FAFCO®

Connected Tube CT

Separated Tube ST

Solar Pool Heating Systems

INSTALLATION MANUAL

FOR USE WITH SWIMMING POOLS TO HARNESS THE ENERGY OF THE SUN

Made in the U.S.A.

FAFCO® SOLAR WATER HEATING

Installation Manual

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System Overview

Since 1969, FAFCO®'s goal has been to design, test, and produce the world's highest performing solar pool heating systems.
Installing a FAFCO® solar pool heating system is straight-forward and relatively simple. This manual provides a step-by-step installation procedure for most applications. For those situations not covered in this manual, please contact your FAFCO® representative.
Please read this manual completely before starting the installation and take special care to comply with all local ordinances and building codes.

Theory of Operation

Each year, as summer approaches, the strength of the sun's rays intensifies. The tilt of the earth in summer puts the sun higher in the sky focusing the rays over a smaller area. A properly installed solar Panel harnesses the energy of the sun.

Water flows through each Thermal Panel, and absorbs heat from the sun.

The heated water then returns to the swimming pool to reduce, and often eliminate, the need for a pool heater, and reduces roof temperatures. This lowers household energy costs and increases the homeowner's comfort.

Panel Components

(CT Panel shown)

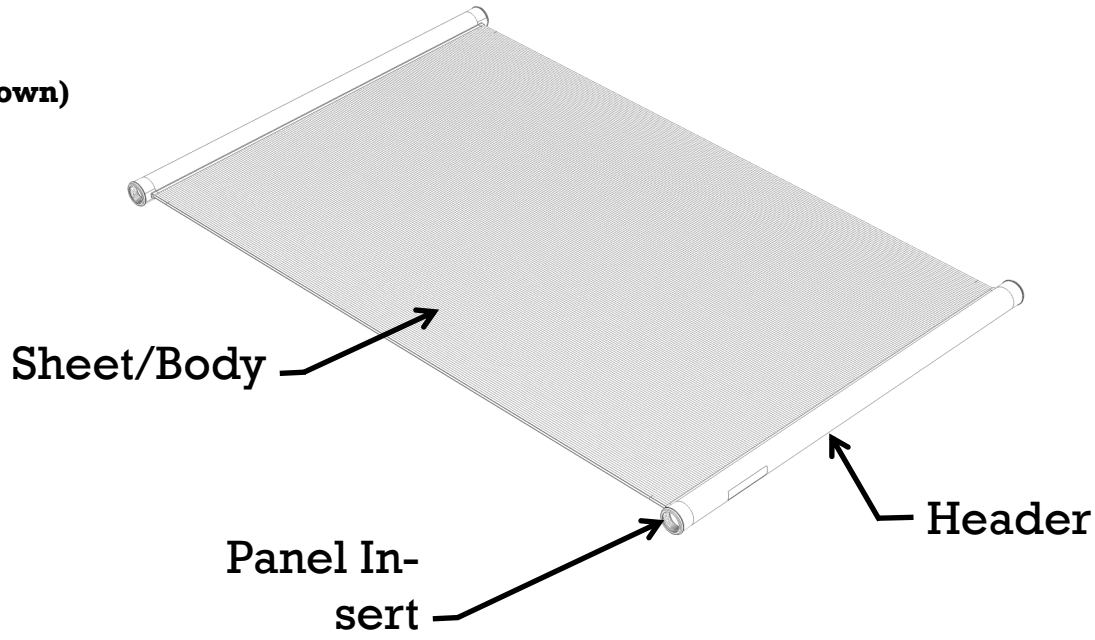


Figure 1 | Connected Tube *CT* Panel Make Up

Each Connected Tube *CT* Panel consists of the Sheet or Body, the Panel Insert and a Header Pipe. The Sheet or Body is the primary portion of the Panel which collects thermal energy from the sun and may also be referred to as a Thermal Panel.

Specifications, Certifications & Listings

Panel Specifications							
Panel Area	14ft²	17.5ft²	21ft²	22.5ft²	30ft²	37.5ft²	45ft²
Panel Dimensions (HxWxD)	**2x8**	**2x10**	**2x12**	**4x6**	**4x8**	**4x10**	**4x12**
Weight (lbs empty)	7.0lbs 3.18kg	8.3lbs 3.76kg	9.6lbs 4.35kg	10.7lbs 4.87kg	15.0lbs 6.80kg	17.8lbs 8.07kg	20.6lbs 9.34kg
Roof load (lbs full)	23.5lbs 10.7kg	25.8lbs 11.7kg	29.2lbs 13.2kg	33.7lbs 15.3kg	47.0lbs 21.3kg	55.2lbs 25.0kg	62.7lbs 28.4kg
Fluid Capacity (gal)	1.8gal 6.8L	2.1gal 7.9L	2.4gal 9.1L	2.71gal 10.25L	3.8gal 14.4L	4.5gal 17.0L	5.1gal 19.3L
Fluid Connection Type	FAFCO® Proprietary						
Chemical Resistance	Chlorine and Saline Pool Compatible						
Freezing	Drain at 45°F prior to Freezing Conditions						
Absorptivity	0.96						
Emissivity	0.9						

Panel Thermal Specifications*	
Thermal Energy Output	1800 Btu / (ft2-day)
System Operating Pressure (<100 °F) At Bottom Header	30 psi
System Intermittent Pressure (<100 °F) At Bottom Header	40 psi
Factory Test Pressure / Burst Pressure Per Panel	50 psi / 220 psi
Recommended Flow Rate Per Panel	0.1 gal/min/ft2
Delta T (at y intercept)	6°F
Operating Temperature Range (typical)	60-100 °F
Stagnation Temperature	160°F

*All performance data calculated at STC (Standard Test Conditions) 80 °F, 317 Btu/hr./ft², 1.5 AM, Inlet Water of 70 °F, Wind speed=3 mph

Connected Tube *CT* Panels have been certified and listed for the following:

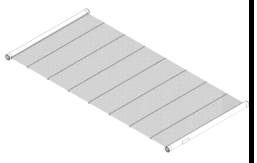
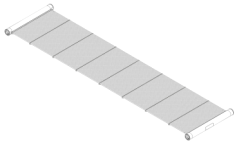
- SRCC OG-100 #10002113
- ICC-SRCC Listing #16006

Connected Tube *CT* Panels have been certified and listed for the following:

- SRCC OG-100 #10002112
- ICC-SRCC Listing #16006

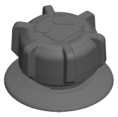
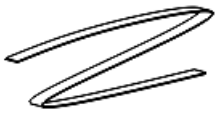
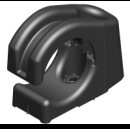
Components & Parts List

Panel Part Numbers

Item	Image	Name	P/N	Description
1		Connected Tube *CT* (4ftx 12ft) (4ft x 10 ft) (4ft x 8 ft) (4ft x 6ft)	20412 (12ft) 20410 (10ft) 20408 (8ft) 20406 (6ft)	4ft Connected Tube *CT* Panels. These 4ft wide Panels are available in four different lengths, 12ft (45 sq.ft.), 10ft (38 sq.ft.) and 8ft (30 sq.ft.) and 6ft (23 sq.ft.)
2		Connected Tube *CT* (2ft x 12 ft) (2ft x 10 ft) (2ft x 8 ft)	20212 (12ft) 20210 (10ft) 20208 (8ft)	2ft Connected Tube *CT* Panels. These 2ft wide Panels are available in three different lengths, 12ft (21 sq.ft.), 10ft (18 sq.ft.) and 8ft (14 sq.ft.)
3		Separated Tube *ST* (4ftx 12ft) (4ft x 10 ft) (4ft x 8 ft) (4ft x 6ft)	30412 (12ft) 30410 (10ft) 30408 (8ft) 30406 (6ft)	4ft Separated Tube *ST* Panels. These 4ft wide Panels are available in four different lengths, 12ft (45 sq.ft.), 10ft (38 sq.ft.) and 8ft (30 sq.ft.) and 6ft (23 sq.ft.)
4		Separated Tube *ST* (2ft x 12 ft) (2ft x 10 ft) (2ft x 8 ft)	30212 (12ft) 30210 (10ft) 30208 (8ft)	2ft Separated Tube *ST* Panels. These 2ft wide Panels are available in three different lengths, 12ft (21 sq.ft.), 10ft (18 sq.ft.) and 8ft (14 sq.ft.)

Components & Parts List

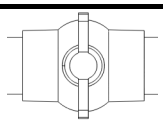
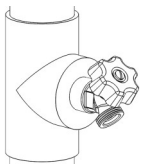
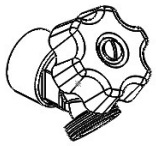
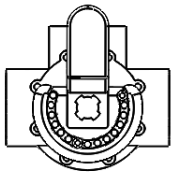
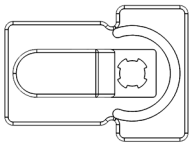
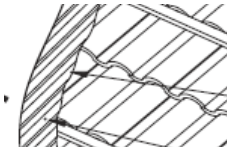
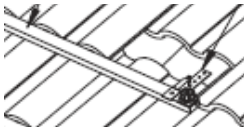
Array Components

Item	Image	Name	P/N	Description
5		Vacuum Relief Valve (VRV)	188	Black, weather resistant CPVC, 2" PVC pipe size, barbed. Seals system when pressurized and allows Panels to drain when the system is off. Adapts to Solar Panel using Panel Coupler.
6		CPVC End Cap	05380	Black, weather resistant CPVC, 2″ PVC pipe size, barbed. Adapts to solar Panel using a Panel Coupler.
7		CPVC Pipe Adapter	05381	Black, weather resistant CPVC, 2" PVC pipe size, barbed female slip. Used with a Panel Coupler to adapt the VRV to PVC.
8		Strap Anchor		Black, weather resistant polymer. Mounts solar Panel header and body straps to a roof or rack using a 1/4″ lag bolt and cap.
9		Coupler Clamp	10195	Polymer $2^{1}/_{2}$" hose clamp. Secures Panel Couplers to barbed fittings. Tighten using channel lock pliers.
10		Panel Coupler	10196	3" long, $2^{3}/_{8}$" inner diameter used to join the barbed fittings on a VRV with those on the Pipe Adapter.
11		Panel Strap	10006 or 03430 for a roll	Black, weather resistant braided polyester. Anchors solar Panel body to Strap Anchor.
12		Header Anchor	10194	Used to secure the upper header to the roof.

Panel Kits Available

Item	Kit	P/N	Purpose/Use	Contents
13	Panel Kit	10201	Plumbs and mounts a Panel. (One per Panel)	(2) header anchors, (4) coupler clamps, (2) panel couplers, (7) strap anchors
14	System Kit	10202	Terminates plumbing and mounting a single bank, adds a check valve at plumbing (One per System)	(1) vacuum relief valve, (1) CPVC end cap, (7) strap anchors, (3) pipe adapters, (2) panel couplers, (4) coupler clamps, (1) 150ft roll of body strap, (1) Fixed Point Insert, (1) installation manual
15	Spacer Kit	10203	Allows for space around an obstacle. (one per row space needed)	(4) pipe adapters, (4) coupler clamps, (4) strap anchors, (4) panel couplers
16	Equipment Pad Kit	10213	Used to tie into pool plumbing at the equipment pad for the solar system.	(2) check valves, (1) 3-way valve, (2) 2-way valves, (1) Tee

Alternate Vendor Components

Item	Image	Component	Purpose/Use	Suggested Vendors
17		Isolation Valves (2-way pool, gate, or ball valves)	Enables isolation of solar (use for winterization or troubleshooting purposes)	Plumbing Supply Vendor
18		Manual Vertical Solar Drain Valves	Can enable manual draining of a system (use when a solar system is located below pool level or to drain roof plumbing in special circumstances)	Plumbing Supply Vendor
19		Manual Panel Drain Valves	Enables Manual Draining of a Panel (use in low point plumbing if trapped water remains on shut down)	Plumbing Supply Vendor
20		3 Way Diverter Valve	Enables pool water to be directed to solar or directly to the pool return (use in all solar equipped systems)	Jandy, Hayward, Pentair (available from FAFCO in Equipment Pad Kit PN: 10213)
21		Automated Solar Diverter Actuator	Enables automatic movement of 3-way diverter valve (use with pool automation and pool controllers)	Plumbing Supply Vendor
22		Panel Substrate	Used as both a barrier and a support structure. Use substrate on all tile roofs and in cases where runners span more than 16".	Building Supply Vendor
23		Metal Runners	Use as a support and mounting structure. Install under Panels and anchor to roof or rack with proper penetrations.	Building Supply Vendor

System Overview

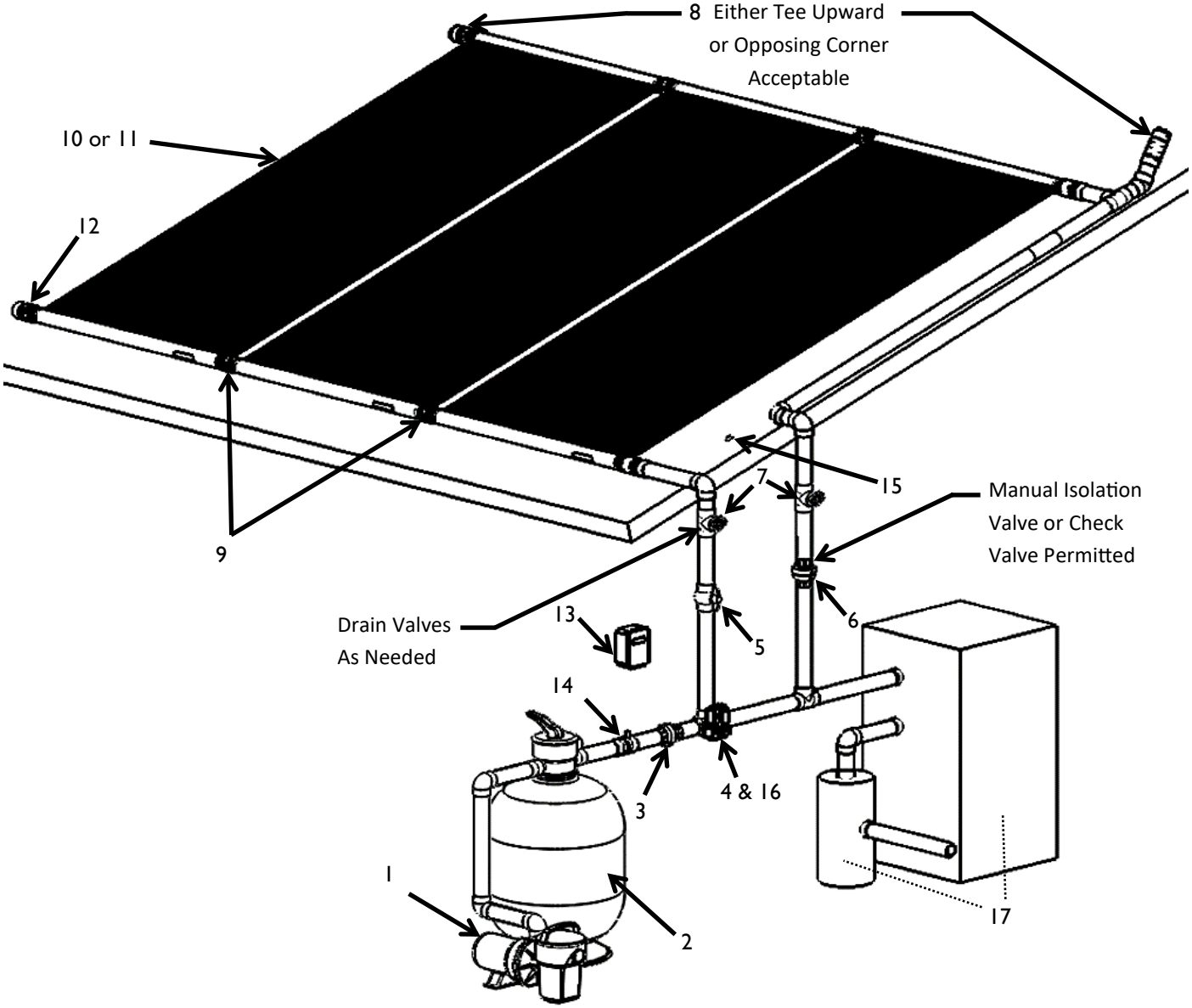


Figure 2 | Example System

The typical solar pool system consists of a combination of FAFCO®-sourced parts and standard equipment. The above figure and the component list below depicts standard equipment components and shows the proper placement of all components. All FAFCO® pool systems should have the standard equipment listed and shown.

Legend for Figure 2

Standard Equipment

1 **Pool Pump**
2 **Filter**
3 **Check Valve**
4 **Diverter Valve**
5 **Isolation Valve**
6 **Isolation/Check Valve**
7 **Solar Drain Valves (2)**
8 **Vacuum Relief Valve**
9 **3" Panel Coupler**
10 **Connected Tube *CT* Panels**
11 **Separated Tube ST Panels**
12 **End Cap**

Automation Equipment

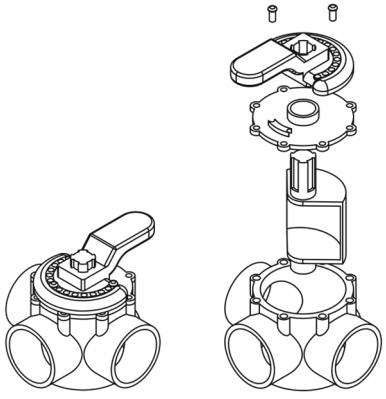
13 **Automation Controller**
14 **Pool Temperature Sensor**
15 **Solar Temperature Sensor**
16 **Actuator for Diverter Valve**
17 **Auxiliary Equipment**

Optional Pool Equipment (Aux)

A **Back Up Heater**
Not Shown:
Chlorinator
Additional Pumps

Figure 3

Diverter Valve Schematic



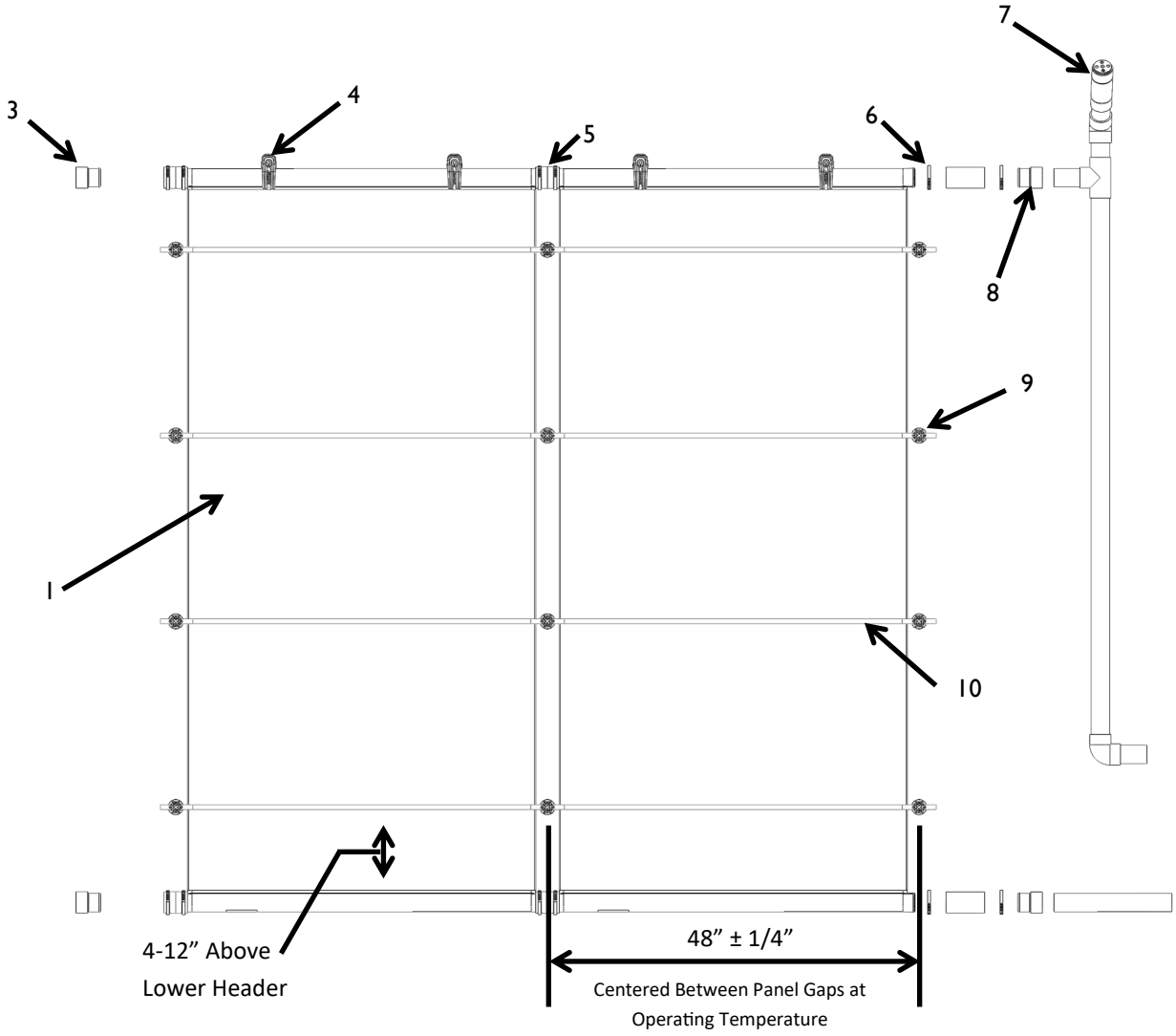


Figure 4 | Typical Panel Array Layout Components

The typical solar pool system consists of a combination of FAFCO®-sourced parts and standard equipment. The above figure and the component list below depicts common Array Layout Components and shows the proper placement of all components.

Legend for Figure 4

Array Layout Components

1 Panel (45in wide)
2 Panel (2ft wide)
3 End Cap
4 Header Anchor
5 Panel Coupler
6 Coupler Clamp
7 Vacuum Relief Valve
8 Pipe Adapter
9 Strap Anchor
10 Body Strap

Refer to the *Array Components List* on the previous pages for further details about the array components in the above figure

* Number of Body Straps determined by local wind load requirements

Safety & Disclaimer

As with any installation, safety is the first priority. The department of Occupational Safety and Health Administration (OSHA) requires certain personal safety precautions to be taken by all solar installers who walk, carry or lift anything and especially when doing so up ladders and on the top of structures. Please familiarize yourself with and implement the appropriate safety regulations before beginning any installation.

Quick Tips, Panel Installation

- Suggested order of Roof Equipment installation: *Panels → Plumbing →Penetrations → Secure Plumbing*
- Suggested order of Thermal System Plumbing installation: *Supply and Return Lines → Pool Equipment*
- The most resilient method of installing Panels requires that mid-Panel anchors are measured out prior to Panel placement.

  Alternatively, Panel banks can be plumbed and circulated with pool water to ensure that mid-Panel anchors are centered at operating temperature. This process is known as the Circulation Method.

- Panels must be installed with a minimum of a 2”/12” slope to maintain uniform flow and properly drain. See appendix for flat or trellis installation guidelines.
- Avoid walking on Panels wherever possible. Walking on Panels can cause damage and the potential for leaking.
- When laying out Panels for installation, check for miscellaneous hardware or other items which could get caught between the roof and the Panels that may strike and damage a Panel.
- Systems installed on tile or standing seam roofs must be installed on a substrate barrier so that the Panels are supported and protected from abrasion.

  Alternatively, if metal runners are installed to support the Panels, runners must be spaced no more than 16”. Installations with runners do not require substrate to be installed under Panels.

- Panels installed on Barrel Tile, Flat Tile or on Standing Seam Metal Roofs include adequate panel support along the width and length of the panels with substrate or sufficient runner support such that panels span no more than 16” along their length and are protected from abrasion (see *Appendix D* for details).

Quick Tips, Plumbing

- It is typically acceptable to use Schedule 40 PVC for system plumbing. In extreme conditions, CPVC plumbing may be more applicable. See **Table 4** in *Appendix C*.

- Flush out all pipes before connecting them to Panels in order to clear any chips which may have become trapped in the plumbing.

- Systems with low spots in the plumbing should have a way of manually draining the line for easy winterization. Banks should be mounted so that the centermost Panel is fixed.

- The upper header on the panel to Fix-Mount (see **Figure 11**). Doing so will limit bank movement when pressure and temperature cycling takes place through normal operation.

- Banks can be installed with 3" couplers when connecting to plumbing supply and return lines.

- Mid-bank obstacles should maintain a clearance of 2" from Panels. See *Appendix C* for specific exceptions.

- *Plumbing Offsets* may be used to allow for lateral movement between banks and system plumbing as shown in *Phase I—Site Preparations & Planning* **Figures 6 and 7** and in **Figures 19 through 22** of *Appendix C*.

- An expansion joint can be used to allow for both bank and plumbing movement. To use an offset for absorbing bank movement, use the offset distance for obstacle avoidance in **Table 3** of *Appendix C* to size the offset distance needed for the selected offset method (**Tables 5 through 7** of *Appendix* C).

- It is acceptable to utilize industry standard practices not mentioned in this text to accommodate for plumbing expansion and contraction.

- Movement in a straight run of plumbing more than 10ft in length should have a means of accommodating thermal expansion and contraction.

- All plumbing must be painted. Flexible PVC plumbing must be thoroughly protected from UV exposure by means of paint, wrapping or equivalent means of preference.

- It is generally not advised to install FAFCO Separated Tube ST panels with roof vents protruding from between the tubes, but if necessary it can be permitted as long as the vent is away from the header pipes by at least 12" and the vent is no greater than a 2" Pipe. See Splitting Panels Around Roof Vents in Phase I, for details.

PHASE I — Site Preparations & Planning

Planning a roof layout for necessary penetrations, mounting, and plumbing will make installation easier and promote a cleaner looking system. While systems install quickly, there are some special considerations to keep in mind. The following sections of *Phase I* will help prepare you for a simple and successful install.

Panel Layout

Panels should only be installed in portrait orientation so that water will flow directly up the roof. Banks are to have a **maximum of 15 Panels plumbed together in a row.** All panel banks must be plumbed in a parallel flow path.

Since the expansion or contraction of a bank is dependent on temperature, the preferred method of installation is to measure out the placement of the Panels on a roof, and position the penetrations by measuring them and using a chalk line and tape measure to locate all penetrations.

When using the pre-measured method, the spacing should be set at 48" on center. The last mounting points in the bank should be placed with an extra 2-4" of clearance for excessive bank movement.

A secondary means of placing mid-bank penetrations would be to install the mounting hardware by centering everything at operation temperatures using the *Circulation Method*. See ***System Detail Installation*** in **Phase II** for specifics about centering penetrations at temperature.

In addition, Panels may need to be spaced out to allow for mid-bank obstacles or changes in roof shape. In most cases, the banks will need to have additional spacing added so that the bank can be plumbed around the obstacle. Gaps can be filled by connecting PVC runs to Pipe Adapters and Couplers as depicted in **Figure 10.**

Spacing Panels and Penetrations

Panels will also grow or shrink along the length of the Panel. Be sure to mount Panels so that there is at least 2" of clearance from the bottom headers to any obstacles below the bank.

It is not acceptable to install two stacked banks so that the upper header of the lower bank and the lower header of the upper bank are touching and tied together. Instead, mount each bank individually with adequate clearance.

Many roofs have vents and other obstacles protruding from the surface. It is common for Panels to be installed with spaces in the bank. Roof obstacles pose an additional factor to consider during planning the roof layout. Panel movement is a normal occurrence with pressure and temperature fluctuations in the system. If not properly placed, Panels can collide into penetrations or roof obstacles and cause damage to the Panels. To limit unnecessary damage and likely voiding of FAFCO®'s Panel warranty, banks must be installed so that proper clearance is allowed on either side of an obstacle. See **Table 3** in *Appendix C* for more specifics about proper obstacle clearance upon installation. A best practice rule of thumb to use for proper obstacle clearance is 2" but less clearance may be acceptable depending in the size of the bank installed as indicated in **Table 3.** In most cases, banks will need to be adapted to PVC by using couplers and pipe adapters to plumb to PVC Pipe (**Figure 10**). This method allows for any gap size seen in common practice.

Splitting Panels Around Roof Vents

It is generally not advised to install FAFCO Separated Tube *ST* panels with roof vents protruding from between the tubes, but if is absolutely necessary it can be permitted under the following conditions:

- Protruding roof vent is no greater than a 2" pipe diameter (2-3/8" or less outside diameter)
- The vent carries no heated exhaust such as that from appliances or heaters of any kind
- The vent must be more than 12" away from the sheet to header weld on either end of the panel
- If the ST strip is within 2" of the vent, the strip should be cut to allow more spread between the tubes
- At least 10 tubes must be removed from the closest strip on both the top and the bottom side of the vent
- Loose tubes can be tied away from the vent with a plastic cable tie but not tightened enough to cause damage to the tubes
- Flashing around vent must be smooth and free of edges which can rub tubing. If rough edges are present, use discretion to protect tubing from abrasion or puncture.

Plumbing Layout

Roof-based plumbing involves two parts, the plumbing connections between several individual Panels and the supply and return lines that connect each row of Panels to the pool plumbing.

Row-to-piping connections may only be installed in the End Supply/Return or Reverse/Return styles. To ensure each Panel receives adequate flow, install End Supply/Return rows with a maximum of 10 Panels and Reverse/Return rows with a maximum of 15.

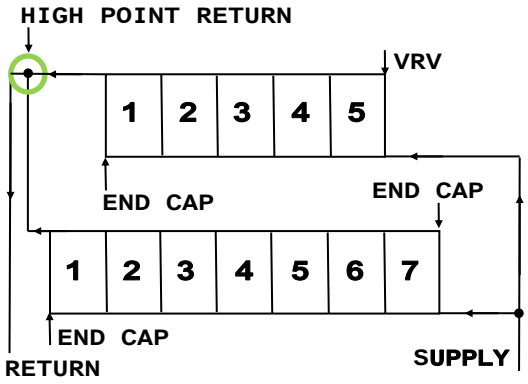
Row-to-piping connections must be designed in such a way that all bottom headers can drain when the system is turned off. Ensuring that horizontal runs of pipe have a level or slightly downward slope will allow proper drainage to the pool. If plumbing does not drain down when the system is turned off due to local entrapment, manual drain valves should be installed for simple winterization. Systems that require manual draining will be required to maintain a winterization service record history.

NOTE: See your warranty policy for specifics of coverage policies.

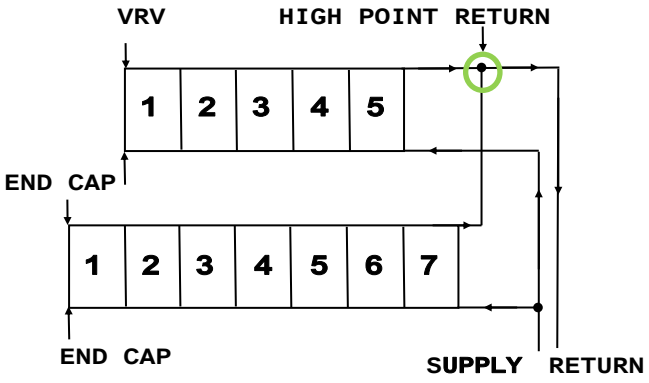
Systems with more than one row require means of flow balancing. A common high point return (seen in **Figure 5**) will achieve proper Panel flow uniformity. Plumbing the return line with a high point will enable a comparable backpressure on the return line of each bank and therefore match Panel flow throughout the array.

Unlike FAFCO® CoolPV® Systems, Connected Tube *CT and Separated Tube ST* Systems do not utilize an individual high-point-return line. When installing both Connected Tube *CT* and CoolPV® Systems, plumbing must conform with the schematics in **Figure 8** to ensure the system is properly balanced and drains as intended.

It is acceptable to omit a high point return and use balancing valves to achieve adequate bank flows. In most cases, a high point return style plumbing will be the easiest to achieve, but in circumstances where a high point plumbing routing is not a good option, balancing valves can be used instead. For specifics of installing a Connected Tube *or Separated Tube* system with balancing valves, refer to *Appendix C*.



A) Multi-Bank Reverse Return



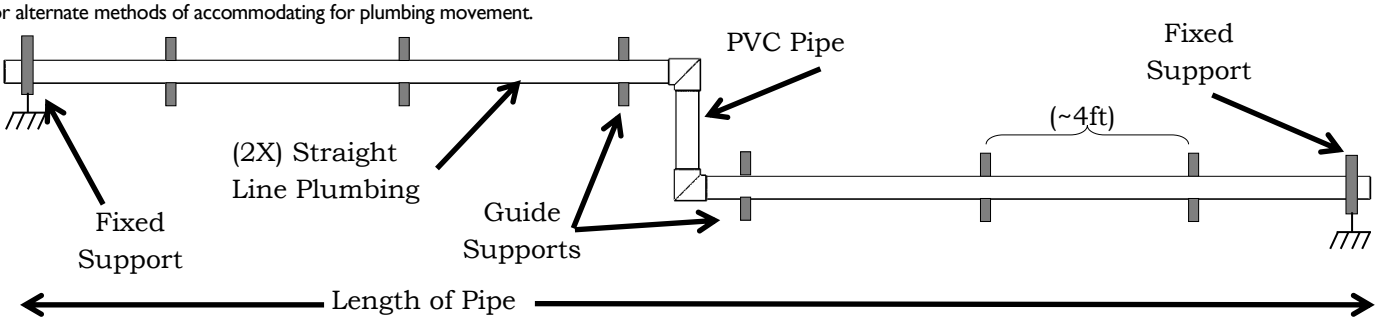
B) Multi-Bank Same End Return

Figure 5 | High Point Return Line

Multi-Bank CT Pool Systems utilize a common high point return line. This enables each bank to have proportional feed and return line backpressures which limits the water to favor the path of least resistance. Without a common high point return line, the lowest bank will see too much flow and the top won't see enough, resulting in poor performance of the top bank. Notice A) is an example of a *Multi-Bank Reverse Return* and B) is a *Multi-Bank Same End Return.*

Figure 6 | Row Plumbing Movement

A straight line of plumbing can move up 1" for a length of 20ft. Plumbing expansion joints are advised to accommodate this movement. An industry standard method, such as an *offset* should be used so that the line can move as needed. Refer to **Table 5** for regular PVC joint offset lengths and *offset* type for a length of pipe. See *Appendix C* for alternate methods of accommodating for plumbing movement.



When routing plumbing, consideration should be taken to ensure it will be properly guided so that it moves as intended. Common practice is to strap plumbing lines with a galvanized plumbing strap anchored by 1 or 2 fasteners. This type of mounting allows for movement perpendicular to the direction of the strap. If plumbing is strapped parallel to the direction of movement without a means of accommodating it in the line, thermal expasion can tear out the strapping and cause costly damages. Refer to local plumbing codes for proper mounting practices of PVC.

There are multiple methods of accommodating both bank and plumbing movement. **Figure 7** below explains some ways of accommodating both bank and plumbing movement. More details are available in *Appendix C* for reference.

The use of a plumbing offset is a largely common means of enabling axial growth and shrinkage in longer runs of plumbing. By offsetting the plumbing with 90° fittings and strapping it in accordance with **Figure 18** and **Table 5** in *Appendix C*, proper movement can be allowed to take place without cracking fittings, tearing out mounting points, and restricting the movement of a solar system.

Note that this is not the only means of properly accommodating for plumbing and bank movement. Industry standard methods are also acceptable. For more details on proper plumbing mounting and movement, consult a certified plumbing specialist and local plumbing codes.

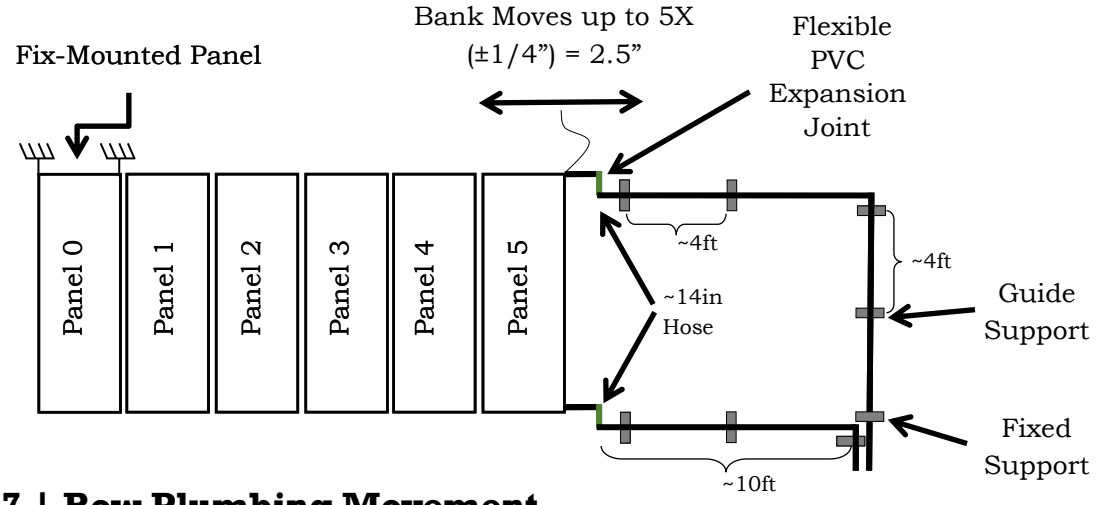


Figure 7 | Row Plumbing Movement

A bank of 5 Panels from the Fixed Panel can move up to 2.5" from normal temperature fluctuations (1.25" in a single direction). In this case, one could use two Flexible PVC Hoses to accommodate this movement when the plumbing is strapped as shown. Refer to **Table 6** in *Appendix C* for recommended Flexible PVC Hoses lengths. In this case, the movement in the bank corresponds to ~1.2" which can also be transposed to an equivalent of 30ft PVC pipe (**Table 5**). Additionally, there is a 10ft line of PVC. Adding the two provides 40ft of equivalent length, requiring 13.4" of PVC Hose (sourced from **Table 6**). Since the plumbing can be mounted as *Fixed* or *Guide* supports, an offset may also be useful to absorb some or all of the movement in the above figure. Refer to *Appendix C* for more variations of *Row Plumbing Movement*.

Note: It's also acceptable to use another industry standard method to accommodate for thermal movement. Variations of these recommendations can be used as long as sufficient movement for a standard temperature range of 80°F is allowed.

Supporting PVC Pipe

Horizontal runs of PVC pipe must be supported every **four** feet and all vertical runs of PVC pipe must be supported every **ten** feet. Vertical lines take the water from the ground up to the roof and are usually on the walls of the main structure. Pipe supports on the roof should be sealed according to an industry standard method.

Pipe supports should be secured and properly guide thermal movement (see figures in *Appendix C*). Proper plumbing installation enables the plumbing to move minimally but accommodates movement of solar Panel banks.

Both *Floating Guide* and *Fixed Guide* connections should be incorporated in conjunction with an industry standard method to absorb plumbing movement as referenced in **Figures 19-21** of *Appendix C*.

Prime consideration should be given to system drainage and appearance when running pipe from the pool pump to the Panels and back. Best practice allows system drainage with a slight and consistent downward slope in all horizontal runs.

Plumbing Materials

Roof plumbing should be schedule 40 PVC conforming to ASTM D1785 or equivalent standard.

PVC is generally an acceptable material for plumbing FAFCO® solar thermal systems. In most cases, an operating solar thermal system does not exceed the temperature rating of PVC. Unless it can be shown that black PVC withstands equivalent temperature and pressure specifications of PVC by providing documentation that it conforms to ASTM D1785 or an equivalent standard, it should not be used for solar plumbing.

Due to the poor UV resistant properties of PVC, it should be painted upon completion of the installation. In many jurisdictions, painting the plumbing is required by code.

Instances occur where a system will be pressurized while at elevated temperatures. CPVC offers a much higher operating temperature and should be considered for use on the supply and return lines, especially for installations of more than two stories and those likely to see water temperatures above 140°F such as sections of plumbing where water can be entrapped at an elevated temperature. (see **Table 4,** *Appendix C*).

Roof Penetrations

All mounting penetrations must be installed as described in *Phase I Site Preparation and Planning.*

All roof penetrations should be sealed with an industry standard method.

Hybrid System Layouts

Panels are compatible with most systems, including FAFCO®'s CoolPV® panels.

The best way to install a hybrid *CT*/CoolPV® system is to prioritize placement and plumbing to the CoolPV® panels and then to install Panels on the remaining roof space. Panels are less sensitive to location, which will have a lesser impact on performance than a CoolPV® panel. To see how a split Hybrid system should be plumbed, refer to **Figure 8**.

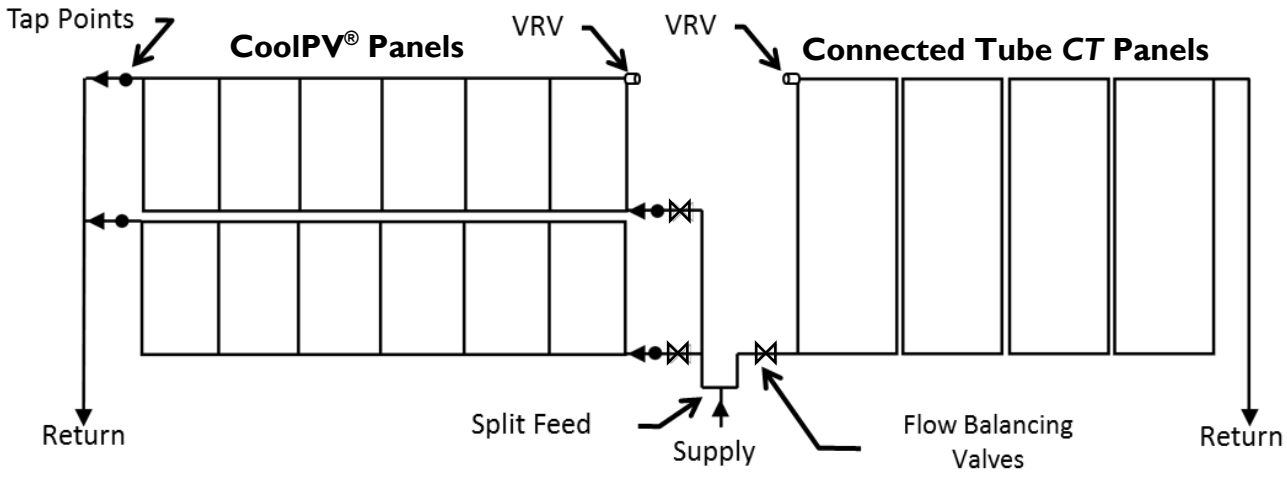


Figure 8 | Hybrid CoolPV® and Connected Tube *CT* Plumbing Schematic

PHASE II — System Installation Detail

Mounting Panels

Be mindful when handling Panels. Rough handling can cause unnecessary body damage which will likely result in premature failure or leaking.

CAUTION: Before installing Panels, check roof and racking for protruding hardware that may damage the Panels.

Panels should be installed insert to insert with the coupler pushed all the way up to the edge of the Panel body and insert dam.

Panels can increase up to 1" in length as they heat up on hot summer days. Ensure there is roughly 2" of extra space at the end of the Panel for growth with temperature.

Because of this movement, it's advisable to put some material under the couplers to prevent any unwanted abrasion to the roof or mounting structures.

When installing the Panels, pay careful attention to install the couplers all the way up against the Panel insert and to position the coupler clamps as indicated in Figure 9 below. This greatly reduces the need for Panel adjustments later on.

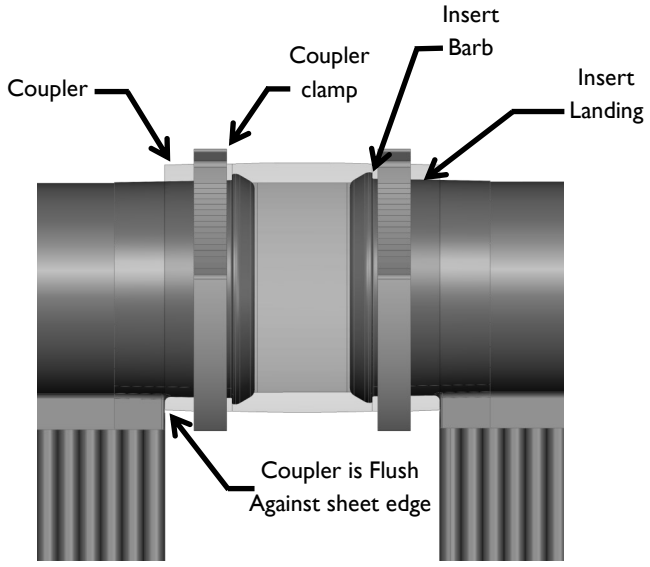


Figure 9 Panel Coupling

Initial Panel alignment can be done while installing the Coupler connections. Note that the Panel Coupler Clamps must be installed all the way up against the Insert Barb and positioned to clamp over the Insert Landing. The Coupler Clamps must be positioned as depicted. Incorrect placement of these components can lead to excessive expansion of the Panel bank and cause damage and leaking. Placement should be checked when the system is up and running, by making sure all couplers haven't moved more than 1/8".

Note: It is crucial that the Panel couplers and coupler clamps are installed properly. If improperly positioned, the coupler clamps and couplers can move and the entire bank of Panels can expand severely under pressure, causing the Panel body to collide with roof-mounted obstacles.

When installing mounting hardware, it is best practice to use the premeasured method mentioned in *Panel Layout* of *PHASE I—Site Preparations and Planning*.

It can be easier to place penetrations after all plumbing is installed. Therefore, it is also acceptable to use the *Circulation Method* when placing mid-bank penetrations as described below.

Note: <u>The Circulation Method</u> can only be used if the pool can be circulated to the solar system such that the Panels have an approximate surface temperature of 70-90°F. The surface of the Panels can be measured with an irradiance meter or similar surface temperature measuring device. If needed, adjust the flow rates to the solar system to achieve an acceptable reading for the procedure.

Note: Use caution if employing this method and do not perform in high wind conditions since Panels aren't fully mounted.

Follow these steps to mount Panels using the <u>Circulation Method:</u>

1. Lay Panels in desired locations and plumb them together.
2. Determine the centermost Panel (or a Panel which the bank needs to move about) and fix-mount it by the upper headers (described in **Figure 11a**) or by another means of limiting bank movement.
3. Mount upper headers of remaining Panels.
4. Route and connect all plumbing to the system.
5. Let pool water circulate through the Panels until all air is purged out and the Panels have reached an operating temperature of 70-90°F.
6. While the solar system is running, mount hardware by centering penetrations between each Panel.
7. Once all mounting has been completed, turn the system off and ensure that the bank doesn't move into mounting hardware. If it does, address as needed.

Connect Supply & Return Lines

Panel Couplers (PN 10196) are used to make a semi flexible connection from a *Panel* bank to Schedule 40, 2" PVC piping. Below is the best order to follow for connecting the supply and return lines:

1. Check that all supply lines are connected to the lowest end of their Panel row and that the upper ends feed to a common high point in the system. (as in **Figure 5**).
2. Connect panel couplers (PN 10196) on upper and lower inserts of all Panel corners for supply and return plumbing. Be sure to install Coupler Clamps as depicted in **Figure 9.**
3. Route supply line to the bottom header of each row.
4. Route the return line to the upper header of each row.
5. **If there are straight pipe runs in the plumbing exceeding 10ft without an offset, there must be either a plumbing expansion kit installed or an industry standard method to accommodate for any expansion and contraction (see *Plumbing Layout* and *Appendix C* for details).**
6. Both supply and return line plumbing must be mounted so that it is allowed to move an equivalent of 1/2" for every Panel between it and the Fix Mounted Panel in the bank. If there are multiple Panels, it may be advisable to install an expansion joint immediately in the plumbing so that when the bank moves with temperature, the plumbing will be able to absorb the movement immediately. Refer to *Plumbing Layout* and *Appendix C.*

CAUTION: Overtightening Hose Clamps can deform couplers and lead to leaks.

Obstacle Avoidance

Since the Panels are made of a polymer that experience large temperature swings, there can be a lot of natural movement in an array as well as all plumbing. If simple practices are not adhered to, this natural movement can cause damage to solar Panels, plumbing and roof penetrations.

As seen in *Phase I, Plumbing Layout* and *Appendix C, Panel* banks move both laterally and longitudinally along the roof. It's often best to mount the midpoint of the bank so that the movement is divided evenly to both sides of the bank. This can be done by use of fixed point header anchors on the fixed Panel of both upper headers (see **Figure 11**). Use a means of fix-mounting this Panel which best fits the practices of the installation company. The movement of the bank will translate to the plumbing. It is crucial to plumb the banks so that this movement can either be absorbed in the coupler or absorbed in the plumbing. To accommodate for movement in the banks, all plumbing must be coupled to the bank with a panel coupler (PN 10196) and if there is a long run of plumbing going directly to the bank, accommodations for thermal expansion must be utilized. Refer to the **Figures 16 and 20** in *Appendix C.*

Panels may need to be spaced out to allow for mid-bank obstacles or changes in roof shape. In most cases, the banks will need to have additional spacing added so that the bank can be plumbed around the obstacle. Gaps can be filled by connecting PVC runs to Pipe Adapters and Couplers as depicted in **Figure 10**. For simplicity, the FAFCO Spacer Kit (PN 10203) contains added components to space out a panel row around roof obstacles.

Regardless of the type of gap needed in a bank, the procedure will be as following:

1. Begin by laying the Panels as intended in the layout. Start with the Panel(s) which pose the most limitations on mounting. As each Panel is placed, ensure there is proper obstacle avoidance by allowing a 2" clearance.
2. If less than a 2" clearance is available, consult **Table 3** in *Appendix C* to determine an absolute minimum gap size needed for the obstacle.

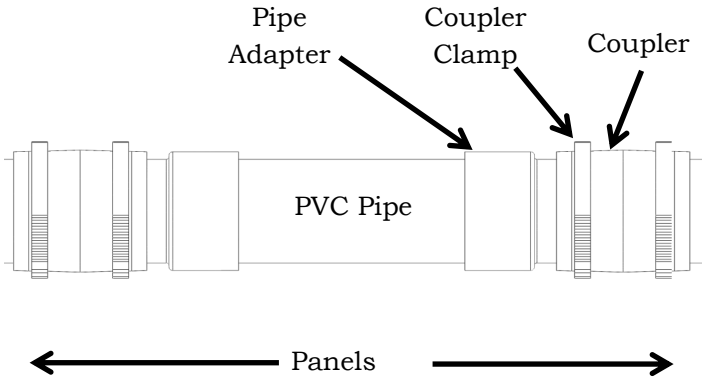


Figure 10 | Adding Space to a Row

In order to accommodate for obstacles in a row, Panels may need to be spaced out by adapting the couplers to PVC (Split Pack, PN 155)

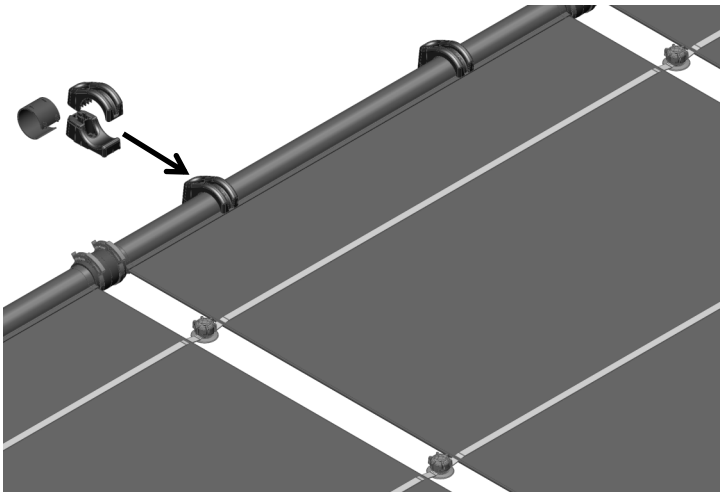


Figure 11 | The Fixed Point

A fixed point should be identified as a point where the thermal expansion moves away from. On the Fix-Mounted Panel, a fixed point insert (PN10209) should be used on one header anchor per bank. This will keep the Panel at the center point of bank movement. The header anchor has a special insert to hold the header in place. A means of limiting plumbing movement should be used which best fits the practices of the installation company. Refer to Appendix C.

Note: Narrow Panels (2ft wide) can be useful on roofs where there are multiple obstacles to avoid and standard size Panels don't fit.

1. Once all Panels have been positioned with clearance, finish plumbing the Panels as described in *Phase I — Mounting Panels* and *Connect Supply and Return Lines.*
2. After turning on the system, ensure the banks have not moved too close to obstacles and address as needed.
3. Once fitment is verified, finish mounting by adding mid-bank roof penetrations by centering with the system running.
4. The Panels may then be strapped down with Panel body straps. Do so by starting on one side of the bank, tightening down the strap with the Strap Anchor and working through the bank one strap at a time. **Note: Panel straps should be installed with a mild amount of tension so as to not be exceptionally loose. If necessary, let slack into the series and repeat. Do not install strapping around lower headers. Panels need to move up and down the roof with temperature fluctuations.**

VRV & End Caps

Install a Vacuum Relief Valve (VRV) by plumbing up with a "TEE" fitting on the return line from the highest bank. See the Panel to VRV section of **Figure 4** for an assembly schematic. Only one is necessary for each roof pitch in a typical system and should be installed on the highest bank. Note that it's permissible to install the VRV so that it functions as an end cap for the opposing corner of the bank and that there are fewer parts involved if doing so this way. The primary reason for "Teeing" up the VRV is that it will likely be less prone to failure from sediment buildup during operation. Systems with rows on multiple roofs require an additional VRV for each pitch.

Install End Caps to seal headers opposite the supply and return connections.

Diverter Valve

The Diverter Valve is the "on switch" for the solar system. It should be set to both allow and prevent flow into the solar system (shown in **Figure 12**) and installs in the pool plumbing as detailed in **Figures 26-29** of *Appendix E.*

An actuator will be needed when automating a solar system. Follow the procedure specified by the manufacturer of your actuator. By positioning the valve as in **Figure 12,** the actuator cams can be left 180° apart, as provided by the manufacturer.

See *Appendix E* for detailed alternate Diverter Valve placements and types.

The 2877 Jandy Pro Series non-positive diverter valve, or equivalent is recommended along with a pool automation system of choice.

When installed as specified by FAFCO® Inc. no modification of diverter valves or actuators is necessary.

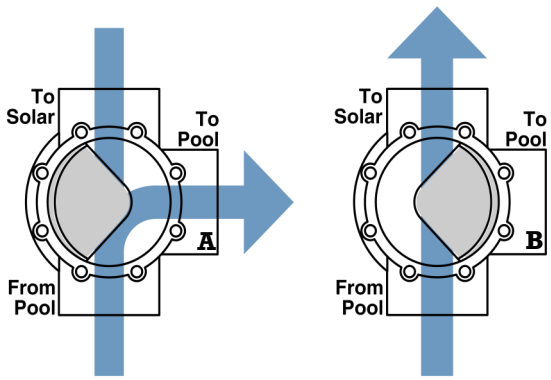


Figure 12 | Diverter Flow

Diverter Valves should be set to allow two flow options. One design option is depicted. Alternate methods are outlined in *Appendix E.*
A) System Off, Leaving all three paths open **B)** System On, Closing the path on the To Pool side. (In some cases, plumbing the Diverter with a Neutral flow position (depicted) can allow partial flow to the solar and overheat the pool. Consult your local install department or FAFCO® for further details.)

Pool Equipment Tie In

Once the plumbing is completed and ready to tie in to the solar array on the roof, the plumbing is ready to be connected to the pool equipment.

Note: It is critical to manually flush any debris out of the lines before connecting the solar array and the pool equipment.

Follow these steps for flushing the lines:

1. Ensure all plumbing is connected except the couplings to the solar array and the final lines at the pool equipment.
2. Manually plug the solar lines at the pool equipment with a rag or loose pipe cap (or at the low point in the plumbing).
3. Using a garden hose, fill both supply and return lines with water at the high points in the system.
4. Allow the water to release from the lines and purge the debris from the plumbing system.
5. Repeat if necessary.

Note: This procedure can also be performed by plumbing everything except the final connection to the Panel banks and using the pool pump to circulate water to the roof.

Once lines are properly purged of any chips or other debris, both the solar array and the pool equipment can be connected. See **Figure 2** and *Appendix E* for a complete description of all necessary components at the pool equipment.

Pool Plumbing

The solar thermal system is installed after the pump and filter but before additional pool equipment. (**Figure 2**).

Alternatively, if pool equipment is specifically labeled by the manufacturer then it may be installed before the solar equipment. Such equipment may include intellichems, and ultraviolet cleaning systems.

The first component after the filter is a check valve. Always leave room for check valves to be cut out and replaced. The use of pool swing or spring check valves, such as the 7305 Jandy Pro Series, are recommended.

Next, the diverter valve and PVC tees are installed.

Install an isolation valve, such as a PVC ball valve or equivalent, on the piping going to the solar. Install a second isolation valve on the return line. If desired, a check valve can be used on the return line in place of the isolation valve. These components are always installed before any back up pool heaters or chlorinators.

CAUTION: If the isolation valve on the return line were closed while the system was running, damage to the system would result from over-pressurization.

Always be sure to turn both valves when isolating the solar system from the main pool equipment.

Manual solar drain valves are only recommended to be placed on plumbing lines which don't drain when equipment is turned off. The primary purpose of manual drain valves is to provide easy draining access for service and winterization.

Drain valves should be installed in an accessible location at the lowest elevation possible and MUST adhere to the placement shown in Figures 2 and 13.

Flush out all pipes before they are connected to the thermal system as specified in *Pool Equipment Tie In.* Once plumbing is connected, ensure all lines exposed to the sun are properly protected from UV exposure. Most common practice is to thoroughly paint all plumbing.

Note: If using *Flexible PVC* lines as a means of absorbing Thermal Movement, use multiple coats of paint or cover the segments with a UV barrier such as a braded sheathing to keep the segment thoroughly protected from excessive UV exposure.

Thermal System Automation

Automating the solar pool heating system is not required, though is highly recommended by FAFCO®. Systems that are automated will be able to run when ambient conditions support pool heating. If the pool system is not automated, the solar system may be mistakenly left on when there is not adequate solar energy to heat the pool and could cause the pool to lose heat, thus countering the purpose of the solar heating system. In addition, a manual diverter valve can be left on and overheat the pool or cause a stagnation effect when the pump is turned off. **Caution: Stagnated solar systems can trap water at scalding temperatures and result in severe burns.**

Electrically operated solar controllers are available from a variety of manufacturers. When installing an automated system be sure to read and follow the directions for the controls equipment to ensure their proper operation. It is highly recommended that all solar systems be installed in conjunction with a pool automation system for optimum system performance.

PHASE III — Commissioning

Diverter Valve

The diverter valve is critical to the function of the thermal system. Ensure it functions properly.

1. Check that the actuator repositions the valve when directed.
2. Check that the set positions direct flow as expected.

Pressure & Leak Check

Test that the thermal system will hold under normal operating pressure without leaking (no greater than 30 psi with the system below 100°F).

CAUTION: Over-pressurizing Panels will void the warranty.

1. Open the isolation valve and direct the diverter valve to allow flow into the thermal loop.
2. Turn on pool pump.
3. Allow the system to run, checking all pipes, connections, and Panels for signs of leaking.
4. If no leaks appear then the system is ready for operation. If leaks do occur, address the issue and repeat the test procedure.

Placement of Sensors

When automating a system it is critical that temperature sensors be placed in appropriate positions. Please refer to the manufacturer's installation manual of your chosen controller.

Pool Temperature Sensor

A pool temperature sensor is used by the automation controller to decide when to turn the system on or off for efficient temperature control and energy use.

Solar Temperature Sensor

By taking measurements of the roof, the controller can compare the solar temperature to the current pool temperature. This information allows the system to achieve the desired, final pool temperature.

System Automation

To ensure optimum performance, it is highly recommended to automate all solar thermal systems with an automation package of choice. There are many automation packages which are available from pool suppliers such as Pentair, Jandy, and Hayward. It is recommended by FAFCO® to source from a supplier of your preference.

A Solar Pool Automation Kit should include a minimum of the following:

1. A Diverter Valve Actuator (180° or 90°)
2. An in-plumbing Pool Temperature Sensor
3. An ambient Solar Temperature Sensor
4. A Programmable Automation Controller

It is common to program the controller so that the solar system will run if roof temperatures are 6°F or greater above the pool temperature and to bypass the solar loop if the roof is less than 3°F above pool temperature. For further system automation, see instructions from the Manufacturer of the equipment being used.

Commissioning Checksheet

Ensure the full solar pool system is operational. Refer to the associated installation manuals as necessary. Once everything is functioning as intended for normal operation, fill out the *Commissioning Check Sheet* located in *Appendix A*.

The Commissioning Check Sheet has been provided as an aid to make sure that your system is installed correctly. In addition, the Commissioning Check Sheet can be used as a supplementary reference document for future service work.

PHASE IV — Routine Maintenance

Winterization

Note: Panels are not warrantied against freeze damage.

CT Panels must be completely drained and isolated before winter to prevent freeze damage. Not all climates have cold enough weather to cause freeze damage, so the rule of thumb is if the ambient temperature drops below 45°F at any point, the system needs to be winterized.

In most cases, winterizations will be performed throughout September and October but may be performed as late as November. The best time to winterize a system is when it is no longer producing additional heating to the pool during typical solar heating hours.

Solar Panels will withstand freezing conditions when properly drained and isolated as follows (refer to **Figure 13** for component locations):

1. Turn off the pool pump and pool sweep (1)
2. Turn off the solar system controller (2)
3. Open optional solar drain valves if included (3)
4. Remove end caps (4) and vacuum relief valve (5). Leave off and store in a safe place for winter
5. Let the system completely drain for 5 minutes
   Note: Blowing the lines with a shop vac, leaf blower, or compressor will NOT remove water completely
6. Close isolation valve(s) (7) for winter (**Figure 14**)
7. Ensure the solar system remains off for winter
8. The pool pump, filter, and sweep can now be used while isolated from the solar system

Spring Startup

Spring Startup for solar Panels is essentially the opposite order of winterizing but also includes checking for leaks and any damage which could have occurred during the winter season.

Typically a system should be recommissioned for summer use whenever ambient temperatures and sunshine is able to produce reasonable heat to exchange with the pool. The startup season will vary by location, but is usually anywhere from early to late Spring.

Follow the below steps to recommission the solar system (refer to **Figure 13** for component locations):

1. Put system into service mode, (turn off the pool pump and pool sweep (1) if running)
2. Close optional solar drain valves if included (3)
3. Reinstall end caps (4) and vacuum relief valve (5) (Retrieve from stored location during winter)
4. Inspect plumbing lines and service if attention is needed
5. Open the solar isolation valves (7) for spring startup (**Figure 15**)
6. Turn on the pool pump (1) and run the solar system controller (2)
7. Inspect the system for any leaking, and address as needed
8. Watch the pool inlet to ensure that all air is purged and that no champagne bubbles remain. If bubbles remain, address the issue
9. Run through the automation system (2) and ensure the system is operating as intended
10. Repaint any solar plumbing that needs touch-ups. **Note: If *Flexible PVC Hoses* are used, ensure there is not degradation of paint or other UV protective materials. Address as needed.**
11. Check all mounting components and roof penetrations to ensure that everything is secure and properly sealed
12. The pool pump, filter, sweep, and solar system can now be used for the summer

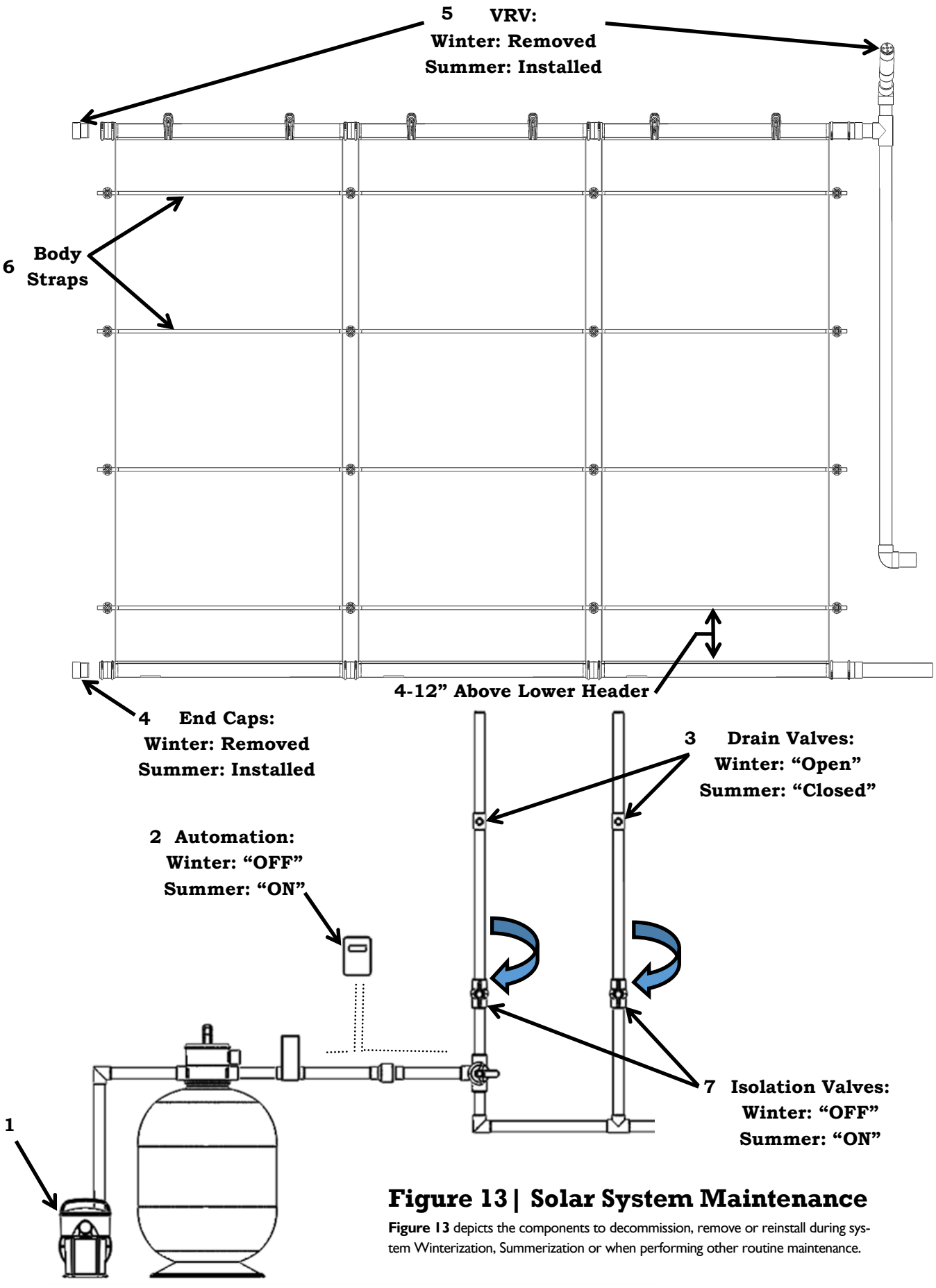
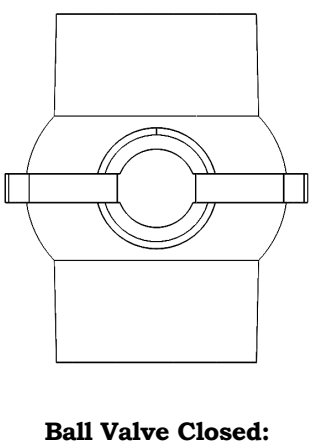
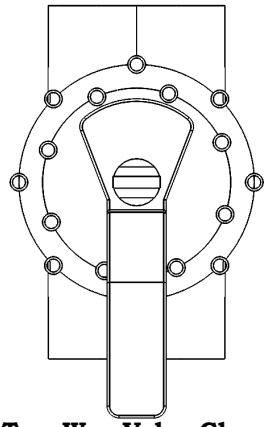


Figure 13 | Solar System Maintenance

Figure 13 depicts the components to decommission, remove or reinstall during system Winterization, Summerization or when performing other routine maintenance.



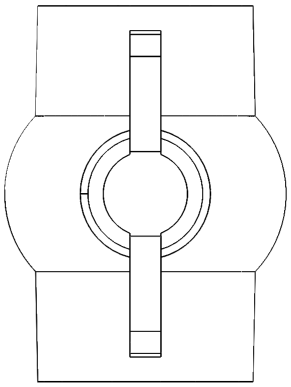
Ball Valve Closed:
Handle Perpendicular to direction of flow



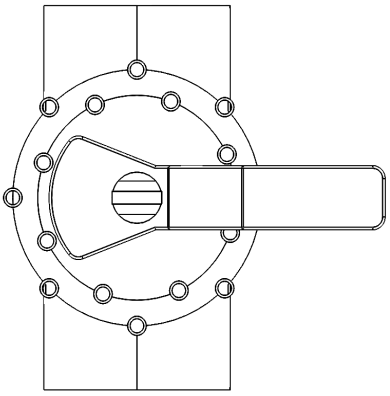
Two-Way Valve Closed:
Handle in-line with direction of flow

Figure 14| Closed Isolation Valves

Figure 14 depicts the position of both a Closed PVC Ball Valve Handle (left) and a Closed 2-way Pool Valve Handle (right) on an Isolated, Winterized System or a system being serviced.



Ball Valve Open:
Handle in line with direction of flow



Two-Way Valve Open:
Handle Perpendicular to direction of flow

Figure 15 | Open Isolation Valves

Figure 15 depicts the position of both an Open PVC Ball Valve Handle (left) and an Open 2-way Pool Valve Handle (right) on a Summer ready System.

Pool Maintenance

Solar isolation should be performed during pool maintenance as well. Follow these steps before filter cleaning, backwashing, or pool vacuuming (see **Figure 13** for component locations):

1. Turn the pump and solar system "OFF" (1 & 2)
2. Close the solar isolation valves (7) (See **Figure 14**)
3. Proceed with filter cleaning or vacuuming
4. After pool maintenance is complete, run the pump for a few minutes to clear any debris from pool lines
5. Open the solar isolation valves (7)
6. Turn the solar automation system "ON" (2)

Panel Repairs

NOTE: All Panel repairs are to be expressly performed with FAFCO® parts, and repair kits in accordance with FAFCO® repair procedures. Attempts to repair leaking Panels outside of these guidelines will void the warranty.

There can be a variety of reasons for Panel leaking but the solution for repair is generally the same. A tube leak can be repaired if damage is located at least 2" away from the header. Refer to the product warranty policy for information regarding other damages.

In order to repair a tube leak, use only a FAFCO® Panel Repair Kit (PN 161). Refer to the detailed instructions in the repair kit for a complete repair procedure. If the Panel develops a leak anywhere along the header or where the header and Panel body connect, these leaks are not repairable. In the event that a leak develops away from the Panel body, the Panel cannot be repaired and should be replaced. If the Panel is still under manufacturer's warranty, contact FAFCO® to determine replacement eligibility.

IMPORTANT: Attempts to repair Panels by any other means will void FAFCO®'s Manufacturer's Warranty. All repairs are only to be performed with FAFCO® parts, and repair kits in accordance with FAFCO® repair procedures. Do not attempt to apply screws, epoxy or any other types of sealant!!

Closing Checklist

It is critical to the performance and longevity of the system that the following requirements be met:

- ☐ The centermost Panel in a bank should be "Fix-Mounted" so that the rest of the bank moves about the centermost Panel (Fix-Mounted Panel may be located elsewhere if governed by another factor)
- ☐ Each Panel is mounted and spaced to allow for thermal expansion and contraction
- ☐ Strap Anchors must be centered between Panels when system is running at operating temperatures
- ☐ The system must be capable of draining (if not, manual drain valves should be installed and annual winterization records must be kept)
- ☐ All plumbing in the system must hold under pressure without leaking
- ☐ All plumbing in the system utilizes a standard method to allow for thermal movement
- ☐ If used, all Flexible PVC lines are thoroughly protected from UV exposure by paint, wrapping, or other method
- ☐ Non-draining plumbing is able to be manually drained
- ☐ There must be a VRV installed at the highest elevation in the plumbing for each major roof line/pitch
- ☐ All panels installed on a barrel tile, flat tile or standing seam metal roof have full-length substrates fully protecting each panel from abrasion and uneven contours

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Revision History

Rev.	Date	Comments
-	3/2023	NEW COMBINED RELEASE INCLUDING: Updated for narrow panels, new couplers, coupler clamps, strap clamps, header anchors and combined CT and ST manual.

FAFCO®, Inc.
435 Otterson Drive
Chico, CA 95928
Phone: (530) 332-2100
FAX: (530) 332-2109
P/N 10222
REV -

Commissioning Check Sheet

System Owner: _____ **Phone:** _____

Installation Address: _____

Installed By: _____ **Install Date:** ___/___/___

Install Company: _____ *if applicable* **Phone:** _____

General Installation Practices

- ☐ The centermost Panel in a bank is "Fix-Mounted" so that the rest of the bank moves about the centermost Panel
- ☐ Each Panel is mounted and spaced to allow for thermal expansion and contraction
- ☐ Strap Anchors are centered between Panels when system is running at operating temperatures
- ☐ The system automatically drains or manual drain valves are installed for annual winterization
- ☐ All plumbing in the system holds under pressure without leaking
- ☐ All plumbing in the system utilizes a standard method to allow for thermal movement
- ☐ Non draining plumbing can be manually drained with a relief valve or by removing fittings
- ☐ The VRV is installed at the highest elevation in the plumbing for each major roof line/pitch
- ☐ All panels installed on a barrel tile, flat tile or standing seam metal roof have full-length substrates fully protecting each panel from abrasion and uneven contours

Array Plumbing Method

- ☐ Same Side Feed/Return
- ☐ Opposite Side Feed/Return

Plumbing Used

- ☐ Sch. 40 CPVC
- ☐ Sch. 40 PVC

Elevation Of System

- ☐ 1st Story
- ☐ 2nd Story
- ☐ 3rd Story
- ☐ Ground Level
- ☐ Pool Surface
- ☐ ≤20ft Below Pool Surface

Array Layout

- ☐ A copy of the installed layout for this system has been sketched.
- ☐ A copy of the installed layout for this system has been attached.

Filter Pressure

Filter Gage Functional: YES / NO (circle one)

Thermal System On: _____PSI Off: _____PSI Difference:_____ PSI

Stickers Placed

- ☐ Thermal Supply Isolation Valve
- ☐ Thermal Return Isolation Valve
- ☐ Filter Backflush Instructions
- ☐ *Valve Flow Direction*
- ☐ *Means of Freeze Protection*

Pump Sizing Calculation Tables

Table 1: Head Loss Calculation Table for 2" PVC Fittings

Fitting Used	Equivalent Pipe Length Head Loss of Fitting (ft)	Quantity Used	Totals
45° Elbow	Box A 2.7	Box E	Box I (A*E)
90° Elbow	Box B 8.5	Box F	Box J (B*F)
Sweep	Box C 3.6	Box G	Box K (C*G)
Tee's	Box D 12	Box H	Box L (D*H)
Total Fitting Equivalent Length (ft)		Box M	(I+J+K+L)
Feet of Straight Piping Used (ft)		Box N	(total pipe length used)
Equivalent Sys Straight Pipe Length (ft)		Box O	(M+N)
Panel Eq. Head Loss (ft)	# Panels on Roof/# Rows	Average Bank Size	Pressure Drop (ft)
	Box P /	Box Q (Box P result)	Box R (Box Q*5.1 ft ea. panel)
System Dynamic Head Loss Calculation	System Flow Rate (GPM) (#Panels*0.1GPM/ft² ea.)	Head Loss/ft Piping (ft) (from System Flow Rate)	*Total Dynamic Head Loss (ft)*
	Box S	Box T (Table A2 from box S)	Box U (T*O)
Vertical Head Loss (ft)		Box V	(Pump to top header height)
Head Loss in other Pool Equipment (ft)		Box W	(Losses for filter, heater, etc.)
Total Head Loss (ft)		Box X	(R+U+V+W)
Total Head Loss (psi)		Box Y	(X*0.43)

Table 2: Head Loss at Flow Rates in 2" PVC

Flow Rate (GPM)	Head Loss/ft Piping (ft)	Flow Rate (GPM)	Head Loss/ft Piping (ft)
0	0.000	45	0.036
4.5	0.0005	50	0.043
8	0.001	55	0.053
10	0.002	60	0.060
15	0.004	65	0.070
20	0.008	70	0.079
25	0.010	75	0.091
30	0.017	80	0.102
35	0.018	85	0.114
40	0.028	90	0.126

2" PVC Acceptable for Flow Rate *2" PVC Not Recommended for Flow Rate*

Example Pump Sizing Calculation

Example Table 1: Head Loss Calculation Table for 2" PVC Fittings

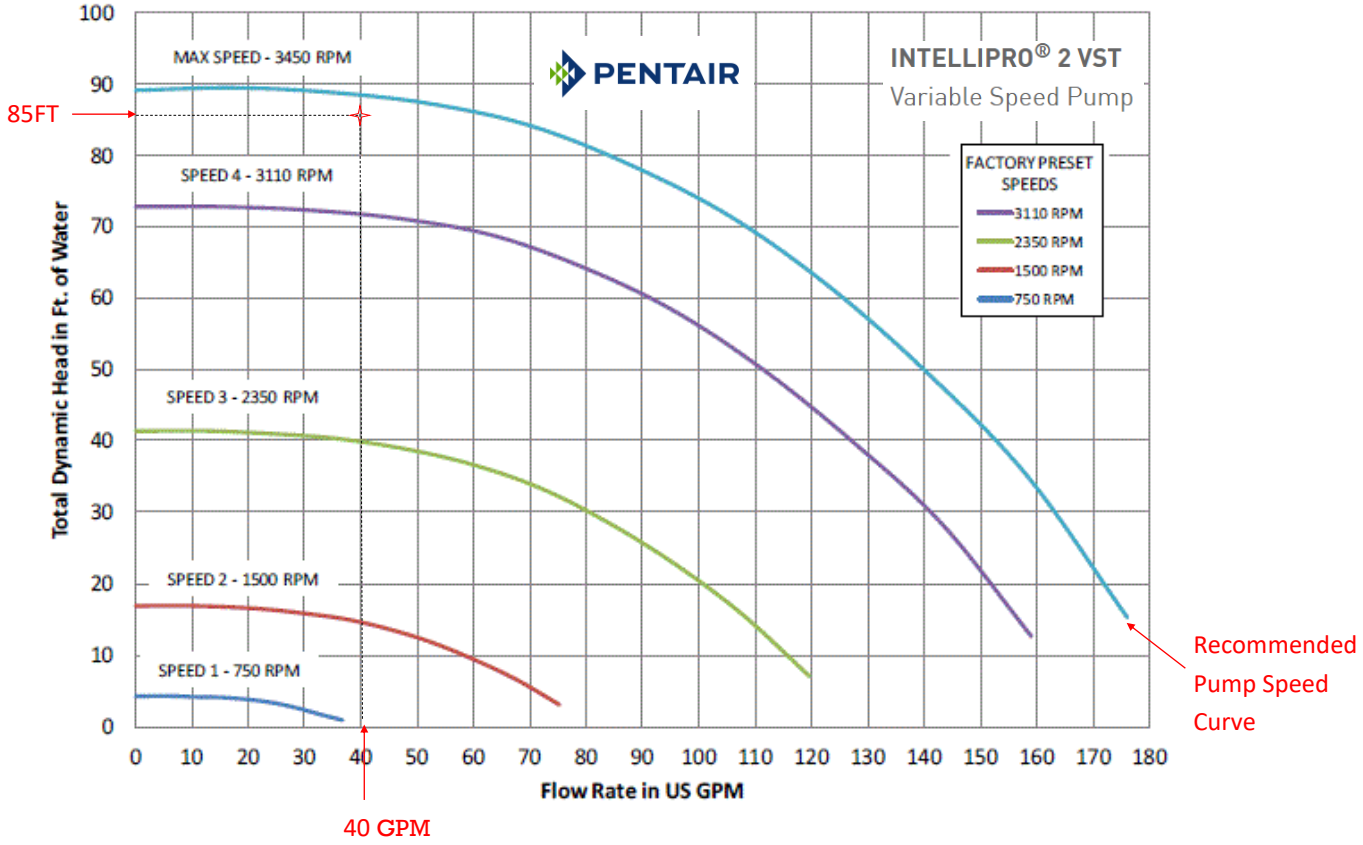
Fitting Used	Equivalent Pipe Length Head Loss of Fitting (ft)	Quantity Used	Totals
45° Elbow	Box A 2.7	Box E 8	Box I (A*E) = 22
90° Elbow	Box B 8.5	Box F 18	Box J (B*F) = 153
Sweep	Box C 3.6	Box G 0	Box K (C*G) = 0
Tee's	Box D 12	Box H 3	Box L (D*H) = 36
Total Fitting Equivalent Length (ft)		Box M 211	(I+J+K+L)
Feet of Straight Piping Used (ft)		Box N 80	(total pipe length used)
Equivalent Sys Straight Pipe Length (ft)		Box O 291	(M+N)
Panel Eq. Head Loss (ft)	# Panels on Roof/# Rows	Average Bank Size	Pressure Drop (ft)
	Box P 8 / 2	Box Q 4 (Box P result)	Box R 20.4 (Box Q*5.1 ft ea. panel)
System Dynamic Head Loss Calculation	System Flow Rate (GPM) (#Panels*0.1GPM/ft² ea.)	Head Loss/ft Piping (ft) (from System Flow Rate)	Total Dynamic Head Loss (ft)
	Box S 38.4 (round to 40)	Box T 0.028 (Table A2 from box S)	Box U 8.1 (T*O)
Vertical Head Loss (ft)		Box V 24	(Pump to top header height)
Head Loss in other Pool Equipment (ft)		Box W 32 (~14 psi)	(Losses for filter, heater, etc.)
Total Head Loss (ft)		Box X **85 FT**	(R+U+V+W)
Total Head Loss (psi)		Box Y **36 PSI**	(X*0.43)

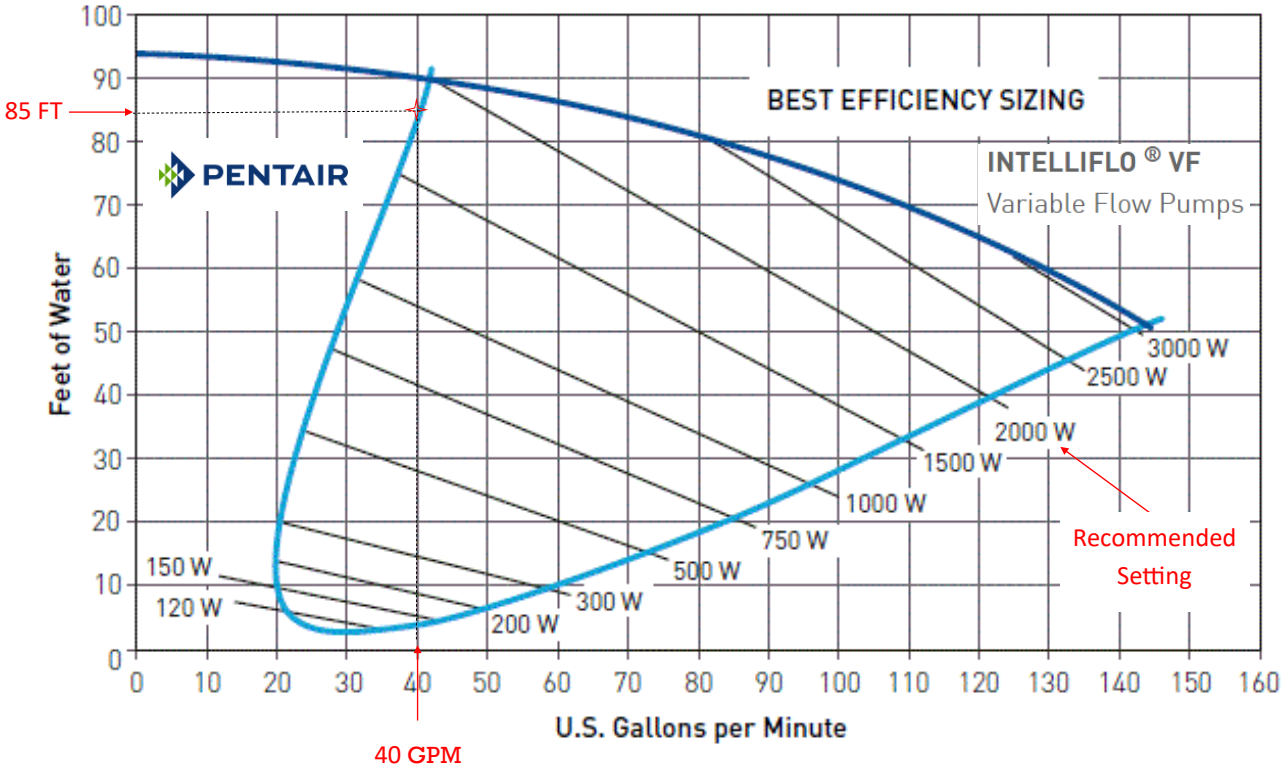
Example Table 2: Head Loss at Flow Rates in 2" PVC

Flow Rate (GPM)	Head Loss/ft Piping (ft)	Flow Rate (GPM)	Head Loss/ft Piping (ft)
0	0.000	45	0.036
4.5	0.0005	50	0.043
8	0.001	55	0.053
10	0.002	60	0.060
15	0.004	65	0.070
20	0.008	70	0.079
25	0.010	75	0.091
30	0.017	80	0.102
35	0.018	85	0.114
40	0.028	90	0.126

2" PVC Acceptable for Flow Rate *2" PVC Not Recommended for Flow Rate*

Example Manufacturer's Pump Curves





Bank Movement Clearances

Table 3 | Obstacle Clearance

Obstacle Clearances Needed	
# of Panels from Fixed Panel:	Permissible Obstacle Clearance (in):
1	1/4
2	1/2
3	3/4
4	1
5	1-1/4
6	1-1/2
7	1-3/4
8	2

Under normal movement of a bank, each Panel will have an incremental growth and contraction factor of 1/4" for each Panel away from the fix-mounted Panel in the bank. The body of the manual suggests a 2" obstacle clearance for installation. Use this table in cases where less than 2" nominal may be needed.

For example, if there is an obstacle on the right of the second Panel to the right of the fixed Panel (2 Panel gaps), there should be 1/2" clearance from the obstacle.

Plumbing Heat and Pressure Tolerances

Table 4 | CPVC vs. PVC

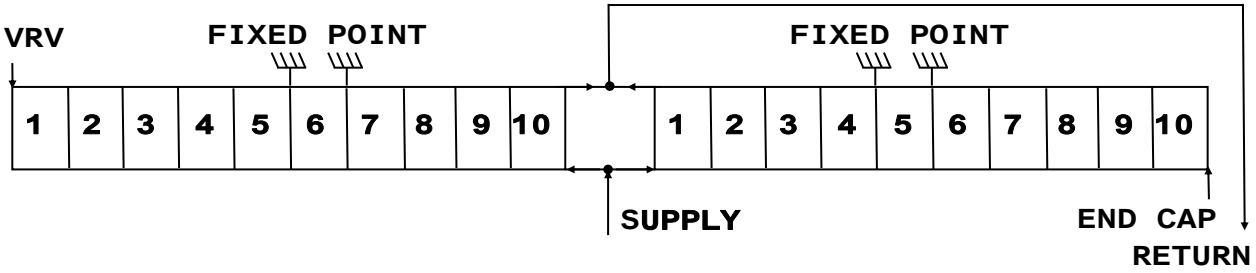
Maximum pressures that CPVC and PVC piping can withstand at higher temperatures.

Temperature [°F]	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**
CPVC Pressure [psi]	280	255	230	202	182	160	140	118	106	81.2	70.0
PVC Pressure [psi]	246	210	174	143	112	86.8	61.6	41.3	24.2*	10.1*	-

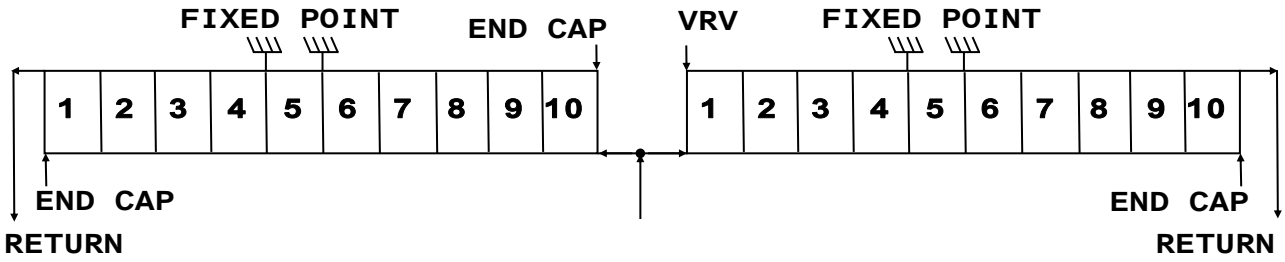
*** Systems must be rated to a minimum of 30 psi at the bottom header.**

Various Plumbing Configurations & High Point Return

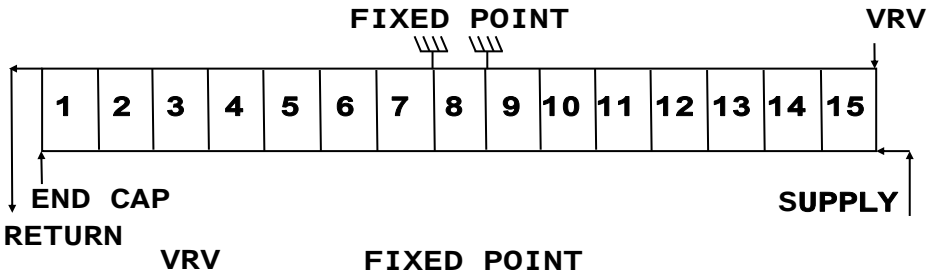
SPLIT FEED / SPLIT RETURN



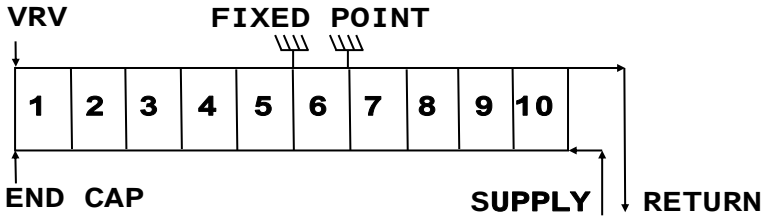
SPLIT FEED / REVERSE RETURN

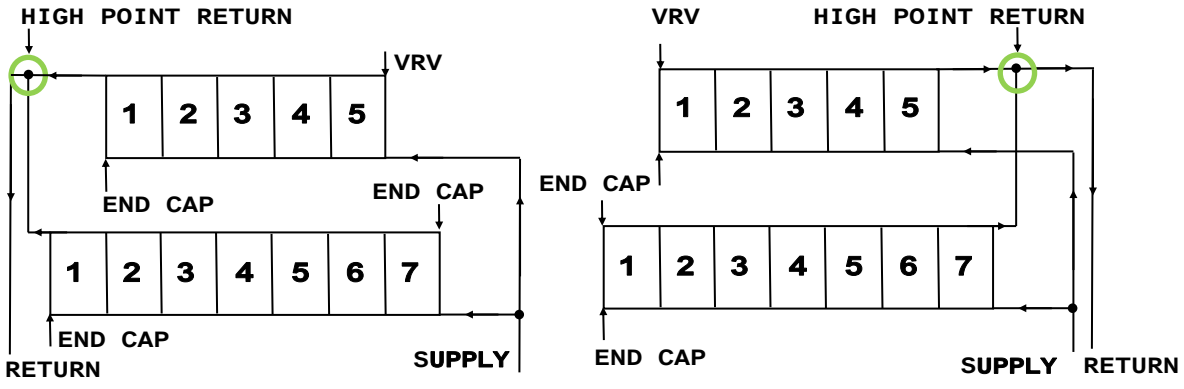


REVERSE RETURN



SAME END RETURN





I) **STACKED REVERSE RETURN**

II) **STACKED SAME END RETURN**

Figure 16 | High Point Return Line

Multi-Bank Pool Systems utilize a *common high point return* line enabling each bank to have proportional feed and return line backpressures which limits the water to favor the path of least resistance. Notice I) is an example of a stacked *Reverse Return* and II) is a stacked *Same End Return.*

Plumbing with Balancing Valves, No High Point Return

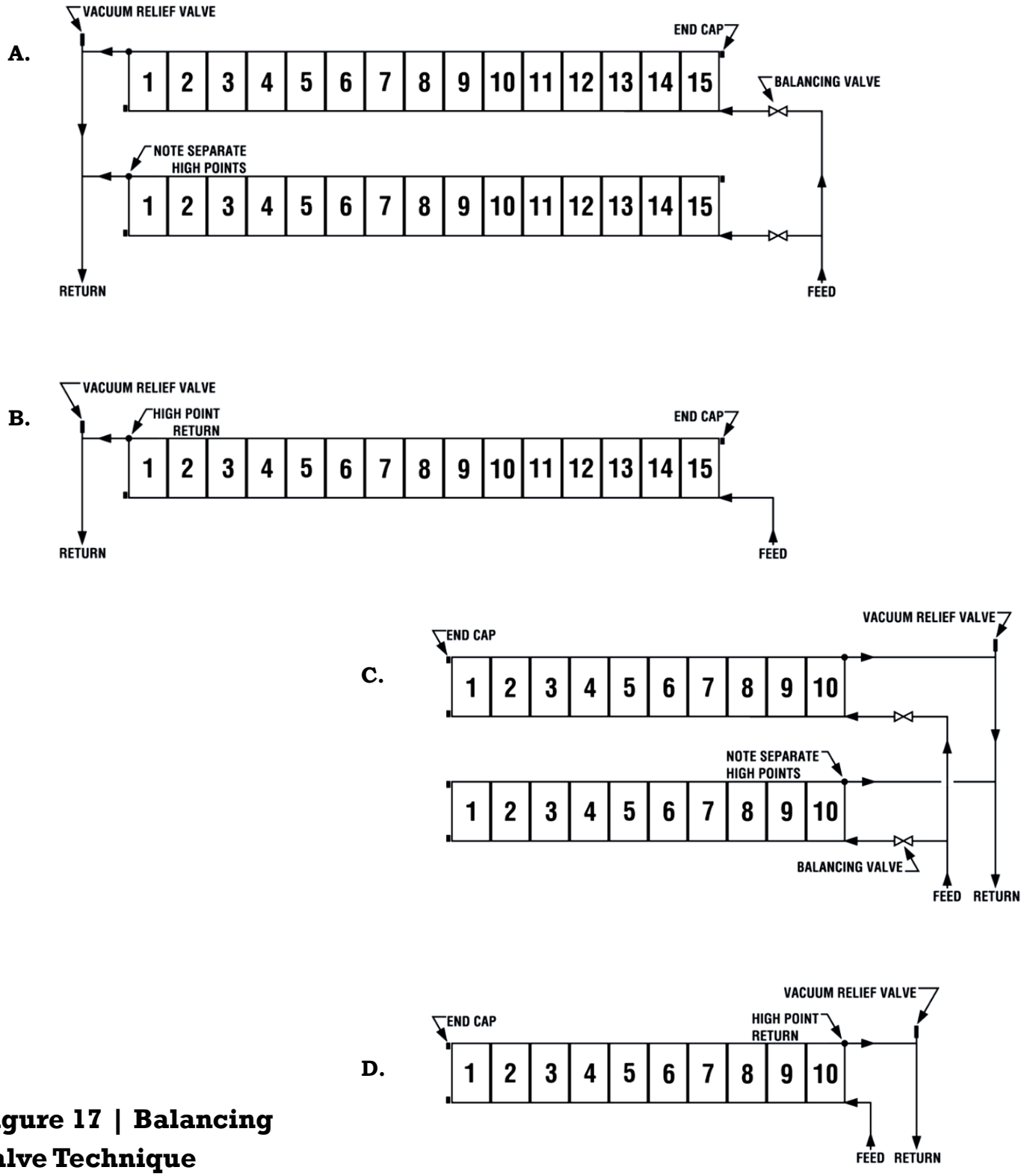


Figure 17 | Balancing Valve Technique

Multi-Bank Pool Systems utilize balancing valves on the supply line enabling each bank to have proportional feed which limits the water to favor the path of least resistance. Notice **A)** is an example of a *Reverse Return Multi-Bank* system where the balancing valves are needed and **B)** is a *Single Bank Reverse Return* which doesn't need balancing valves. Similarly, **C)** is an example of a *Same End Return Multi-Bank* system where the balancing valves are needed and **D)** is a *Single Bank Same End Return* which doesn't need balancing valves.

Plumbing Movement

Figure 18 | PVC Plumbing Offset

Right: A common industry standard for a plumbing offset (see **Table 5** below for offset distance L).

This offset can be oriented vertically (as shown) or horizontally to accommodate thermal movement in the direction of the plumbing. Notice the loose plumbing mounting points which restrict movement except in the axial direction. Refer also to **Figures 19, 20, 21 and 22 A, B and C,** along with associated tables for further use of offsets.

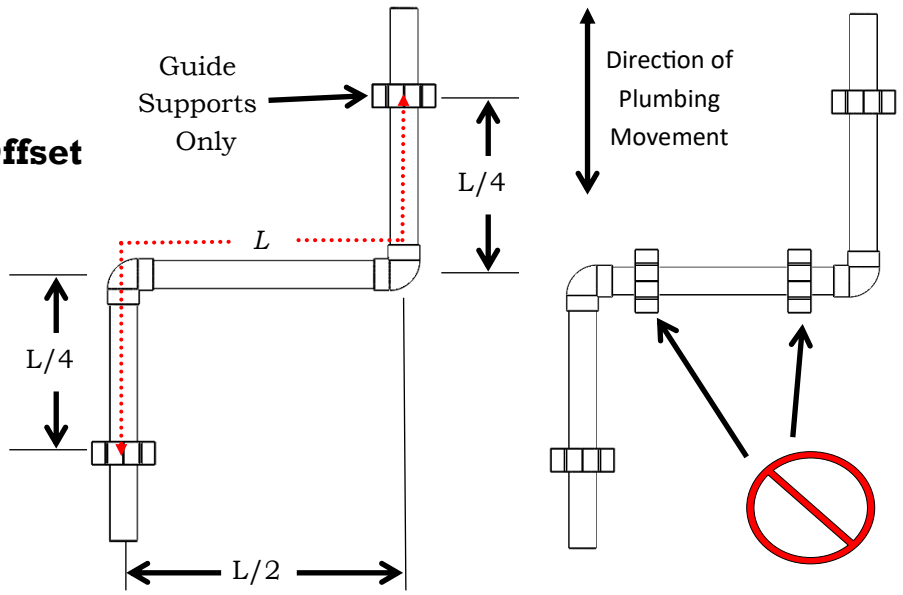
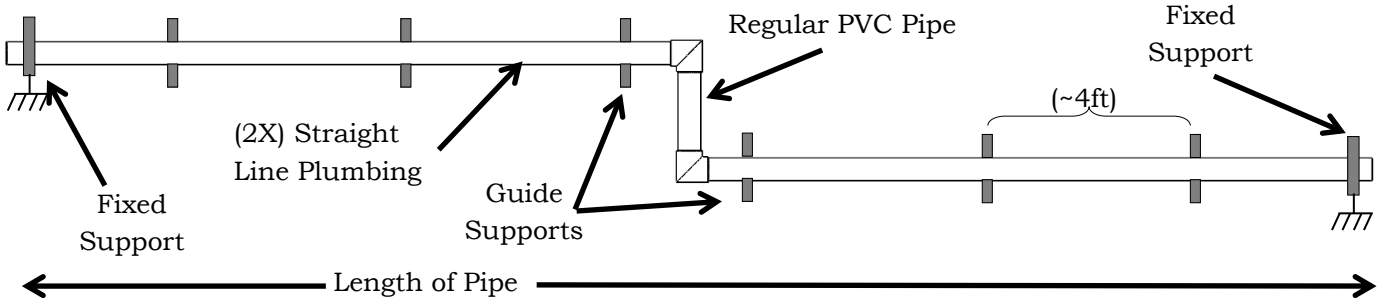


Figure 19 | Row Plumbing Movement

A straight line of plumbing can move up 1" for a length of 25ft. Plumbing expansion joints are advised to accommodate this movement. An industry standard method, such as an *offset* should be used so that the line can move as needed. Refer to **Table 5** for Regular PVC joint offset lengths and *offset* type for a length of pipe.



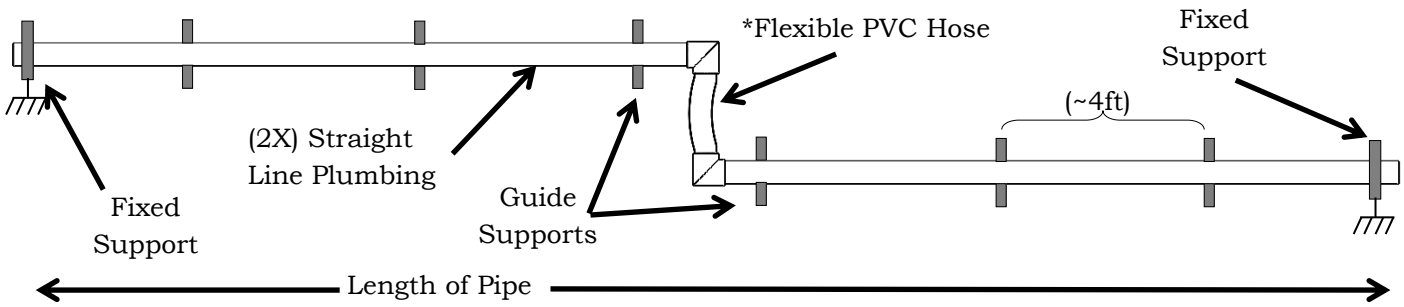
Expansion Dimensions Chart for PVC Offsets △T=80°F										
	Most Installations		*Most Installations, with Bank Movement*				*Uncommon Installations*			
Length of Pipe (ft)	10	20	30	40	50	60	70	80	90	100
Thermal Exp (in)	5/8	13/16	1-1/4	1-1/2	1-13/16	2-1/8	2-3/8	2-11/16	3	3-5/16
L/4 (in)	7	10	12	14	16	17	19	20	21	22
L/2 (in)	14	20	24	28	32	34	38	40	42	44
Single Offset Dist (in)	28	40	48	56	64	68	76	80	84	88
Exposed PVC (in)	8-11/16	14-11/16	18-11/16	22-11/16	26-11/16	28-11/16	32-11/16	34-11/16	36-11/16	38-11/16

Table 5 | Thermal Expansion of PVC Piping

To accommodate for long plumbing runs, refer to the table or incorporate an industry standard plumbing offset. If space doesn't permit, it may be advisable to use an alternate *Offset* method (as in **Figures 20 or 21**) for a single long run of plumbing.

Plumbing Movement

Figure 20 | Flexible PVC Offset



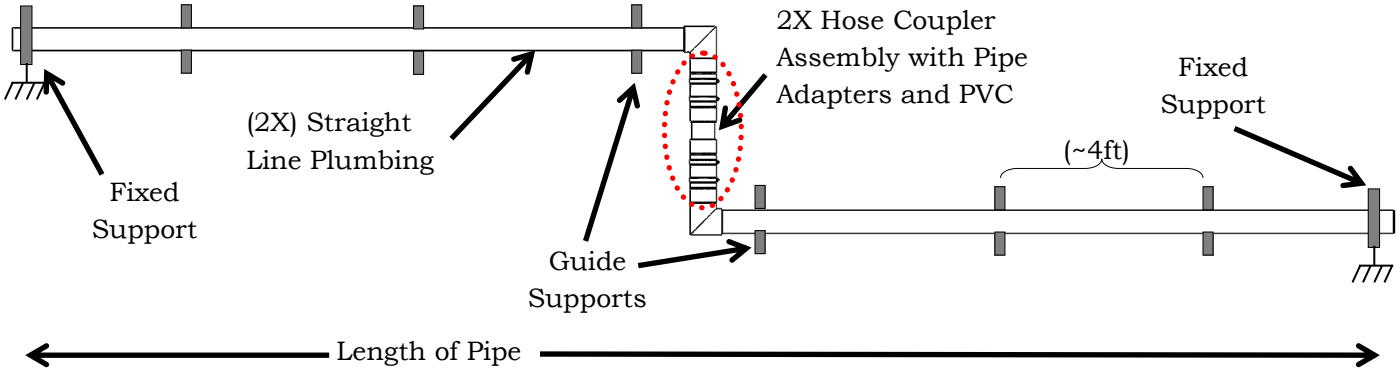
Expansion Dimensions Chart Flexible PVC Line Offsets△ T=80°F										
	Most Installations		*Most Installations, with Bank Movement*				*Uncommon Installations*			
Length of Pipe (ft)	10	20	30	40	50	60	70	80	90	100
Thermal Expansion (in)	5/8	13/16	1-1/4	1-1/2	1-13/16	2-1/8	2-3/8	2-11/16	3	3-5/16
Leg L/4 (in)	4-1/2	5	5-5/8	6-1/4	6-11/16	7-1/4	7-13/16	8-5/16	8-13/16	9-5/16
Leg L/2 (in)	9	10	11-5/16	12-5/16	13-3/8	14-3/8	15-1/2	16-5/8	17-5/8	18-11/16
Single Offset Dist L (in)	18	20	23	25	27	29	31	33	35	37
Exposed Flexible PVC (in)	3-13/16	4-11/16	6	7-1/8	8-1/8	9-1/4	10-5/16	11-5/16	12-3/8	13-3/8

Table 6 | Thermal Expansion of PVC Piping with Flexible PVC Offset

To accommodate for long plumbing runs or bank movement using a Flexible PVC Line, refer to the table below. Since the plumbing can be mounted as *Fixed* or *Guide* supports, a Conventional *Offset* can also be useful to absorb some or all of the movement in plumbing and solar banks. Other industry standard methods are also acceptable.

***Note: This method requires thorough UV protection of the *Flexible PVC Hose* segment. (*See Phase II, Pool Plumbing*)**

Figure 21 | Doubled Coupler Offset



Expansion Dimensions Chart for PVC Line Offsets with 3" Couplers in Line △T=80°F										
	Most Installations		*Most Installations, with Bank Movement*				*Uncommon Installations*			
Length of Pipe (ft)	10	20	30	40	50	60	70	80	90	100
Thermal Expansion (in)	5/8	13/16	1-1/4	1-1/2	1-13/16	2-1/8	2-3/8	2-11/16	3	3-5/16
Leg L/4 (in)	8-11/16	9-1/4	9-13/16	10-3/8	10-7/8	11-3/8	12	12-1/2	13	13-1/2
Leg L/2 (in)	17-3/8	18-3/8	19-11/16	20-11/16	21-13/16	22-7/8	23-7/8	25	26	27-1/8
Single Offset Dist L (in)	35	37	39	41	44	46	48	50	52	54

Table 7 | Thermal Expansion of PVC Piping with PVC and Coupler Offset

To accommodate for long plumbing runs or bank movement using a PVC Line and two *Couplers* in the offset, refer to the table below. Since the plumbing can be mounted as *Fixed* or *Guide* supports, a Conventional *Offset* can also be useful to absorb some or all of the movement in plumbing and solar banks. Other industry standard methods are also acceptable.

Bank and Plumbing Movement

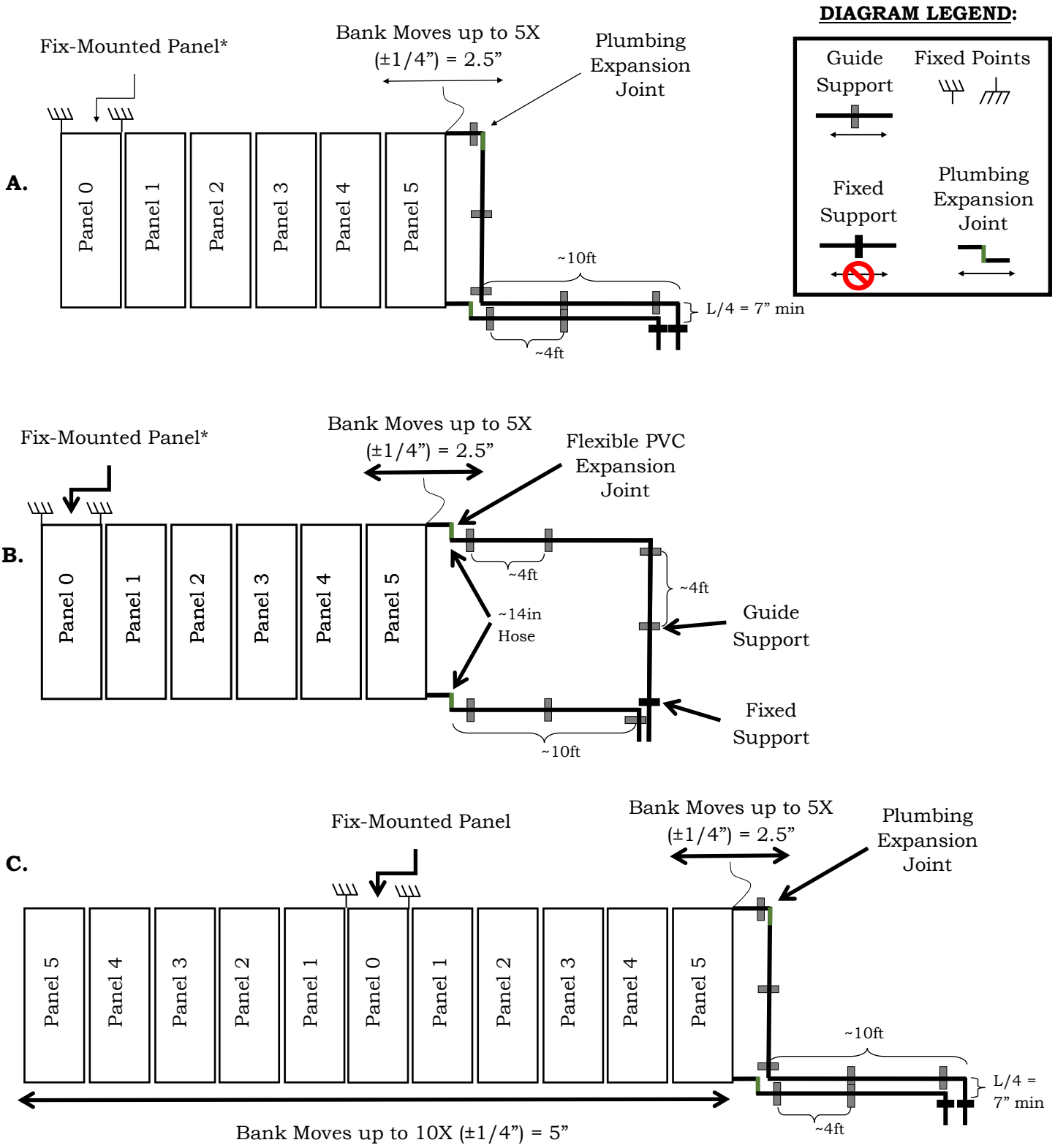
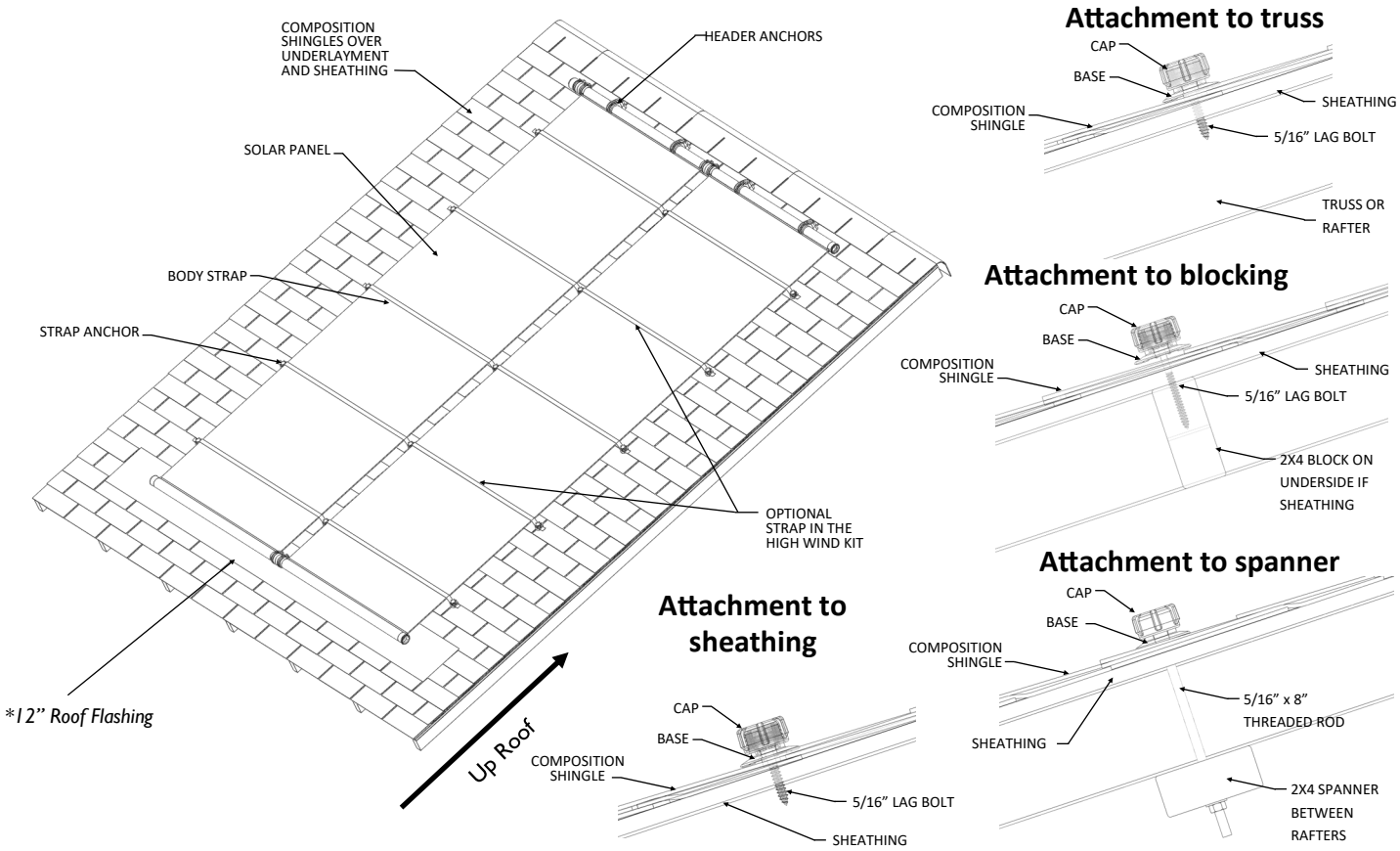


Figure 22 | Bank and Plumbing Mounting

There are multiple ways to accommodate for thermal expansion and contraction in a bank. The recommended way to mount a bank of panels is to fix-mount the top header of the centermost panel in a bank, though alternate locations are permissible. When mounting a bank, prime consideration must be given to allow for movement in the plumbing as well, especially if the fix-mounted panel is away from the plumbing side of the bank as depicted in images **A, B** and **C**. Notice the use of a plumbing expansion hose in these figures, the *Offset Method*, and the difference between *Fixed Supports* and *Guide Supports*. Bank expansion can be calculated and used to determine the total plumbing movement needed. See **Table 6** in *Appendix C for details.*

*It is recommended for the *Fix-Mounted Panel* to be at a the centermost point in a bank as seen in image **C** of **Figure 22** when possible.

Connected Tube *CT* Panels on Composition Roofs



NOTE: IF local codes allow the lag bolt to be secured only into the sheathing, be sure not to overtighten. The bolt may tear through the sheathing and reduce pull out strength.

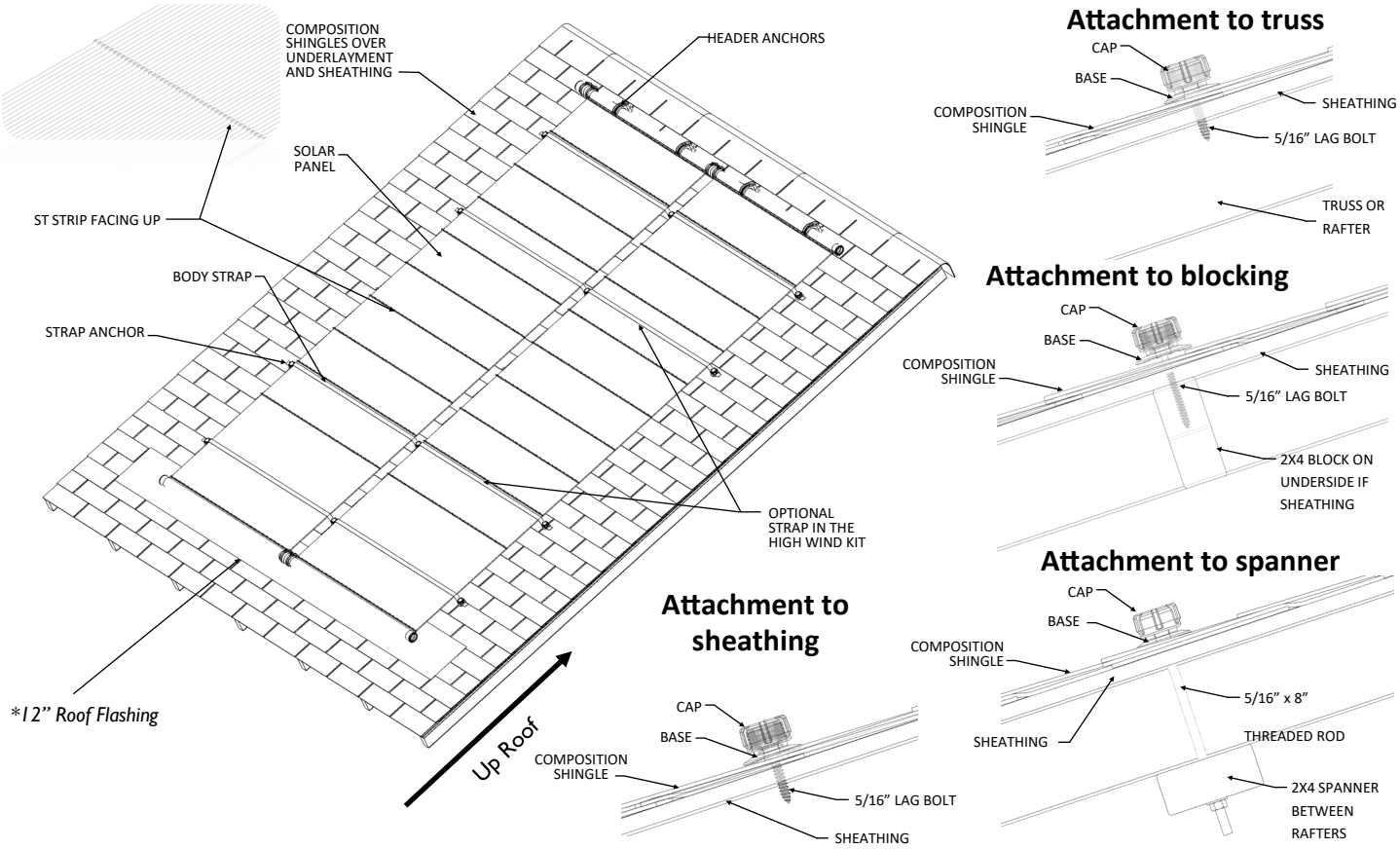
It is recommended to install 12" wide flashing under bottom header to protect composition roof from possible panel movement.

Figure 23 | Composition Roof and Membrane Roof Mounting

The figures depict an example of mounting on a composition shingle roof. Substrate is not required to support and protect the Panels but it is recommended to put a barrier between the lower headers and the roof for extra protection when the Panels move with temperature fluctuations.

Note: All mounting hardware must be installed with care. Seal all roof penetrations according to an industry standard method. If local codes allow the lag bolts to be secured only into the sheathing, be sure not to overtighten bolts.

Separated Tube *ST* Panels on Composition Roofs



NOTE: IF local codes allow the lag bolt to be secured only into the sheathing, be sure not to overtighten. The bolt may tear through the sheathing and reduce pull out strength.

It is recommended to install 12" wide flashing under bottom header to protect composition roof from possible panel movement.

Figure 24 | Composition Roof and Membrane Roof Mounting

The figures depict an example of mounting on a composition shingle roof. Substrate is not required to support and protect the Panels but it is recommended to put a barrier between the lower headers and the roof for extra protection when the Panels move with temperature fluctuations.

Note: All mounting hardware must be installed with care. Seal all roof penetrations according to an industry standard method. If local codes allow the lag bolts to be secured only into the sheathing, be sure not to overtighten bolts.

Connected Tube *CT* Panels on Tile and Standing Seam Roofs

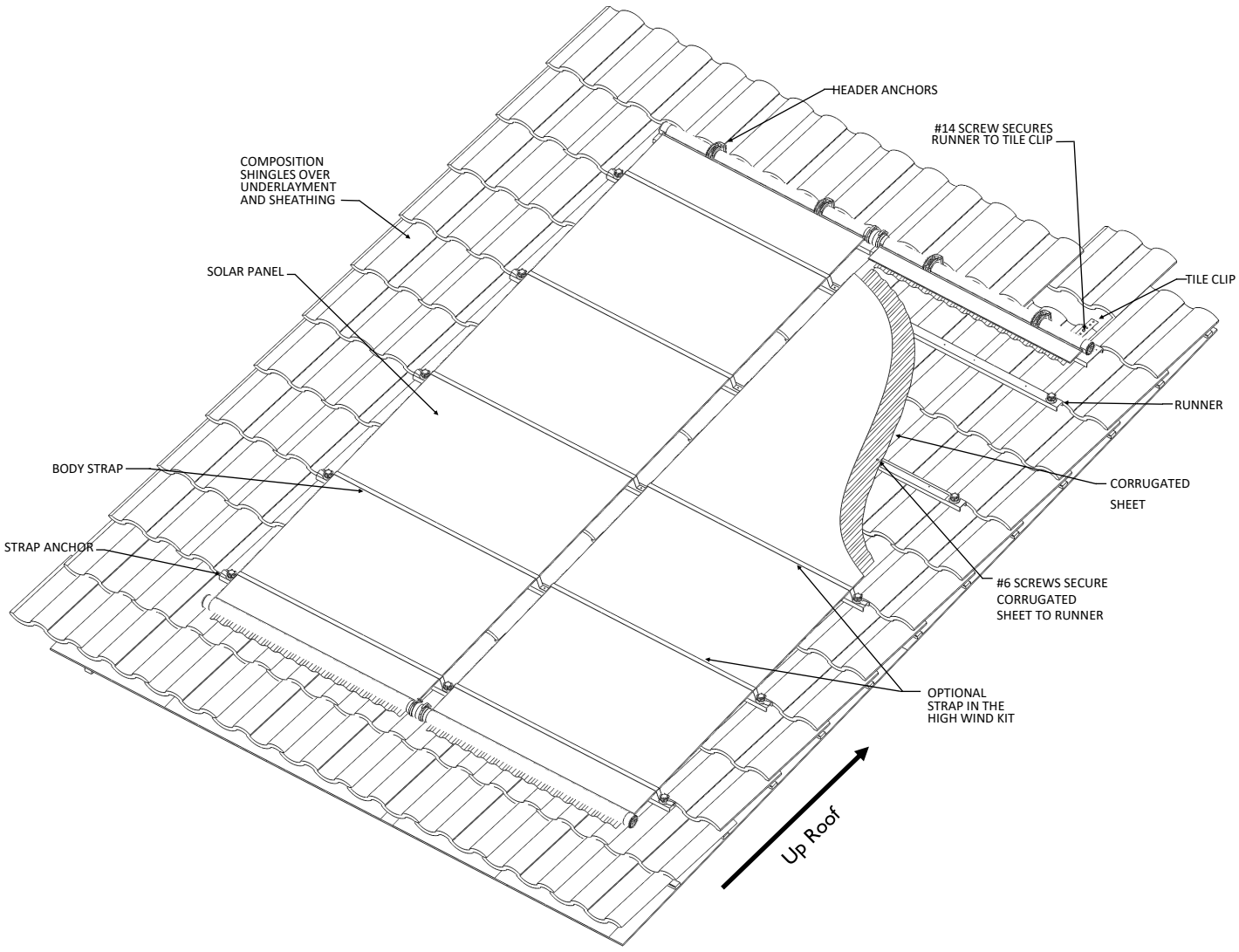


Figure 25 | Tile and Standing Seam Roof Mounting

This figure depicts an example of mounting on a traditional Barrel Tile Roof. Connected Tube *CT* panels must be properly protected from uneven contours in the mounting surface which are seen especially in Barrel/S-Tile, Flat Tile and Standing Seam Metal type Roofs. Due to the need for support and protection from abrasion, substrate is required to support and protect the Panels. If preferred, substrate may be substituted by a roof rack with support from runners not exceeding 16" separation. If the rack/runners have a spacing greater than 16", a substrate must be used to support the Panel from excessive sagging and uneven contours in the panel.

Note: This method of installation applies to Barrel Tile, Flat Tile, and Standing Seam roofs. Using substrate and runners will allow for thorough support to the panel body which will also protect it from abrasion or puncture points seen in many roofs of these types. If a system must be installed without adequate substrate and runners, it's best advised to install the FAFCO Separated Tube *ST* Panel rather than the FAFCO Connected Tube *CT* panel.

Mounting hardware must be installed on a runner and the runner must be mounted into the sheathing of the roof with the same number of penetrations. Seal all roof penetrations according to an industry standard method. Roof penetrations can be substituted by an equivalent industry standard non-penetrating fastener rated for *Standing Seam Metal Roofs* with equivalent pullout ratings.

Separated Tube *ST* Panels on Tile and Standing Seam Roofs

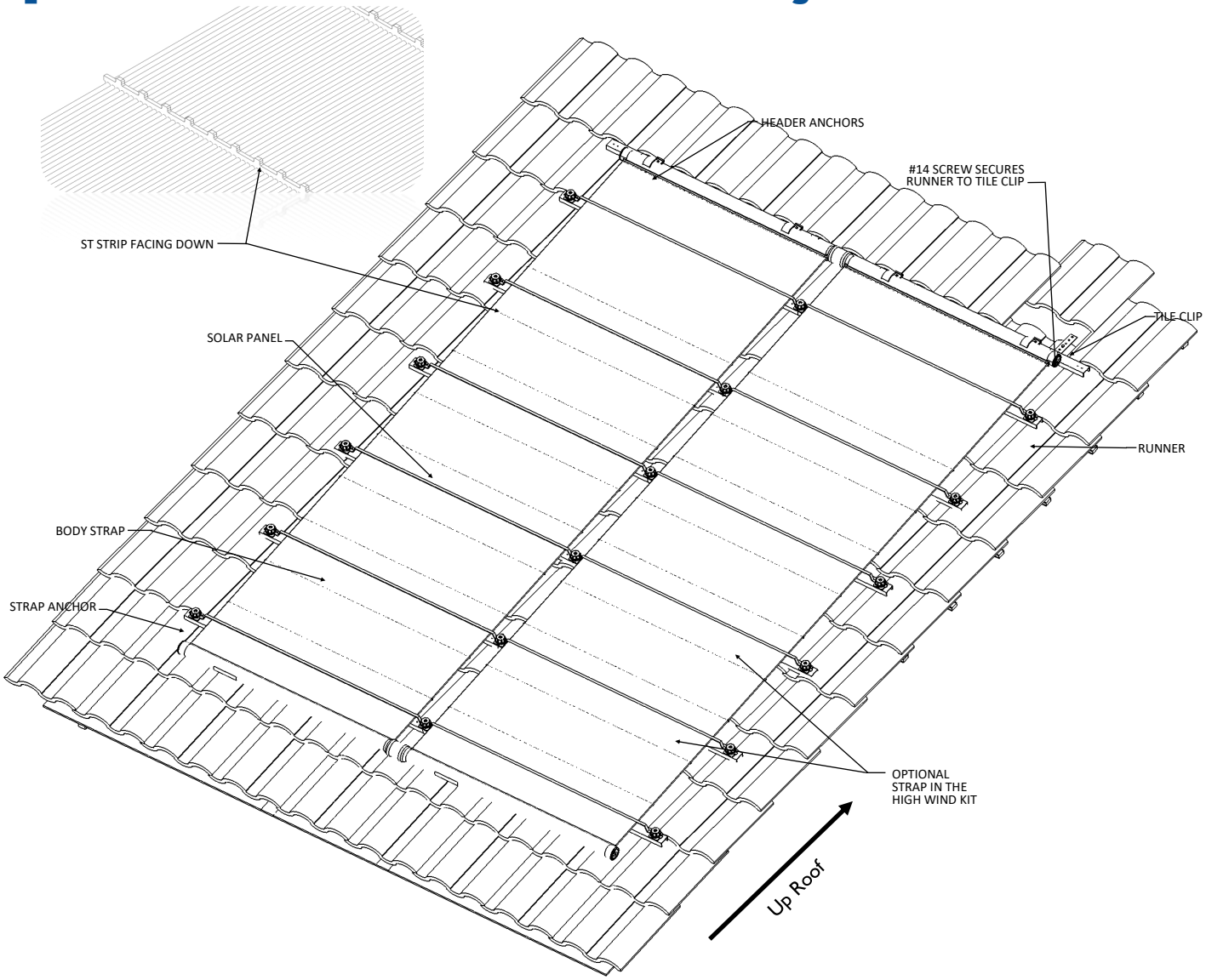


Figure 26 | Tile and Standing Seam Roof Mounting

This figure depicts an example of mounting on a traditional Barrel Tile Roof. Separated Tube *ST* panels must be properly protected from uneven contours in the mounting surface which are seen especially in Barrel/S-Tile, Flat Tile and Standing Seam Metal type Roofs. Due to the need for support and protection from abrasion, substrate is required to support and protect the Panels. If preferred, substrate may be substituted by a roof rack with support from runners not exceeding 16" separation. If the rack/runners have a spacing greater than 16", a substrate must be used to support the Panel from excessive sagging and uneven contours in the panel.

Note: This method of installation applies to Barrel Tile, Flat Tile, and Standing Seam roofs. Using substrate and runners will allow for thorough support to the panel body which will also protect it from abrasion or puncture points seen in many roofs of these types. If a system must be installed without adequate substrate and runners, it's best advised to install the FAFCO Separated Tube *ST* Panel rather than the FAFCO Separated Tube *ST* panel.

Mounting hardware must be installed on a runner and the runner must be mounted into the sheathing of the roof with the same number of penetrations. Seal all roof penetrations according to an industry standard method. Roof penetrations can be substituted by an equivalent industry standard non-penetrating fastener rated for *Standing Seam Metal Roofs* with equivalent pullout ratings.

Panels on Tile and Standing Seam Roofs

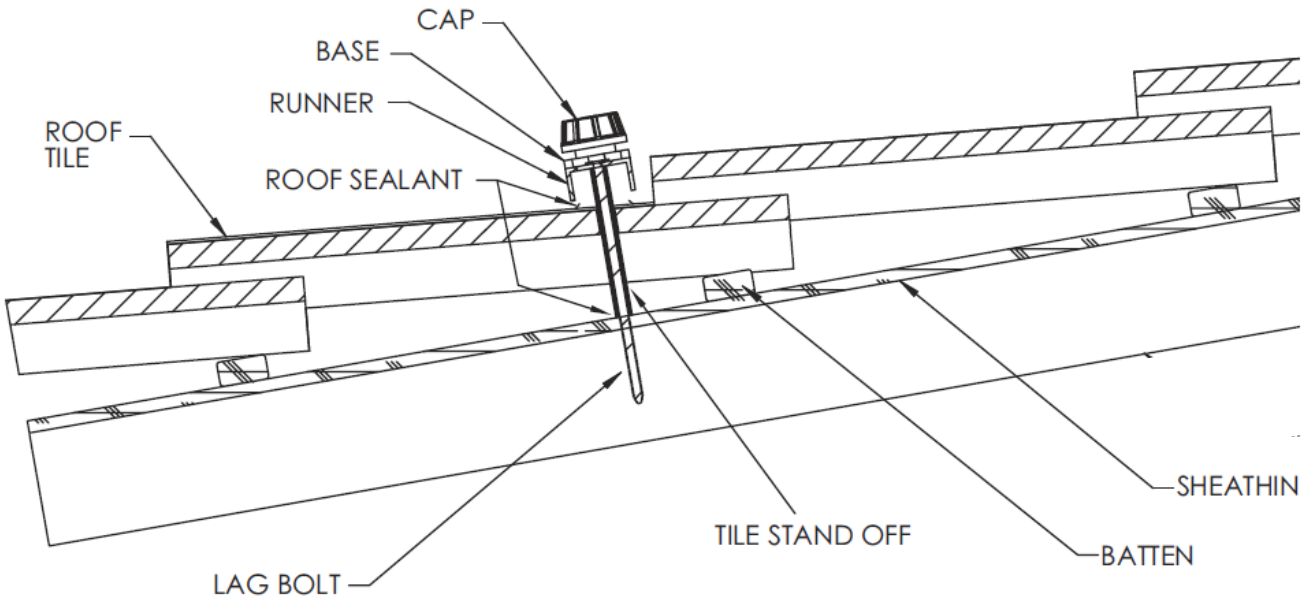


Figure 27A | Tile Stand Off Method

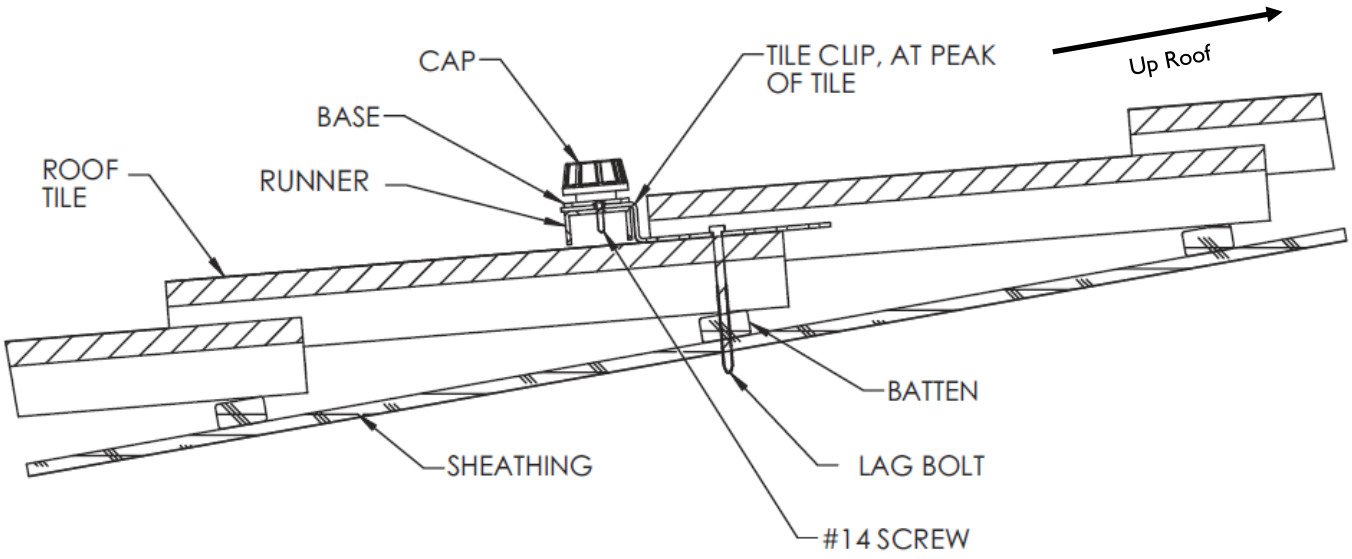


Figure 27B | Tile Clip Method

The figures depict examples of mounting hardware on *Flat Tile* roofs. Substrate is required to support and protect the Panels from abrasion but may be substituted by a roof rack with support from runners not exceeding 16" separation. If the rack has spacing greater than 16", a substrate must be used to support the Panel from excessive sagging.

Header Clamp Mounting on Tile Roofs

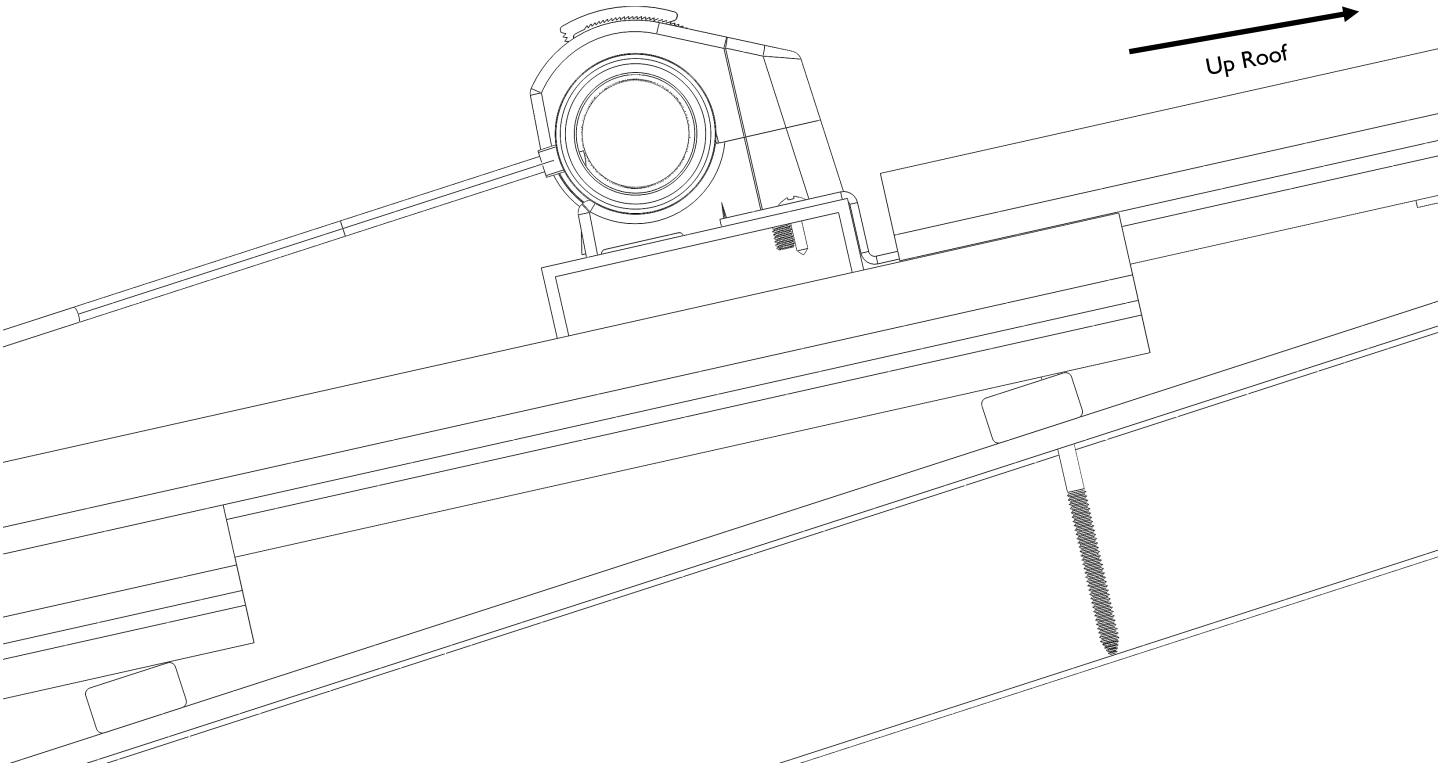
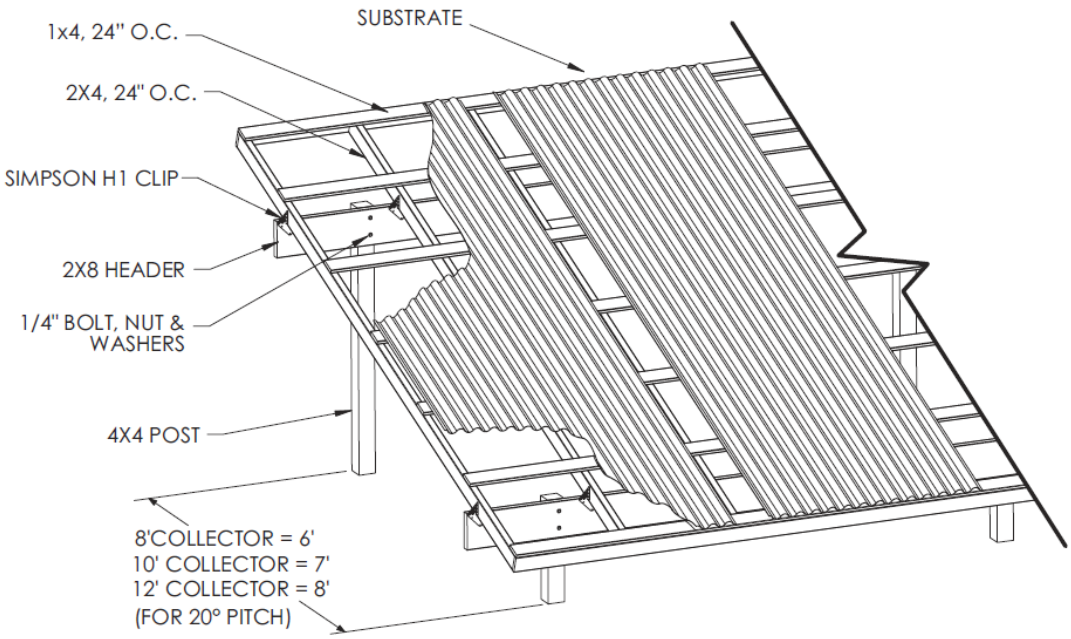
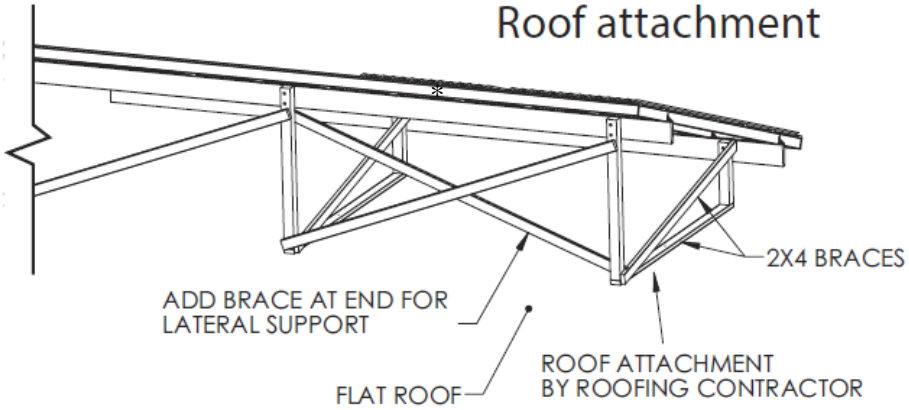


Figure 28 | Header Clamp Mounting

The figures depict examples of mounting a Header Clamp on tile roofs. When mounting on a tile roof, the panel must be installed so that the ST Strip is facing downward toward the tile. With the Separated Tube Panel, only one body strap will need to be installed. Be sure to use one of the methods above to mount the Strap Anchors to a runner.

Panels Wood Rack Mounted*





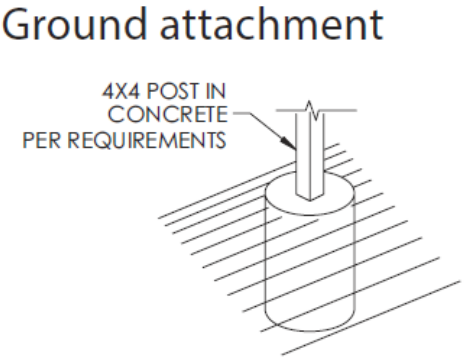


Figure 29 | Wood Ground Rack Mounting

The figures depict examples of a wood ground rack. Substrate is not required if the rack has runners at a minimum spacing of 16". If the rack has spacing greater than 16", a substrate must be used to support the Panel from excessive sagging between lateral supports.

*** Connected Tube *CT* panels are to be installed no more than 20 vertical feet below pool surface to the bottom header due to static head pressure at stagnation temperatures.** If a system must be installed further below the pool surface level, it's best advised to install the FAFCO *Separated Tube ST* Panel rather than the FAFCO Connected Tube *CT* panel.

Connected Tube *CT* Panels Metal Rack Mounted*

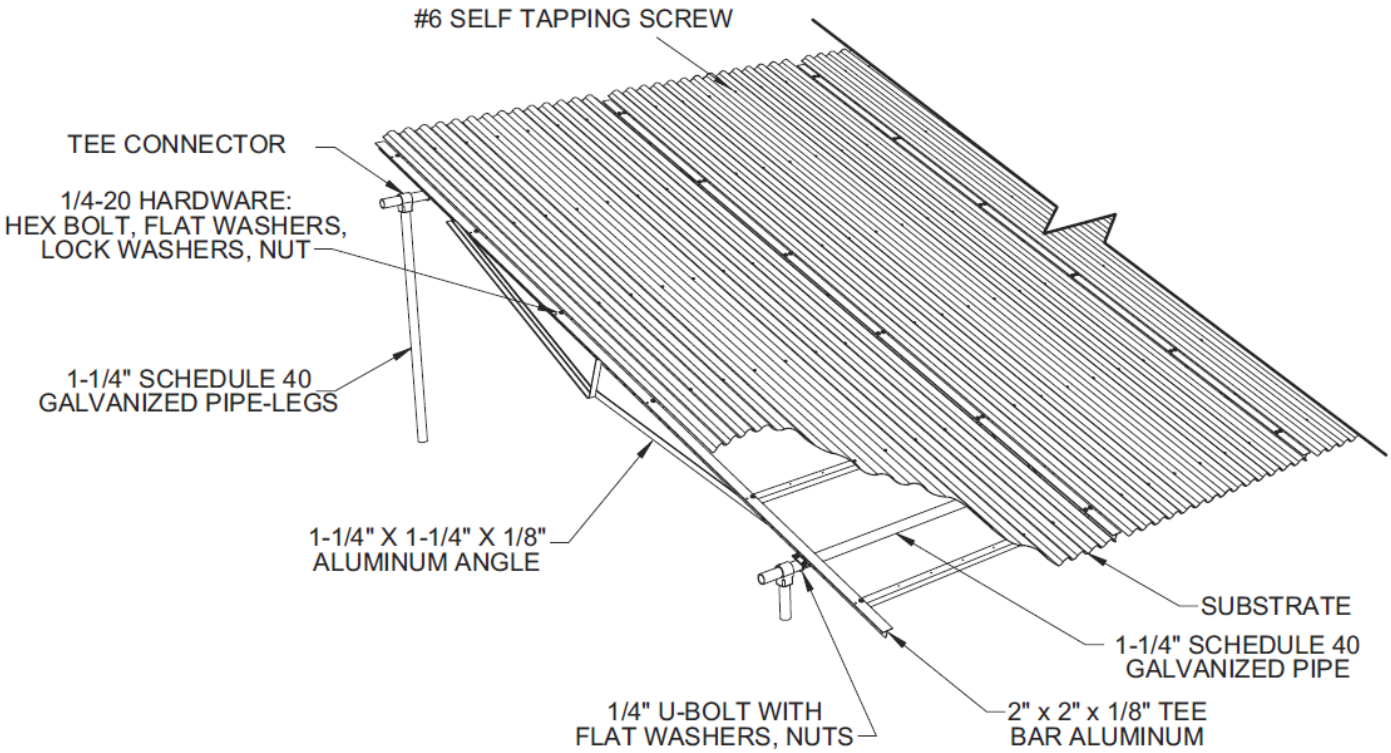
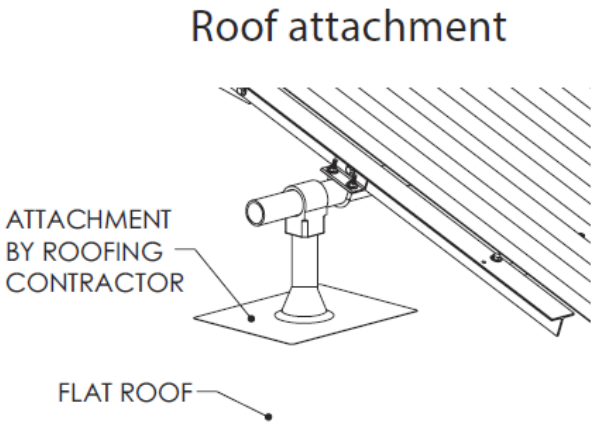
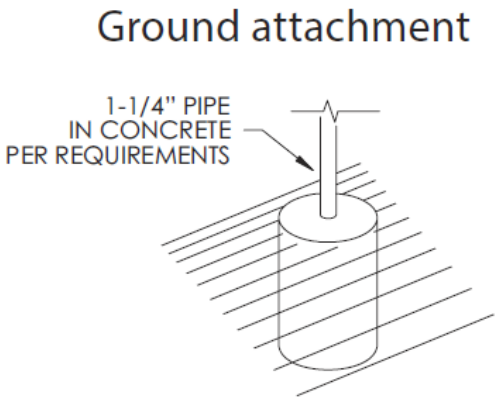


Figure 30 | Metal Ground Rack Mounting

The figures depict examples of a metal ground rack. Substrate is not required if the rack has runners at a minimum spacing of 16". If the rack has spacing greater than 16", a substrate must be used to support the Panel from excessive sagging between lateral supports.

***FAFCO Connected Tube *CT* panels are to be installed <u>no more than 20 vertical feet below pool</u> surface to the bottom header due to static head pressure at stagnation temperatures.** If a system must be installed further below the pool surface level, it's best advised to install the FAFCO Separated Tube *ST* rather than the FAFCO Connected Tube *CT* panel.

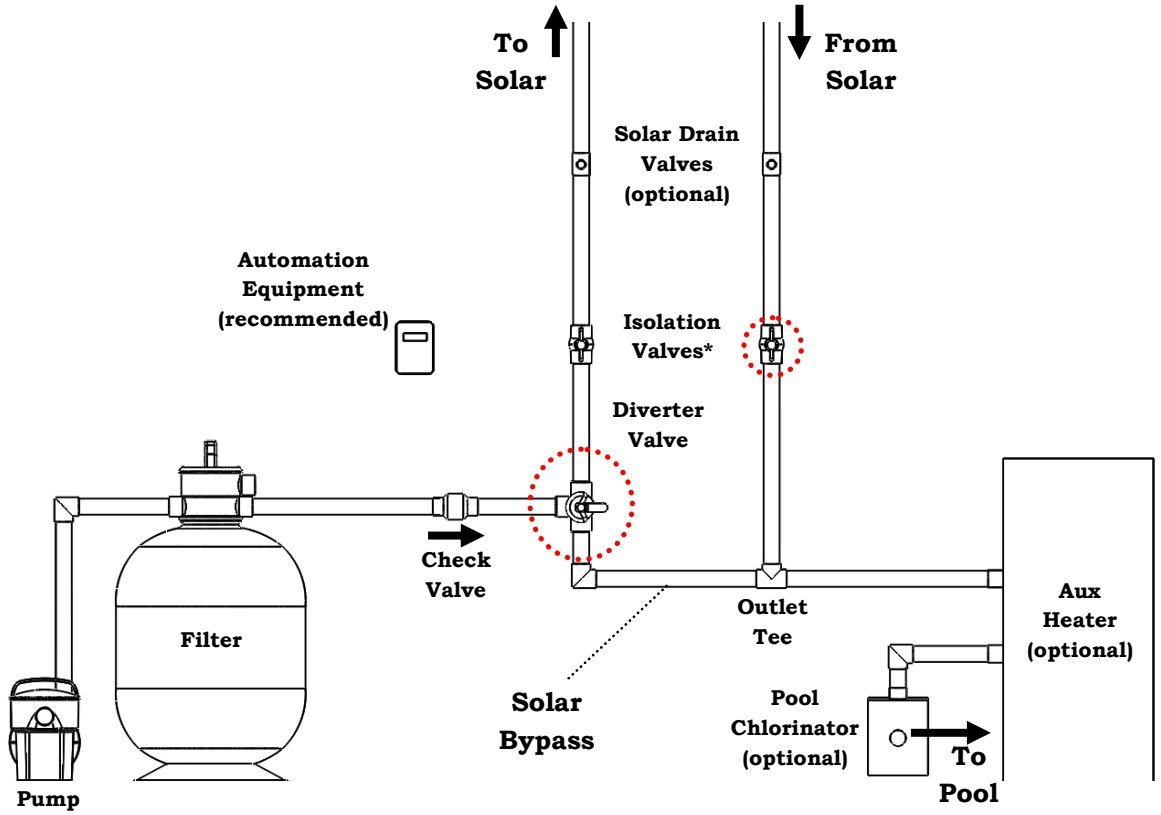




Acceptable Installation of Valves

Figure 31 | Diverter Valve on Supply, Isolation on Return

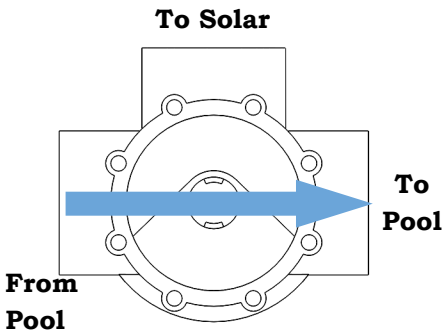
The below figures depict alternate types and locations of the diverter valve and check/isolation valve. Non-draining configurations should be manually drained for winter, self-draining systems do not require draining for winterization.

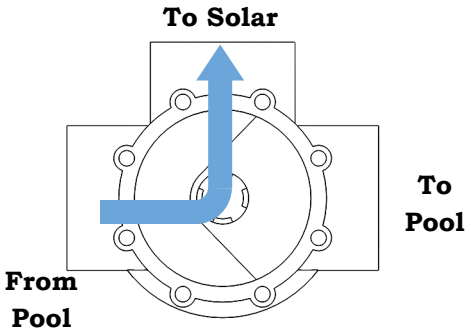


*Installing an isolation valve on the return line has the potential to deadhead, (over-pressurize), the system if closed and supply valve is left open while operating.

90° Actuator

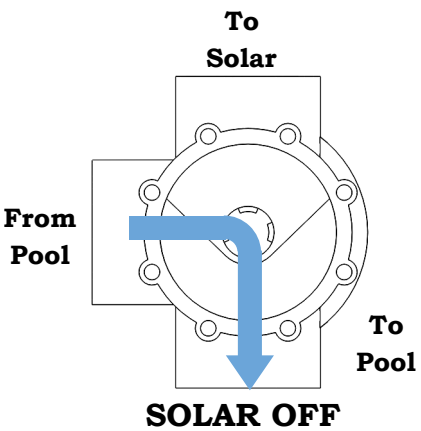
Self-Draining

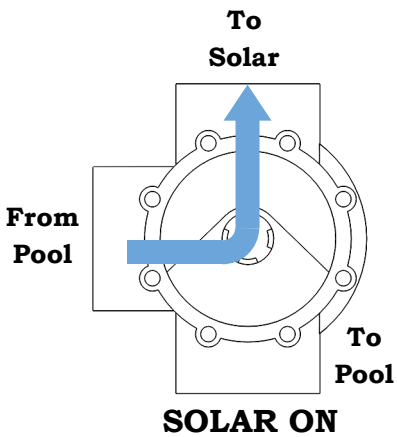




180° Actuator

Non Positive Valve is Self-Draining

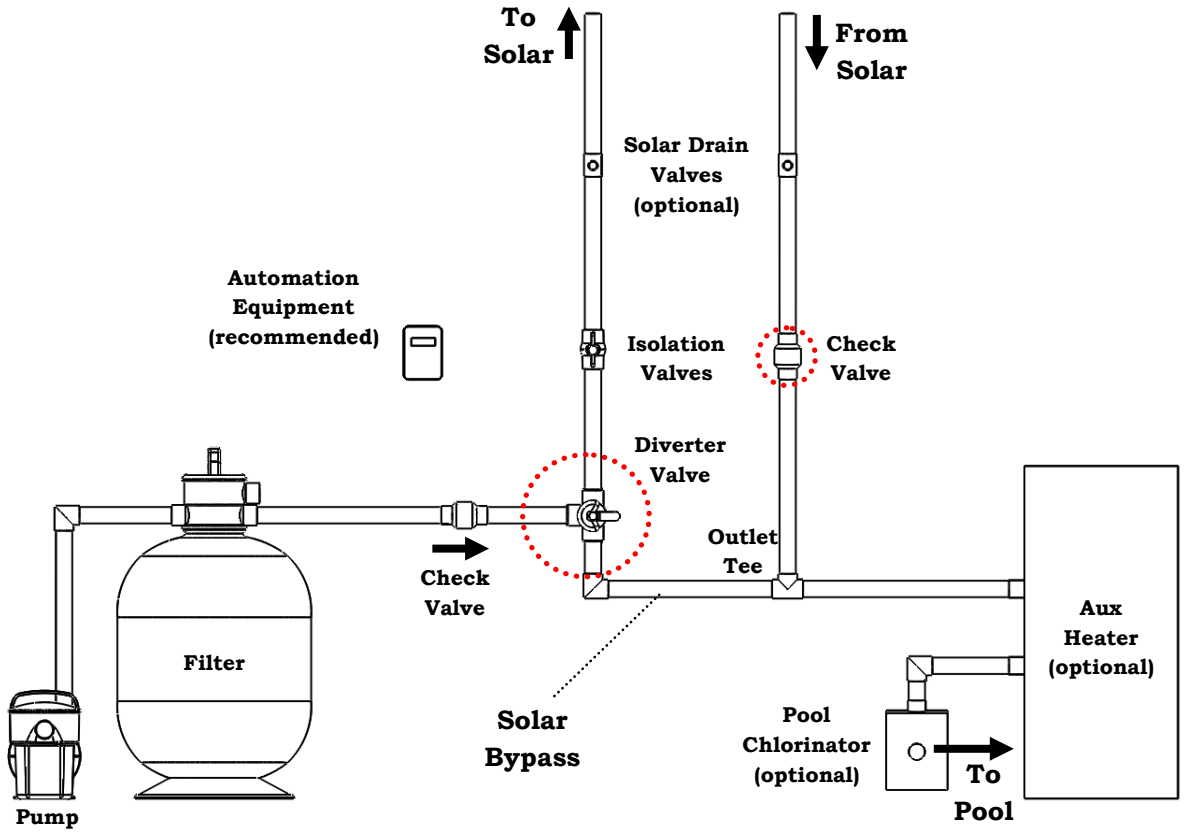




Acceptable Installation of Valves

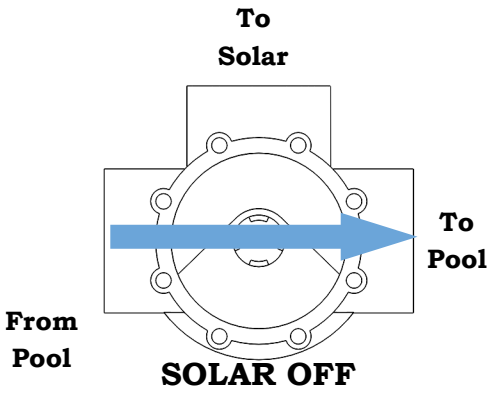
Figure 32 | Diverter Valve on Supply, Check Valve on Return

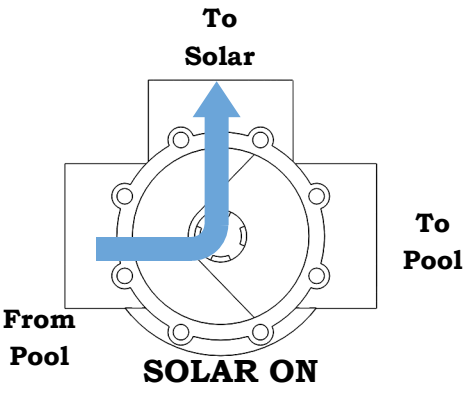
The below figures depict alternate types and locations of the diverter valve and check/isolation valve. Non-draining configurations should be manually drained for winter, self-draining systems do not require draining for winterization.



90° Actuator

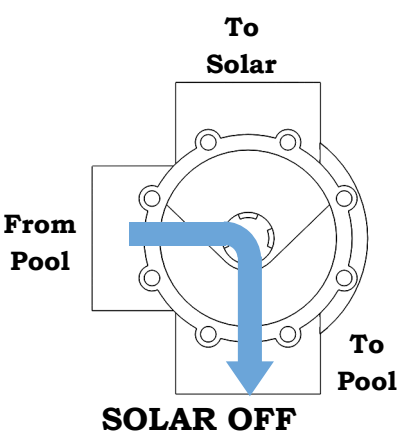
Self-Draining

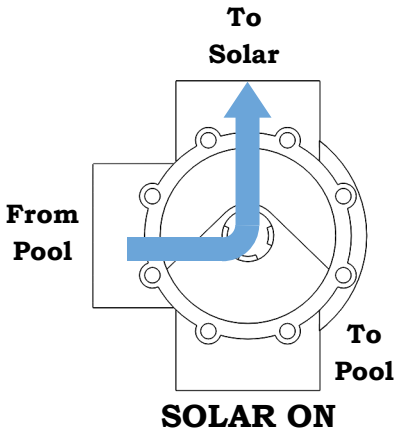




180° Actuator

Non Positive Valve is Self-Draining

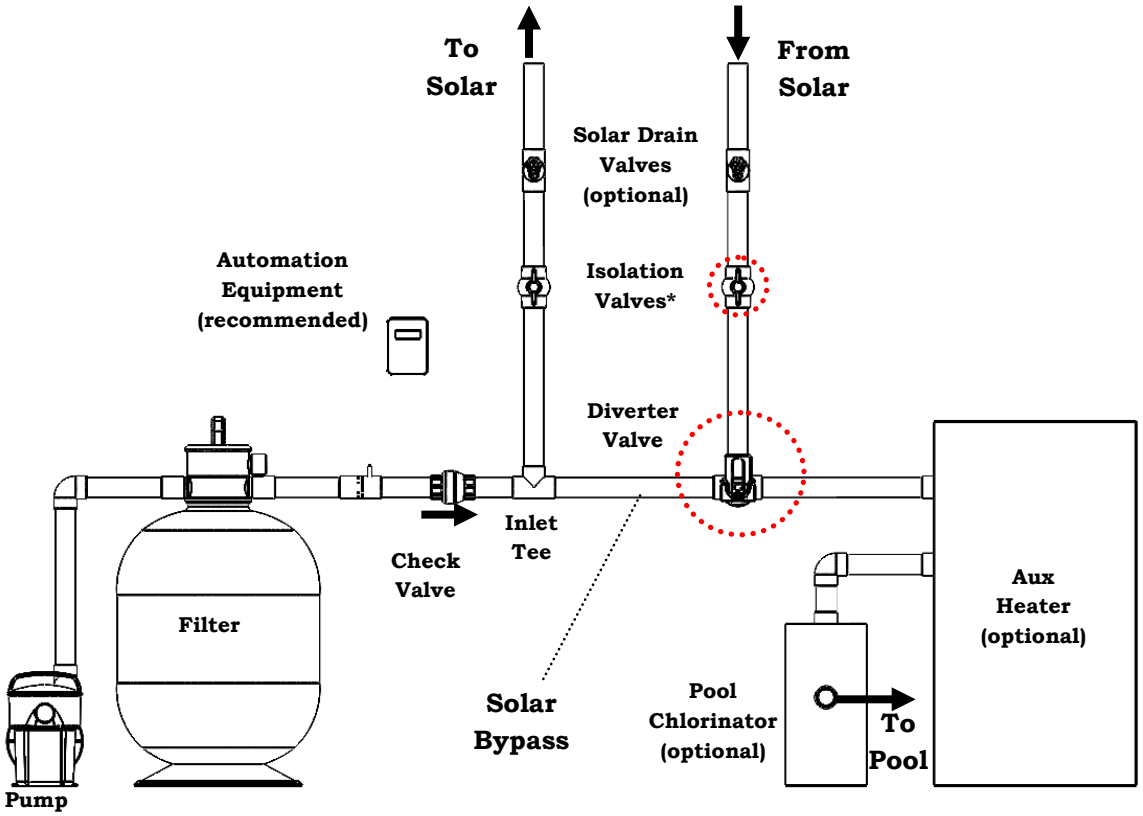




Acceptable Installation of Valves

Figure 33 | Diverter Valve on Return, Isolation on Return

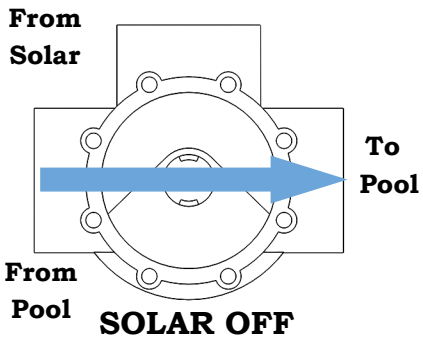
The below figures depict alternate types and locations of the diverter valve and check/isolation valve. Non-draining configurations should be manually drained for winter, self-draining systems do not require draining for winterization.

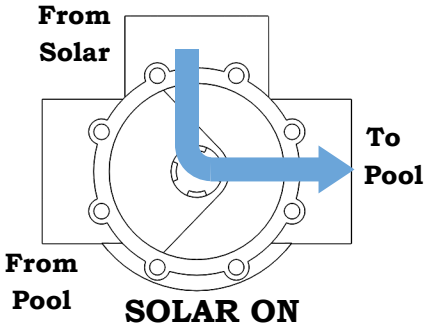


*Installing an isolation valve on the return line has the potential to deadhead, (over-pressurize), the system if closed and supply valve is left open while operating.

90° Actuator

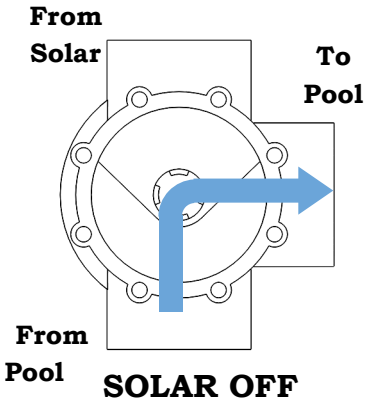
Self-Draining

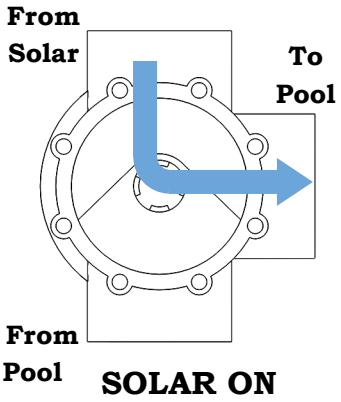




180° Actuator

Non Positive Valve is Self-Draining

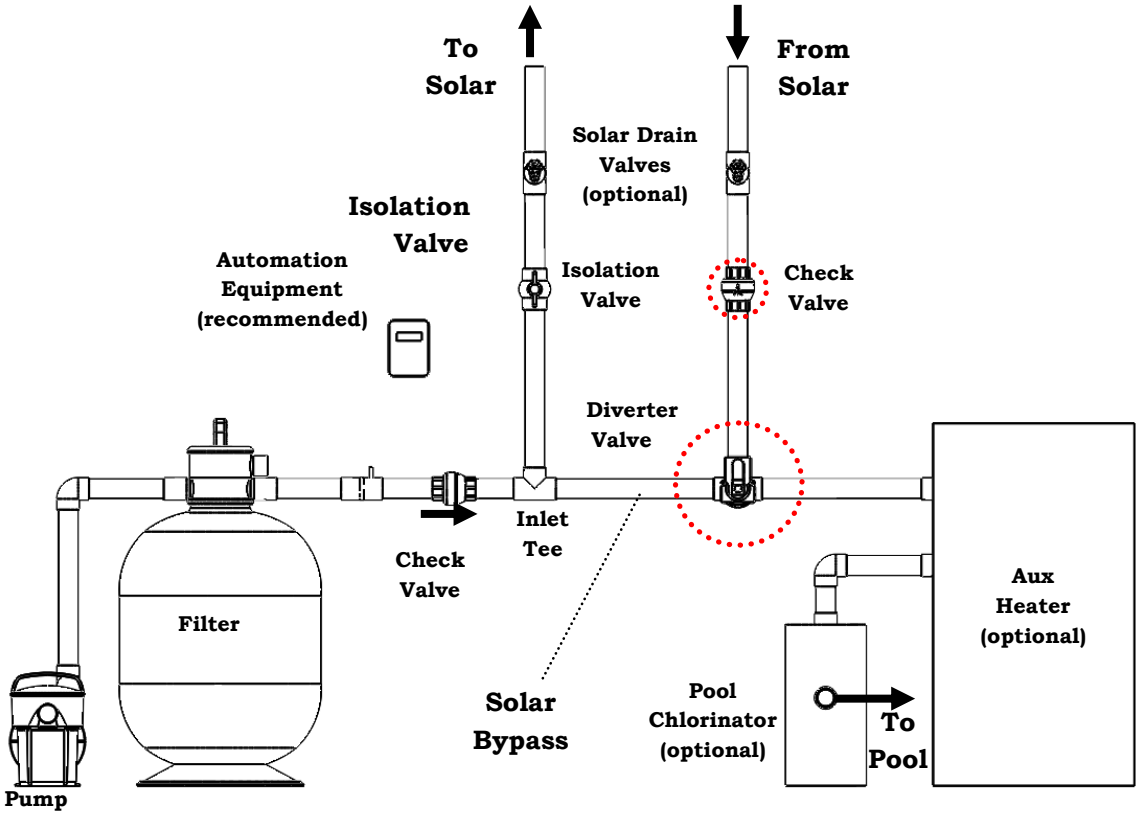




Acceptable Installation of Valves

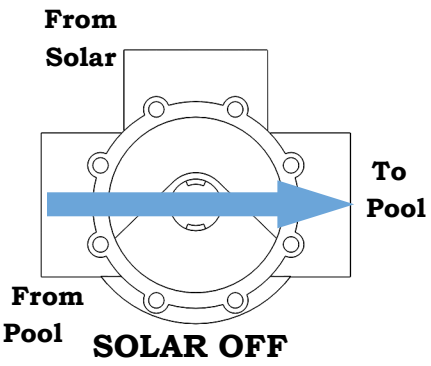
Figure 34 | Diverter Valve on Return, Check Valve on Return

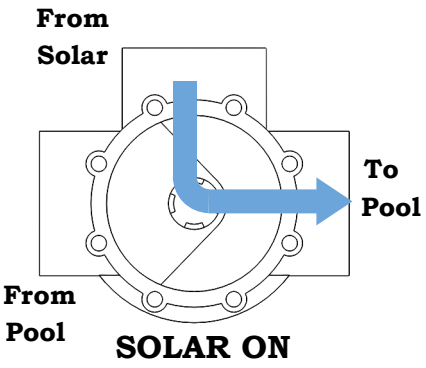
The below figures depict alternate types and locations of the diverter valve and check/isolation valve. Non-draining configurations should be manually drained for winter, self-draining systems do not require draining for winterization.



90° Actuator

Self-Draining





180° Actuator

Non Positive Valve is Self-Draining