

PLASKOLITE

OPTIX® ACRYLIC SHEET

FABRICATION GUIDE



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This manual is a general guide for working with PLASKOLITE OPTIX® sheet. Because actual results vary with differences in operating conditions, thickness, color, and composition of the OPTIX sheet, nothing contained herein can be construed as a warranty that PLASKOLITE's OPTIX sheet will perform in accordance with these general guidelines.

Important Notice: Our recommendations, if any, for the use of this product are based on tests believed to be reliable. The greatest care is exercised in the selection of raw materials and in the manufacturing operations. However, since the use of this product is beyond the control of the manufacturer, no guarantee or warranty expressed or implied is made as to such use or effects incidental to such use, handling, or possession of the results to be obtained, whether in accordance with the directions or claimed so to be. The manufacturer expressly disclaims responsibility. Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing laws and/or patents covering any material or use. Anyone experiencing problems fabricating OPTIX sheet should refer those questions to the PLASKOLITE Inside Sales Department. This manual does not constitute an offer to sell by the Company. The Company sells ONLY under its current Terms and Conditions of Sale, which appear on its Acknowledgements and invoices. A current copy of the Company's Terms and Conditions of Sale will be supplied upon request. The details provided are believed to be accurate at the time of publication; however, no description is a warranty that the product is suitable for any application. THE COMPANY MAKES NO WARRANTIES, AND UNDERTAKES AND ACCEPTS NO LIABILITIES, EXCEPT ONLY AS SET FORTH IN ITS CURRENT TERMS AND CONDITIONS OF SALE.

Introduction

ACRYLIC CLASSIFICATIONS

PLASKOLITE is uniquely positioned to manufacture all three types of acrylic for any of your applications.

We offer excellent solutions for all acrylic projects.

Continuously processed (extrusion and OPAT)

Acrylic sheet made by extrusion process or specialized PLASKOLITE single pass technology. Product has low molecular weight, optical clarity and good craze resistance.



Continuous cast

Acrylic sheet made by polymerizing liquid monomer into PMMA between two highly polished, stainless-steel belts. This is a unique process by which sheet is produced on continuous moving belts. It combines the best properties of extruded acrylic sheet with cell cast sheet. Excellent thickness control, high molecular weight, and better craze resistance.



Cell cast

Acrylic sheet made by pouring liquid MMA monomer between two glass plates surrounded by gasket. They are placed into an oven to complete the process. Product has the highest molecular weight, highest hardness, and best craze resistance of the three types listed.



Typical Properties

OPTIX® Acrylic Sheet

Property	Test Method	Units	Values
PHYSICAL			
Specific Gravity / Relative Density	ASTM D792	-	1.19
Optical Refractive Index	ASTM D542	-	1.49
Light Transmission - Total	ASTM D1003	%	92
Light Transmission - HazeA	STM D1003	%	<2
Sound Transmission	ASTM E90 / E413	dB	27
Water Absorption	ASTM D570	%	0.4
Mold Shrinkage	ASTM D955	mils/in	2-6
MECHANICAL			
Tensile Strength	ASTM D638	psi	11,030
Tensile Elongation - Max.	ASTM D638	psi	5.8
Tensile Modulus of Elasticity	ASTM D638	psi	490,000
Flexural Strength	ASTM D790	psi	17,000
Izod Impact Strength - Notched	ASTM D256	ft-lb./in	0.4
Tensile Impact Strength	ASTM D1822	ft-lb./in²	20
Abrasive Resistance - Change in Haze			
10 cycles	ASTM D1044	Haze %	11.2
50 cycles	ASTM D1044	Haze %	24
200 cycles	ASTM D1044	Haze %	24.9
Rockwell Hardness	ASTM D785	-	M-95
THERMAL			
Maximum Recommended			
Continuous Service Temperature	-	°F	170-190
Softening Temperature	ASTM D1525	°F	210-220
Deflection Temperature			
@ 264 psi (1.8 MPa)	ASTM D648	°F	203
Deflection Temperature			
@ 66 psi (0.45 MPa)	ASTM D648	°F	207
Coefficient of Linear Thermal Expansion	ASTM D696	in/in/°F	3.0 x 10 ⁻⁵
Thermal Conductivity	ASTM C177	Btu-ft/ft²/hr/°F	0.075
Flammability (Burning Rate)	ASTM D635	in/min	1.0
Flammability	UL 94	-	HB
Smoke Density Rating	ASTM D2843	%	3.4
Self-Ignition Temperature	ASTM D1929	°F	833
Flame Spread Index	ASTM E84	-	115
Smoke Developed Index	ASTM E84	-	550

OPTIX® SG Acrylic Sheet

Property	Test Method	Units	Values
PHYSICAL			
Specific Gravity	ASTM D792	-	1.15 - 1.19
Light Transmission- total	ASTM D1003	%	90 - 92
Light Transmission- haze	ASTM D1003	%	<3
Water Absorption	ASTM D570	%	0.4
Mold Shrinkage	ASTM D955	Mils/in	2-6
MECHANICAL			
Tensile Strength	ASTM D638		
SG		psi	11,030
SG05		psi	8,000
SG10		psi	5,600
Tensile Modulus of Elasticity	ASTM D638		
SG		psi	490,000
SG05		psi	340,000
SG10		psi	250,000
Flexural Strength	ASTM D790		
SG		psi	17,000
SG05		psi	12,000
SG10		psi	8,300
Izod Impact Strength - Notched	ASTM D256		
SG		ft-lb./in	0.4
SG05		ft-lb./in	0.7
SG10		ft-lb./in	1.1
Rockwell hardness	ASTM D785		
SG		-	95
SG05		-	68
SG10		-	46
THERMAL			
Maximum Recommended			
Continuous Service Temperature	-	°F	170-190
Softening Temperature	-	°F	210-220
Deflection Temperature			
@ 264 psi (1.8 MPa)	ASTM D648		
SG		°F	203
SG05		°F	194
SG10		°F	185
Coefficient of Thermal Expansion	ASTM D696	in/(in-°F) x 10 ⁻⁵	3.0 - 5.0
Flammability (Burning Rate)	ASTM D635		
SG		in/minute	1.0
SG05		in/minute	1.25
SG10		in/minute	1.97
Flammability	UL 94	-	HB
Smoke Density Rating	ASTM D2843		
SG		%	3.4
SG05		%	8.5
SG10		%	16.5
Self-Ignition Temperature	ASTM D1929	°F	833

DURAPLEX® Sheet

Property	Test Method	Units	Duraplex 30%	Duraplex 50% (SG05)	Duraplex 70%	Duraplex 100% (SG10)
PHYSICAL						
Specific Gravity	ASTM D792	-	1.18	1.17	1.16	1.15
Light Transmission - Total	ASTM D1003	%	92	92	90	90
Light Transmission - Haze	ASTM D1003	%	2	2	<3	<3
Water Absorption	ASTM D570	%	0.3	0.3	0.3	0.3
Mold Shrinkage	ASTM D955	mils/in	3-6	3-6	3-6	3-6
MECHANICAL						
Tensile Strength	ASTM D638	psi	9,000	8,000	7,100	5,600
Tensile Modulus of Elasticity	ASTM D638	psi	376,000	340,000	304,000	250,000
Flexural Strength	ASTM D790	psi	13,690	12,000	10,610	8,300
Izod Impact Strength - Notch	ASTM D256	ft-lb./in	0.6	0.7	0.9	1.1
Rockwell hardness	ASTM D785	-	M-78	M-68	M-59	M-46
THERMAL						
Deflection Temperature						
@ 264 psi (1.8 MPa)	ASTM D648	°F	198	194	190	185
Coefficient of Thermal Expansion	ASTM D696	in/in/°F	3.5 x 10 ⁻⁵	4 x 10 ⁻⁵	4.5 x 10 ⁻⁵	5 x 10 ⁻⁵
Flammability (Burning Rate)	ASTM D635	in/min	0.85	1.25	1.53	1.97
Flammability	UL 94	-	HB	HB	HB	HB
Smoke Density Rating	ASTM D2843	%	5.2	8.5	11.5	16.5
Self-Ignition Temperature	ASTM D1929	°F	>850	>850	>850	>850

Typical Properties

OPTIX® L Continuous Cast Acrylic Sheet

Property	Test Method	Units	Values
PHYSICAL			
Specific Gravity	ASTM D792	-	1.19
Optical Refractive Index	ASTM D542	-	1.49
Light Transmission- total	ASTM D1003	%	92
Light Transmission- haze	ASTM D1003	%	<1
Water Absorption	ASTM D570	%	0.2
MECHANICAL			
Tensile Strength	ASTM D638	psi	11,000
Tensile Modulus of Elasticity	ASTM D638	psi	465,000
Flexural Strength	ASTM D790	psi	14,700
Flexural Modulus of Elasticity	ASTM D790	psi	461,000
Izod Impact Strength - Milled Notch	ASTM D256	ft-lb./in	0.32
Compressive Strength	ASTM D 695	psi	83,300
Shear Strength	ASTM D732	psi	11,200
Rockwell hardness	ASTM D785	-	M-100
THERMAL			
Maximum Recommended Continuous Service Temperature	-	°F	175
Deflection Temperature @ 264 psi (1.8 MPa)	ASTM D648	°F	200
Coefficient of Linear Thermal Expansion	ASTM D696	in/in/°F	3.5 x 10 ⁻⁵
Thermal Conductivity	ASTM C177	Btu-ft/ft ² /hr/°F	0.12
Flammability (Burning Rate)	ASTM D635	In/min	1.18
Flammability	UL 94	-	HB
Smoke Density Rating	ASTM D2843	%	13.5
Self-Ignition Temperature	ASTM D1929	°F	750
Flame Spread Index	ASTM E84	-	110
Smoke Developed Index	ASTM E84	-	530
ELECTRICAL			
Dielectric Constant @ 1 KHz	ASTM D150	-	3.0
Dielectric Constant @ 1 MHz	ASTM D150	-	2.7
Dielectric Strength	ASTM D149	V/mil	354
Volume Resistivity	ASTM D257	Ohms/cm	>3.91 x 10 ¹⁵

OPTIX® Cell Cast Acrylic Sheet

Property	Test Method	Units	Values
PHYSICAL			
Specific Gravity / Relative Density	ISO 1183-1	-	1.19
Haziness	ISO 14782	%	0.5
Refractive Index	ISO 489	-	1.49
Water Absorption	ISO 62	%	0.5
MECHANICAL			
Tensile Strength	ISO 527-2/1B/5	MPa	78.1
Tensile Elongation	ISO 527-2/1B/5	%	4.2
Tensile Modulus of Elasticity	ISO 527-2/1B/1	MPa	3065
Bending Strength	ISO 178	MPa	127.8
Bending Modulus	ISO 178	MPa	3610
Impact Strength			
Izod - Unnotched	ISO 180/U1	kJ/kg	14.8
Izod - Notched	ISO 180/A1	kJ/kg	1.7
Charpy - Unnotched	ISO 179-1 FU	kJ/kg	19.8
Charpy - Notched	ISO 179-1 EA	kJ/kg	1.4
Rockwell Hardness	ISO 2039-2	M scale	103
THERMAL			
Vicat Softening Temperature	ISO 306	°C	min. 110
Coefficient of Linear Thermal Expansion	ISO 11359-2	mm/m/°C	7 x 10 ⁻⁵
Bending Temperature Under Load	ISO 75-2/A	°C	104.6
Size Change with Heating	Annex A	%	2.4

OPTIX Grade	Key Product Features	Typical Applications
General Purpose*	Clear and colors, weather resistant, good alternative to glass, easy to fabricate and form	Lighting, signage, picture framing, glazing, transportation, POP display
95*	Translucent matte finish one side, resistant to smudge and fingerprints, easy to fabricate and form	Room/office partitions, pantry/cupboard doors, signage and POP displays
99*	Ultra-light matte, minimizes unwanted glare, shatter resistant	Ideal for glazing, signage and POP displays
Non-glare Heavy Matte*	Non-glare translucent heavy matte, shatter resistant and lightweight	Signage, silk-screening and POP displays
Non-glare Light Matte*	Non-glare translucent light matte, shatter resistant and lightweight	Interior/exterior glazing, signage, silk-screening and POP displays
Patterned*	Adobe and Haircell patterns, translucent, interior and exterior applications	Shower doors, displays, indoor/outdoor furniture and home furnishing
Duraplex*	3 levels of impact strengths (low, medium, high), superior optical properties and UV stability, easy to fabricate and form	Indoor and outdoor displays, skylights, signage, replacement windows
Thin*	Crystal clear, strong and engineered for electronic applications	Electronics
Thick*	Crystal clear, impact resistant, clear and colors	POP displays, furniture, architectural glazing
NB*	Block traffic noise, UV stable, extremely weatherable, high impact strength, high clarity	Highway noise barriers
SG*	Sheet and reels, excellent forming, high optical clarity and superb weatherability, available in 3 impact strengths	Interior and exterior signages, POP displays, skylights
LD*	Superior diffusion, easy to fabricate and form, exceptional UV stability, visible hot spots eliminated	Signs, interior and exterior displays
UVF*	Enhanced ultraviolet filtering, absorbs up to 98% of damaging UV, high optics, weather and impact resistant	Lighting, POP displays, picture frames, artwork, glazing, transportation, signage
LED Lighting*	Superior optics, easy to fabricate and form, exceptional UV stability	Interior and exterior signage, lighting fixtures, retail displays
LED Lighting* Impact Modified	High impact strength, superior optics, easy to fabricate and form, exceptional UV stability	Interior and exterior signage, lighting fixtures, retail displays,
DA*	Optimal adhesion of UV curing inks, specially formulated for printing	Interior and exterior, signage, graphics, dry-erase boards
E-DA*	Abrasion and chemical resistant, optimal adhesion of UV curing inks, specially formulated for printing, erasable	Signage, graphics, dry-erase boards
AMGARD*	Antimicrobial protection, half the weight of glass, easy to fabricate and clean	Protective barriers, office partitions, safety enclosures, equipment housings
AMGARD* SR	Scratch resistant, antimicrobial protection, chemical resistant, half the weight of glass, easy to fabricate and clean	Protective barriers, office partitions, safety enclosures, interior windows and glazing
L**	High clarity, exceptional UV, superior craze and chemical resistance, easy to fabricate and form	Furniture, cosmetic displays, interior partitions, signage
Black/White**	Appears black during the day and illuminates white, red, green, blue or other colors at night depending on the color of LEDs used	Same-sign night or day applications, displays, lighting fixtures
Block***	Optimized light transmission, interior or exterior, lightweight	Signage, display
Ecoshade**	Reflects more than 75% infrared radiation, reduces heat gain and loss	Skylights, windows, doors and partitions
Edge Lit**	Light diffusion technology when used with Neon, Fluorescent, and LEDs	ADA compliant signs, display, lighting fixtures, wayfinding, frame signage
Frame**	100% guarantee no black speck contamination, easy to fabricate and form, interior/exterior	Framing solutions for museums, public buildings and private showcases
Museum Grade**	Filters out 98% damaging UV light, meets museum standards, 100% guarantee no black specks, superior optics, uniform thickness	Exhibit display cases
MYST**	Frost look permanently infused in sheet, maintains frost look during processing	Advertising display, corporate identity, tradeshow exhibits, interior design, POP display, store fixtures and solid surfaces
UTRAN**	Transmits UV light down to 289nm, high gloss surface easy to clean and keep sterile, easy to form and is impact resistant	Indoor tanning beds, animal habitats, greenhouses



Chemical Resistance

Chemical Resistance

NO ATTACK

Alum, Ammonium
Alum, Potassium
Aluminum Fluoride
Aluminum Sulfate
Ammonia Gas
Ammonium Carbonate
Ammonium Chloride
Ammonium Hydroxide
Ammonium Phosphate
Ammonium Sulfate
Antimony Trichloride
Barium Chloride
Barium Hydroxide
Barium Sulfide
Battery Acid (10%)
Benzoic Acid
Boric Acid
Calcium Hypochlorite
Carbonic Acid
Citric Acid
Copper Chloride
Detergent Solution
Diesel Oil
Diethylene Glycol
Ethylene Glycol
Fatty Acids
Ferrous Chloride
Ferrous Sulfate
Magnesium Sulfate
Formaldehyde
Glycerin
Hydrochloric Acid (10%)
Hydrogen Sulfide
Kerosene
Lubricating Oil
Nickel Chloride
Nickel Sulfate
Soap Solution
Sodium Carbonate
Sodium Chloride
Sodium Hydroxide
Sulfuric Acid (10%)
Turpentine
Water (Distilled)

ATTACK

Acetaldehyde
Acetic Acid
Acetic Anhydride
Acetone
Alcohol, Amyl
Alcohol, Butyl
Alcohol, Ethyl
Alcohol, Methyl
Alcohol, Propyl
Ammonia
Amyl Acetate
Aniline
Battery Acid (Conc.)
Benzaldehyde
Benzene
Butyl Acetate
Butyric, Acid
Carbon Tetrachloride
Chloroacetic Acid
Chlorosulfonic Acid
Dimethyl Ether
Dimethyl Formamide
Ethyl Acetate
Ethyl Alcohol
Ethyl Chloride
Ethylene Dichloride
Ethyl Ether
Formic Acid
Gasoline
Hydrofluoric Acid
Isopropyl Alcohol
Lactic Acid
Methyl Ethyl Ketone
Nitric Acid (Conc.)
Sulfuric Acid (Conc.)
Toluene
Xylene



Cleaning Recommendations

Cleaning Recommendations

OPTIX® cleaning instructions

Periodic cleaning of OPTIX and OPTIX L sheet is recommended to prolong the service life of the material. To minimize the risk of damage, use only compatible cleaners and the correct cleaning method.

General cleaning instructions:

- » For dust removal; lightly moisten a soft cotton or fine micro fiber cloth and wipe evenly across the sheet.
Note: Take special care to wipe gently as dust particles can scratch acrylic.
- » The material may be cleaned with mild soap solution, PLASKOLITE Plastic Cleaner or compatible cleaners, along with lukewarm water and light pressure of the cleaning cloth.
- » Rinse with clean water and dry by blotting with a chamois or soft non-abrasive cloth.

Removing heavy oil, grease and tars:

- » Thoroughly pre-rinse with warm water to loosen and wash away surface residue, grit, and grime
- » Gently rub area with a soft non-abrasive cloth and approved cleaners – Follow manufacturers directions outlined on their containers.
- » Rinse with lukewarm clean water to remove cleaning residue

Removing adhesive-backed labels:

- » Vinegar or kerosene will help lift adhesive
- » Immediately rinse thoroughly with clear, lukewarm water
- » To prevent water spots, dry with a soft cloth

Important reminders:

- » Do not clean OPTIX with any cleaners other than those on the approved, compatible list included in this guide, or those tested and found compatible.
- » Do not use abrasive cleaners
- » Do not apply cleaners under direct sunlight or at elevated temperatures
- » Do not use scrapers, squeegees, razors or other sharp instruments as they may permanently scratch OPTIX
- » Dry or gritty cloths may cause scratches on the sheet surface

Removing scratches:

Deep scratches and gouges made by sharp objects such as keys, screwdrivers and knives cannot be repaired. Fine scratches may be reduced in severity or cosmetically hidden by using a plastic scratch remover, such as a NOVUS® branded plastic scratch remover, and a soft flannel pad. When the scratches have disappeared, remove any remaining cleaner and polish.

For deeper scratches: Use wet super or ultra fine (400 grit or higher) sandpaper. Using plenty of water and rinse the sandpaper frequently. Buff with a clean muslin wheel and approved polishing compound.

Polishing gloss surfaces:

- » To protect the gloss surface OPTIX may be polished using a compatible commercially available plastic polishing compound (e.g., NOVUS®). Apply a thin, even coat with a soft non-abrasive cloth. Wipe with a clean damp cloth to prevent dust particles from forming.

A teal-tinted photograph of industrial machinery, likely a lathe or mill. The image is dominated by a large, angled metal component. On this component, there are several safety labels. The most prominent one is a large, white label with black text that reads "CAUTION DISCONNECT POWER BEFORE REMOVING THIS COVER/DOOR". Below this, there is a smaller label that says "DANGER HANDS OUT". Further down, another label with a triangle icon and the word "DANGER" is visible, followed by the text "Keep hands and fingers away". In the bottom left corner, there is a small, partially visible label with the number "3" and some text. The background shows various mechanical parts, including a coiled cable at the top left and a horizontal bar on the right. The overall image has a monochromatic teal color scheme, except for a solid red rectangle on the right side.

CAUTION
DISCONNECT POWER
BEFORE REMOVING
THIS COVER/DOOR

DANGER
HANDS OUT

⚠ DANGER
Keep hands and
fingers away

Fabrication & Machining

Fabrication & Machining

Cutting

OPTIX® sheet products are easily fabricated using standard cutting tools. Carbide tipped cutters are recommended for circular saws and carbide router bits. Always use properly sized cutting tools.

Cooling

Cooling OPTIX sheet can be achieved using compressed air or vortex tube cooled air systems. These systems are clean to operate and easy to maintain. A mist system uses a water-soluble oil to provide blade lubrication and cooling. These systems require more maintenance and the sheet will need to be cleaned after fabrication. Please confirm the oil used is compatible with OPTIX acrylic sheet.

TECH TIP:

Wear eye protection, and ensure equipment has safety guarding. Stock feed rates must be carefully controlled as an excessive rate causes vibration and may crack the part.

Dimensional accuracy

The rate at which OPTIX sheet expands is a movement rate of 0.060" per 12 inches of linear dimensions, over a 70°F temperature change. **Note:** as a general rule, the dimension should always be checked at room temperature.

Protective masking

OPTIX sheet comes with protective masking. This film guards against surface damage during shipment and handling as well as fabrication. This masking should be left on during fabrication.

Masking cannot withstand direct outdoor exposure for prolonged periods and must be removed soon after installation. If not removed, the film will degrade and may become difficult if not impossible to remove. Storing sheets outdoors is not recommend for this reason.

Remove the masking prior to doing any type of heat processing.

SAWING, DRILLING, MILLING & ROUTING

CIRCULAR SAWING

As shown in the accompanying illustration, use a carbide-tipped, circular saw blade with triple-chip tooth design, which cuts clean and lasts longer than high strength steel. Blade is hollow-ground and slotted for expansion and cooling, with a rake angle 0 - 10°, and a clearance angle of 0 - 15°.

The blade cutting speed should be 5000-6000 ft/min, and the table saw setup gap (between saw blade and bed) must be kept to a minimum for clean cuts.

Circular saw blade and cutting	
Cutting speed (rpm)	5000 - 6000
4" Blade	8 - 10 teeth/inch
8 - 10" Blades	6 - 8 teeth/inch

Circular saw troubleshooting

PROBLEM: Melting or Gummed Edges

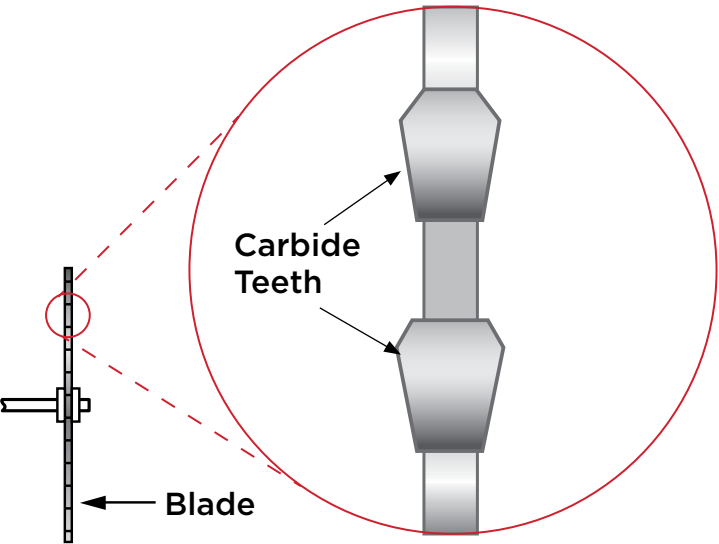
SUGGESTED SOLUTIONS:

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

PROBLEM: Chipping

SUGGESTED SOLUTIONS:

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



Fabrication & Machining

BAND SAWING

Band sawing is preferred for cutting contours and irregular shapes.

General guidelines:

- » Use precision or standard blades for sheet and parts made from thin gauge
- » Use buttress or skip-tooth blades for sheets thicker than 1/8 inch
- » Choose band saw blades with generous set to reduce friction and heat buildup
- » Cool the cut junction with air or a water mist
- » Control the feed rate carefully to prevent binding and gumming
- » Use saw guides whenever possible

Band saw troubleshooting

PROBLEM: Melting or Gummed Edges

SUGGESTED SOLUTIONS:

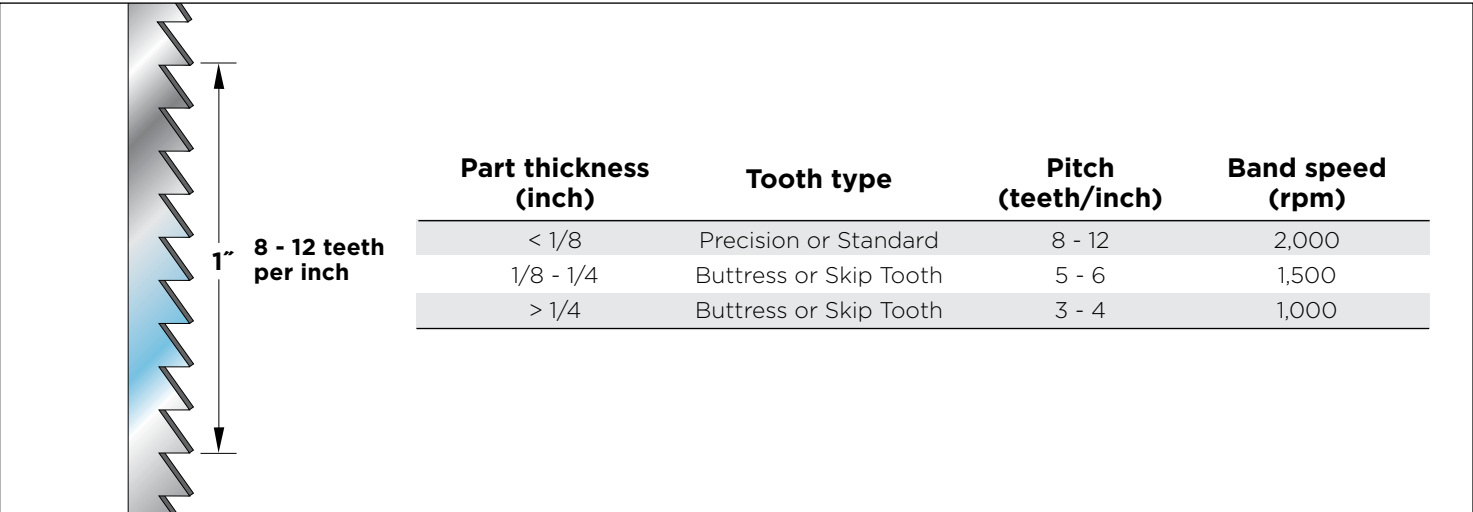
1. Increase blade tooth size
2. Reduce saw speed
3. Use compressed air to cool blade
4. Check blade sharpness

PROBLEM: Chipping

SUGGESTED SOLUTIONS:

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

Band saw blade design



Fabrication & Machining

DRILLING

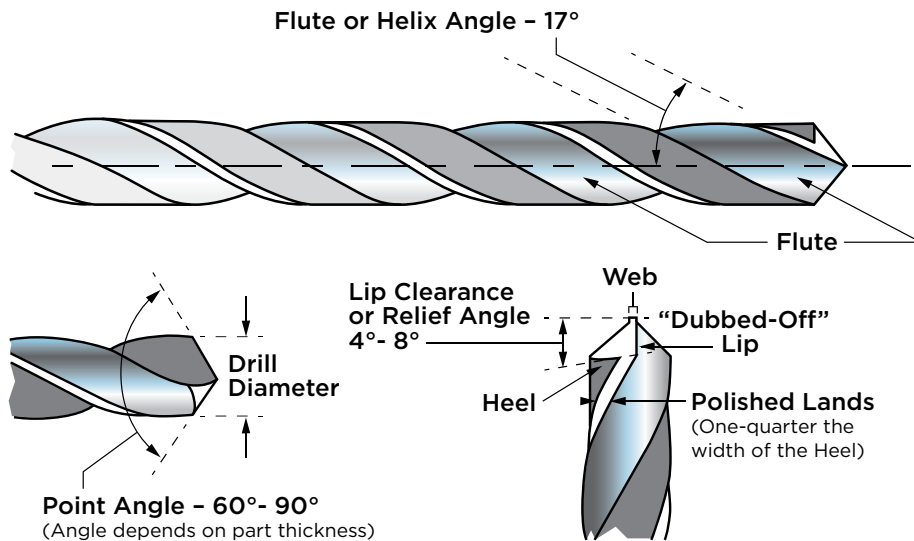
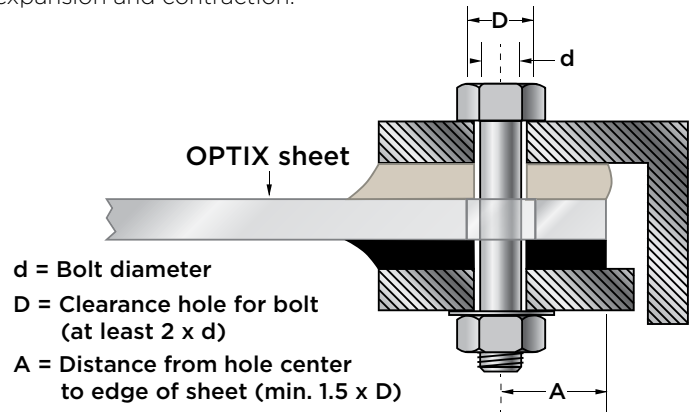
Drilling holes is performed best on a drill press with commercially available plastic cutting drill bits. Standard drill bits can be used, as long as modifications to the bit are performed to allow the bit to scrape rather than cut through the acrylic sheet.

- » Drill point angles typically range between 60 and 90 degrees
- » Drilling speeds range between 700 and 3500 rpm, with lower speeds for thicker sheets.

These conditions produce smooth surface holes with smooth continuous chips. Air or liquid coolants should be used when possible to reduce heat generated. If the depth of hole exceeds the diameter a coolant should be used for any hole $> 0.25"$. In addition, cold air guns are cleaner to use than liquid coolants, however the trickle from the liquid coolants result in better hole finishes. Other compatible solvents are suitable for use.

TECH TIP: When using standard bits, it is recommended to place a second substrate on the back side of the sheet like tape or another section of acrylic for support, so the bit doesn't "blow out" the back when exiting the sheet. This usually works to prevent cracking.

To avoid cracking when using a bolt for installation, drilling distance from edge of sheet should be at least 2 times the diameter of the bolt. The distance from the center of the hole to the edge of the sheet should be at least 1.5 times the diameter of the drilled hole. This will allow adequate space for thermal expansion and contraction.



Common drilling problems and remedies

Description of problem	Probable cause	Remedy
Hole too large	1. Unequal angle on length of cutting edge 2. Burr on drill bit	1. Properly regrind drill bit 2. Properly regrind drill bit
Rough or burred hole	1. Dull drill bit 2. Improperly ground drill bit 3. Too fast feed	1. Regrind properly 2. Regrind properly 3. Reduce feed
Breaking of drill bit	1. Feed too fast in relation to spindle speed 2. Dull drill bit - grabs in work 3. Inadequate chip cleaning	1. Reduce feed or increase speed 2. Regrind drill 3. Check application setup
Chipping of high-speed drill bit	1. Improper heat treatment after regrinding 2. Too coarse feed	1. Follow manufacturers' recommendations 2. Reduce feed

Fabrication & Machining

MILLING

Periphery milling is used to remove large volumes of plastic with relatively high accuracy and precision. Mounted in a drill press, an end mill can remove material with a starting depth of 0.100" of the cut per pass and increase depth of cut to 1/2 - 2/3 of the cutter diameter. Equip machines with vacuum devices or compressed air to clear chips and debris away from the blades and to control heat generation.

Milling OPTIX® sheet typically works best at feed speeds of 5-10 inches/minute and cutting speeds between 100-200 rpm.

Carbide cutters generally provide smoother finish and allow for higher feed rates. Special cutters designed specifically for plastics produce the smoothest finish at the fastest feed rates. Check with your cutter supplier for the latest designs for acrylic.

Consider the following when milling OPTIX sheet:

- » Excessive feed rates can cause chipped edges
- » Insufficient feed rates can generate too much heat and cause part melting
- » Air or water mist help to cool the part to prevent melted edges
- » Improper milling can induce high stress levels causing future problems (ie. crazing or cracking)

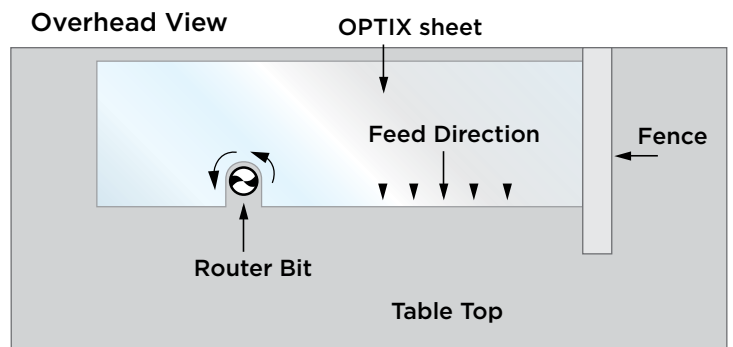
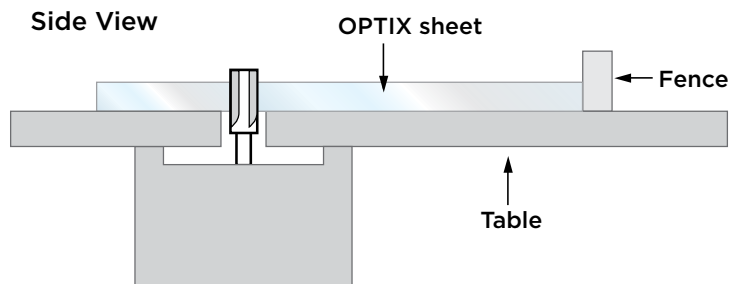
ROUTING

Router cutting produces a smooth edge on OPTIX sheet and easily cuts curved or irregular shapes. Use a recommended router speed of 20,000 to 25,000 RPM with a straight 2 or 3 fluted carbide-tipped or high speed bits with diameters 1/4 inch to 1/2 inch.

A chip load of 0.004" - 0.015"/tooth will create stability better for the cutter and sheet. Typical feed rate for OPTIX sheet is from 100 to 300 inches per minute.

General guidelines for router cutting OPTIX sheet:

Router bit design	
Clearance angle	5 - 10°
Rake angle	0 - 10°
Cutting speed (rpm)	20,000 - 25,000



Important: Feed the sheet against the router bit rotation and use a fence for sizing when making straight, conventional cuts.

Fabrication & Machining

Machining

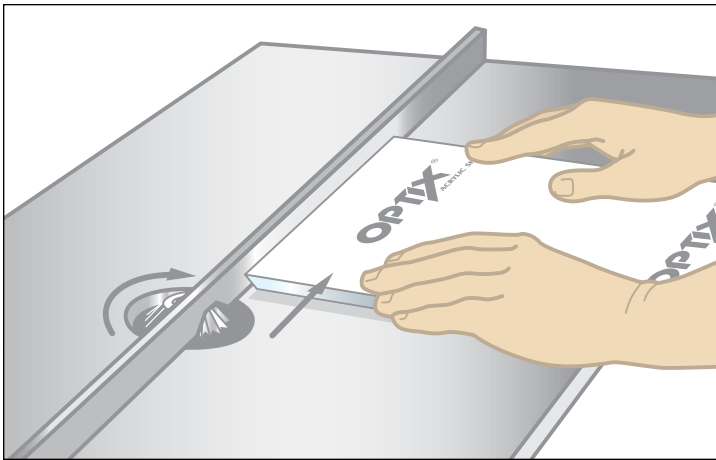
Machining equipment used in fabricating OPTIX® sheet are varied, such as jointers, edge-finishing machines and shapers. Most were originally designed to be used with wood. Use proper cutting tools in good repair to avoid failure of finished part. Confirm with the manufacturer if the machine can be used to fabricate acrylic. The machine should be balanced to avoid vibration and produce clean cuts.

Consider the following when machining acrylic:

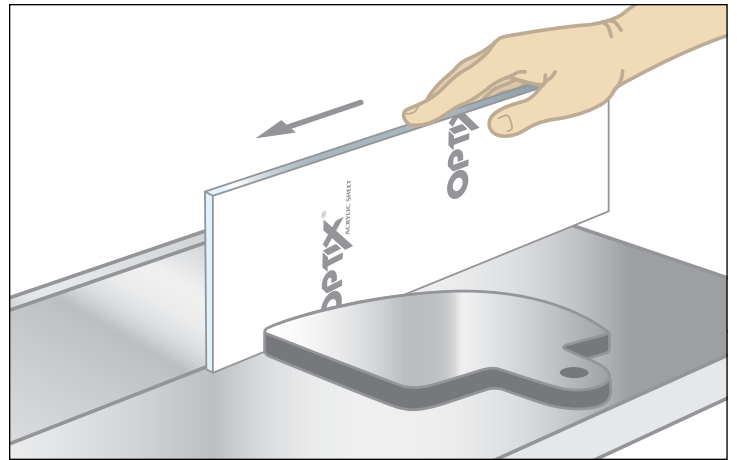
- » Chatter marks can be avoided by reducing feed rate speed
- » To correct vibration, stabilize platform
- » Work with sharp tools, and avoid using tooling for other substrates. For example, do not use the same tooling on acrylic that was previously used on wood.
- » To avoid melted edges, increase feed rate
- » To reduce chip buildup add compressed air, water, mist of emulsion cooling

Machining Edges

Many methods are used to produce a desirable edge finish. Edge finishing machines with diamond cutting wheels, produce an edge with a polished look, excellent for cementing.



Shapers and table routers can machine square, beveled, bull nose, ogee, and other decorative edges.



Jointers are used to square and prepare edges for cementing or hand finishing. Multiple sheets can be stacked to increase efficiency.

Fabrication & Machining

Laser Machining

Laser cutting is best achieved when the correct laser wattage is used. Allow for feed rate to match the thickness of the material, <0.25" at 40 watt and slow feed rate of approximately 20 inches per minute is best. For thicker sheets or faster feed rate a laser with a higher wattage is recommended. For most acrylic sheets, a 180-watt laser is the most economical and provides a clean edge. Check with the laser manufacturer for recommendations on laser etching and cutting acrylic. No laser units perform identically.

Note: different acrylic types require adjustments of laser power and speed.

Summary on laser machining:

- » Increased power of the laser will result in a glossy finish but this may increase stress in the part
- » Laser beams are small bursts not a continuous stream
 - Control pulse rate; proportionally to time and distance
- » Edge stress is always a possibility
 - The highest risk when the sheet is heated and the cut sheet is vulnerable to crazing
- » Adjusting feed and pulse rate and power can minimize stress
- » Always cut the sheet to proper blank size before dot laser etching, otherwise cracking or crazing may occur in the finished part

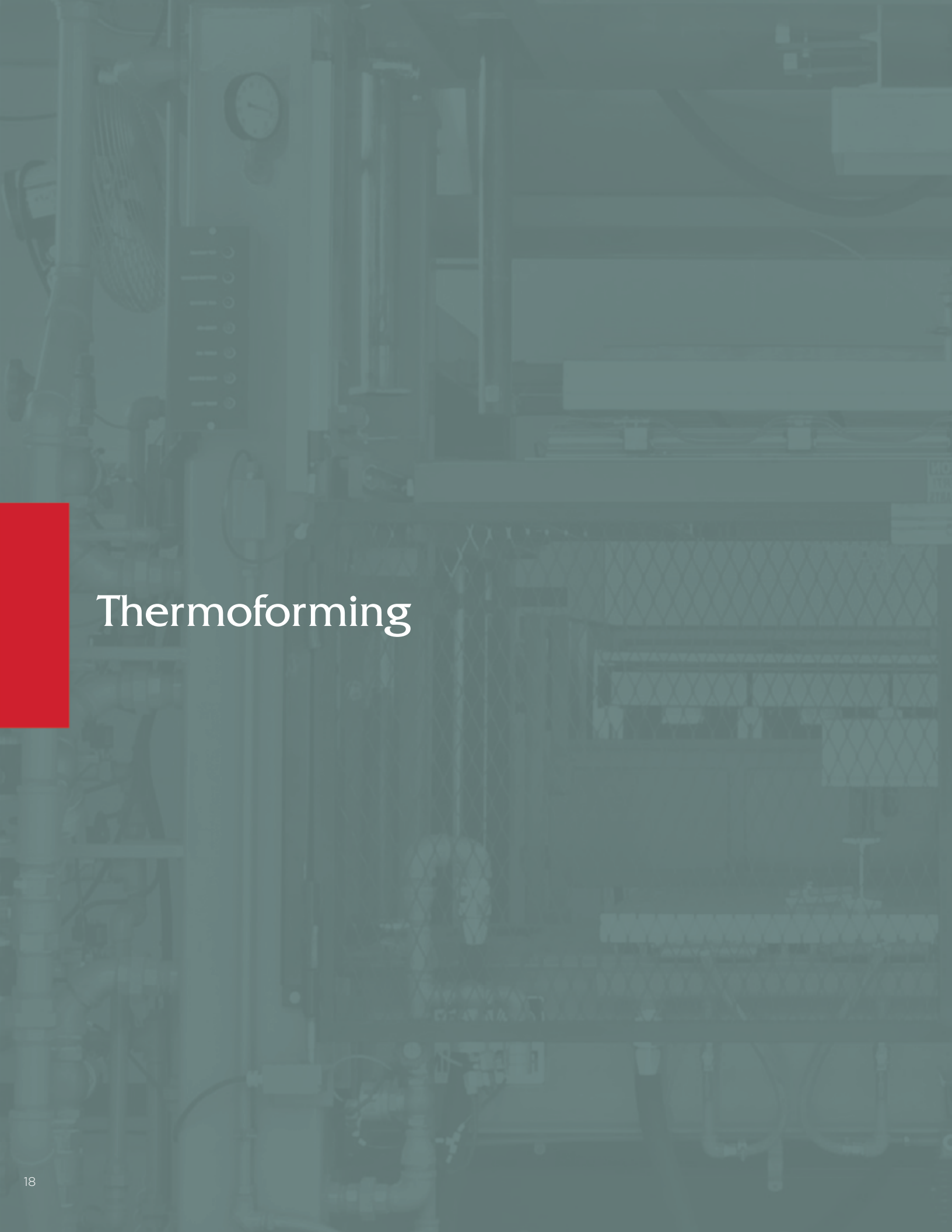
TECH TIP: Laser Fabrication - Please check with laser manufacturer to verify specific laser parameters for etching or cutting acrylics. In general, when cutting thickness is comparable on different lasers, using a larger wattage system will cut the same material at a faster rate.

Laser Wattage	Raster / Vector	Cutting	Cutting vs Thickness Up to...
50	Yes	Yes	0.25" / 6.35mm
100	Yes	Yes	0.50" / 12.7mm
150	Yes	Yes	0.75" / 19mm
200	Yes	Yes	0.75" / 19mm
250	Yes	Yes	1.00" / 25.4mm
400	Yes	Yes	1.00" / 25.4mm

Note: these are approximate parameters and will depend on the application, laser system, and type of acrylic. Be sure to test before starting production and make adjustments to achieve desired results.



TECH TIP: Proper safety glasses are recommended when using lasers. ANSI Standard Z136.1 states that safety eyewear must be labeled with the wavelength and optical density protection factor. Standard safety glasses do not provide the necessary ratings.



Thermoforming

Thermoforming

Thermoforming is a cost-effective and practical processing method for producing three-dimensional shapes from a flat thermoplastic sheet using heat and pressure. Thermoformed parts can be found across transportation, signage, architectural, specialty, and industrial markets. Known for its low tooling cost and moderate equipment investment, thermoforming is most economical where production volumes are 10,000 parts per year or less. It allows for great design flexibility and serves as a practical means for prototyping and pre-production trialing of injection molded applications.

TECH TIP: OPTIX L - With respect to mold temperatures, the key is to have the part set. Having a mold temperature of 130°F is sufficient. In cases where you get “cold-flow” you may want a specific mold area up and around 170°F. Avoid having the mold too hot with temperatures at or above the softening point which could occur around 180°F for OPTIX L.

OPTIX® product	Vacuum forming	Drape forming	Line bending
OPTIX	*	*	*
95 / 99 Textured	*	*	*
Duraplex	*	*	*
NB	*	*	*
SG	*	*	*
Thin	*	*	-
LD	-	-	*
UVF	*	*	*
LED Lighting	*	*	*
FABBACK	-	-	-
DA	*	*	*
E-DA	-	-	-
AMGARD	*	*	*
AMGARD SR	-	-	-
L	*	*	*
Black / White	*	*	*
Block	*	*	-
Ecoshade	*	*	*
EdgeLit	*	*	*
Frame	*	*	*
Museum Grade	*	*	*
MYST	*	*	*
UTRAN	*	*	*

* Recommended - Not Recommended

Thermoforming

Forming equipment

When setting up the thermoformer, ensure there is adequate clearance between the clamping frame and mold to allow for deep sheet sag. Optimize the platen speed and clamp frame to maximize the heating elements.

Recommended heater elements include ceramic, quartz, and halogen. Calrods and nichrome elements can also be used, but typically do not perform as well for heating control. The most efficient thermoforming machines have both top and bottom heater banks for heating acrylic sheet. One-sided heating limits forming method options, tends to overheat the sheet

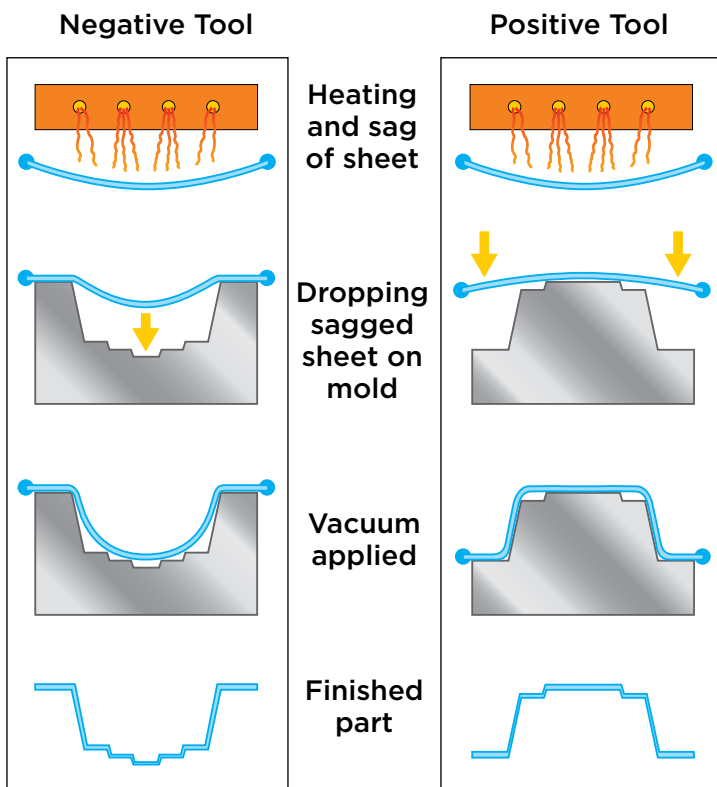
surface and lengthen cycle times. One-sided heating is not recommended for sheet thicker than 0.170". Two sided heating should be used for sheets thicker than 0.170". Zone heating allows different banks of heating coils to be controlled separately to produce even heating. Unbalanced heating can lead to a non-uniform temperature profile in the sheet and is evident by uneven sag of the sheet.

The thermoformer's reserve vacuum tank must be 4-10x the volume of the largest mold. The pump should be capable of generating 26-30 inches Hg pressure and shouldn't drop below 15 inches of Hg during the vacuum cycle.

FORMING TECHNIQUES

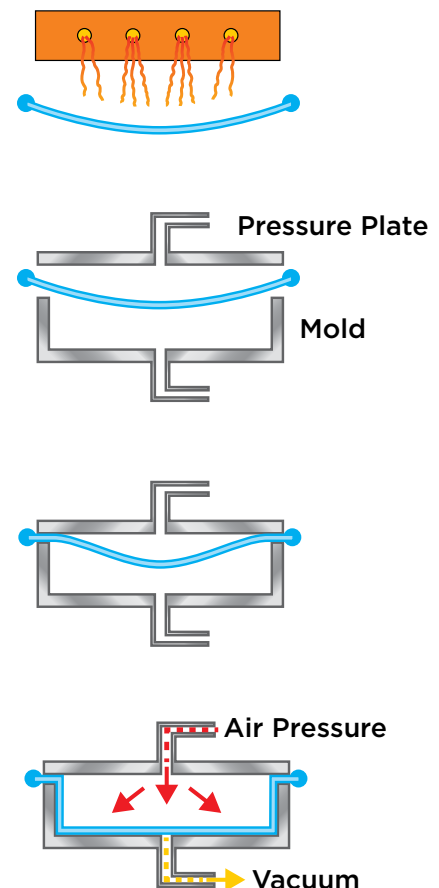
VACUUM FORMING

Selection of a negative tool versus a positive tool depends on the application and is most often determined by the part's appearance or the importance of its fit or assembly. Negative tooling is used where the 'outside' part geometry is more important than the surface finish. Positive tools are for applications needing 'inside' geometry detail and a blemish-free part surface. Make note that any blemish on the tool (positive or negative) will result in an imperfection on the part.



PRESSURE FORMING

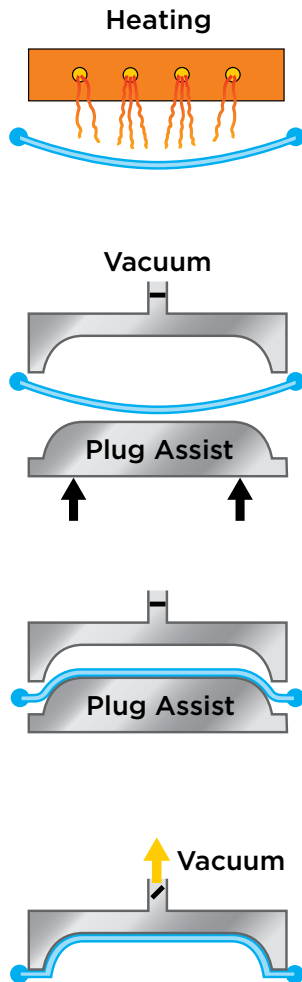
Pressure forming uses compressed air (up to 100 psi) to force the sheet into the mold. It allows for greater part definition and dimensional control. It also achieves more mold surface detail than other methods for applications that require texturing or lettering.



Thermoforming

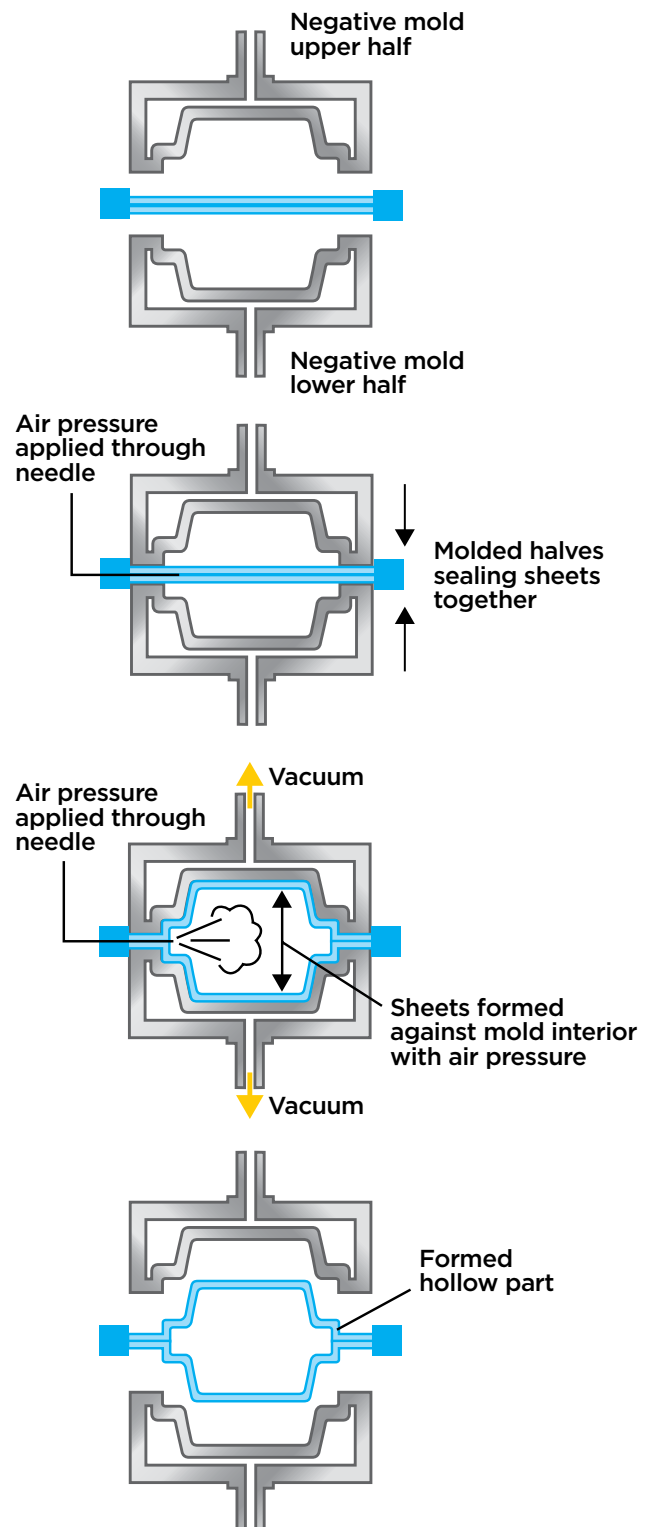
PLUG-ASSISTED FORMING

Plug-assisted forming prevents excessive thinning of material in deep-mold cavities. A plug-assisted formed part has more uniform thickness in the walls than a part produced by typical, single-stage vacuum forming.



TWIN SHEET FORMING

Twin sheet forming uses two sheets of plastic and two negative molds in a single clamp frame setup. A blow pin is inserted between the sheets, and pumps hot air between them to prevent sticking as they soften and sag. This process requires a two-side heater bank. Twin sheet forming is ideally suited to hollow parts with sealed edges, and parts made of two different materials.



Thermoforming

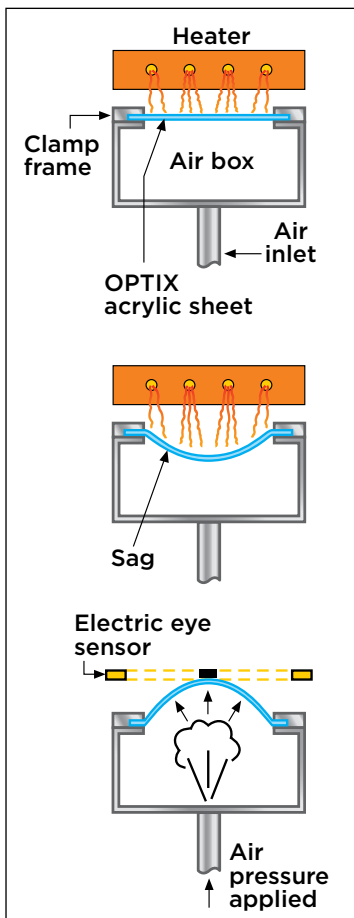
FREE FORMING

Free-blown billow forming (as shown below) is a process used for making dome shapes. Apart from the mold, the procedures and equipment are the same as vacuum forming. Billow forming can be done with compressed air or vacuum.

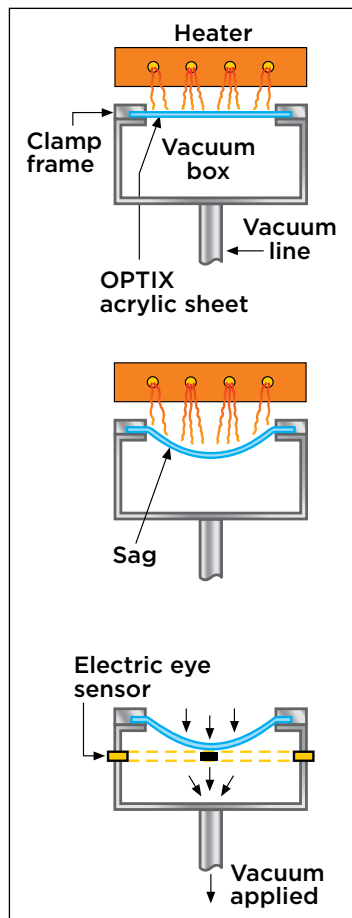
Procedure:

1. Preheat clamps and tooling to 130°F for OPTIX, 175°F for DURAPLEX SG-05, and 170°F for DURAPLEX SG-10
2. Place sheet in clamping frame of thermoformer
3. Heat sheet until uniform sag forms (270-350°F)
4. Remove heat source
5. Lower pressure box to seal air supply pressure
6. Apply high air pressure initially. As dome takes shape, reduce air pressure
7. When overall height is achieved, maintain positive air pressure until part cools
8. Be sure air source is properly filtered and uniformly dispersed for even formation of dome
9. Utilize electric eye designs or micro switches for height control and consistency
10. Remove and trim part

Blown dome forming



Drawn dome forming

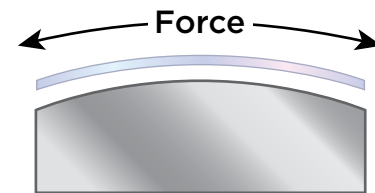


DRAPE FORMING

Drape forming requires a felt or flannel covered wood tool, or flocked rubber for making a single radius of curvature parts, or designs of slight contours. Face shields and recreational vehicle windscreens are examples of parts made by this method. The sheet is typically heated on an oven shelf or other means of supporting sheet.

Procedure:

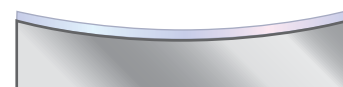
1. Pre-drying OPTIX® sheet is not typically required in drape forming
2. High quality, reproducible forming requires consistent orientation in handling and cutting (top versus bottom), as well as extrusion direction. Do not flip or rotate sheets.
3. Heat the sheet to 270°F - 350°F
4. Locate the oven shelf at the midpoint of the oven for optimum heat balance. Place a felt covered piece of plywood or other flat rigid, heat-resistant sheet on the oven rack or on a portable oven dolly. Be sure to use a fabric cover to protect the sheet from scratches.
5. Bring OPTIX sheet to forming temperature in the oven at 270°F - 350°F. Depending on gauge, this may take several minutes. For example, sheet gauges from 0.100" - 0.375" take approximately 1 - 10 minutes.
6. Manually remove the heated sheet from the oven, and immediately position it over the felt covered mold.
7. Apply pressure at the edges of the sheet to help the sheet take the form of the mold or use matched molds (clamshell molds). Cooling takes about 0.5 - 4 minutes.
8. Always wear thermal gloves when handling hot sheet, holding the material by its edges.



Positive Mold



Negative Mold



TECH TIP:

- 22 Utilize an electronic eye to control height consistency.

Thermoforming

Molds

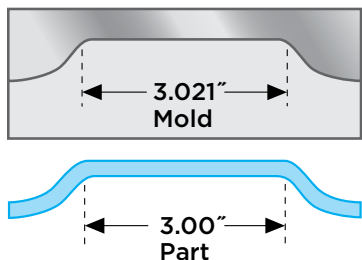
Extremely durable and higher quality than lower cost counterparts, aluminum molds are ideal for high volume and recurring production programs. However, for limited or small run volumes, less expensive mold materials like epoxy, fiberglass and wood may be more economical choices.

Note: Aluminum tools require internal heating to maintain a surface temperature of 130°F for OPTIX®, 175°F for DURAPLEX SG-05, and 170°F for DURAPLEX SG-10.

Mold design

Mold shrinkage: Molds require oversizing in their design to compensate for part shrinkage due to cooling. The typical mold shrinkage value for OPTIX acrylic is 0.2% - 0.6%, or 0.002 in/in to 0.006 in/in.

The typical mold shrinkage value for Impact-modified acrylic is 0.3% - 0.7%, or 0.003 in/in to 0.007 in/in.



Draft Angles: Draft angles greater than 5° allow for easier removal of the part from the mold.

Radii and Fillets: Use generous radii wherever possible. The radius minimum should be equal to or greater than the starting material thickness, as this minimizes the thinning of the sheet, improves part rigidity and avoids creating a stress riser point. On negative tooling, use corner fillets.

Vacuum Holes: To form sheet rapidly and allow for fast air evacuation make several holes with small diameters. A 0.030 inch diameter hole is usually small enough unless the part's wall thickness is less than 0.030". In negative molds, use air evacuation holes at all deep draw areas, especially around the mold perimeter where the sheet draws last.

Tips on mold design

- » In both positive and negative tooling, keep the diameter of the drilled holes no larger than the thinnest wall section to avoid marking the sheet. Additionally, in negative tooling, design long thin slots for air evacuation.
- » Vapor hone or sand blast metal tools for a uniform surface finish
- » A highly-polished mold surface is not recommended as it causes sticking and air pockets
- » The radius minimum should be equal to the sheet's original thickness to relieve stress riser points
- » Preheat mold. Cold molds can cause surface defects, warping, and may increase internal stress in the part
- » If mold temperature becomes too high during thermoforming, OPTIX sheet can stick to the mold. Control mold temperature to 130°F for OPTIX, 175°F for DURAPLEX SG-05, and 170°F for DURAPLEX SG-10.

Vacuum forming heating cycle

The target sheet temperature for vacuum forming OPTIX® is between 270°F to 350°F for 0.100" - 0.375" thick sheet. The temperature profile of the sheet will define the resulting sag in the sheet. Maintaining the sag depth and shape provides a visual indicator for forming consistency.

TECH TIP:

Heating from top and bottom shortens cycle time.

Characteristics of thermoforming acrylic

While OPTIX sheet forming characteristics are different than other thermoplastic sheet materials, it outperforms them in production efficiency due to its short heating times, and rapid forming and cooling cycles.

Important reminders for thermoforming OPTIX

- » Thermoforming temperature is relatively narrow: 270°F - 350°F
- » Acrylic has a softening temperature of 210°F - 220°F
- » Normally OPTIX does not need to be pre-dried unless forming temperatures are excessive (or the sheet has absorbed significant moisture)
- » Acrylic cools rapidly. Platen movement and clamp frame travel must operate at appropriate rates without delay
- » Pre-drying is, however, recommended before forming sheet that was vinyl laminated (wet lamination)

Forming temperatures	
Sheet temperature	
Typical	270°F - 350°F
Optimum	
OPTIX	320°F
Duraplex SG-05	315°F
Duraplex SG-10	310°F
Mold temperature	
OPTIX	130°F
Duraplex SG-05	175°F
Duraplex SG-10	170°F



Bending, Annealing

Bending

Cold Bending

A bend in OPTIX® acrylic sheet can be accomplished without applying heat. A minimum radius of 200 times the thickness of the acrylic is required to avoid stress cracking.

Line bending or strip heating

Line bending, also referred to as strip heating, is a technique for producing linear bends. For thicker sheets, back routing or V-grooving along the bend line is recommended.

There are several options for line bending OPTIX acrylic sheet. The most commonly used method for a straight bend is to use a straight nichrome wire resistance heater for sheet thickness up to 0.118". Thickness greater than 0.118" may be bent but the material must be flipped over halfway during the heating cycle. Heat the material until it softens. Place the bent part into a cooling jib. Secure with weights or clamps. Cool roughly the same amount of time it took to heat the sheet. Do not overheat or lay the OPTIX sheet on the elements or the sheet may blister or retain marks.

***Please be aware an unguarded nichrome wire is a shock/burn hazard. Proper guard and PPE are encouraged**

Coiled resistance wire can be used in place of the straight wire element. It is more difficult to evenly heat a coiled wire across the sheet surface which could cause uneven stress and distortion. Follow the same method as used with the nichrome wire resistance heater. However, flip the sheet over to obtain even softening of the sheet prior to bending.

Procedure:

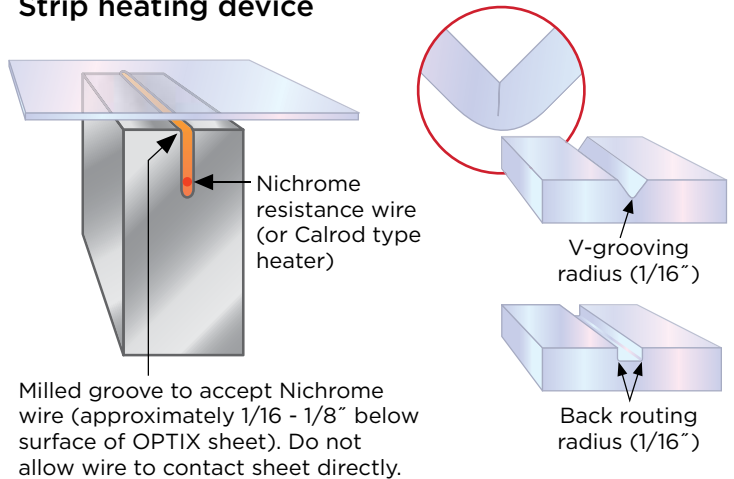
1. Remove protective masking in bend area
2. Regulate heating element to 270°F - 350°F
3. Place sheet over heating element at bend area
4. Allow heat to soften material. The amount of time depends on gauge
5. Remove sheet and make desired bend on a felt covered fixture
6. Bend immediately as acrylic cools quickly
7. Allow part to cool on the fixture until set up - about 30 seconds

Note: Some bends may require a degree of over-bend to achieve desired angle.

TECH TIPS:

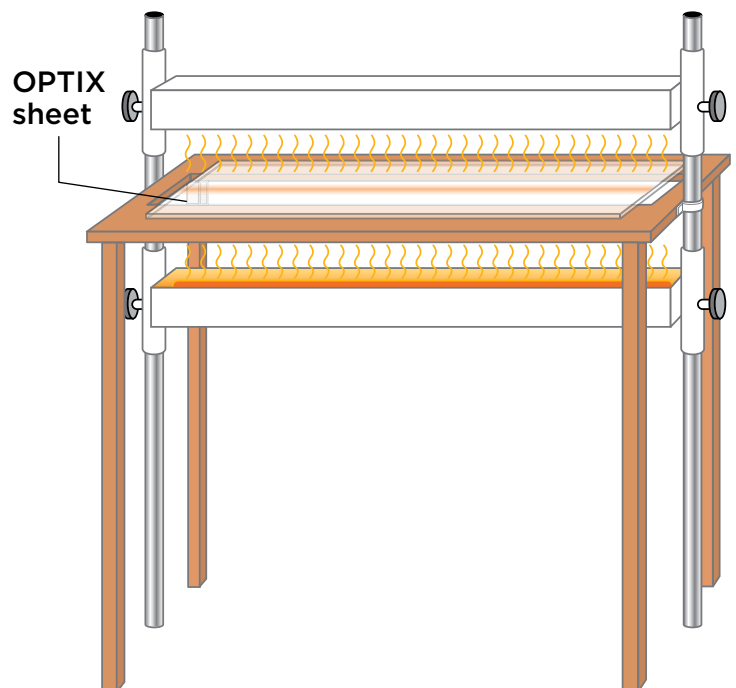
- » Line bending works best for lengths of 24" or shorter. Longer dimensions require preheating the entire piece to 200°F first to prevent warping.
- » Even heating, perpendicular to the sheet's manufacturing direction is recommended (to avoid post bending shrinkage in the extrusion direction).
- » For best results with gauges greater than 0.177", use two-side heating, or turn the part frequently when using a one-side heater. This helps with even heat penetration, preventing moisture bubbling.
- » Additionally, for gauges greater than 0.177", back route or V-groove with a 1/16-inch radius to heat cross section. Again, this will help avoid moisture bubbling, while still creating a sharp angle.

Strip heating device



Tubular Rod Heaters

Tubular rod heaters are used to heat OPTIX sheets thicker than 0.118". When using rod heaters an aluminum reflector is needed to deflect the heat into the sheet. Heaters can be placed above and below the sheet and use water-cooled supports to avoid mark off on the OPTIX sheets. Follow the same method as used with the nichrome wire resistance heater; however, the acrylic sheet should be at least one half inch away from the heaters to avoid overheating.



Bending

Radiant Quartz Tube Heaters

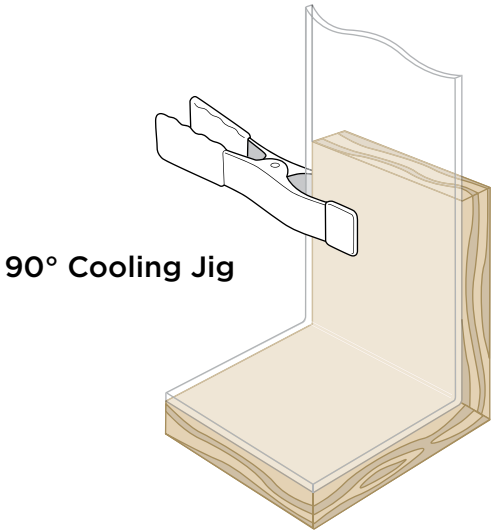
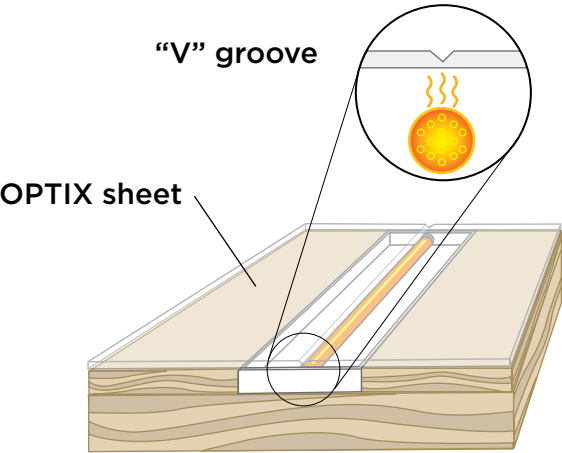
Radiant quartz tube heaters are an efficient means of energy. These heaters have the capability to bend OPTIX® acrylic sheet 0.060" and greater. To achieve the most efficient heating use an aluminum reflector with a quartz tube heater. Follow the same method as used with the nichrome wire resistance heater. To avoid overheating the sheet maintain a distance of at least one half inch from the heaters.

To achieve the best line bends be sure to use a 90° cooling jig to maintain the proper angle of the sheet bend. This will prevent the sheet from returning to its original shape and reduce stress on the part as it cools. This jig can be modified to each part.

To create a bend less than 90° increase or decrease the heated area. With this method, the sheet can be bent to a more gentle curve.

TECH TIPS:

- » Do not use hot air guns to heat OPTIX sheet for bending. A heat gun produces uneven heat which could cause warp.
- » To minimize bowing when making long line bends of 24" reduce the width of the heated sheet or V-groove the sheet along the bend line. When it exceeds 36" the bend should run perpendicular to the direction of extrusion (DOE); if this is a requirement please consult customer service when placing your order.



Troubleshooting for bending

Description of problem	Probable cause	Remedy
Bubbling or blistering	Overheating	Increase sheet and heater distance Lower heat Reverse or flip sheet
	Wet Material	Pre-dry sheet
Wrinkling	Bending part the wrong way	Bend away from heated side
	Narrow heating	Increase bend radius, should be at least twice sheet thickness Widen heated area
Mark-off	Sheet surface contact	Avoid overheating Cover cooling jig with felt and reduce contact with jig
Bowing	Stress on heated and unheated areas	Use nichrome wire to decrease heated area Reverse curve in cooling jig Heat part in oven Use v-groove to bend line
	Shrinkage in sheet	Bend sheet perpendicular to DOE - contact manufacture for details

Annealing

The roughness and solvent-craze resistance of internally stressed acrylic sheet can sometimes be improved by relieving the stress through annealing which increases the strength of cemented joints. Acrylic sheets can be annealed by heating them in a forced-air oven below the temperature which will cause the part to distort. Time required for annealing depends on the annealing temperature, the thickness, and the type of acrylic involved. In general, a longer time at lower temperatures is preferred to shorter times at higher temperatures.

Annealing temperatures will normally be in the range of 140° to 180°F (60° to 82°C), with annealing times in the range of 5 to 8 hours. After heating for the suggested time, the parts should be cooled slowly to at least 110°F (43°C).

To obtain maximum benefit from annealing, the parts should be:

- 1. Annealed after all fabrication has been completed
- 2. Free of protective spray coatings or masking paper
- 3. Annealed in a uniformly heated, forced-air oven rather than by immersion in hot liquid
- 4. Cooled slowly to room temperature after annealing
(For example, some fabricators cycle their oven temperatures so the annealed parts will cool slowly overnight in the oven.)

Suggested Annealing* Times

Acrylic Sheet Thickness		Annealing Time
(inches)	(mm)	(hours)
0.125	3.2	2
0.250	6.4	4
0.500	12.7	6
1.000	25.4	8

*These values reference OPTIX L products.



Bonding

Bonding

Cementing

Successfully cementing OPTIX® acrylic sheet begins with a well machined part. A square flush fit is required to produce a strong, clean joint and will minimize the chance of “blushing”.

For best results preparation of the areas to be bonded are critical. Edges must be cleanly cut and properly machined. Finish rough edges or wet-sand the edges with a flat surface or block. Do not polish edges prior to cementing.

Types of cement used for bonding acrylic are:

Solvent cements – water thin solvents to soften the acrylic, which will diffuse and evaporate allowing the parts to harden together

Mixed solvent cements – Thickened with an acrylic polymer to slow cure times and fill small voids

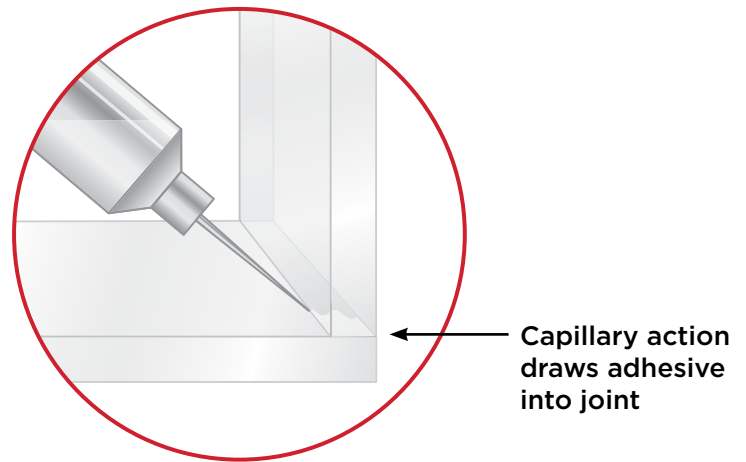
Polymerizable cements – Methyl methacrylate monomer and a catalyst mixed to produce a cement for strong, long lasting museum quality joints

Capillary cementing

This technique allows solvent cement to flow into the joint and melt the parts together. Apply cement with a syringe, solvent applicator or an eyedropper. Use small weights, fixtures and fences to hold the parts in place. Initial bonding occurs within 5-10 seconds. A three-hour cure time is sufficient to allow further fabrication and a 24-48 hour for maximum bond strength.

Dip or Soak cementing

Place small wire brads in a dip or soak tray. Cover the brads with a moderate amount of solvent. Rest the edge of the OPTIX acrylic sheet on the brads for 1-5 minutes depending on the thickness of the sheet. Remove the sheet from the solvent to drain off the excess liquid. Quickly and precisely place the edge on the other part, being careful not to apply pressure. After initial bonding (30 seconds) apply slight but steady pressure to remove air bubbles but take care not to squeeze out the cement. Allow the joint to cure by placing in a jig for 5-20 minutes before moving the part and wait 8-24 hours before any additional machining or finishing. The bond will continue to strengthen over the next several weeks.



TECH TIPS:

- » Cement should be used in a well-ventilated area
- » Low humidity will prevent cloudy joints
- » Parts to be bonded should not be flame or buff polished
- » Protect skin from cements and solvents
- » Ideal temperature 70°F -75°F

Troubleshooting

Description of problem	Probable cause	Remedy
Bubbles in joint	Uneven surface	Prepare joints for squareness Use solvent cement
Crazing	Stress in material	Use proper ventilation when bonding Anneal heat bent areas Dry before flame polishing Use water when sanding to reduce temperature
Joints whitening	Water in cement Fast evaporation	Replace cement Reduce evaporation rate by adding glacial acetic acid 1-3% strength
Weak joints	Uneven surfaces Issue with cement	Check joint for squareness Use solvent cement Store cement properly – follow manufacturers instructions (Solvent evaporation can change cement characteristics)



Mechanical Fastening

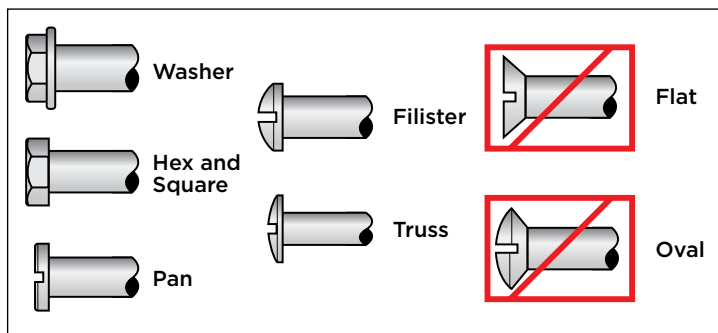
Mechanical Fastening

Mechanical fasteners

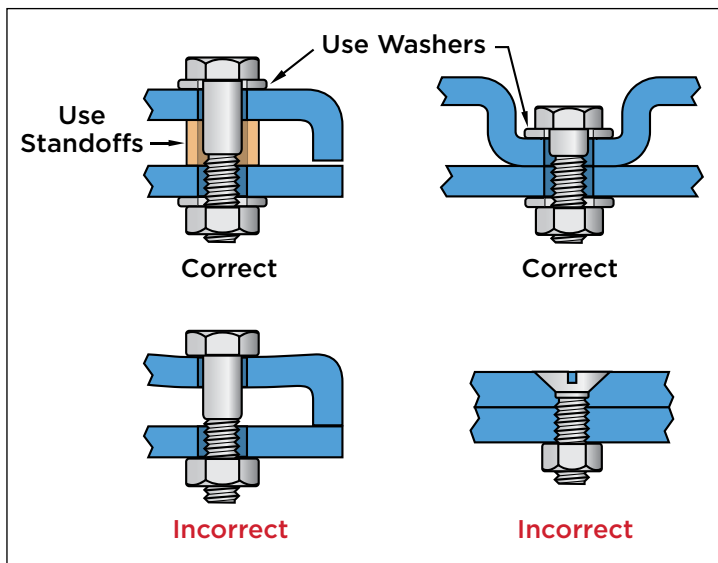
OPTIX® acrylic sheet may be attached with screws, nuts and bolts, rivets, or other mechanical fasteners. However due to fluctuating temperatures allow for expansion and contraction of the substrate. Drilling oversized holes or slots, using washers and spacers, and not over tightening the fasteners will allow the OPTIX sheet to move as needed.

Common head styles of screws and bolts

Pay special attention to the fastener's head. Use bolt and screw heads that have a flat underside, called "pan" or "round" head. This bolt design imparts lower compressive stresses on the material. Conical heads, called flat or oval heads, produce undesirable tensile and hoop stresses and should be avoided.



Fastening with bolts, nuts, and washers

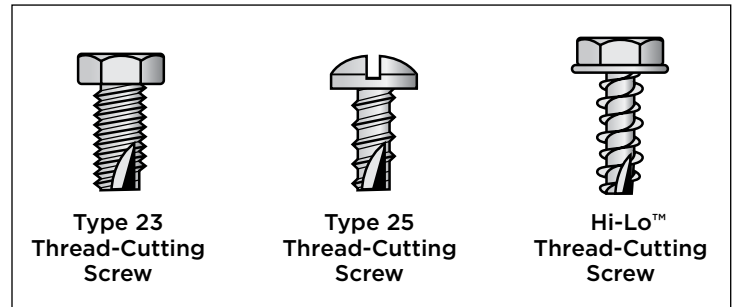


TECH TIP:

Avoid thread locker products and countersunk screws. They are generally incompatible with OPTIX acrylic sheet, causing cracking and crazing.

Fastening with self-tapping screws

Thread-cutting screws may not be appropriate in all applications and environments. Cracks around the screw hole may form under conditions where the acrylic expands and contracts due to temperature variations. Use thread-cutting screws, which cut away material from a pre-drilled hole to form a mating thread and result in better long-term performance. Note the radial and hoop stresses imparted to the part by thread-cutting screws are lower after installation vs. thread-forming screws. Typically, thread-cutting screws are classified as ANSI BT (Type 25), ANSI T (Type 23).

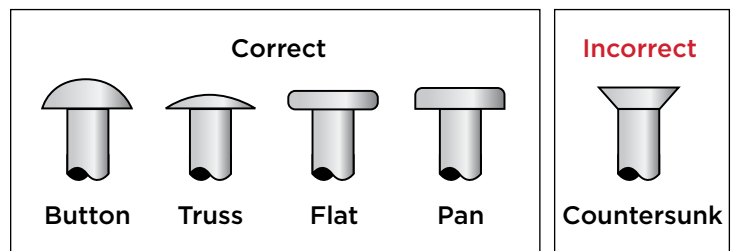


Hi-Lo is a trademark of ITW Shakeproof

Fastening with rivets

Rivets offer a low-cost and simple hardware solution for static parts. Aluminum rivets are preferred over harder materials. Select rivets with large flat heads and three times the shank diameter. Use of washers on the flared end are helpful in distributing loads, but be careful not to over-tighten as it can result in compressive stress and damage to the plastic.

Four standard rivet heads



Use flat aluminum or hard plastic washers under nuts and fastener heads to evenly distribute the applied force. Their ability to resist over-compression helps to prevent localized stressing of the joining part. Ensure there is sufficient distance between the edge of the fastener's hole and the part's edge: at minimum, two-times the diameter, and twice the part's thickness. Note: Slotted holes require more edge clearance.

Mechanical Fastening

Joining dissimilar materials

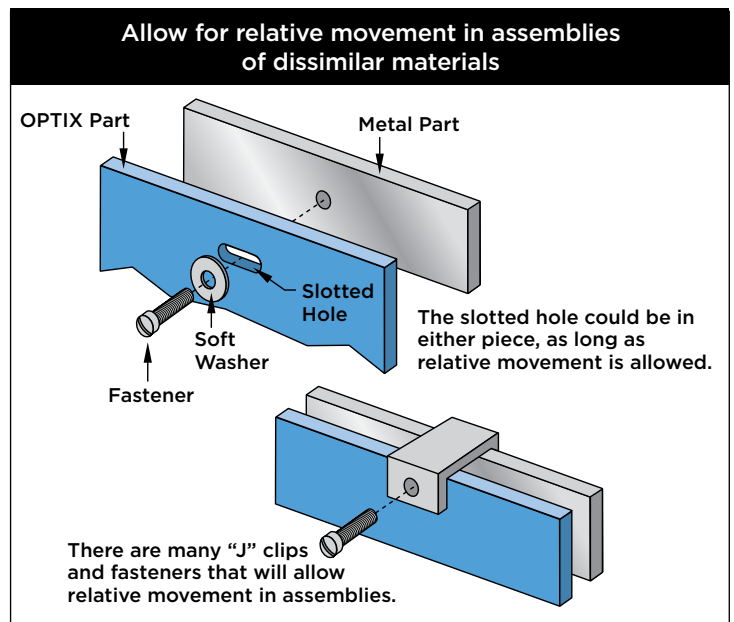
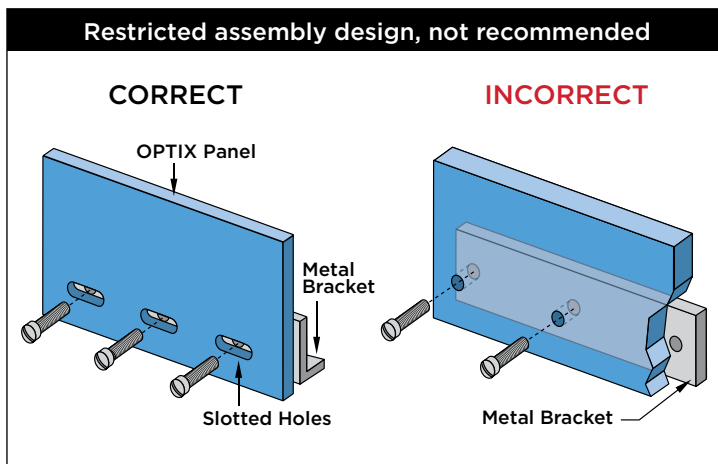
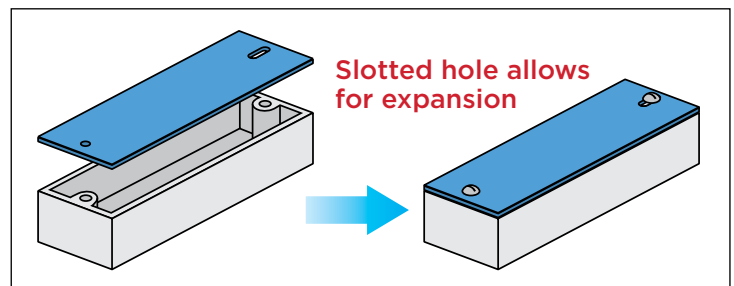
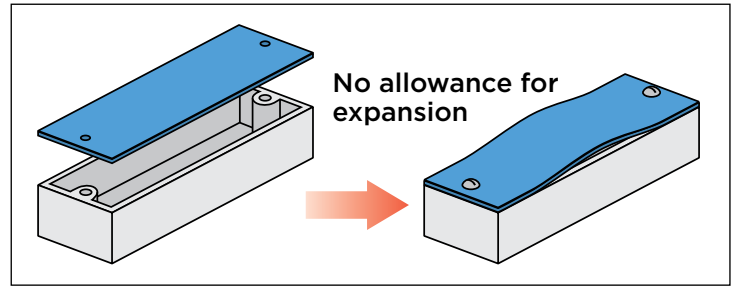
For assemblies constructed of a combination of OPTIX® sheet and metal (two dissimilar materials), it is important to design for thermal effects. When heated, the plastic may buckle, due to its higher thermal expansion rate. Conversely, when cooled, the greater thermal shrinkage of plastic will cause strain-induced stress and may exceed the plastic's working limit. This could lead to part failure.

The figure to the right shows a plastic part fastened to a metal component. As the ambient temperature rises, the plastic will expand more than the metal because the plastic's coefficient of linear thermal expansion is four times higher.

For applications where wide temperature variations exist, use slotted screw holes in the plastic part. When joining plastic and metal parts, do not tighten fasteners to the point where joint friction and compressive loads prevent relative movement. If the fasteners are too tight it negates the effect of the slotted holes.

Factors to consider when joining plastic and metal parts:

- » The size of the parts to be joined
- » The magnitude of the temperature range
- » The relative thermal expansion coefficients of the materials used in the part



Mechanical Fastening

Coefficient of Linear Thermal Expansion (CLTE) values for materials

Material	CLTE (10 ⁻⁵ in/in/°F)
OPTIX®	3.0
Aluminum	1.3

A simple calculation is to allow 1/16" per linear foot for expansion and contraction

Example 1: Calculate the change in length for a 96 inch part that is constructed at 70° F, but will see operating temperatures up to 120° F

$$\Delta L = (\text{plastic CLTE}) * \text{temperature change} * \text{length of part} = (0.000030) * 50 * 96 \dots \Delta L = 0.144 \text{ inches}$$

Therefore, the design has to accommodate a growth of 0.144 inches.

Example 2: How much shrinkage will the same part see at -20° F

$$\Delta L = (\text{plastic CLTE}) * \text{temperature change} * \text{length of part} = (0.000030) * 90 * 96 \dots \Delta L = 0.26 \text{ inches}$$

Therefore, the design has to accommodate a contraction of 0.26 inches.

Ultrasonic welding

Sonic welding can be used to press parts together. The use of electrical energy is converted to mechanical vibration, melting the acrylic sheet to create the bond.

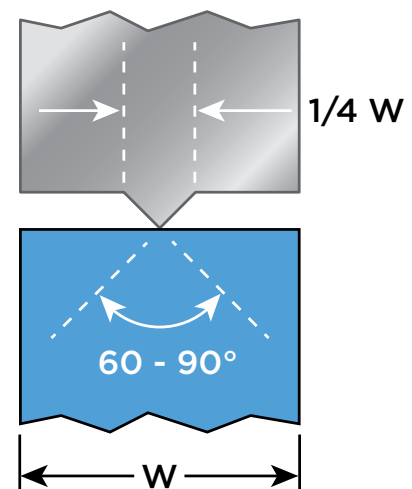
An ultrasonic welder has two primary parts: a horn and a nest. The horn typically presses down on the upper plastic part (of the two to be welded), clamping the two parts together. The nest supports the bottom plastic part to prevent it from moving. The horn is vibrated ultrasonically for a preset time. Friction from mechanical vibrations cause localized heating, resulting in plastic melting at the interface of the two parts. Pressure is then maintained after the vibrations are stopped until the melted plastic cools. Once the plastic has solidified, the clamping pressure is retracted and the two joined parts can be removed from the nest fixture.

The most important feature for a clean, ultrasonically welded joint is for one of the parts (to be welded) be designed with a triangular-shaped energy director. This minimizes the initial contact between parts. During welding, the ultrasonic energy is concentrated at the director tip, melting it and ultimately, joining the interface with molten resin.

Design energy directors with an apex angle from 60 to 90°. Generally, the base width of the energy director should not be more than 20 to 25% of the wall thickness supporting it.

For optimum welding:

- » The horn, fixture and parts must be aligned properly
- » The stationary part should fit snugly in the nest or fixture
- » The height of the energy director should be approximately 0.020 inch
- » Join parts made of the same resin



Painting, Finishing



Painting

OPTIX® acrylic sheet can be easily decorated using commercially available paints produced specifically for acrylic or vinyl. Be sure to use only paints that have been tested to be compatible with OPTIX sheets. Follow paint manufacturers guidelines for thinners, viscosity, methods, and volumes for optimal results. Proper machining, forming and fabricating techniques should be followed to reduce the chance of crazing. After handling and fabrication, clean the OPTIX sheet. Remove dust, masking residue and static charges prior to painting or vinyl application. Painting reduces the impact resistance of OPTIX and design considerations should be taken into account to minimize potential damage.

OPTIX acrylic sheet is excellent for back painting, which is applying paint to the side that will be not exposed to weather elements. However, if you need to expose the painted surface apply a protective coating over the paint. Suppliers can recommend a suitable coating.

The use of masking in a paint operation will provide a protective layer for flat signs. A liquid maskant may be used when applied 10-12 mils thick wet (3-5 mils dry) for spray paint designs. These maskants are water solutions and must be stored above 32°F to prevent freezing. Minimum drying time is 2 hours but it is better to allow the maskant to dry overnight to assure complete evaporation. Prior to painting score the design on to the film with enough pressure to cut the film without scratching the OPTIX sheet. Leave the film in place until the paint has dried completely.

Best results for spray painting is achieved with an atomizing spray gun to uniformly distribute paint free of water and oil.

The use of backlighting during the process will aid in determining the uniformity of the paint application. Certain restrictions, such as heating temperature, time and depth of draw, and the thickness of the paint will affect the quality of the end product. Refer to the manufacturers guidelines for details.

Paint removal

Remove excess paint immediately from the acrylic sheet using approved cleaners. Using a clean, soft rag, wipe the paint off to reduce the chance of crazing. Be sure to minimize the time cleaners are in contact with OPTIX acrylic sheet.

Vinyl decorating

Application of colored vinyl film is a common decoration technique for OPTIX acrylic sheet. Follow the vinyl film manufacturer's directions for product use.

Digital printing

UV cured inks are used in digital printing due to their quick cure times. Historically a UV mercury arc lamp has been used as the light source but newer UV LED curing lamps are now preferred. These bulbs use less electricity, produce less heat, last longer and do not require a warm-up period. It's important to note the market has reported intermittent adhesion issues when printing on plastic substrates when curing with UV LED systems. Pretreating the plastic substrate with corona discharge, flame, UV light, solvent wipes or adhesion promoters has proved successful in overcoming adhesion issues.

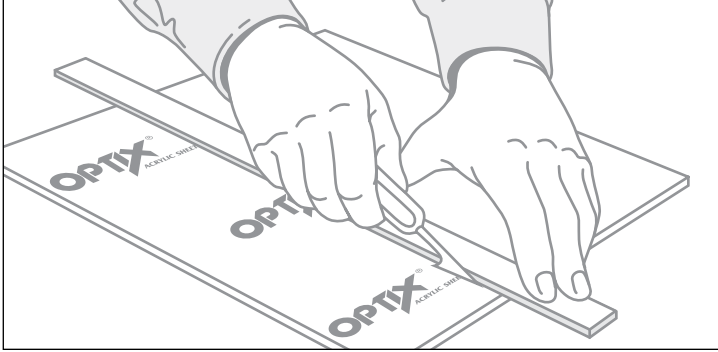
Troubleshooting

Description of problem	Probable cause	Remedy
Maskants		
Weak and brittle maskant	Air bubbles in film	Dilute slightly
	Film not thoroughly dry	Wait recommended drying time
Excessive adhesion	Maskant film too thin	Increase film thickness to 3-5 mils (10-12 mils)
	Coating exposed to UV	Do not store sprayed acrylic outdoors
Spray Painting		
Poor adhesion	Incorrect paint	Use paints recommended for use with acrylic sheet
	Dirt or residue on sheet	Clean surface before painting
Blotches of paint	Static electricity	Neutralize charges with ionizing wands, bars or air blowers. Wipe sheet with a soft rag and a mixture of water/IPA (30%). Avoid using commercial cleaners or anti-static solution as they may affect ink adhesion and print quality
Screen Printing		
Poor Detail	Screen mesh too coarse	Use a finer mesh
	Paint too thin	Reduce thinner additive
	Worn screen	Replace screen
Paint drying on screen	Hot, dry weather	Add retardant to slow paint drying
	Large lapse of time between screening	Flood screen between passes
Crazing	Stress from fabrication	Review fabrication methods
	Flame polishing	Flame polish as last step

Finishing

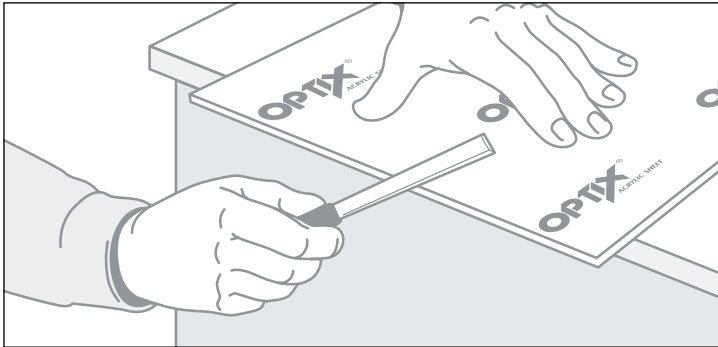
Scribing & Breaking

For OPTIX® acrylic sheet up to 1/4" thick, score repeatedly along a straight edge with a plastic cutting tool, or Fletcher Terry Knife. Score to penetrate 1/2 through the sheet. Align the score with the edge of the table and apply gentle pressure to break the sheet along the score line.



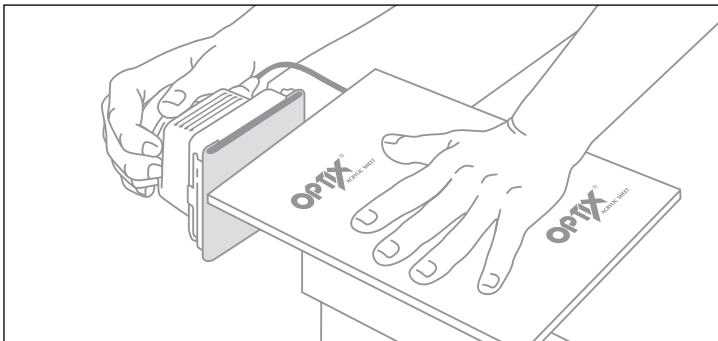
Scraping

Scrapers are sharp tool-steel devices used to eliminate machining marks and ease sharp edges.



Sanding

All methods of sanding will result in the removal of machining marks, and produce a matte finish. The choice of hand, palm, random orbit, disc, belt, or drum sanding, depends on the quantity, size and shape of the acrylic sheet. Like sanding wood, work from coarse to fine paper. Use light pressure, and keep the part or sander moving to avoid heat build up. After sanding, the edge is ready for buffing or flame polishing. It should be noted that mechanical sanding, even aggressive hand sanding can induce heat stress in the sheet. This could increase the risk of crazing if not managed properly.

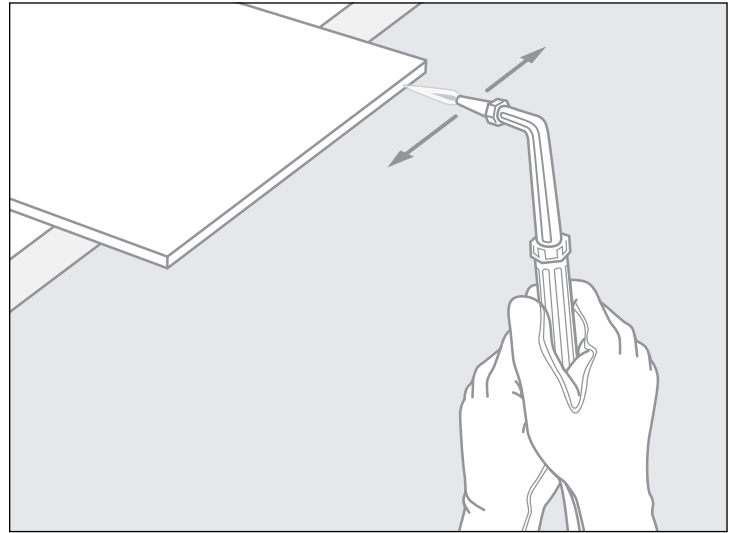


Flame Polishing

A hydrogen-oxygen torch, with a #4 or #5 tip, gently melts the sanded or machined edges of OPTIX acrylic sheet, providing a smooth glossy look. Low line pressures create a torch flame that is 2-3" long, bluish, nearly invisible, and narrow enough to prevent overshooting onto the face of the acrylic sheet.

Remove the masking from the acrylic sheet and guide the torch along the edge at a rate of approximately 3-4" per second. As with other cutting and machining processes, avoid excessive heat build up. Bubbles, stress, and crazing will occur if the flame is moved too slowly. Do not cement a flame-polished edge.

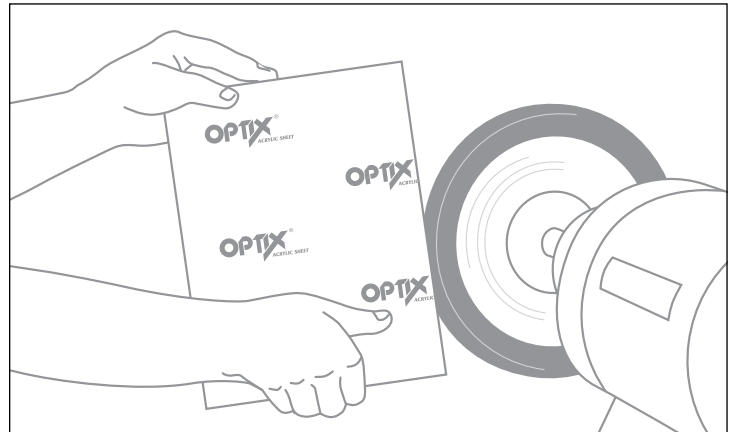
As a reminder, flame polished parts can be annealed to reduce internal stress.



Buffing

A well machined edge is required to polish without additional sanding. Preferably, use stationary machines with polishing wheels dedicated to buffing acrylic. Wheels 8-14" diameter, 2-3" wide, of bleached muslin with bias strips, run cooler than ones fully stitched. With light pressure, keep the OPTIX acrylic sheet moving across the wheel to prevent excess heat build up.

Finish quality depends on the polishing compounds used. A medium cutting compound will result in a good finish in one operation. A high luster finish can be achieved by first applying a fast cutting compound, to remove machining and sanding marks, followed by a fine compound on a finishing wheel.



Finishing

Troubleshooting

Problem	Probable cause	Remedy
Dull edge after flame polishing	Missed spots	Allow sheet to cool and reflare
	Too much heat	If necessary change torch tip size
Char on edge	Wrong fuel type	Use oxygen/hydrogen mixture
	Dirt or contamination	Wipe with lint free, dry cloth prior to flame polishing
	Too much heat	Reduce heat in 2° to 5° increments until desired edge is obtained
Edge blister	Wet sheet	Pre-dry sheet
Crazing after flame polishing	Incompatible cleaner used prior or at conclusion of flame polishing	Use approved cleaners

Handling and Maintenance

Proper storage of OPTIX® acrylic sheet is important to protect the material from dirt and moisture. Leave the protective wrap on the pallet until ready to use to minimize warpage. Sheets should be stored vertically where they can at approximately 10% angle. The racks should be constructed of full sheets of plywood to support the weight of the material.

OPTIX acrylic is protected with film masking from scratches. Film masking can be marked with grease pencils or certain felt tip markers and for paper masking pencils, pens and felt tip pens can be used to write on the masking.

Sheet masking should be left on during the fabrication process to protect the sheet surface. It may be removed if necessary but care must be taken to not damage the sheet. Avoid handling unmasked sheet unless necessary.

Masked OPTIX sheet should be stored away from sunlight, heat and humidity, and the masking should be removed upon installation. If masking is left on the sheet after installation, it may become difficult to remove.



Troubleshooting Guide

Troubleshooting Guide

Description of Problem	Possible Causes	Possible Corrective Action
SAWING		
Chipping on edge of sheet	• Feed rate is too fast	• Slow the feed rate
	• Teeth on blade bent	• Check condition of blade so teeth are correctly positioned
	• Vibration of stacked sheets	• Clamp sheets together tightly
Melting of acrylic	• Dull blade	• Sharpen blade
	• Feed rate is too slow	• Increase feed speed
	• Incorrect blade angle	• Blade angle should be parallel to direction of travel
	• Stopping of sheet while sawing	• Material needs to move evenly through saw
CEMENTING		
Crazing in machined edge of cemented joint	• Stress due to machining	• Make sure the tool is sharp • Check speed of tool • Anneal parts before cementing to reduce pressure
	• Edge polishing	• Do not polish prior to cementing
	• Chemical attack by cement	• Change type of cement
Cloudy joints	• Excessive moisture	• Use slower evaporating solvent • Reduce environment humidity
Poor joint strength	• Bubbles	• Improve surface contact between parts
	• Dry spots	• Use slower evaporation solvent
	• Extra solvent squeezing from joint	• Reduce clamping pressure
	• Solvent action reduced because of low ambient temperature	• Warm solvent • Increase room temperature

Troubleshooting Guide

Description of Problem	Possible Causes	Possible Corrective Action
SPRAY PAINTING		
Poor adhesion	• Incorrect paint	• Use paints recommended for use with acrylic sheet
	• Dirt or residue on sheet	• Clean surface before painting
Blotches of paint	• Static electricity	• Neutralize charges with ionizing gun • Wipe with damp cloth
SCREEN PRINTING		
Poor Detail	• Screen mesh too coarse	• Use a finer mesh
	• Worn screen	• Replace screen
	• Paint too thin	• Reduce thinner additive
Paint drying on screen	• Hot, dry weather	• Add retardant to slow paint drying
	• Large lapse of time between screening	• Flood screen between passes
Crazing	• Stress from fabrication	• Review fabrication methods
	• Flame polishing	• Flame polish as last step
THERMOFORMING		
Bubbles	• Overheating	• Lower temperature • Shorten the heating cycle • Increase the distance between heat and sheet
	• Moisture	• Pre-dry material before forming • Keep masking on sheet until formed • Attach baffles, circulate heated air
Bumps in formed part	• Entrapped air between sheet and form	• Change venting system
	• Mold temperature too cold	• Increase mold temperature or preheat mold
	• Sheet too hot leaving mark-off from the mold	• Lower temperature • Shorten the heating cycle
Crazing in formed skylights and other glazing applications	• Plasticizer in gasket on finished part	• Change material in gasket • Flexible vinyl gasket not recommended
	• Chemical put on formed part to clean or polish	• Use mild soap and water, isopropyl alcohol or recommended cleaner
	• Stress concentration	• Round or bevel the mold corners to a 45° angle