Altuglas International
Automotive
Acrylics

Assembly Methods and Design Guidelines

PLEXIGLAS® acrylic resins from Altuglas International offer:

- Cost-effective part design
- Assembly versatility
- Excellent aesthetics
- Long service life

Plexiglas acrylic resins may be assembled to themselves or other polymers through thermal bonding (welding), mechanical assembly or chemical bonding. Each of these techniques have certain advantages which should be fully understood for proper assembly technique selection.

Assembly Technique Selection

	Assembly Method		
Joint Requirement	Thermal	Mechanical	Chemical
High strength	▲	●	●
Leak proof	▲	×	▲
Repeat assembly	×	●	×
Recyclability	▲	●	●
Dissimilar materials	●	▲	▲
Contamination free	▲	●	×
Chemical resistance	▲	●	▲
Fast cycle time	▲	▲	×
Low capital cost	×	▲	●

▲ Preferred
● Recommended (Conditions Permitting)
× Not Recommended

Plexiglas acrylic resins are compatible with each of these techniques. This versatility provides designers with freedom to create attractive, functional parts cost-effectively. The stability of Plexiglas acrylic resin provides for long service life assemblies even under continuous outdoor exposure conditions.

Altuglas International has a staff of engineers ready to assist you with Plexiglas acrylic resin part design and assembly technique selection.

All Altuglas International resin production facilities carry the QS 9000/ISO 9002 certification. This assures that when Plexiglas resins are specified, you receive the quality your application demands.

For more information on PLEXIGLAS acrylic resin, call **1-215-419-7506**

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Thermal Methods

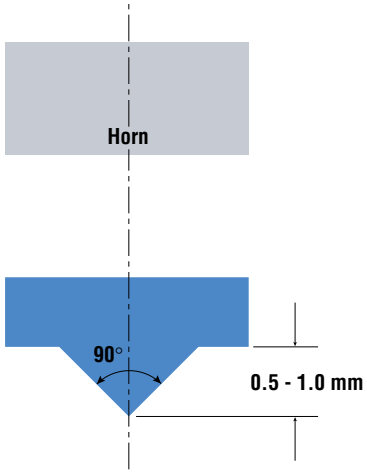
Welded assemblies result from frictional or conduction heating of the polymers under applied pressure such that a melt bond occurs between the components. Welding methods are best suited for applications where leak proof, permanent, attractive, or contamination free high strength bonds are required. Common welding techniques include; ultrasonic, vibration, and hot plate. These techniques are best suited to polymers with similar melt characteristics. The broad melting range of Plexiglas acrylic resins make them compatible with a number of common amorphous thermoplastic polymers.

I The following guidelines may be used as reference points when welding Plexiglas acrylic resins. Optimum conditions will vary with application depending on part size, geometry, and materials employed.

I Thermal Method Guidelines

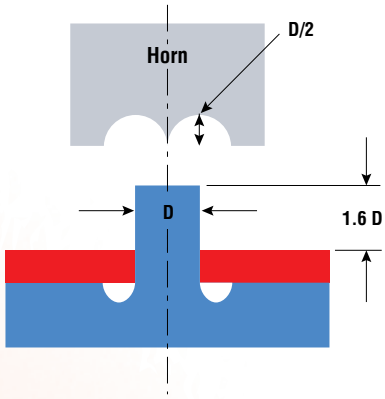
	Ultrasonic (20kH)	Vibration	Hot Plate
Amplitude	40-70µm	.030-.070”	NA
Pressure	30-60 psig	200-500 psi	NA
Temperature	NA	NA	600-800° F
Melt Depth	NA	NA	.030”-.040”
Seal Depth	NA	NA	.010”-.020”

II Energy Director Design



II The use of an energy director is recommended for ultrasonic welding of Plexiglas acrylic resins. The director concentrates energy to speed softening and melting of the joint. When welding different polymers, the energy director should be incorporated in the higher modulus material.

III Heat Stake Design



III Plexiglas acrylic resins may be heat staked for assembly to materials that cannot be welded, e.g. metals and crystalline polymers. Staking is readily accomplished using heat or ultrasonic energy.

Weld Compatibility

		Plexiglas V-Series			Plexiglas MI-7			Plexiglas DR		
Polymer	*(method)*	*Ultrasonic*	*Vibration*	*Hot Plate*	*Ultrasonic*	*Vibration*	*Hot Plate*	*Ultrasonic*	*Vibration*	*Hot Plate*
PMMA		G	E	E	G	E	E	G	E	E
ABS		G	E	E	G	E	E	G	E	E
ABS/PC		G	VG	VG	G	VG	VG	G	VG	VG
PC		G	VG	VG	G	VG	VG	G	VG	VG

Weld Rating	Excellent	Very Good	Good	Fair	Poor
Percentage of polymer* strength attainable	**90–100%**	**70–90%**	**50–70%**	**25–50%**	**0–25%**

* Tensile strength of weaker material

Mechanical Methods

Mechanical methods include techniques such as screw fastening, riveting, or snap-fits which employ a fastener or physical means of part assembly. These techniques are used for applications requiring non-destructive disassembly or rapid assembly with low capital investment. Unlike other fastening methods, these techniques are readily used for joining all materials, including metals. Plexiglas acrylic resins may be joined with themselves or other materials, providing appropriate design considerations have been taken.

I Accumulation of material, not only in walls, but at joints and corners should be avoided by coring out. Good practice aims at minimizing risk of sinkmarks, voids and deformation in the design process.

II Snap-fit assemblies must be designed within the elastic limitations of the materials employed. The following formulas may be used to estimate the percent deformation of Plexiglas acrylic resin for a given design.

For Cantilever: $e = d/(0.67 \times l^2/h)$

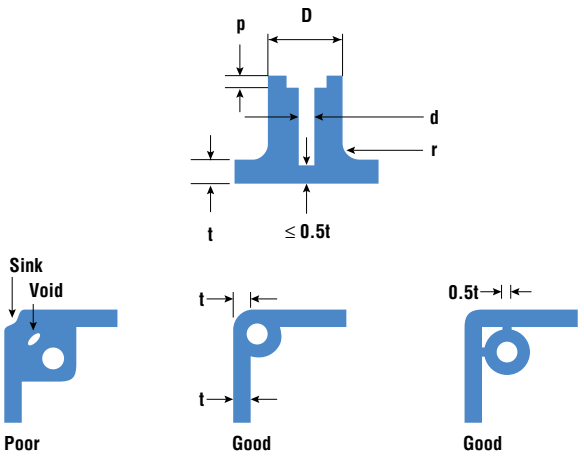
For Bush Fit: $e=(d1-d2)/d1 \times 100$

β angle range for a dismountable system = 40-50°

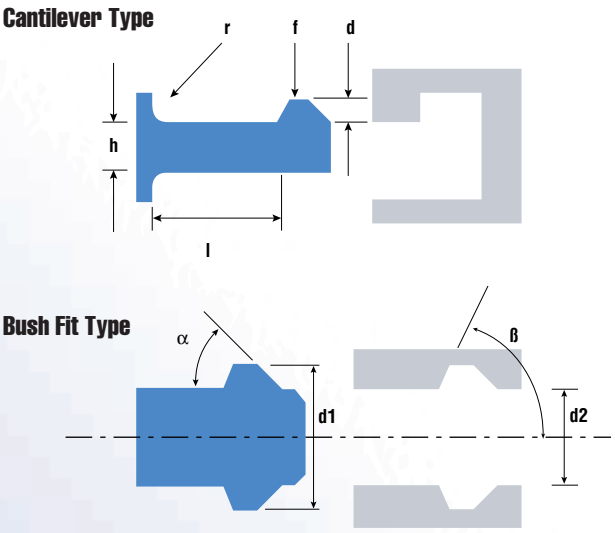
β angle range for an undismountable system ≥ 50°

α angle should be between 20° and 30°

I Bosses



II Snap-Fits



Mechanical Assembly Design Guidelines for Plexiglas Acrylic Resins

	Plexiglas V-Series	Plexiglas MI-7	Plexiglas DR
Screw Attachments			
Pilot hole (d)	≥ 0.90 x screw OD	≥ 0.90 x screw OD	≥ 0.85 x screw OD
Boss diameter (D)	≥ 2.5 d	≥ 2.5 d	≥ 2.0 d
Screw guide (p)	≥ 2mm	≥ 2mm	≥ 2mm
Base radius (r)	> 0.6t	> 0.6t	> 0.6t
Preferred screw type	BT thread cutting	BT thread cutting	BT thread cutting
Snap Fits			
Permissible deformation (e)	2%	3-4%	4-5%

Chemical Methods

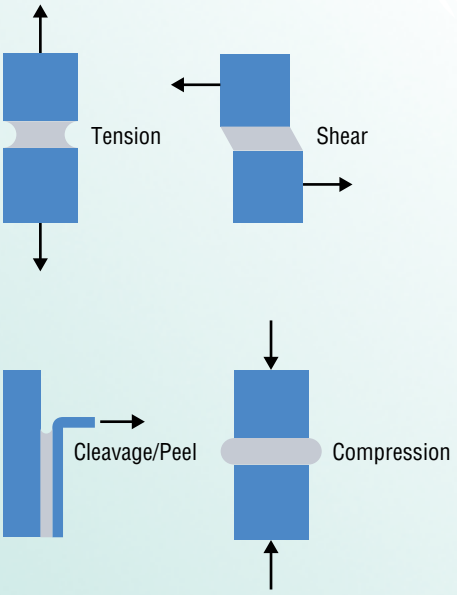
Chemical methods of assembly include the use of adhesives, adhesive tape or cements. These methods are readily used for attaching awkwardly shaped or fragile materials. Adhesives are also frequently used for leak proof assembly of dissimilar materials. The strength of chemical bonds is limited by the tensile strength of the bonding agent or its degree of adhesion to the substrate. Chemical methods may require longer cycle times and part fixturing as the adhesive or cement cures. Solvent cements may be used in select cases, usually with like materials, to provide a strong leakproof bond.

I The strength of a chemical bond is dependent on the material and bonding agent used, the joint design and the orientation of the applied load. Bond strength is maximized when compatible materials are loaded in compression or shear evenly distributed over the maximum possible area. Cleavage and peel stresses should be avoided when possible.

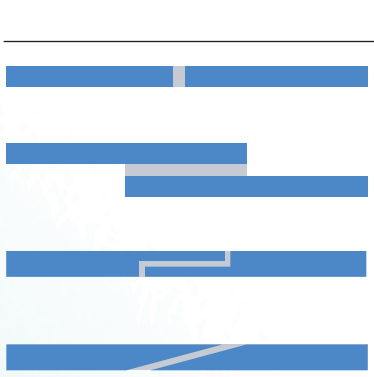
II Plexiglas acrylic resins are compatible with a wide variety of commonly used adhesives providing versatility of use with other polymers for optimized part design.

Methylene dichloride has proven to be an effective solvent for bonding Plexiglas acrylic resins.

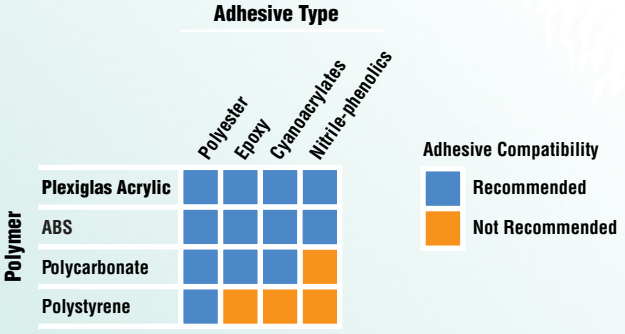
I Applied Load and Stress Orientation



I Joint Design



II Adhesive Compatibility



Design Considerations

Design for assembly of plastic materials requires that special consideration be given to the strength requirements, operating environment, material properties, joint function, safety and regulatory requirements of the application to insure successful performance.

Assembly performance is sensitive to polymer orientation, strain rate, application temperature, applied stress and chemical environment as well as the physical properties of the materials used. Each of these issues should be considered to optimize assembly performance.

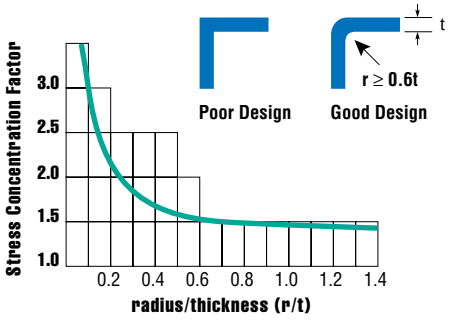
Properties

Plexiglas V-Series acrylic resins are high modulus, high tensile strength polymers with maximum heat resistance and dimensional stability. Plexiglas MI-7 and DR impact modified acrylic resins provide 7-10 times the impact strength of Plexiglas V-Series resins and have a higher elongation to failure for increased tolerance to assembly induced strain.

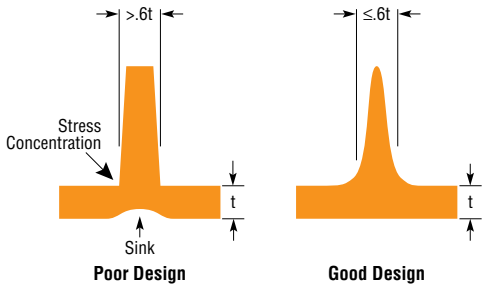
Property	Units	PLEXIGLAS® Resin Grade V052	V825	V826	MI-7	DR
Tensile Strength (ASTM D638)	*psi*	10,200	10,200	10,200	7,000	5,500
Tensile Elongation @ Break (ASTM D638)	*%*	6	6	6	35	50
Flexural Modulus (ASTM D790)	*psi*	450,000	450,000	450,000	380,000	270,000
Poisson's Ratio	–	0.34	0.34	0.34	0.34	0.34
Vicat Softening Point (ASTM D1525 90°F/hr, 11.0 lb.)	*°F*	200	220	220	191	185
Falling Dart Impact Strength	*ft-lb*	1	1	1	7	10

Radii

Generous radii should be designed into all corners and edges to avoid sharp changes in geometry which develop stress concentration areas prone to failure.

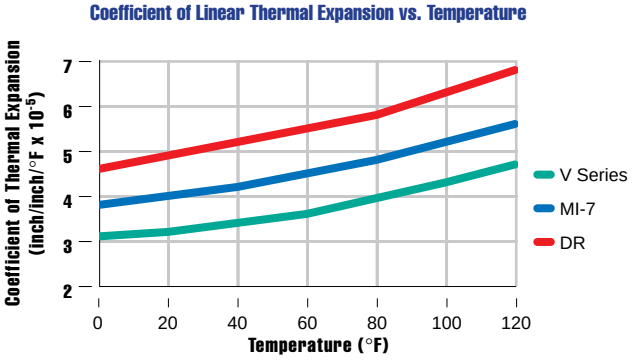


Ribs



Properly designed ribs can increase load carrying capacity, permit a decrease in wall thickness and increase part stiffness. Excessive rib thickness may result in sink or part warpage.

Thermal Expansion



Thermal expansion rates of dissimilar materials must be considered to avoid the development of high stresses during temperature changes.

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Plexiglas resins are combustible thermoplastics. Observe fire precautions appropriate for comparable forms of wood and paper. For building uses, check fire code approvals. Impact resistance is a factor of thickness. Avoid exposure to heat or aromatic solvents. Clean with soap and water. Avoid abrasives.

Plexiglas acrylic plastic is a combustible thermoplastic. Observe fire precautions appropriate for comparable forms of wood and paper. For building uses, check code approvals. Impact resistance is a factor of thickness. Avoid exposure to heat or aromatic solvents. Clean with soap and water. Avoid abrasives.

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