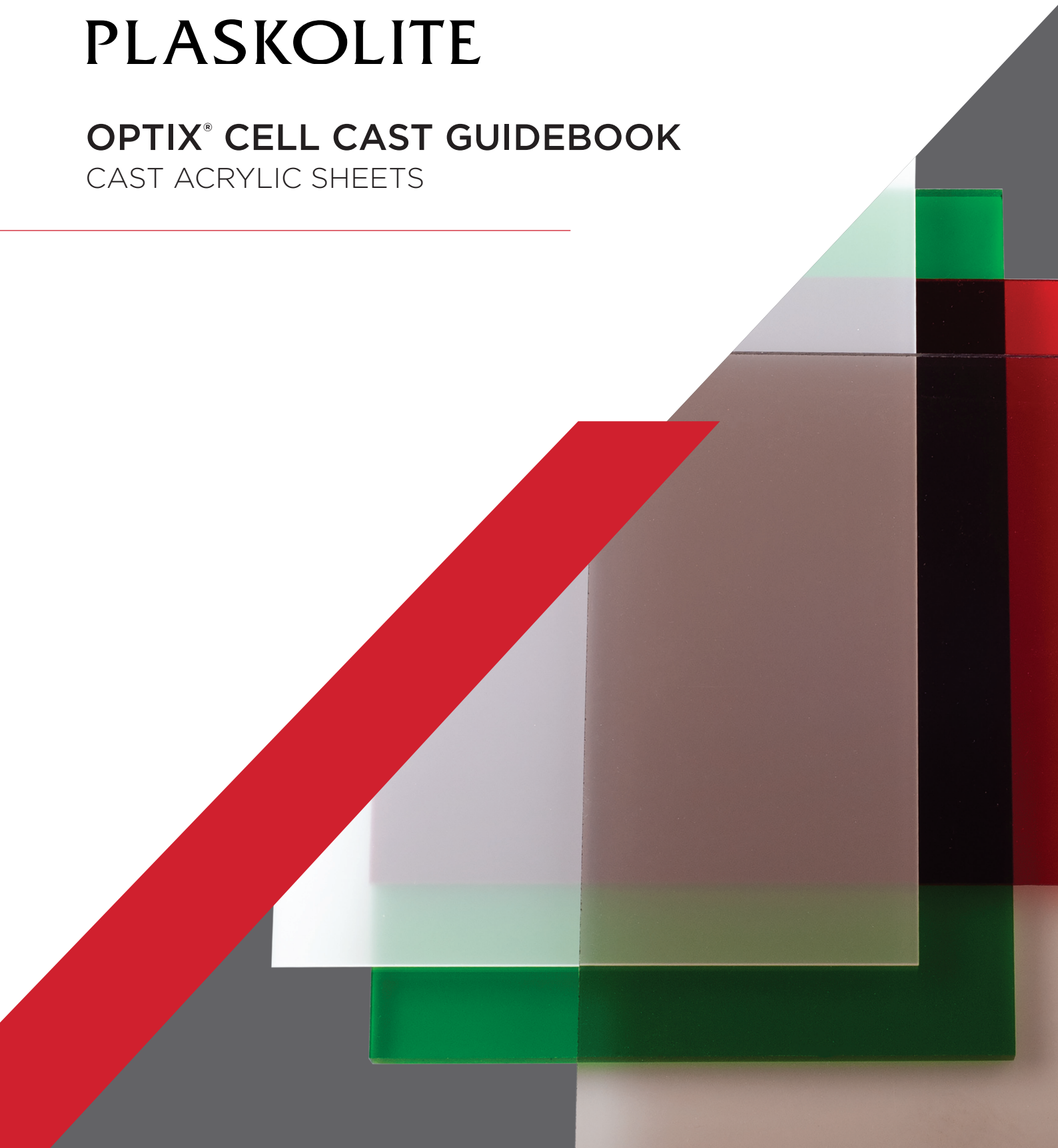
PLASKOLITE

OPTIX® CELL CAST GUIDEBOOK

CAST ACRYLIC SHEETS



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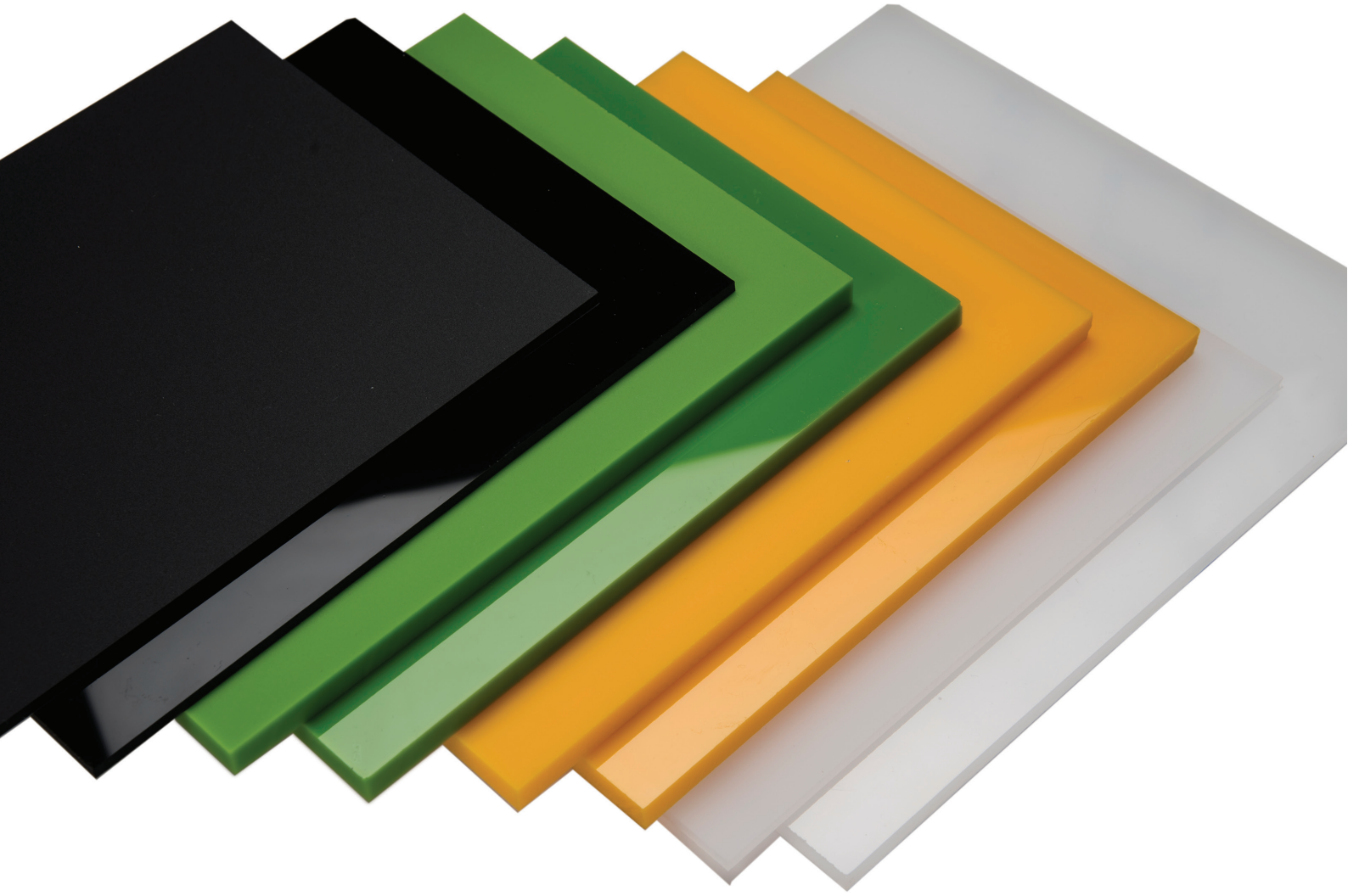
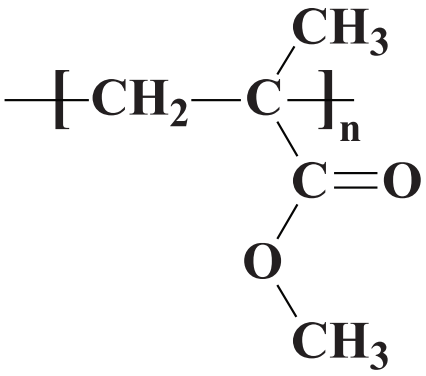


1. INTRODUCTION

OPTIX Cell Cast is the trade name of cast acrylic (PMMA) sheets made by the PLASKOLITE.

PMMA (polymethyl methacrylate) is the most important member of the acrylic polymers. Acrylic was first produced in early 1930s for potential uses in aircraft glazing.

PMMA Molecule



Acrylic is the most beautiful plastic, outstanding for its crystal-like optical qualities and weatherability. It is the most transparent polymer with a visible light transmittance of 92%, more than glass and any other transparent polymer. It has a unique inherent resistance to sunlight and environmental exposure for a long period of time. Does not yellow or undergo significant physical changes and keeps its original color and finishes for many years. It has also high scratch resistance and can be manufactured to have a beautiful high gloss finish. Acrylic can be modified by different additives to perform specific applications: impact resistance, UV and IR blocking, etc.

With bright clarity and gloss, excellent transparency and easy fabrication, OPTIX Cell Cast cast acrylic sheets provide long-life UV resistant products for a wide range of applications. OPTIX Cell Cast is available in wide range of thicknesses, colors, textures and special effects.

OPTIX Cell Cast sheets are produced by the monomer cast process from high quality raw materials in specialized production lines. A skilled team of engineers and chemists work 24 hours a day, 7 days a week, to improve materials and production processes and provide technical support to customers and help them to solve any technical challenge.

OPTIX Cell Cast sheets are produced according to the EN ISO 7823-1 standard.

CHARACTERISTICS

2. CHARACTERISTICS

2.1 QUALITIES

- Highly transparent > 92%
- Low Haze
- High gloss surface
- Satin surface also available, one or two sides
- Excellent color stability with a wide range of transparent, translucent and opaque colors
- Lightweight: Approximately half weight of glass
- UV resistant, excellent weathering and ageing resistance.
- High hardness, stiffness and strength
- Excellent dimensional stability
- Special UV blocking or UV transmitting sheets available
- Easily machined and thermoformed by standard techniques
- Cold curving capability
- Easy to glue and bond
- Easily polished and reshaped
- Excellent chemical resistance to a wide range of substances
- Easy to clean
- OPTIX Cell Cast sheets and their polyethylene protective layers are fully recyclable
- Contact with food OPTIX Cell Cast grades are available
- Environment friendly. Does not contain toxic materials or heavy metals
- Do not produce toxic or corrosive gases upon burning
- Fire can be easily extinguished with water
- Ten year limited product warranty
- REACH and RoHS declarations available
- Recyclable symbol 7, which includes the word "other", stands for other types of plastics not found within groups 1-6. This group of plastics includes but are not limited to; acrylic, ABS, polycarbonate plastic, polylactic fibers, nylon, and melamine.

2.2 APPLICATIONS

OPTIX Cell Cast acrylic sheets are versatile and easy to fabricate. They are the preferred choice for manufacturers and designers alike. These acrylic sheets can be used both indoor and outdoor for a wide variety of domestic and industrial applications:

- Glazing
- Skylights
- Noise Reduction Barriers
- Aquariums
- Swimming Pools
- Transparent Tanks
- Interior Decoration
- Trade Shows Exhibits
- Furniture
- Sanitary Applications
- Light Fittings
- Illuminated Signs (LED)
- POP Display Stands.
- Light Diffusers
- Display Cases
- Photo Covers
- Art Preservations

GLAZING

INTERIOR DESIGN

BRIDGE BARRIERS

ACOUSTIC BARRIERS

ARCHITECTURE

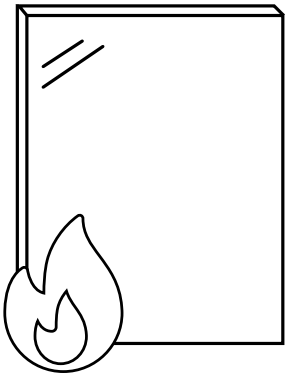
POP DISPLAY STANDS

HANDLING

3. HANDLING

OPTIX Cell Cast is a rigid sheet, which with wrong handling can break, leaving sharp edges. Handling OPTIX Cell Cast must be done with care, always using protective gloves and shoes.

3.1 BURNING BEHAVIOR

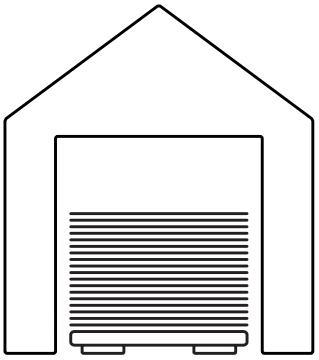


OPTIX Cell Cast sheets are combustible, and if not extinguished, will burn to completion once ignited.

When burning, in the presence of sufficient air, OPTIX Cell Cast releases CO_2 and water however if there is a lack of sufficient air, toxic CO gas can form.

When storing or working with OPTIX Cell Cast, the necessary fire precautions must be considered, taking into account the burning behavior of OPTIX Cell Cast

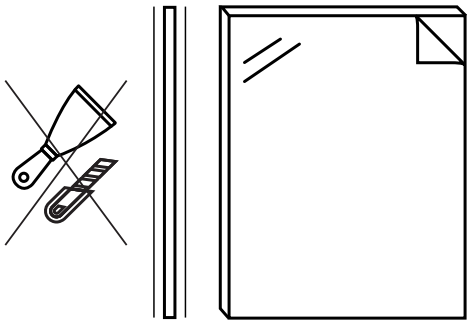
3.2 SHEETS STORAGE



OPTIX Cell Cast sheets must be stored with their original protective masking in a cool, dry and well-ventilated room, at a reasonable constant temperature, away from direct sunlight, excessive humidity, rain or solvent‘s vapors. Failing to store OPTIX Cell Cast in adequate conditions can produce distortions in the sheets and other effects, which will make later fabricating, a more difficult task. OPTIX Cell Cast sheets are best stored on their original delivery pallets. Pay attention to avoid pressure on the unsupported areas.

Never leave uncovered sheets or pallets. It is advisable to replace the original packaging over the stack after a sheet is removed from stock to avoid moisture absorption. Do not leave uncovered sheets or pallets.

3.3 PROTECTIVE FILM



Both surfaces of OPTIX Cell Cast sheet are protected by a fully recyclable polyethylene (PE) film. Keep this film in position as long as possible and remove only and immediately after installation. The strength of the PE film may increase with time. Sharp objects, sharp particles or even small chips can penetrate the protective PE masking, and damage the surface, therefore always lay OPTIX Cell Cast on a clean smooth surface.

OPTIX Cell Cast protective film is suitable for shallow thermoforming and laser cutting (except for satin sheets).

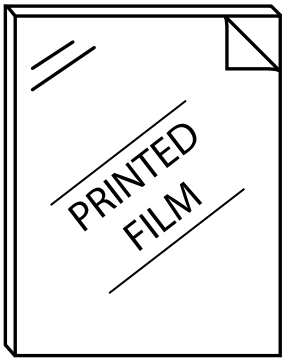
3.4 MACHINING AND FORMING WITH PE FILM

It is preferable to leave the protective film in position throughout machining to keep the sheet surface in perfect condition. Normal thermoforming temperatures do not affect the adhesive used for the film on OPTIX Cell Cast sheets and can therefore be left in place during most heating and forming operations. However, care should be taken to ensure there are no defects in the film (holes, scratches, bubbles), which could mark the part during the forming process. High-heat deep-draw thermoforming applications can

cause the PE film to adhere more strongly. Printed film must be removed before thermoforming, to avoid transfer of the printing ink to the sheet's surface.

3.5 CLEANING OPTIX CELL CAST SHEETS

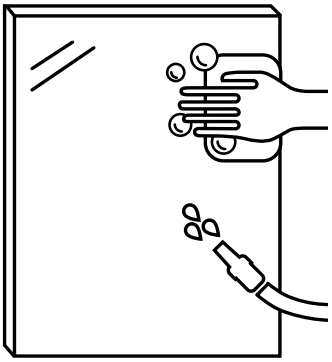
OPTIX Cell Cast sheets are produced in clean room environment and do not need to be cleaned before use. However, cleaning may be needed after fabrication, before sensitive processes like vacuum metallization or printing or for maintenance during use. In the case that OPTIX Cell Cast sheets needs to be cleaned, wash the sheet surface with clean fresh water with a mild soap. Be sure that the soap you are using is compatible with PMMA. Test a hidden area before cleaning. Use a clean, soft cloth or sponge and rinse well. Do not scrub or use brushes. Dry with a soft cloth. Do not rub dry. The use of window cleaning fluids or solvents such as alcohols, turpentine, acetone, etc., can cause damage to the sheet.



**Remove before thermoforming*

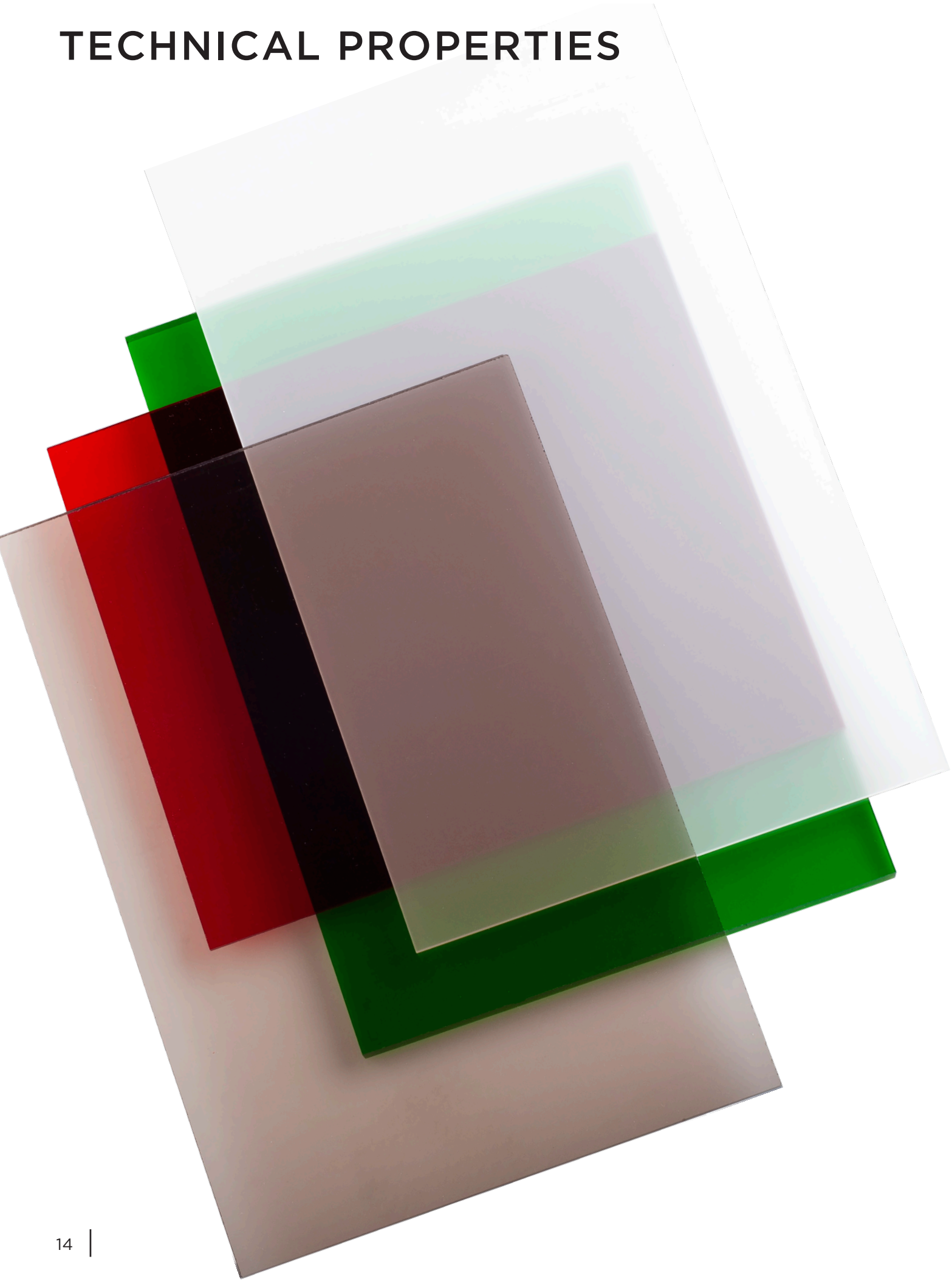
3.6 ENVIRONMENTAL ADVANTAGES

OPTIX Cell Cast sheets are environmentally friendly. The outstanding chemical stability and long-time resistance to aging and weathering of OPTIX Cell Cast sheets often ensures a service time of decades. They do not need to be removed or replaced for many years reducing the environmental burden of plastics waste. They do not contain any toxic materials, halogens or heavy metals which may cause environmental damage or health risks. OPTIX Cell Cast sheets do not contain Bisphenol-A. Ozone Depleting Substances (ODP) are not used in the manufacture of the sheets. OPTIX Cell Cast do not release pollutant substances to the environment during manufacture. They do not produce toxic or corrosive gases upon burning. Fires can be extinguished with water.



OPTIX Cell Cast sheets can be used for energy recovery and chemical recycling. OPTIX is not classified as hazardous waste. Small amounts can be disposed as household refuse. Large quantities should be recycled.

TECHNICAL PROPERTIES



4. TECHNICAL PROPERTIES

Please note that technical values given in this guidebook are typical values for your guidance. They are not to be taken as specifications and are subject to certain variability.

4.1 STANDARD SIZES

THICKNESS	DIMENSION
3 - 6 mm (0.118-0.236″)	3050 X 2050 mm (120 x 80.7″)
8 - 35 mm (0.314-1.37″)	3050 X 2030 mm (120 x 79.9″)
40 - 60 mm (1.57-2.36″)	3000 X 2000 mm (118.11 x 78.7″)

Sheets are also available cut to size, according to customer requirements

4.2 COLORS

OPTIX Cell Cast sheets are naturally colorless and exceptionally clear, however they can be pigmented to obtain a wide range of tints and colors. They are available clear and in a wide range of transparent, translucent, opaque colors, opals and diffusers. OPTIX Cell Cast colored sheets maintain the same light transmission percentages regardless of thickness (except for special types of opals, diffusers and LEDs). Machining the sheet to a reduced thickness will increase the light transmission and may change the color shade of the reduced area. For a list of updated colors please contact your regional supplier.

4.3 FIRE PROPERTIES

PMMA is a combustible material and will burn if ignited. However, unlike other polymers, does not produce toxic or corrosive gases and produces very little smoke, an important safety benefit. OPTIX Cell Cast Acrylic sheets classify:

- HB according to UL94
- E according to EN 13501

4.4 NOISE REDUCTION PROPERTIES

OPTIX Cell Cast sheets are used widely as noise reduction barriers along roads and highways. CE Markings for OPTIX Cell Cast sheets are available according to: EN-14388 - “Road Traffic Noise Reducing Device.”

4.5 TYPICAL PROPERTIES - CAST ACRYLIC SHEETS

PROPERTIES	METHOD	UNITS	VALUE
General			
Density	ISO 1183	g/cm^3	1.2
Water Absorption	ISO 62 (1)	%	0.3
Mechanical			
Tensile Strength	ISO 527-2	MPa	70
Elongation at Break	ISO 527-2	%	4
Tensile Modulus	ISO 527-2	MPa	3300
Flexural Strength	ISO 178	MPa	104
Flexural Modulus	ISO 178	MPa	3000
Rockwell Hardness	M scale		100
Impact Resistance (Charpy unnotched)	ISO 179/1fu	kJ/m^2	15
Impact Resistance (Izod notched)	ISO 180/1A	kJ/m^2	1.5
Optical			
Refractive Index	ISO 489		1.49
Light Transmission (clear sheet)	ASTM D1003	%	92
Haze (clear sheet)	ASTM D1003	%	< 1
Thermal			
Vicat Softening Temp.(50N)	ISO 306	°C	105-112
Heat Deflection Temp. (1.82 MPa)	ISO 75-1	°C	105
Coeff. of Linear Thermal Expansion		$°K^{-1}$	$7x10^{-5}$
Thermal Conductivity	ASTM C177	W/mK	0.19
Maximum Continuous Service Temp.		°C	82
Electrical			
Dielectric Strength	DIN 53481	kV/mm	20-25
Dielectric Constant (50Hz)	DIN 53483		3.6
Dissipation Factor tan delta (50Hz)	DIN 53483		0.06
Surface Resistivity	IEC 60093	Ohm	$>10^{15}$
Volume Resistivity	IEC 60093	Ohm.cm	$>10^{15}$

* ***All values (unless specified) measured at room temperature***

4.5 CHEMICAL PROPERTIES

OPTIX Cell Cast sheets have good resistance to water, alkalis, aqueous inorganic salt solutions and most common dilute acids. Some substances do not produce any effect on OPTIX Cell Cast, some cause staining, swelling, crazing, weakening or dissolve it completely. The chemical resistance table below gives an indication of the chemical resistance of OPTIX Cell Cast to a range of common chemicals, judged by visual examination of small unstressed samples immersed in various liquids at 20°C (68°F) for various periods of time. The data in the table is based on general literature. This information should be used with caution since the performance of articles is influenced by temperature and by stresses applied to the material when machined or thermoformed or under service conditions. In case of doubt, it is recommended that appropriate tests be carried out to simulate the actual service conditions of the intended application. Please contact PLASKOLITE Iberica for information regarding special applications.

NOTE

Any substance that comes with contact with PMMA should be checked for compatibility. Even if the supplier confirms that the material is suitable for PMMA, please apply it first to a hidden area to see if there are any effects. However, this will cover you for short-time effects only. To assess long-term effects of substances on PMMA, laboratory testing is required.

CHEMICAL	CONCENTRATION	COMPLIANCE(DB)
Acetaldehyde		Dissolved
Acetic acid		Dissolved
Acetic acid	10% aqueous	Not affected
Acetic anhydride		Affected
Acetone		Dissolved
Acetonitrile	Aqueous	Dissolved
Ammonia		Dissolved
Ammonium chloride	Saturated	Affected
Amyl acetate		Dissolved
Aniline		Dissolved
Benzaldehyde		Dissolved
Benzene		Dissolved
Benzyl alcohol		Dissolved
Butyl acetate		Dissolved
Butyl alcohol		Dissolved
Calcium chloride	Saturated	Not affected
Carbon dioxide	Gas	Not affected
Carbon disulfide		Dissolved
Carbon tetrachloride		Dissolved
Chlorine	2% aqueous	Not affected
Chlorine	Gas	Not affected
Chlorine	Conc.	Affected
Chlorobenzene		Dissolved
Chloroform	Saturated	Dissolved
Chromic acid	10% aqueous	Not affected
Chromic acid		Dissolved
Citric acid		Not affected
Cyclohexane		Dissolved
Cyclohexanone		Dissolved
Dibutyl phthalate		Affected
Diesel oil		Not affected
Diethyl ether		Dissolved
Dioctyl phthalate		Affected
Epichlorohydrin		Dissolved
Ethyl acetate		Dissolved
Ethyl alcohol	10% aqueous	Not affected
Ethyl alcohol	50% aqueous	Affected
Ethyl alcohol		Dissolved
Ethylene dichloride	90% aqueous	Dissolved
Ethylene glycol		Not affected
Formaldehyde	40% aqueous	Not affected
Formic acid	10% aqueous	Not affected
Formic acid		Dissolved
Glycerin		Not affected

CHEMICAL	CONCENTRATION	COMPLIANCE(DB)
Hexane		Not affected
Hydrochloric acid		Not affected
Hydrofluoric acid	90% aqueous	Dissolved
Hydrogen peroxide	10% aqueous	Not affected
Hydrogen peroxide		Dissolved
Isopropyl alcohol	10% aqueous	Affected
Isopropyl alcohol	50% aqueous	Affected
Lactic acid		Not affected
Lanolin		Not affected
Methyl alcohol		Dissolved
Methyl alcohol	10% aqueous	Not affected
Methyl alcohol	50% aqueous	Affected
Methyl ethyl ketone		Dissolved
Methyl salicylate		Dissolved
Nitric acid	95% aqueous	Dissolved
Nitric acid	10% aqueous	Not affected
Nitrobenzene	98% aqueous	Dissolved
Nitrogen		Not affected
n-octane		Affected
Olive oil		Not affected
Oxygen		Not affected
Paraffin		Not affected
Phosphoric acid		Dissolved
Phosphoric acid	10% aqueous	Not affected
Potassium hydroxide	Saturated	Not affected
Salt water		Not affected
Silicone F110		Affected
Silicone F130		Affected
Silicone R220		Affected
Sodium carbonate	Saturated	Not affected
Sodium chloride	40% aqueous	Not affected
Sodium hydroxide		Not affected
Sodium thiosulfate		Not affected
Sulfuric acid		Dissolved
Sulfuric acid	10% aqueous	Not affected
Sulfuric acid	30% aqueous	Affected
Tetrahydrofuran		Dissolved
Tetralin		Dissolved
Toluene		Dissolved
Trichloroethane		Dissolved
Trichloroethylene		Dissolved
Turpentine oil		Not affected
Water		Not affected
Xylene		Dissolved

4.6 ESC (ENVIRONMENTAL STRESS CRACKING)

ESC (Environmental Stress Cracking) is a well-known phenomenon in plastics including PMMA, and a common reason of product failure. ESC is a result of the combination of stress and chemical exposure. Under harsh chemical environment, stressed sheets will fail by cracking and crazing. The level of stress needed for ESC is lower than the normal failure mechanical stress of PMMA in a chemical-free environment. Stresses can be induced during forming and fabrication. These can be eliminated by an annealing process (see machining and forming instructions page 31). Stresses can be induced also by improper installation (see installation instructions page 69). Cold bended sheets under permanent induced stress or sheets under periodic stress (fatigue) are also susceptible to ESC.

4.7 HEAT TRANSMISSION

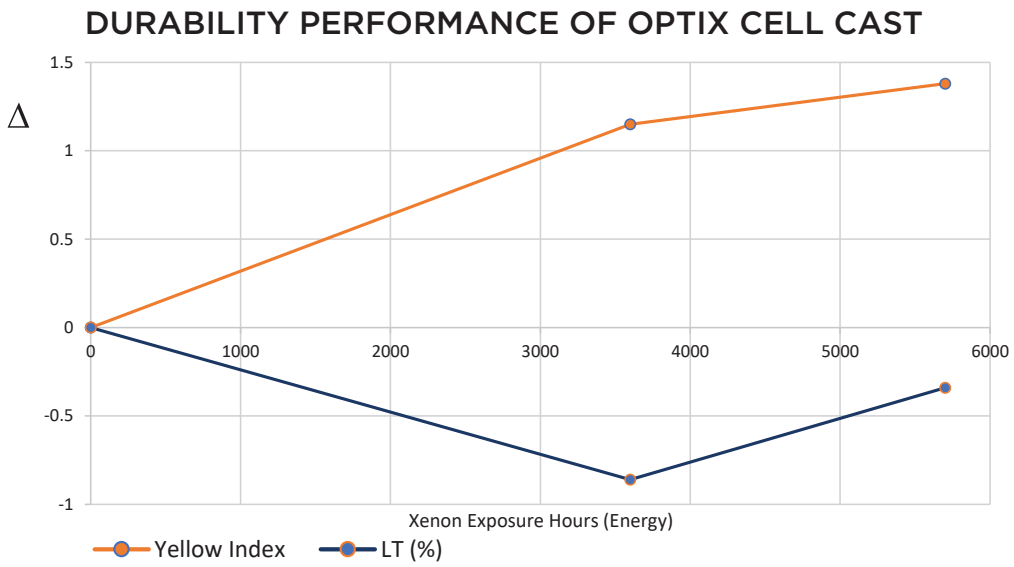
The U-factor, or overall heat transmission coefficient, is the amount of heat which will pass through one square meter in one second for a specific thickness of material. Is an important factor to consider when choosing a glazing material, due to its influence on thermal efficiency and energy loss in winter (heating) or summer (air-conditioning). OPTIX Cell Cast sheets insulate better than glass, contributing to substantial energy conservation for single glazing.

THICKNESS mm (in)	OPTIX CELL CAST	GLASS
	U Factor W/m2*°K, BTU/hr*ft²*°F	
3 (0.118”)	5.38, 0.95	5.78, 1.02
6 (0.236”)	4.96, 0.87	5.68, 1.00
12 (0.472”)	4.29, 0.75	5.49, 0.97
20 (0.787”)	3.63, 0.64	5.26, 0.93
30 (1.18”)	3.05, 0.54	5.00, 0.88

Total Heat Loss or Gain through a Window due to Conduction/Convection:
Heat Loss = Window Area X [Indoor Temp - Outdoor Temp] X U-Factor

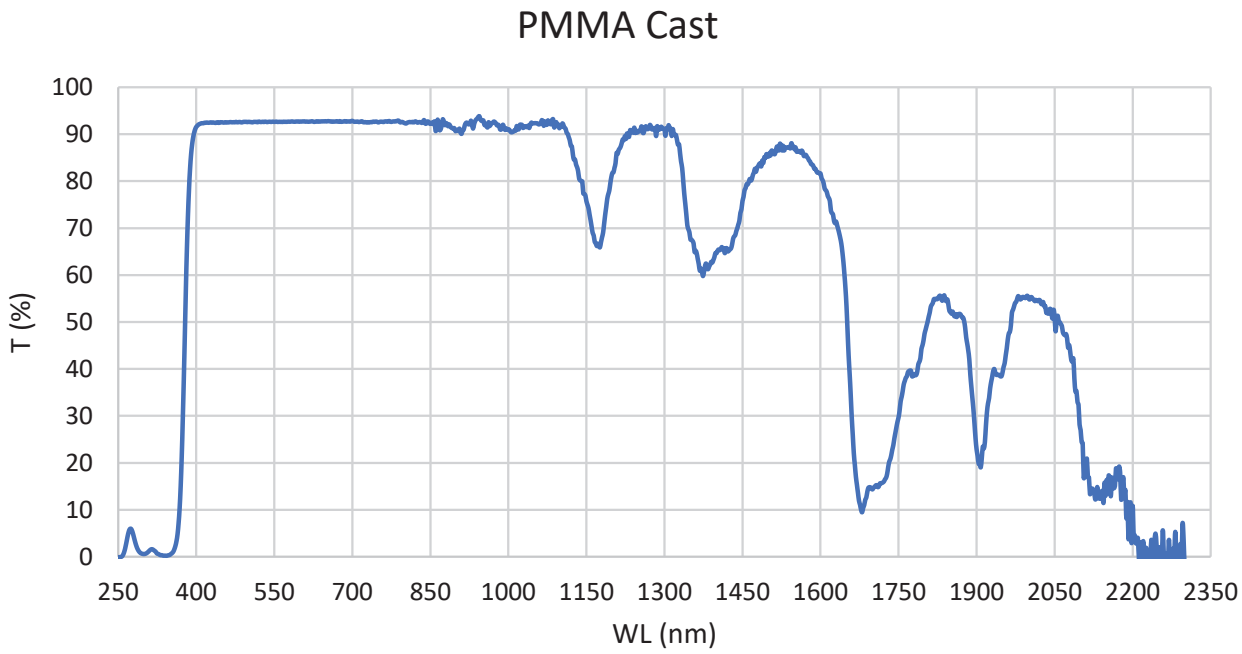
4.8 WEATHERING RESISTANCE

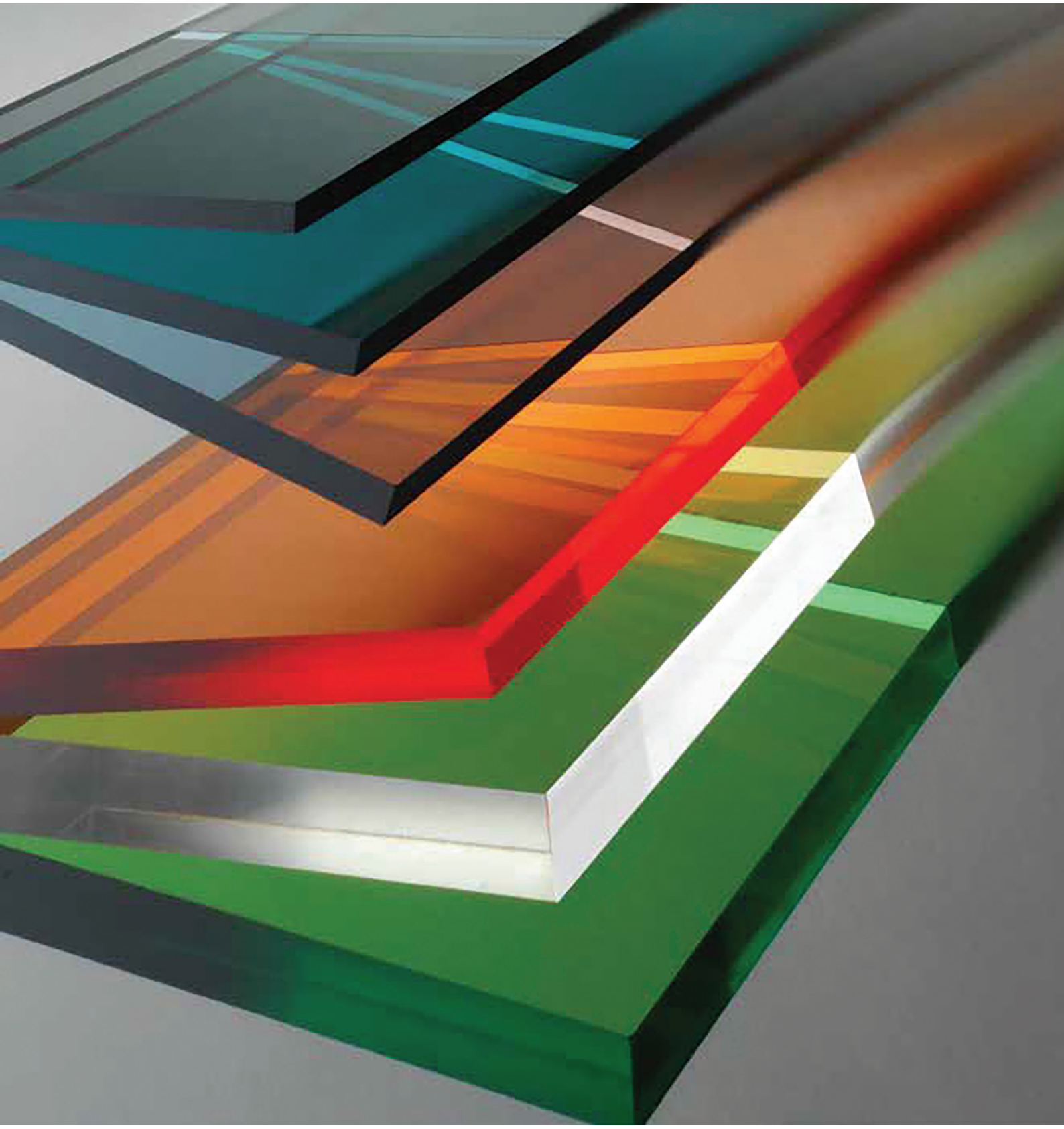
PMMA is intrinsically resistant to UV radiation and does not have to be protected using UV protection layers. OPTIX Cell Cast sheets have outstanding weathering resistance and will keep their transparency and properties for decades.



4.9 SOLAR TRANSMISSION

The Sun spectrum that reaches the earth surface ranges roughly from about 250 nm to 2500 nm wavelength. This spectrum can be divided in three regions of increased wavelength. The ultra-violet (UV) region below 400 nm, the visible region between 400 and 750 nm and the infrared (IR) region above 750 nm. OPTIX Cell Cast transparent sheets block partially the UV and transmit visible light and IR radiation. For special applications where more UV blocking is needed (e.g. preservation applications) a special product that blocks the UV radiation (OPTIX Cell Cast UV Stop) has been developed. Also, in the case where more UV is needed (e.g. solarium applications) a special UV transmitting product (OPTIX Cell Cast UV Open) can be used.

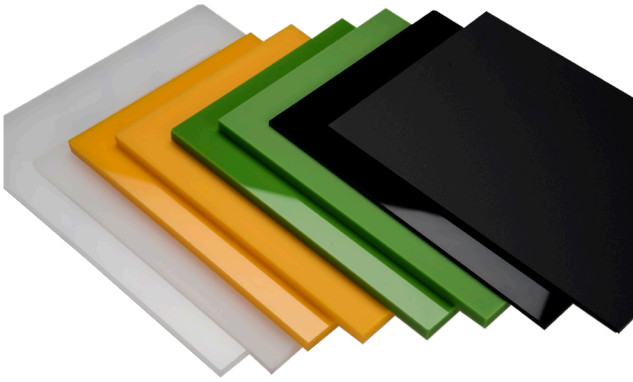




SPECIAL GRADES

5. SPECIAL GRADES

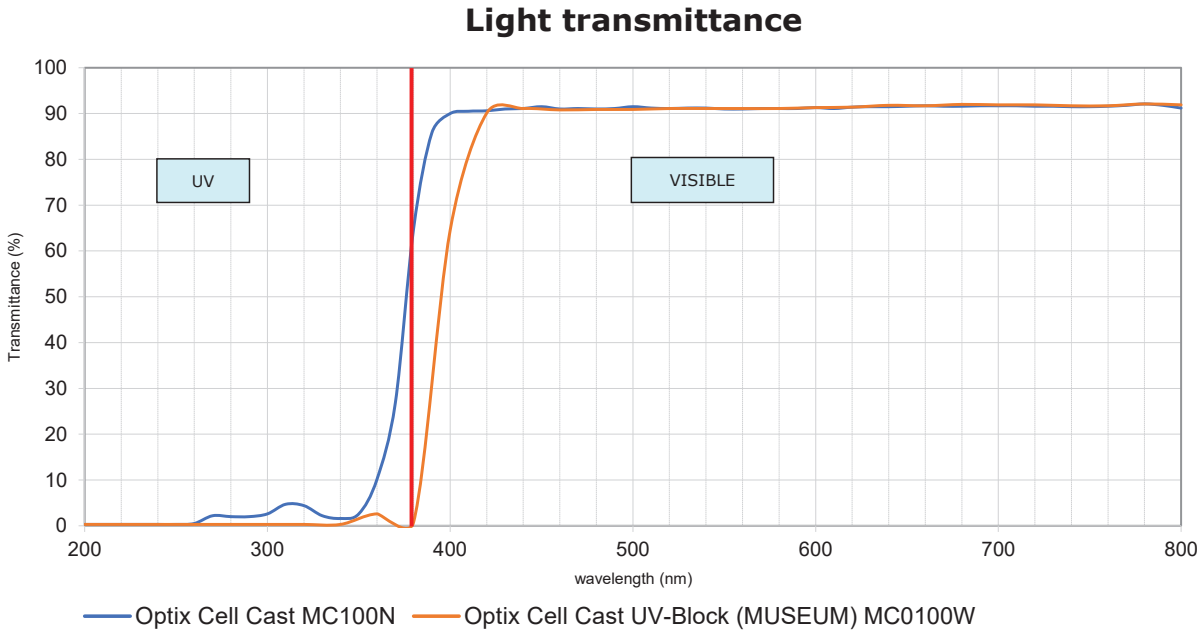
5.1 SATIN/DOUBLE SATIN



OPTIX Cell Cast sheets have normally a very glossy surface; however, they are also available with a matt/satin surface from one or both sides. The satin surface is created during the production process and is fully integrated to the product. It does not crack or delaminate from the surface as it is part of the Cast sheet itself. Beside their beautiful aesthetical appearance, the satin surface diffuses light without compromising the light transmission, providing an excellent solution for lightning applications. The satin surface also hides the effects of fingerprints and surface scratches.

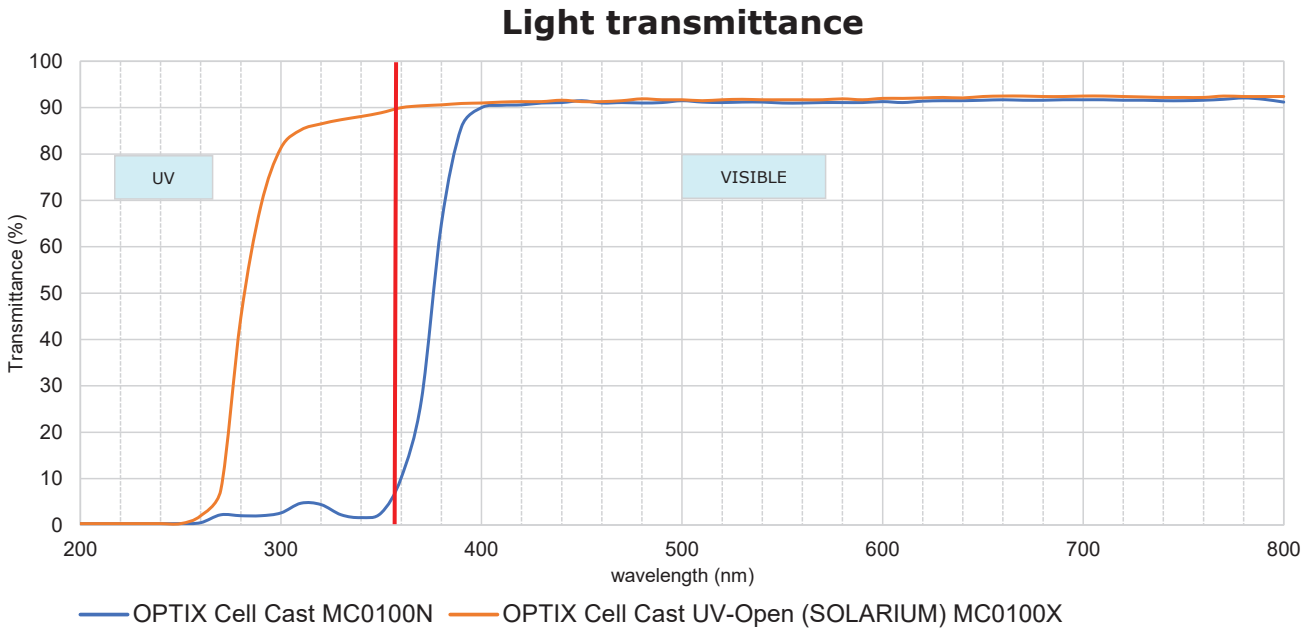
5.2 UV BLOCK (MUSEUM)

Standard PMMA sheets transmit part of the UV light. OPTIX Cell Cast UV-Block blocks most of the UV light providing an excellent solution for any application that needs to maintain transparency while protecting against fading and yellowing due to UV radiation transmitted through the sheet. Applications include: museums, exhibitions, picture framing and windows. The OPTIX Cell Cast UV-Block blocks 98% of the UV light from 300-380 nanometer, while keeping the outstanding intrinsic visible light transmission of the PMMA of about 92-93%.



5.3 UV - OPEN (SOLARIUM)

OPTIX Cell Cast sheets intrinsically absorb some UV light. In certain applications this is not the most desirable situation (e.g. solarium windows). OPTIX Cell Cast UV - Open sheets are highly transparent to UV light, while maintaining a high UV resistance to degradation.
Applications include: Solarium, greenhouses where the UV light is required, therapeutic purposes in spas and hospitals, etc. OPTIX Cell Cast UV-Open sheets are transparent to UVA light up to 80% and transparent to visible light up to 93%.



OPTIX Cell Cast UV-Open is available in different colors: clear, blue, yellow, violet, pink

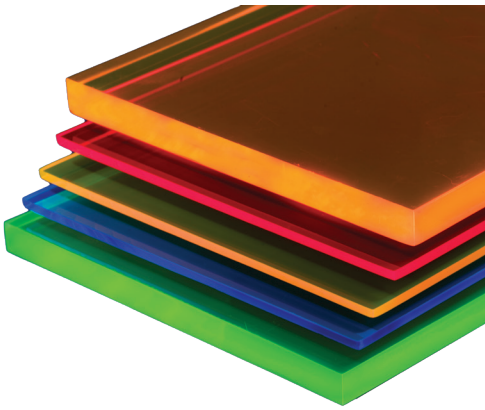
5.4 CHEMICAL-RESIST (CROSS - LINKED)

OPTIX Cell Cast Chemical-Resist is a cross-linked cast PMMA sheet with improved chemical resistance. In the cross-linking process, the polymer molecules connect to each other forming huge macromolecular structures. These enhance the chemical resistance to some common chemicals such as gasoline gases, common marine cleaners, cosmetics, perfumes and mild household day-by-day cleaners. Especially useful for perfume and cosmetic displays, kitchen covers, windows, machine protections, etc. OPTIX Cell Cast Chemical-Resist is available in a wide color range. It must be noted that the same effect that increases the chemical resistance may limit the bonding capacity of the sheet.

5.5 SANITARY

OPTIX Cell Cast Sanitary is a mild cross-linked cast PMMA sheet with improved chemical resistance for sanitary applications. It is designed to allow easy and deep thermoforming for the creative fabrication of sinks, bathtubs, shower trays and other sanitary appliances. Another successfully-proven application is the covering of bathrooms walls. Its beautiful glossy surface gives a life-long product, superior than standard enamel coated appliances. The cast surface is highly smooth, non-porous and scratch resistant and do not foment the development of bacteria and mildew. It comes in a wide range of colors.

5.6 FLUORESCENT



OPTIX Cell Cast Fluorescent beautiful appearance is an excellent choice for designers and fabricators. The fluorescent effect lights-up the sheet's edge as it has a light of its own. The sheets are available in different fluorescent colors, strong and soft, appropriate for each preference. The sheets are specially designed and suitable only for interior design applications.

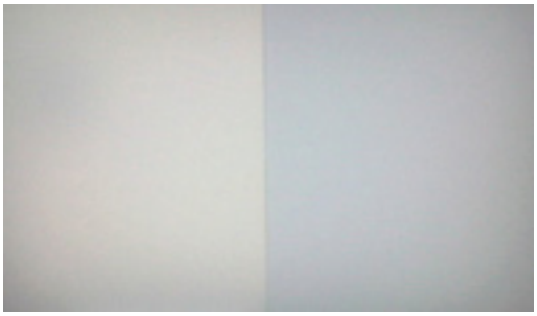
5.7 LED

LEDs are the most economical device in the field of illumination.
They are gaining popularity and are now replacing older illumination technologies. Unlike fluorescent or neon tubes, which have an angle of dispersion of 360°, LED's have a much narrower angle (from 40° to 140° for example) and appear as tiny spots of light. OPTIX Cell Cast LED sheets avoid this phenomenon known as "hot spots" and optimize uniform diffusion without compromising light transmission. OPTIX Cell Cast LED sheets transmit around 80% of the LED light (measured by luxmeter).
OPTIX Cell Cast LED sheet enables sign makers and designers to enjoy the benefits of LEDs and create elegant solutions that are cost and eco-efficient, whilst enhancing intensity and color.
OPTIX Cell Cast LED sheets from PLASKOLITE come in two standard white shades "warm" and "cold" feel and in a wide range of special colors: blue, red, green, yellow, etc.

OPTICAL PROPERTIES

OPTIX CELL CAST LED	CODE #	HAZE ASTM D1003	CLARITY ASTM D1003	LIGHT TRANSMISSION (%) (LED box test**)
Cold Feel	1693N	104	2.4	>60
Warm Feel	1695N	104	1.8	>65
White	1845N	104	1.2	>55
Orange	2139N	104	0	>10
Yellow	2471N	104	0	>22
Red	3496N	104	0	>2
Pink	4486N	104	0	>3
Blue	5569N	104	0	>3
Green	6409N	104	2.3	>30

* *Optical properties were measured on 3-4 mm sheets.*
** *LED box Test: box size 29x19.5 cm, distance of LED grid to measured sheet 5 cm, LED grid: 11X7 LED type LH-DM-25 12V, measured using a Lux light meter.*



WARM FEEL (1695N) COLD FEEL (1693N)

OPTIX CELL CAST LED COLORS

OTHER SPECIAL ACRYLED PRODUCTS

MC1710N is the newest development, specially designed for machining and LED inserting.
Light transmission in this product changes with thickness in order to achieve a perfect light diffusion and a clear white light when the thickness is reduced.



OPTICAL PROPERTIES OF ACRYLED MC1710N:

THICKNESS (mm, in)	HAZE ASTM D1003	CLARITY ASTM D1003	LIGHT TRANSMISSION (%) (LED box Test**)
10	104	0	45-50
15	104	0	40-45
20	104	0	35-45
25	104	0	25-35
30	104	0	25-35

** *LED box Test: box size 29x19.5 cm, distance of LED grid to sheet 5 cm, LED grid 11X7, LED type LH-DM-25 12V, measured using a Lux light meter.*

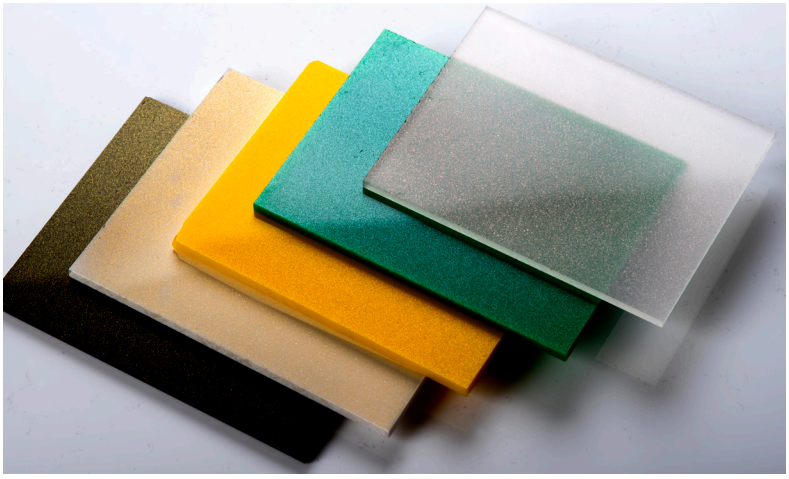
5.8 DUAL COLOR

OPTIX Cell Cast Dual Color has one color during the day and another color when illuminated with backlight during the night. Various combinations of colors are available for the designer's choice.

TECHNICAL CHARACTERISTICS OF DUAL COLORS

PRODUCT	TYPE	WITH LIGHT	WITHOUT LIGHT	LIGHT TRANSMISSION (%)
8079NMM	Black&White	White	Black	20
8681NMM	Black&Blue	Blue	Black	25
8682NMM	Black&Green	Green	Black	10
8683NMM	Black&Magenta	Magenta	Black	10
8684NMM	Black&Red	Red	Black	20
8688NMM	Black&White	White	Black	20
5680NMM	White&Blue	White	Blue	55
5686NMM	White&Green	White	Green	54
4685NMM	White&Red	White	Red	70


5.9 METAL



OPTIX Cell Cast Metal incorporates special pigments that give a metallic effect to the finished product. The pigments which produce this metallic look are fine layers of mica covered with titanium dioxide and/or other oxides. These layers are laid parallel to the surface of the sheet and the brilliance of the color comes from light reflecting off their smooth surfaces. A variety of effects are obtained depending on the size of the particles used. Larger particles will give a flecked appearance; smaller particles result in a softer, smoother shine. The metallic effect is present only on one side of the sheet. The pigments are not hazardous (they are biologically inert) and do not pollute, as they are not water soluble and contain no heavy metals. They do not conduct electricity and they withstand very high temperatures.

5.10 SMR

OPTIX Cell Cast SMR is a Stainless-Steel Metal Reinforced Cast PMMA panel specially designed for use in acoustic panels. The sheet is reinforced with 2 mm (0.79") diameter stainless steel rods and wires separated 30 mm (1.18mm) form each other, specially designed to give an optimal combination of strength and flexibility and to prevent pieces falling as a consequence of traffic accidents. Since the rods and wires are for stainless steel fully embedded in the cast acrylic matrix they keep their properties for life, while other solution that include polymer strings will degrade with time. The sheet complies with European regulations for installation of acoustic elements in bridges and upper level highways. The rods and wires are visible showing a high contrast and helping birds not to collide and get killed by the panel. The contrast does not fade with time. The stainless steel does not corrode for decades.
OPTIX Cell Cast SMR complies with EN14388 - Road traffic noise reducing devices.

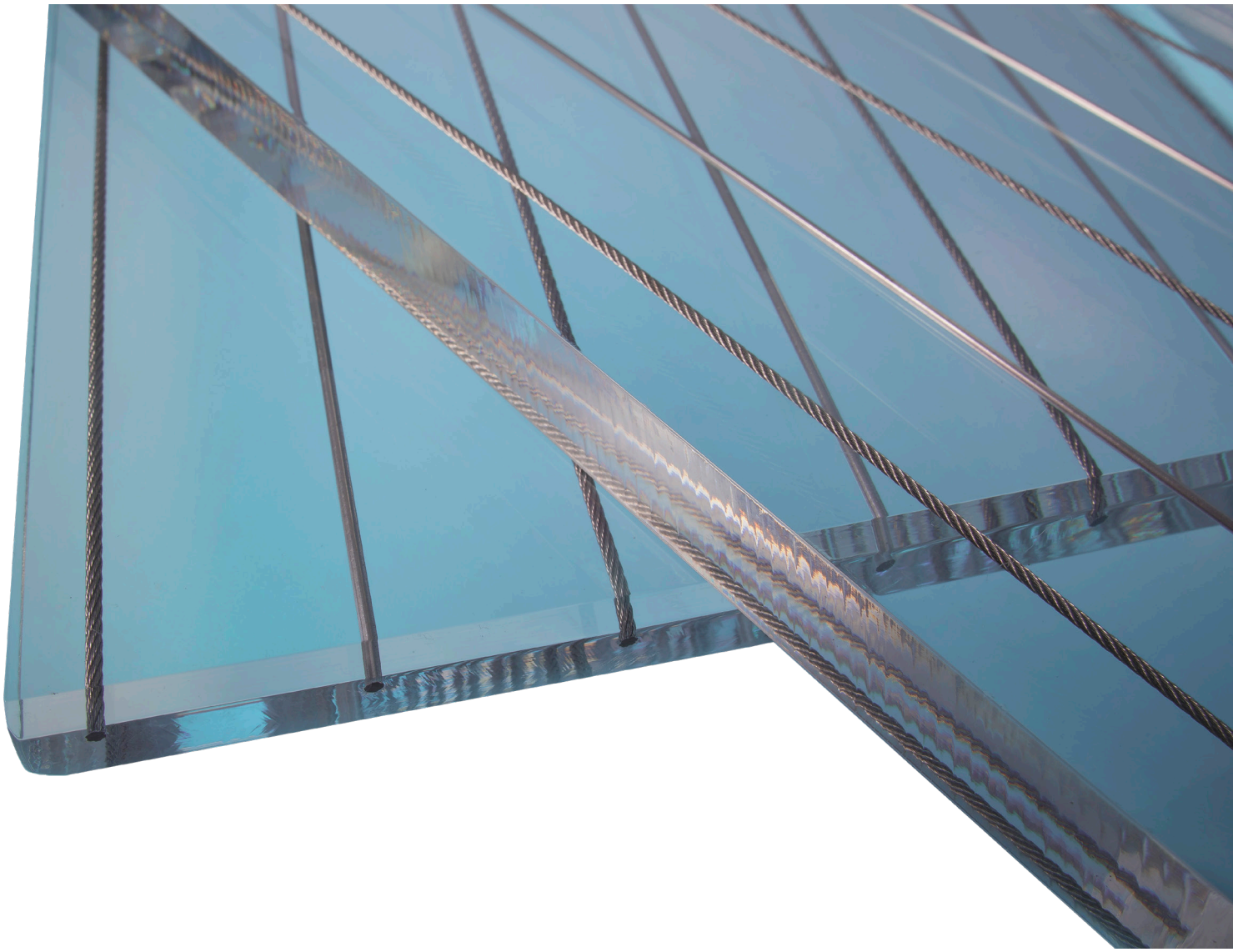
TECHNICAL SPECIFICATIONS

THICKNESS (mm, in)	SATISFACTORY PERFORMANCE FOR THE DESIGN WIND LOAD	NOISE REDUCTION (CATEGORY B3)	
		R_W	DL_R
15	1600 N/m², 33psf	32 dB	30 dB
20	1900 N/m², 40psf	34 dB	32 dB
25	>1900 N/m², >40psf	>34 dB	>32 dB

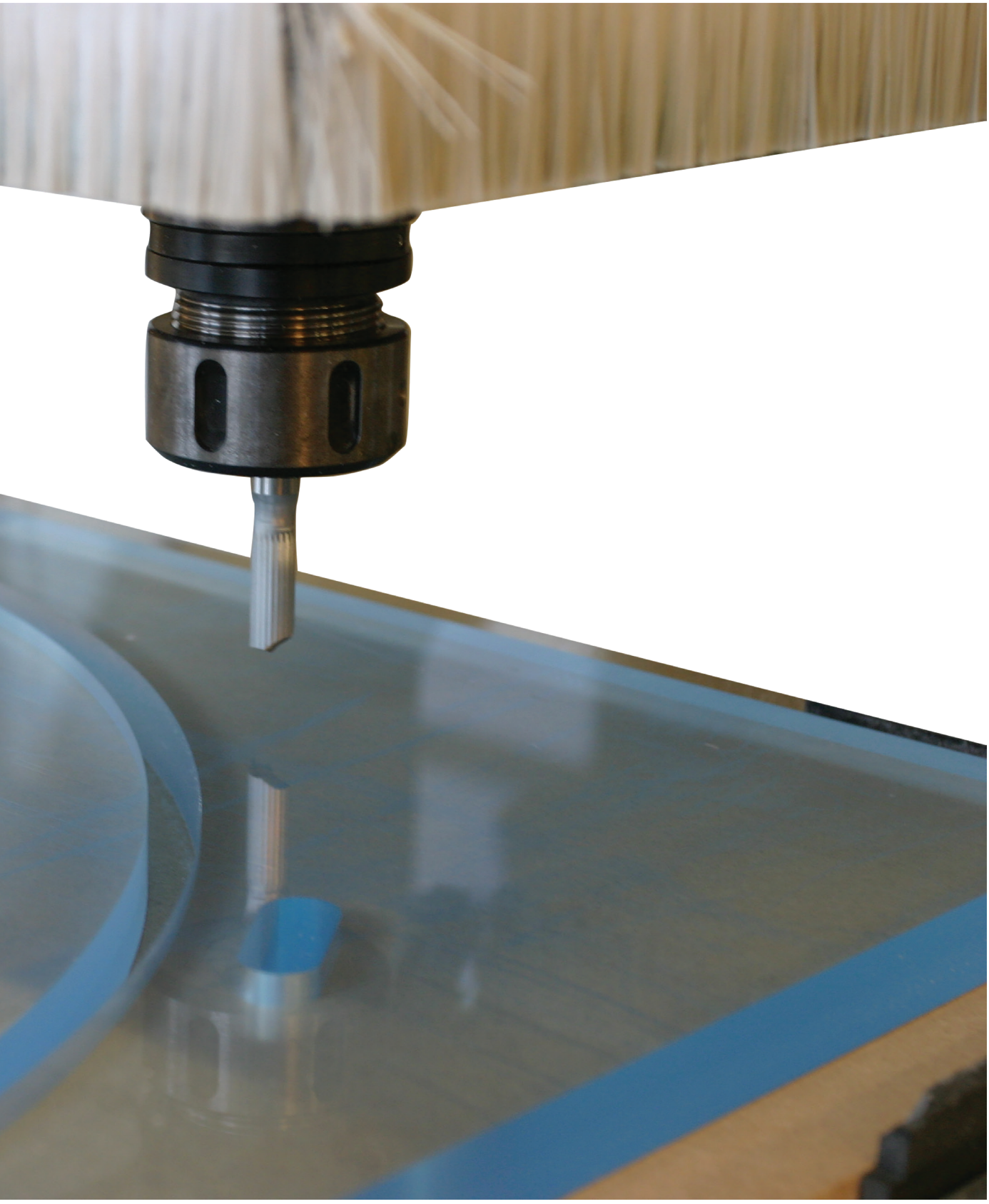
OPTIX Cell Cast SMR is available in 15, 20 and 25 mm thick, 2050X3050 mm (80.7 x 120")
Other sizes may be available upon request.

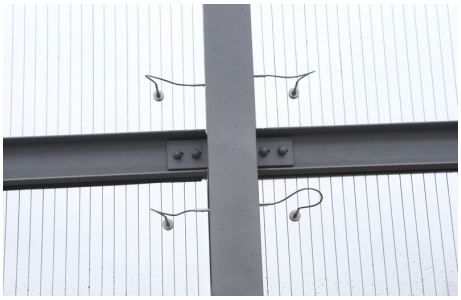
OPTIX Cell Cast SMR is patented:
- Honk Kong - HK 1187658.
- China - Utility Model ZL 201520035582.7
- US Patent - 8,651,232 B2
- Europe - EP 2619370

OPTIX Cell Cast SMR can be cut and bend (under certain restrictions).



MACHINING





6. MACHINING

OPTIX Cell Cast sheets can be cut, sawn, drilled, milled and bent easily using standard workshop equipment for wood or metal. However, it is always recommended to use specific tools specially designed for plastics. OPTIX Cell Cast sheets are ideal for fabricating for a wide range of indoor and outdoor applications. It is preferable to leave the protective film in position throughout machining to keep the sheet surface in perfect condition.

6.1 BASIC RULES FOR MACHINING

All methods of machining cause local overheating, generating internal stress, which can result in crazing (very fine cracks) later evolving into larger cracks, during forming or in the presence of solvents (for example during bonding or painting).

Crazing can be significantly reduced if the following general instructions are applied.

1. **COOLING** - Keep the working tools cooled with compressed air. Beware from using coolants that can chemically attack the acrylic and the material will soften if heated above 80-90°C.
2. **SWARF REMOVAL** - Ensure efficient removal of swarf. Machining without suction requires frequent stops for manually cleaning the swarf.
3. **SHARPENED TOOLS** - Use only adequate tools and keep them perfectly sharp.
4. **MATERIAL SUPPORT** - Support the sheet firmly during machining, especially close to the machined area, to avoid vibration of the sheet.
5. **FEED RATE** - The faster the feed rate is, the better the cut, but when the tool exceeds a certain speed the sheets start to chip, therefore the speed should be a little slower than this “chipping speed”. Maintain as constant feed rate as much as possible.
6. **ROTATION PLANE** - Keep the rotation plane of the working tool exactly parallel or perpendicular (depending on the machine used) to the feed direction.
7. **ANNEALING** - Anneal the sheets before exposure to solvents, printing or excessive temperature changes (see page 53).

6.2 CUTTING

When choosing the equipment for cutting OPTIX Cell Cast, a few factors must be considered:

1. The complexity of the cut
2. The accuracy needed
3. The quantities needed (cost efficiency)
4. The edge finishing that is needed
5. The process following the cutting operation

HAND CUTTING

Thin OPTIX Cell Cast sheets up to 4 mm thickness, (0.157”) can be cut using a scoring knife. Draw the scoring knife along a ruler held firmly in place. Score several times applying very light pressure, at least 1/3 way through OPTIX Cell Cast thickness. Align the cut with a straight edge (for example, a table edge)

and apply gentle pressure, on both sides of the cut, starting at one end of the sheet, working your way slowly along the cut until full breakage is achieved.

JIGSAW

OPTIX Cell Cast sheets up to 6 mm (0.236″) thick can be cut by jigsaw, but results may be poor. Cutting OPTIX Cell Cast with jigsaw results in inaccurate cuts and very rough edges. This type of cutting also causes high internal stress and will often cause melting and welding of the cut.

It is recommended to take note of the following guidelines to obtain best results:

1. A fine tooth saw with 4-5-teeth/cm (in) is recommended.
2. The blade must be kept vertical to the sheet.
3. Vibration of the sheet, during sawing, must be avoided, therefore a firm support, especially close to the machined area, is required.
4. High but steady advance speed will reduce the chances of melting.
5. Allow the blade to stop before withdrawing it from the cut.

BAND SAW

Although nice clean edges can never be achieved with a band saw, these types of saws are very easy to operate and are the most cost-efficient method for cutting curved sections and trimming excess material from thermoformed parts before final machining.

It is recommended to take note of the following guidelines to obtain best results:

1. The thickness of the blade should be 0.5-1.2 mm (0.020-0.047″).
2. The width of the blade will range from 5 to 50 mm (0.197 - 1.97″). A narrow blade will allow a curved cut with a smaller radius but with a poorer quality.
3. Use a saw blade with no side-set teeth.
4. Slow but steady advance speed will reduce the chances of melting.
5. Avoid blade twisting by keeping the saw guides as close as possible.
6. Use the blade speed as per the recommendation in table below.

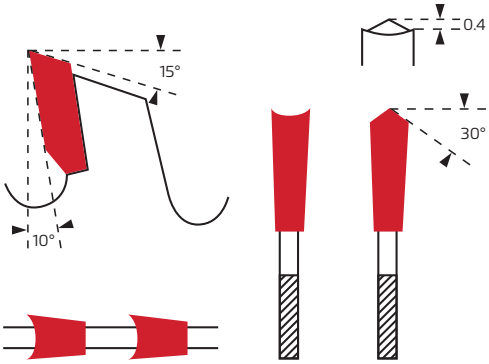
BLADE SPEED (m/min, ft/min)		SAW PITCH (teeth/in)
Up to 3mm, 0.118″	1200-1500, 3900-4900	8-10
3-10mm, 0.118-0.394″	1000-1200, 3300-3900	3-6
Over 10mm, 0.394″	750-1000, 2500-3300	2

CIRCULAR SAW

Using this saw, it is possible to achieve a straight accurate cut with a clean edge. The edge is matt but simple polishing will restore its bright finish. Fixed table and moving cutting head machines are far more accurate and easier to handle and therefore perform better than stationary motor /moving table saws. Working with saw blades, which were designed especially for acrylic will have best results but, in their absence, standard woodworking blades can be used.

CIRCULAR SAW BLADE

BLADE CHARACTERISTICS



OPTIX Cell Cast sheets from any thickness can be cut this way. Many factors influence the performance of cutting. Only by experimenting with them all, the best quality will be achieved.

RECOMMENDED PARAMETERS:

RANGE	
Saw thickness (mm, in)	2.8 - 5.0, 0.11-0.20″
Blade diameter (mm, in)	300 - 450, 12-18″
Number of teeth	60 - 80,
Saw speed (rpm)	2500 - 4000
Saw advance (m/min, ft/min)	15-18mm, 0.6-0.7″
Saw blade projection (mm, in)	15 - 35mm, 0.6-1.4″

CUTTING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Sheet breakage	Excessive vibration	Support the sheet properly, especially close to the cut
Chipping	Blunt blade	Replace blade with a sharp blade
	Wrong blade type	Use a blade with characteristics according to the instruction in this guide
		Use a blade with more teeth per cm
	Blade too thin	Use a wider blade
	Wrong blade projection	Adjust the blade projection to 15-35 mm(0.6-1.4″)
	Advance speed too high	Decrease the advance speed
	Rotation speed too low	Increase the rpm
Melting	Blunt blade	Replace blade with a sharp blade
	Wrong blade type	Use a blade with characteristics according to the instruction in this guide
		Use a blade with less teeth per cm
	Advance speed too low	Increase the advance speed
	Rotation speed too high	Decrease the rpm
White cutting edges	Blade is not parallel to the cut	Adjust the blade or the blade's carriage to be perfectly parallel with the feed direction
Blade-exit chipping	Cutting-out-flow speed too high	Decrease the cutting-out-flow-speed
Sheets welding	Melting when cutting more than one sheet at a time	See melting problems and solutions
Crazing	Contact with chemicals, even in vapor form	Remove any chemicals close to the working area

6.3 LASER CUTTING

OPTIX Cell Cast, up to 20 mm (0787″) thick, may be laser cut to make complex and intricate shapes. Laser cut results in a very accurate clean polished cut but with high internal stresses, which must subsequently be relieved by annealing if the product is to be exposed to solvents or paints. Many factors influence the performance of laser cutting. Only by experimenting with them all, the best quality will be achieved.

The major factors that influence the quality of the laser cut are:

1. **POWER OF THE LASER** - The stronger the power, the deeper or quicker you can cut.
2. **LASER FOCUSING** - If you are out of focus, you must burn though more material, and it will take longer. Cutting thick materials may require a delicate balance between the need for a focused beam and a wide gap so the edges don't stick back together when the cut is finished.
3. **SPEED OF THE CUT** - The speed that the laser is moved over the material determines how much burning power is applied to any one spot.
4. **DEPTH OF THE CUT** - At a given speed a deeper cut requires a more powerful laser beam.
5. **PULSES PER Cm, In** - This is another factor determining the power applied to any one spot.
6. **THICKNESS OF MATERIAL** - The thicker the material, the more power it takes to cut it. Good focusing and the number of times the laser beam is passed over the sheet, are the key to a good cut of thicker materials.

7. **NUMBER OF PASSES** - The more the laser beam is passed over the sheet, the deeper the cut.
8. **PROPER COOLING** - An air jet, directed at the cutting point, might be needed to prevent flaming and in some cases will help in achieving a cleaner cut.
9. **PROPER VENTILATION** - Consistent ventilation of the smoke and vapor.

Changing one factor will affect another. Finding the right combination requires a lot of practice. Optimal performance depends on the laser machine. For more specific details consult with your laser machine manufacturer.

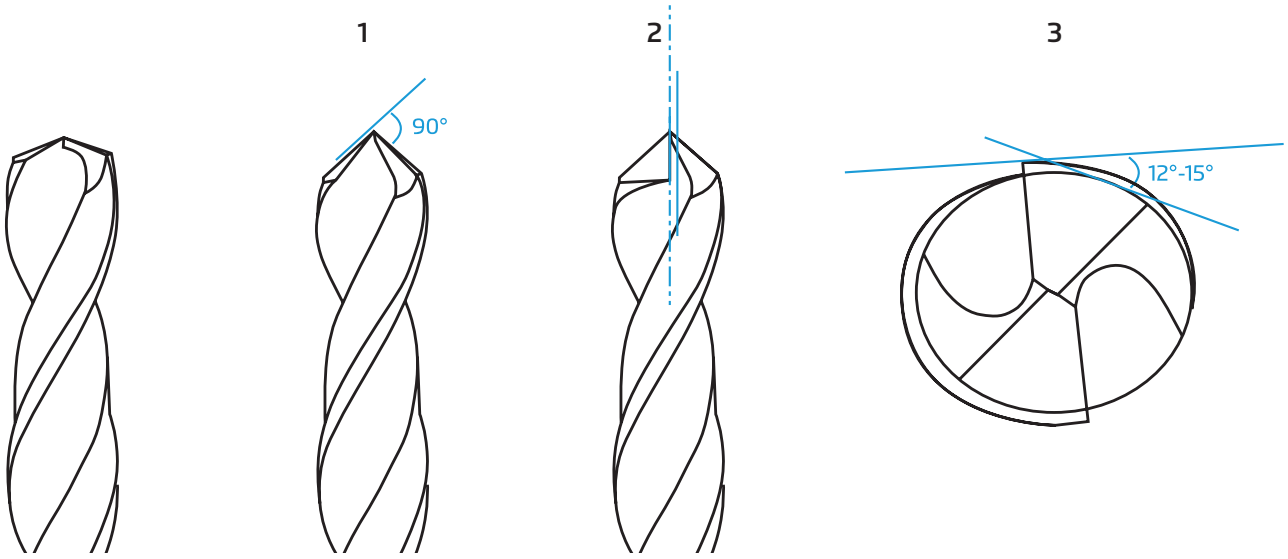
NOTE

When laser cutting OPTIX Cell Cast, as with all other materials, it is very important to provide adequate ventilation at the cutting head to remove any trace of unpleasant combustion vapor.

6.4 DRILLING

As in the case of saws blades, working with drills and bits that were designed for plastics will have the best results, but in their absence, modified woodworking drill bits can be used.
Modifying standard woodworking drill bits to fit acrylic consist of three stages.

1. Grind the tip angle of the bit to 60°-90°.
2. Grind the cutting edge to be parallel to the bit's length line.
3. Grind a clearance angle of 12°-15°.



It is recommended to observe the following guidelines to obtain best results:

1. To prevent chipping the sheet should be backed with either a piece of scrap OPTIX Cell Cast or a piece of hard wood so that the drill bit continues into solid material as it exits the bottom surface.
2. A center punch should not be used to mark the position of the hole, as this will crack the OPTIX Cell Cast.
3. When drilling with a greater diameter than 10 mm (0.394″), a small pilot hole should be drilled first to locate the drill.
4. The drill bit must be kept vertical to the sheet.
5. When drilling a hole three times deeper than the diameter, back feed the drill at regular intervals to ensure removal of swarf.
6. Suggested RPM = 11,000 / drill diameter in mm, in.
7. Maintain a slow constant feed rate (use a slower feed rate as the bit enters and exits the OPTIX Cell Cast).
8. Do not stop the drill before withdrawing from the drill hole.

DRILLING TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Sheet breakage	Excessive vibration	Support the sheet properly, especially close to the drill
	High pressure application	Apply very light pressure
	Wrong bit withdrawn	Withdraw the drill bit slowly and stop the rotation only after full withdrawal
Chipping	Wrong drill bit	Use a drill bit with characteristics according to the instruction in this guide
	Blunt drill bit	Replace the drill bit with a sharp drill bit
	Curved drill bit	Replace the drill bit
	Excessive vibration	Support the sheet properly, especially close to the drill
	Advance speed too high	Decrease the advance speed
	Rotation speed too low	Increase the rpm
	Bit diameter too big	Drill a pilot hole
Bit-exit chipping	Insufficient back support	Use wood or scrap OPTIX Cell Cast to back support the drill
Melting	Blunt bit	Replace the drill bit with a sharp drill bit
	Curved drill bit	Replace the drill bit
	Advance speed too low	Increase the advance speed
	Rotation speed too high	Decrease the rpm
	Insufficient cooling	Cool with air and back feed the bit more frequently
Crazing	Contact with chemicals, even in vapor form	Remove any chemicals close to the working area

6.5 ROUTING

Routing OPTOX Cell Cast with Standard CNC, table or even hand routers produce a better edge than other mechanical machining. Bits designed especially for routing acrylic are commercially available and will perform the best.

Routing OPTIX Cell Cast is a very complex task comprising several variables.

1. **BIT SELECTION** - The geometry of the cut, especially minimum inside radius, define the required diameter of the bit. The bit type is chosen according to the geometry, the depth and the required finish of the cut. It may well be that two types of bits are required for one job, the first one for fast, rough cutting and the second for good quality finishing of the cut.
2. **CUTTING PARAMETERS** - The cutting performances are highly sensitive to the spindle speed, feed rate and maximum cut depth per pass, thus making it very hard to find the best combination by trial-and-error. It is advisable to first obtain the recommendation of the bit manufacturer for the parameters for every specific bit type. Typical spindle speeds are 16,000-20,000 rpm. Typical feed rates are 2-5 m/min (6.56-16.4ft/min). Cutting depth per pass should not exceed twice the diameter of the bit.
3. **FEED DIRECTION** - Conventional cutting will usually result in a better quality cut than climb cutting. Since most routers turn clockwise, the feed direction should be counterclockwise for external edges and clockwise for inside edges. When for a specific bit the manufacturer recommends climb cutting, use the opposite direction to those mentioned above.
4. **COOLING** - Routing OPTIX Cell Cast is best done dry, therefore cooling and swarf removal with an air jet is recommended.
5. **VIBRATIONS** - The cutting performances are highly sensitive to vibration of both the sheet and the cutter. The sheet must be properly and firmly fixed by using vacuum or clamps. The Spindle, shaft collets and bearings must be clean and in perfect condition.

ROUTING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Chipping	Blunt bit	Replace the bit with a sharp bit
	Excessive tool vibration	Check the collets, the bearing and the bit's shaft. Replace the defected part
	Excessive sheet vibration	Support the sheet properly
	Advance speed too high	Decrease the advance speed
	Rotation speed too low	Increase the rpm
Tool breakage	Advance speed too high	Decrease the advance speed
	Bit not properly installed	Fix the bit in collets and close it tight
	Heavy chip load	Increase number of flutes
		Ensure proper swarf removal
	Excessive tool vibration	Check the collets, the bearing and the bit's shaft. Replace the defected part
Melting	Blunt bit	Replace the bit with a sharp bit
	Advance speed too low	Increase the advance speed
	Rotation speed too high	Decrease the rpm
	Insufficient cooling	Cool with air and back feed the bit more frequently
Crazing	Contact with chemicals, even in vapor form	Remove any chemicals close to the working area

6.6 ENGRAVING

Engraving OPTIX Cell Cast is done with the same machinery as routing. The fine differences, separating engraving from routing, are listed below.

1. Use a small diameter cut head 2-6 mm (0.079-0.236″).
2. Remove the PE protective film before engraving (It is recommended to place back the PE film, when the engraving process is over).
3. Typical spindle speed should be 9,000-10,000 rpm.
4. Typical feed rate should be 1-3 m/min (3.28′-9.84′/min).
5. Typical cutting depth, per pass 0.3 mm (0.12″).
6. Anneal the engraved section before painting.

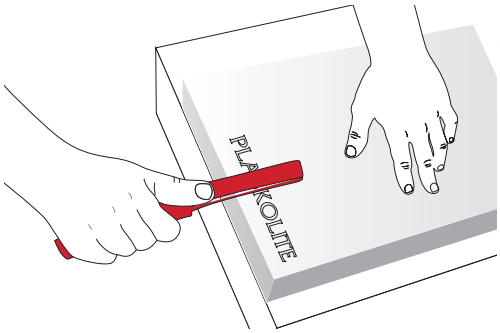
**For general instructions about Laser engraving, see "Laser cutting" instructions.*

6.7 FINISHING

The finish obtained depends primarily on the smoothness of the machined surface. Machine marks can be removed by scraping or sanding resulting in a smooth but mat surface. To obtain gloss finish, polishing will be needed.

6.8 SCRAPING

Removal of machine marks as well as easing sharp edges can be done using steel scrapers with a sharp blade set at 90°.

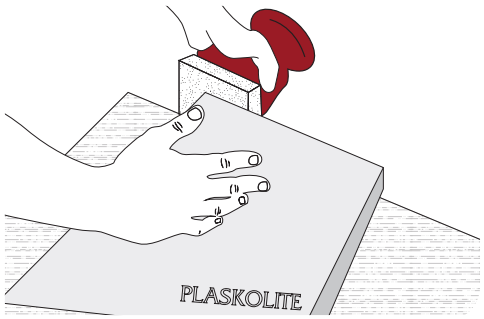


6.9 SANDING

Standard woodworking equipment is used to sand OPTIX Cell Cast sheets. Bench mounted, portable sanders or belt sanders can be used to remove machine marks or saw cut marks from the edge of OPTIX Cell Cast. Sandpaper with 150-400 grit is needed, but if polished later, it is recommended to sand OPTIX Cell Cast with 600 or 1000 grit sandpaper. If OPTIX Cell Cast is very deeply scratched a 3-stage sanding process might be needed. First, the deep scratches should be sanded using 60-80 grit paper, then a 200-400 at the third stage 500-1000 grit paper should be used to prepare the surface for polishing. To prevent softening or melting of the surface, apply very light pressure and keep either part or sander in constant circular motion. Sanding with sandpapers 150 grit or finer, should be done wet. After any sanding operation it will be necessary to anneal the part if bonding or surface decoration is intended.

HAND SANDING

This technique is efficient only for sanding small areas or when power sanding is not possible, due to lack of equipment or inaccessible surface. Use a wooden or rubber sanding block. If the surface that is to be sanded is other than flat, the sanding block must have its mirror shape enabling to apply even pressure on all the sanded surfaces. Deep scratches should first be removed using 220-600 grit. To regain a smooth, almost glossy surface, 1000 grit grade waterproof sandpaper should be applied wet with light pressure and constant motion, preferably circular.



SANDING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Melting	Excessive heat	Apply less pressure Keep the part in constant movement.
Burning	Excessive heat	Apply less pressure Keep the part in constant movement
Scratches on the sanded part	Paper too fine	First use a coarser paper and then finish with the finer one
Paper clogging	Excessive dust	Use plenty of water

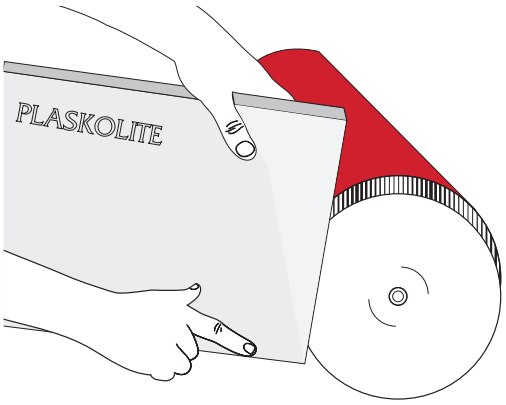
6.10 POLISHING

When polishing OPTIX Cell Cast edges, all machine marks must be removed by scraping, sanding, routing or even by power buffing using a fast cutting abrasive buffing compound.

**Don't glue polished edges. This will cause crazing.*

POWER BUFFING

Stationary and portable machines with rotating calico mops, bleached muslin or felt are the traditional polishing technique for OPTIX Cell Cast. Apply mild abrasive buffing compound and with light pressure. Keep the OPTIX Cell Cast or the wheel in constant circular motion. When restoring the original gloss to OPTIX Cell Cast surface, the polished area should be much larger than the damaged surface, to "feather" the edges and avoid optical distortion.



POWER BUFFING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
No polish is achieved	Insufficient rubbing	Apply more pressure
		Increase the speed of the wheel
	Excessive heat	Apply less pressure
	Insufficient buffing compound	Apply more buffing compound
	Surface not sanded	Sand the surface according to the instructions

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Optical distortion	Too small area	Polish a wider area and feather its edges
White edges	Excessive rubbing	Apply less pressure
		Decrease the speed of the wheel
Breaking	Chipped edges	Use only perfect cut and drilled sheets

FLAME POLISHING

A standard hydrogen-oxygen torch as well as a small blowtorch type gas-air flame will produce a highly polished clean edge. The proper gas is methylacetylene-propadiene-propane (MAPP). It burns hotter than propane and produces a good flame polished edge. It is highly recommended to practice this process on a piece of OPTIX Cell Cast scrap. A smooth OPTIX Cell Cast edge, clean of machine marks, is essential for flame polishing. Adjust a narrow 5-10 cm (1.97-3.94") long flame, and slightly pass the hottest part of the flame rapidly across the sheet. If the flame is moved too slowly, a mat surface, bubbles or even ignition of the surface can occur. While flame polishing will result in a highly polished edge on OPTIX Cell Cast clear sheets, it might give a poor performance on certain OPTIX Cell Cast colored sheets, resulting in a matt finish or discoloration. Annealing of the part will be necessary if the flame polished edges are to be bonded or decorated.

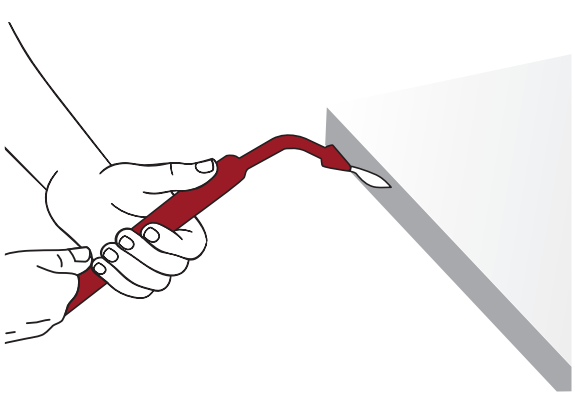
NOTE

» Remove the PE film protection from the areas to be flame polished
» Before flame polishing, read the flame torch manufacturer safety note
» OPTIX Cell Cast sheets are combustible

HOT AIR GUN POLISHING

Hot air gun polishing will give the same results as in flame polishing. This process is almost as rapid as flame polishing but much less skill is required, and it is far less hazardous. A smooth OPTIX Cell Cast edge, clean of machine marks is essential also for this type of polishing. Adjust the temperature to 400-500C at a distance of 10 cm (3.94") and slightly pass the hot air flow rapidly across the sheet. If the hot air gun is moved too slowly, a mat surface or bubbles can occur.

FLAME & HEAT POLISHING - TROUBLESHOOTING



PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Mat surface	Excessive heat	Pass the heat source faster across the sheet
Bubbles		Pass the heat source further from the sheet
Melting		Use a lower temperature of the heat source
No polish is achieved	You gave up too soon	It usually takes a few attempts to obtain a perfect polish
Crazing	It is most recommended to anneal the heat-polished part	Sand the surface according to the instructions

DIAMOND POLISHING

Edge finishing machines are commercially available. Using diamond-polishing machines is the fastest way for obtaining edge with a smooth and even glossy surface. This technique results in straight highly polished edges without the need for sanding or scraping.

FORMING

7. FORMING

7.1 THERMOFORMING

OPTIX CELL CAST SOFTENS WITH TEMPERATURE ALLOWING FOR EASY THERMOFORMING:

OPTIX CELL CAST ACRYLIC																	
TEMPERATURE (°C / °F)																	
60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230
140	158	176	194	212	230	248	266	248	302	320	338	356	374	392	410	428	446
SOLID						PLASTIC									DEGRADE		

THREE STAGES OF THERMOFORMING

» **Heating** - softening OPTIX Cell Cast until its plastic/soft phase.
» **Forming** - forcing OPTIX Cell Cast into the desired form.
» **Cooling** - restoring OPTIX Cell Cast its initial rigidity.

FORMING WITH PE FILM

The protective PE masking film can be left in position during heating and forming. However, when deep thermoforming is needed it is recommended to remove the film before forming. When introducing the OPTIX Cell Cast sheet to the thermoforming machine avoid scratching and indenting the sheet. Small hardly visible scratches and indentations in the sheet will expand and may become visible after thermoforming.

GHOSTING PROBLEMS WHEN FORMING WITH PE FILM

When OPTIX Cell Cast sheets are intended for forming applications it is recommended to order the sheets with plain PE protective film (i.e. without any printed logos). Printed logos in the PE films can cause “ghosting“, i.e. a “watermark-like“ defect on the formed sheet. Printed film must be removed before thermoforming, to avoid ghosting.

SAFETY NOTE

OPTIX Cell Cast sheet is combustible. Before heating OPTIX Cell Cast, the necessary fire precautions must be considered, based on regional regulations and good judgment, taking into account the burning behavior of OPTIX Cell Cast. When heating OPTIX Cell Cast horizontally, extra care should be taken to prevent sagging on the heater causing damage and a possible risk of fire. OPTIX Cell Cast surface temperature must not exceed 220°C (428°F), as this might cause flammable decomposition gasses to occur.

PRE-DRYING

OPTIX Cell Cast can be thermoformed without pre-drying, however, if improperly stored or stored for a very long time, OPTIX Cell Cast sheets can absorb moisture which will affect their thermoforming performance. Unlike other materials, moisture in OPTIX Cell Cast during thermoforming doesn’t result in degradation of the material but can affect the appearance of the part. The appearance of small bubbles

in the sheet, after the heating process, is an indication that too much moisture was absorbed in OPTIX Cell Cast and therefore the rest of the sheets must be pre-dried. Remove the protective film and pre-dry in a ventilated oven at 70°-80°C (158°F-176°F) for a period of 1-2 hours per mm (per 0.04 inch) thickness.

HEATING

If OPTIX Cell Cast is formed before it is soft, stress is generated and reduction of mechanical properties leading to mechanical failure may occur. Too much energy will melt the material, making it impossible to work with, or might even cause surface blisters. Hot spots may even cause local material degradation and reduction of mechanical properties. Care should be taken to ensure that OPTIX Cell Cast is uniformly heated: temperature differences exceeding 5°C (41°F) across the sheet may lead to internal stresses. The working area must be sealed from drafts. Wind will badly influence the results. Certain OPTIX Cell Cast colors can change slightly during the heating process, specially is the sheet is overheated. Moreover, since the sheet is stretched due to drawing, there will be an inevitable thinning of the sheet, giving rise to a decrease of opacity (in opaque sheets) or an increase in light transmission (in translucent sheets) through the thinner area.

HOT-AIR CIRCULATION OVEN

This technique is characterized by the uniformity of heating and by its mass production capabilities. More than one sheet can be in the oven in different stages of heating, therefore it is the obvious choice of high-volume producers. Temperature should be accurately controlled. For optical quality products sheets should be hung vertically to avoid any contact with a surface. Hang the sheets along their longest dimensions using suitable clamps. When forming large and heavy sheets, elongation of the sheet in the vertical direction and shrinkage in the transversal direction may be caused because of gravitational pull of the softened sheet.

INFRARED HEATING

Infra-red inline heating machines (all three thermoforming stages done on the same machine) are the preferred option for heating OPTIX Cell Cast. These machines have a heating head, which can be moved freely when the heating process is done, making room for the forming and cooling process. Suitable machines have zone heating control, which allows to set up proper uniform heating across the sheet. Control of uniform heating is critical: temperature differences exceeding 5°C (41°F) across the sheet may lead to internal stresses. OPTIX Cell Cast of 5 mm, 0.197”) thickness and above must be heated by a two-sides heating device. Two-sided infrared heating machines are preferable in all cases because they will cause a more uniform heating through the sheet thickness. In this method, although heating time is very short, the possibility to heat only one sheet at a time makes this method cost efficient only for low volume / high versatility production.

HEATING CONDITIONS

The following factors should be taken into consideration when determining the temperature and time of the heating process:

1. The sort of heating source (infrared or hot air circulation)
2. The distance between the sheet and the heating source
3. The uniformity of the heating (on all three dimensions of the sheet).
4. The material thickness
5. The type of mold
6. The depth and complexity of the required shape.
7. Degree of stretching required

HEATING TEMPERATURES

Minimum temperature	**130°C (266°F)**
Maximum temperature	**190°C (374°F)**
Recommended range	**165°C - 180°C (329-356°F)**

Finding the optimal heating temperature and time is a trial-and-error process, particular to each product and machine.

SHRINKAGE

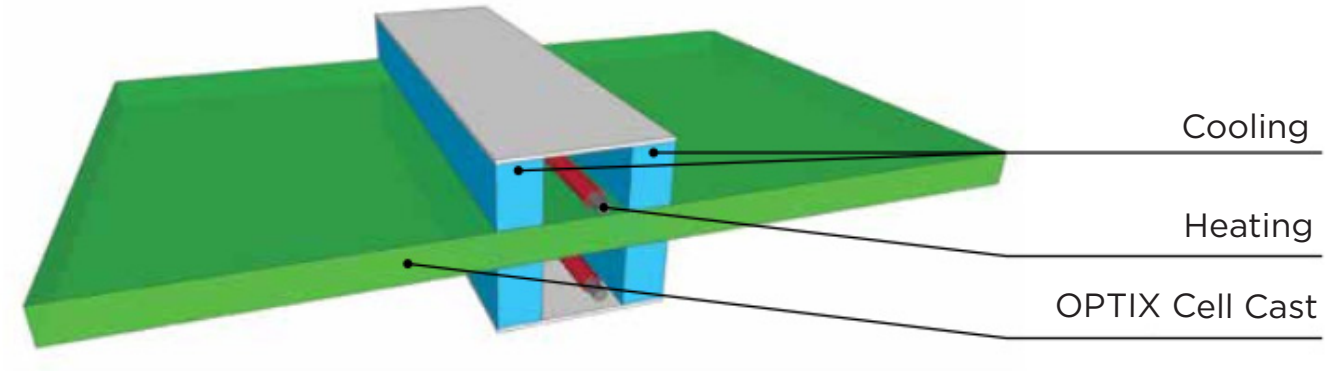
One of the advantages of the Cast PMMA sheet over the Extruded PMMA sheet is its lower and isotropic shrinkage. When heated, OPTIX Cell Cast sheets shrink the same in all directions up to a maximum of 2%.

FORMING

While in its soft phase, OPTIX Cell Cast can be formed to almost any shape, by different methods and equipment. Home-made machines as well as sophisticated commercial machines can be used depending on the product requirements (complexity, quality and volume). After heated to the recommended temperature 165°-180°C, (329-356°F), high pressure must be applied to OPTIX Cell Cast to cause deformation, and the pressure must be applied gradually, avoiding large changes in pressure. Abrupt pressure changes can lead to cracks.

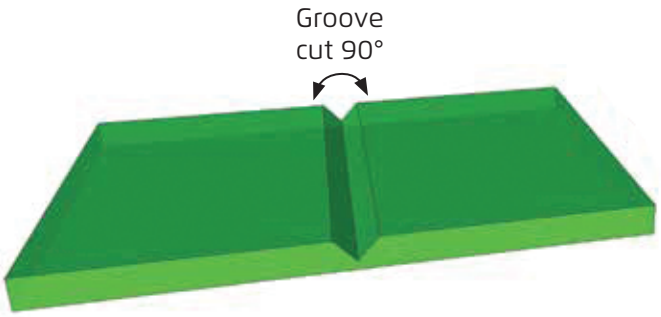
LINE BENDING

Most common line bending simple equipment will give excellent results. Double side heating machines with cooling strips are recommended if a very accurate bend and high quality surface near the bend is needed. Ceramic and quartz tubes or even metal rod heaters equipped with a thermoregulator and installed with parallel support on both sides are most commonly used. The supports should keep OPTIX Cell Cast at least 0.5 cm (2″) away from the heater. First, remove the PE Film from the bend line facing the heater then, lay OPTIX Cell Cast on the supports with the bend line above the strip heater. OPTIX Cell Cast is sufficiently heated when it slightly resists bending. Remove the sheet from the heater, place it in a fixture with the desired angle, clamp it and leave it to cool naturally. Line heating and bending of PMMA (as any other thermoplastic) induces stress into the material. Design and processing good practices will reduce the level of stress; however, the properties of the material in the bent area will be unavoidable lower. Bent areas should be kept away from adhesives and chemicals that can produce ESC.

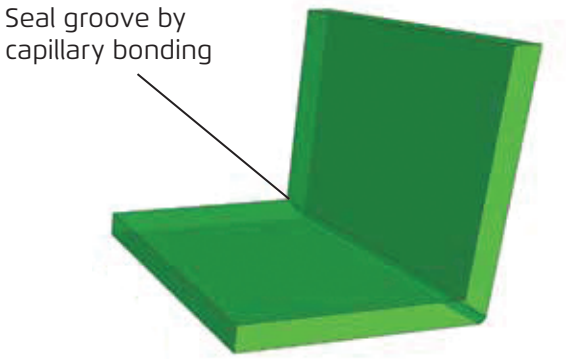


NOTE

1. Avoid direct contact of OPTIX Cell Cast with the hot strip heater.
2. Sheets of more than 5 mm (0.197″) thickness should be heated from both sides. If the two sides are not heated simultaneously, heat the outer side of the bend last.
3. If OPTIX Cell Cast is to be acutely bent, make a 90° V-groove on the inner side of the bend prior to the heating.



Groove depth 3/4ths of the sheet thickness



4. A bend line longer than 1000 mm (39.4″) might bow across the bend.
5. The greater the diameter of the rod heater and the more the rod heater is distant from OPTIX Cell Cast, the wider the heating zone, enabling formation of a bend with a larger radius.
6. The width of the heating zone should be:
7. Bending OPTIX Cell Cast up to 90° - 3 times the thickness.
8. Bending OPTIX Cell Cast more than 90° - 5 times the thickness.
9. Avoid contact of the heated OPTIX Cell Cast with hard rough surfaces. Felt, flannel or aluminum can be used to cover the surface of the fixture, to help prevent stamping.
10. Anneal the bent part before exposure to solvents or excessive temperature changes.

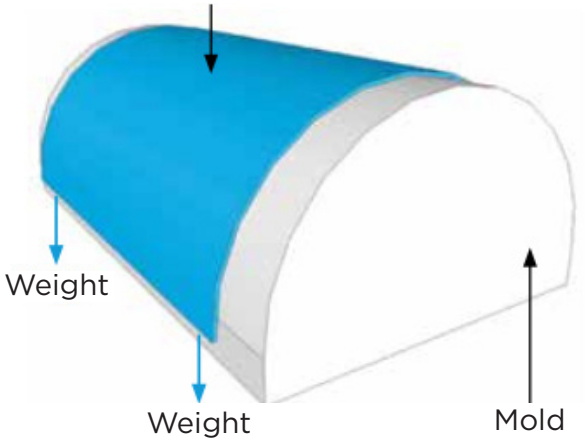
HOT LINE BENDING - TROUBLESHOOTING

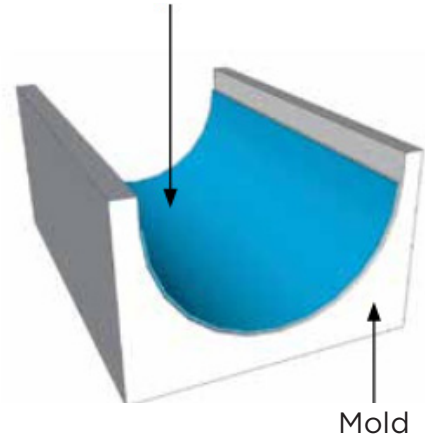
PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Blisters on the surface of the sheet	Overheating	Shorten the heating time
		Lower the heaters temperature
		Increase distance between sheet and heating source
Bubbles in the sheet	Moisture in the sheet	Pre-dry the sheet before hot bending
Radius of bend too wide	Heated zone too wide	Use a heater rod with smaller diameter
		Lay the sheet closer to the heater
Edges swell	Sheet too thick	Make V shape cut
		Use a thinner sheet
Crazing	Heated zone too narrow	Use a heater rod with bigger diameter
		Increase distance between sheet and heating source
	Excessive stress	Anneal the bent part
	Contact with chemicals, even in vapor form	Remove any chemicals close to the working area

DRAPE FORMING

This method of forming is restricted to two dimensional or very simple three dimensional shapes, which require no stretching for forming. Heat OPTIX Cell Cast typically between 140°C - 150°C (284°F - 302°F) and without delay, drape it over the mold. In drape forming it is crucial that OPTIX Cell Cast is placed on the mold at the right temperature. If not hot enough, OPTIX Cell Cast will not obtain its shape but if too hot, it will curl and twist. OPTIX Cell Cast will often obtain its form by the force of its own weight

but in some cases the help of some forcing is needed. The hot edges of OPTIX Cell Cast tend to curl and therefore clamping or heavy covering should force the edges to the mold. Pre-heating the mold may improve results and reduce internal stresses.





FREE BLOWN FORMING

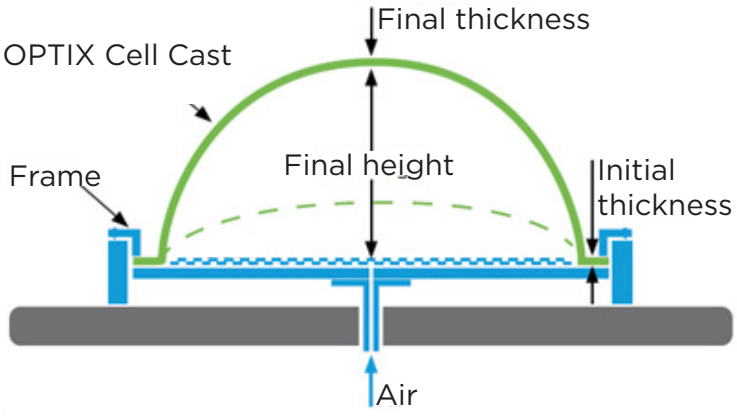
This method is suitable for high optical quality and limited to bubble-like part shapes. Requiring low cost equipment and short production cycles, this method is the most cost efficient for sky dome production. The free blowing equipment is composed of a plywood board attached to a compressed air source with a pressure control device. Heat OPTIX Cell Cast, frame it tightly to the board and gradually increase the air pressure (or vacuum) to the desired point. Let OPTIX Cell Cast cool and dismantle it after regaining its rigidity.

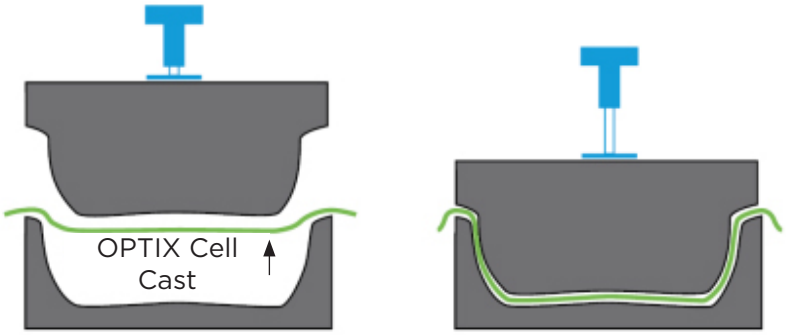
NOTE

a. The air pressure controls the height of the dome.
b. The shape of the dome can be altered by an imprint and by using a different frame shape.
c. The top part of the dome will be thinner than the part close to the base.
d. Since vacuum is restricted to 1 atmosphere, the use of vacuum free forming will limit the height of the dome.
e. Commonly used air pressure is 3 - 4.5 atmospheres.
f. Disperse the incoming air, using a protective plate felt or cotton wool. Cold air jet directed onto the hot OPTIX Cell Cast will cause rapid local cooling and as a result high stress and non-uniform expansion of the sheet.
g. Forming big domes is better preformed when blowing with hot air.

PRESS FORMING

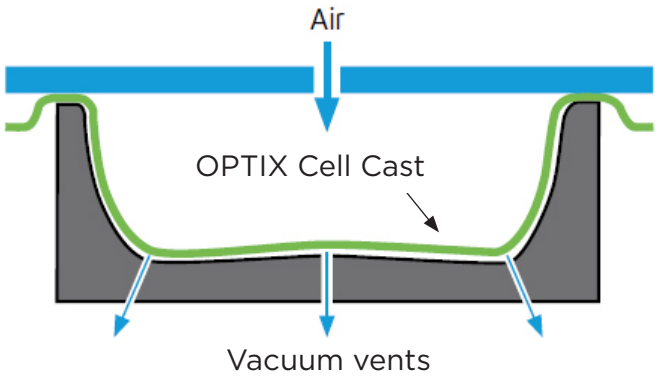
Restricted to forming shallow parts with low quality surface (especially on the inside corners), this method is mainly used in the sign industry. The heated OPTIX Cell Cast is clamped over the cavity, and then pressured into it, up to a fixed depth, by the plug. Pressing can be done by a manual drill press, air cylinder or pneumatic cylinder. The plug and cavity must match in a way that enough space will be left for the sheet.





STRAIGHT VACUUM (PRESSURE) FORMING

This is a very simple method with fairly good results. The quality of the surface is good and the wall thickness for shallow drawn parts is quite even. Both female and male molds can be used. The heated OPTIX Cell Cast is clamped over the mold. The air, trapped between OPTIX Cell Cast and the mold, is then sucked through vacuum forcing the sheet to form against the mold. When using air pressure instead of vacuum it is essential to make vent holes in the mold to enable evacuation of the trapped air to form its final shape. Since vacuum is restricted to 1 bar, straight vacuum is limited to forming shallow simple parts. Using high pressure (up to 5 bar) the straight forming method can be used for more complex parts.



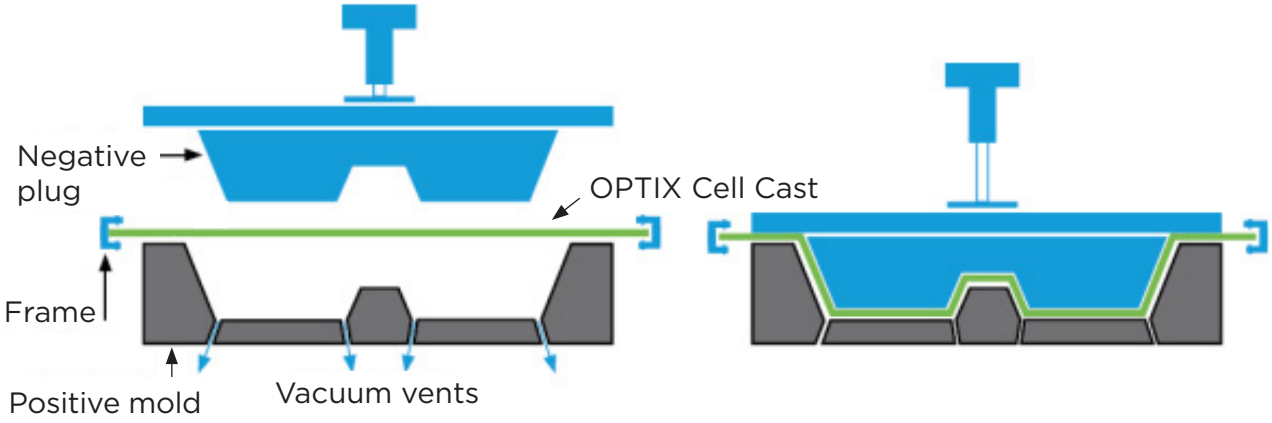
REVERSE BLOW FORMING

This method is quite similar to the straight pressure forming method and the same machinery can be used. Although the only difference between the two methods is the order of events. With this method the uniformity of the wall thickness will be much better. The heated OPTIX Cell Cast is clamped over a pressure box. Air pressure is used to blow OPTIX Cell Cast to a bubble. The plug is then lowered into the bubble, forming the desired shape.

PLUG-ASSIST FORMING

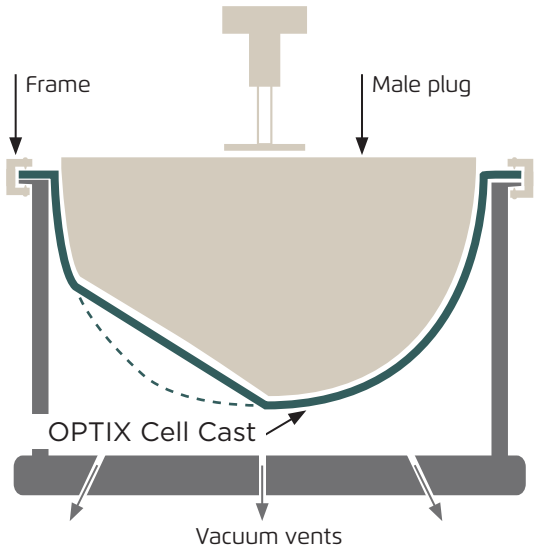
This is a more demanding process. Better control of forming rate and temperature are required, and only experienced workers will be able to achieve the needed results. Plug-assist is used for forming deep drawn parts that require a better wall thickness uniformity. The heated OPTIX Cell Cast is clamped over the cavity and the plug is then lowered to stretch the sheet. When the plug is in its final course, applied vacuum from the cavity or pressure from the plug forces OPTIX Cell Cast against the cavity to form its final shape. For even better wall thickness uniformity, vacuum is first used to create a maximal bubble and only then the plug is lowered. When the plug is in its final course, pressure from the plug forces OPTIX Cell Cast against the cavity to form its final shape. The plug will be 80% - 90% of the volume of

the cavity. The shape of the plug will influence the distribution of wall thickness. The plug should be heated or at least made of low thermal conductivity material to prevent mark-off.



SNAP-BACK FORMING

With this method complex shapes can be formed but depth is restricted. The heated OPTIX Cell Cast sheet is clamped over a vacuum box. Vacuum is used to draw the OPTIX Cell Cast sheet into the box forming a bubble, slightly bigger than the plug. The plug is lowered and when in place the vacuum is released causing the sheet to snap back onto the plug and form its shape. The process must be done fast enough to ensure that OPTIX Cell Cast is sufficiently hot to perform the snap back. Forming complex shapes by this method requires the use of applied vacuum from the plug or pressure from the box to help OPTIX Cell Cast gain its final shape from the plug.



COOLING

After shaping, OPTIX Cell Cast must be left on the mold, with the applied pressure to cool. Remove OPTIX Cell Cast when at 60°C-70°C (140°F-158°F). If too hot the sheet might not retain its shape, but if left for too long, OPTIX Cell Cast might cool and shrink too much on the mold, causing excessive stress and making it hard to release it from the mold. Avoid drafts and when working in a cold environment cover OPTIX Cell Cast with felt or flannel. Covering is also very important for cooling uniformly through the bulk of thick wall final parts. A heated mold helps with the gradual cooling process. Slow uniform cooling is essential to prevent stress. Cooling to fast will induce internal stresses in the part reducing its properties and making it more susceptible to ESC. A better part quality comes at the expense of a lower output rate.

MOLDS

Used in different forming methods and for production of different products, molds can be made of a variety of materials such as hard wood, aluminum, steel, gypsum, reinforced polyester or epoxy resins. Laminating and finishing of molds made of other materials than metal, should produce a surface which will resist wear and will prevent distortion by moisture. Aluminum made molds with temperature control will achieve best results for large quantity production. Faults in the finished mold will leave imprints on the molded part. When making a mold, the shrinking properties of OPTIX Cell Cast, must be taken into account. Allow for shrinkage, to make sure that the finished part is not smaller than required (see shrinkage instructions). Mold clearance angle must be a 3°-6° for convex parts and 0.5°-1° for concave parts (OPTIX Cell Cast tends to shrink on convex parts and away from concave parts). A heated mold will result in better part shaping and will cause a more gradual cooling, reducing induced stress. When molding OPTIX Cell Cast the mold temperature range should be 60°C-80°C (140°F-176°F). Uniform mold heating is necessary to obtain the highest surface detail and optical quality. Keep the mold clean. Dirt and dust in the mold will imprint on the molded part. Surface embossing is produced by pressing the hot sheet against a mold having a textured surface, and it is sometimes used to produce patterned surfaces in OPTIX Cell Cast sheets for applications such as lightning fixtures.

THERMOFORMING TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Blisters on the surface of the sheet	Overheating	Reduce the temperature or shorten the heating time
		Prevent hot spots
		Increase distance between sheet and heating source
Bubbles in the sheet	Moisture in the sheet	Pre-dry the sheet before thermoforming
Uneven form	Uneven heating of the sheet	Fix malfunctioning heaters
		Eliminate drafts
	Bad clamping	Ensure firm clamping of the sheet
Surface defects	Sheet is too hot or too cold during forming.	Adjust temperatures or time
	Mold too cold	Increase the mold temperature Use controlled heat mold
	Defect in the mold	Replace the mold
	Dirt on the mold	Clean mold thoroughly before heating
	Dirt on the sheet	Clean sheet thoroughly before heating
	Scratches or indentations on the sheet before forming	Keep the sheet from scratching or indenting while handling before thermoforming. Small scratches and indentations will amplify during forming
	Defects on the PE protective film.	Thermoform sheets either with perfect PE film or without PE film
Imperfect form	Low pressure	Increase the pressure applied
	Defect in the mold	Replace the mold
	Cooling time too short	Ensure sheet is sufficiently rigid before removing from mold

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Crazing	Sheet is too hot or too cold during forming.	Adjust temperatures or time
	Drawing is done too quickly.	Reduce drawing speed
	Mold too cold	Increase the mold temperature Use controlled heat mold
	Uneven heating of the sheet	Fix malfunctioning heaters
		Eliminate drafts
	Cooling time too long	Do not allow the sheet to shrink too much on the mold
	Internal stress	Anneal the part
	Contact with chemicals, even in vapor form	Remove any chemicals close to the working area
Cracks or broken areas	Sheet is too hot or too cold during forming.	Adjust temperatures or time
	Drawing is done too quickly.	Reduce drawing speed
	Mold too cold	Increase the mold temperature. Use controlled heat mold.
	Mold angles are too sharp	Round angles and corners in the mold
	Internal stress	Anneal the part

7.2 ANNEALING

Internal stress in OPTIX Cell Cast as a consequence of machining and forming can result in crazing (very fine cracks) which will later evolve into larger cracks, especially in the presence of chemicals (for example during bonding or painting) or exposure to harsh environmental conditions (industrial and agricultural areas, motorways, repeated cleaning, etc.).

Internal stress can be a result of:

1. **MACHINING** - All methods of machining cause local overheating, thus resulting in internal stress.
2. **FORMING** - Forming OPTIX Cell Cast too cold, overheating OPTIX Cell Cast or cooling OPTIX Cell Cast too fast or unevenly after thermoforming, will cause internal stress.

It is strongly recommended to anneal OPTIX Cell Cast sheets before any bonding, painting or printing operations.

ANNEALING TIME AND TEMPERATURE

OPTIX Cell Cast should be annealed at 65°C-80°C. The time needed for annealing OPTIX Cell Cast will depend on the thickness of the sheet and the temperature chosen.

The general guidelines for annealing OPTIX Cell Cast sheets are given in the table below:

ANNEALING TEMPERATURE	ANNEALING TIME (HOURS)	COOLING TIME UNTIL 60ºC (140°F) (MÍNIMUM)	COOLING RATE	REMARKS
65°C (149°F)	= 1 + [0.3 x thickness (mm, in)]	2 hours	12°C(54°F) /hour	Recommended for annealing of sheets following thermoforming or bonding.
65°C (149°F)		2 hours	15°C, (59°F)/hour	Recommended for annealing of flat sheets following machining.

» Insert the sheet in the annealing oven only when the oven has reached the target temperature.

» Beware that the oven temperature does not drop significantly during sheet insertion.

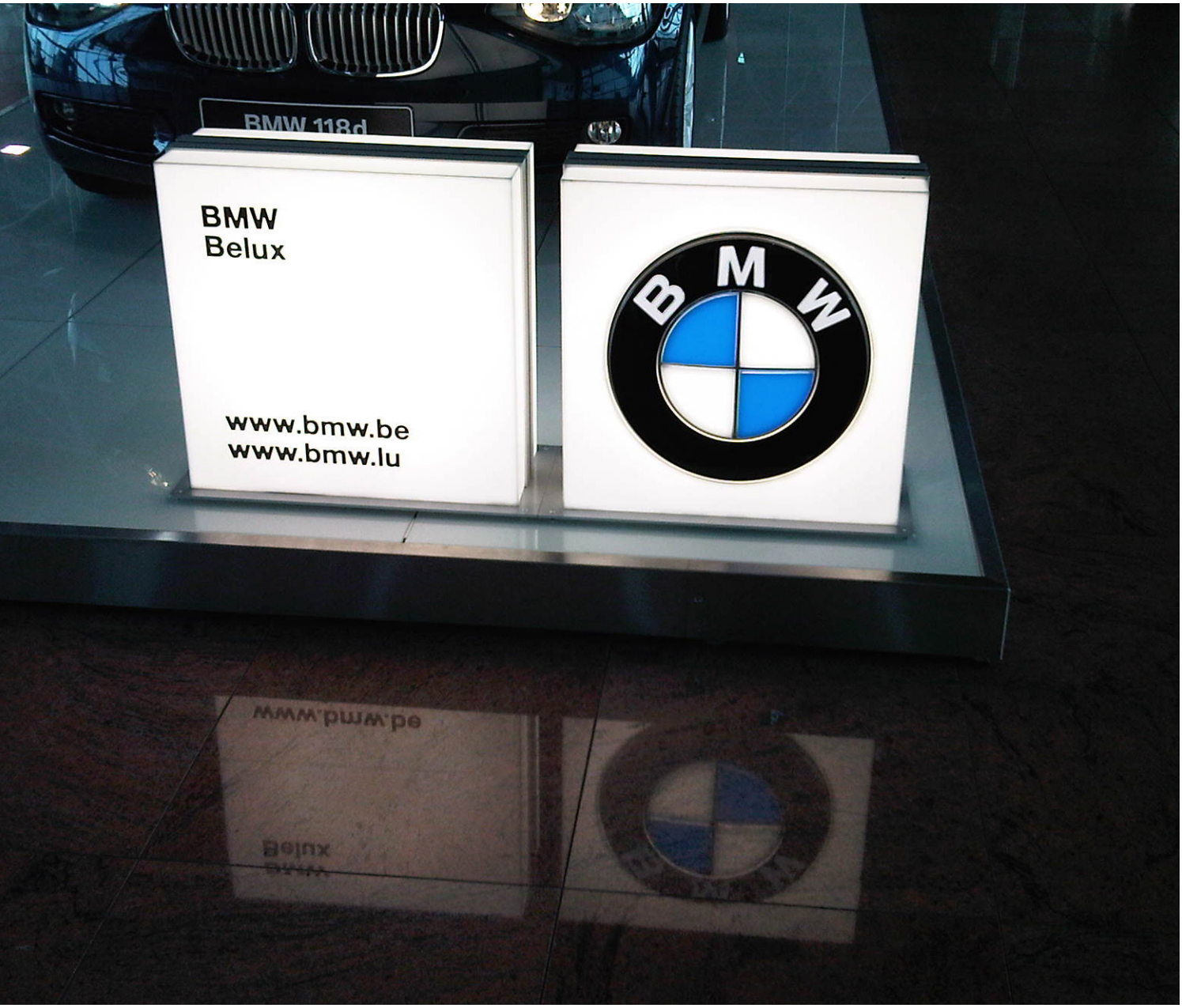
» Sheets thicker than 8 mm (0.315″) should be cooled for 3 hours.

» Remove the sheet from the oven only after it has cooled below 60°C (140°F).

» It is recommended to anneal without the PE protection film.

It is important to allow the annealed parts to cool slowly in the oven, at stated above, to avoid the development of new stresses due to thermal shock during the annealing process.

PRINTING



8. PRINTING / DECORATING

OPTIX Cell Cast can be decorated by screen, digital and pad printing and spray-painting. Inks and paints formulated for acrylic sheets must be used. Beware of using inks and paints that can chemically attack PMMA. OPTIX Cell Cast sheets can also be covered with vinyl adhesive film and can be vacuum metalized.

When choosing the decorating method a few factors should be regarded:

1. The quality of coloring and the number of colors needed.
2. The shape of the OPTIX Cell Cast sheet to be decorated.
3. The required level of durability.
4. Ensure that inks have appropriate UV stability.
5. Will the OPTIX Cell Cast be thermoformed after decoration?
6. The volume of production.

PREPARING

When decorating OPTIX Cell Cast, it is important to keep its surface clean. Smallest particles, surface stains and even static charges will cause uneven spread or adherence failure of the paint. Remove the protective PE film as close as possible to the beginning of the decorating process. Keep the surface from being stained and if necessary clean it properly. Use an ionizing air gun to remove dust and neutralize static charges.

SCREEN PRINTING

This method is very cost efficient for high volume production and results in high quality coloring. Screen printing can be applied only on flat OPTIX Cell Cast but if properly performed, thermoforming of the painted OPTIX Cell Cast is possible. The screen is set to OPTIX Cell Cast and then the paint is applied uniformly, passing through the open mesh on the screen transferring the pattern onto OPTIX Cell Cast.

When screen printing two factors should be considered:

1. Paint Viscosity
2. Mesh Openings

If the paint is too diluted or the mesh is too big the paint can sag without keeping the shape of the desired print. If the paint is too thick or the mesh is too small the paint will not flow correctly through the mesh resulting in imperfection of the print. Only the right combination, of these two factors will result in quality painting.

SCREEN PRINTING - TROUBLESHOOTING

Problem	Possible cause	Possible solution
Imperfection of the print	Paint doesn't flow through mesh	Dilute the paint
		Use a rougher mesh
	Paint sags	Reduce thinner additives in the paint
		Use a finer mesh
	Worn screen	Replace screen
	Premature paint drying	Use a slower drying paint
Crazing	Excessive stress	Anneal the sheet prior to painting
	Chemical attack	Ink is not compatible with PMMA
Poor paint adhesion	Incorrect paint	Use paints recommended by the manufacturer to acrylic
	Dirty surface	Use only sheets with clean surface

SPRAY PAINTING

The shape of OPTIX Cell Cast does not limit spray painting and formed OPTIX Cell Cast can be sprayed.

When spray painting few factors should be considered:

1. **PAINT VISCOSITY** - together with the air pressure this factor will define the paint flow. If the flow is too fast, the paint will sag and if too slow, a dry spray will result in a matte surface.
2. **AIR PRESSURE** - use the lowest air pressure possible.
3. **DISTANCE OF PAINT GUN**- wrongly placing the gun will cause the same problems mentioned above.
4. **MOISTURE** - the air delivered in the spray gun must be free of moisture.
5. **STATIC ELECTRICITY** - ionized air delivered in the spray gun will result in a more uniform paint spread.

SPRAY PAINTING -TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Poor paint adhesion	Incorrect paint	Use paints recommended by the manufacturer to acrylic
	Dirty surface	Use only sheets with clean surface
	Poor paint flow	Dilute the paint
		Increase air pressure
	Paint delivered too far from the sheet	Position the air gun closer to the sheet
	Excessive moisture	Treat the delivered spray to reduce moisture
Paint sagging	Excessive paint flow	Decrease air pressure
		Reduce thinner additives in the paint
	Paint delivered too close to the sheet	Position the spray gun further from the sheet
Non-uniform paint spread - Ghosting	Static electricity	Use ionized air in the spray gun

DIGITAL PRINTING

This technology is suitable to paint individual pieces with unique designs. The ink is ejected from an ink-jet print head, like in standard ink jet printers. The main difference is the ink applied by them. Standard ink jet printers use water-based inks and they dry almost immediately on the paper media. These inks cannot be applied on plastic surfaces. New LED-UV cured digital printers use environmentally friendly inks (solvent- free) and cure at a narrow wavelength. The curing power of these printers and the lack of solvents in their inks, often led to poor adhesion to the plastic. Pretreatment with an adhesion promoter is recommended when using when using UV-LED cured digital printer systems.

GHOSTING

When OPTIX Cell Cast sheets are intended for printing applications it is recommended to order OPTIX Cell Cast sheets with plain PE protective film (i.e. without any printed logos). Printed logos in the PE films can cause “ghosting“, i.e. a “watermark-like“ defect on the printed sheet. If some logo is required in the PE protective sheet, printing should be performed in the reverse side of the sheet. Electrostatic charges on the sheet surface can also cause ghosting. They should be dissipated before printing.

ADHESIVE FILM

Decorating OPTIX Cell Cast, using this method, offers unlimited options. Different patterns, colors and surface finishing can be obtained. The film must be carefully chosen for the desired application. The film must be compatible with PMMA. For specific instructions, on how to apply the film to PMMA, consult the film manufacturer. Thermoforming OPTIX Cell Cast with adhesive decoration film is difficult but can still be accomplished. The decorative film manufacturer should be consulted about the conditions for thermoforming.

ASSEMBLING

9. ASSEMBLING

When choosing the assembling method for OPTIX Cell Cast sheets, a few factors should be regarded:

1. The strength of the joint needed.
2. The transparency needed.
3. The material assembled to OPTIX Cell Cast.
4. Size and units to be bonded.
5. End use environment.
6. Required durability.
7. Is disassembling needed?
8. Thermal expansion of the assembled parts (specially if assembled to a different material)

9.1 ASSEMBLING WITH SCREWS

When assembling OPTIX Cell Cast to a different material (wood, metal, other plastics) or to rough and inaccurately fit surfaces, screws may be the preferred solution. Like all other machining operations, cutting screw threads in OPTIX Cell Cast is done in the same manner and with the same standard tools as cutting screw threads in wood. Drill a hole of the required size in OPTIX Cell Cast, then use a screw-tap to cut the screw threads. It is recommended to cut threads only in one of the parts being assembled, leaving the other part with a smooth drill hole. The great advantage of assembling by screwing is that it is a reversible process, which allows for repeated assembling and disassembling.

When screwing OPTIX Cell Cast sheets a few factors should be considered:

1. Use sharpened screw-taps.
2. When tapping a hole three times deeper than the diameter, back feed the drill, at regular intervals, to ensure removal of swarf.
3. Metal fixings are recommended especially if dismantling is likely.
4. Anneal the cut areas if glue is to be used.
5. When OPTIX Cell Cast will be exposed to fluctuating temperatures, allowances for thermal expansion and contraction must be provided. Drill oversize holes and slots, use compatible spacers and washers and do not overtight the screws.
6. OPTIX Cell Cast should not be placed in contact with incompatible materials such as soft PVC washers or silicone sealing compounds containing acetic acid or acetates. Use EPDM or neoprene washers. Use only neutral silicone.
7. Special care must be taken when assembling OPTIX Cell Cast sheets to other materials. Different materials have different coefficients of thermal expansion. When screwing OPTIX Cell Cast to other materials allow for thermal expansion clearance.
8. The space between the screw hole and the sheet‘s edge should be 1.5 times the hole diameter.

ASSEMBLING WITH SCREWS - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Crazing while tapping	Bad drill holes	See drilling troubleshooting
	Chemicals	Remove any chemicals close to the working area
Crazing while screwing	Excessive stress	Use a screw with smaller diameter.
		Use only reasonable force to fasten screws
		Use rough threaded taps and screws
	Contact with chemicals, even in vapor form	Remove any chemicals close to the working area
	Glue presence	Anneal the part if glue is to be used.
Threaded wearing	Excessive disassembling and assembling	Use metal fixing.
Cracks during service	Thermal Expansion	Assemble according to instructions - allow space for thermal expansion and contraction
	Environmental Stress Cracking	Use of incompatible washers, silicones, cleaning agents, incompatible chemicals of any sort including in vapor form
	Excessive stress	Release stress from screws

9.2 BONDING

OPTIX Cell Cast sheets can be bonded using different methods. It is essential to anneal the parts previously to bonding, in order to prevent crazing of OPTIX Cell Cast. It is also recommended, after the bonded part has dried and hardened at room temperature, to perform another heat treatment for 2 to 5 hours at about 60°C (140°F) to improve the quality and strength of the joint. The surfaces to be bonded must be kept clean and free from oil, dust and contaminants of any type. Cleaning the surfaces prior to bonding is recommended. Bonding techniques are considered generally to be irreversible and are used in applications where disassembling is not required.

SAFETY MEASURES

Most types of solvents and adhesives are highly volatile, flammable and toxic.

1. Always follow the adhesive manufacturer's instructions and safety instructions according with the adhesive's Safety Data Sheet (SDS).
2. Always work in a well-ventilated area.
3. Keep open flames from the area. Do not smoke in the area.
4. Use respiratory protection as described in the adhesive's SDS.
5. Protect skin and eyes from contact with solvents as described in the adhesive's SDS

SOLVENT BONDING

Solvent bonding is a popular method used to bond OPTIX Cell Cast. The solvent dissolves and softens the surfaces. Upon pressure application, a complete fusion can be achieved at the interface of the joint which then hardens by solvent evaporation. Possible solvents are: Dichloromethane (synonyms; DCM, Methylene chloride), Chloroform, Methyl Ethyl Ketone (synonyms; MEK), Acetone. A more tender use of pure solvents is made by mixing: Dichloromethane with 10% Acetic Acid.

WARNING! Solvents are harmful if swallowed, inhaled or absorbed through skin. Always work according to solvent's SDS instructions.

ADHESIVE TYPES

MIXED SOLVENT ADHESIVES

This type of adhesives contains small quantities of MMA and PMMA in a solvent, and therefore are more viscous than pure solvent. Similar to solvent bonding, they act by dissolving and softening the surfaces of the part, application of contact pressure and solvent evaporation. These adhesives can be used to bond parts which do not fit perfectly together. Commercial adhesives of this type are available. Dissolving additional PMMA chips can be done to increase adhesive viscosity.

POLYMERIZABLE ADHESIVES

CATALYST ACTIVATED

These adhesives are made from two parts, a viscous solution of acrylate monomers and a catalyst. The two parts are mixed, prior to the bonding. The catalyst polymerizes the monomers making the material in the joint chemically similar to OPTIX Cell Cast. These types of adhesives render stronger joins reaching 60% to 75% of the original adjacent material strength.

UV ACTIVATED

Polymerization takes place under UV lamp radiation. Because acrylics are opaque to the lower UV spectrum, check that the activation wavelength of the adhesive is higher than 390 nm. Results are good for small parts. This kind of adhesives is expensive.

CHARACTERISTICS OF THE JOINT	SOLVENTS	MIXED SOLVENT ADHESIVES	CATALYST ACTIVATED 2-COMPONENT ADHESIVES	UV ACTIVATED ADHESIVES
Strength	Fair	Good	Excellent	Fair
Weather resistance	Poor	Good	Excellent	Good
Fixing time	Rapid	Slow	Can be adjusted	Very Rapid
Transparency	Excellent	Fair	Excellent	Fair

BONDING TECHNIQUES

Always work on clean parts, free of dust and oils. Try keeping the area dust free. Remember not to clean acrylic with alcohols or organic solvents. If you need to clean the best way is with warm water and mild soap and let the parts dry completely from humidity.

SOAK BONDING

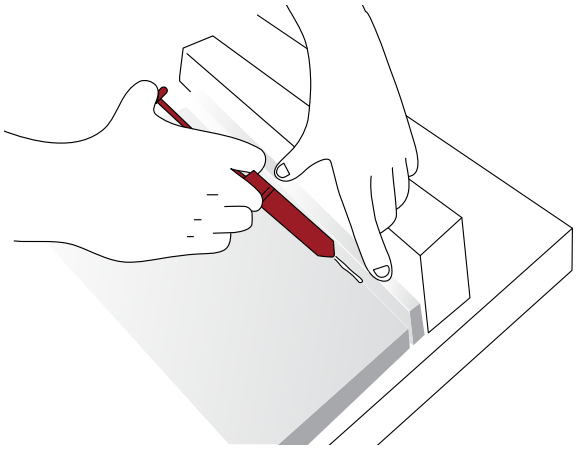
A solvent bonding method. Requires smooth cuts and surfaces that fit perfectly together. The process involves soaking one of the pieces of OPTIX Cell Cast that are to be joined in deep solvent. The soaked OPTIX Cell Cast must be masked to ensure that only the bonded areas will be in contact with the solvent. The masking used can be any strippable coating through which the solvent cannot penetrate. OPTIX Cell Cast is left in the solvent until the surface is sufficiently soft. Excessive exposure will result in a longer fixing time and may even result in a weak joint. When the surface has softened to the right point, OPTIX Cell Cast is removed from the solvent and held for a few minutes to drain off the excess solvent. Then the parts should be quickly bonded and held together for 30 seconds before any pressure is applied, allowing the solvent from the soaked part to work on the un-soaked part. After these 30 seconds, the joined parts are fitted into a jig and uniform pressure should be provided. The pressure applied must be sufficient to squeeze out air bubbles and ensure good contact of the surface, but not excessive, to avoid squeezing out the material or even crazing. The joined parts must be left in the jig for 10 to 30 minutes, depending on the thickness of the joint, allowing it to harden sufficiently. Allow the joint to fix for 24 hours before further working on it.

DIP BONDING

A Solvent bonding method. This is a very delicate process requiring great skill and great care. This method also requires smooth cuts and surfaces that fit perfectly together and it is limited to the bonding of straight-line surfaces. The process involves dipping the edge of one of the pieces of OPTIX Cell Cast that are to be joined in the solvent. Since only the edge is dipped, the masking process, as in soak cementing, is unnecessary. The dipping tub must be leveled. Pieces of wire or fine pins are placed in the tub to help with the support of the soaked edge. The tub is filled with solvent just above the line of the pins. OPTIX Cell Cast's edge is placed on the pins to soften, held in an upright position. The help of a support is recommended to keep OPTIX Cell Cast steady and in an upright position. When the edge has softened to the right point, OPTIX Cell Cast is removed from the solvent, held to drain, bonded and held to fix as described above, in the dip bonding technique.

CAPILLARY BONDING

This is the most common method of bonding. This method also requires smooth cuts and surfaces that fit perfectly together and it is limited to the bonding of straight-line surfaces. Water thin adhesives are the type of adhesives used in this method. The parts are first joined together, fixed in a jig in a way that the joint is horizontal. Then the



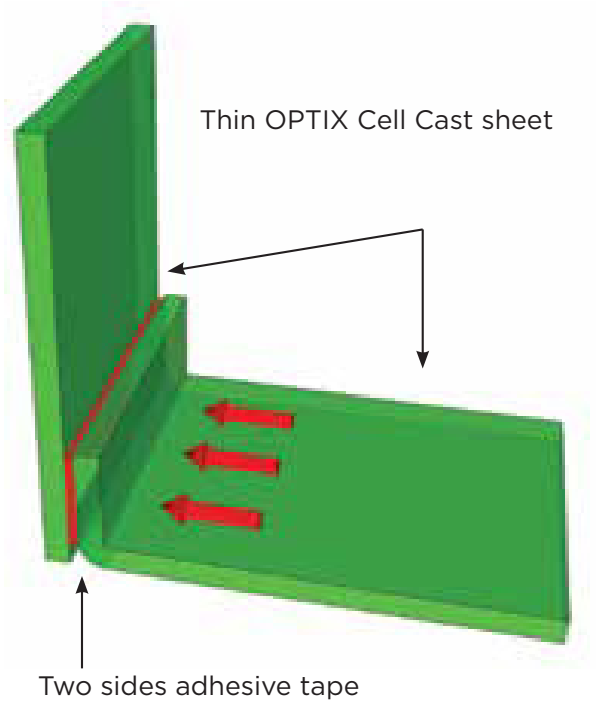
adhesive is applied to both edges of the joint by syringe, eyedropper or a needle applicator. The adhesive will flow through the area of the joint by capillary action. The part must be left to thoroughly dry before it is removed from the jig. The time of drying depends on the thickness of the joint and the type of adhesive. It is crucial to work according to the adhesive producer's instructions.

SMEAR BONDING

This method is used when the surfaces do not fit perfectly together. Thick polymerizable or viscous type adhesives are used in this method. The adhesive is smeared on the edge of one of the pieces of OPTIX Cell Cast that are to be joined. Then, the parts are quickly bonded and fitted into a jig. The joined parts must be left in the jig for 5 to 10 minutes, depending on the thickness of the joint and the type of adhesive, allowing it to harden sufficiently. Allow the joint to fix for 24 hours before further working on it.

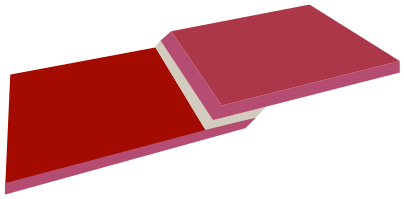
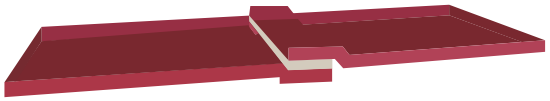
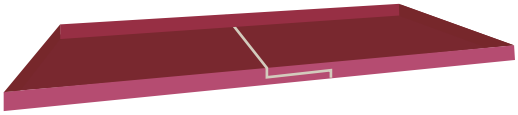
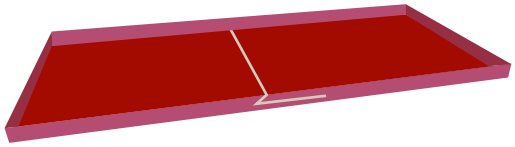
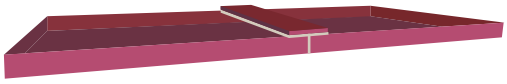
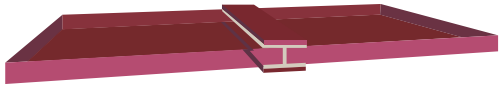
BONDING TO DIFFERENT MATERIALS

OPTIX Cell Cast can be bonded to other materials such as metal, glass, wood, stone, etc. Cyanoacrylate and two-side adhesive tape can be used for small jobs. Care should be taken when bonding OPTIX Cell Cast to other materials. Differences in thermal expansion can cause tensions that will produce failure of the bonding. In these cases, an elastic adhesive or an adhesive with an intermediate coefficient of thermal expansion should be used. Consult the adhesive or tape provider for suitability and compatibility of the adhesive to PMMA and the joined material.



DESIGN OF ADHESIVE JOINTS

The design of the adhesive joint has an influence on the final strength of the bond. Joints should be designed in a way that transform tensile or compressive stress to shear stress. The larger the bonding area, the stronger the bonding. Anneal parts after machining the designed joint and before bonding.

POSSIBLE	BETTER
	
	
	

BONDING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Bubbles	Too much adhesive	Decrease the soaking time or apply less adhesive (depending on the bonding method)
	Premature pressure application	Apply pressure only 30 seconds after the parts were joined.
	Pressure too low	Increase the pressure applied on the joint parts.
	Premature pressure release	Keep the joined parts pressured according to cement manufacturer instructions
Cloudiness	Moisture too high	Work in a less humid environment
		Use slower evaporating solvents
		Use polymerizing adhesives
Crazing	Stressed edges	Anneal the parts before bonding
	Excessive exposure to solvent	Decrease the soaking time
		Use polymerizing adhesives
	Curing to fast	Use slower evaporating solvents or slower curing adhesives.

BONDING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Poor joint strength	Parts not perfectly fit	Machine parts to perfect fit
		Use the “Smear bonding” method.
	Wrong use of adhesive	Check the adhesives manufacturer instructions and act accordingly.
	Wrong or bad adhesive	Replace adhesive or adhesive type.
	Insufficient adhesive	Increase the soaking time or apply more adhesive (depending on the bonding method).
	Premature pressure release	Keep the joined parts pressured according to cement manufacturer instructions
	Adhesive squeezed out	Decrease the pressure applied on the joint parts.
	Insufficient fixing time	Allow joint to fix for 24 hours before further working on it
	Unclean surfaces	Clean surfaces before bonding
	Bad designed joint	Design joint to maximize shear stress

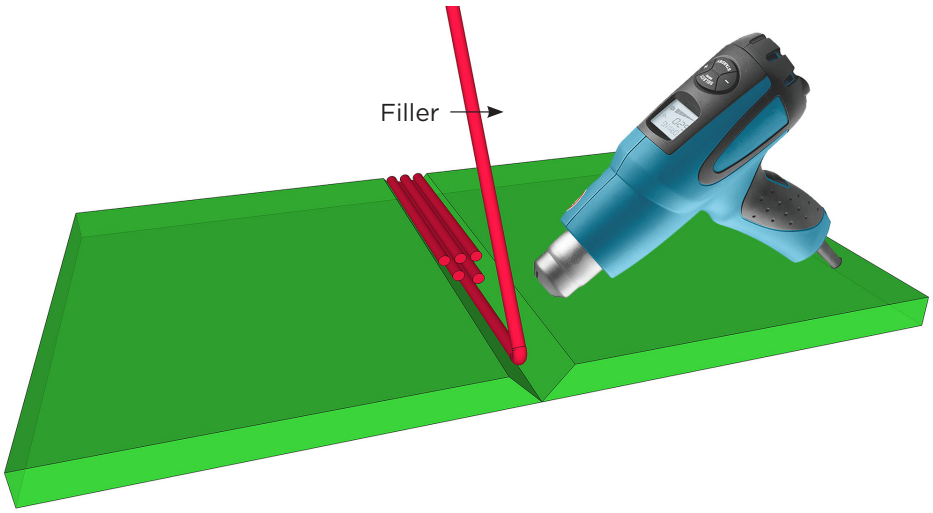
SEALING

Joints can be sealed, either with thick polymerizable or viscous type cements, or with silicone. The type of sealant used must be compatible with OPTIX Cell Cast and the joined material.

WELDING

OPTIX Cell Cast can be welded by different methods: hot gas, induction, ultrasonic etc. Welding is most useful when attaching OPTIX Cell Cast to itself. For assembling OPTIX Cell Cast to other materials, screwing or bonding may be a better option. The different welding methods generate heat energy by different ways that soften the edges and thus weld the joint. This process leaves great stress in the material, which must be relieved later by annealing. This method results in weak joints, 10% to 40% of the original strength. Welding techniques are considered generally to be irreversible and are used in applications where disassembling is not required.

Hot Gas Welding



INSTALLATION

10. INSTALLATION

10.1 GENERAL GUIDES

Lightweight, high transparency and outstanding weather performance makes OPTIX Cell Cast a superior glazing and signage material for both exterior as well as interior uses. After the general desired dimensions of the window/sign are chosen, the exact dimensions of OPTIX Cell Cast and frame are determined according to the following stages.

1. Determining the maximum wind load.
2. Determining thickness of the OPTIX Cell Cast sheet.
3. Determining the expansion clearance.
4. Determining the groove dimensions and the exact dimensions of the OPTIX Cell Cast sheet.

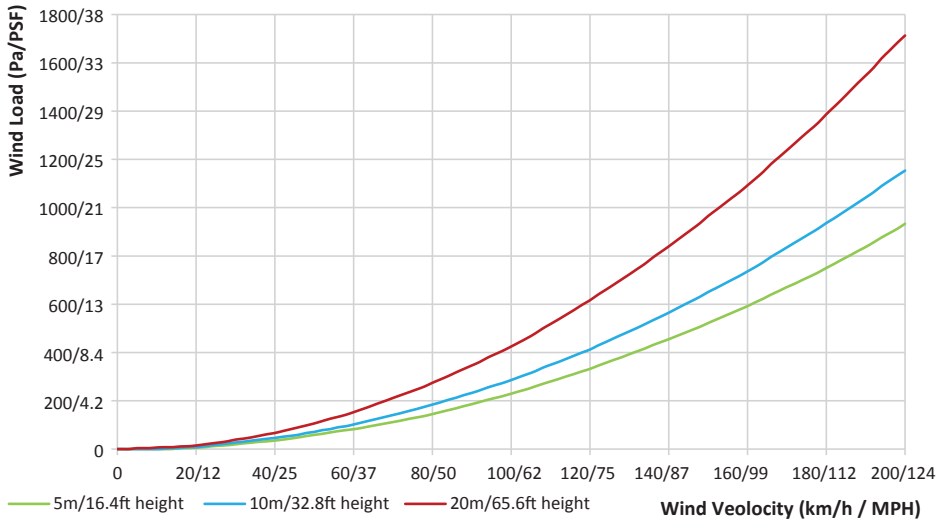
The following data is intended as a basic guideline for simple windows/signs applications. When OPTIX Cell Cast sheets are to be mounted in construction projects (constructions, domes, acoustic walls, etc.) under complicated load fields, curved designs, complicated supporting systems and/or extreme temperature and environmental conditions, accurate engineering analysis is required. Seek advice from a construction engineer.

10.2 MAXIMUM WIND LOAD

Determine the maximum wind load, which will be applied on the mounted sheet according to Figure 1. The maximum wind velocity in the area and the height of the mounted OPTIX Cell Cast determines the wind load.

NOTE The graph refers to a vertically placed, straight sheet (not curved) - The load does not take into consideration the self-weight of the sheet and snow weight load.

FIGURE 1 - WIND VELOCITY - LOAD CONVERSION



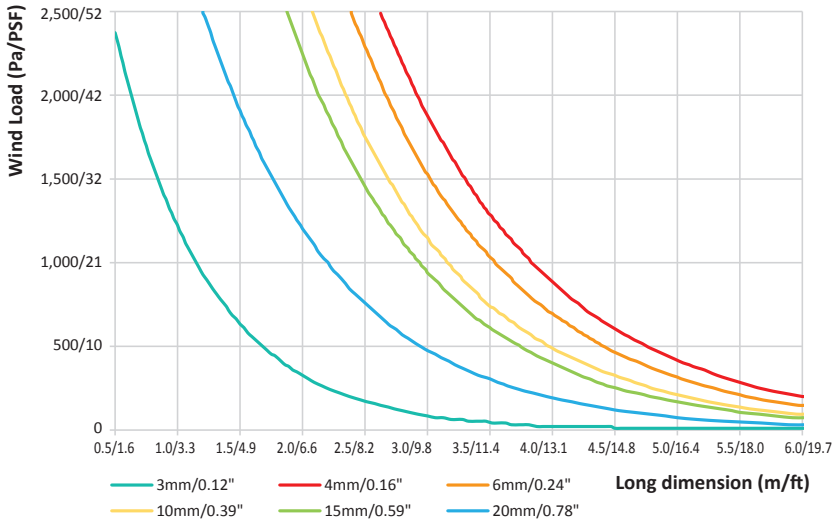
10.3 THICKNESS

Determine the recommended thickness for the mounted sheet according to Figure 2. The wind load, as determined in the previous section, and the long dimension of the mounted sheet determine the sheet thickness.

The data in Figure 2 is subject to the following remarks:

1. The sheet is supported on all four edges.
2. The width is maximum 0.75 of the length - For larger widths choose the next largest thickness.
3. The width is minimum 0.25 of the length - For smaller widths choose the next smallest thickness.

FIGURE 2 - OPTIX CELL CAST PMMA SHEET THICKNESS RECOMMENDATION



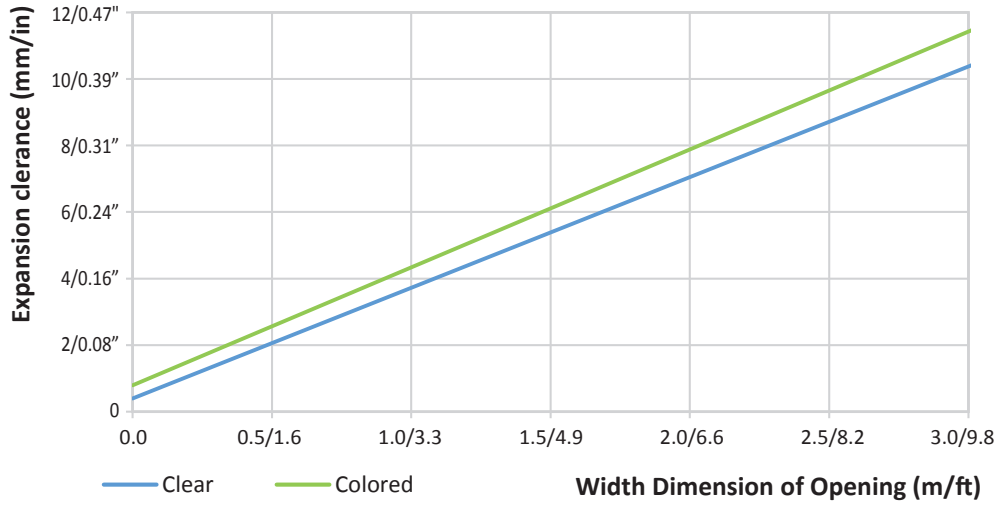
10.4 EXPANSION CLEARANCE

Acrylic, like most plastics, has a coefficient of thermal expansion higher than all other non-plastics materials used for framing. Enough clearance must be given allowing the sheet to expand freely. OPTIX Cell Cast sheets have a linear thermal expansion of about 0.070 mm/m°C (4.0 x 10^{-5} in/in/°F). Humidity is also an expansion parameter. OPTIX Cell Cast sheets expand when humidity rises. The maximum expected value of linear expansion depends on the final sheet's application temperature and humidity. Design the sheet's final dimensions and the frame considering the expansion clearance. Insufficient expansion clearance will cause stresses in the sheets, causing distortions and eventually cracking and breakage of the sheets.

The sheet dimension determines the size of the expansion clearance needed.

1. Cut OPTIX Cell Cast shorter than the sash opening by the amount taken from the graph in Figure 3.
2. Cut OPTIX Cell Cast into the correct size at room temperature 23°C, (73.4°F).
3. When a sealant is used, cut OPTIX Cell Cast shorter than described in paragraph 1, by twice the thickness of the sealant.
4. Use only sealing agents compatible to cast acrylic sheets. Non-rigid PVC and PUR foam are incompatible due to migration of plasticizers. So are silicone sealing compounds containing acetic acid or acetates. Use only neutral silicones.
5. If OPTIX Cell Cast is dark tinted or mounted as an illuminated sign, use the graph line named "colored".

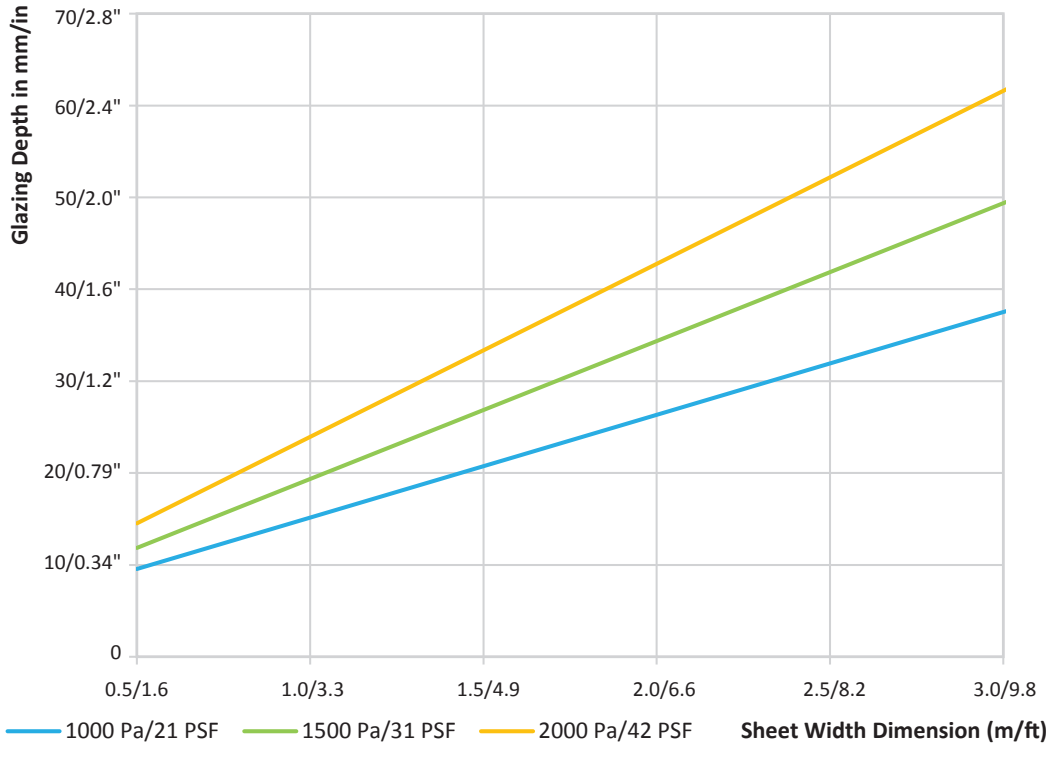
FIGURE 3 - EXPANSION CLEARANCE FOR OPTIX CELL CAST PMMA SHEETS



10.5 GLAZING DEPTH

Determine the recommended glazing depth for the mounted sheet according to Figure 4. The wind load and the long dimension of the mounted sheets determine groove depth.

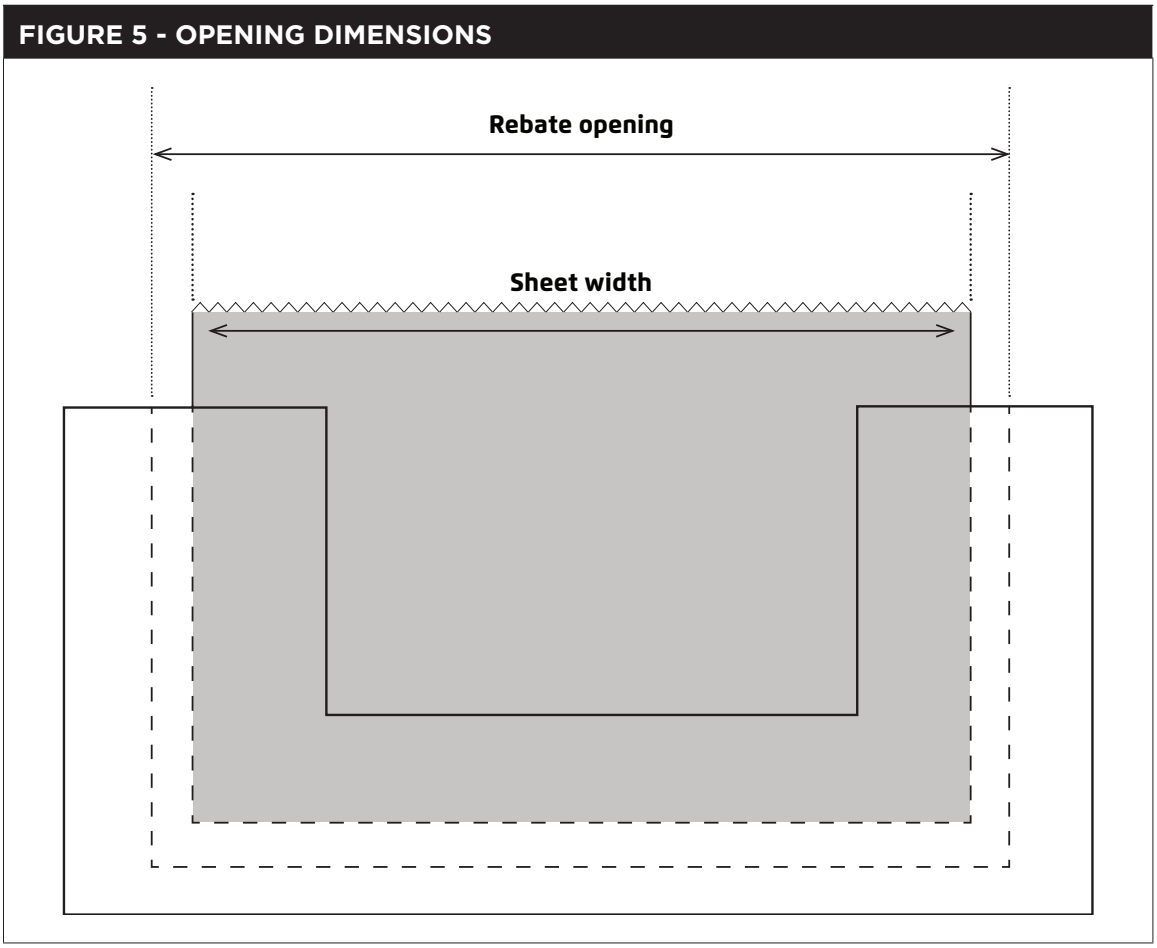
FIGURE 4 - GLAZING DEPTH



10.6 GLAZING WIDTH

The glazing width will vary according to the sheet's width, the sealant width, the sealant type and the way the sheet is mounted into the glazing. The glazing must be wide enough to allow insertion of the sheet and the sealants beads, but not too wide to prevent any possibility for vibrations of the sheet.

FIGURE 5 - OPENING DIMENSIONS



RECOMMENDED REBATE DEPTH

PANEL SIZE mm, in	**MINIMUM REBATE** mm, in	**CONTRACTION-EXPANSION** mm, in	**TOTAL REBATE** mm, in
1000 (39.4″)	30 (1.18″)	± 5	40 (1.57″)
1500 (59.1″)	33 (1.30″)	± 8	50 (1.97″)
2000 (78.7″)	35 (1.38″)	± 10	55 (2.17″)
3000 (1118″)	40 (1.57″)	± 15	70 (2.76″)

10.7 COLD BENDING

Unlike in the case of thermoforming, cold bended OPTIX Cell Cast will not keep its form unless installed into a frame. The sheet must be with perfect edges to avoid breakage during bending. The length between the two edges of the bend should not exceed the minimum length in order to avoid high permanent stress, which would eventually cause small cracks or even break the sheet.

Minimum recommended bend radius of 300 times the thickness of the sheet.

For 3 mm (0.118″) sheets minimum radius is 900 mm (35.4″)

For 4 mm (0.157″) sheets minimum radius is 1200 mm (47.2″)

For 5 mm (0.197″) sheets minimum radius is 1500 mm (59.1″)

For 6 mm (0.236″) sheets minimum radius is 3600 mm (142″)

Cold bended sheets are at stress and special attention must be paid not to install them in environments with chemicals. The combination of high stress and chemical attack (ESC - Environmental Stress Cracking) may cause cracks and cloudiness.

COLD BENDING - TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Crazing	Radius of curve is too small	Enlarge the radius of the curve or use a thinner sheet
	Contact with chemicals, even in vapor form	Remove any chemicals from the environment
Breaking	Chipped edges	Use only perfect cut and drilled sheets
	Excessive Stress.	Anneal the sheet especially if it is to be in presence of solvents

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CONTRIBUTING TO MAKE THE WORLD A BETTER PLACE

From our founding, we strive to treat our employees, our customers, our community and the world with kindness, dignity and respect. This drives our continuing effort to perform sustainable manufacturing and create products in an environmentally-friendly manner, for generations to come. This on-going commitment is expressed in our Three Pillars of Sustainability:

WHAT WE MAKE

Versatile, high-quality, durable thermoplastic sheets instead of single-use plastics.

HOW IT'S MADE

We create products to reflect our sustainable philosophy of improving our environment.

HOW IT'S USED

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