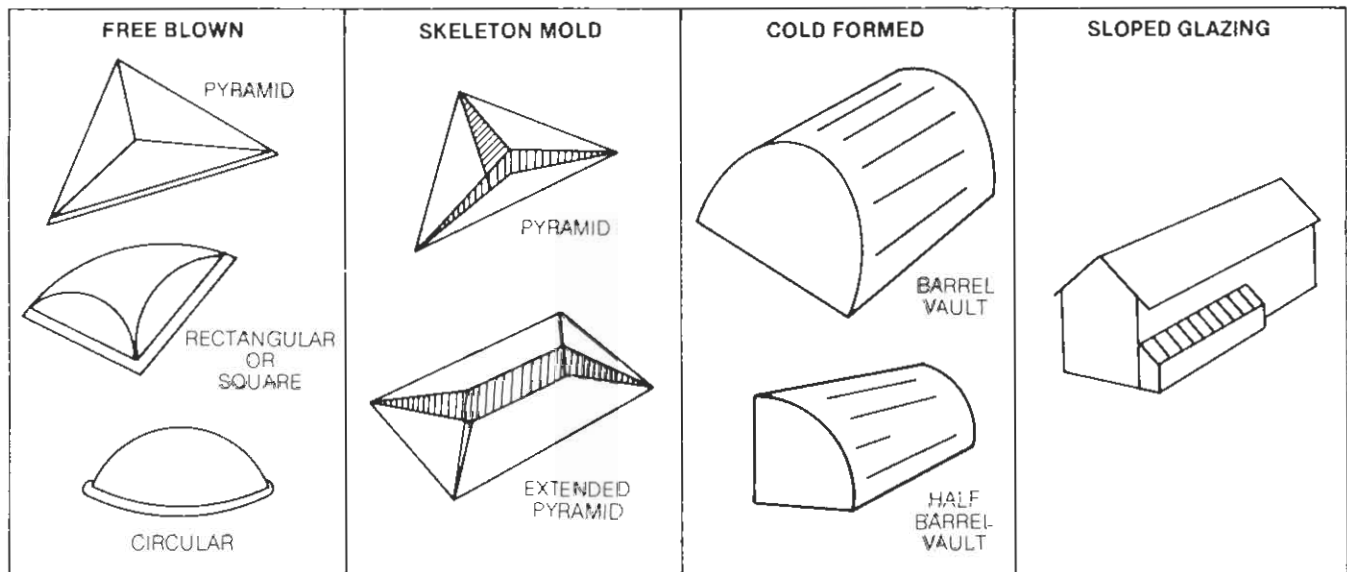


## Applications

### # 3 Forming Skylights



#### This brief gives advice for:

- Varieties of Domes
- Physical Properties
- Equipment
- Dome Design
- Tool Design
- Trouble-Shooting
- Thermoforming Conditions
- Equipment and Material Supplies
- Additional Technical Information and Assistance

**NOTE**—This brief is a companion piece to CYRO's Fabrication Tech Brief #10, Thermoforming. Brief #10 covers thermoforming basics; the brief you are reading adds to that information with specific data on skylights. Don't attempt to thermoform skylights until you understand the advice in both briefs.

**IMPORTANT** —Always consult with local building code officials prior to installing skylights made from ACRYLITE acrylic sheet. Some restrictions may apply.

You can often use ACRYLITE FF acrylic sheet, made by a continuous manufacturing process, in place of ACRYLITE GP cell-cast sheet for skylights. ACRYLITE FF sheet's engineered characteristics require slight fabrication modifications. These changes, such as lower oven temperatures and shorter heating times, reduce cycle time and production cost.

#### Varieties of Shapes

The illustrations above show many possible dome configurations, including free-blown domes in circular, square, and rectangular shapes. Using skeleton mold fabrication, other potential shapes include pyramid and extended pyramid domes. Also shown are cold-formed barrel vaults and sloped glazing. You can cold-form ACRYLITE FF sheet within limitations. Radius of curvature must equal or exceed 330 times the sheet's thickness. Sheet length must not exceed 8 feet. If these criteria are not met, internal stresses may cause crazing (numerous tiny cracks) in the material.

#### Physical Properties Related to Dome Design

##### Safety

ACRYLITE FF sheet is safer than glass because of greater breakage resistance. Under impact beyond its resistance, ACRYLITE FF sheet doesn't shatter into small slivers but breaks into comparatively large pieces. It complies with American National Standards Institute (ANSI) Z97.1-1975, Safety Glazing for Buildings.

##### Design Loads

Although ACRYLITE FF sheet's tensile strength is 10,000 psi at room temperature (ASTM D638—room temperature=68°F/20°C), continuous loads below this

value can induce stress-crazing. For glazing applications, continuously imposed design loads shouldn't exceed 1,500 psi. In other applications involving continuous loading, loads should be less than 750 psi at 23°C (73°F).

### Light Transmission

All thickness of colorless ACRYLITE FF sheet transmit 92% of visible light. White translucent ACRYLITE FF sheet comes in three densities. Each white color's light transmission decreases as thickness increases.

#### Approximate Light Transmission of White Translucent ACRYLITE FF Sheet

Color No.	Color Name	Thickness			
		3mm (.118")	3.8mm (.150")	4.5mm (.177")	6mm (.236")
020-4 FF	White	49%	N/A	37%	31%
015-2 FF	White	30%	N/a	21%	16%
030-7 FF	White	—	70%	—	—

Other ACRYLITE FF colors available in 3, 4.5, and 6mm thicknesses are listed in the chart below. Light transmission of these transparent colors is the same for all thicknesses.

#### Approximate Light Transmission of Transparent ACRYLITE FF Colors

Color No.	Light Transmission	Solar Energy Transmission
Gray 103-2	25%	42%
Gray 104-1	13%	26%
Bronze 126-4	45%	56%
Bronze 131-2	27%	35%
Bronze 311-1	10%	20%

For more information on light transmission, see our Brochure 1213, *Light Transmission and Reflectance*, and Application Tech-Brief #1 Glazing.

### Cleaning

Wash ACRYLITE FF sheet with a mild soap (dishwashing liquid) and plenty of lukewarm water. Apply light pressure with a soft, clean cloth. Rinse with clear water; blot dry with a damp cloth or chamois.

To remove grease, oil, or tar, use a good grade of hexane, aliphatic naphtha, or kerosene. Obtain these solvents at a paint or hardware store; use as recommended by manufacturers. Immediately wash away oily film residues with a mild soap and water solution.

**DO NOT USE: Window cleaning sprays, kitchen scouring compounds, or solvents such as acetone, gasoline, benzene, carbon tetrachloride, or lacquer thinner.**

**CAUTION: Alcohol may cause crazing.**

### Dusting

Dust with a soft, damp cloth or chamois. Dry or gritty cloths can scratch the surface.

### Polishing

Where necessary, wax ACRYLITE FF sheet occasionally with non-solvent auto paste wax to protect it and maintain its surface gloss. Apply a thin, even coat with a soft, clean cloth; polish lightly with cotton flannel. Then, wipe with a damp cloth to help eliminate electrostatic charges. Keep the surface dust-free.

### Storage

Store sheets in their original shipping cartons. Don't handle sheets unnecessarily until ready to use them. If storage procedures are correct, predrying before thermoforming is rarely needed.

For more information on handling and storage, refer to Fabrication Tech Brief #1, Handling and Storage.

### Equipment

Several heating methods are available for thermoforming ACRYLITE FF sheet into skylights. These include flat, horizontal heaters, constant temperature horizontal ovens, or thermoforming machines.

Vertical hot air ovens are seldom used. Because of poor air circulation, they heat unevenly, causing temperature differentials within the oven. This can result in uneven shapes.

For a complete review of equipment available to thermoform skylights, see Fabrication Tech Brief #10, Thermoforming.

### Radiant Energy

To heat acrylic quickly, assure the sheet absorbs the wave length of the radiant heat source. Optimum wave length for absorption of infrared waves is 3.2-3.6 microns for ACRYLITE FF sheet. This requires emission temperatures of 1000-1200°F. If emitter frequency is outside this range, the sheet is transparent to much of the infrared radiant energy. Only surface conduction heats it.

### Vertical Ovens

These comments add to statements made in Fabrication Tech Brief #10, Thermoforming.

- Set the oven temperature at about 295°F.
- In addition to foam, consider rubber-backed felt or woven glass fiber cloth on the tool surface to prevent mark-off.

### Forming Mechanisms

Many machine operation methods work in skylight manufacture. Each has advantages and disadvantages and depends on production volume, piece size, floor space, and dome shape.

### Dome Design

Variables in dome design include dimensions, curb design, wind load requirements, and solar gain. Obtain information in publications from:

#### American Architectural Manufacturers Association (AAMA)

2700 River Road  
Des Plaines, IL 60018  
(312) 699-7310

### Dome Rise

Another common term, dome rise, can be defined as:

- The formed height divided by the base dimension for square-base domes,
- The formed height divided by the shorter base dimension for rectangular-base domes,
- and
- The formed height divided by the diameter for circular-base domes.

## Structural Changes

Forming ACRYLITE FF sheet orients molecules in the direction of stretching. This structural rearrangement improves certain properties. Strength is enhanced due to biaxial stretching, so you can use thinner material for a curved dome than for a flat skylight. Also, chemical resistance improves.

## Tool Design

Heating method provides the basis for tool design. If you use a thermoforming machine, the manufacturer supplies tooling details and also establishes the machine tool design.

Positive pressure and vacuum are two dome-forming methods. Vacuum sealing requires less clamping force but also requires a deeper box than pressure blowing. For custom systems, consider a pressure box.

If you heat sheet from one side, corner areas may require extra heat. Place lamps or reflectors below the sheet to supplement heat from above. If you form double or triple domes, use interchangeable box frames to change dome dimensions.

Often, you can leave polyethylene masking on one side of the sheet while heating it from the other side. Peel masking, which guards domes against scratches prior to installation, from the plastic after it has cooled.

Design tooling so the sheet is heated uniformly, especially in corners. Turned-up corners and wavy edges indicate high fabrication stresses.

## Clamping Mechanisms

Clamp systems should allow preheating of clamping bars. A system temperature of 160°F assures a low stress, straight-edged dome. If automatic clamping is available, a low/high two-stage pressure clamp promotes uniform heating without stresses.

Clamping mechanisms range from pneumatic devices to an inexpensive hand system with several clamps on a side joined by an operating handle. Volume production may justify a pneumatic system. For custom, low-volume shops, multiple hand clamps often do the job.

## Dome Height

Several methods automatically control dome height or depth.

### —Electronic Proximity Switch (Capacitive Type):

Controls an on/off solenoid in the air line. Mount the switch above the blowing area's center on an adjustable support. Design supports to swing sideways, providing work clearance.

—**Photoelectric Control:** Design a photoelectric light source in the tooling to control height. Breaking the light beam will stop air pressure or vacuum. Consider light beam positioning when designing tools.

—**Microswitch Circuit:** Mount a microswitch on a movable arm to control air pressure or vacuum. The tip of the switch contacts the plastic and may leave a mark.

## Thermoforming Conditions

### Heating Requirements

ACRYLITE FF sheet's forming temperatures are 290-320°F. **Don't overheat.** Establish heating cycles

using temperature indicating tapes that change color as material heats.

If you heat sheet 3.0mm (.118") thick or greater without a clamping frame, it may shrink up to 3% in the manufacturing direction. (See the discussion of manufacturing direction under "Procedures—Shrinkage" in Fabrication Tech Brief #10, Thermoforming.)

## Vacuum Requirements

In vacuum-forming, provide enough vacuum to keep the gauge above 20 inches of mercury during the forming process. Vacuum storage capacity should be twice that required for the dome.

## Mark-off

If heated sheet contacts a surface, mark-off may occur. To prevent this, cover tooling with thin polyurethane foam, flocked rubber, or billiard table felt.

## Cooling

After forming, cool domes evenly in open air. Diffuse cooling air, if used, to avoid optical distortion.

## Post trimming

If post-trimming is required, a carbide triple-chip tooth design saw blade works well. The blade should protrude about 1/8" above the workpiece. A relatively fast cutting rate minimizes frictional heat build-up between sheet and blade.

## Trouble-Shooting

<u>Problem</u>	<u>Cause</u>	<u>Solution</u>
<b>Bubbles</b>	Heating too rapidly	Lower heat temperature Increase distance between heaters and sheet
	Uneven heating	If tubular rod isn't the same red color from end to end, replace rod Use screening to balance heat
	Excess moisture	Predry sheet Preheat Keep moisture-proof masking on sheet until formed Use older material first
<b>Uneven dome</b>	Uneven heating	Check heater for heating evenness Eliminate drafts Baffle heat on all sides
	Clamping frame cold	Preheat clamping frame
<b>Bad surface</b>	Mold surface markings	Use mold covering (foam, felt, flocking)
	Dirt on sheet	Clean sheet with deionized air

<b>Uneven edges</b>	Excessive forming temperature differential	Preheat clamping frame Use slip clamp system (low/high)
<b>Raised corners</b>	Excessive stress	Heat frames before inserting sheet Add supplemental heat to corners
<b>Cracking in corners during service</b>	Stress concentration	Heat sheet evenly Preheat frames Add supplemental heat to corners

## Ovens

**Despatch Oven Company**  
P.O. Box 1320  
Minneapolis, MN 55440  
(612) 331-1873

**Trent, Inc.**  
201 Leverington Ave.  
Philadelphia, PA 19127  
(215) 482-5000

**The Grieve Corporation**  
500 Hart Road  
Round Lake, IL 60073  
(312) 546-8225

**Snow Corp., EMC Div.**  
P.O. Box 9800-T  
Fort Worth, TX 76107  
(800) 433-2108 or  
(817) 732-5554

## Additional Technical Information and Assistance

### Technical Literature Available

For more detailed information, see your local authorized ACRYLITE sheet distributor or contact CYRO Industries. Literature is available for these and other topics:

### Physical Properties—

#1121—"Physical Properties of ACRYLITE FF Acrylic Sheet"

### Fabrication Tech Briefs—

These cover individual operations of fabrication such as cutting, drilling, thermoforming, etc. Be sure to ask for the latest listing of available Tech Briefs from your ACRYLITE distributor or CYRO Industries.

### Application Tech Briefs—

These cover required fabrication operations for specific applications like glazing, signs, etc.

### Technical Service

For complete technical assistance contact CYRO Industries, Technical Service.:

**CYRO Industries**  
25 Executive Blvd.  
Orange, CT 06477  
(203) 795-6081

*In Canada:*  
**CYRO Canada, Inc.**  
6285 Northam Drive  
Suite 300  
Mississauga, Ontario  
LV4 1X5  
(905) 677-1388

### Offices

For the name of your local Authorized Distributor call toll-free 1-800-631-5384 or contact the nearest CYRO office:

**Rockaway, NJ 07866**  
100 Enterprise Drive  
(973) 442-6130

**San Ramon, CA 94583**  
3180 Crow Canyon Place  
Suite 240  
(510) 866-9300

**Plano, TX 75074**  
101 East Park Blvd.  
Suite 1039  
(214) 424-6830

*In Canada: (See above)*

Note: See FLAMMABILITY and IMPORTANT NOTICE on Fabrication Tech Brief #10, Thermoforming.

## Equipment Suppliers

The suppliers listed below offer materials and equipment tested and approved by CYRO Industries. Authorized ACRYLITE Sheet Distributors may also offer materials and equipment.

### Thermoformers

**AAA Plastic Equipment, Inc.**  
P.O. Drawer 163169  
Fort Worth, TX 76161-3169  
(817) 625-7221

**Brown Machine**  
P.O. Box 434  
Beaverton, MI 48612  
(517) 435-7741

**Drypoll, Inc.**  
131-40 Maple Ave.  
Flushing, NY 11355  
(718) 353-3426

**Snow Corp., EMC Div.**  
P.O. Box 9800-T  
Fort Worth, TX 76107  
(800) 433-2108 or  
(817) 732-5554

**Plastic Vac, Inc.**  
214 Dalton, Box 5543  
Charlotte, NC 28225  
(800) 438-4139

### Temperature Tapes

**Celsistrip Tape**  
**Solder Absorbing Technology**  
144 Oakland St.  
Springfield, MA 01108  
(800) 628-8862

**Thermolable Sensitive Tape**  
**Paper Thermometer Co.**  
P.O. Box 129  
Greenfield, NH 03047  
(603) 547-2034



CYRO Industries, Rockaway, New Jersey 07866