PLEXIGLAS® SHEET: ANNEALING CONDITIONS

ACRYLIC SHEET

Health and Safety Precautions

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

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

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

Annealing

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

Annealing consists of prolonged heating of the acrylic part at temperatures lower than those used for forming, followed by slow cooling. Internal stresses set up during fabrication of the article are reduced or eliminated by this treatment All edges should be cut or machined with as little internal stress as possible. If excessive internal stress is present in the parts to be cemented, crazing will occur during the cementing process. It may be necessary to anneal the parts to reduce internal stresses that set up in the parts during fabrication or thermoforming operations. Annealing results in greater dimensional stability and greater resistance to crazing. Heat treating also improves the strength of certain cemented joints.

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

TABLE A

Recommended Annealing Times and Temperatures for Plexiglas® sheet

	Heating Time (Hours) in Forced Circulating Air Ovens Maintained at the Indicated Temperature for Parts Made of Plexiglas® G and MC Sheet				
Max. Thickness (Inches)	**Time to Heat Mid-Plane (hrs)***	**230°F (110°C)**	**221°F (105°C)**	**212°F (100°C)**	**203°F (95°C)**
0.060 to 0.177	1/2	1- 1/2	3 -1/2	7-1/2	24 -1/2
0.236 to 0.354	1	2	4	8	25
0.472 to 0.708	2	3	5	9	26
0.944	3	4	6	10	27
1.500 to 1.750	6	7	9	13	30
2.00	8	9	11	15	32

PLEXIGLAS® SHEET: ANNEALING CONDITIONS

ACRYLIC SHEET

***** The time required to raise the temperature of the mid-plane to a temperature equal to room temperature plus 99% of the difference between room temperature and annealing temperature.

Notes:
(1) Anneal parts at the highest temperature for indicated time. If distortion occurs, try the next lowest temperature.
(2) The cycles given will be satisfactory for most formed parts. For extreme forming, such as 100% biaxial stretching, use lower temperatures.
(3) Air should circulate around each part.

TABLE B
Cooling Times for Plexiglas® Parts (All Formulations)

		Time (Hours) to Cool Plexiglas® Sheet Parts From the Indicated Temperature to 120°F			
Maximum Thickness (Inches)	**Cooling Rate (°F/Hr.)**	**230°F (1010°C)**	**221°F (105°C)**	**212°F (100°C)**	**203°F (95°C)**
0.060 to 0.177	140	3/4	3/4	1/2	1/2
0.236 to 0.354	54	2	1-3/4	1-3/4	1-1/2
0.472 to 0.708	25	4-1/2	4	3-3/4	3-1/4
0.944	18	6	5-1/2	5	4-1/2
1.500 to 1.750	12	9	8	8	7
2.00	10	11	10	9	8

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

Determination of Best Annealing Temperature

The optimum temperature for annealing any specific part can best be determined by experimenting with a few samples to find the maximum temperature at which the part can be heated for the times indicated in Table A without objectionable deformation. Parts should be annealed at as high a temperature as possible. Annealing at temperatures lower than those listed in Table A will not give effective relief and redistribution of stresses.

Machined Plexiglas® sheet parts that have not been heated to forming temperature should be annealed with caution in the higher temperature ranges.

The annealing temperature should be approximately 10°F below the minimum temperature at which the part shows deformation of 1 percent. A greater change indicates that the part has not been properly formed. The fabrication process should be carefully reviewed and revised until the parts will withstand these annealing temperatures. Particular attention should be given to forming temperatures and conditions because parts allowed to cool too much before forming is completed tend to relax at lower annealing temperatures

PLEXIGLAS® SHEET: ANNEALING CONDITIONS

ACRYLIC SHEET

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

Annealing also lessens the effect of solvent smears and "runs" which may result from errors in cementing. Proper annealing will eliminate any tendency toward immediate crazing or cracking of parts subjected to brief exposure to solvents, e.g., parts which are to be painted. If the solvent makes the Plexiglas® sheet sensitive to crazing as do some types of paints, the parts should be annealed after each exposure. When only surface stresses are present, only the surface needs to be heated. This will greatly reduce annealing times for thick parts. Drilled holes may be considered a special case of surface machining. Parts with through holes must be placed in the oven so that the air flow is along the hole passage.

Caution #1: Protective spray masking coatings must be removed from Plexiglas® sheet parts before they are annealed. If such coatings are not removed prior to annealing, optical distortions may appear in the annealed part in areas where the thickness or surface of the coating is irregular.
Caution #2: Plexiglas® sheet parts to be annealed should be clean and dry and should be supported so that they are not under stress while being annealed. This is particularly true when clamps are used to hold cemented assemblies together during the annealing or curing period. The weight of the clamps or excessive clamping pressure may set up local stresses which may warp or even craze the parts unless proper precautions are taken.

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

Slow Cooling After Annealing

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

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