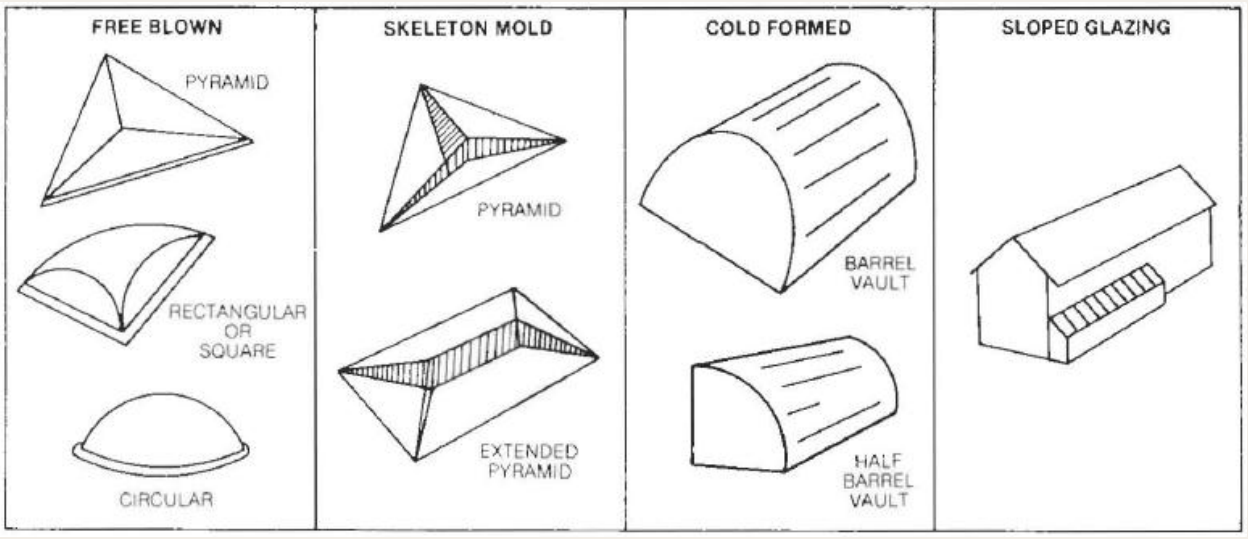
Technical Information

ACRYLITE® extruded (FF)

#3 Forming Sky Lights



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 *Evonik 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® extruded (FF) acrylic sheet, made by a continuous manufacturing process, in place of ACRYLITE® cast (GP) sheet for skylights. ACRYLITE® extruded (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®

extruded (FF) 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

ACRYITE® extruded (FF) sheet is safer than glass because of greater breakage resistance. Under impact beyond its resistance, ACRYLITE® extruded (FF) 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® extruded (FF) 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® extruded (FF) transmit 92% of visible light. White translucent ACRYLITE® extruded (FF) comes in three densities. Each white color's light transmission decreases as thickness increases.

Approximate Light Transmission of White Translucent ACRYLITE® extruded (FF) Sheet

Color Number	Color Name	Thickness			
		3mm	3.8mm	4.5mm	6mm
		.118	.150	.177	.236
WT031	White	49%	N/A	37%	31%
WT030	White	30%	N/A	21%	16%

Other ACRYLITE® extruded (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® extruded (FF) Colors

Color Number	Light Transmission	Solar Energy Transmission
Grey 7C025	25%	42%
Grey 7C026	13%	26%
Bronze 7C024	45%	56%
Bronze 7C049	27%	35%
Bronze 8C030	10%	20%

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

Cleaning

Wash ACRYLITE® extruded (FF) 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® extruded (FF) sheet occasionally with non-solvented 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, pre-drying 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® extruded (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® extruded (FF). 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® extruded (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® extruded (FF) 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

Problem	Cause	Solution
Bubbles	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
Uneven Dome	Uneven heating	Check heater for heating evenness Eliminate drafts Baffle heat on all sides
	Clamping frame cold	Preheat clamping frame
Bad Surface	Mold surface markings	Use molding covering(foam, felt, flocking,)
	Dirt on sheet	Clean sheet with deionized air
Uneven edges	Excessive forming temperature differential	Preheat clamping frame Use slip clamp system (low/high)
Raised corners	Excessive stress	Heat frames before inserting sheet Add supplemental heat to corners
Cracking in corners during service	Stress concentration	Heat sheet evenly Preheat frames Add supplemental heat to corners

Fire Precautions

ACRYLITE® sheet is a combustible thermoplastic. Precautions should be taken to protect this material from flames and high heat sources. ACRYLITE® sheet usually burns rapidly to completion if not extinguished. The products of combustion, if sufficient air is present, are carbon dioxide and water. However, in many fires sufficient air will not be available and toxic carbon monoxide will be formed, as it will when other common combustible materials are burned. We urge good judgement in the use of this versatile material and recommend that building codes be followed carefully to assure it is used properly.

Compatibility

Like other plastic materials, ACRYLITE® sheet is subject to crazing, cracking or discoloration if brought into contact with incompatible materials. These materials may include cleaners, polishes, adhesives, sealants, gasketing or packaging materials, cutting emulsions, etc. See the Tech Briefs in this series for more information, or contact your ACRYLITE® sheet Distributor for information on a specific product.

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