inch throat are best, although smaller band saws are satisfactory for small work. The blade should run at a speed of 2,300 to 7,500 feet per minute. As a general rule, as the thickness of the Plexiglas® acrylic sheet increases, the number of teeth per inch on the blade should decrease. See Table 3 for recommendations.

Metal cutting blades and, in particular, bimetallic blades stay sharp longer than blades designed for cutting wood and are better for use on Plexiglas® acrylic sheet. They are supplied by several manufacturers in 100-ft. coils and can be cut to the proper length and brazed or welded. The weld must be annealed and dressed.

Blade thickness, width, and the number and type of teeth depend on the size of the band saw, the thickness of the material to be cut, and the minimum radius to be cut. Band saw blades

Band Saw Blade Recommendations (Metal-Cutting Blades Should Be Used)

Thickness To Be Cut	Blade Width (Front to Back)	No. Teeth Per Inch	Tooth Style
Up to .118"	3/8"	18	Regular (Raker Set)
.118"- .472"	1/2"	10-14	Regular (Raker Set)
.472"-2.00"	3/4"	6	Skip or Buttress

TABLE 3

of 0.250-inch to 0.375-inch width should be used for cutting curves; blades of 0.50-inch to 0.75-inch widths should be used for straight ripping or cutting large-radius curves. The diameter of the band saw wheels will determine the maximum thickness of the blade. The thickness of the blade increases as the diameter of the wheels increases.

Special band saw blades, called “skip tooth” or “buttress” blades, have been developed for soft materials such as plastics and are available with 2, 3, 4, or 6 teeth per inch. These blades should be used when cutting thicknesses greater than 0.472 inches. These blades are hardened and will retain their sharpness for long periods when used only for cutting Plexiglas® acrylic sheet.

Variable pitch (number of teeth per inch) blades work well in reducing chipping when cutting sheet 0.472 inches thick or less.

Band Saw Operation

The tension on the saw blade should be just enough to prevent slipping on the wheels, but not enough to stretch the blade and cause misalignment. The guide rolls or blocks should be set so they just miss the teeth but support the rest of the blade width. They should be set so that their rotation can be stopped with pressure from the thumb and forefinger when the saw is turned by hand. The backup roll should be adjusted so that it does not turn when the saw is idling, but will provide support while the saw is cutting. When cutting formed sections, it may be necessary to raise the upper guide. When this is done, extra care is necessary to insure proper alignment. For added safety, the upper guide should be as low as possible (within $\frac{1}{2}$ inch of the Plexiglas® acrylic sheet).

The action of the saw carries sawdust from the Plexiglas® acrylic sheet and the masking paper onto the wheels. The dust builds up on the wheels and may cause the blade to run off. Therefore, this accumulation of dust must be removed. Stiff-bristle brushes can be placed so that they touch the tires and clean them as they revolve. The brushes should be held with a light spring tension so that they will make contact, yet not cause excessive wear on the tires.

Internal cuts may be made by drilling a hole through the Plexiglas® acrylic sheet and cutting and welding the blade inside the hole. Once the internal cut is completed, the blade must be recut, removed from the hole, and rewelded. This technique may be useful for special jobs but is too time-consuming for production use.

When cutting unmasked Plexiglas® acrylic sheet on a band saw, special care must be taken to prevent scratching. The saw table must be kept clean and should be free of nicks or burrs. Kraft paper or cardboard should be placed on the table under the unmasked sheet. Tape or rubber cement can be used to hold the paper and the Plexiglas® acrylic sheet together to ensure that both will move through the saw together. When trimming flanges on formed parts, the flange will slide on the saw table so any scratching will not be objectionable for most applications. For other curved work, a piece of wood about $\frac{1}{2}$ -inch thick by 1.0 inch wide can be run partially through the saw and clamped to the saw table at the ends. The main portion of the acrylic part will be raised slightly above the saw table, while the kerf is supported by the wood strip.

For Plexiglas® MC acrylic sheet, band saw blades should be of the edge-hardened metal-cutting type with raker set or broach-style teeth. Blades should have 10 to 14 teeth per inch. Speeds should be between 2,300 and 5,000 feet per minute. In general, the thicker the stack of material, the slower the blade speed should be to avoid overheating. Blade speed and material feed and thickness should be such that each saw tooth cuts a clean chip. The welded joint of the blade should be smooth and carefully aligned to prevent chipping or cracking of the material during the cutting operation. A band saw cut should not be considered a finished edge and, if not a rough cut, should be further finished by scraping.

Scroll Saws

Scroll saws may be used for cutting sharp radii and closed holes in thin pieces of Plexiglas® acrylic sheet, but are less suitable for cutting thick sections or multiple sheets. Because of the short stroke, scroll saw blades do not clear the chips and tend to gum up. When this happens, the plastic softens and welds around the blade. Scroll saws must be used with a light feed and without forcing the work. The teeth should be cleared often. As soon as the blade stops cutting cleanly, it should be backed out, the chips removed, and the sheet cooled. Welding of the plastic behind the blade may be alleviated by using two blades mounted side by side, or by using an air blast to remove chips and cool the Plexiglas® acrylic sheet. A coolant may also be used. Masking material should always be left intact to provide lubrication in addition to protecting the sheet. Blades should be sharp with 10 to 14 teeth to the inch. Hold-downs are necessary to prevent vibration.

Saber Saws

Portable saber saws may also be used for making either straight or curved cuts in Plexiglas® acrylic sheet. When using this type saw, however, it is necessary to provide adequate support for the Plexiglas® acrylic sheet, since the vibration caused by the reciprocating action of the saw blade may chip or crack the sheet. Chisel-type sabre saws should be adjusted so that the cutting chisel stroke is about $\frac{3}{16}$ inches greater than the thickness of the work to be cut. Two thicknesses of corrugated fiberboard should be placed on the working surface under the Plexiglas® acrylic sheet. The stroke of the chisel should clear the upper surface of the sheet by about $\frac{1}{16}$ inch and penetrate into the corrugated fiberboard about $\frac{1}{8}$ inch, thus driving the plastic chips into the board. The blade should be the same type used for scroll saws.

Veneer Saws

Veneer saws are small circular saws mounted on arbors and powered by high-speed electric or air motors. They are available as stationary or portable models. The saw blades are made in 3-inch and 4-inch diameters with several teeth per inch and have considerable set. They should be driven at 10,000 to 15,000 rpm to give a surface speed of 8,000 to 15,000 feet per minute. Veneer saws cannot be easily guarded and must be used with great care. Carbide-tipped blades should not be used unless designated for high-speed operations.

Portable veneer saws are most often used to trim large formed parts of Plexiglas® acrylic sheet held in trimming fixtures. (See Machining Plexiglas® Acrylic Sheet, page 11.) Stationary veneer saws can be used in woodworking shapers or routers for trimming the flanges of compound formed parts when the flange is on one plane. The height of the saw is adjusted to the proper distance above the table and the work is moved past the revolving blade.

Hole Saws

A hole saw is a tubular tool with teeth filed on the lower edge of the tube. The teeth are set to cut a groove wider than the thickness of the tool wall. A shaft is fastened to the top of the tube so that it can be mounted in a drill press to drive the saw. Usually a pilot drill and guide are provided to locate and center the hole saw. Knockout holes are located in the top of the saw to allow removal of the discs. Hole saws are stocked in sizes from $\frac{5}{16}$ -inch to 4-inch diameters. Large-diameter hole saws may be made by inserting a piece of band saw blade in a groove machined in a steel disc and holding it with set screws. Coarse-tooth saws should be used for cutting Plexiglas® acrylic sheet.

The Plexiglas® acrylic sheet should be cut halfway through, turned over, and the finishing cut made from the other side. When cutting sheet greater than 0.236 inches thick, a detergent/water lubricant and coolant should be used. A saw-cut hole is typically rough and often melted, requiring a post-finishing operation. Better quality holes can be achieved by machining with a router or circle cutter.

Routing Plexiglas® Acrylic Sheet

Portable routers are used for trimming the edges of flat or formed parts, particularly when the part is too large or it is too awkward to use a band saw or stationary router.

Routers should have a minimum no-load spindle speed of 10,000 rpm – higher speeds are more desirable. Double, straight-fluted cutters $\frac{5}{16}$ inches to $\frac{1}{2}$ inch in diameter will produce the smoothest cut at this speed. Cutters should be kept sharp and should have a back clearance angle of approximately 10° and a positive rake angle up to 15° . Templates should be provided to guide the router. Machining Plexiglas® Acrylic Sheet (page 11) gives complete details for routing Plexiglas® acrylic sheet.

For Plexiglas® MC acrylic sheet, double or triple, straight, fluted router bits with a maximum diameter of $\frac{3}{4}$ inches, a back lip clearance of 10° , and a positive rake angle of about 10° produce good edges. Two fluted edges are recommended. Steel router bits will produce an excellent initial cut, but carbide bits can give a comparable cut and will give many times longer life. The spindle speed required to produce a satisfactory edge is 10,000 to 20,000 rpm. A smooth, constant feed rate of 10 to 25 feet per minute is required to prevent localized heat buildup, which will cause smearing or gumming of the cut edge. Low-horsepower (1 hp) routers should not be used, since they may bind on the material, removing chunks rather than yielding a smooth edge. Avoid using router bits less than $\frac{5}{16}$ inches in diameter because smaller diameter bits tend to clog and break. Use a router setup design that will effectively remove router chips.

Routers with computerized numerical control are favored by some fabricators involved with high-speed production operations.

Scribing and Breaking

Straight cuts in 0.236 inches or thinner pieces of Plexiglas® acrylic sheet can be made by scribing with a special Plexiglas® acrylic sheet cutting tool available at Authorized Plastics Products Distributors. Scribing is effective when the quantity of sheet to be cut is limited, for it requires very little capital outlay for tools. Neither thick sections nor patterned Plexiglas® acrylic sheet can be cut by this method, however. If the sheet is masked, it should first be scored using the tip of the tool and a metal straight edge as the guide. Then the hook point of the cutting tool is placed at the far edge of the material and drawn the full width while

applying firm pressure. This is repeated once for every 0.025 inches to 0.040 inches of sheet thickness.

The scribed line is then positioned face up over a $\frac{3}{4}$ -inch diameter wood dowel running the length of the intended break. The sheet is held with one hand and downward pressure applied with the other hand on the short side of the break. The hands should be kept adjacent to one another and successively repositioned about 2 inches behind the break as it progresses along the scribed line. The practical minimum cutoff width for scribing and breaking is $1\frac{1}{2}$ inches.

Scraping Edges of Plexiglas® Acrylic Sheet

After cutting Plexiglas® acrylic sheet, it is often desirable to scrape the edges. Scraping serves two purposes: it removes any nicks or burrs that may form a notch to weaken the material, and it improves the appearance of the edge by removing cutting marks. Dubbing both edges at the same time may be done by grinding a V-notch into the scraper.

A suitable scraping tool may be made from a piece of power-hacksaw blade or tool steel with one edge ground to a sharp 90° edge.

The Plexiglas® acrylic sheet part should be held firmly in a vise or holding fixture. Scraping can be accomplished by pushing or drawing of the tool, whichever is more comfortable. Firm, steady pressure should be used throughout the scraping operation. Care must be taken to keep the scraped edge square.

MACHINING PLEXIGLAS®

ACRYLIC SHEET

Health and Safety Precautions

Machining Plexiglas® acrylic sheet should not result in harmful concentrations of vapors provided that adequate ventilation is employed. To insure this, both general and local exhaust ventilation are recommended. See Concentration Levels and Ventilation Standards, page 3.

Before using any soluble oils or wax sticks as machining aids for Plexiglas® acrylic sheet, review and follow each manufacturer's recommendations for safe use of these products.

Plexiglas® acrylic sheet is a combustible thermoplastic material. Observe fire precautions appropriate for comparable forms of wood and paper products.

Machining

The usual rules of good machining practice apply to the machining of Plexiglas® acrylic sheet. An experienced machinist should have no difficulty handling Plexiglas® acrylic sheet as soon as he gets the feel of the material. Acrylic has working qualities similar to those of brass and copper.

Tools and work should be held firmly to prevent chattering. Standard metal- or wood-working equipment can be used, such as milling machines, drill presses, lathes, planers and shapers. In general, machining tools should be operated at high speeds with moderate feed rates. Tools should be sharp, clean and free of nicks and burrs.

Because it is a thermoplastic material, Plexiglas® acrylic sheet softens when heated to its forming temperature. The frictional heat generated by machining tends to soften the material in the immediate vicinity of the cut, and causes gumming and sticking of the tool or tearing of the plastic if excessive heat buildup occurs. When proper speed, feed and cutters are used, machined Plexiglas® acrylic sheet surfaces will have an even, semi-matte surface, which can be brought to a high polish by sanding and buffing.

If tools are sharp and properly ground, coolants are seldom required for machining Plexiglas® acrylic sheet. Coolants may be desirable for an unusually smooth finish or for deep cuts. If coolants are employed, only detergent in water or a compatible, soluble oil in water should be used. Other coolants may contain chemicals harmful to Plexiglas® acrylic sheet.

Plexiglas® acrylic sheet can be machined to close tolerances and finished parts should be annealed (see page 30, Annealing Plexiglas® Acrylic Sheet).

For applications that require both close tolerance and good optical properties, such as periscope prisms and lenses, acrylic blanks should be annealed before and after rough machining. The parts may then be machined to close tolerance, removing as little material as possible. When final machining is complete, the parts should be given a final annealing. Since temperature and humidity affect the dimensions of Plexiglas® acrylic sheet, machining to close tolerance must be done under conditions like those that will prevail when the parts are tested and put into service.

Turning

Plexiglas® acrylic sheet can be turned on a lathe to give an excellent semi-matte surface. Surface speeds of 500 feet per minute with feeds of 0.004 to 0.005 inches per revolution will cut a clean continuous chip. If the feed stops, the Plexiglas® acrylic sheet may be marked. The maximum permissible depth of cut is controlled by the rigidity of the section being turned.

Plexiglas® acrylic sheet discs may be turned on a lathe. Circular blanks should be rough cut with a band saw approximately $\frac{1}{8}$ inch over size. The blanks are clamped between the face plate and a tailstock fitted with a live center, and a pressure pad. The blanks should be mounted slightly off-center, so the waste is thrown clear. The cutting tool should be ground to a rake angle of 0° to 5°.

Routing and Shaping

Woodworking shapers (also called table routers) and overhead or portable routers are used in edge-finishing operations and for cutting flat or formed Plexiglas® acrylic sheet parts to size. For edging small parts, the table router is convenient; portable routers are useful whenever the acrylic part is too large or awkward to bring to the machine.

Routers should have a minimum no-load spindle speed of 10,000 rpm. Higher speeds of 20,000 to 25,000 rpm are desirable and should be used when possible. At slower spindle speeds, cutters should have more flutes or larger diameters to produce necessary surface speeds. Double or triple straight-fluted cutters $\frac{5}{16}$ to $\frac{1}{2}$ inches in diameter will produce good cuts. Smaller diameter cutters should be used with care. If cutters larger than $\frac{1}{2}$ inch in diameter are used, the material should be machine-fed rather than hand-fed to overcome chatter. For safety, cutter shanks should be as large as cutters in diameter. Single-fluted cutters should not be used under any circumstances.

When machining thick sections of Plexiglas® acrylic sheet, better-quality edges may be produced by using spiral-fluted cutters. Spiral-fluted cutters always have a cutting edge in contact with the material and chatter less than straight-fluted cutters. This is done best when the material is held down securely.

Carbide-tipped cutters should be used whenever possible since they stay sharp longer than high-speed steel cutters. All cutters should be kept sharp and should have a back clearance of about 10° and a positive rake angle of up to 15° .

The most common operations performed with routers are deflanging and flange trimming. These cuts are illustrated in Figure 3 (shown at right). Such cuts may be made with router cutters or with veneer saw blades attached to portable or table routers by suitable arbors. Typical deflanging cuts commonly made on formed Plexiglas® acrylic sheet are shown in Figure 4A (page 13).

When deflanging cuts must be made to close tolerances, fixtures should be used to support the Plexiglas® acrylic sheet and index the cut. Female fixtures are used for close tolerance referred to the convex side of a formed part; male fixtures, to the concave side as indicated in Figure 4B (page 13). The material should be clamped to the fixture. In trimming close tolerance work, the part should not be supported by its flange.

In contrast to deflanging where the entire flange is removed, flange trimming is merely reduction of the size of the flange. Table and panel saws can be used for flange trimming and will produce a good-quality edge. For high accuracy trimming with a table saw, place the part on a lightweight male shape with runners to fit the saw table grooves. Another method is to install a gauging device on the saw fence so that the flange is trimmed by indexing from the outer surface of the return of the part. These methods are illustrated in Figures 5A and 5B (page 13).

Portable routers or table shapers equipped with woodworking router bits are also commonly used in this operation. Depending on the equipment used, a template may or may not be necessary.

Figure 6 (page 14) shows deflanging cuts made with a table router with and without a template. The lower illustration shows a special router cutter tipped with a ball bearing pilot. This cutter is useful in trimming cemented assemblies. The pilot is the same diameter as the cutter and rides the guiding surface of one part of the assembly as the cutter trims the other.

Another cutting operation using a portable router is shown in Figure 7 (page 14). A template is cut to size and held to a work table, along with the Plexiglas® acrylic sheet to be cut, by means of air cylinder clamps mounted overhead. The router is fitted with a bushing that enables it to follow the template, cutting only the sheet.

FIGURE 3

Common Router Operations

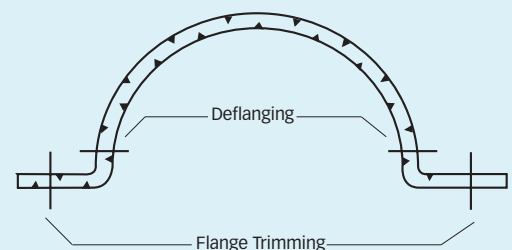


FIGURE 4A

Deflanging Cuts with Veneer Saw Blades

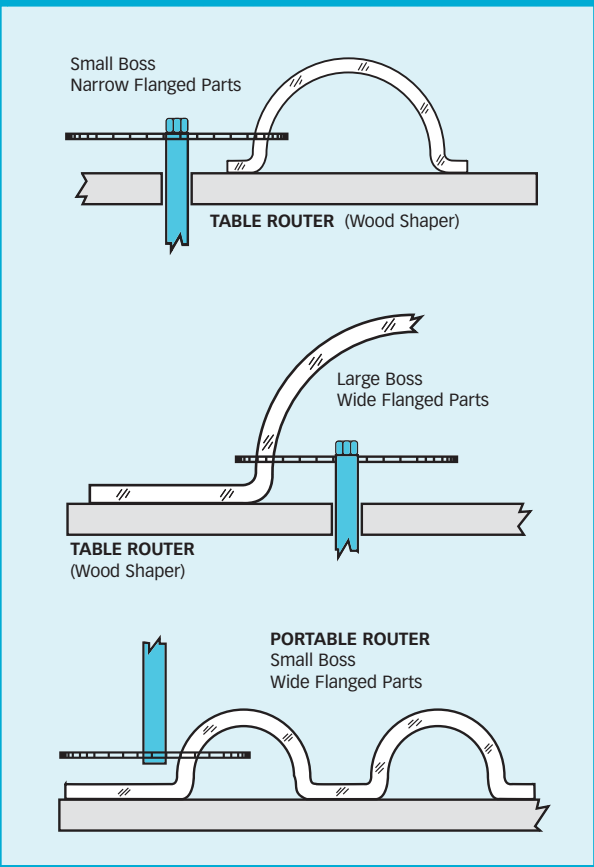


FIGURE 4B

Close Tolerance Deflanging Cuts with Veneer Saw

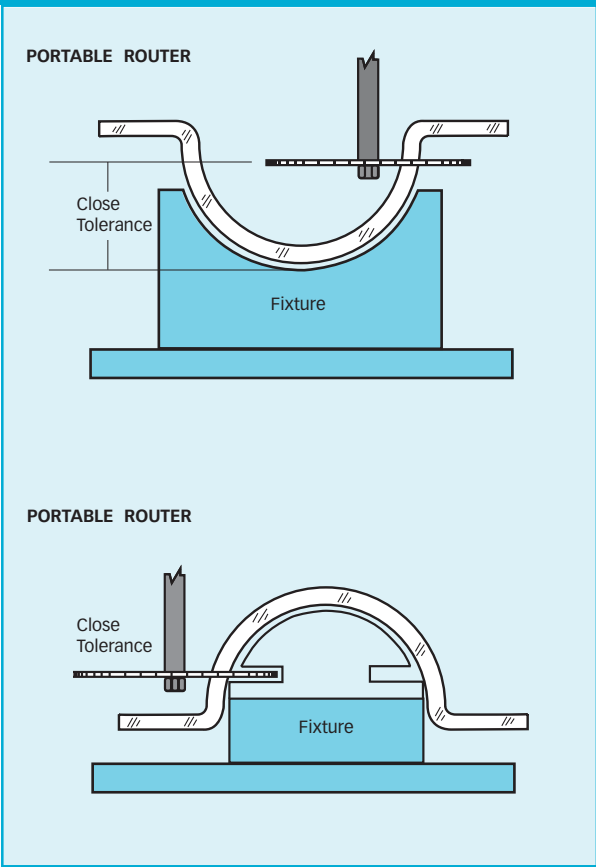


FIGURE 5A

Flange Trimming with Table Saw

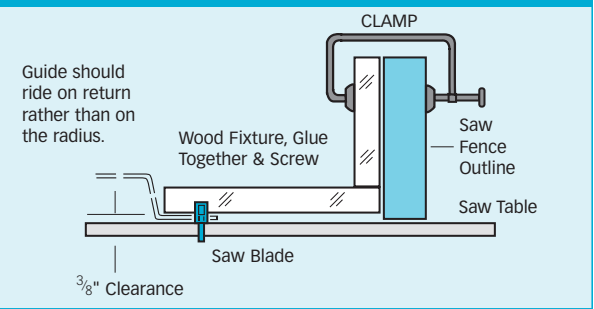


FIGURE 5B

Alternative Flange Trimming

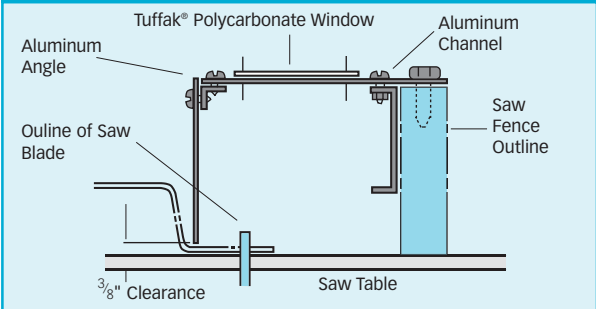


FIGURE 6

Flange Trimming Table Router

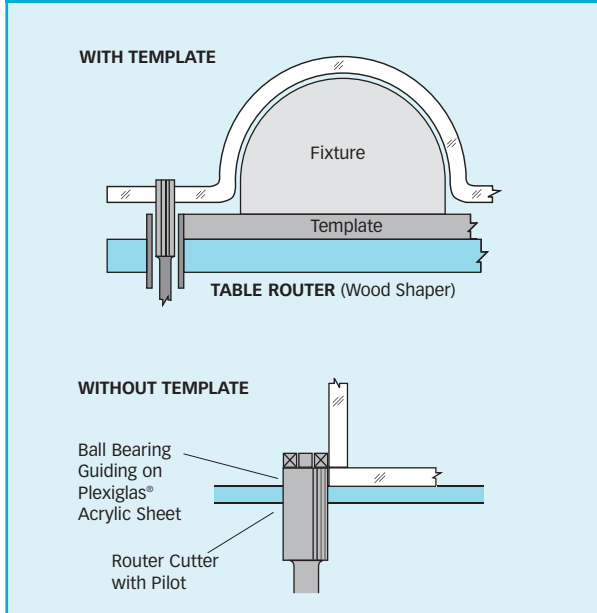
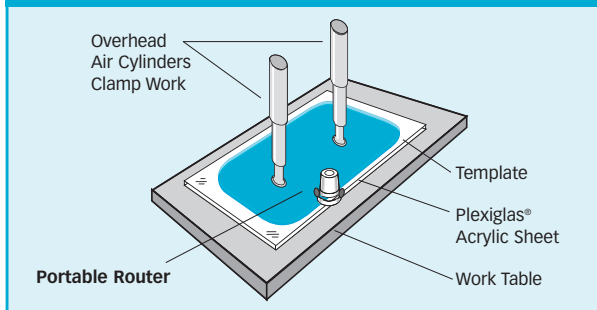


FIGURE 7

Trimming with a Portable Router



Drilling

When drilling Plexiglas® acrylic sheet, best results will be obtained using standard twist drills that have been modified, as described below. High-speed steel drills should be used.

Specially ground drills for Plexiglas® acrylic sheet are available from Authorized Plastic Products Distributors.

**Modification of Drills:
Instructions for Sharpening Bits**

Chuck the bit in an electric drill. Insert the bit through a wood or metal bushing clamped to the support rest of an abrasive wheel. The bushing must be clamped so that an approximately 60° total included angle is ground on the bit. With the electric drill operating, insert the bit through the bushing so that it contacts the face of the rotating abrasive wheel, thus grinding a conical point on the bit. See Figure 8A, at right. Remove the bit from the chuck.

Using the side of the rotating abrasive wheel, grind a 0° rake angle on each of the cutting edges. This provides a scraping action rather than a cutting action. See Figure 8B, right.

Then, using the face of the rotating abrasive wheel, grind a clearance behind each of the cutting edges of about 8° to 12°. Do not touch the cutting edges. See Figure 8C, right.

The resultant bit will produce good-quality surfaced holes in Plexiglas® acrylic sheet, and will eliminate the problem of the bottom surface breaking out when the holes are drilled. Pickup of masking paper adhesive will also be eliminated.

FIGURE 8A

Drill Modification – 60° Tip Angle

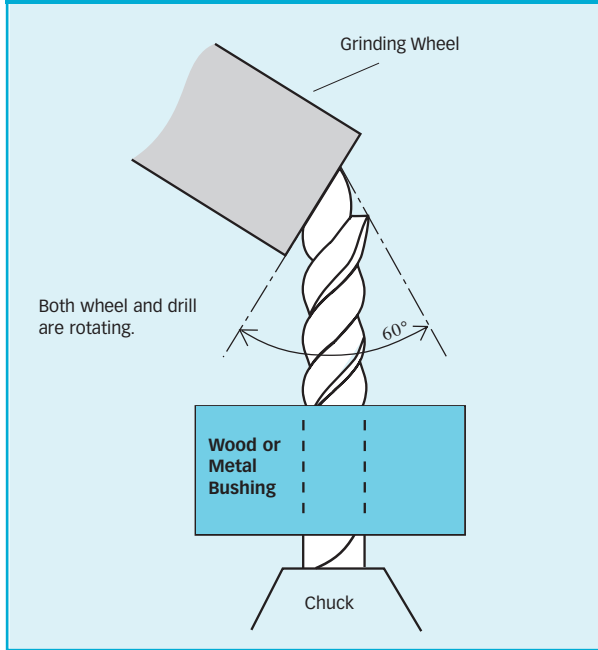


FIGURE 8C

Drill Modification – Clearance Behind Cutting Edges

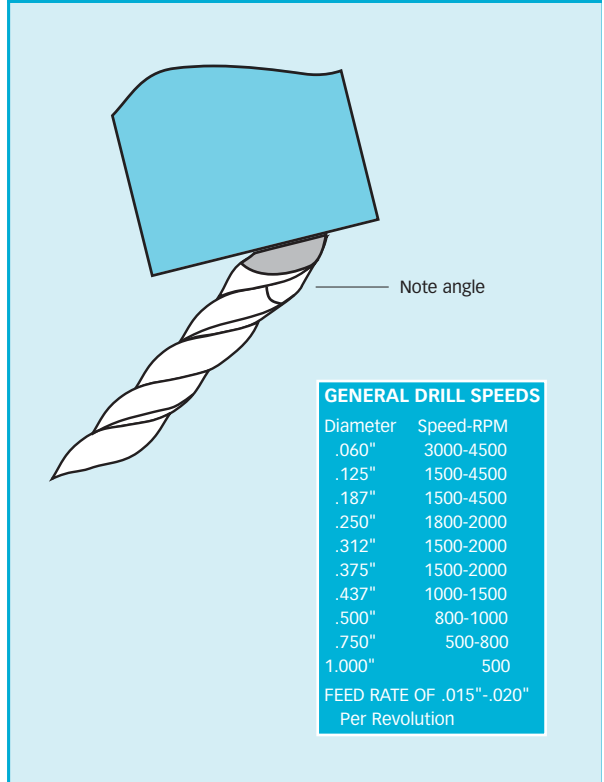
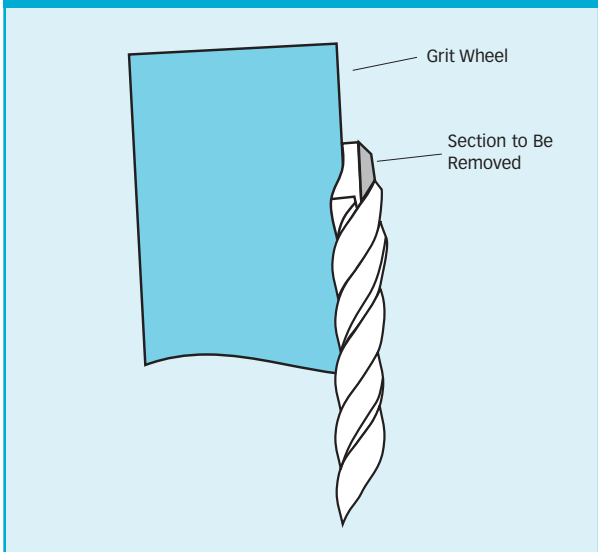


FIGURE 8B

Drill Modification – 0° Rake Angle



Drilling Techniques

Whenever holes in Plexiglas® acrylic sheet penetrate the stock, standard twist drills should be modified, as previously described, up to a 1.00 inch diameter. A 60° tip angle allows the drill to emerge from the second surface without fracturing the sheet.

When holes are to be drilled that do not penetrate the Plexiglas® acrylic sheet, the rake and lip clearance angles of the drill should be modified as described, but tip angles larger than 60° clear chips from the hole better.

Shallow holes having depth to diameter ratios less than 3:1 should be made with drills ground to a tip angle of 90°. Large deep holes with depth to diameter ratios greater than 3:1 should be made with drills having a tip angle of 118°.

Coolant is seldom required when drilling Plexiglas® acrylic sheet, but better surfaces result if coolant is used when drilling large deep holes. Water or a 10 percent solution of a compatible oil in water or kerosene makes a satisfactory coolant and is best fed into the hole by filling a pilot hole nearly as deep as the finished hole. If masked sheet is drilled using coolant, the wet masking paper should be removed promptly. If the masking paper dries in place, a residue may be left behind when the sheet is finally unmasked.

Unusually clear and smooth deep holes can be made in Plexiglas® acrylic sheet by filling a pilot hole with a wax stick, then redrilling to the final diameter. The wax lubricates the cut and supports and expels chips during drilling. A mixture of tallow and kerosene, mixed to the consistency of a slurry, also lubricates well and acts as a coolant.

Large-diameter holes can be cut with hollow end mills, circle cutters or trepanning tools. The cutters of the latter should be ground to a 0° rake angle and adequate back clearance, just as lathe tools are ground.

Plexiglas® acrylic sheet may be drilled using any of the conventional tools: portable electric drills or flexible shafts, drill presses or lathes. The drill should always run true since wobble will affect the finish of the hole. When drilling holes that penetrate the second surface, it is desirable to back up the sheet with wood and slow the feed as the drill point breaks through. For accuracy and safety, Plexiglas® acrylic sheet should be clamped during drilling.

Tapping and Threading

Standard machine shop tools and procedures may be used for tapping and threading. Wherever possible, the “national coarse thread” system should be applied. On diameters over 1 inch, Acme threads are preferred to V-threads. The root should be radiused.

When transparency is a requirement for the tapped threads, a wax stick should be inserted in the drilled holes before tapping. As in drilling, the wax lubricates the cuts and supports and expels the chips, resulting in cleaner, more-transparent threads.

Taps should be backed out often to clear the chips. The wax stick is particularly useful for blind holes, since it tends to clean out the chips as they are formed.

FINISHING PLEXIGLAS®

ACRYLIC SHEET

Plexiglas® acrylic sheet should be handled carefully to avoid scratching its surface. It is easier to avoid scratches than to remove them. Scratched surfaces can be restored to a good finish by a process of polishing and/or sanding. Sawed edges and machined surfaces can also be polished to a high gloss. Where power-operated polishing equipment is not available, it is possible to hand-polish minor scratches from the surface of the sheet. Minor scratches can be polished by rubbing with soft flannel and a good grade of automotive paste wax.

Before sanding, buffing, or polishing, clean the Plexiglas® acrylic sheet carefully. The buffing wheels and compounds should also be free from dirt and grit. Separate buffs should be reserved for Plexiglas® acrylic sheet. They should be cleaned by running the buffing wheel against a hard metal edge to remove hardened tallow, grease or other binders.

The friction of buffing, sanding, or polishing too long or too vigorously in any one spot can generate enough heat to soften or “burn” the acrylic surface, resulting in visual distortion and possibly discoloration. To avoid this, keep the Plexiglas® acrylic sheet constantly in motion relative to the wheel. Use light pressure, and change the direction of buffing often. Air-cooled buffing wheels are often used to help reduce heat of friction.

Polishing techniques vary with the equipment available and the size or shape of the acrylic parts being polished.

Sanding and buffing cause thickness variations in the scratched area of the Plexiglas® acrylic sheet. If skillfully done, these operations cause only minor optical distortions that should not be objectionable for most applications. In critical sections, even minor distortions may not be acceptable. Such sections, even though scratched, should not be sanded or buffed. They should be simply washed and waxed. However, applications that must be sanded should be sanded by hand, using progressively finer grit paper up to grits of 12,000. These grits are available as cushioned abrasive cloth.

Sanding

If there is a scratch in the Plexiglas® acrylic sheet, it should not be sanded unless the surface imperfections are too deep to be removed by light buffing and the resultant optical distortion can be tolerated. The way to tell if sanding is necessary is to rub your fingernail over the scratch. If it can be felt, then sanding is required. Use the finest sandpaper that will remove the

imperfections. Coarse paper can cause scratches deeper than the original imperfection, and additional finishing operations will be needed.

First try using 600 grit sandpaper wrapped around a rubber-padded sanding block. Sand over the scratch using increasingly larger areas of sanding. If this does not readily remove the scratch, step down to 400 grit. The sanding should be done in directions mutually 30° apart to produce a diamond pattern. After sanding and stepping up to 600 grit, polish the sheet as described below.

Do not use disc or belt sanders dry. The greater danger of heat generation with mechanical sanders makes the use of water or oil coolants doubly desirable. Wet sanders are preferred, but dry orbital sanders can be used with care. Open coat sandpaper should be used, since it does not become clogged as fast as closed coat sandpaper.

Machine Buffing

The Plexiglas® acrylic sheet should be clean and dry at the start of each buffing operation. Some polishing compounds leave the surface clean after buffing. If these materials are not used, washing should follow the last step in polishing.

If the part has previously been sanded or is deeply scratched, an abrasive-coated wheel is used first. The abrasive is a standard polishing compound composed of very fine alumina or similar abrasive and tallow.

When most of the scratches have been reduced on the first wheel, the Plexiglas® acrylic sheet is buffed on the second wheel charged only with tallow. These first two wheels should be air-ventilated cotton muslin rag wheels and should operate at 3,000 to 4,500 surface feet per minute (SFPM). To calculate: SFPM equals $\frac{1}{4}$ the diameter of buffing wheel in inches multiplied by the spindle speed in rpm.

The Plexiglas® acrylic sheet is next brought to a high polish by a soft, loose buff in which no abrasive or tallow is used. These cleaning buffs should be very loose and should be made of imitation chamois or cotton flannel. The wheels should be 10 to 12 inches in diameter and should run at 3,000 to 4,500 SFPM. A hand-applied coat of wax may be used in place of buffing on the finish wheel, if desired.

Polishing Drilled Holes

A properly drilled hole has a smooth semi-matte finish that can be brought to a high polish. A wood or metal rod approximately $\frac{1}{8}$ inch smaller in diameter than the drilled hole is split to a depth equal to the depth of the hole plus $\frac{1}{2}$ inch and mounted in a drill press. If the inner surface of the hole is rough, steel wool or strips of emery cloth or sandpaper are wound around the rod and gripped in the slot. When the inner surface is smooth, a good grade of flannel is wound around the rod and the compounds for buffing are applied. Poor grades of flannel may throw lint and require further cleaning.

Polishing Edges

In many installations, the edges of Plexiglas® acrylic sheet are completely hidden in a mounting frame or channel and smooth edges, free of chips and major irregularities, are entirely satisfactory. Sometimes good machine-finished edges are used as a decorative element in the design of a part made of Plexiglas® acrylic sheet. Well-polished edges, however, may be required for household accessories, jewelry, and other decorative items.

Saw marks can be removed from the edges of Plexiglas® acrylic sheet by scraping with a hard steel or Carboloy scraper square-ground to a straight, smooth edge. After scraping, the edges should be sanded on a wet belt sander with 320 grit then 400 grit sandpaper.

A fast method to polish Plexiglas® acrylic sheet is to make buffs of layers of medium density 100 percent wool felt about $\frac{3}{16}$ to $\frac{1}{4}$ inch thick. The felt should have a specific gravity of about 0.27. The wheels should be 10 to 12 inches in diameter and should be held between hard faceplates about three inches smaller in diameter than the buff. The wheels should be run at a speed of 3,000-4,500 SFPM.

The edges are buffed on a felt wheel charged with abrasive and tallow. The final polish is given to the edges with a soft cotton buff. Felt wheels should not be used on large flat areas since there is a tendency to burn and distort the sheet.

Whenever possible, a number of Plexiglas® acrylic sheet parts should be locked together in a jig leaving only the edges exposed, so that the edges may be planed, sanded, and polished simultaneously. This technique is faster and gives better results without rounding the edges. Lapidary wheels surfaced with high-density felt may also be used for polishing flat surfaces.

To prevent heat buildup, the sheet may be buffed with a paste or liquid wax with an abrasive.

Flame Polishing

Flame polishing is a fast, economical method of edge polishing that is preferred by some fabricators, but it cannot be fully recommended for use on Plexiglas® acrylic sheet, because of its tendency to cause crazing – which is often not apparent until sometime after the article has left the fabricator's shop. This technique is never recommended if other fabrication steps, such as cementing, forming or painting, are planned after the polishing step. Contact Altuglas International if additional information is needed.

CEMENTING PLEXIGLAS®

ACRYLIC SHEET

General Health and Safety Precautions

Care must be taken whenever heating any thermoplastic, including Solarkote® capped film. When fabricating, use good practices consistent with any operation that uses high speed saw blades, bits or drills. The use of machine guards and hold down bars is recommended whenever possible. To avoid burns during thermoforming, the use of thermally protective gloves and sleeves is recommended.

The heat of thermoforming, cutting, machining, finishing, annealing, or otherwise processing Plexiglas® acrylic sheet may result in the release of vapors, including methyl methacrylate (MMA) monomer. In addition, cementing Plexiglas acrylic sheet introduces other vapors relating to the formulation of adhesives. Cutting Plexiglas acrylic sheet may also generate polymer dust. Any dust produced is considered nuisance dust and should be removed with adequate vacuum dust removal at the point of generation. It is important to use adequate ventilation during any processing of Plexiglas® acrylic sheet. High concentrations of MMA vapors can cause eye and respiratory irritation, headache and nausea. Preferably the ventilation should be as close to the point of vapor generation as possible.

Flammability The ignition temperature of Plexiglas® acrylic sheet is higher than that of most woods, but it will ignite readily. Take precautions when flame polishing, laser cutting or any operation that requires intense heat so that the Plexiglas® acrylic sheet will not ignite. Plexiglas® acrylic burns vigorously and generates heat rapidly. Burning Plexiglas® acrylic sheet does not produce excessive quantities of smoke or gases more toxic than those produced by wood or paper. The concentration of carbon monoxide and/or carbon dioxide released by burning Plexiglas® acrylic sheet depends on the quantity of Plexiglas® acrylic sheet involved and the condition of burning.

Storage & Handling Plexiglas® acrylic sheet is a combustible thermoplastic material. In general the same fire precautions that are observed in connection with the handling and use of any ordinary combustible material should be observed when handling and storing or using Plexiglas® acrylic sheet. Avoid exposure to extreme heat or aromatic solvents.

General Joining Comments

Pieces fabricated from Plexiglas® acrylic sheet may be joined using mechanical methods such as bolts, thermal methods such as welding, or chemical methods such as cementing. The following sections discuss the techniques commonly used to cement Plexiglas® acrylic sheet to itself and to other materials.

Cementing Plexiglas® acrylic sheet is relatively easy, but proper techniques must be practiced to avoid problems. The two most common problems are crazing and poor joint strength.

Acrylic plastics will eventually craze when subjected to high stresses for a long time. Crazing is a network of fine cracks running on, or slightly under, the surface of plastics materials. The tendency to craze is greatly increased when the stressed material is exposed to a solvent or to solvent vapors. Most of the cements described in this manual may craze Plexiglas® acrylic sheet if used improperly.

Stress may be introduced into a part during the thermoforming operation, or during fabrication operations such as machining or polishing. Stress may sometimes be held to a minimum by altering the processing conditions when forming parts, and by using sharp tools of the recommended types when cutting or machining. For machining instructions, see page 11.

The possibility of crazing may be greatly reduced by minimizing internal stresses by annealing the parts before cementing. For annealing instructions, see page 30.

Low joint strength may be due to a number of causes. Improper fit of parts, inadequate mixing of the cement, excessive clamping pressures, or poor technique may all help weaken cemented joints. The best way to avoid problems is to follow the recommendations in this manual.

Preparation of the joint is very important when cementing Plexiglas® MC acrylic sheet. The parts must fit accurately and smoothly without force. If the parts do not match or fit well, the edges to be cemented should be machined smooth to fit, but should not be polished, since polishing tends to round edges. Proper preparation of edges is necessary to ensure that little or no internal stress is present in the material. Such stresses will cause crazing on contact with solvent. To prevent crazing, avoid flame polishing and dry belt or disc sanding where solvent contact may occur.

Cementing Plexiglas® Acrylic Sheet to Plexiglas® Acrylic Sheet

Cementing provides a versatile and simple method for joining pieces of Plexiglas® acrylic sheet. Properly cemented assemblies of Plexiglas® acrylic sheet have nearly the appearance of a single piece; however, cemented areas of colored material, especially white translucent colors, may deviate from the original color when the joints are viewed under certain reflected- or transmitted-light conditions.

Cementing permits the manufacture of parts that cannot conveniently be made by other methods because of process limitations (e.g. part size, undercuts), low production volume, or cost. Good cemented joints are also air- and water-tight.

The two types of cement used for Plexiglas® acrylic sheet are solvent cements and polymerizable cements. The solvent cements may be used as supplied, or may be thickened with Plexiglas® acrylic sheet chips or Plexiglas® acrylic molding resin. Polymerizable cements, such as PS-30™ and Weld-On 40™ or 42™, are viscous as supplied.

Solvent cements work by softening and swelling the Plexiglas® acrylic sheet, permitting actual cohesion of the parts. After assembly, the solvents evaporate or dissipate through the material, leaving a hard, clear joint. Thickened solvent cements work the same way, but allow for longer solvent action due to slower evaporation, limit capillary flow between two closely fitted surfaces, and provide limited gap-filling capability. The polymerizable cements have little or no solvent action, but actually form new polymer in the joint, thus holding the parts together.

Both Plexiglas® G and MC acrylic sheets may be cemented with either solvent or polymerizable cements. Generally, however, a polymerizable cement, such as PS-30 or Weld-On 40 or 42, provides better joint strength and appearance.

Any of the unthickened cements may be used if the parts will not be used outdoors. The choice may be governed by the availability of the solvent or by previous experience with a particular cement. (Cement PS-30 or Weld-On 40 or 42 is best for outdoor use, however.)

For names of manufacturers of cements discussed in this manual, call the Altuglas International Polymer Technology Center at 800-217-3258 your local Plexiglas® acrylic sheet distributor, or one of the Sales Offices listed at the back of this manual.

Solvent Cements

Depending on technique, cast acrylic surfaces to be joined are softened, and in some cases swollen into a cushion, by contact with commercially available solvent cements. Plexiglas® MC acrylic sheet should not be soaked in cement as long as Plexiglas® G acrylic sheet, for it tends to dissolve rather than swell into a cushion.

Since solvents evaporate at different rates, the composition of cements made from a mixture of several solvents should be periodically checked to maintain correct proportions. In many cases, checking the specific gravity with a calibrated hydrometer may be adequate.

The surfaces to be cemented may be left as cast, sanded (either wet or by hand), scraped, or machined according to methods described in Machining Plexiglas® Acrylic Sheet, page 11. The edges to be cemented should not be polished, as this may cause crazing when the cement contacts the edges. The pieces should fit accurately without forcing or flexing. Well-fitted parts produce stronger joints.

If a part is to be immersed in solvent, the softening action of the cement must be confined to the area of the joint by masking the surrounding Plexiglas® acrylic sheet. Tapes, gelatin solutions, or commercially available masking compounds that are impervious to the action of the cement, and do not affect the hardening or color of the cement, may be used to mask the material. The part to be masked is coated with the mixture, so a fairly thick film adheres to it. The coated piece is hung until it cools and dries. When the film is no longer tacky, it is stripped from the areas to be cemented with a razor, taking care to avoid scratching the surface of the plastic. The edge of the part is then soaked and assembled, and the remaining film is stripped from the material. The glue may be reused several times.

The temperature and humidity conditions in the cementing room, and the temperature of the parts to be cemented are important. Unthickened cements should not be used at temperatures below 65°F. Low temperatures reduce the solvent action and increase the soak time, increasing the possibility of crazing. Adding 10 percent diacetone alcohol to the solvent cement will reduce blushing in humid conditions.

Thickened Cements

Thickened solvent cement is made by adding clean Plexiglas® acrylic sheet chips or Plexiglas® acrylic molding resin to a solvent to produce a syrupy cement that can be applied like glue. Plexiglas® VS-100 acrylic molding resin dissolves more readily than other molding resin grades or cast sheet chips, producing a cement with a higher solids content. The solvent in the thickened cement swells both surfaces to be cemented, to permit the formation of the bond. The joint hardens as the solvent evaporates or dissipates through the material. The viscous cement acts as a carrier for the solvent, since the solids content is too low to fill any sizeable voids without developing bubbles. The parts should fit as closely as possible to minimize bubbles and maximize joint strength.

Thickened cement should primarily be used as a perimeter cement. If parts fit well it will run under only $\frac{1}{16}$ inch and give a neat appearance. This should be for indoor use only.

In general, thickened solvent cement produces an inferior joint compared to straight solvent cement in the important areas of strength and appearance. Thickened cements should only be used to minimize run-under by capillary action when perimeter-cementing appliques, to increase solvent attack of a solvent-resistant material or to join two parts that cannot be feasibly made to fit closely. If the part to be cemented requires soaking in a tray or on a saturated pad of solvent cement, limit the soak time to $1\frac{1}{2}$ minutes to obtain the best joint appearance (minimal squeeze-out) and optimum set time.

If areas are cemented, they should be small – large areas show many bubbles when dry. Large areas may require eight hours or more to dry.

Polymerizable Cements

Polymerizable cements are those in which a catalyst is added to an already thick monomer/polymer syrup to promote rapid hardening. Cements PS-30 and Weld-On 40 or 42 are polymerizable cements of this type. They are suitable for cementing all types of Plexiglas® acrylic sheet. At room temperature, the cements harden (polymerize) in the container in about 45 minutes after mixing the components. They will harden more rapidly at higher temperatures. The cement joints are usually strong enough for handling one to two hours after assembly depending upon part configuration. The joints may be machined four hours after assembly, but it is better to wait 24 hours.

PS-30 and Weld-On 40 or 42 joints retain excellent appearance and color stability after outdoor exposure. These cements produce clear, transparent joints and should be used when the clarity and appearance of the joints are important.

PS-30 and Weld-On 40 or 42 should be used at temperatures no lower than 65°F. If cementing is done in a room cooler than 65°F, it will require a longer time to harden and the joint strength will be reduced. The cement should be prepared with the correct proportions of components (preferably fresh) as given in the supplier's instructions and thoroughly mixed, making sure neither the mixing container nor mixing paddle adds color or affects the hardening of the cement. Clean glass or polyethylene mixing containers are preferred. Table 4, page 23, summarizes these procedures.

PS-30 may be thinned by adding up to 25 percent MMA inhibited monomer to Component A to minimize bubbles when laminating. Up to twice the normally recommended amount of Component B may be used to increase the polymerizing rates.

Adding about 10 percent (by weight) Plexiglas® VS-100 acrylic molding resin will reduce shrinkage of the cement during polymerization, but also decreases joint strength slightly. The pellets must be thoroughly dissolved before mixing the components.

Because of their short pot life (approximately 45 minutes), Cement PS-30 and Weld-On 40 or 42 must be used quickly once the components are mixed. Time consumed in preparation shortens the effective working time, making it necessary to have everything ready to be cemented before the cements are mixed. For better handling, pour cement within 20 minutes of mixing.

For maximum joint strength, the final cement joint should be free of bubbles. It will usually be sufficient to allow the mixed cement to stand for 10 minutes before cementing to allow bubbles to rise to the surface.

To remove the bubbles quickly, spin the cement with an electric drill. This is done by drilling a hole in the center of a metal jar cap and placing a bolt through it, then placing a nut on the outside. This bolt is gripped by the chuck of an electric drill. Screw jar into cap and spin cement for one minute. This is for up to 6-ounce jars only. For large sizes, a centrifuge that contains the jar should be used.

The gap joint technique should only be used with colorless Plexiglas® acrylic sheet, or in cases in which joints will be hidden, or when light leaks are not a problem. Inconspicuous joints in colored sheet are difficult, if not impossible, to achieve. Adding acrylic sign paints to Component A can be effective at times, but may adversely affect the joint strength.

Cement forms or dams may be made with masking tape as long as the adhesive surface does not contact the cement. This is most easily done with a strip of tape placed over the masking tape adhesive. The tape must be chosen carefully. The adhesive on ordinary cellophane tape prevents the cure of PS-30 and Weld-On 40 or 42. Before actual fabrication of parts, sample joints should be tried to ensure that the tape system used will not harm the cement. Since it is important for all the cement to remain in the gap, only contact pressure should be used. Types of joints are shown in Figures 9A, 9B, and 9C (pages 24 and 25). Figure 10 combines the joints into a box construction.

Bubbles will tend to float to the top of the cement bead in a gap joint after the cement is poured. These cause no problem if the bead is machined off. A small wire (not copper), or similar object may be used to lift some bubbles out of the joint; however, the cement joint should be disturbed as little as possible.

Since polymerizable cements shrink as the cement hardens, the freshly poured cement bead should be left above the surfaces being cemented to compensate for the shrinkage. If it is necessary for appearances, the bead may be machined off after the cement has set, as shown in Figures 11 (A and B) and 12 (on page 26).

Figures 13 and 14 (page 27) illustrate two cementing techniques that have proven useful with the furnishings industry. The first shows a thick section butt joint using polymerizable cement, with the thick Plexiglas® acrylic sheet preset into a fixture. The latter Figure shows a system for making inside joints that cannot be routed and finished as described previously.

Procedures for Using Polymerizable Cement

To get good performance from polymerizable cement, the following directions must be closely followed:

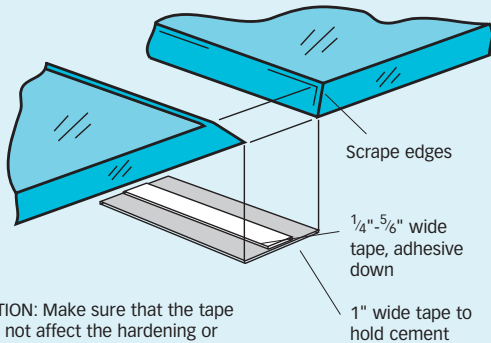
1. If at all possible, store Component B, the catalyst, under refrigeration not below 40°F. If this is impossible, be certain that Component B is stored in a dark place and that it is definitely kept out of direct sunlight. If Component B turns yellow or amber, discard it and obtain a fresh lot from the supplier.
2. When mixing Components A and B, be sure to use clean containers. Make sure that any disposable containers are not lined with a coating that will affect either component. If the container coating is soluble in either of the cement components, it may contaminate the cement and cause improper curing.
3. Both Component A and Component B should be at room temperature at the time of mixing. It may be convenient to remove a one day supply from refrigeration the day before mixing.
4. When Components A and B are combined, be certain that the two components are continuously under agitation for two minutes to insure their complete mixing. Let the air bubbles rise to the surface before using the cement.
5. Combine Components A and B in the ratio of 95 parts Component A to 5 parts Component B, either by weight or by volume. Do not use a mixture containing less than 93 parts Component A or more than 7 parts Component B.

TABLE 4

FIGURE 9A

Open "V" Joint Polymerizable Cementing

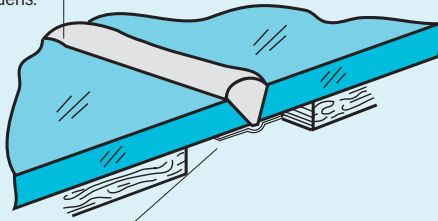
1. Prepare Parts for Cementing.



CAUTION: Make sure that the tape does not affect the hardening or color of the cement.

2. Pour Cement.

Overfill to allow for cement shrinkage as it hardens.



NOTE: Bottom fillet may not require finishing in many applications.

Keep nozzle of dispenser deep in joint to insure complete filling.

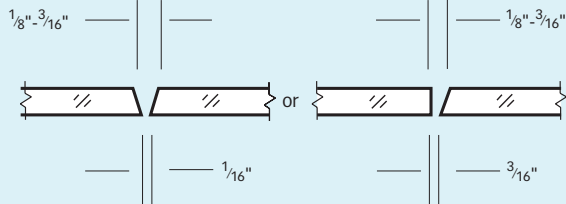
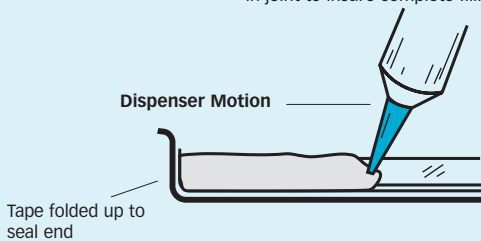
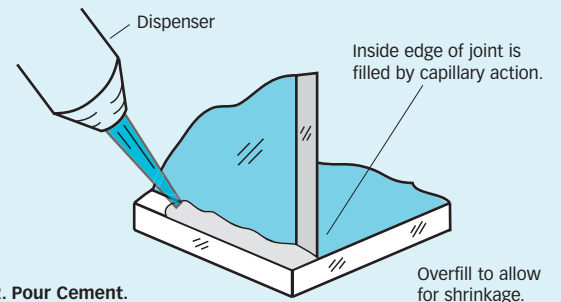
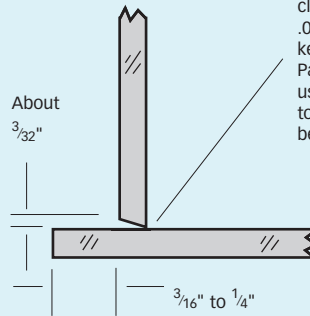


FIGURE 9B

Open "V" Angle Joint Technique

1. Position Parts for Cementing.

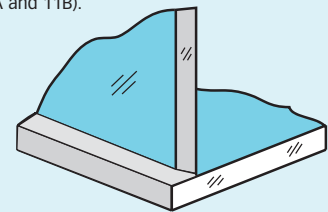
Position pieces with small clearance not greater than .015". This clearance must be kept to prevent a dry notch. Paper, small wire, etc., may be used to position the parts prior to clamping. Remove spacers before cementing.



2. Pour Cement.

3. Allow Cement to Harden.

4. Machine Off Excess Material
(See Figures 11A and 11B).



5. Final Finishing, Sanding, Buffing, etc.

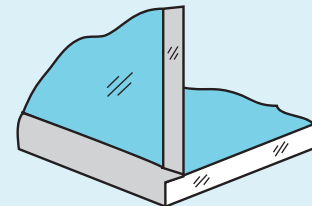
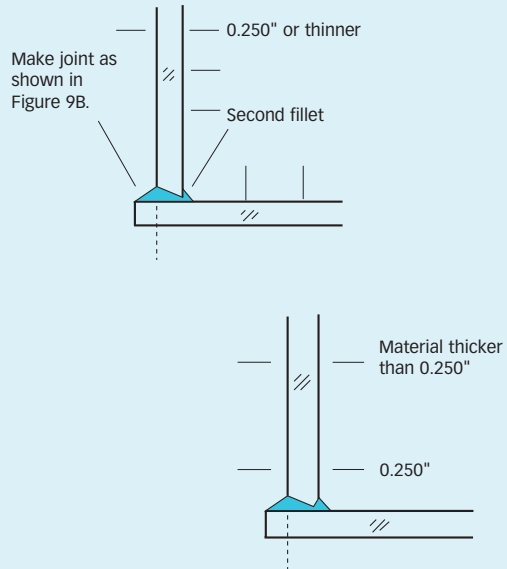


FIGURE 9C

Open "V" Angle Construction Variations

Configuration of joints to be subjected to internal pressure such as by air or water.



Various Angle Configurations

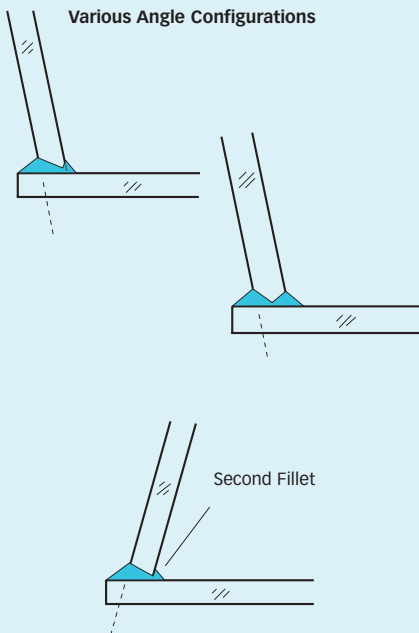
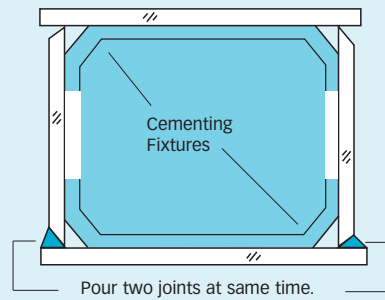
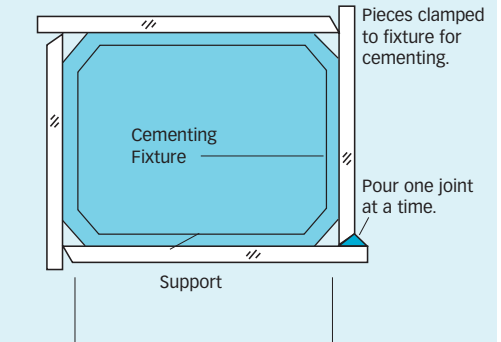


FIGURE 10

Box Construction Using Polymerizable Cement

1. Cement Sides Together.



2. Remove Excess Material From Sides
(see Figures 11A and 11B).

3. Add End.

4. Finish Entire Box.

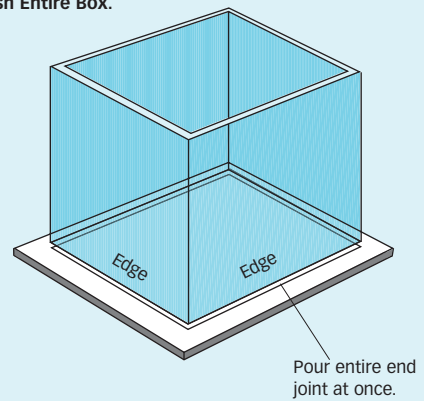


FIGURE 11A

Removal of Cement Bead and Lip-Open "V" Angle Joint

Operation of guide.

Rough cuts to remove excess material.

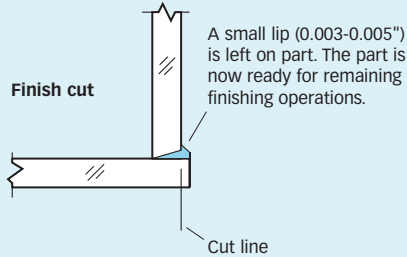
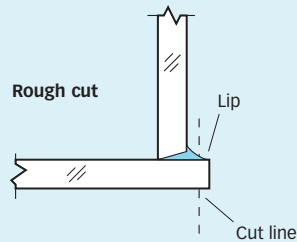
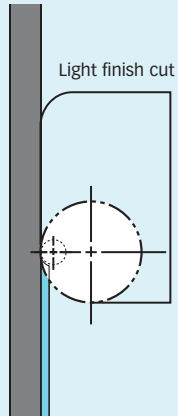
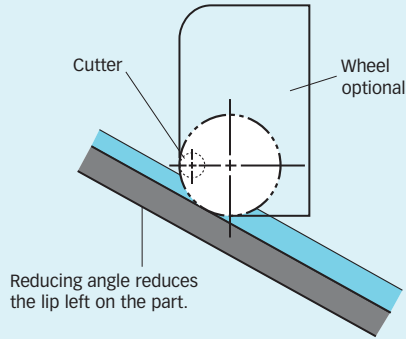
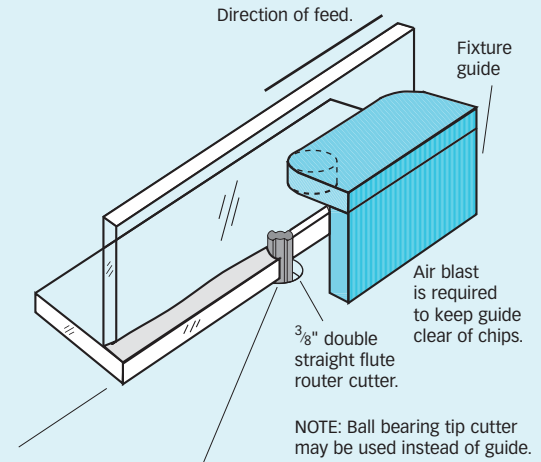


FIGURE 11B

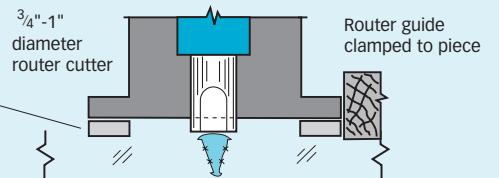
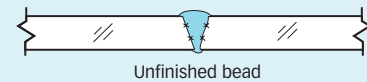
Removal of Cement Bead and Lip-Open "V" Angle Joint



Varying this angle will regulate depth of cut, see Figure 11A.

FIGURE 12

Removal of Cement Bead-Open "V" Butt Joint



Clearance strips made of wood, Polyethylene (slippery), etc. clamped or attached with double-backed tape to piece.

Sand remaining bead and bottom bead with successively finer grits of sandpaper (320 to 600) in preparation for buffing.

Buff sanded beads using technique recommended for finishing Plexiglas® acrylic sheet.

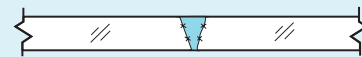
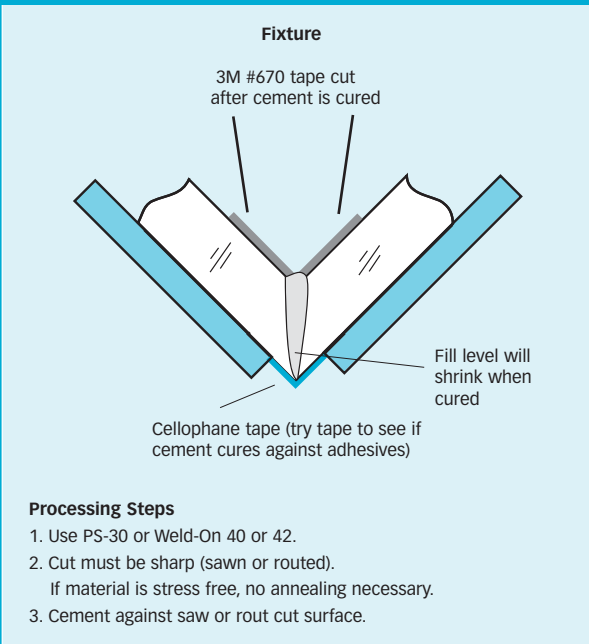


FIGURE 13

Thick Section Butt Joint Techniques



Processing Steps

1. Use PS-30 or Weld-On 40 or 42.
2. Cut must be sharp (sawn or routed).
If material is stress free, no annealing necessary.
3. Cement against saw or rout cut surface.

FIGURE 15

Capillary Action Cementing with Unthickened Cements

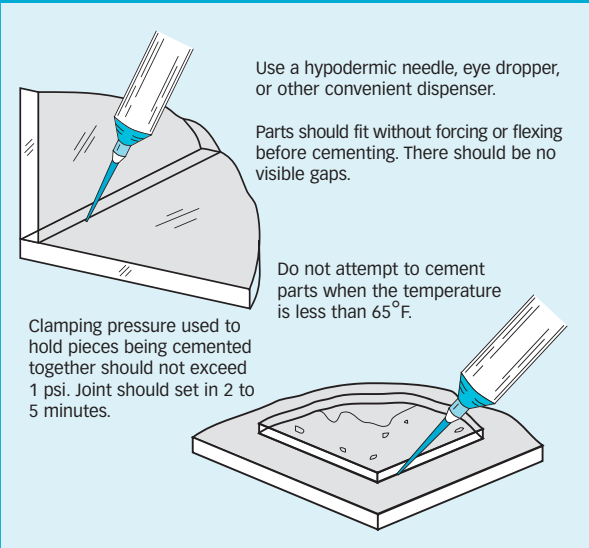
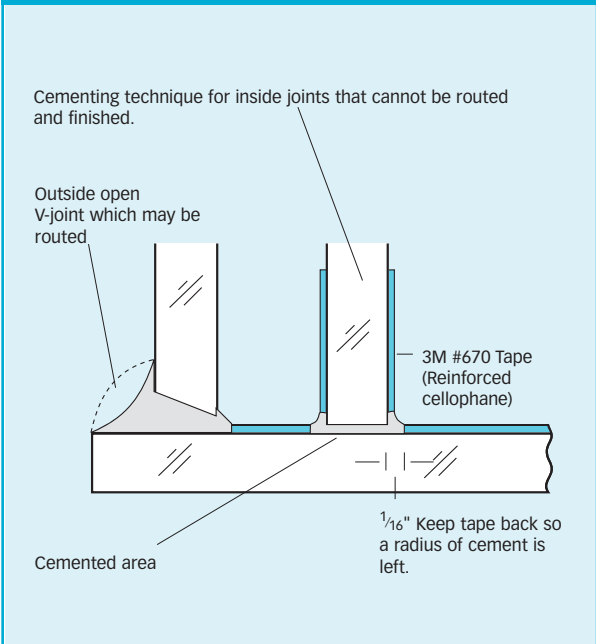


FIGURE 14

Technique for Inside Joints

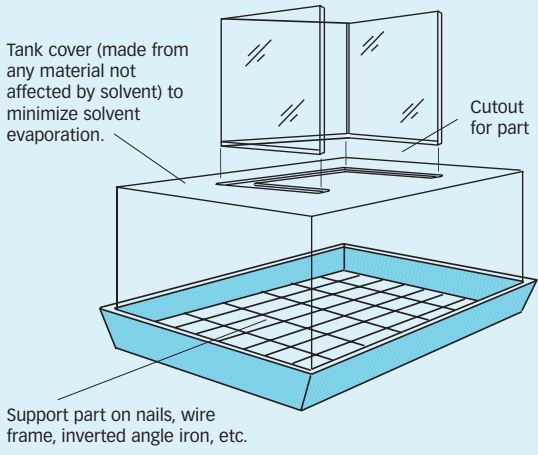


1. Thin PS-30 or Weld-On 40 or 42 15% with MMA.
2. Mix with component "B"— degas cement and pour in area left by #670 tape which is to be cemented.
3. Float vertical piece on cement. (If heavy, support weight with a fixture.)
4. Clean off excess cement with a spatula that has a radius on tip to create a radius of cement.
5. Let cure and cut carefully along tape edge and remove tape.

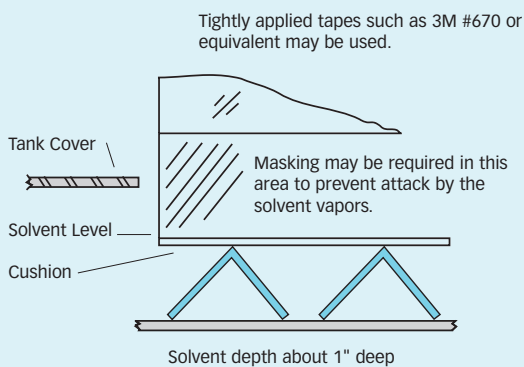
FIGURE 16

Soak or Drip Cementing Techniques

1. Machine pieces with sharp tools so the parts to be joined fit without forcing or flexing. Do not polish edges to be cemented. Apply masking if required.
2. Dip or soak the parts until the desired amount of cushion is obtained.



Soak tank made from any material not affected by the solvent.



Basic Cementing Techniques

The two basic cementing techniques using unthickened cements are:

1. The capillary action method.
2. The soak or dip joint method.

The soak or dip joint method is not recommended for Plexiglas® MC acrylic sheet, because it dissolves rather than softens the sheet.

To use the capillary action method, the parts must be closely fitted, with no visible gaps. The parts to be cemented are either unclamped or very lightly clamped together. The cement is dispensed (from a hypodermic needle, eye dropper or similar instrument) along the edge of the joint. Capillary action draws the cement between the parts. The time for the joint to set will vary from two to five minutes (sometimes longer), depending on the solvent used and temperature and humidity conditions. Figure 15 illustrates this method.

Do not flow or drip solvent cement on a flame-polished laser-cut, strip-heated or dry-belt-sanded surface, since these conditions show the maximum amount of fabrication stress possible in plastic sheet. With Plexiglas® MC acrylic sheet, use a minimum amount of solvent and pressure in the joint, since it is more readily attacked by solvents, resulting in longer set times, lower joint strength, whitening in the joint and increased risk of crazing because the solvent takes longer to evaporate.

In the soak or dip method, the parts must also fit closely. One of the parts is placed in a container holding a solvent cement until the edge softens into a cushion. When the parts are assembled, the cushion from the first part forms a cushion on the other part by solvent action.

Masking may be required near the edges to be cemented, to prevent excessive softening. The parts should be allowed to set for 24 hours before handling. Figure 16 illustrates this method.

Cementing Plexiglas® Acrylic Sheet to Other Materials

Before specifying cementing for attachment of Plexiglas® acrylic sheet to dissimilar materials, the possibilities of mechanical attachment should be carefully evaluated. Properly designed mechanical attachment overcomes the difficulties often encountered with cementing. For some applications, pressure-sensitive, double-faced tape may be suitable for joining Plexiglas® acrylic sheet to other materials.

Satisfactory joints between Plexiglas® acrylic sheet and other plastics and non-plastics are more difficult to make than Plexiglas® acrylic to Plexiglas® acrylic joints and usually give lower joint strength.

In most cases, there is a substantial difference in thermal expansion between Plexiglas® acrylic sheet and non-plastic materials. When joints between dissimilar materials are exposed to rising or falling temperatures, the materials expand and contract by different amounts, placing large stresses on any bond between them. Only cements that remain permanently flexible will continuously withstand these stresses.

When it is necessary to cement Plexiglas® acrylic sheet to non-plastics, the dimensions of the cemented areas should be as small as possible. This is especially true if acrylic is cemented to materials that have much smaller coefficients of thermal expansion than Plexiglas® acrylic sheet does.

If it is unnecessary for the joint to be transparent, many adhesives, such as silicones, polysulfides, and rubber-based adhesives, are available. Most of these adhesives are suitable for outdoor applications.

Table 5, below, gives a partial list of cements suitable for joining Plexiglas® acrylic sheet to other materials.

Joining Plexiglas® Acrylic Sheet to Other Materials

PLEXIGLAS® Sheet Joined to:	Cement or Adhesive (4)	Remarks
Metal (1)	Contact cements, Polysulfide cements	Joint Life is limited. Maximum bonding size is 2 ft. by 2 ft.; not suitable for outdoor use; joint is transparent; joint strength is low.
Rubber	PS-30, Weld-On 40 or 42	Before Plexiglas® acrylic sheet may be joined to rubber with cements that do not attack its surface, it is necessary to treat the rubber with sulfuric acid until the surface face hardens. The rubber is then washed and flexed, breaking the surface into cracks, which provide the means for mechanical adhesion of the cement to rubber.
Wood	PS-30, Weld-On 40 or 42	Suitable for outdoor use; joint is transparent.
Vinyl (2)	PS-30, Weld-On 40 or 42 Cyclohexanone	Suitable for outdoor use; joint is transparent. Not suitable for outdoor use; joint is transparent.
ABS (3)	PS-30, Weld-On 40 or 42, Solvent	Joint is transparent.
Polycarbonate (3)	PS-30, Weld-On 40 or 42, Solvent	Joint is transparent.
Polystyrene, Impact Styrene (3)	Solvent	Joint is transparent.
Styrene Acrylonitrile (SAN) (3)	PS-30, Weld-On 40 or 42, Solvent	Joint is transparent.
Cellulose Acetate Butyrate (CAB) (3)	PS-30, Weld-On 40 or 42, Solvent	
Phenolics	PS-30, Weld-On 40 or 42	

TABLE 5

- (1) Thoroughly clean surfaces of metal with an organic solvent prior to joining.
- (2) Avoid grades containing plasticizers that may migrate through the joint causing crazing of Plexiglas® acrylic sheet.
- (3) These materials are not as durable as Plexiglas® acrylic sheet, when used outdoors.
- (4) Consult the manufacturer or supplier for the appropriate MSDS for each adhesive or cement.

ANNEALING PLEXIGLAS®

ACRYLIC SHEET

Health and Safety Precautions

Annealing Plexiglas® acrylic sheet should not result in the release of harmful concentrations of vapors or gases under the annealing conditions recommended in this manual. However, Plexiglas® acrylic sheet may release high concentrations of vapors and monomers if heated to temperatures in excess of 350°F without adequate ventilation.

The annealing oven should have forced-circulation and should have bleed and makeup vents, so that the air is changed at least twice an hour to remove fumes and cement-solvent vapors. Fumes and cement-solvent vapors should be exhausted to the outdoors. Parts should be heated to and held at the recommended annealing temperatures for the recommended times (see Table 6).

Plexiglas® acrylic sheet is a combustible thermoplastic material. Observe fire precautions appropriate for comparable forms of wood and paper products.

Annealing

Proper annealing is one of the most effective single measures that can be taken to insure good service from parts made of Plexiglas® acrylic sheet.

Annealing consists of prolonged heating of the acrylic part at temperatures lower than those used for forming, followed by slow cooling. Internal stresses set up during fabrication of the article are reduced or eliminated by this treatment. All edges should be cut or machined with as little internal stress as possible. If excessive internal stress is present in the parts to be cemented, crazing will occur during the cementing process. It may be

necessary to anneal the parts to reduce internal stresses set up in the parts during fabrication or thermoforming operations. Annealing results in greater dimensional stability and greater resistance to crazing. Heat treating also improves the strength of certain cemented joints.

To obtain the benefits of annealing, the Plexiglas® acrylic sheet parts must be annealed after all fabrication steps, including polishing, are completed. In addition to annealing after final finishing, machined parts should be annealed before cementing to reduce stress due to machining in the cement joint area.

Determination of Best Annealing Temperature

The optimum temperature for annealing any specific part can best be determined by experimenting with a few samples to find the maximum temperature at which the part can be heated for the times indicated in Table 6 without objectionable deformation. Parts should be annealed at as high a temperature as possible. Annealing at temperatures lower than those listed in Table 6, below, will not give effective relief and redistribution of stresses. Machined Plexiglas® acrylic sheet parts that have not been heated to forming temperature should be annealed with caution in the higher temperature ranges.

The annealing temperature should be approximately 10°F below the minimum temperature at which the part shows deformation of one percent. A greater change indicates that the part has not been properly formed. The fabrication process should be carefully reviewed and revised until the parts will withstand these annealing temperatures. Particular attention should be given to forming temperatures and conditions because parts

Recommended Annealing Times and Temperatures for Plexiglas® Acrylic Sheet

Maximum Thickness (Inches)	Time* (Hours) to Heat Mid-Plane	Heating Time (Hours) in Forced-Circulation Air Ovens Maintained at the Indicated Temperature for Parts Made of Plexiglas® G and MC Acrylic Sheet			
		230°F (110°C)	221°F (105°C)	212°F (100°C)	203°F (95°C)
0.060 to 0.177	1/2	1 1/2	3 1/2	7 1/2	24 1/2
0.236 to 0.354	1	2	4	8	25
0.472 to 0.708	2	3	5	9	26
0.944	3	4	6	10	27
1.500 to 1.750	6	7	9	13	30
2.0	8	9	11	15	32

TABLE 6

* The time required to raise the temperature of the mid-plane to a temperature equal to room temperature plus 99% of the difference between room temperature and annealing temperature.
Notes: (1) Anneal parts at the highest temperature for indicated time. If distortion occurs, try the next lowest temperature.
(2) The cycles given will be satisfactory for most formed parts. For extreme forming, such as 100% biaxial stretching, use lower temperatures.
(3) Air should circulate around each part.

Cooling Times for Plexiglas® Acrylic Sheet Parts (All Formulations)

Maximum Thickness (Inches)	Cooling Rate (°F/Hr)	Time (Hours) to Cool Plexiglas® Acrylic Sheet Parts from the Indicated Temperature to 120°F			
		230°F (110°C)	221°F (105°C)	212°F (100°C)	203°F (95°C)
0.060 to 0.177	140	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$
0.236 to 0.354	54	2	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$
0.472 to 0.708	25	$4\frac{1}{2}$	4	$3\frac{3}{4}$	$3\frac{1}{4}$
0.944	18	6	$5\frac{1}{2}$	5	$4\frac{1}{2}$
1.500 to 1.750	12	9	8	8	7
2.0	10	11	10	9	8

TABLE 7

Notes: (1) Parts are usually held in the forced circulation air oven and the temperature of the oven dropped at the cooling rate.
(2) As in heating, the air should circulate around each part.

allowed to cool too much before forming is completed tend to relax at lower annealing temperatures.

In addition to increased dimensional stability and resistance to crazing, annealing increases the strength of certain cemented joints.

Annealing also lessens the effect of solvent smears and “runs” that may result from errors in cementing. Proper annealing will eliminate any tendency toward immediate crazing or cracking of parts subjected to brief exposure to solvents, e.g., parts that are to be painted. If the solvent makes the Plexiglas® acrylic sheet sensitive to crazing, as do some types of paints, the parts should be annealed after each exposure.

When only surface stresses are present, only the surface needs to be heated. This will greatly reduce annealing times for thick parts.

Drilled holes may be considered a special case of surface machining. Parts with through holes must be placed in the oven so that the air flow is along the hole passage.

Caution: Protective spray masking coatings must be removed from Plexiglas® acrylic sheet parts before they are annealed. If such coatings are not removed prior to annealing, optical distortions may appear in the annealed part in areas where the thickness or surface of the coating is irregular.

Annealing Procedures

Plexiglas® acrylic sheet parts to be annealed should be clean and dry and should be supported so that they are not under stress while being annealed. This is particularly true when clamps are used to hold cemented assemblies together during the annealing or curing period. The weight of the clamps or excessive clamping pressure may set up local stresses, which may warp or even craze the parts unless proper precautions are taken.

Room should be provided between parts to permit free circulation of air. This will avoid traps or pockets of dead air where solvent vapors can settle.

Slow Cooling After Annealing

The rate of cooling must be slower for thick sections than for thin sections. Table 7 lists suitable cooling rates for various thicknesses of Plexiglas® acrylic sheet.

Annealing cycles can be worked out in many ways. Some fabricators allow their forming ovens to cool to annealing temperature near the close of the day's work, place the fabricated parts in the oven and hold them at the annealing temperature for the specified time, then adjust the oven to cool during the night at the specified cooling rate.

MAINTENANCE OF PLEXIGLAS®

ACRYLIC SHEET

Dusting

Always damp dust Plexiglas® acrylic sheet. For best results, mix a solution of one teaspoon of dishwashing liquid, or other mild soap or detergent, and a pint of water; apply this solution to Plexiglas® acrylic sheet with an atomizer or spray bottle and wipe until dry and glossy smooth with a clean cotton flannel or jersey cloth. Do not use dishwashing liquid containing hand lotions, such as aloe or lanolin.

Cleaning

To clean Plexiglas® acrylic sheet, wash with plenty of mild soap or detergent and lukewarm water using the bare hand to feel and dislodge any caked dirt or mud. A soft cloth, sponge or chamois may be used, but only as a means of carrying water to the plastic. Rinse well.

Dry by blotting with a clean damp cloth or chamois. Rubbing a dirty surface with a dry cloth will scratch the material. In addition, rubbing builds up an electrostatic charge on the Plexiglas® acrylic sheet so that it attracts dust particles from the air. Wiping with a damp chamois will remove this charge as well as the dust.

Do not use window cleaning fluids, scouring compounds, leaded or ethyl gasolines, benzene, acetone, carbon tetrachloride, fire extinguisher or de-icing fluid, lacquer thinners, or other strong solvents. To remove tar, grease, paint, etc., use a good grade of VM & P naphtha, kerosene, or other aliphatic hydrocarbon compound.

Polishing

If, after washing, the Plexiglas® acrylic sheet surface shows minor scratches, most can be removed or reduced by application of polish. To apply polishes, use a small pad of soft cotton flannel dampened with water. Rub the sheet along the length of the scratches with a back and forth motion (or use a circular motion). Avoid excess rubbing on any one spot. Several applications may be necessary, but most minor scratches can be reduced and the clarity improved within a relatively short time.

After waxing, wipe with a clean damp cloth to remove static charges that may attract dust particles. Do not use household spray waxes, as many of these contain agents harmful to the surface of Plexiglas® acrylic sheet.

Buffing

Scratches too deep to be removed by the hand application of cleaners are often readily removed by buffing.

Best buffing results are obtained with cotton buffing wheels. There are a number of standard commercial buffing compounds satisfactory for use with Plexiglas® acrylic sheet. These usually consist of very fine alumina or similar "abrasive" in combination with wax, or grease binders and polishing tallow. Both are available in the form of bars or tubes for convenience in applying to the buffing wheel. Such compounds are sometimes referred to as coloring compounds.

If the buffing wheels have been used before, remove any hardened tallow by running them against a sharp metal edge. Start the buffing wheel spinning and touch the stick of tallow to the wheel. Bring a bar of buffing compound in contact with the edge of the wheel for a few seconds. Apply the edge of the spinning wheel to the sheet surface very lightly. Keep it moving over the surface and put only light pressure on the buff. Excessive pressure may heat and soften the plastic. Buff along and across any scratch and continue buffing until scratches have been removed. Finally, remove the buffing compound from the Plexiglas® acrylic sheet with a clean buff and apply a coat of wax.

If scratches are too deep to be removed by buffing alone, it is sometimes necessary to use sandpaper. Sanding should not be used unless some type of mechanical buffing equipment is available, since hand polishing is not sufficiently effective to restore luster to a sanded surface.

Since sanding or excessive buffing may introduce objectionable optical distortion, it may be better to leave in deep scratches.

Sanding

Where sanding must be done, the finest grade sandpaper that will remove the scratch or other defects (no coarser than grade 320) is used first. The paper is wrapped around a hard felt or rubber block and the area rubbed lightly using water, or soap and water, as a lubricant. Abrasive paper should be of the waterproof type. Sand with a free circular motion, using light pressure over the area of the scratch. An area having a diameter two or three times the length of the defect should be sanded in order to minimize local optical distortion. Initial sanding should be followed by similar treatment using progressively finer grades of sandpaper: grade 360A, 400A, and 500 or 600A. Wash the Plexiglas® acrylic sheet after each sanding operation. During each step the scratches left by the preceding grade of abrasives should be removed.

Where a large amount of polishing is undertaken, ashing compounds may be used with power buffing equipment in place of hand sanding.

STORAGE AND HANDLING

Plexiglas® acrylic sheet is shipped in corrugated fiber cartons or in wood-reinforced fiberboard boxes having a gross weight of 400 pounds or more or on pallets weighing approximately 2,000 pounds. All Plexiglas® G and MC acrylic sheets are boxed in standard packages. The number of sheets in each package depends on the size and thickness of the sheets.

Containers should be handled carefully to prevent damage to the Plexiglas® acrylic sheet. When possible, forklift trucks should be used to move containers. Otherwise a special hand truck can be constructed or purchased to facilitate safe and economical handling of cases of Plexiglas® acrylic sheet.

Storage areas should be well ventilated. Air should circulate freely and should be relatively moist and cool. The temperature should not exceed 125°F. If Plexiglas® acrylic sheet is stored in a hot, dry environment or for extremely long periods of time indoors, the adhesive on the masking paper may eventually dry out, making it difficult to remove. Excessive moisture may cause the paper to deteriorate and reduce its effectiveness for protecting the plastic.

Storage areas for Plexiglas® acrylic sheet should be completely separated from spray painting booths and other possible sources of solvent vapors that may attack and soften the surface of the material.

Plexiglas® should never be stored outdoors. Packages of Plexiglas® acrylic sheet should be stored on edge at a 10° angle from the vertical. Two-by-three inch wood strips placed on the floor about 42 inches apart will keep package edges off the floor and facilitate handling with forklifts or hand trucks.

Formed sections of Plexiglas® acrylic sheet must be stored in relatively cool areas. If the parts are to be stacked, they must not be nested, but should be placed in simple frames or racks that fully support the parts so that they will not deform.

Masked Sheets

Plexiglas® G and MC acrylic sheets are supplied with either paper or polyethylene masking. Paper masking may be difficult to remove if stored for extended periods of time.

The masking helps prevent accidental scratching during normal handling and fabrication operations, and should be kept in place for most cutting and machining procedures. Although the masking provides a significant degree of protection against surface marring, the fabricator should avoid sliding the sheets over each other or across rough or soiled surfaces.

Paper masking should be removed from both sides of the sheet before it is thermoformed.

Masked pieces of Plexiglas® acrylic sheet are best stored on edge in A-frame storage racks. Typically these racks are constructed of plywood and slotted angle iron. The supporting floor of each partition is ½ inch thick plywood. The floor panel may be covered with galvanized sheet metal for increased wear resistance. The rack's A shape equalizes the weight and eliminates stresses on building walls.

These racks give full support to the sheets yet permit easy removal of individual sheets from any rack.

If masked sheets must be stored flat, avoid trapping chips and dirt between the sheets. Such chips and dirt may scratch or press into the surface of the material. Plexiglas® acrylic sheet should not be piled more than 18 inches high. Small sheets should be stacked on top of the larger ones to prevent unsupported overhang.

It is good practice to store sheets of similar formulation, color, and thickness together. Mark this and other pertinent information on the masking of sheets that have been cut so they can be identified when needed.

The adhesion of masking paper on the Plexiglas® acrylic sheet may increase over time, making it difficult to unmask. Use older stock first. Newly received sheets should be placed behind the older sheets in the storage bins.

The masking paper used on Plexiglas® acrylic sheet is not water repellent. If masked Plexiglas® acrylic sheet is soaked with water, a white residue may be left on the material when the masking paper is removed. To avoid this, store masked sheet where it cannot come into contact with water. If a residue is deposited on the Plexiglas® acrylic sheet, it may be removed by wiping the surface gently with a clean, soft, damp cloth and drying it with a soft flannel cloth.

Unmasking

Plexiglas® acrylic sheet can be unmasked by lifting the masking paper along one edge and rolling it around a dowel or cardboard tube. The paper may be built up on the dowel or tube in successive layers using the adhesive layer to secure the turned up edge of the masking to the paper-covered dowel. Remove all residual adhesive from the sheet surface at the time of masking removal. Any residue that remains can be cleaned off by wiping with a soft clean cloth dampened with isopropyl alcohol.

Unmasking usually builds an electrostatic charge on the Plexiglas® acrylic sheet. The electrostatic charge attracts dust and lint to the acrylic surface. Eliminate the charge by wiping the sheet with a dampened cloth after unmasking. During dry weather, wet down the shop floor occasionally to minimize dust.

For operations such as a strip heating, cementing, or applying glazing sealants, only the masking paper in the area being worked on should be removed from the sheet. When cutting out small sections of masking paper, take care not to score or scratch the Plexiglas® acrylic sheet surface underneath. Scoring the sheet may reduce its impact resistance.

Special tools can be employed to minimize the possibility of scoring or scratching the Plexiglas® acrylic sheet when removing small masking sections (contact Altuglas International for information on commercial tools and materials for Plexiglas® acrylic sheet). When used properly in combination with a suitable solvent, these tools will not score or scratch the sheet.

Masking paper may be difficult to remove in the following circumstances: 1) Plexiglas® acrylic sheet that has been stored outdoors and exposed to sun and moisture; and 2) sheet has been stored indoors for lengthy periods or has been exposed to heat or high humidity. When the sheet will be thermoformed, and the masking paper is not adhering too tightly, flash heating the sheet for 60 seconds at 350°F will loosen the paper enough for easy stripping.

In cases where the paper is sticking more tenaciously, it may be necessary to choose a more aggressive solvent to loosen the masking paper. In such cases, thoroughly soak the masking paper with the solvent, and allow at least 10 minutes for the solvent to penetrate the paper. Strip as described above. If necessary, apply more solvent along the separation line between the masking paper and the Plexiglas® acrylic sheet.

Use only solvents that will not attack the Plexiglas® acrylic sheet. A list of recommended solvents for removing masking paper is available from Altuglas International. Remove the solvent from the Plexiglas® acrylic sheet as soon as possible by first washing the sheet with isopropyl alcohol, then with soap and water and, finally, with clear water.

Before attempting to remove tightly adhering masking with solvents, become familiar with the properties of the appropriate solvents and take proper safety precautions. Obtain Material Safety Data Sheets from the manufacturer. Ventilate the work areas as OSHA requires, and prohibit smoking or open flame.

Unmasked pieces of Plexiglas® acrylic sheet should be stored in the original shipping cases. Full cases can be stored on edge. Open cases can be stored flat or they can be placed on edge in roller-type racks. Uncased sheets may be stored in A-frame racks. The interleaving tissues should not be removed until the sheets are used.

Remasking

The masking paper used on Plexiglas® acrylic sheet will regain its tack and may be replaced if desired. The adhesive bonds firmly to itself, however, so the coated sides of the masking paper must not be allowed to contact each other. The masking paper can be rolled up in loose tubes and stored on pegs in a clean, dry area. Take care to avoid contaminating the masking paper with dirt to keep from scratching the Plexiglas® acrylic sheet when the masking paper is reapplied.

Prepared masking papers are available from a number of sources and may be used for remasking. Before using one of these products, however, check its adhesive to be sure it will not attack the Plexiglas® acrylic sheet.

Protective Coatings

Masking compounds are available that can be sprayed on the Plexiglas® acrylic sheet and later peeled off. These are especially useful when remasking formed parts.

The spray masking compounds should not have a harmful chemical action on the Plexiglas® acrylic sheet. Some masking compounds may be used indoors for periods as long as twelve months. In general, no masking compound should be used on parts that will be stored outdoors.

When using spray masking compounds, apply a coating at least 3-5 mils thick. If the film is too thin, it may be difficult to remove. The film should also be uniform and free from runs and other imperfections.

To remove spray masking from Plexiglas® acrylic sheet, peel it off or lift a corner of the film and blow a jet of compressed air under it. If the film is hard to remove because it was applied too thinly, apply a fresh coating of the masking compound, let it dry, then remove it. In some cases, it might be necessary to apply a layer of cheesecloth over the fresh spray coating and let it dry before attempting removal. The cheesecloth reinforces the spray coating and makes it easier to remove.

Remove protective spray masking coatings from Plexiglas® acrylic sheet parts before the parts are annealed. Otherwise, optical distortions may occur in areas where the thickness or surface of the coating is irregular.

The manufacturers of the protective spray masking should provide the precautions necessary for the safe usage of their products.

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