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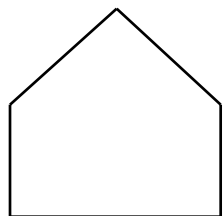
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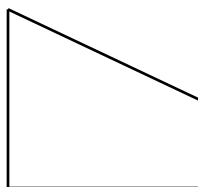
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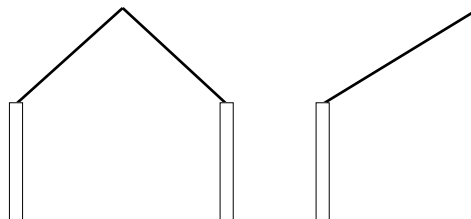
**Introduction:** This manual is a general guide for builders, owner builders, growers and designers. While special attention is given to greenhouse construction most of the principles and details also apply to solariums, pool enclosures, covered walkways, etc. Typically, a frame is fabricated from lumber and covered with double or triple-wall polycarbonate sheet. Add an exhaust fan, inlet shutters, shade cloth, a heater and misting equipment to complete a basic greenhouse.



Greenhouse &  
Pool Enclosures



Sunrooms



Covered Walkways

## Part One: Initial Considerations - Planning & Design

**Sizing:** A number of questions should be addressed when determining the size of your greenhouse. What plant species will you grow? How much space is needed to grow the amount you desire? Is the greenhouse just for growing or will it be used for additional living space, as is the case with sunrooms? If the greenhouse is attached and is providing solar space heating, how much heat would you like to gain? The larger the greenhouse, the more heat is gained. Note that plants, soil and water in attached greenhouses actually absorb the majority of the winter solar heat gain. To gain sufficient heat to supplement the adjacent structure, a south facing sunroom is best. These structures also do not use misting systems, making the air drier and more suitable for transfer to the main living space. A final sizing note is to give yourself a little extra square footage. People love their greenhouses and welcome the extra space.

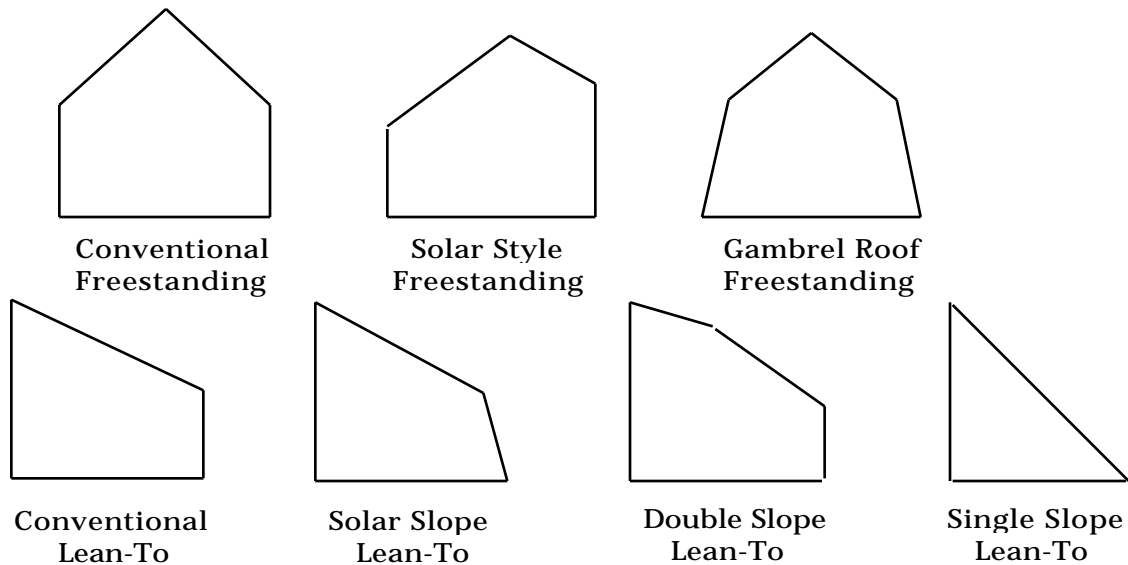
**Style:** Decide whether you would like an attached or a freestanding structure.

South facing attached greenhouses are excellent passive solar collectors, providing substantial heat for the greenhouse. The soil, plants and moisture absorb most of the heat. Do not plan on moving hot air to the adjoining structure. Often this air is moist and might adversely affect your home. This warm room addition will dramatically reduce the heat loss on this side of your house, so there is actually a net gain. The solar gain in a south facing sunroom will often be enough to heat the sunroom, with additional heat transfer to the adjoining living space via doors, windows or a room-to-room fan. On cool days with little sun, and during the hours of no sun, it is often best to close off the greenhouse or sunroom from the house. This will help in maintaining sufficient temperature levels. A gas or electric heater may be used to provide backup heat for maintaining desired temperature levels inside your greenhouse or sunroom.

If you would like a greenhouse close to the garden, a freestanding design may be best. Foundations can be very basic and permits are seldom required.

Swimming pool enclosures are becoming very popular. Polycarbonate is a low cost and economical way to cover these large structures.

## Typical Greenhouse Designs



**Siting:** Position the greenhouse with the long wall facing true south. True south is typically a number of degrees east or west of magnetic south. A compass indicates magnetic south. For locations that are positioned along a imaginary line running from Chicago, IL to Tallahassee, FL, magnetic south is true south. If your location is east of this line, true south is west of magnetic south. For locations west of this line true south is east of magnetic south. In Bangor, ME, true south is 20 degrees west of magnetic south. In Vancouver, WA, true south is 20 degrees east of magnetic south.

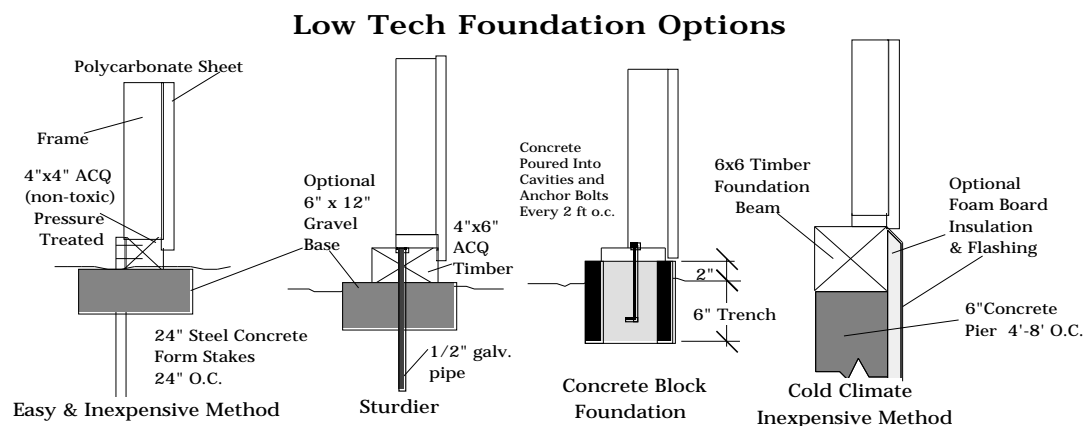
As long as your greenhouse orientation is within 25 degrees of true south it will function well as a solar collector. With this in mind, survey your site for the best location. Considerations such as proximity to garden, garage, entrance to house, electricity and water, may be as important to you as solar orientation. Look for a balance between these concerns. Check for any obstructions that will cause shade as the sun passes overhead. Deciduous trees will provide shade during the warm months and let in the sun during cooler months, when leaves have fallen. When tracking the sun's path keep in mind that the path is low in the winter and high in the summer. Note: Refer to solar reference books should you wish to be more exacting than these rule-of-thumb guidelines. Your local library, book store and lumber yard will have helpful publications.

A level site with good drainage is important. Pick a site that will not flood during heavy rains. Pick an area that you enjoy spending time in. People find a greenhouse to be a place that is regularly visited.

**Building Permits:** It is best to call your local building department before you build. Freestanding greenhouses usually do not require a permit. Attached models typically require a permit, especially if there is access to the house. Generally these permits are easy to obtain. The information the building department requests will help you make certain your design is sound and inspectors can also be helpful.

**Foundation Design:** The foundation design depends on greenhouse style, climate, site situation (soil, slope, etc.), desired thermal efficiency, budget, available materials and building codes. For freestanding greenhouses, the foundation can be as simple as 4"x4" ACQ pressure treated sill timbers fastened to steel stakes driven into the ground. ACQ is a non-toxic pressure treated wood product using copper based preservative with a high retention rate. Being biodegradable in soil, any leaching that occurs is safe for plants and humans. Check with your local lumber yard or call (800) 421-8661 for the nearest ACQ dealer. Another safe option is cypress, available in the southeast.

As the size of your greenhouse increases, a more substantial foundation is required. A properly designed, concrete thickened edge slab is also a good solution. Attached sunrooms are add-on living spaces that require a foundation similar to the one used for the adjoining structure. Often a solid concrete wall extending below the frost line and wrapped with foam insulation is used. See details below for examples of a few simple designs. Refer to general construction books to further investigate foundations.



**Wood Framing:** Lumber is an excellent framing material for structures covered with multi-wall polycarbonate. Redwood, cedar and cypress are rot resistant. We highly recommend sealing high moisture areas of the frame with McCloskey, marine grade Man-O-War Spar Varnish. This commonly available finish will protect the moisture prone areas, such as the top and bottom plate, and any area where the polycarbonate sheet comes in contact with the wood frame. This decreases likelihood of wood rot and eliminates wood discoloration. The smooth surface also provides a low friction surface for the expanding & contracting polycarbonate to move on, decreasing possible movement noise. Semi-gloss and gloss paint are high friction finishes and noise may result. Stains may react adversely with the polycarbonate. Always apply spar varnish as final finish layer. Apply one coat and let cure for 24 hours. Apply another coat and allow 2-3 days curing time. This provides sufficient time for proper hardening and eliminates the possibility of an adverse reaction with the polycarbonate. See pg. 7.

If using pressure treated select dry lumber. Prime and paint on one coat of high quality paint before assembly. Let dry thoroughly, lightly sanding between coats. Assemble and apply final coat. It is important to effectively seal the wood so that no harmful chemicals leach out. White is highly reflective and best for greenhouse use. Now place one coat of spar varnish on areas described above and let dry 2-3 days.

Select straight kiln dried lumber. If using cypress, you may use green lumber, because shrinkage is far less than with other species. See p. 4 - 6 for rafter sizing and spacing.

**Wood Frame Design for Multi-Wall Polycarbonate:** The simplest way to frame for multi-wall polycarbonate is to set studs and rafters 24-1/4" on center. This dimension will allow for a slight gap between sheets, required for fasteners and sheet movement. The first and last framing member positioning should be 23 1/2" on-center (see Frame Layout, pg 7). This will line up the outside edge of the first and last sheets with the outside edge of the first and last rafters and studs.

For small greenhouses, frame lumber is typically 2x3's or 2x4's. On larger structures and in areas with high snow loads, care must be taken to make roof framing strong enough to support the load (see below and page 5 ). To decrease rafter size, incorporate a brace or truss in your design. On long rafter runs, you may want to install blocking to keep the rafters straight. Hold this blocking 3/8" back from the inner surface of the sheet, allowing for movement of condensation past blocking (see page 4b).

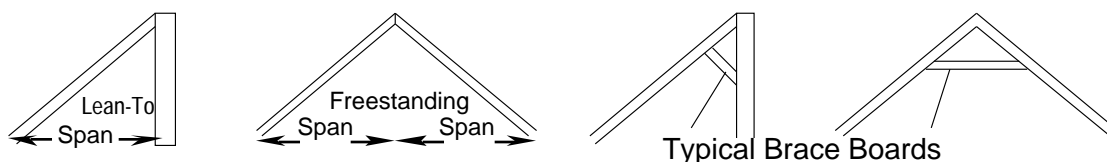
On large greenhouses and pool enclosures, the designer may want to have large rafters and studs spaced further apart. Set intermediate rafters and studs 48-1/2" on-center. When using 4x lumber (4 x 4, 4 x 6, etc.), the first and last framing member should be 46-3/4" on-center. Use 48" wide roof sheets, as it is difficult to reach fastening points with 72" sheets. Blocking that properly supports the sheet is required (see chart below). To allow for the movement of condensation past blocking, our neoprene spacer, small piece of aluminum channel or some other moisture proof spacer may be placed at the center of the blocking (see page 4b). Select lumber with less height than surrounding frame material and set the blocking back from the outer surface of the adjoining rafter.

In either case sheet must be supported on all 4 edges with min. 1/2" of sheet bearing on frame. When using sheets that have been cut along the length, and no longer have a rib at the edge, sheet may need to bear up to 5/8" on frame (if 8mm used & first rib in 3/8") or 1" on frame (if 16mm used & first rib in 3/4").

The chart below provides guidelines for blocking spacing. The chart is provided to address roof snow & wind load, but may also be used as a guide for wall design.

Sheet Thickness	Rafter Spacing	Blocking Spacing		
		35 lb. load	45 lb. load	60 lb. load
8mm	24-1/4"	not needed	every 8 ft.	every 6 ft.
8mm	48-1/2"	every 2.5 ft.	every 2 ft.	do not use
16mm	24-1/4"	not needed	not needed	not needed
16mm	48-1/2"	every 4 ft.	every 3 ft.	every 2.5 ft.

**Load Description For Blocking, Rafter Spacing & Span :** The load is both live (wind & snow) & dead (weight of rafter and what lies on it). A 35 lb. load is for areas with no snow and little wind. 45 lb. loads are areas of normal wind and snow. 60 lb loads, high wind and snow. On roof slopes over 30 degrees (7/12 pitch) the roof span may be increased or rafter size decreased due to a decrease in snow load from the steep slope. Refer to local code book or speak to building department for snow load adjustments.



## **Large Span Wood Framing Systems:**

Laminated Timber Beams (glulams) are an excellent choice for large span (width) sunrooms, greenhouses and pool enclosures.

These manufactured wood products are made by stacking, gluing and clamping layers of sawn lumber. For example, a standard size glulam of 3" wide x 5-1/2" high will consist of 4 layers of sawn lumber, laid flat. The end result is a structural member with a bending strength approximately double that of the equivalent size commercially available solid sawn timber. As well, improved shear strength is realized. Common wood species used are douglas fir or larch and pine.

To determine the size timber required you may refer to the page on Recommended Spans for Rafters (page 5). From this guide use some common sense to estimate the size of the timber required for your application and run it by your building dept. for their approval. If you are a builder, designer or architect refer to appropriate load charts resources available to you.

For joints and connections we suggest using structural connectors engineered for this specific purpose. For an excellent selection of connectors see the Simpson Strong-Tie web site at <http://www.strongtie.com> or visit your local lumber yard for a catalog.

For photos and a general overview of glulams see the Unadilla Laminated Products web site at <http://www.unalam.com>. For a more in depth coverage of glulams see the Willamette Industries web page on glulams at <http://www.wii.com/GLULAM.HTM>. From this page you can download a PDF file with their Western Willamette Classic Glulam Design Guide with product descriptions and design properties of glulam products available throughout the western United States.

Metal Plate Connected Wood Roof Trusses can be used to span large width structures, such as freestanding greenhouses and pool enclosures. Trusses are made from dimension lumber and metal connector plates.

Pre-fabricated trusses have revolutionized residential roof framing over the last three decades. Today, over 75 percent of all new homes are constructed with trusses. Trusses are lightweight and no on-site assembly is required.

The main disadvantages of trusses are that the triangular pattern of 2 x 4's is not as attractive as conventional lumber or glulam rafters, the structure occupies some of the overhead space and trusses will block more light than a glulam will. To increase reflected light and help the trusses blend into a clear or white polycarbonate roof paint the trusses white.

Advantages are lower cost and installation is quick, making large span wood frame greenhouses and pool enclosures possible for those with more modest budgets.

We suggest 4 ft. spacing to create the most open effect possible, but 2 ft. spacing is also ok. For 4 ft. spacing position intermediate trusses 48-1/2" on-center, the first and last truss should be 47-3/4" on-center. Use 48" wide roof sheets, as it is difficult to reach fastening points with 72" sheets. To see 2 ft. spacing dimensions see Typical Layout for Multi-Wall Polycarbonate Over Wood Frame (page 7).

Blocking that properly supports the sheet is required (see chart below). To allow for the movement of condensation past blocking, our neoprene spacer, small piece of aluminum channel or some other moisture proof spacer may be placed at the center of the blocking (see drawing at bottom of page). Select lumber with less height than the adjoining truss and set the blocking back from the outer surface of the adjoining rafter. Securely fasten blocking.

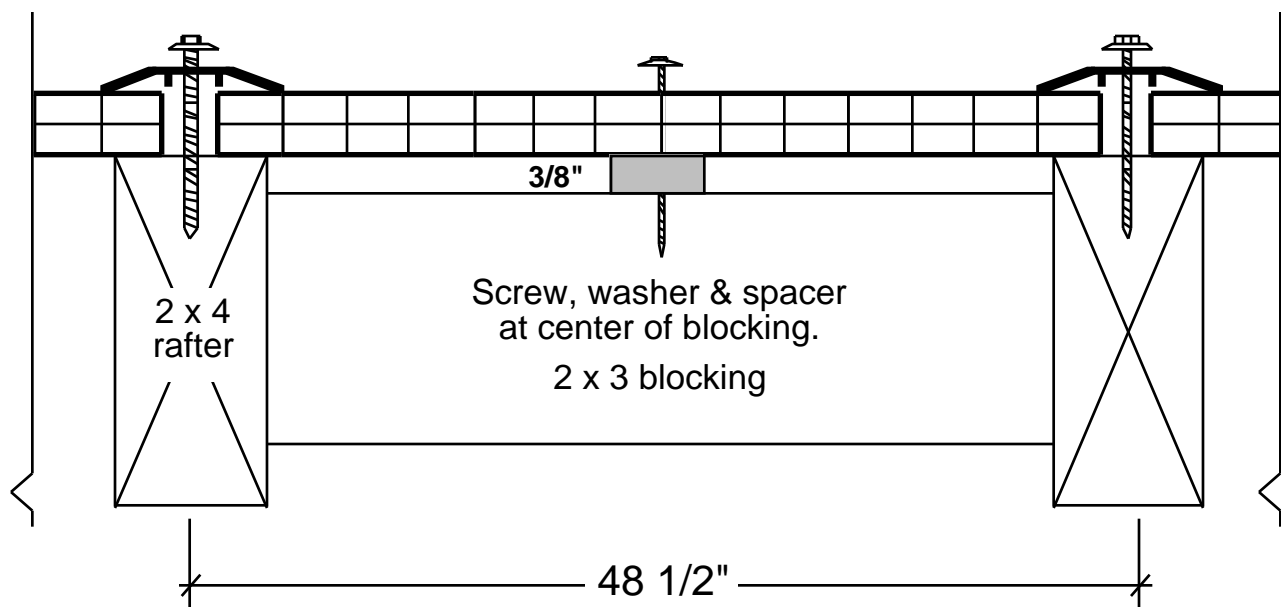
Always seek approval from the building dept. for your roof design. They may require diagonal bracing to prevent racking.

Set trusses, and add additional blocking at ridge and eave, so that the sheet is supported on all 4 edges, with a minimum of 1/2" of sheet bearing on the frame. When using sheets that have been cut along the length, and no longer have a rib at the edge, sheet may need to bear up to 5/8" on frame (if 8mm used & first rib in 3/8") or 1" on frame (if 16mm used & first rib in 3/4").

The chart below provides guidelines for blocking spacing. The chart is provided to address roof snow and wind load, but may also be used as a guide for wall design.

### **Rafter spacing and blocking placement for 8mm & 16mm polycarbonate.**

<u>Sheet Thickness</u>	<u>Rafter Spacing</u>	<u>Blocking Spacing</u>		
		<u>35 lb. load</u>	<u>45 lb. load</u>	<u>60 lb. load</u>
8mm	24-1/4"	not needed	every 8 ft.	every 6 ft.
8mm	48-1/2"	every 2.5 ft.	every 2 ft.	do not use
16mm	24-1/4"	not needed	not needed	not needed
16mm	48-1/2"	every 4 ft.	every 3 ft.	every 2.5 ft.



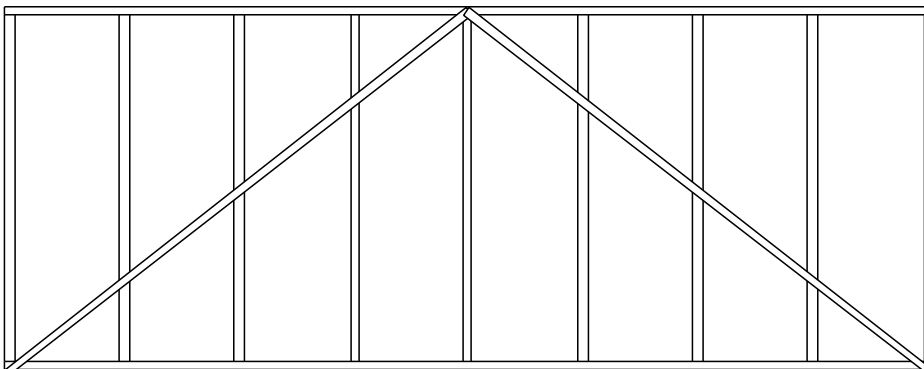
For more information on trusses see Metal Plate Connected Wood Trusses For Residential Roofs at <http://www.umass.edu/bmatwt/metal.html> and do a Yahoo search for wood trusses.

**Diagonal Bracing:** To eliminate racking of a wood structure, conventional construction methods incorporate diagonal bracing and/or a skin material with shear strength (such as plywood). Greenhouses are covered with glazing materials that are great for letting in the light, but offer no shear strength. It is wise to use some method of diagonal bracing on at least the end bays of larger greenhouse side walls and roof, and also on smaller greenhouses that are in high wind areas.

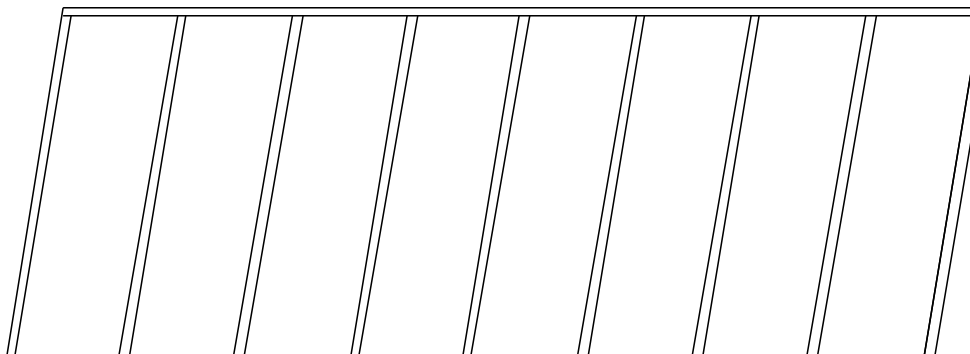
To maximize light transmission and minimize installation time we suggest using light gauge steel Wall Bracing Straps, as manufactured by Simpson Strong-Tie (#WB) and other structural connector manufacturers, using similar product numbers. These 1-1/4" wide x 9' 6" long straps are manufactured from galvanized steel. Numerous holes are punched in the strap, providing for simple and quick attachment. You may choose to paint these prior to installation. White blends well with clear polycarbonate. Position on exterior surface of frame, as shown below, and then install the polycarbonate.

These structural building components are recognized by your local building department. If the building department questions you about diagonal bracing, bring the structural connector product literature along with your plans.

Stud wall with steel Wall Bracing Straps in place.



Stud wall where racking has occurred.



## RECOMMENDED SPANS FOR RAFTERS

24" & 48" spacing is common when covering frame with 4 ft. wide multi-wall polycarbonate.

36" spacing is often employed when using 6 ft. wide multi-wall polycarbonate.

Load is shown in lbs. per sq. ft. Spans may be substantially increased by incorporating a brace board that attaches to corresponding rafters, or wall of adjoining structure, creating a strong truss (see diagram on bottom of page 4).

Spacing	Load	2 x 3	2 x 4	2 x 6	2-(2 x 3's)	2-(2 x 4's)	2-(2 x 6's)	4 x 4
24"	35 lb.	4'7"	6'6"	9'6"	6'5"	9'3"	13'5"	8'9"
	45	4'1"	5'8"	8'4"	5'10"	8'0"	11'10"	7'7"
	60	3'6"	4'11"	7'3"	5'0"	7'0"	10'3"	6'8"
36"	35 lb.	3'9"	5'4"	7'9"	5'4"	7'6"	10'11"	7'1"
	45	3'4"	4'8"	7'0"	4'9"	6'7"	9'8"	6'3"
	60	2'7"	3'8"	5'11"	3'8"	5'2"	8'4"	4'9"
48"	35 lb.	3'2"	4'7"	6'8"	4'7"	6'6"	9'5"	6'2"
	45	2'7"	3'8"	5'11"	3'8"	5'2"	8'4"	4'11"
	60	2'0"	2'9"	4'4"	2'10"	3'10"	7'3"	3'8"

**Notes:** Maximum allowable spans shown apply to #2 Douglas fir or larch with roof slope of (7/12 pitch) or less. For steep roof slopes refer to bldg. dept. for deductions in snow load and rafter size.

Table may be used for other species and grades of wood by adjusting the spans as follows:

For these grades and species the span may be increased by the following percentages:

Douglas fir or larch, select structural: increase 20%  
 Southern pine, select structural: increase 18%  
 Calif. redwood, clear select structural: increase 36%  
 Calif. redwood, #1: increase 36%

Douglas fir or larch, #1: increase 10%  
 Southern Pine, #1: increase 7%  
 Calif. Redwood, select structural: increase 18%  
 Western cedar, select structural: increase 2%

For the these grades and species the span may be decreased by the following percentages:

Southern pine, #2: decrease 2%  
 Western cedar, #1: decrease 6%  
 Hemlock or fir, #1: decrease 2%  
 Spruce, #1: decrease 9%

Calif. redwood #2: decrease 2%  
 Western cedar #2: decrease 14%  
 Hemlock or fir #2: decrease 11%  
 Spruce #2: decrease 16%

(Source: Add-On Solar Greenhouses & Sunspaces by Andrew M. Shapiro)

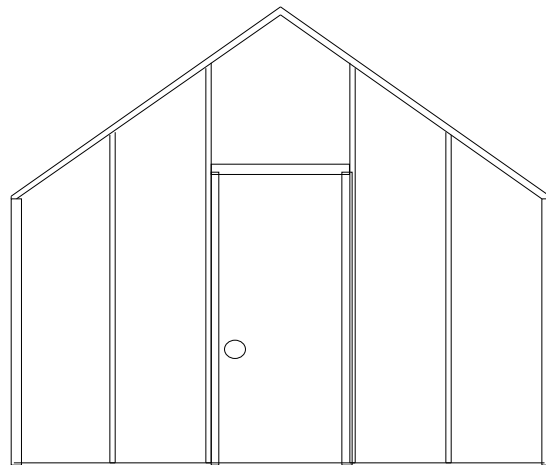
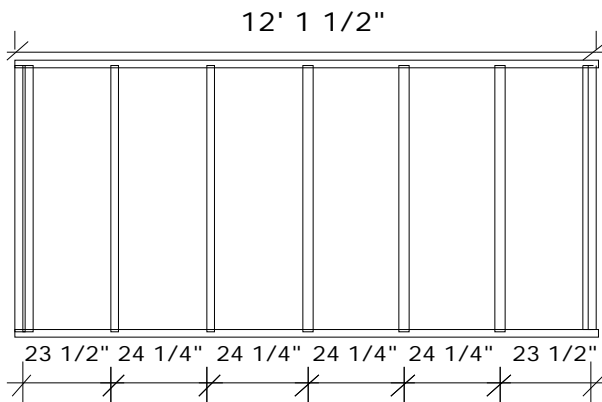
**Note:** Cypress is similar in strength to douglas fir. Consult with your source for exact figures.

**Wood Frame Layout For Multi-Wall Polycarbonate:** Prepare a drawing of the greenhouse you are planning. Framing of the longer walls of a greenhouse (called sidewalls on freestanding and front walls on attached greenhouses) are typically set with an on-center measurement of 24 1/4", for intermediate studs and rafters. The first and last framing member measurement should be 23 1/2" on-center. This will align the outside edges of the first and last sheets with the outside edges of the first and last rafters (See drawings below and details on next few pages). If these measurements are used, framing will easily accommodate standard size polycarbonate sheets, without cutting sheets to width. Always plan for 1/2"-1" of sheet edge bearing on framing.

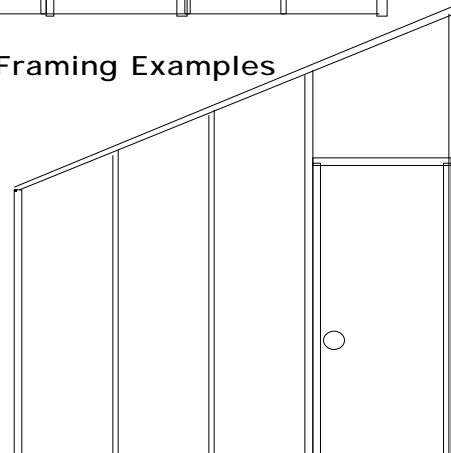
The shorter walls of a greenhouse are typically the end walls. Custom cutting is required for roof slope, doors, windows and ventilation equipment. Adhering to frame on center measurements, as described above, may eliminate cutting of sheet width. When laying out end wall framing, try to get the most you can out of a sheet. Cut offs can be used to go over doors or utilized on other projects such as cold frames.

At ends of roof and wall, you may want to double up the framing. This provides extra wall corner strength and double rafters act as top plates for end wall framing. Framing around a door or window can also be double. Follow standard framing techniques for the best results. See Fan, Shutter, Window, Door and Skylight, Details, page 10, for examples of how framing and polycarbonate interfaces with these building components.

Example of Roof and Wall Framing Layout  
(sidewall of freestanding greenhouse or  
front wall of attached greenhouse)

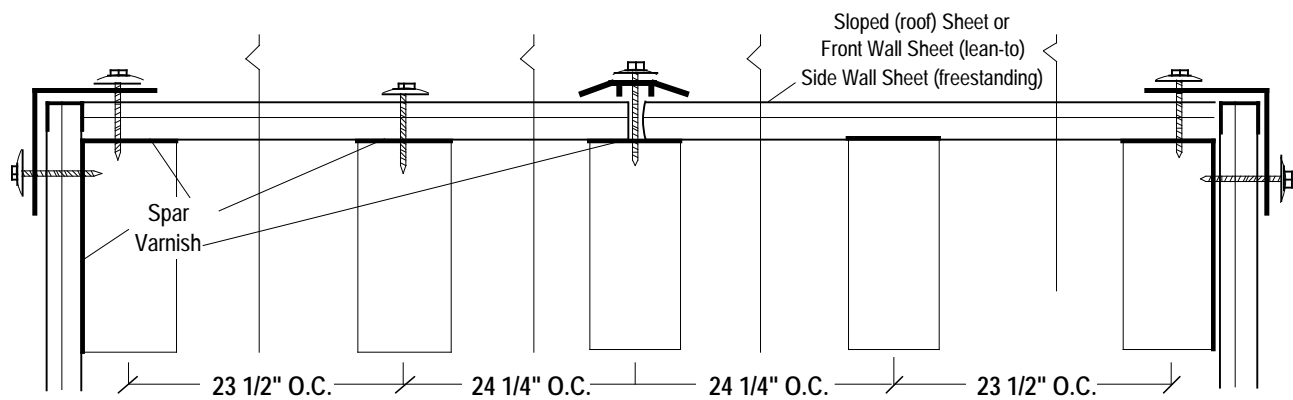


End Wall Framing Examples



## Typical Framing Layout For Multi-Wall Polycarbonate Over Wood Frame

### Polycarbonate Sheet, Corner Trim Method (Standard 48" or 72" Sheets)



**Framing of the longer walls of a greenhouse (sidewalls on freestanding and front walls on attached greenhouses) are typically set with an on-center measurement of 24 1/4", for intermediate studs and rafters. First and last framing member on-center measurement should be 23-1/2" on-center. This will line the outside edges of the first and last sheets with the outside edges of the first and last rafters and allow for spacing between sheets.**

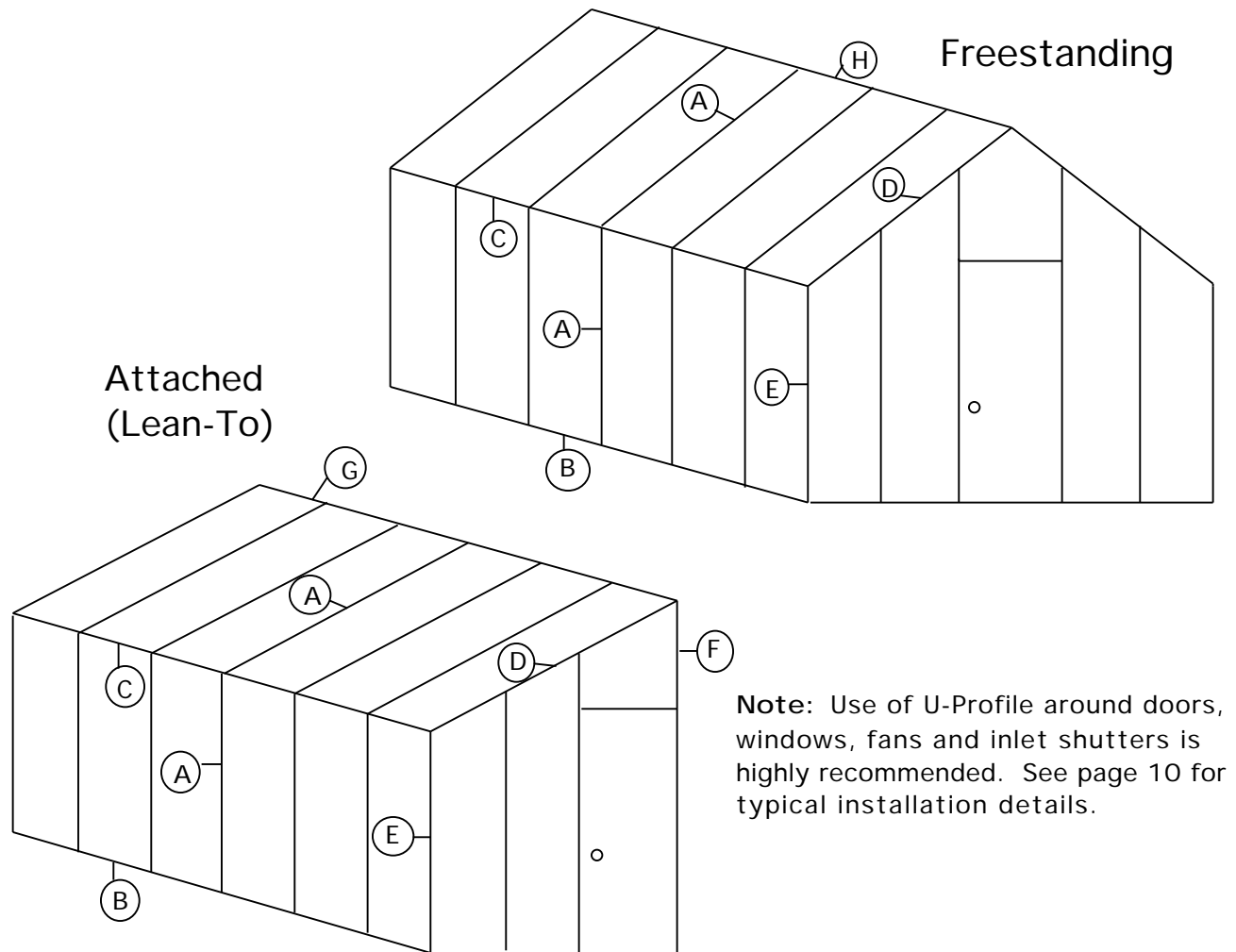
**Wood Sealer:** Shown above are a few locations on a wood frame where we suggest applying a marine grade spar varnish. It is also wise to treat other moisture prone areas, such as the top and bottom plate. This will decrease the likelihood of wood rot and eliminates wood discoloration. The smooth surface also provides a low friction surface for the expanding & contracting polycarbonate to move on, decreasing possible movement noise. Semi-gloss and gloss paint are high friction finishes and noise may result. Stains may react adversely with the polycarbonate. Always apply spar varnish as final finish layer. McCloskey Man-O-War Spar Varnish is recommended.

Apply one coat and let cure for 24 hours. Apply another coat and allow 2 to 3 days curing time. This will provide sufficient time for proper hardening and eliminates the possibility of an adverse reaction with polycarbonate.

**Multi-Wall Polycarbonate Sheet Specification:** This material comes in clear for maximum solar gain and opal or bronze if reduced solar gained is desired. Thicknesses are 6mm, 8mm and 16mm. The thicker the sheet, the greater the R-Value. Standard widths are 48" & 72". Standard lengths are 4 ft. to 36 ft.

Frame layout determines the sheet width. In the example shown in Frame Layout Section (pages 6 & 7), both 4 ft and 6 ft wide sheets will fit. The length is determined by wall height and length of roof framing. It is a good idea to add a few extra inches to make sure you have enough. Keep in mind that the channels in the polycarbonate sheet are parallel to sheet length and must run vertically. Only one side of the sheet has the special co-extruded layer that protects the sheet from U.V. damage, this side must face towards the exterior.

**Multi-Wall Polycarbonate Trim Specification:** When properly installed, these trim components provide an attractive and watertight skin for your greenhouse. The details on the following pages illustrate usage of the trim components in most of the common applications. The drawings below indicate details that correspond to a specific location in a greenhouse or sunroom. Letters correspond to details on following page.



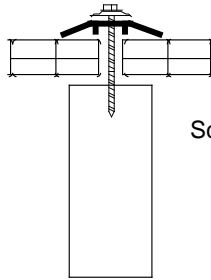
**Note:** Letters correspond to details on following page.

# Multi-Wall Polycarbonate Trim Install Details

Determine your own material need and Save 5%!  
Online, Fax, Mail or Phone Orders 800-776-2534

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## Narrow Profile Cap, Sheet Joining:

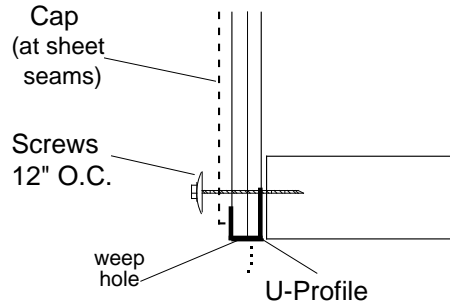


Screw & Washer  
12" O.C.

A

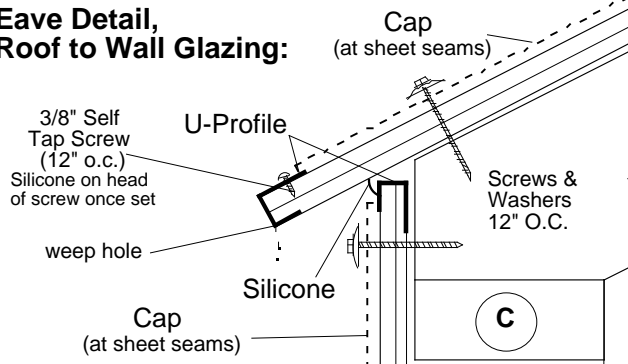
**Note:** Sheet must be spaced so that Cap covers a minimum of 1/2" of the polycarbonate sheet edge, including at least 1 rib. No silicone required to achieve an excellent, watertight seal.

## Lower Edge, Wall Glazing:



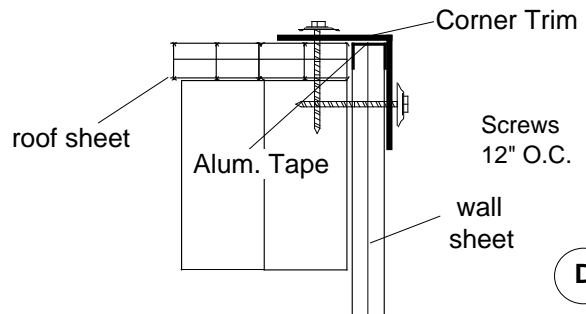
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## Eave Detail, Roof to Wall Glazing:



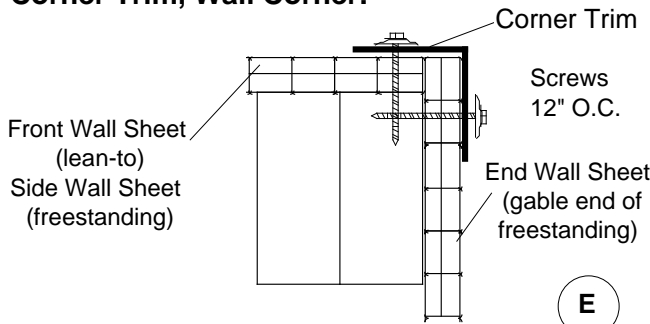
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## Corner Trim, Roof Corner:



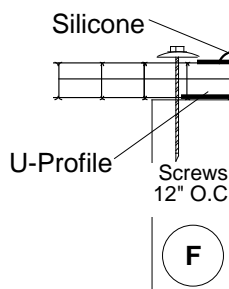
D

## Corner Trim, Wall Corner:



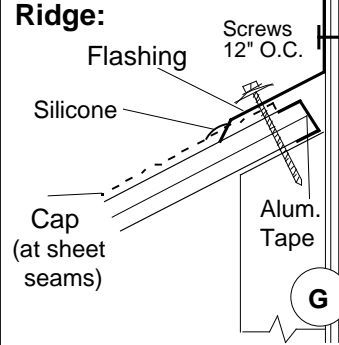
E

## Gable End To Existing Wall:



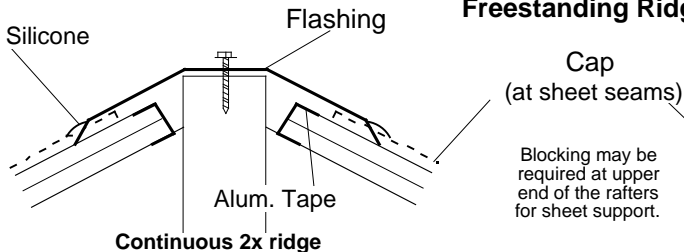
F

## Lean-To Ridge:



G

## Freestanding Ridge:

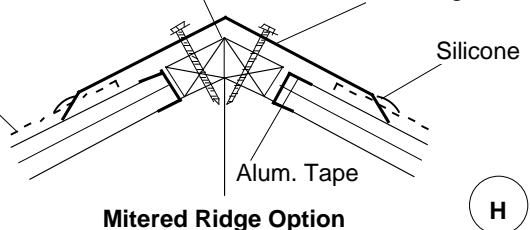


Cap  
(at sheet seams)

Blocking may be required at upper end of the rafters for sheet support.

Continuous 2x ridge

## Mitered Ridge Option



H

**Framing:** 24-1/8" to 1/4" on-center for intermediate members. First and last framing member 23-1/4" on-center.

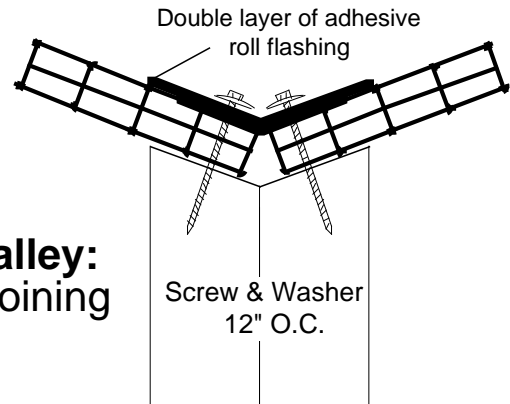
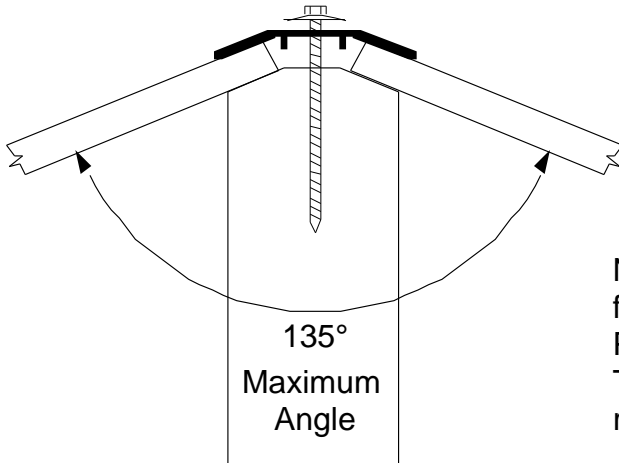
**Flashing:** Have local sheet metal shop fabricate flashing for your specific needs. Use sturdy gauge material.

**U-Profile:** U-Profile requires a 1/16" weep hole, every 12" along lower edge, for moisture release.

(9)

## Angle Wall or Hipped Roof

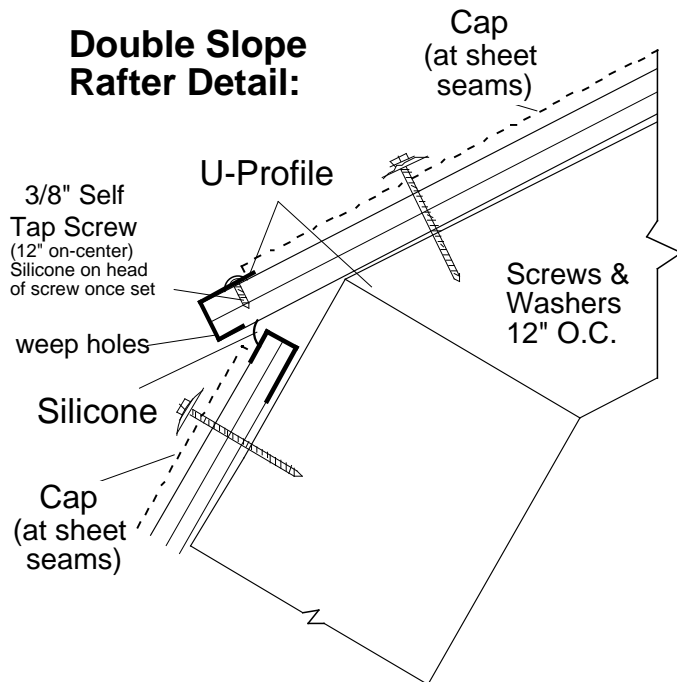
Screw & Washer  
12" O.C.  
(no silicone required)



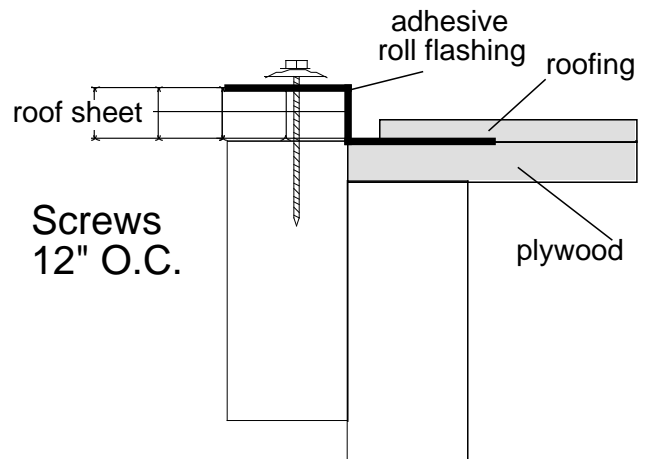
## Roof Valley: Sheet Joining

Note: Joint sealed with a double layer of roll roof flashing with Butyl Adhesive on the side facing the Polycarbonate and a shiny Aluminum Foil or White Tedlar backing facing the weather. No silicone is required to achieve an excellent, watertight seal.

## Double Slope Rafter Detail:

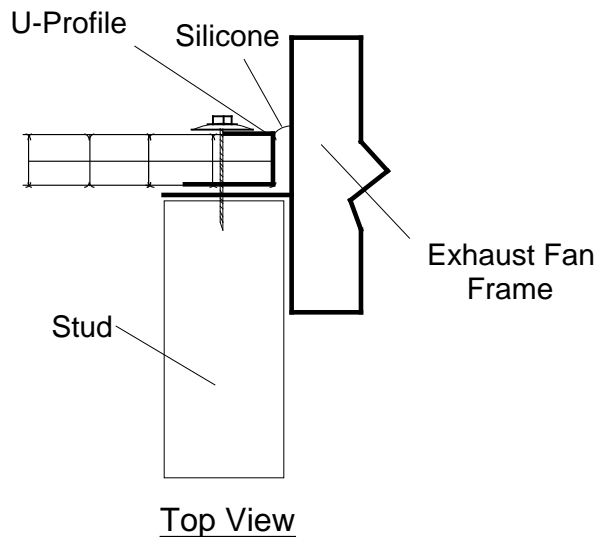


## Poly. to Existing Roofing:

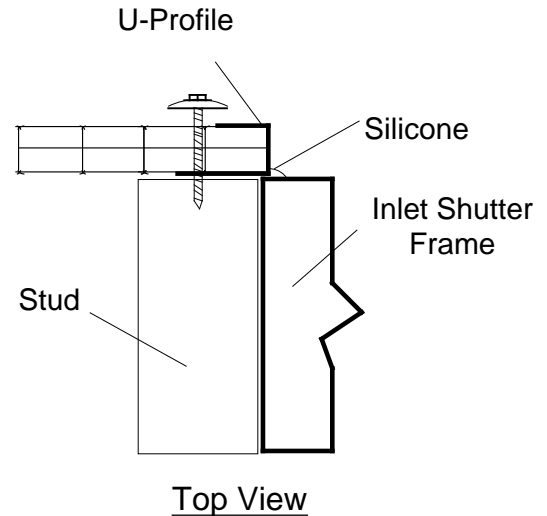


**Fan, Shutter, Window, Door & Skylight Details:** Installing polycarbonate sheet adjacent to these building components is a straightforward process. Refer to drawings below for examples of common installation techniques. A greenhouse typically does not include skylights and windows, but a sunroom often does. Doors are most often purchased from a lumber yard or home improvement center. Select one that is appropriate for your application. A wide selection of doors are available. Common choices are wood entrance doors with 1 large lite of glass, many small pieces of glass, combination storm doors and patio doors. Some builders will construct a door frame and cover the frame with polycarbonate. Select option best suited to your needs & skill.

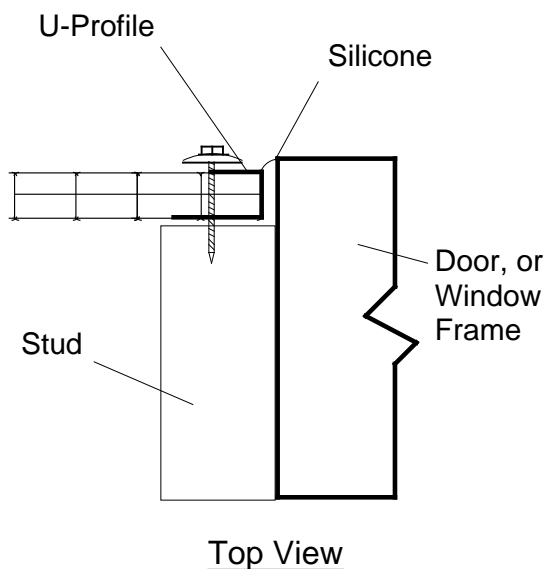
**Exhaust Fan**



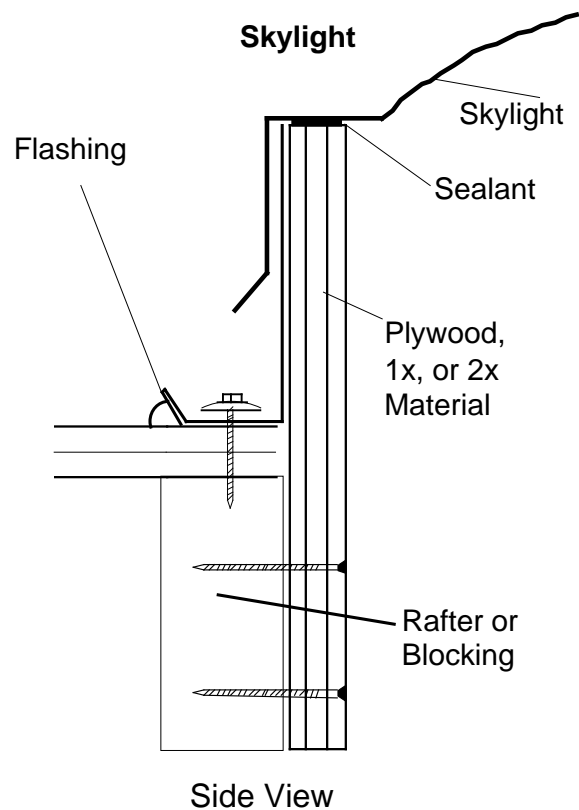
**Inlet Shutter**



**Door or Window**



**Skylight**



**Exhaust Fans:** For freestanding greenhouses, use the formula, width x length x average height, to get the required fan cfm (cubic feet per minute). For attached greenhouses plan on 7 cfm of fan capacity for every sq. ft. of south facing glazing. Include roof and wall area in the total. The fan should be located on an end wall away from the prevailing winds (usually on the South or East wall). Ideally the best position of the exhaust fan is at the peak of the end wall, opposite the wall with the door. Position inlet shutters on either side of door. The Quiet Power Fan may be positioned in the wall or roof. The dome covering the fan, provides protection from the wind.

**Single speed fans** are generally used in locations without cold winters or in areas where the winters are cold, but there is not much sun. These fans power up to the rated cfm fairly quickly. This is ok if it is warm outside. If it is a sunny day, with an outdoor temperature of 30 degrees, it may be 80 degrees inside the greenhouse. When the fan turns on, your plants may experience a blast of cold air.

**Two speed fans**, (Models GP, PD & PDS), start at the slow speed, avoiding any sudden chills. The Two Stage Thermostat senses a 3 degree F. temperature rise, and switches to the high speed. As the greenhouse cools, the fan speed is stepped down. This is most needed in areas where the outdoor winter temperature is low and the sun is often shining. Use Gravity Inlet Shutters. Motorized Inlet Shutters will not work with two speed fans.

**Inlet Shutters:** Follow size and quantity guidelines provided on the Inlet Shutter page of the Catalog. Gravity inlet shutters are activated by air pressure created by the fan. Tension on shutter vanes may be adjusted by moving the spring hook up or down holes in the tie bar. Attachment to structure is via holes in the side of shutter frame. Motorized shutters are activated when thermostat sends power to the fan, but may only be used with single speed fans. Attachment is through the flange on outside edge of the frame. Rough opening dimensions for each is the same as the shutter size noted in the Catalog. To reduce possibility of wind opening the shutters when fan is not running, add a storm hood.

**Thermostats:** Model GP, PD and PDS Exhaust Fans are available in 1 and 2 speed versions, requiring a one or two stage thermostat to match speed option. The one stage thermostat turns on the single speed fan at preset temperature. The two stage thermostat senses a 3 degree F. temperature rise and switches to high speed. As the greenhouse cools the fan speed is stepped down. Quiet Power Fans come with a wall mounted thermostat.

**Speed Controls:** Model GP, PD & PDS Exhaust Fans have a variable speed control for various one speed models and a 2 speed switch for 2 speed fans (use gravity inlet shutters on 2 speed and variable speed units). Quiet Power Fans have a speed switch for speeds of 500, 750 and 1000 cfm. As the season progresses towards warmer months increase the speed setting. The thermostat energizes a motor, opening the cover, and activating the fan.

**Shade Cloth:** Numerous shade cloth percentages and widths are available. Most greenhouse growers will position shade cloth so that the roof and 2/3 of the side walls are covered. Shade Panels come with edge reinforcement and grommets for a variety of attachment methods. Rope or cable are appropriate for various applications.

## Misting:

The introduction of moisture into a greenhouse assists in cooling through evaporation. The mist holds heat. For best performance, set the Hydrofogger close to air inlet shutters. The exhaust fan will draw the moist air through the greenhouse, distributing the mist and lowering the temperature. Finally, the heat laden mist is removed from the greenhouse, via the exhaust fan. To fine tune the air movement, select the single speed fan, the variable speed switch and the gravity inlet shutters.

Use 1 Hydrofogger/XE-301 per 500 sq. ft. of greenhouse (misting only) for misting and cooling 250 sq. ft. Connect to water line or water hose and plug 115 volt power cord into outlet. The Hydrofogger does not require a filter, hard water may be used.

Humidity enhances plant health & growth. A relative humidity of 60-70% is best.

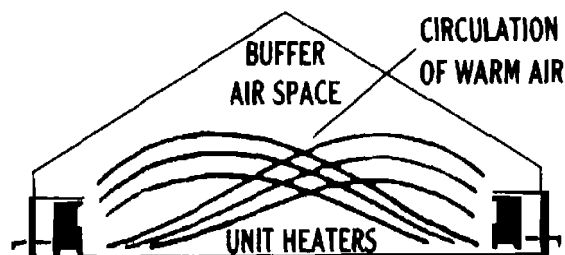
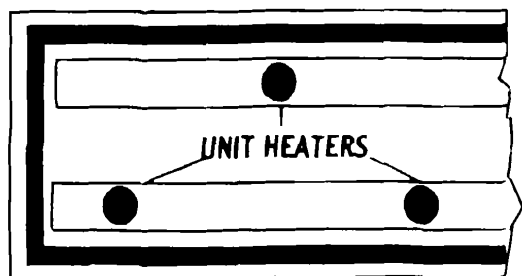
## Heating:

Natural or LP (liquid propane) gas is an efficient way to heat a greenhouse. Electricity gets very expensive and risks plant loss if the power is down during a winter storm.

Southern Burner Heaters have been the choice of backyard growers for decades. No electricity is required to run the heater and no fan is required to distribute the heat. The heater is equipped with a millivolt control and wall thermostat. Control of the heater is in a closed loop between heater & thermostat. For heat distribution, convective heat currents move warm air from low positioned heater through the greenhouse interior. In addition, the polished aluminum firebox reflects the heat across the greenhouse.

2 styles of thermostats are available. Single Stage Thermostat has a temperature range of 35-75 degrees. When you select a temperature setting the heater will cycle on and off at this setting. Regardless of the time of day or night. The Second Style is a Day and Night Set-Back Thermostat. This gives you the capability of two separate temperatures, one for day, one for night. The thermostat has an adjustable clock that you can choose from 15 minute intervals to set the temperature change from day to night settings. The clock is powered by an "AA" Alkaline battery still giving you the convenience of no electricity. Temperature range is from 45 to 90 degrees. Mounting of the thermostat can be up to 25 feet from the heater and should be shielded from direct sunlight or water.

Heater selection is easy. Take total roof and wall area of your greenhouse (A). Multiply this times (D), the difference between the coldest outdoor temperature and the lowest indoor temperature desired. Total is equal to the heater BTU rating ( $A \times D = \text{BTU}$ ). For double-wall polycarbonate subtract 25%. For triple-wall polycarbonate subtract 40%. For lean-to greenhouses and solariums subtract an additional 30%.



Heaters should be placed alternately, as shown above, for maximum circulation. The reflection of heat generated by the burner, from the polished aluminum back, assures more heat, more evenly distributed for less in fuel costs.

### **Pool Enclosure Dehumidification System:**

When designing a swimming pool enclosure, it is important to control the interior moisture level. Moisture during the warmer months is most often reduced through a fan ventilation system. Ventilation during the winter months will reduce humidity levels, but will also result in massive heating bills. This is also the time of year when interior moisture and condensation levels are at their highest

The first step is to install a swimming pool cover. If the water is covered, moisture levels are greatly decreased. When the pool cover is removed, moisture is introduced into the interior environment and condensation usually appears on the inner surface of the glazing, (polycarbonate and any glass doors and windows). At this point, a properly designed dehumidification system will begin to operate and within a short period of time, reduce humidity enough to eliminate condensation.

A fairly simple and straightforward dehumidification system incorporates a forced air heating system and a heat recovery ventilator.

The forced air heating system must include a method of delivering the warm air to the glazing. A common method is a round spiral duct that is positioned on the inside of the pool enclosure at the point where the roof meets the side wall. A side wall height of 7-8 ft. is sufficient to provide space for ducting above patio doors, that are typically installed along the side walls. Set air delivery registers in duct so that the glazing areas are washed with warm air. The heat recovery ventilator is a common unit in new, well sealed homes. The air in these houses can easily become stale and moisture laden. The heat recovery ventilator dumps a small amount of stale air, via a duct, to the outside. Prior to exhausting the air, this stale, warm and moist air is sent through a heat exchanger. The heat exchanger strips a high percentage of the heat out of this air. Cool fresh air is introduced via a duct that includes tubing from the heat exchanger. This warms the fresh air prior to entering the building. In a pool enclosure, run a small duct to the upper layer of air in the structure. This stale air will usually have a high level of moisture.

The above description is written in laymen terms, outlining the basic concepts. Successful implementation of these systems usually requires the expertise of a competent HVAC (heating, ventilating, air conditioning) contractor or a builder familiar with these systems. A term for this type of system, familiar to HVAC contractors, is a "makeup air system." Our intent is to give you an overview of a basic system, with relatively low installation and running costs.

Electrical dehumidification systems are expensive to run and do not address the issues of heating the structure or venting stale air.

### **Pool Enclosure Heating System:**

For passive solar heating, orient the long wall of your pool enclosure to the south. Maximize glazing on this wall and minimize glazing on the north wall. Clear polycarbonate on the roof will let in the most heat. This is great for the winter, but often creates too much heat in the summer. White or bronze polycarbonate on the roof and clear polycarbonate and glass on the walls is a common solution. See the Dehumidification System section above for further information on heating systems for pool enclosures.

## Part Two: Construction & Installation

**Foundations:** In the Planning & Design Section, we briefly conveyed our thoughts on selecting foundation design. The kind of foundation you choose depends on which type of structure you build. The stake method for freestanding greenhouses is a simple way to anchor the structure so it does not tip over in strong winds. Other designs take more time to plan and install. In all cases it is necessary to have a foundation that is solid, level and properly laid out. It is important that the frame is positioned so that the sill plate is flush with the outside edge of the foundation. Polycarbonate is fastened to the frame in such a way that any water flowing down the walls, or weeping out of the multi-wall sheet, will proceed past the joint between the sill plate and foundation. (See Low-Tech Foundation Options, page 3).

**Framing Notes:** Before beginning framing, finalize the location of the inlet shutter, exhaust fan, vents, doors and windows. The Model G & P Exhaust Fans are set into a standard frame opening (see Catalog for wall opening sizes). The Quiet Power Fan requires a 14" x 14" opening in the polycarbonate and a 2" x 2" frame behind the polycarbonate to attach the fan to. When using the Quiet Power in a conventional wall or roof, frame a 14" x 14" rough opening. The fan is installed over the sheathing. Next, siding or roofing is installed to create the desired appearance. Inlet Shutters are also set into a standard frame. Frame opening size is equal to nominal shutter size.

Greenhouses are subjected to dramatic moisture and temperature swings. Use galvanized deck screws and/or metal connectors to hold joints together.

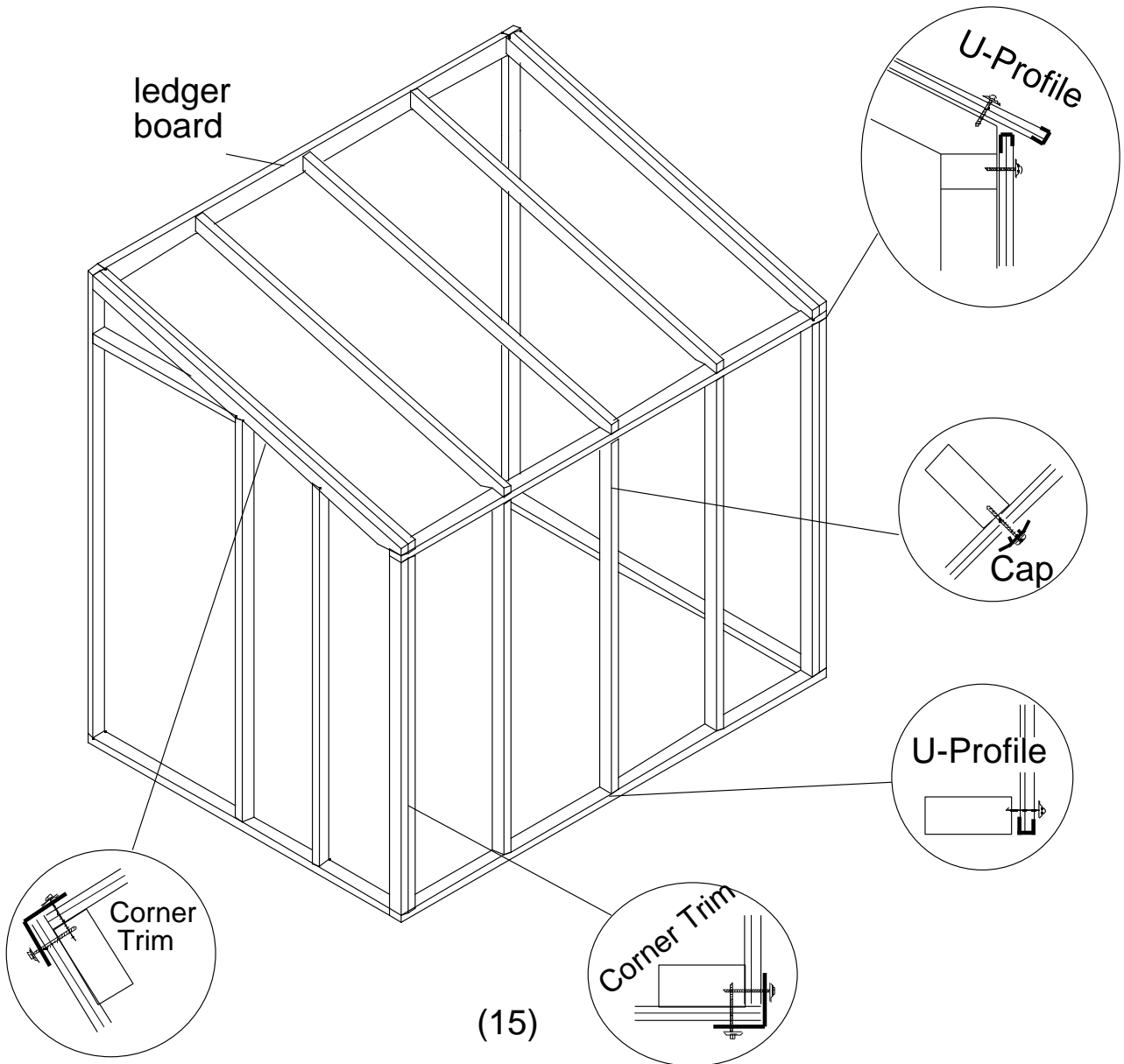
**Lean-To Greenhouse Framing:** On the following page is a drawing of a typical lean-to style greenhouse frame, for multi-wall polycarbonate. It is best to start with the ledger board. Bevel the top edge of 2"x6" or 2"x8" ledger board at an angle that is equal to the slope of the greenhouse roof. Securely fasten to the existing framing with lag bolts. Position of rafter and wall framing on center measurements were determined by the drawings you completed in the planning stage. Lay out rafter placement along ledger board and attach steel rafter hangers. These steel connectors are an excellent way to securely and efficiently attach rafters to the ledger board.

The next step is **front wall framing**. First layout the location of the studs on top and bottom plate. Build your wall on the ground and tilt up completed wall so it sits on top of the foundation. Brace the wall by attaching lumber diagonally from the top of the wall to the ground and fasten the base plate to the foundation.

Next construct the **roof frame**. Do angle cuts at the top and lower end of one of the rafter boards so that when in place the joints are tight and clean. Use this board as a template for cutting other rafters. Install rafters, making sure to use double rafters on the ends. Use blocking as required by your design.

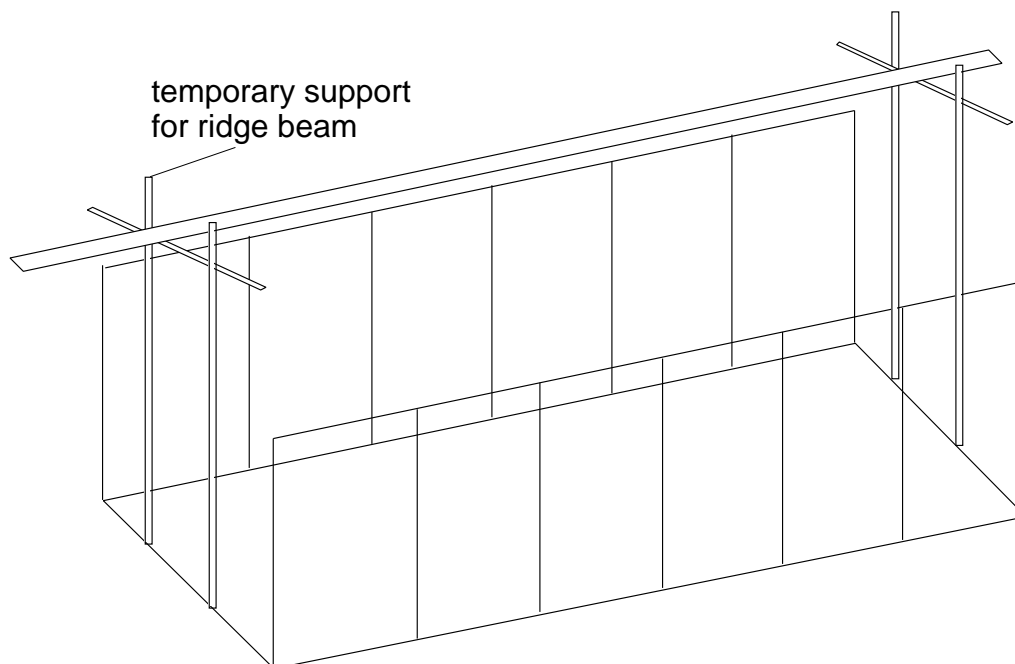
**End wall framing** comes next. Build the wall in place or build it first on the ground and then tilt it up. Make sure to frame out for doors, windows, fan and inlet shutters.

Lean-To (attached) Greenhouses  
Sunrooms and Patio Covers  
(Multi-Wall Polycarbonate)

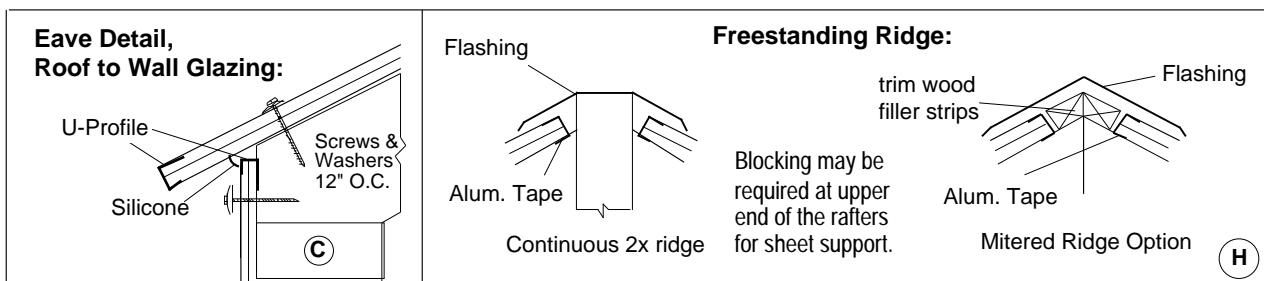


**Freestanding Greenhouse Framing:** Begin with the side walls. Framing is the same as front wall framing for lean-to greenhouse. Brace walls in preparation for framing roof.

Roof framing often incorporates a continuous 2x (2 x 4, 2 x 6, etc.) ridge board, as shown below, detail #H. For greater strength, screw or bolt a 2x brace to the rafters, as detailed on the bottom of page 4. Place board 2-3 feet down from the peak and securely fasten. This member is often called a collar tie and creates a small truss. The result is a triangle that provides superior strength. Ridge member can be held in position by a temporary 2 x 4 support (see below). Cut a rafter so that a tight fit is achieved at top plate of wall and at ridge board. Use as a template for cutting the other rafters. Securely fasten rafters to top plate and ridge board, at proper locations, and remove temporary support.

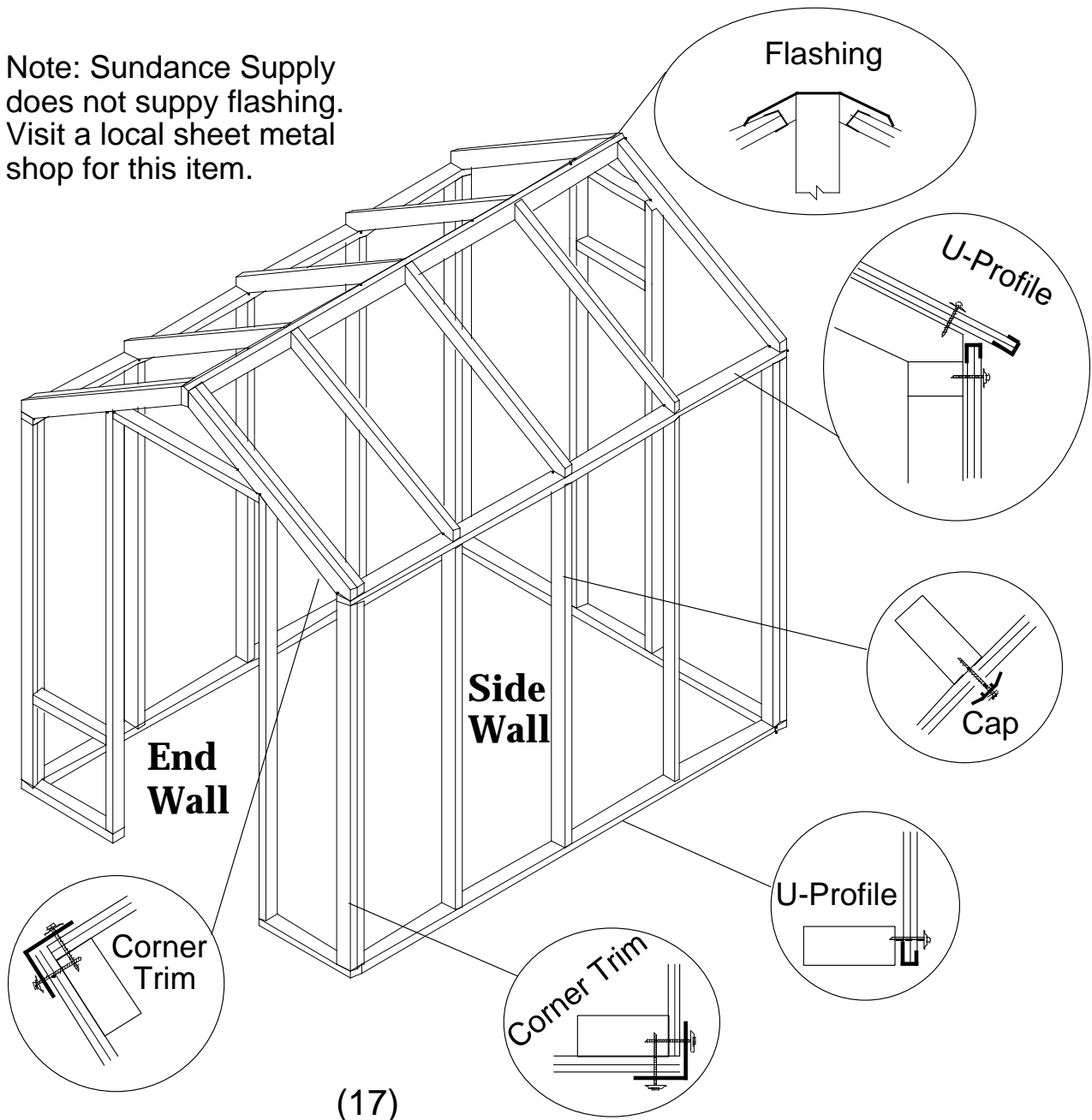


Set blocking as required by your design. If using multi-wall and a lot of condensation is expected, set blocking back 3/8" from surrounding rafters by use of rubber spacers (we can supply). (See p. 4 for more information, call to order spacers). To extend frame life, it is wise to seal wood subjected to condensation and wood that sits behind polycarbonate. These are the areas most likely to rot. Refer to page 3, Wood Framing and page 7, Typical Framing Layout for Multi-Wall Polycarbonate Over Wood Frame, for instructions on wood sealing. End walls are built in place, using the double rafter, or 4x material, as the top plate. The framing for a freestanding greenhouse is basically the same as two lean-to greenhouses back-to-back. See framing drawings on previous and next page.



## Freestanding Horticultural Greenhouses (Multi-Wall Polycarbonate)

Note: Sundance Supply does not supply flashing. Visit a local sheet metal shop for this item.



## Polycarbonate Storage, Cutting & Installation Guidelines

**Storage:** Store in dry, shaded and well ventilated areas. Supported, sloped stacking is best. Store sheets in covered areas, but not under flexible PVC coverings.

**Sheet Orientation Warning:** Only one side of the sheet has the protective U.V. absorbing surface and this surface must be facing towards exterior. Sheets are covered with a thin plastic film and marked with a sticker to designate exterior side. Prior to installation, peel film off sheet and mark exterior side with a grease pencil.

**Thermal Expansion:** Sheet will expand in hot weather and contract in cold. Figure about 1/32" per foot for 70 degrees of temperature change. For small greenhouses, the impact is minimal. The only way you could ever get into trouble is if installation is on a very cold day and the sheet is jammed tight against some object. Even then the sheet would likely absorb the flexing. Follow Installation Details and everything will be fine.

**Cutting:** 6 & 8mm sheets may be cut to length with a sharp utility knife. Clamp straight edge to sheet with rubber tip spring clamps and use as a cutting guide. Run blade along guide a few times to achieve sufficient cut. Turn sheet over and snap in same fashion as in cutting sheet rock. Now cut along back crease to separate. To cut 6 & 8mm sheet width, for all angle cuts and for all cuts on the 16 mm sheet we strongly suggest using a small circular saw with a plywood blade or a jig saw with a fine tooth blade. This method produces a clean even cut. Vacuum any dust from multi-wall channels or blow out with compressed air. Leave film on sheet until ready to install.

**Sheet Positioning:** Install polycarbonate sheets with channels running vertically on walls, and with the slope on the roof. Ribs run parallel to the sheet length.

**Closure Tape:** Prior to installing polycarbonate, close top edge of roof and end wall sheets with aluminum tape. Other edges should be closed with the U-Profile. Lower edge must allow for weepage of moisture (see weep holes).

**Sheet Installation:** Refer to Installation Details for a graphic description of sheet and trim installation.

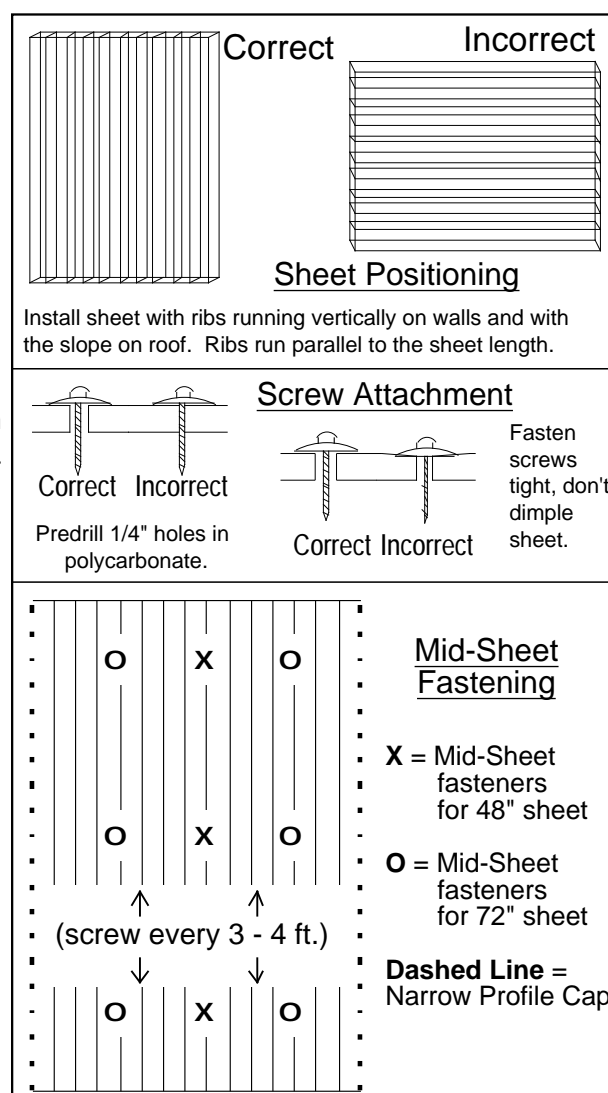
**Attachment:** Fasten screws and washers as shown in Details. Pre-drill with 1/4" bit to allow for expansion.

**Mid-Sheet Fastening:** Polycarbonate sheets are attached to middle framing member/s as shown in drawing at right. Rule of thumb is position fasteners every 3-4 ft, along length. Narrow Profile Caps are used at seams of adjoining sheets.

**Weep Holes:** When using the multi-wall sheet, lower edge of the vertical and roof sheets must have a provision that allows for moisture weepage. This can be achieved by drilling 1/16" weep holes in U-Profile, every 12" on-center.

**Sealing:** Refer to Installation Details for placement of sealant. Sealant should also be used at aluminum, vinyl and flashing joints.

**Cleaning:** Clean with warm, soapy water. If any dirt remains wipe with soft cloth. Do not scrub, scrape or use solvents. Rinse and dry with soft cloth. Cleaning will extend sheet life.



## **Installation Tools:**

**Ladders and Padding**

**Safety Goggles & Work Gloves**

**Level (for getting things level & plumb)**

**Marking Pen (medium point for laying out cuts on plastic film that covers polycarbonate)**

**Saw Horses & Planks (for laying sheet on when cutting)**

**Circular Saw (a must for 16mm sheet, a trim saw is best, but larger saws will do)**

**Circular Saw Blades (fine tooth plywood blade for cutting polycarbonate)**

**Jig Saw with Fine Blade (option to using a circ. saw for polycarbonate, best for curved cuts)**

**Fine Tooth Key Hole Saw (for cutting fan opening in sheet if jig saw not available)**

**Power Miter Box with fine tooth blade (for cutting extrusions)**

**Hacksaw (optional method of cutting extrusions)**

**Vacuum or Blower (for cleaning polycarbonate chips from center of sheet)**

**Straight Edge (for cutting polycarbonate when using a utility knife)**

**Spring Clamps w/rubber tips (for holding straight edge when cutting sheet)**

**Utility Knife & Sharp Blades (change often when cutting polycarb. for quick, safe cuts)**

**Cordless Drill w/ Adjusting Chuck (a great tool for driving screws to proper tightness)**

**Magnetic Hex Head Drivers**

**Socket Wrench (a labor intensive way to drive screws)**

**1/16", 3/16", 1/4" & 3/8" steel cutting drill bits (good and sharp)**

**Caulking Gun**

## Multi-Wall Polycarbonate and Trim Installation

In the following section, typical installation procedures are described. Read the section carefully and plan the sequence of steps for your specific application. Refer to the detail diagrams on page 9, using the perspective key on page 8 to locate each diagram. Letters in brackets below, identify relevant diagrams from page 9.

### 1. General Considerations

**Wall Covering Installation:** Inspect frame for proper on-center placement, blocking, etc. Walls are generally covered first. Begin with either the end walls or the side walls (front wall for lean-to greenhouses). Corner Trim is installed after all polycarbonate is in place, { D & E }. Use aluminum tape on the top edges of the end wall sheets, { D }. The lower edge of the sheet is capped with the U-Profile, { B }. Drill 1/16" weep holes, 12" on center, prior to installing U-Profile. Cut sheets to length, (and width if required) and vacuum or blow out channels. Note: custom cut and install end wall sheets, one at a time, so that the top and lower edges remain consistent.

Use the U-Profile for the open channel edges next to doors, windows, shutters, etc., (see diagrams page 10). Cut out for the fan opening, after the sheet is secured in place. Drill holes at the corners of the opening. Use a jig saw or fine tooth key hole saw to make your cuts. Inlet shutters are typically at lower edge of sheet and cut out is made prior to sheet installation.

Start at one end. Just prior to installing the polycarbonate, peel the protective film off the sheet, remembering which side will face the sun. Position the sheet on the frame. Check to make sure that proper alignment and minimum sheet bearing on frame has been achieved. Drill 1/4" pilot holes in sheet and attach to frame at a minimum of two mid-sheet fastening points, with screws and washers provided. Install screws snug, but not too tight. Once you are confident that the position is correct go ahead and set the next sheet and cover the joint with the Narrow Profile Cap { A }. See p. 18 for cutting, mid-sheet fastening and screw attachment.

• **Narrow Profile Cap Installation:** Drill 3/16" holes in Cap for screws to pass through. Start with holes 2" from the ends of Cap and drill holes every 10"-12". Finally attach Caps to frame. Screws should be snug, but not too tight. Cap now effectively covers both sheets, providing a clean, tight detail, { A }.

• **Corner Trim:** Install with 1/4" gap between two lengths if it's a cold day, tight if a hot day. Make screw holes oversized by using a 3/8" bit. Cover gap with silicone.

### **Note: Expansion & Contraction of Polycarbonate and Trim Components**

Polycarbonate, aluminum & vinyl will all expand and contract at about the same rate. Plan on a movement of 1/32" per ft. of material during a 70 degree temperature swing. Plan for expansion and contraction along the length of each material. 8 foot Trim Components installed during the summer, when it is 90 degrees outside, will shrink 1/4" when the outdoor winter temperature reaches 20. Provisions to accommodate for movement are fairly simple and straightforward. The recommendations made below (or next page) assume installation during the summer, resulting in winter contraction.

**Polycarbonate Sheet:** Follow specified framing on-center spacing. Pre-drill oversized holes in polycarbonate with 1/4" drill.

**Cap & Corner:** Butt upper edge against any adjoining material. After polycarbonate sheeting is in place, wipe joint with rubbing alcohol. Lay a bead of silicone to compensate for contraction of aluminum or vinyl. When joining 2 lengths, butt them close together and cover joint with a flat bead of silicone.

**U-Profile:** Follow the general description for Cap and Corner.

**Roof Covering Installation:** Follow procedures outlined above when preparing the sloped roof sheets. Start at one end of roof and begin laying the sheets. The top edge of the roof sheets are always closed with the aluminum tape, { G & H }. Continue as described for the wall sheets but after the second sheet is set, fasten the Cap joining the two sheets, { A }. It is easier to reach now. Install Corner Trim, so it covers the edges of the roof and end wall sheets { D }.

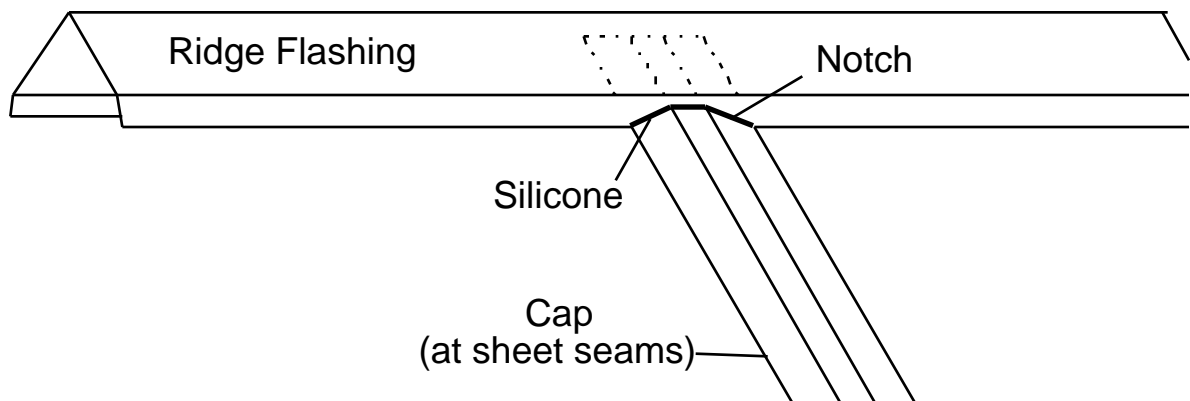
**Roof Access Notes:** Access to the roof for Trim, screw and sealant placement on flashing is best done from a step ladder positioned in between the rafters where polycarbonate has not been set yet. Installation of 1st and last sheet offers the ease of placing a ladder outside the structure. Working from one of the steps towards the top of the ladder your body should be positioned so you can reach over the sheet to do the required work. The 4 foot wide sheets are much easier to reach over to set screws and are highly recommended for roof applications. Starting at one end of the greenhouse work your way towards the other end of the greenhouse. Do all the steps as you go, as detailed in Ridge method 1) below, and it will not be necessary to gain access to the roof again. Cleaning of sheet may be done with a hose. Do often, dirt will not build up.

Access to the ridge to install and/or seal the flashing may also be achieved by placing padded boards over the installed polycarbonate, resting on the Narrow Profile Cap. These boards can be used to walk on, but great care must be employed to not deform the polycarbonate or Trim Components. One misstep could also result in injury. Some advance planning to proceed as described in the previous paragraph may result in a easier installation. Your situation and skill level will dictate the best way to proceed.

• **Ridge Flashing:** Flashing sections, as detailed below, are typically fabricated in 8 ft. sections. There are two way to proceed with the installation of flashing.

1) The easiest method of installation is to set and screw down a section of flashing that covers the first sheet of polycarbonate (on freestanding greenhouses install sheets on both sides of the greenhouse). Set screws so flashing presses against polycarbonate, place a bead of silicone at this point { see G or H } and stop there. Lay the next sheet of polycarbonate and fasten the Narrow Profile Cap so that it butts against the edge of the flashing that comes in contact with the polycarbonate. Now screw down the flashing and place a bead of silicone along the edge of flashing that comes in contact with the polycarbonate, and also where the Cap comes in contact with the flashing. Continue installing more polycarbonate and flashing. Overlap seams a minimum of 4". Do not cut to length as this will create a slight curl at cut & an uneven overlap. If the overlap ends up being 4 ft., so be it. This method provides a watertight installation, but care must be taken to lay a smooth bead of silicone on a cleaned surface.

2) A more difficult, but a cleaner looking and tighter installation involves installing the flashing after all sheets are set. See { G or H }. This involves acquiring access to the ridge with all polycarbonate in place. As mentioned in the Roof Access Notes above, this can be tricky and is best performed by individuals accustomed to working on roofs or in situations where balance and care during installation procedures is second nature. If you are working on an attached greenhouse you may be able to gain access to this detail from the roof of the adjoining structure. When installing the flashing, first lay in place and mark where the flashing overlaps the Cap at sheet seams. Notch the flange at these locations to fit the Cap. When installed, the flashing will rest flat on the polycarbonate and the Cap. Failure to cut out for the Cap will result in a gap between the polycarbonate and the flashing, wavy looking flashing and a poor weather seal. Overlap seams a minimum of 4". Do not cut to length as this will create a slight curl at the cut and an uneven overlap. If the overlap ends up being 4 ft., ok. The only cutting required is an easy to cut, curved notch where the Narrow Profile Cap slides under the flashing. See drawing below.



It is best to **purchase this flashing** from a sheet metal fabricator. Do a simple scale drawing that shows dimensions, angle, etc. At the edge of the flashing that covers the polycarbonate we suggest a 1/2" long bend (flange). Draw so that the leg(s) of the flashing are tilted down 5° from the actual pitch of your roof. This will create a small amount of pressure against the polycarbonate sheet, useful in achieving a watertight installation. Sheet metal should be a minimum of .019" aluminum or 30 gauge steel. Aluminum is easy to fasten through, easy to cut, but is a little flimsy and care is required in handling. Steel is more sturdy, harder to cut and requires predrilling prior to fastening. Availability at your local sheet metal shop may be the limiting factor. Look in the Yellow Pages under Sheet Metal Work. Some shops, especially those that cater to glass installation contractors, will inventory bright glossy white and architectural medium bronze sheet metal in the thickness you will be looking for. These colors will be a close match to the Trim Components we offer.

**Sealing:** Once all Sheets and Trim are in place, the sealing may begin. All joints at the interface of the Trim Components should be tight, clean and securely fastened. Silicone at joint between flashing and Cap is highly recommended. Make sure to seal any gaps in the U-Profile so that spiders do not get in and build a web. Start with the highest point and work your way down. Clean all joints with isopropyl (rubbing) alcohol and let dry prior to applying silicone. Let silicone dry 24 hours before cleaning the polycarbonate and metal. Always use 100%, plastic compatible, silicone.

## **2. Step-by-Step Polycarbonate Installation**

**Note:** Protective film on the sheet indicates which side is to be positioned to the outside. To assure that the co-extruded U.V. protective layer is facing in the proper direction, remove just before installation. Begin with walls. Cut out for shutters prior to installation of the sheet. Cut out for fan after sheet is already in place.

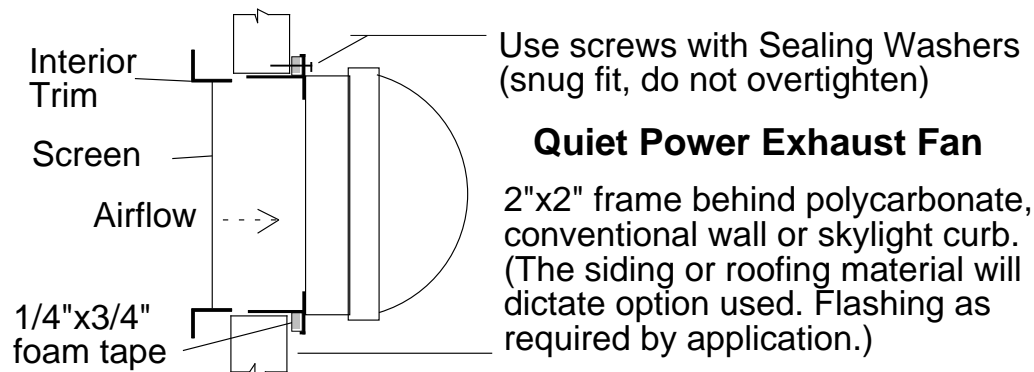
- 1) Cut sheets to length and width as required. Clean out channels.
- 2) Cover channels at the upper edge of roof and gable end wall sheets with Aluminum Tape, { D, G & H }. Roof sheets are eventually covered with flashing, { G & H }. Top edge of gable end sheets are covered with the Corner Trim, { D }.
- 3) Position sheet on frame. Make sure min. overlap of framing (1/2" to 5/8") is present.
- 4) Start at upper edge of the sheet, drill 1/4" holes in sheet and attach to frame at a minimum of 2 points with screws and washers. Install screws snug, but not too tight (see page 18). Install 2 more screws lower to firmly position the sheet. Install adjacent sheet in same manner.
- 5) Continue to attach sheets at perimeter and in the body of sheet as needed.
- 6) Install U-Profile as required. Drill 1/16" holes, every 12", in the U-Profile to be placed on the lower edge of the sheets. Position U-Profile over lower edge of roof with long leg of profile facing up, { C }, and end wall sheets, { B }. U-Profile at lower edge of roof sheets held in place with 3/8" self-drill screws, and silicone over head. Side or front wall sheets should have U-Profile installed on top and lower edges of the sheets.
- 7) Place Narrow Profile Cap at sheet joining locations, { A }. First drill 3/16" holes in Cap, 2" from each end and every 10" - 12". Cap overlaps U-Profile, on bottom of walls and bottom edges of roof sheets, { B }, { C }.
- 8) Install Corner Trim, using 3/8" oversized screw holes, 2" from each end and every 12". Corners overlap U-Profile.
- 9) Place silicone at trim joints as required.

## Exhaust Fans:

GP, PD & PDS fans may be installed in framed openings before or after installation of polycarbonate. Follow wiring diagram on motor. If wiring procedures not clear, seek the assistance of an electrician. 1 Stage Thermostat has four wires. Green for ground, Black for power, Blue for cooling and red for heating (this wire not used, cap off with wire nut). Green is wired to ground. Power coming in is to be connected to the black wire. The blue wire coming out of the thermostat is power going to the fan. The other line in most 12 or 14 gauge wire will be white which is neutral, this wire doesn't have to be cut, but most times will be when cutting the other wires. These wires can be connected back together with a wire nut. 2 Stage Thermostat has 4 wires. Green for ground, black for power, violet wire runs to the high speed on the fan and the blue wire runs to the low speed on the fan. 4 wires must be run from the thermostat to fan motor.

**Quiet Power Fan** may be set in a framed opening, or mounted to poly. using a 2x2 backup frame with a 14"x14" inside dimension. Position frame on inside of structure and clamp in place. Attach deck screws through polycarbonate and into wood at corners. Apply 1/4"x3/4" foam tape to back of exterior fan frame. Fasten through polycarbonate and into 2"x2" frame using our screws with sealing washers. Interior plastic trim is installed from inside of greenhouse. Once fan in place, run a bead of silicone around edge of exterior frame.

Quiet Power Fan may be set in a conventional (non polycarb.) wall or roof. Exterior plywood, building paper and any required flashing should be in place prior to setting fan (see below). Continue as described above. Complete by following wiring diagram.



**Inlet Shutters:** Installation of Gravity Shutters is through side of shutter frame. See drawing at right for alignment of shutter. Spring is at top. Motorized Shutters are fastened through a flange and are attached to exterior of greenhouse frame. Site built screen may be fixed to exterior of Gravity Shutter. The Motorized Shutter vanes pivot towards the exterior. The motor is positioned on the interior. To screen this shutter, first set a 2 x 4 frame, positioned to the exterior of the shutter. This will provide for vane clearance.

**Storm Hoods:** We recommend using a Storm Hood with Gravity Inlet Shutters. The motor on the Motorized Inlet Shutter will keep the vanes closed, in high winds. A Storm Hood is often used with the Motorized Shutter for a weather tight installation.

