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Design & Installation Guide

**Cover greenhouses, solariums, pool enclosures,
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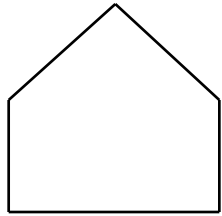
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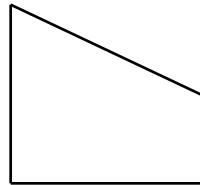
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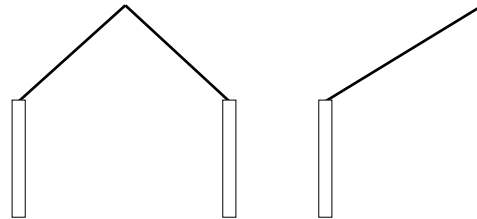
Introduction: This manual is a general guide for builders, owner builders, growers and designers. While special attention is given to greenhouse construction most of the principles and details also apply to solariums, pool enclosures, covered walkways, etc. Typically, a frame is fabricated from lumber and covered with double or triple-wall polycarbonate sheet.



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.

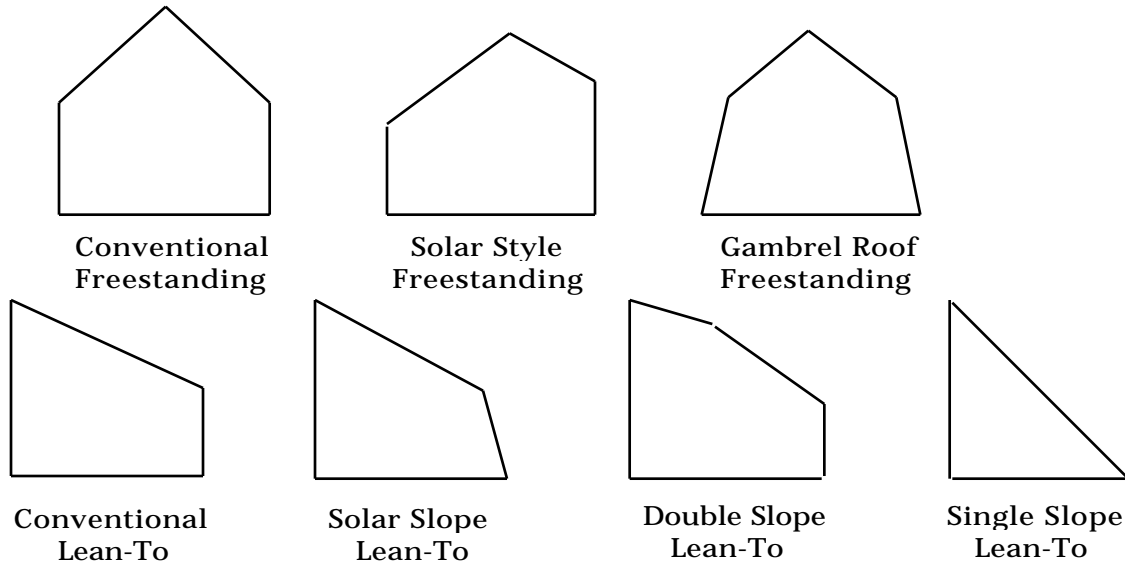
Style: Decide whether you would like an attached or a freestanding structure.

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.

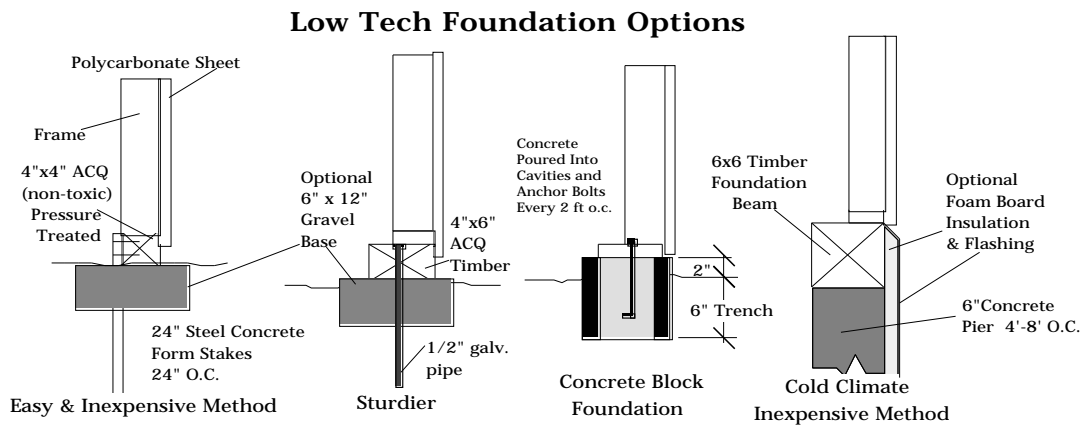
As long as your greenhouse orientation is within 45 degrees of true south it will function well as a solar collector. With this in mind, survey your site for the best location. Considerations such as proximity to garden, garage, entrance to house, electricity and water, may be as important to you as 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 small 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 or books noted below to further investigate foundations. Basics, Ortho's All About Masonry Basics by Larry Erickson. More Advanced for builders, Masonry & Concrete Construction by Ken Nolan.



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 a satin marine grade spar or exterior 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. Apply a satin or flat marine grade spar or exterior varnish as final finish layer. After fully dry lightly sand surface facing polycarbonate, decreasing likelihood of noise from movement of the polycarbonate sheet.

If you desire a painted frame select dry lumber. Prime and paint on one coat of high quality paint before assembly. It is best to paint surfaces facing polycarbonate with flat paint, to minimize noise from sheet movement. Paint other surfaces with gloss or semi-gloss, for easy cleaning. Let dry thoroughly, lightly sanding between coats. Assemble and apply final coat. White is highly reflective and best for greenhouse use.

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 - 7 for frame design, sizing & spacing.

Wood Frame Design for Multi-Wall Polycarbonate: The simplest way to frame for multi-wall polycarbonate is to set studs and rafters 24-1/8" 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 1/4" 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).

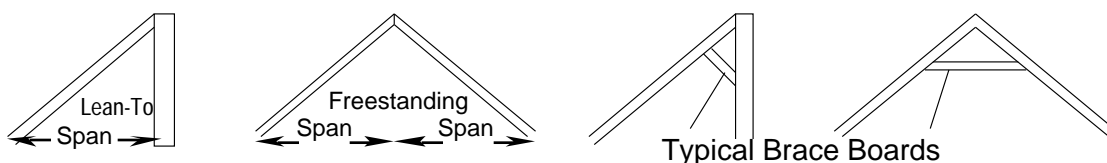
On large greenhouses and pool enclosures, the designer may want to have large rafters and studs spaced further apart. Set intermediate rafters and studs 48-1/4" on-center. When using 4x lumber (4 x 4, 4 x 6, etc.), the first and last framing member should be 46-1/4" on-center. Use 48" wide roof sheets, 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 polycarbonate sheet must be supported on all 4 edges with min. 1/2" of sheet bearing on frame. When using sheets that are cut along the width, and no longer have a rib at the edge, position so first rib is supported by a minimum of 1/2" of frame.

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.

<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	24-1/8"	not needed	every 8 ft.	every 6 ft.
8mm	48-1/4"	every 2.5 ft.	every 2 ft.	do not use
16mm	24-1/8"	not needed	not needed	not needed
16mm	48-1/4"	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. Much improved shear strength is also realized with this structural wood product. Common wood species used are douglas fir or larch & pine.

To determine size timber size refer to page 5, Recommended Spans for Rafters. From this chart estimate timber size. Keep in mind, laminated timbers are approximately twice as strong as dimensional lumber of the same size. Now run design by your bldg. 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.

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 more overhead space and trusses block more light. To increase reflected light, and help the trusses blend into a clear or white polycarbonate roof, paint the trusses white. To minimize noise from sheet movement use flat paint on surfaces facing polycarbonate.

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 48-1/4" on-center, the first and last truss should be 46-1/4" 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 rafter and set the blocking back from the outer surface of the adjoining truss rafter. Securely fasten blocking.

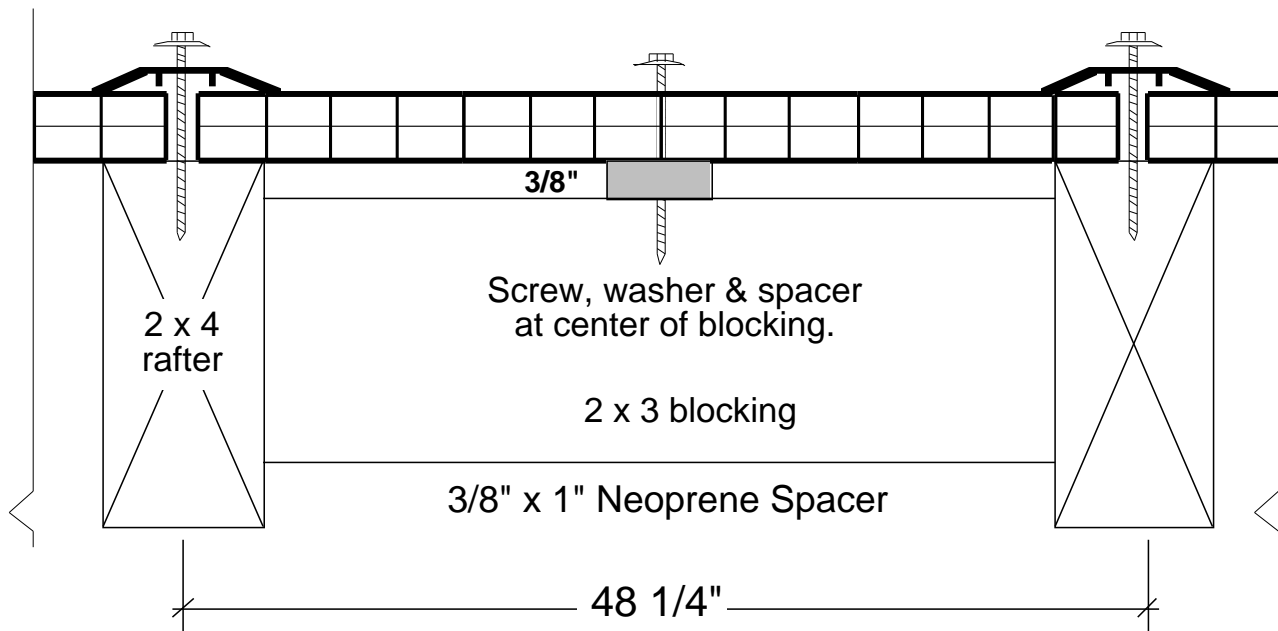
Always seek approval from the building dept. for your roof design. They may require diagonal bracing to prevent racking.

Set trusses at proper on-center spacing 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 are cut along the width, and no longer have a rib at the edge, position so first rib is supported by a minimum of 1/2" of frame.

The chart below provides guidelines for spacing of blocking. 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	24-1/8"	not needed	every 8 ft.	every 6 ft.
8mm	48-1/4"	every 2.5 ft.	every 2 ft.	do not use
16mm	24-1/8"	not needed	not needed	not needed
16mm	48-1/4"	every 4 ft.	every 3 ft.	every 2.5 ft.



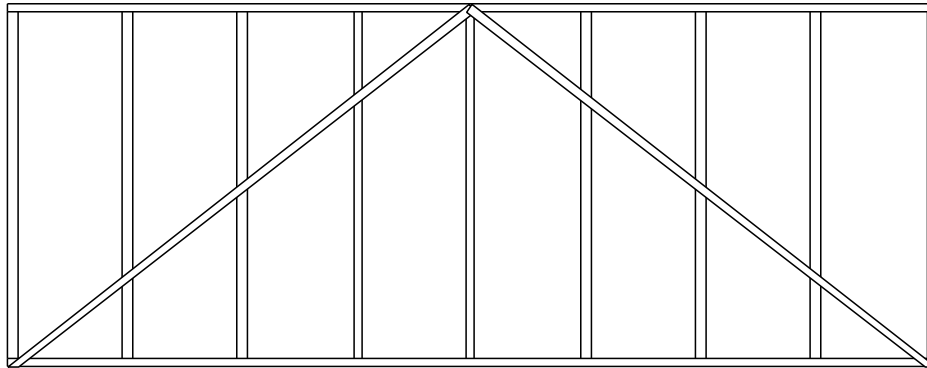
For more information on trusses do an internet search for wood trusses.

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 freestanding greenhouse side walls (front walls of attached greenhouses) and also on roofs in extreme high wind areas.

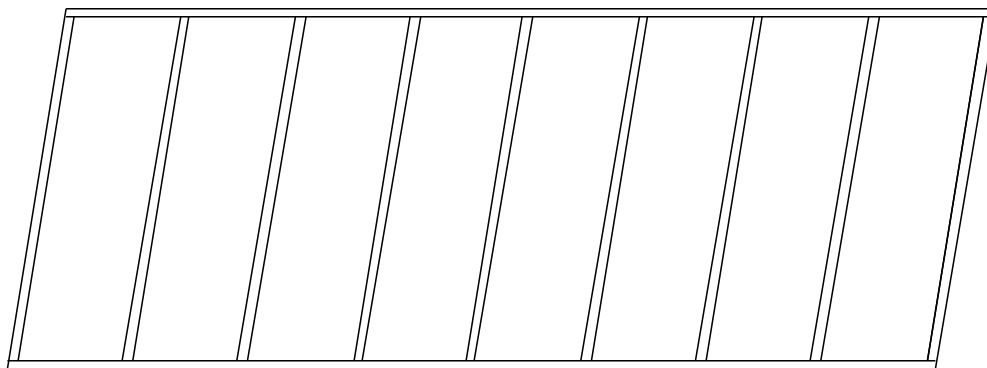
To maximize light transmission and minimize installation time we suggest using light gauge steel Wall Bracing Straps, as manufactured by Simpson Strong-Tie (#WB) and other structural connector manufacturers, using similar product numbers. These 1-1/4" wide x 9' 6" long straps are manufactured from galvanized 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.



Note: This page only covers pop-on panels, not standard installations.

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Polycarbonate Panels Framed with U-Profile:

Pop-on panels are an easy way to enclose screen porch, sunroom or greenhouse walls during the winter. Come spring store the panels and let the breeze move through.

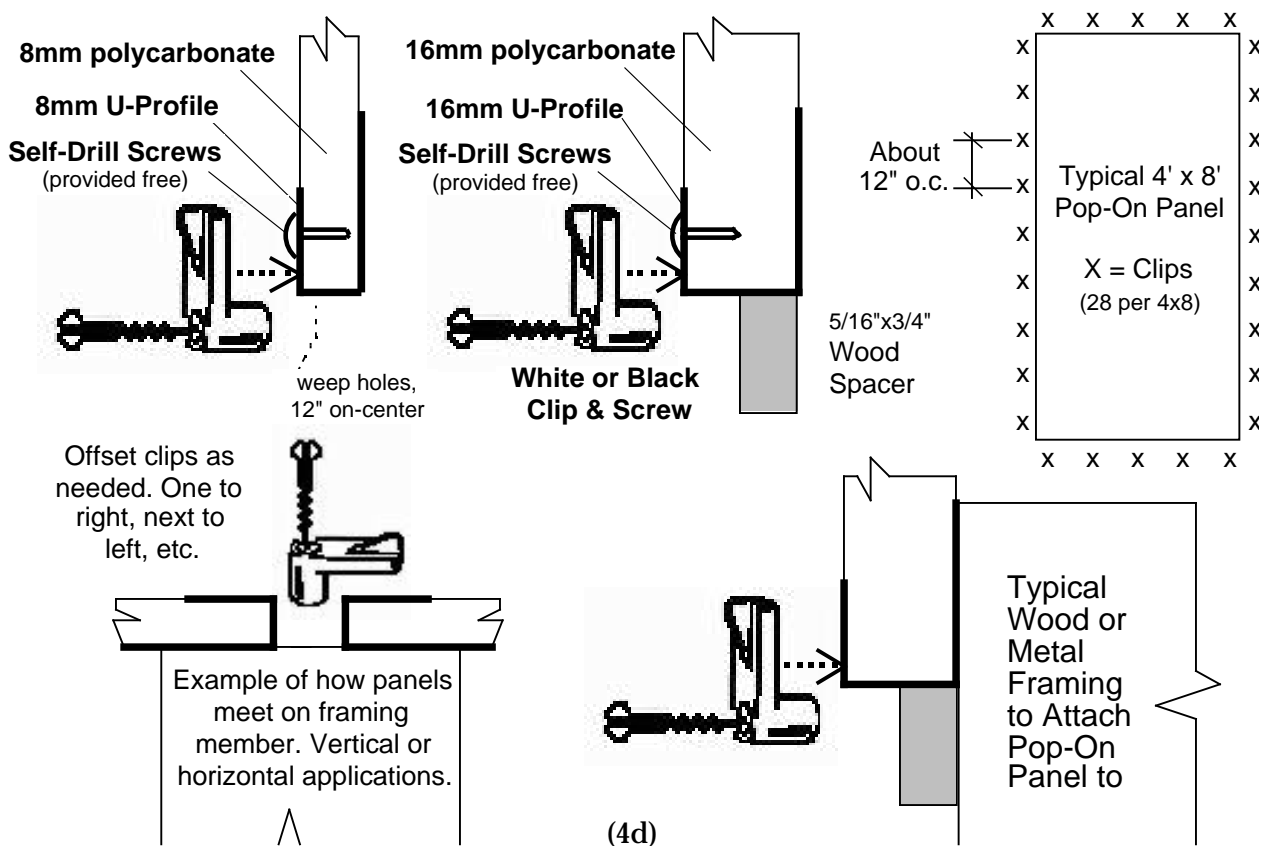
Panels may also be used for sliding panel doors or interior windows. Use metal, wood or plastic track for the top and bottom of the panels. Track must be purchased locally.

8mm and 16mm Polycarbonate Panel Fabrication

- Cut the polycarbonate sheet to required size.
- Do appropriate measurements and angle cut the U-Profile so that a neat miter joint is created at the corners. It is best to have the inside base of the U-Profile snugged up tight against the sheet. This will create a more rigid panel, plus a tight and strong miter joint.
- Starting about 1" from the corners, place 3/8" self-drilling screws through the short leg of the U-Profile and into the polycarbonate sheet. Screws are provided free with U-Profile order. The screw will easily move through the U-Profile and penetrate into the polycarbonate, creating a tight fit. Continue placing screws about every 12" along the extrusion. Repeat for all U-Profiles.

Pop-On Panel Installation:

- Drill 1/16" weep holes in the bottom edge of the lower U-Profile for moisture release.
- Position panel so framing members are behind long leg of U-Profile. Begin securing panel to frame by placing clips close to corners & every 12" on-center. Clips required along top, bottom and sides of panel as shown below. Once you have set the clips you are done with that panel.
- When using 48" wide sheets space framing members (where sheets will meet) a minimum of 48-1/2" on-center. This will allow sufficient room for the clips (if clips are offset).



RECOMMENDED SPANS FOR RAFTERS

24-1/8" & 48-1/4" spacing is common when covering frame with 4 ft. wide multi-wall polycarbonate.

36-1/8" 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
24-1/8"	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"
36-1/8"	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"
48-1/4"	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%	Douglas fir or larch, #1: increase 10%
Southern pine, select structural: increase 18%	Southern Pine, #1: increase 7%
Calif. redwood, clear select structural: increase 36%	Calif. Redwood, select structural: increase 18%
Calif. redwood, #1: increase 36%	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%	Calif. redwood #2: decrease 2%
Western cedar, #1: decrease 6%	Western cedar #2: decrease 14%
Hemlock or fir, #1: decrease 2%	Hemlock or fir #2: decrease 11%
Spruce, #1: decrease 9%	Spruce #2: decrease 16%

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

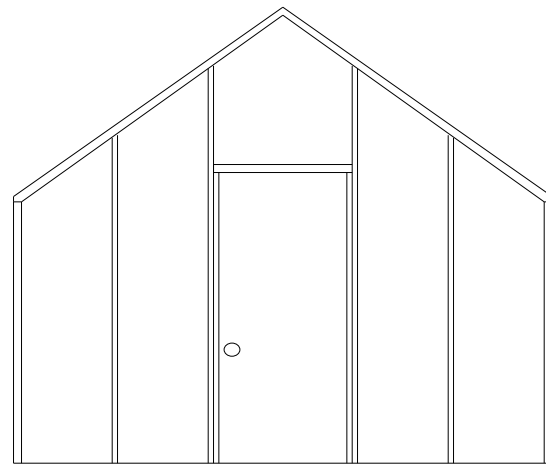
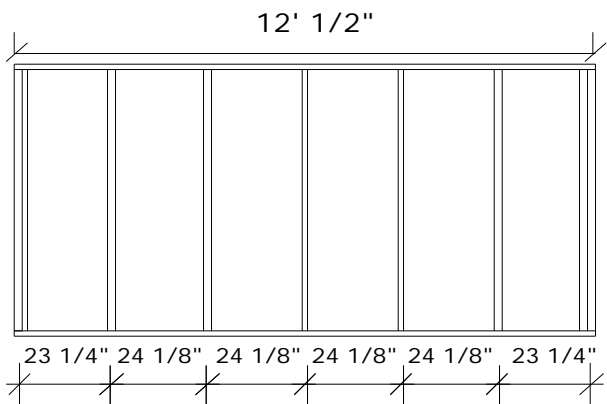
Note: Cypress is similar in strength to douglas fir. Consult with your source for exact figures.

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 1/8", for intermediate studs and rafters. The first and last framing member measurement should be 23 1/4" 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.

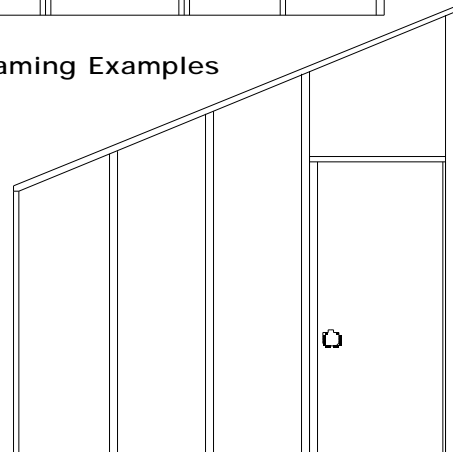
The shorter walls of a greenhouse are typically the end walls. Custom cutting is required for roof slope, doors, windows and ventilation equipment. Adhering to frame on center measurements, as described above, may eliminate cutting of sheet width. When laying out end wall framing, try to get the most 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.

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

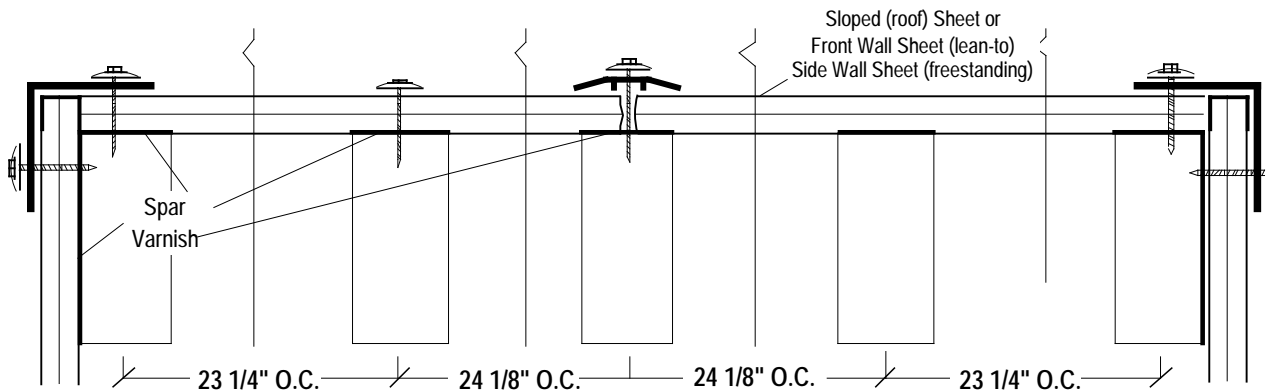


End Wall Framing Examples



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 1/8", for intermediate studs and rafters. First and last framing member on-center measurement should be 23-1/4" 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.

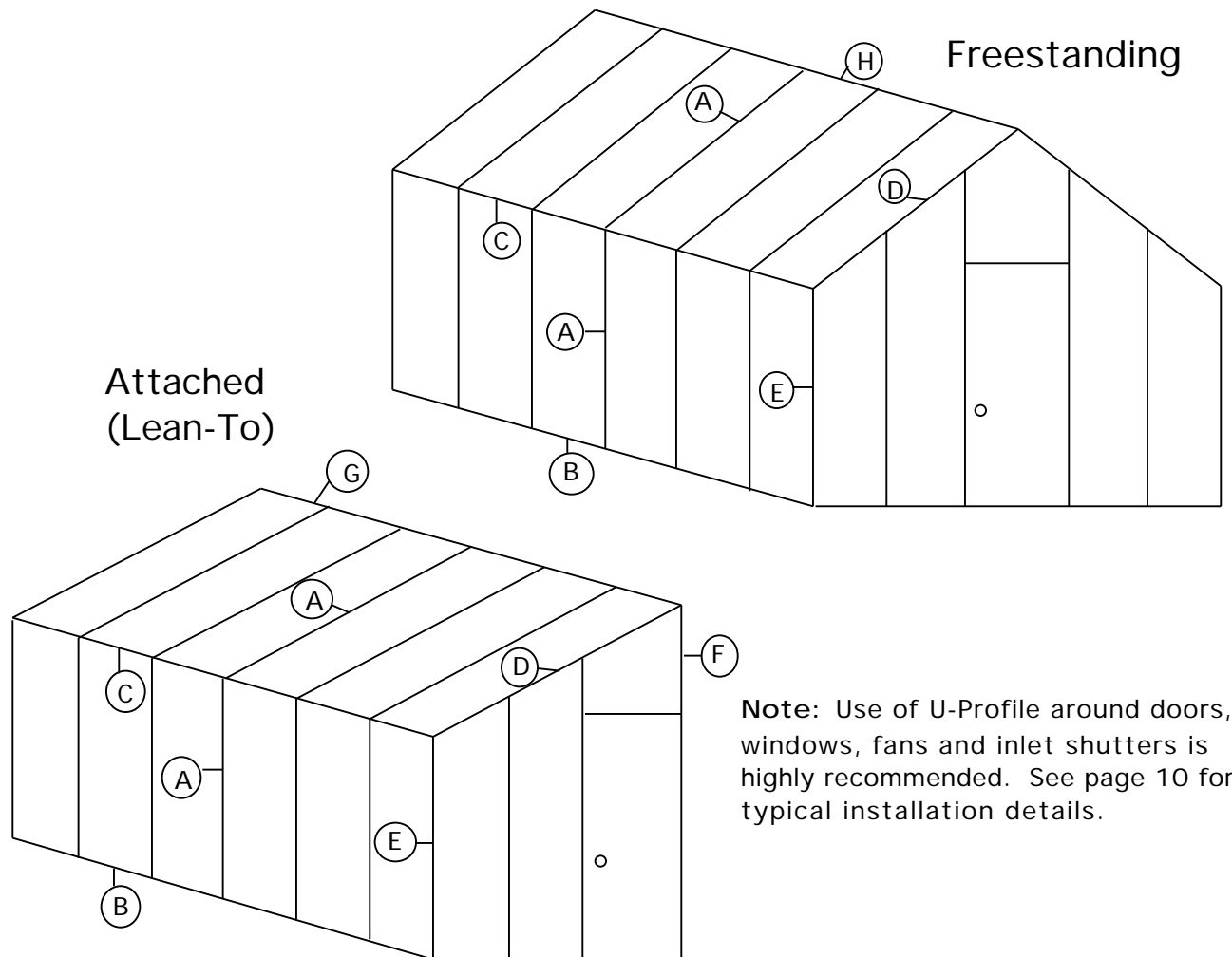
End wall framing determined by wall size. Maintain 1/4" space between sheets. Place studs as needed.

Highly recommended: Seal high moisture areas of frame with satin or flat marine grade spar or exterior varnish. Finish protects moisture prone areas (top & bottom plate and where polycarb. in contact with wood). This decreases likelihood of wood rot and eliminates wood discoloration. Expanding & contracting polycarb. moves on surface. After fully dry gently sand surface facing polycarb., decreasing movement noise. Semi & gloss paint are high friction finishes, noise may result. If painting frame use flat paint on surfaces facing polycarbonate. Stains may react with polycarb. If staining frame use spar or exterior varnish is final finish layer. Let dry & gently sand surface facing poly.

Multi-Wall Polycarbonate Sheet Specification: This material comes in clear for maximum solar gain and white or bronze if reduced solar gain and light transmission is desired. Most common thicknesses are 8mm & 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.

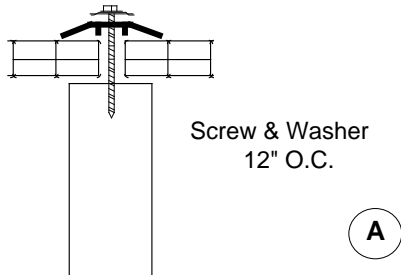


Note: Letters correspond to details on following page.

Multi-Wall Polycarbonate Trim Install Details

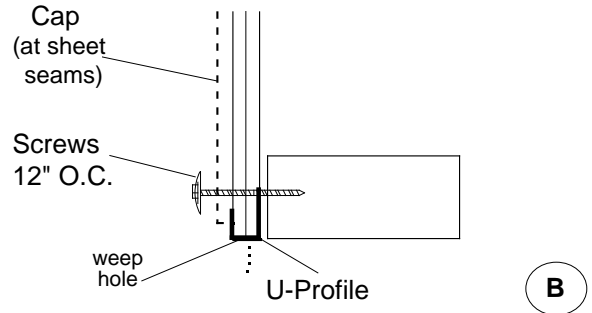
Determine your own material needs and Order Online. **SUNDANCE SUPPLY®**
 ** Screw positioning as noted in drawings below. **

Narrow Profile Cap, Sheet Joining:

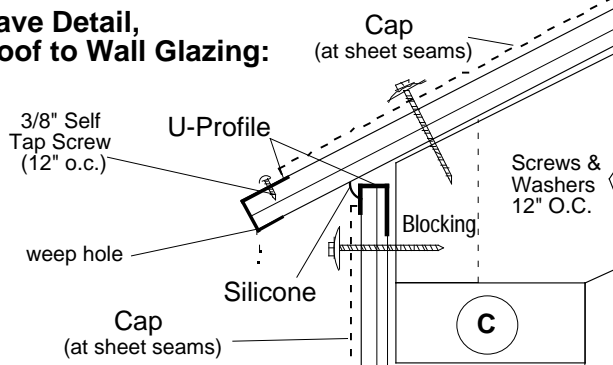


Note: Sheet must be spaced so that Cap covers a minimum of 1/2" of the polycarbonate sheet edge, including at least 1 rib. No silicone required to achieve an excellent, watertight seal.

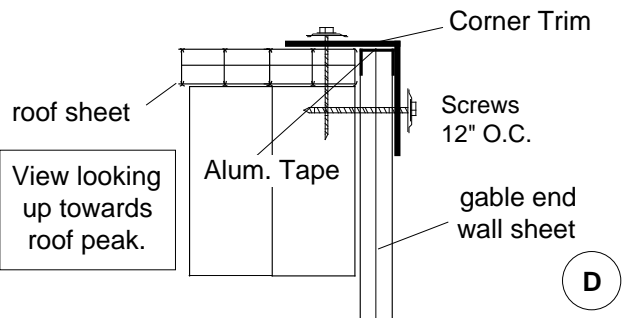
Lower Edge, Wall Glazing:



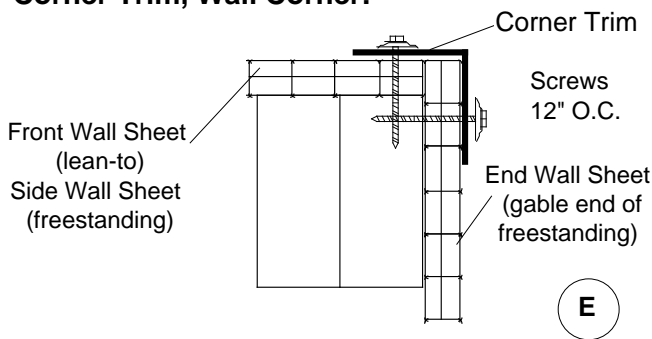
Eave Detail, Roof to Wall Glazing:



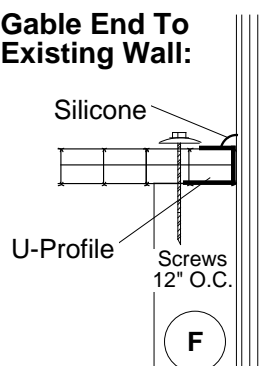
Corner Trim, Roof Corner:



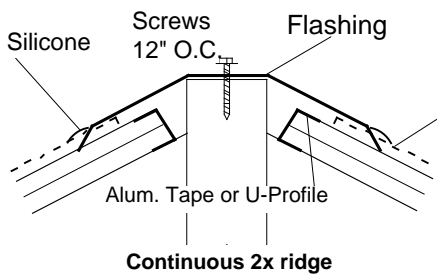
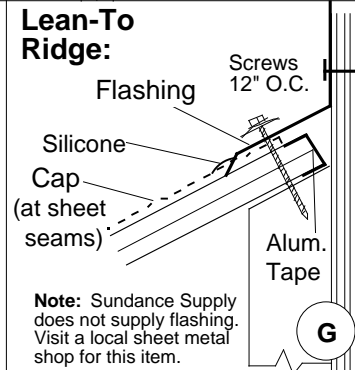
Corner Trim, Wall Corner:



Gable End To Existing Wall:

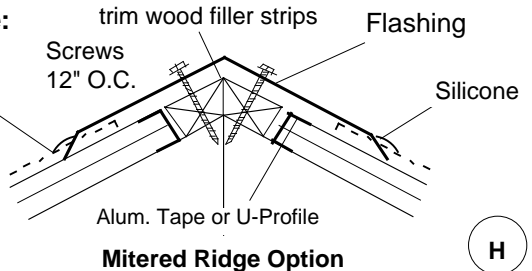


Lean-To Ridge:



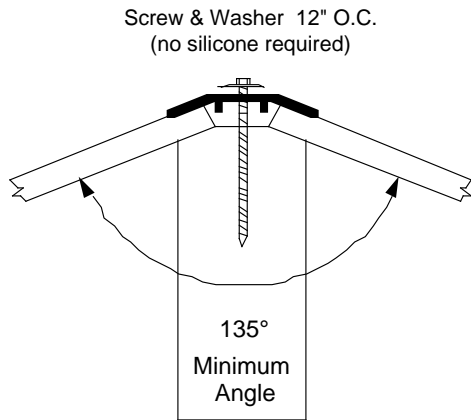
Freestanding Ridge:

Cap (at sheet seams)
 Blocking & Alum. Tape at top edge of sheet if using 48-1/4" rafter spacing.
 With 24-1/8" rafter spacing U-Profile & no blocking is an option.

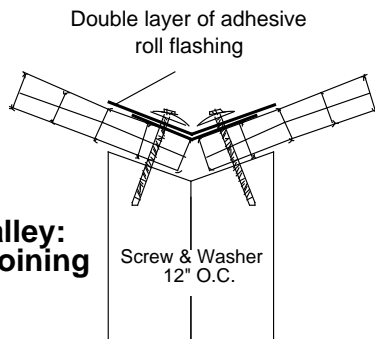


Framing: 24-1/8" on-center for intermediate members. First and last framing member 23-1/4" on-center.
Flashing: Have local sheet metal shop fabricate flashing for your specific needs. Use sturdy gauge material.
U-Profile: U-Profile requires a 1/16" weep hole, every 12" along lower edge, for moisture release.

Angle Wall or Hipped Roof:



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 White Tedlar backing facing the weather. No silicone required to achieve an excellent, watertight seal.

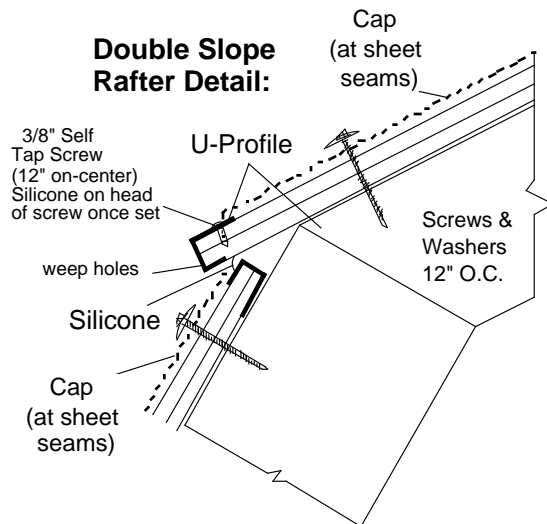
Roof Valley & Poly. to Existing Roofing:

Carlisle Hardcast #SST-3301 3" x 100 ft. Adhesive Roll Flashing (shown above & to the right) has 15 mil Butyl Adhesive (facing down) and a White Tedlar backing (that faces the sun). For wider than 3" areas simply overlay. Make sure polycarbonate is securely fastened to the structure with the screws we sell. To purchase see the Hardware Section of our Online Order forms.

Surfaces must be clean and free of moisture and contamination. Do Not Stretch during application.

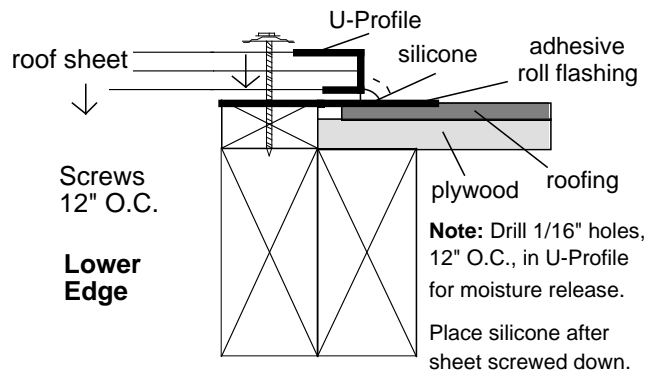
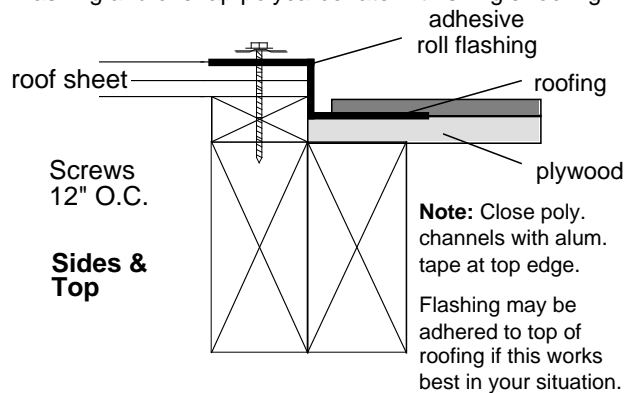
Peel off a few inches of release liner. Apply exactly the first time and do not stretch. Press down firmly at the center and work towards the edge, removing bubbles. Edges must have no openings, tunnels or fishmouths.

Double Slope Rafter Detail:



Poly. to Existing Roofing:

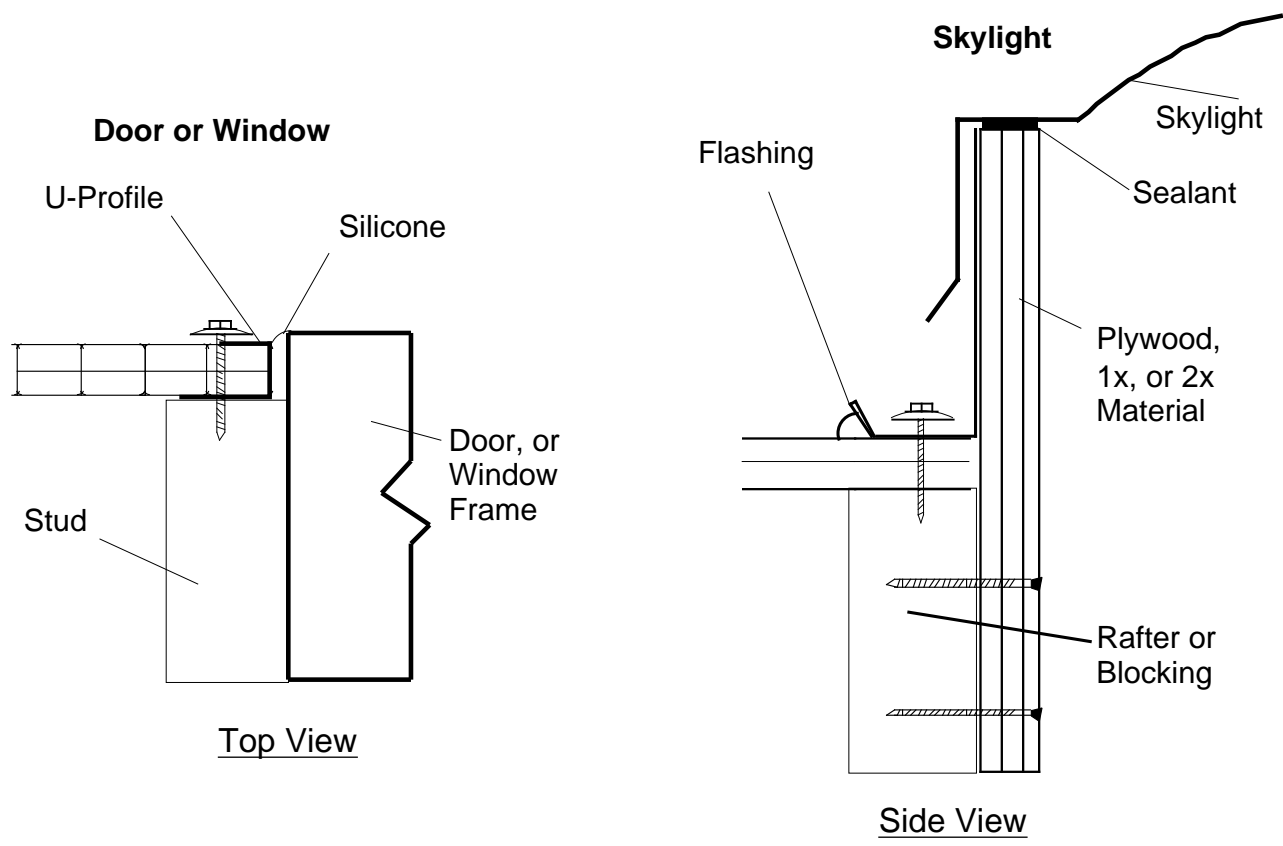
Note: Drawings below show only one option. Builders may also set polycarbonate at same level as surrounding plywood sheathing by eliminating 1x2. Lay adhesive roll flashing and overlap polycarbonate with shingle roofing.



This only silicone used.

(9a)

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.



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 framing, finalize location of inlet shutters, exhaust fan, doors and windows.

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

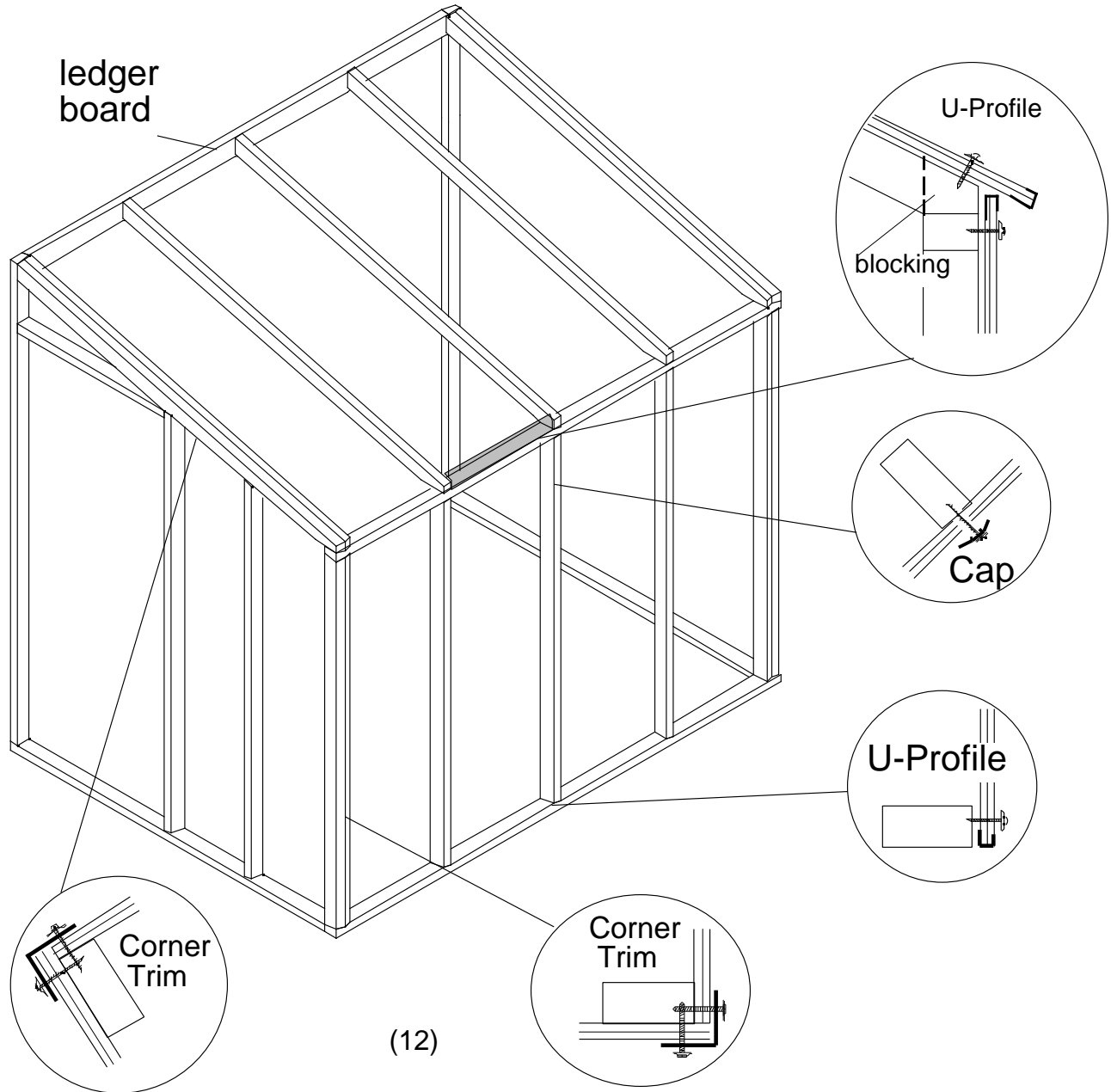
Lean-To Greenhouse Framing: On the following page is a drawing of a typical lean-to style greenhouse frame, for multi-wall polycarbonate. It is best to start with the ledger board. Bevel the top edge of 2"x6" or 2"x8" ledger board at an angle that is equal to the slope of the greenhouse roof. Securely 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. (see page 4)

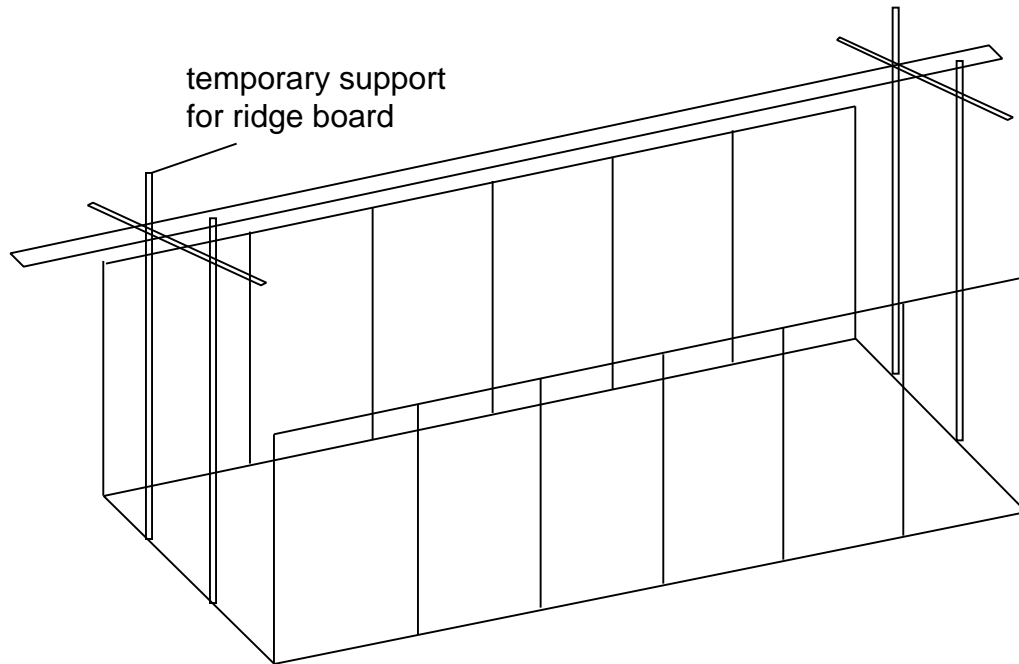
End wall framing comes next. Build the wall in place or build it first on the ground and then tilt it up. Make sure to frame out for doors, windows, fan and inlet shutters.

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

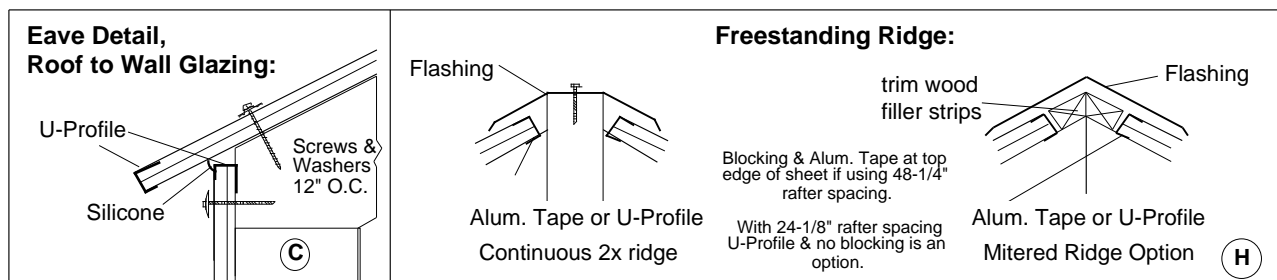


Freestanding Greenhouse Framing: Begin with the side walls. Framing is the same as front wall framing for lean-to greenhouse. Brace walls in preparation for framing roof.

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.

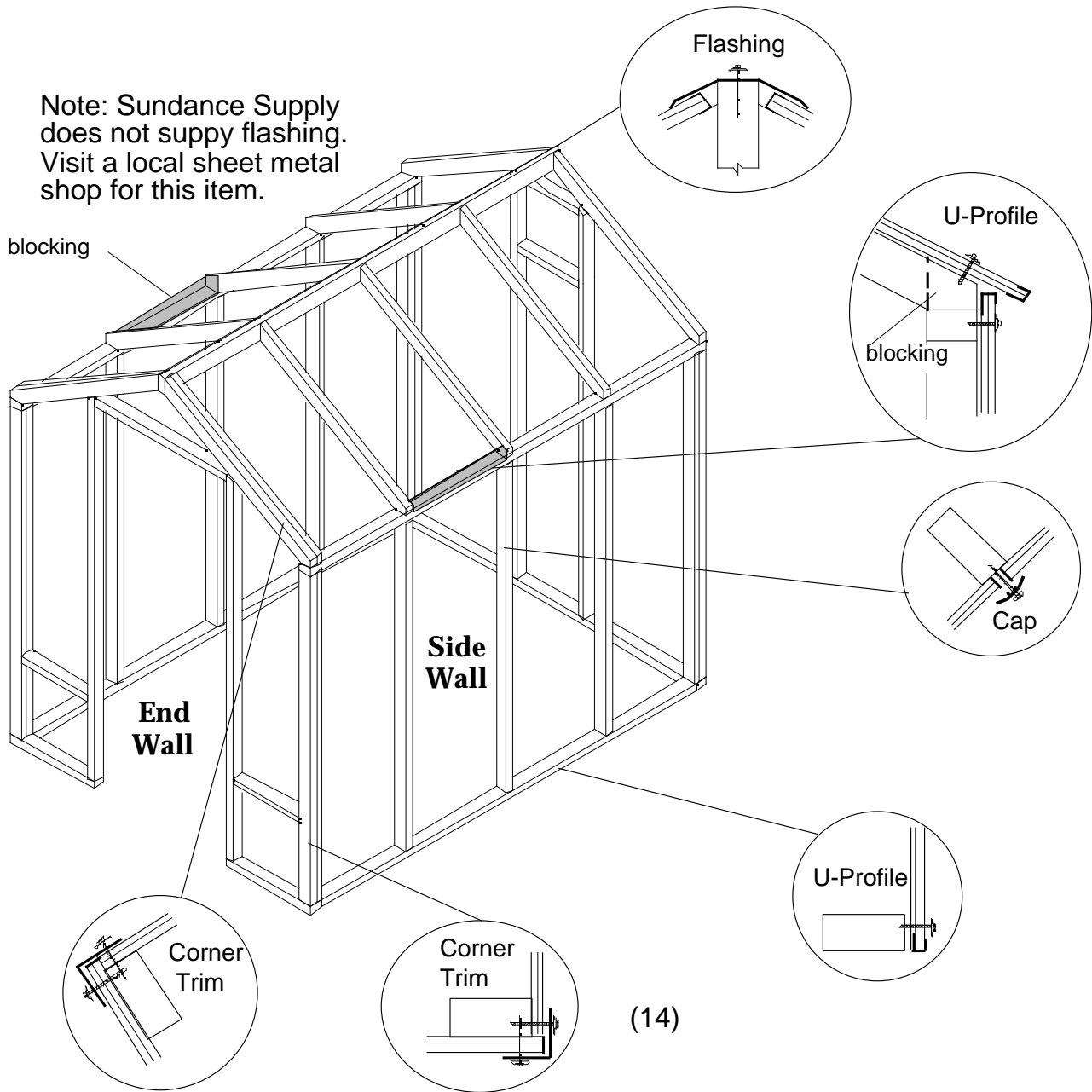


Set blocking as required by your design. If using polycarbonate and a lot of condensation is expected, set blocking back 3/8" from surrounding rafters, so condensation can move past the blocking. For 48-1/4" rafter spacing set neoprene spacers in center of blocking. (See p. 4 for more information). To extend frame life, 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 rafter, 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 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 writing to designate exterior side. Prior to installation, peel film off plastic film and mark exterior side with a grease pencil.

Thermal Expansion: Sheet expands in hot weather, contracts when cold. About 1/32" per ft. for 70° temp. change. For small greenhouses, impact is minimal. Follow Layout for Polycarbonate Over Frame, leave 1/4" between sheets, and follow Details on page 9. If installed on cold day, with sheets touching or tight against a wall, problems may occur as sheet expands. Sheet will absorb some flexing, but best to follow our guidelines. The great amount of expansion and contraction can occur in the spring and fall. Cold nights and warm sunny days can result in dramatic temp. swings.

Cutting: To cut sheet width, for angle cuts, 10, 16 & 25mm cuts and whenever sheet is to slide into Aluminum U use circular saw with plywood blade or jig saw with fine tooth blade. This produces clean, even cut. Cut sheet before taking off film, or static charge attracts fine chips to channels. Shake sheet, vacuum or blow out channels, removing chips prior to install. Condensation moving through layers continues cleaning channels, but get clean as possible. Leave film on sheet until ready to install, remove in area without dust. 6 and 8mm sheets may be cut to length with sharp utility knife. Clamp straight edge to sheet with rubber tip spring clamps and use as cutting guide. Run blade along guide a few times to achieve sufficient cut. Turn sheet over, bend and cut along crease to separate. Cut is ok for placement of 8mm in Vinyl U-Profile, whenever sheet edge is to be covered with aluminum tape and other low tolerance situations.

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 polycarb. install, close top edge of end wall sheets with aluminum tape. Blocking and Alum. Tape at top edge of roof sheet if using 48-1/4" rafter spacing. On freestanding greenhouses with 24-1/8" rafter spacing a U-Profile and no blocking is an option. Other edges should be closed with the U-Profile. Lower edge must allow for proper 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 p 9. Predrill with 1/4" bit to allow for expansion.

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

Weep Holes: Lower edge of vertical & roof sheets need provision allowing moisture weepage. This achieved by 1/16" weep holes drilled in U-Profile, 12" on-center.

Sealing: Refer to Install Details for placement of sealant. Use Dow 999A Silicone available at Sundance. Sealant should also be used at aluminum, vinyl and flashing joints.

Cleaning: Clean with warm, soapy water. Choose a mild dish soap. 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.

Sundance Supply www.sundancesupply.com

• Provide a materials list, order online. (15)

	<p>Correct</p>		<p>Incorrect</p>
<p>Sheet Positioning</p>			
<p>Install sheet with ribs running vertically on walls and with the slope on roof. Ribs run parallel to the sheet length.</p>			
		<p>Screw Attachment</p>	
<p>Correct</p>	<p>Incorrect</p>	<p>Correct</p>	<p>Fasten screws tight, don't dimple sheet.</p>
<p>Predrill 1/4" holes in polycarbonate.</p>			
<p>Mid-Sheet Fastening</p>			
<p>X = Mid-Sheet fasteners for 48" sheet</p>			
<p>O = Mid-Sheet fasteners for 72" sheet</p>			
<p>Dashed Line = Narrow Profile Cap</p>			

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 entire section carefully and plan the sequence of steps for your specific application.** Refer to the detail drawings on page 9, using the perspective key on page 8 to locate each drawing. Letters in brackets below, identify relevant diagrams from page 9.

Screws: See Details p. 9, basically 12" on-center along Cap, Corner & U-Profile (set in).

Sealants: See p. 20, **Sealant Selection & Application**, to achieve watertight integrity.

1. Procedure

Wall Installation Overview: 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. With protective film still on sheet, cut sheets to length, (width if required). Removal of film creates static electricity. Always remove after cutting is done and away from any dust and dirt that may be attracted. Shake sheet and vacuum or blow out channels to remove cutting shavings prior to installation. Movement of condensation through layers will continue cleaning cavity over time, but get clean as possible. Place cut end at lower edge if possible. Custom cut and install end wall sheets, one at a time, so top and lower edges remain consistent.

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

Start at one end. Prior to installing polycarbonate (after sheet cut), peel protective film off sheet, remembering which side faces the sun. Position sheet on frame. Check for proper alignment and minimum sheet bearing on frame. Drill 1/4" pilot holes in sheet and attach to frame at mid-sheet fastening points, via screws with sealing washers. Install screws snug, not too tight. Once confident position correct install remaining screws in upper, lower & mid points of sheet, firmly attach sheet to frame. Attach adjacent sheet and cover the joint with Narrow Profile Cap { A }, sealing butt joints of Cap as you go. See below and p. 15 cutting, mid-sheet fastening & attachment.

• **Narrow Profile Cap Installation** - Drill 3/16" holes in Cap for screws to pass through. Start 1" from ends of Cap & drill holes every 10-12". Attach Caps to frame. Butt upper edge of Cap against any adjoining material. After polycarbonate in place, wipe joint with rubbing alcohol. Lay a bead of sealant to compensate for expansion-contraction. Screws to be snug, not too tight. Cap now effectively covers both sheets, providing a clean, tight detail, { A }. Never place sealant under Cap. When joining two lengths of Cap, butt them close together and cover joint with a flat bead of sealant. Install with 1/8" gap between two lengths of Cap if a cold day, tight if a hot day. (see Expansion & Contraction note below or on next page). Cover joint with sealant, see p. 20.

- **U-Profile** - Simply slid over ends of sheet as required, see Install Details for locations.
- **Corner Trim** - Proceed in the same fashion as described above for Cap.

Important Note - Expansion & Contraction of Polycarbonate and Trim Components.

Polycarbonate and aluminum will expand and contract at about the same rate. A movement of 1/32" per ft. of material during a 70 degree temperature swing is typical. Plan for expansion-contraction along the length of each material. 8 foot Trim 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. When installing during the winter leave an 1/8 gap at joint, in summer butt tight. Cover joint with properly laid bead of sealant, see p 20. Do not install so tight that polycarbonate can not expand & contract or problems occur.

Roof Covering Installation: Follow wall procedures when preparing roof sheets. Start at one end of roof & begin laying sheets. Top edge of roof sheets most often closed with aluminum tape, resting on blocking, { G & H }, but may be Aluminum U-Profile if no blocking & rafters 24-1/8" on-center. Continue as described for wall sheets. After 2nd sheet set, fasten Cap joining the 2 sheets { A } and seal joints (it is easy to reach now). Install lower U & Corner Trim so it covers edges of the roof and end wall sheets { D }.

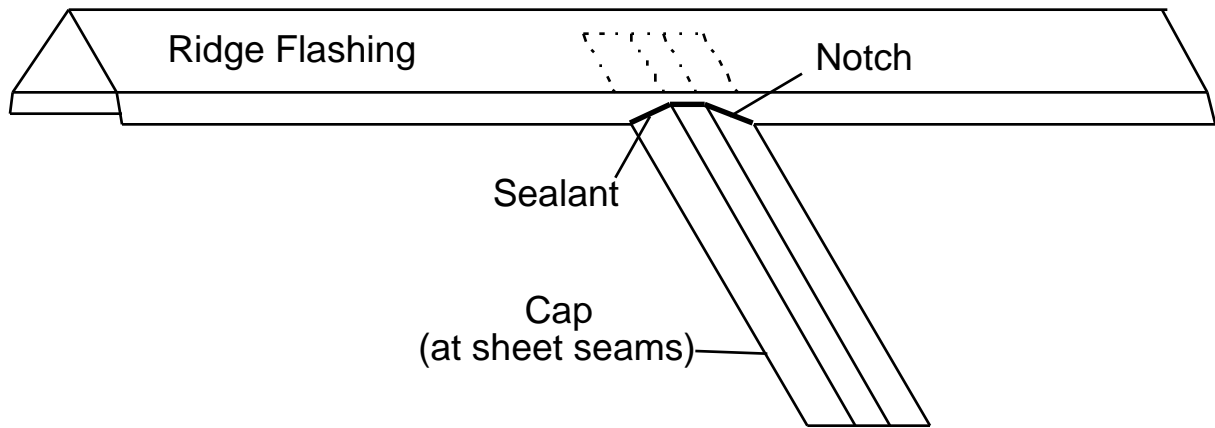
Roof Access Notes: Access to the roof for Trim, screw and sealant placement on flashing is best done from a step ladder positioned in between the rafters where polycarbonate has not been set yet. Installation of 1st and last sheet offers the ease of placing a ladder outside the structure. Working from 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 an 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 ways 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 sealant 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 sealant 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 in flashing 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 sealant 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 rests 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 flashing 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.

Sealant Selection & Application: Silicone is used **below eave { C }, along ridge flashing { H }** and at the interface between **U-Profile and an existing structure { F }**. Use 100%, plastic compatible, silicone. A 1/4" bead is best. When spicing lengths of either **Cap & Corner** place a 1/4" bead of silicone at joint. Gently tool bead flat with saliva covered finger. Do not place same finger in mouth after tooling. The sealant is sticky and somewhat toxic. Joints at the interface of the Trim Components should be clean and securely fastened. Make sure U-Profile is butted tightly so that spiders do not get in and build a web. Clean all joints with isopropyl (rubbing) alcohol and let dry prior to applying the sealant. Allow sealant to dry for 24 hours before cleaning the polycarbonate and metal. **Commercial Grade Dow 999-A Clear Silicone is available through Sundance Supply.** Calculate running ft. of silicone required for your project. One tube will do 25 feet of a 1/4" bead.

2. Step-by-Step Polycarbonate Installation. An outline of procedure covered above.

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) Leave film on sheet. Cut sheets to length & width as required. Clean out channels.
- 2) Cover channels at upper edge of gable end wall sheets with Aluminum Tape, { D}. Top edge of the roof sheets most often closed with aluminum tape, resting on blocking, { G & H }, but may be capped with Aluminum U-Profile if no blocking and rafters at 24-1/8" on-center. Top edge of gable end sheets covered with the Corner Trim, { D }.
- 3) Position sheet on frame, so outer ribs are supported by minimum of 1/2" of frame.
- 4) Drill 1/4" hole/s in mid-sheet fastening points (see Positioning & Attachment notes on page 15) and attach to frame, via screws with 3/4" sealing washers. After you are assured of proper alignment of sheet, make screws snug, but not too tight. Install remaining screws required in upper, lower and mid points of sheet, firmly attaching sheet to frame. Install adjacent sheet in same manner.
- 5) Place Narrow Profile Cap at sheet joining locations, { A }. First drill 3/16" holes in Cap, 1" from each end & every 10" - 12" on-center. Cap overlaps U-Profile, on bottom of walls { B }, and bottom edges of roof sheets, { C }.
- 6) Install U-Profile as required. Drill 1/16" weep 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 U-Profile facing up, { C }. U-Profile at lower edge of roof sheets held in place with 3/8" self-drill screws. Side wall sheets of freestanding greenhouses (front wall for attached) have U-Profile at on top and lower edges of the sheets, gable ends on bottom only, tape & Corner at top. Pressure of sheet against frame holds U-Profile in place.
- 7) Install Corner Trim, predrill 3/16" screw holes, 1" from each end and every 12". Corners overlap U-Profile.
- 8) Place sealant at trim joints as required.