SunMaxx Solar™
Hot Water Solutions

Solar Thermal Collectors
Technical Reference

To maintain the standards used across the Solar Energy Industry, many of the calculations and measurements in this workbook are in metric units. However, we have included factors and equations to convert many of these units from metric to Imperial. If you need assistance, please ask your sales representative.

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1.0 What does SunMaxx offer?

Solar Energy

SunMaxx is a leading solar energy company across the United States, and around the world. With three domestic offices, offshore manufacturing facilities, and future expansions in the works, SunMaxx Solar looks forward to an era of affordable solar energy products by offering the very best, most efficient solar products at the very best prices.

SunMaxx is the manufacturer of SunMaxx Solar Hot Water Systems – a series of Solar Collectors, Solar Hot Water Storage Tanks and Mounting Hardware that is designed to provide maximum performance and efficiency at a price more affordable and more cost-effective than the competition. As a company, SunMaxx Solar is dedicated to making Solar Energy affordable to everyone who desires it.

SunMaxx produces numerous Solar Hot Water Collectors, including Vacuum heat pipe Solar Collectors, as well as Flat Plate Solar Collectors. Additionally, SunMaxx is the manufacturer of a number of Solar Hot Water Storage Tanks, and pre-packaged Solar Hot Water Systems.

Our manufacturing process is dedicated to delivering high volume output with industry-leading quality control. Our unique combination of on and off-shore manufacturing, storage and distribution offers SunMaxx Solar a tremendous amount of flexibility and scalability in our manufacturing process. This scalability, along with our innovative product designs and manufacturing processes, allows SunMaxx Solar to meet the demands of our large chain of dealers, partners and customers around the world.

Assured Quality through Independent Testing

SunMaxx Solar Hot Water Collectors are independently tested and certified by the leading agencies in the United States, and around the world. SunMaxx Vacuum Heat Pipe and Flat Plate Solar Collectors are both Solar Keymark and SRCC Certified to provide optimum performance and efficiency in a variety of conditions. This independent testing proves that SunMaxx Solar provides a comparable, or better, product than the competition at a better price.

The Market

The market has never been stronger for Solar Hot Water products, and SunMaxx Solar Hot Water Systems offer the level of performance and affordability needed to compete in a variety of markets around the world. From residential systems to larger commercial, industrial and municipal applications, SunMaxx Solar Hot Water Systems deliver Domestic Hot Water, Radiant Heating and Pool/Spa Heating to clients in all walks of life.

Our Team of Sales Executives and Solar Thermal Engineers, as well as dealers and partners offer assistance to architects and designers around the world who are interested in using SunMaxx Solar Hot Water Systems.

Technical Support

Of course, should you have any questions or concerns, our highly qualified team of engineers and technicians are always available to provide whatever assistance you may require.

2.0 How to Get the Most out of a SunMaxx System

We recommend that you read this manual thoroughly before commencing installation and that you adhere to the cautions outlined, and to any and all local regulations and relevant standards.

1. SunMaxx Solar Hot Water Systems should only be installed by qualified persons. If you have any doubts about any aspect of your installation, please contact your SunMaxx Dealer or SunMaxx directly.

2. System sizing and applications must be in accordance with the recommendations made by SunMaxx. Technicians are available to assist you in sizing your system.

3. Responsibility for a safe and proper installation of a SunMaxx Solar Hot Water System rests solely with the installer.

4. SunMaxx manifold systems are designed to work with a maximum working pressure of 10 bar (150 psi). To guarantee that this is not exceeded, a pressure relief valve and a pressure gauge must be used.

5. The chloride content of the water used in your SunMaxx Solar Hot Water System should not exceed 40 ppm – check with your local water authorities.

6. In areas with hard water, a heat exchanger (external) should be used – otherwise regular cleaning of the system is essential. Also, you can have your water tested and treated to eliminate this problem altogether.

7. In cold regions use a mixture of water and non-toxic propylene-glycol (not car antifreeze). The percentage of glycol should not exceed 50%.

8. When heating a swimming pool or spa, a heat exchanger must be used between the pool/spa and the collector.

9. Unpack and install the collector tubes ONLY AFTER the manifold has been installed, the pipe work has been connected, and the system has been pressure tested and charged.

10. Ensure that Collector Tubes and Heat Pipes are installed in the correct orientation and that the heat pipe condenser bulb is fully inserted into the manifold

11. The collector tubes must be covered if the system has not been filled and the tubes are exposed to the sun for an extended period (more than 1 day).

12. Gloves and eye protection should be worn at all times when working with glass. Avoid any sudden temperature shock to tubes. Avoid scratching the glass collector tubes, as this will reduce their strength.

13. The collector(s) must be oriented properly so that they get the maximum amount of sun exposure possible. This will be explained in more detail later in this manual.

14. An expansion tank and/or heat dump should be installed to ensure proper care throughout the life of your collectors. There are many ways to accomplish this.

15. You must ground your collectors using braided copper wire and a 6 foot copper grounding rod.

Throughout this handbook, various suggestions have been made for system design and installation. You are strongly advised to follow each of these suggestions; however, final design of any installation is left to the discretion of the installer.

Figure 1

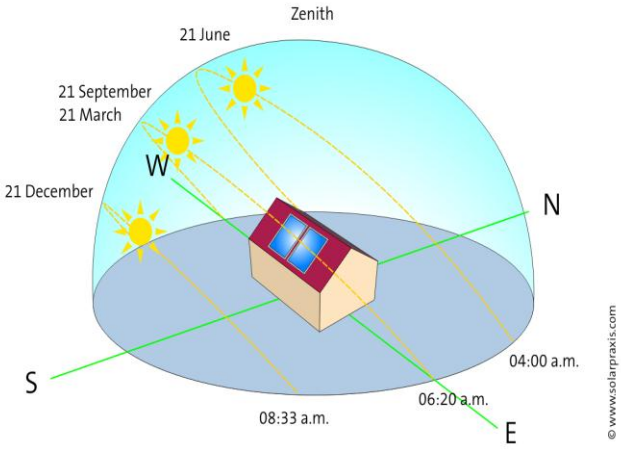
This manual was correct and complete at time of print, but as part of our continuous product improvement and innovation, SunMaxx reserves the right to update and amend specifications without notice.

2.1 Positioning the Collector: Azimuth and Inclination Angle

Azimuth angle refers to the lateral angle between true south and the perpendicular of the face of the collector. Ideally, this angle should be zero, for when the collector faces due south is receives the maximum amount of incident radiation from the sun. However, due to conditions such as the direction an inclined roof faces and objects that produce shade, deviations are usually present and are usually acceptable.

In order to determine the proper azimuth angle, it is necessary to ascertain the direction of true south. True south is the direction pointing to where the sun is highest in the sky, or zenith. True south differs from magnetic south due to the fact that the magnetic poles do not precisely match up with the geographical north/south poles of the earth. To account for magnetic declination, Figure 2 may be used

Inclination angle refers to the angle between the collector and the horizontal ground. Determining the proper inclination angle involves understanding a little bit about how the position of the zenith changes throughout the year.



The change in zenith angle is based on the fact that the axis of the earth's rotation is tilted approximately 23.5°. Because of this, the maximum zenith angle for any particular location is the latitude plus 23.5° (June 22), whereas the minimum zenith angle is the latitude minus 23.5° (December 22). See Figure 1 for an illustration of this concept.

In order to get the best year-round solar fraction, it is recommended that the inclination of solar collectors be as close to your latitude as possible. This represents the average of the zenith throughout the year. However, if a majority of your heat load is during a particular time of year, it would be a good idea to adjust the inclination accordingly (less for high summer usage and more for high winter usage). Appendix A shows recommended dimensions for mounting hardware components in order to accomplish proper inclination angles.

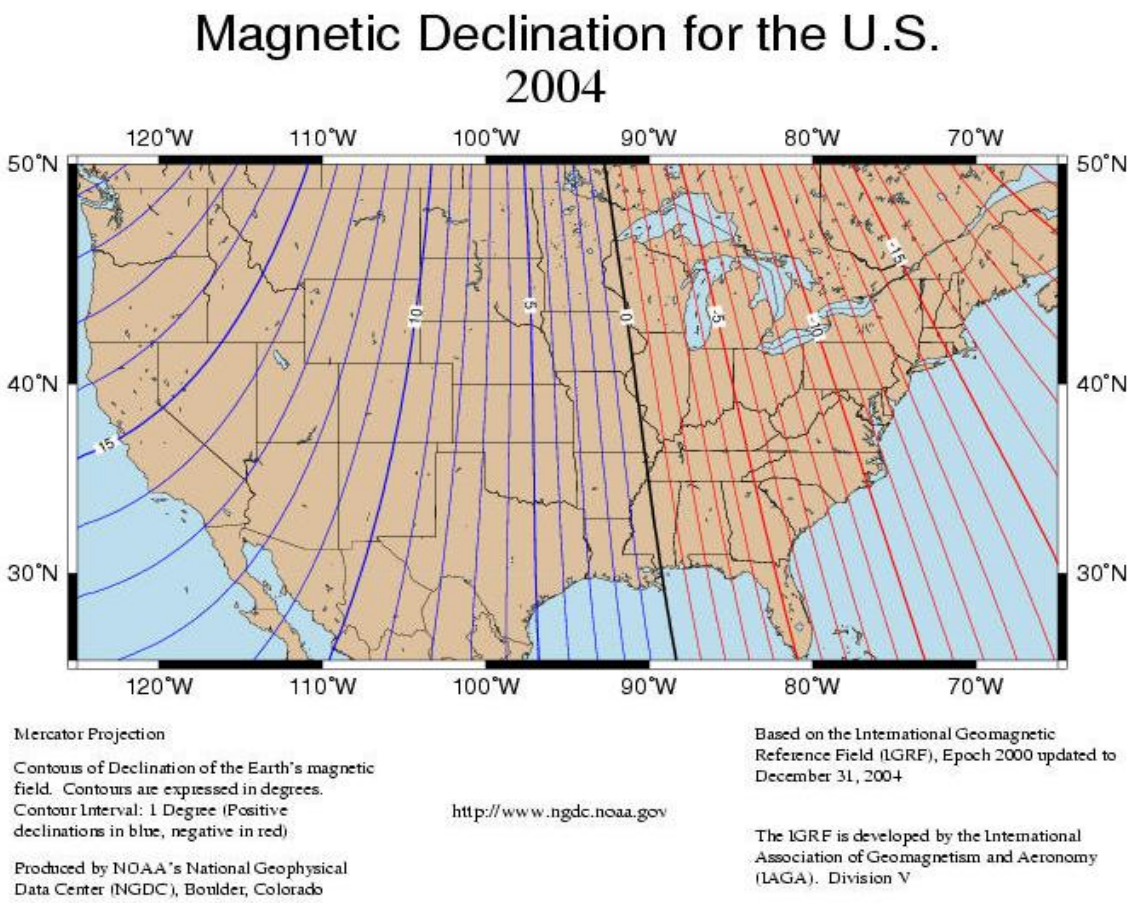


Figure 2

3.0 How Does a SunMaxx System Work

The main components of any SunMaxx Solar System are the solar collectors. They are responsible for converting radiation from the sun into useable energy. There are 2 types of collectors offered by SunMaxx: Vacuum Heat Pipe and Flat Plate.

SunMaxx Collectors feature:

- High Performance
- Low Heat Capacity and High Heat Transfer
- Thermal Diode Operation – Heat flow only in one direction
- Control of the maximum temperature
- High durability
- Freedom from corrosion problems
- Freedom from cold weather/frost problems
- Low maintenance effort
- Easy installation of single or multiple units

3.1 Vacuum Heat Pipe Collectors

Vacuum heat pipe collectors are also known as vacuum tube or vacuum tube collectors. A rendering of a typical vacuum heat pipe collector is shown below in Figure 3.

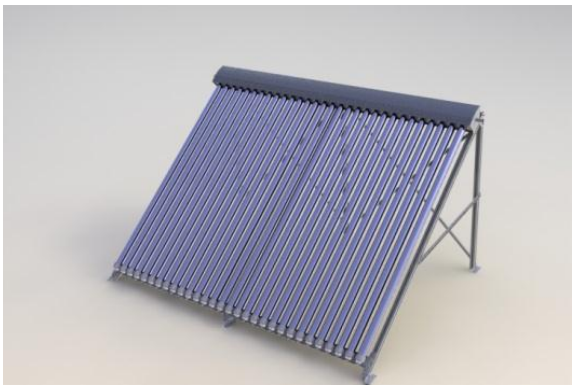


Figure 3

All SUNMAXX Vacuum heat pipe Solar Collectors (the ThermoPower-VHP 10, 20, 25 and 30) use the same Vaccum Solar Tube design. The temperature within the SUNMAXX Vaccum Solar Tubes can reach 304°F, while the exterior of the tube remains cold to the touch. SUNMAXX Vacuum heat pipe solar collectors have a stagnation temperature of 392.5°F.

On all models of Vacuum Heat Pipe Collectors, the specially coated absorber has an absorption rating of >/= 0.94 and an emissivity of </= 0.07.

3.1.1 The SunMaxx Tube

The SunMaxx Heat Pipe Solar Collector Tube shown below in Figure 5 combines the technology of the vacuum glass tube with industry-leading selective coating absorber, copper heat transfer pipe and the condenser header.

The Absorber

The main parts of the Absorber are the ABSORBER PLATE (built into the vacuum heat pipe itself) and the HEAT PIPE. The absorber plate is coated with a special, high-efficiency SELECTIVE COATING that ensures maximum radiation absorption and minimum thermal radiation losses. Figure 4 shows the characteristics of the selective coating. The coating undergoes a stringent quality control test, and only the materials meeting our highest absorption and lowest emittance standards are used in production.

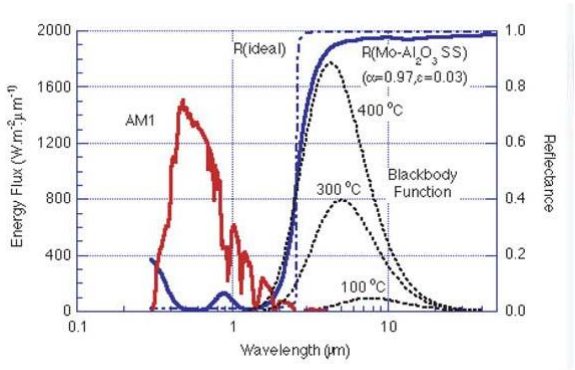


Figure 4

A heat pipe performs like a high-conductance metal-liquid conductor. Due to its thermo-physical properties, its heat transfer rate can be thousands of times greater than that of the best solid conductors of the same dimensions. The heat pipe employs an evaporating-condensing

cycle, which accepts heat from an external source, which is then absorbed into the liquid HTF (Heat Transfer Fluid) within and then releases this heat by reverse transformation (condensation) at the header region. This process is repeated continuously as the condensed fluid returns to its original position due to gravity.

Rapid temperature swings produce localized stresses within all glass to metal joints, limiting the life of the joint. In order to remove these stresses a specially designed THERMAL SHOCK ABSORBER is incorporated into the SunMaxx Vacuum tube. This patented thermal shock absorber is made from metal having a high thermal resistance and high mechanical strength – allowing the thermal shock absorber to completely absorb the temperature swing.

The Vacuum Glass Tube

In a SunMaxx Collector Tube, the Absorber Plate and the Heat Pipe are sealed within the Vacuum Glass Tube. This protects the high efficiency of the absorber plate from adverse weather conditions and airborne pollutants.

The vacuum in the tube (P<5x10-3 Pa) can only be reached and maintained over a long period of time through a specialized evacuation process during production, resulting in an almost total

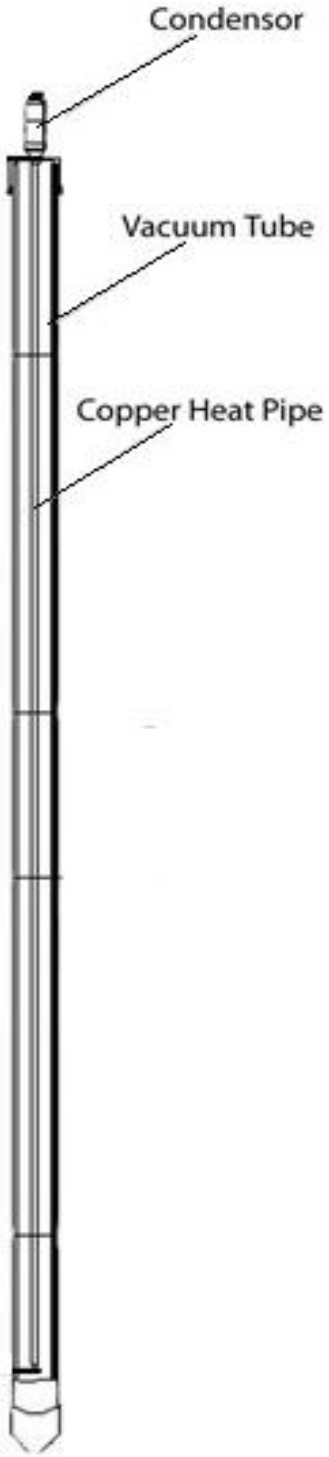


Figure 5

reduction in convection and conduction losses from the collector.

Additionally, due to their tubular shape, each glass tube offers minimal resistance to wind and snow build up.

The Condenser

The heat pipe is coupled to a high-efficiency CONDENSOR, operating as the heat sink in the repetitive evaporation/condensation cycle of the heat pipe. Radiation striking the collector plate is absorbed, and then transferred via the heat pipe as thermal energy to the condenser. When connected to the manifold, the condenser efficiently transfers this heat to the heat transfer fluid of the connected circuit.

The unique design of the SunMaxx condenser assembly provides an advantage over many other similar collectors. The special interior construction of the condenser prohibits any delay of its operation, which may be caused by overheating of the Heat Transfer Vapor in the heat pipe. This condenser design also significantly increases the output of the unit.

3.1.2 The SunMaxx Vacuum Tube Manifold

SunMaxx Manifolds are designed between 3 feet (10 tubes) and 8.4 feet (30 tubes) in length. The size of manifolds can be increased by the addition of collectors in parallel or series. You can connect as many collectors together as needed to meet the heating requirements of your application. It is recommended, however, that you do not put more than 210 tubes in series.

Every manifold is insulated, and is shipped with the support assembly hardware and connections for pipe work. The outer manifold cover is made of 0.03" thick Galvanized Steel and 0.07" thick Alnico painted black. There is a thick, CFC-Free Polyurethane foam insulating jacket inside. The header pipe has a diameter of 1" with NPT brass threads and the material is 0.08" thick.

The manifold has an approximate depth of 6.1", and a variable width corresponding to the number of tubes present. Please see **Error! Reference source not found.** for overall dimensions of all SunMaxx Vacuum Heat Pipe Solar Collector Manifolds. The Collectors' gross area and weight are also listed.

#tubes	10	20	25	30
Dimensions (inches)	36x79	68x79	85x79	101x79
Dimensions (m)	.91x2	1.75x2	2.16x2	2.57x2
Net Aperture Area (ft^2)	10.01	20.03	25.03	30.04
Net Aperture Area (m^2)	.93	1.86	2.33	2.79
Weight (lbs)	88.00	170.00	212.00	252.00
Weight (kg)	39.92	77.11	96.17	114.31

Table 1

The manifold and all welds are fully processed and pressure tested to 150 psi to ensure proper operation during and after installation. Please refer to the CAUTIONS at the beginning of this manual for detailed information about the water quality and application of the system.

3.2 Flat Plate Collectors

A SunMaxx Flat Plate Collector consists of a metal absorber in a flat rectangular housing. It is thermally insulated on its back and edges to prevent heat loss and is fitted with a

transparent glazed top cover to allow radiation to reach the absorber.

Absorber

The flat plate absorber is similar to that of the evacuated tube albeit with a much larger surface area. It is coated with selective black chrome and functions the same way by absorbing the radiation from the sun and transferring it to the heat pipes.

Insulation

To reduce heat losses to the environment by thermal conduction, the back and edges of the collector are insulated with 2 inch thick rock wool. The top of the panel is not fitted with this insulation, as it needs to remain open so as to allow radiation to get to the absorber.

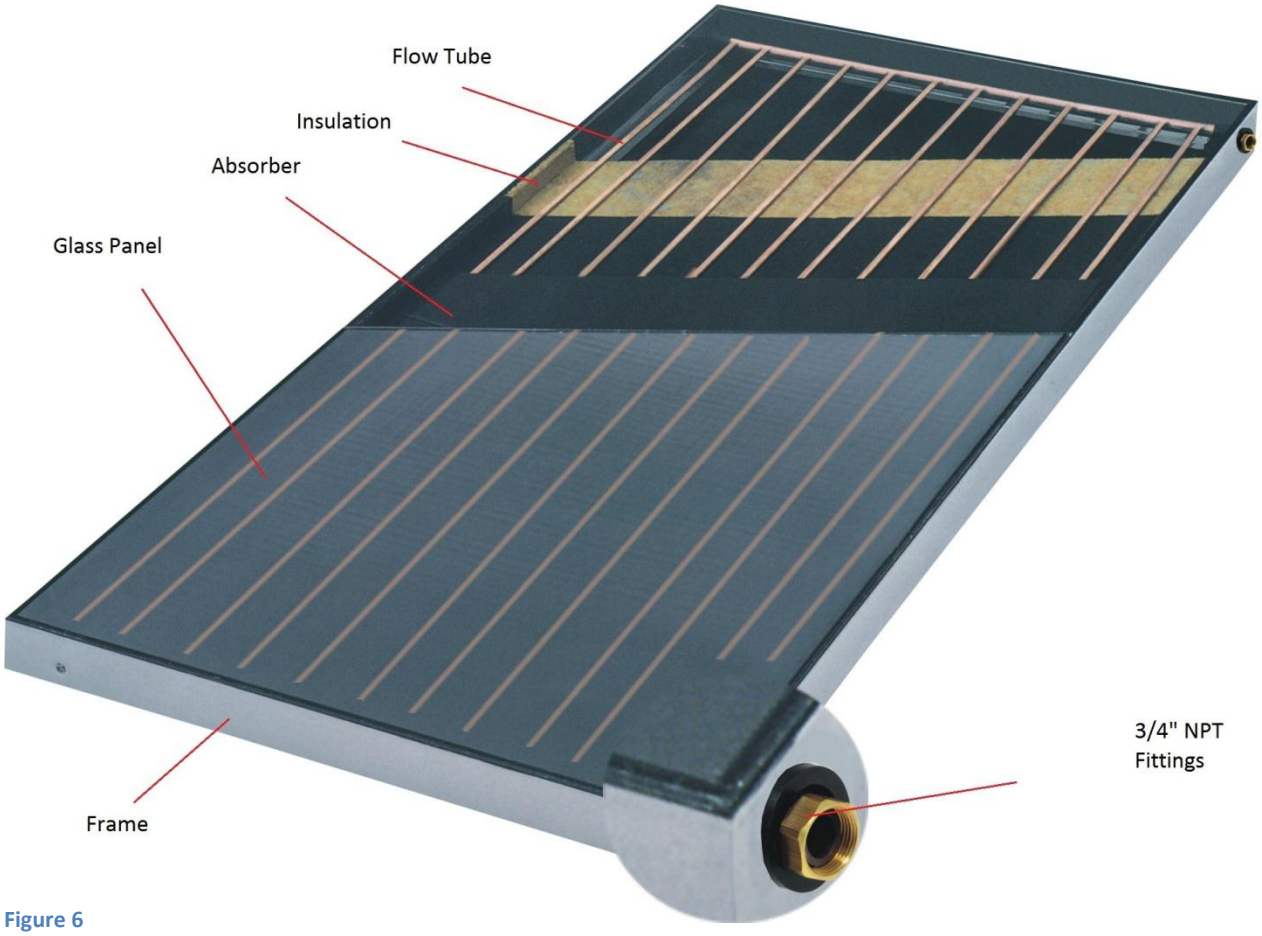


Figure 6

Flow Pipes

The flow pipes of Flat Plate collectors serve the purpose of transferring the energy from the absorber directly into the heat transfer fluid.

This is a direct process, for the fluid itself is funneled through the flow pipes.

There are 2 different configurations for flat plate heat pipes: parallel and serpentine.

The parallel configuration is shown in figure below. Fluid coming from the inlet is forced up all of the heat pipes at the same time, leading to an efficient absorption of solar thermal energy and high yield. When using this configuration with multiple collectors, it is possible to make the entire array function essentially as one unit.

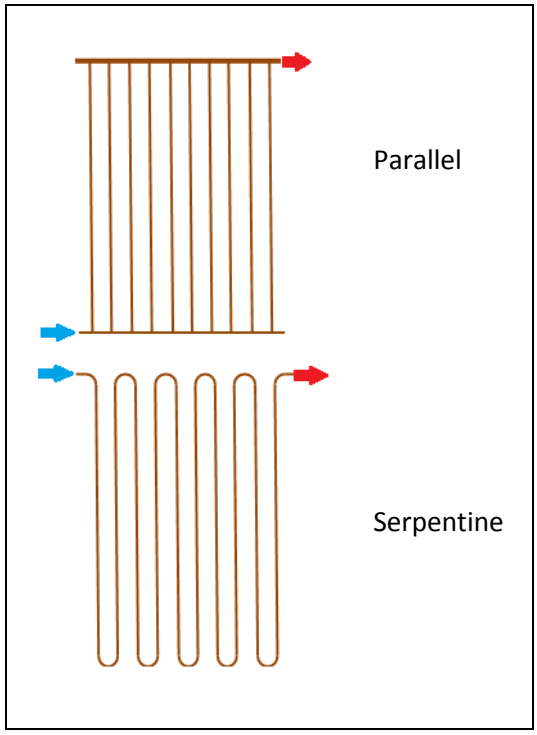


Figure 7

Serpentine or direct flow, heat pipes direct the heat transfer fluid through one continuous path winding throughout the collector. The efficiency and yield of this particular arrangement is less than the parallel flow and requires more pressure from the pumps, but can yield higher temperatures. They can also be more versatile and can be mounted at any inclination angle.

Glass Panel Casing

All of the components of the collector are mounted firmly in the collector housing. The purpose of the glass panel is to allow as much radiation as is possible to enter the collector while minimizing the amount that can be emitted. The glass panel of SunMaxx Flat Plate Collectors is made of patterned low-iron glass with a thickness of .15 inches

3.3 Flat Plate vs. Vacuum Heat Pipe

The choice of which collector to use is dependent on your requirements, location, and personal taste. There are several distinct differences between the vacuum tube solar collectors and the flat plates.

The main advantage of vacuum tubes is that their heat loss to the environment is virtually zero because the vacuum surrounding the absorbers eliminates conductive and convective heat loss. This ultimately leads the collector to be able to maintain higher heat retainment at relatively high temperature differentials (between the ambient air and the heat transfer fluid). This basically means that vacuum tubes are more efficient than flat plates in systems with high temperature requirements and low ambient temperatures.

Table 2 shows several more comparisons between Vacuum Tubes and Flat Plates.

Flat Plate	Vacuum Heat Pipe
Less Expensive	More expensive
Better year-round performance	More susceptible to breaking
Not suitable for high-temp applications	Better Cold Weather Performance
Less susceptible to snow buildup	More difficult to assemble
Less roof space required	Can heat fluid to higher temperatures.

Table 2

3.4 Accessories

To complete a Solar Hot Water System, various parts are needed. SunMaxx supplies the following with every collector sold:

For ThermoPower Systems:

- Manifold/Header
- Evacuated Solar Tubes
- Copper Heat Pipes

For TitanPower Systems:

- TitanPower Flat Plate Collector(s)
- BSP to NPT fittings
- 1" to ¾" converter

To complete your installation you may also require other components which SunMaxx can provide to ensure proper configuration and installation, including:

- Fully Adjustable Tilt Mount Hardware (for flat or low-pitch roofs)
- Ground or Pole Mounting Hardware
- Brazed Plate Heat Exchangers
- Solar Hot Water Storage Tanks
- Circulating Pump
- Differential Temperature Controller
- Grounding Wire
- Flow Meter
- Insulation
- Heat Dump
- Valves (check, pressure relief, isolation, etc.)

SunMaxx does not normally supply any plumbing hardware (except that which is required to connect directly to our main system components). We do this because it is generally more efficient for the system designer/installer to have these parts on hand to meet the needs of the specific installation.

3.4.1 Mounting Kits

A complete listing of mounting hardware offered by SunMaxx is available in Appendix 9.1

Adjustable Frame Kits

Adjustable (Tilt) Mount Kits are offered as an upgrade for every SunMaxx Vacuum heat pipe Solar Collector. This specialized Tilt Mounting Hardware is designed to increase the angle of your SUNMAXX solar collector during installation on flat or low-pitched roofs.

Note: *Installation angle should be equal to the location's latitude + 15 degrees. If roof pitch is within 5 degrees (+/-) this installation angle, a Flush Mounting Face Frame Kit is adequate for the installation.*

SunRack Rail System

The SunRack Rail System consists of 8 foot long sections of extruded aluminum rails that allow the installer to attach them to the roof regardless of rafter spacing.

SunRack Pole

The SunRack Pole is used to pole mount a single SunMaxx solar collector on a pole for a wider variety of installation locations. The SunRack Pole requires a SunRack Pole Interconnect Kit, a SunRack Pole Mounting Base and a 5" steel pole.

Alternate Mounting Methods

SUNMAXX Vacuum heat pipe Solar Collectors can be mounted to any type of roof when properly secured. Certain installations may require a noggin – a beam between two rafters. Contact a SunMaxx representative if you need assistance finding appropriate mounting hardware.

3.4.2 Differential Temperature Controller

SUNMAXX Solar Hot Water Systems use a Differential Temperature Controller to provide automatic ON/OFF operation. This controller regulates the flow of water from the solar collector to the heat exchanger in, or near, the Storage Tank. The controller will automatically operate the system's pump(s) based on settings configured by the installer. SunMaxx offers a variety of controllers to allow the collectors to tie into any existing system. See the website for product brochures.

4.0 How does a SUNMAXX System Perform

4.1 Solar Fundamentals

All solar collector systems have a common energy source; the sun. The performance of any system therefore depends on the conversion of solar radiation into useful thermal energy, and transfers that energy to the hot water system.

The ability to convert solar energy into thermal energy is expressed by the optical efficiency of the system (η_0). The efficiency of a collector changes as the inlet fluid parameter varies. The instantaneous collector efficiency is represented by the following formula:

$$\eta = \frac{thermal\ outbut\ from\ collector\ (\frac{Btu}{hr})}{solar\ radiation\ striking\ GROSS\ collector\ area\ (\frac{Btu}{hr})}$$

Which is equivalent to:

$$\eta_{inst} = \frac{(8.01 \times c \times D) \times (T_{out} - T_{in})}{I \times A_{gross}}$$

Where:

η_{inst} = Instantaneous collector efficiency

$c =$	Specific heat of fluid (Btu/lb/ °F)
$f =$	Flow rate (gpm)
$T_{in} =$	Collector inlet temperature (°F)
$T_{out} =$	Collector outlet temperature(°F)
$I =$	Instantaneous solar radiation intensity in plane of collector (Btu/hr/ft^2)
$A_{gross} =$	Gross collector area (ft^2)
$D =$	Density of fluid (lb/ft^3)

In order to find the ambient temperature of the SUNMAXX Solar Collectors in °K, follow one of these two methods.

From °C:

- °K = °C + 273.15

From °F:

- Convert °C to °F
- °C = (°F - 32) * 5/9
- °K = °C + 273.15

The global solar radiation varies considerably from region to region. On a clear summer day approximately 850 W/m^2 (270 Btu/ft^2) can be expected, whereas clouds can reduce it to 400 Btu/ft^2 (127 Btu/ft^2).

Both Flat Plate and Vacuum Heat Pipe collectors are insulated to prevent heat loss, but due to extremely good insulation properties of the SunMaxx Vacuum heat pipe Solar Collectors, the "only" heat loss is via the SUNMAXX Manifold with its small surface area and thick layer of high-quality polyurethane foam insulation.

4.2 Thermal Performance

SUNMAXX Evacuated Heat Pipe Solar Collectors can supply heat at temperatures significantly higher than those achieved by Flat Plate Collectors. This comparison is particularly relevant in cold, windy and cloudy climates

5.0 How to Design a SUNMAXX System

Sizing is key!

It is important that you use the resources available to you to properly size your system. These include the techniques and calculations listed below, useful online resources (RETSCREEN), simulation software (T*SOL), and of course, SunMaxx staff.

The following explanations are for installations of up to 90 tubes (4 Flat Plates). Some typical examples for the various components are given at the end of this chapter.

5.1 Determining Number of Collectors

The first step to enjoying your SUNMAXX System over a long period of time is to design and specify the number of collectors.

In order to determine the number of collectors needed, you must first take into consideration your heating load, location, and collector type.

5.1.1 Determining Space Heating Load.

The easy way of determining your heating load is to simply take your fuel bill for space heating and determine how much fuel that equates to. From there you can simply determine how much energy that volume of fuel will provide.

If this information is not available or not possible to obtain, you need to calculate the heat loss of the building manually.

A quick and easy way to get a rough estimate is to take the square footage of the area you want to heat and multiply it by an estimated heat loss rate for your building ranging from 10-40 Btu/hr. (10 being good insulation and 40 being poor insulation) If you're house is newer and/or has less opportunity for heat loss, it would be a good idea to use a lower value and if your building is older and has more opportunity for heat loss, use a higher number.

This calculation will give you the Btu/hr amount needed. Simply multiply this number by the amount of hours in a day (24) and then by the amount of days during the year which space heating will be used.

5.1.2 Determining Domestic Hot Water Load

As mentioned before, the easiest way to determine the heat load is to calculate how much energy your fuel bill equates to, however it is possible to determine the energy demand using the following formula:

$$Load = 8.34 \times Gal \times \Delta T \qquad (5.1)$$

8.34	Amount of BTUs needed to raise one gallon 1 °F (constant)
Gal	Hot water requirement (gallons)
ΔT	Difference between desired water temperature

	and ground water temperature. (°F)

Once you have your heat load, you simply need to multiply it by the desired solar fraction. (.7-.9 for hot water, .2-.5 for space heating) to determine the amount of energy your collectors need to provide.

5.1.3 Determining Square Footage of Collectors

Using equation 5.2, an estimation of the overall system contribution can be made.

$$A_R = R * \eta \qquad (5.2)$$

Where:

A_R	System Contribution [kWh/m2] or [BTU/h/ft2]
R	Monthly Solar Radiation [kWh/m2] or [BTU/h/ft2]
ŋ:	Average System Efficiency

For the purposes of this calculation, you can use the following conversion factor to convert from kWh/m2 to BTU/h/ft2:

1 kWh/m2 = 317 BTU/h/ft2

To find the required collector area, the energy demand has to be divided by the system contribution (equation 5.3)

$$A_R = \frac{ED}{SC} \qquad (5.3)$$

SC	System Contribution [kWh/m2] or [BTU/h/ft2]
ED	Energy Demand [kWh] or [BTU]
A_R	Required Collector Area [m2] or [ft2]

For the purposes of this equation, you can convert your energy demand from kWh to BTU and vice-versa using the following conversion factors:

1 kWh = 3412.1415 BTU

1 BTU = 0.00029307108 kWh

Table 3 shows the approximate collector areas for the different SUNMAXX Solar Collectors.

SunMaxx Model	Aperture Area (m2)	Aperture Area (ft2)
SunMaxx-10	.93	10
SunMaxx-20	1.86	20
SunMaxx-25	2.32	25
SunMaxx-30	2.79	30
TitanPowerPlus	1.86	20

TitanPowerPlus SU2	1.86	20
TitanPower AL2	1.86	20

Table 3

For more precise predictions of the overall performance of the solar system, SUNMAXX technicians and sales representatives can run your installation through our sizing software over the phone or via email. Please access our SunMaxx quote request form for immediate sizing response or contact your local representative.

5.2 Determining Solar Storage.

As a guide, you can use Table 4 below to size a solar storage tank. This table is based on the solar coverage throughout the year in a mid-north American climate.

Gallons per tube:	Temperature requirement
2 gallons	145 °-170 °F
2.5 gallons	125 °-145 °F
3 gallons	105 °-125 °F

Table 4

5.2 Flow Rate

When determining the proper flow rate for your system, you need to determine the specific flow rates for your collectors. This flow rate is measured in [l/min] or [g/min]. See Table 5 for specific flow rates for SunMaxx Collectors.

Collector	Flow Rate [g/min]	Flow Rate [l/min]
Flat Plate	.79	3
Vacuum Heat Pipe	.0826/tube	.02/tube

Table 5

Finding the overall system flow rate involves taking the number of collectors installed in series and adding them together. If collectors are mounted in parallel with one another, their net flow rate is equal to that of the collector with the lowest flow rate.

To convert the system flow rate V_s into the unit [m3/h] that circulation pumps are generally specified in, use the conversions below.

$$m^3/h = [l/min] * 0.600$$

OR

$$m^3/h = [g/min] * 0.227$$

The collectors that are connected in series, the higher the specific flow rate (V_T) should be. SUNMAXX *strongly recommends that you do not connect more than 210 tubes (10 Flat Plates) in series*.

The flow rate further affects the achievable temperature difference (ΔT) in [K] between the collector outlet and the solar tank return. This value is used to switch the circulation pump(s) in the system on and off. The longer the pipe-work in the installation, the larger the ΔT should be to avoid toggling the pump.

Through observation and some experience, the flow rate can easily be altered after completion of the installation, if necessary, by using a ball

valve installed in the pipe-work or the setter on the pump control unit.

5.3 Selecting Pipe Size

Some recommended pipe sizes are given in table 6.

Flow Rate [l/min]	Pipe Size [mm]
2.0 - 6.0 @ 1 m/s	15 x 1
7.0 - 10.0 @ 1 m/s	18 x 1
12.5 - 17.5 @ 1 m/s	22 x 1
17.5 - 22.5 @ 1 m/s	28 x 1.5
Flow Rate [g/min]	Pipe Size [Inches]
.5 - 1.6 @ 3.3 ft/s	1/2"
1.8 - 2.6 @ 3.3 ft/s	3/4"
3.3 - 4.6 @ 3.3 ft/s	1"
4.6 - 5.9 @ 3.3 ft/s	1-1.5"

Table 6

The sizing of the pipe has to be viewed under 2 aspects:

1. Installation Costs
2. Energy Costs for Operation
3. Heat Loss From Piping

As the anti-freeze causes approximately 1.3 times higher pressure drop passing through the system compared to water, the v in [m/s] of the fluid passing through the system should be within the following ranges:1.0 </= v </= 1.25 [m/s].

- $1.0 \leqq v \leqq 1.25$ [m/s]
- $3.3 \leqq V_t \leqq 4.1$ [ft/s]

Equation 5.4 gives the required pipe diameter $Ø_i$ in [mm] or [in].

$$Ø_i = \sqrt{\frac{4 * V_s}{\Pi * v}} \qquad (5.4)$$

$Ø_i$ Pipe inside diameter [mm] or [in]

V_s System flow rate [l/min] or [g/min]

v Velocity of fluid [m/s] or [ft/s]

Please ensure that the pipe with the best matching inside diameter [$Ø_i$] has been chosen. SUNMAXX recommends the use of copper pipe not smaller than 15mm outside diameter. We do not recommend using PVC or PEX Pipes in solar installations (within the collector loop) as high temperatures and the compatibility with the anti-freeze can cause failure.

Any insulation used needs to be UV stable where it will be exposed to sunlight, and resistant to high temperatures. To prevent high heat loss through the pipe network it is recommended that you use insulation with a thickness that is at least half the pipe diameter and a U-Value in [W/(mK)] of U <0.035 [W/(mK)].

5.3.1 SunMaxx LineSet

SunMaxx also offers pre-insulated line set which includes flexible piping that is specifically

designed to make solar thermal installations easier. It comes in two pipe diameter sizes: 5/8" and 3/4" and is available in increments of 30',50',80', and 160'.

5.4 The Circulator Pump

The circulation pump has to overcome the total pressure drop of the system caused by the different components at the given flow rate V_s.

In analogy to the correlation in electricity where Ohm's law applies: every resistance (= resistance) causes a pressure drop (= Voltage Drop) as soon as there is a flow rate (= current).

As the flow rate V_s is already determined (see chapter 5.2) the pressure drop ΔP_s in [Pa] of the system has to be calculated. The system pressure drop ΔP_s equals the sum of all single pressure drops of components in the installation connected in series (not parallel). Mainly these are:

Hence:

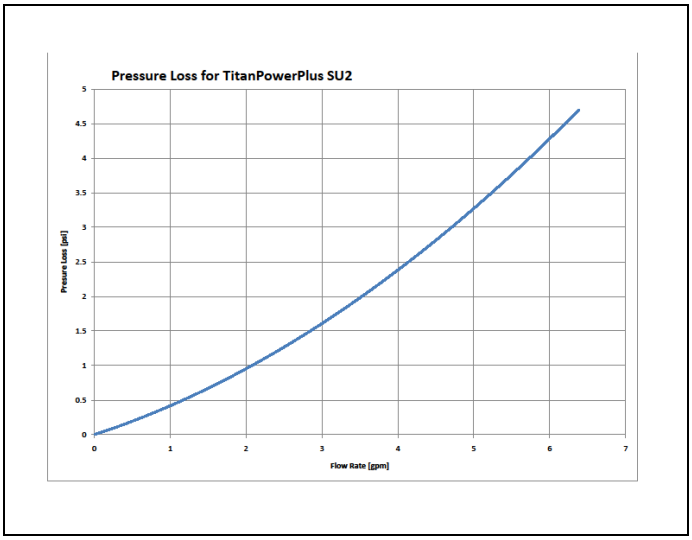
$$\Delta p = \Delta p_{col} + \Delta p_p + \Delta p_{he} \qquad (5.4)$$

Δp	Total pressure drop
Δp_{col}	Pressure drop across collectors
Δp_p	Pressure drop from pipe work
Δp_{he}	Pressure drop from heat exchanger

The pressure drop of the pipe work ΔP_p can be found in standard plumbing tables or in the manufacturer's information. **Please remember to multiply the values in the tables by 1.3 to account for the anti-freeze flowing through the system in place of water. It also is a good idea to take the pressure drop from your piping and add 50% of that value to account for head loss due to bends and other piping circulation obstacles.**

Likewise, the pressure drop for the heat-exchanger ΔP_{he} in [Pa] can be found in the manufacturer's information.

The pressure drop of several SunMaxx collectors are shown below in Figure 8



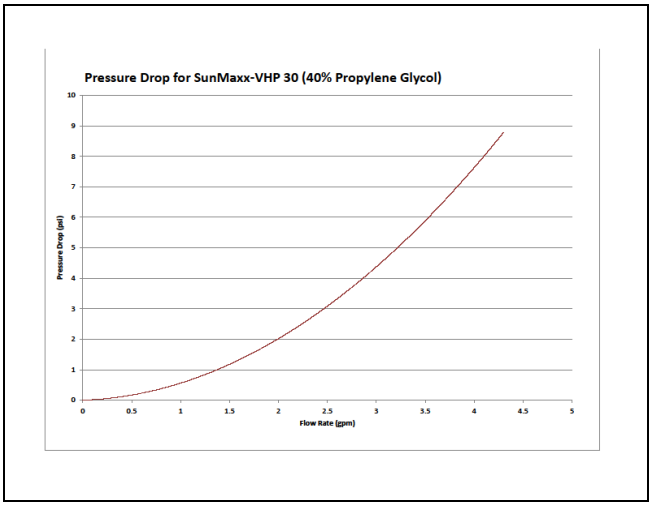


Figure 8

For collectors in series, the net pressure drop is simply the various pressure drops added together. If the collectors piped in parallel, the net pressure drop is the value of the collector with the highest pressure drop.

According to the information given above, the overall pressure drop of the system ΔP_s in can be calculated by adding together all of the individual pressure drops of the system.

To convert any of your PSI readings to Pa, you can use the following conversion formula:

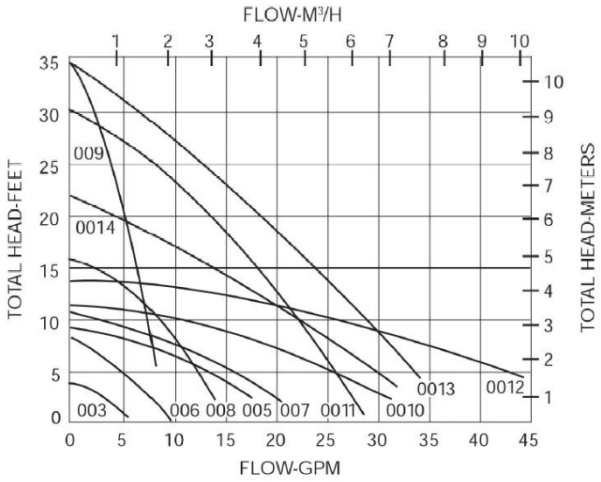
PSI * 6.894757 E+3 = Pa

And, to convert the Pa pressure measurements calculated in this section back to PSI, you can use the following conversion formula:

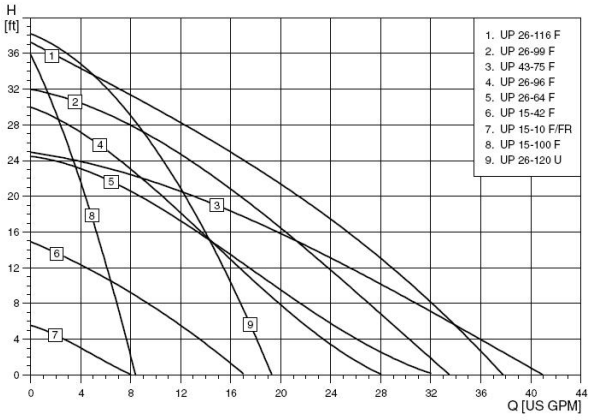
Pa * 1.4503774 E-3 = PSI

Figure 8 shows the relationship between the flow rate and the head pressure of various pumps used in SUNMAXX Solar Hot Water Systems.

TACO 00
Series



Grundfos



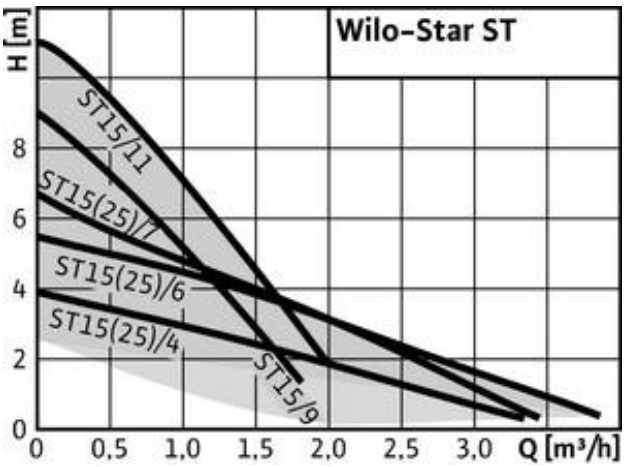


Figure 9

5.5 Sizing Expansion Vessel

If the water temperature in the system rises, the water volume will increase, resulting in a rise in pressure and the possibility of damage to the system if the expansion is not absorbed. By incorporating an expansion vessel into the system, the increase in water volume may be contained until the water temperature has reduced and the water volume returns to its initial level.

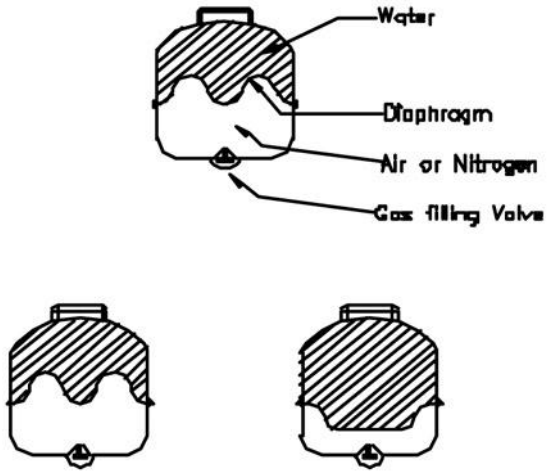


Figure 10

During stagnation periods, the collectors can reach temperatures of up to 180°C (356°F) for flat plates and 200°C (392°F) for vacuum heat pipes. Temperature this high will cause the water in the system to evaporate, increasing the volume and pressure of the system and forcing the glycol out of the collectors. To accommodate for this, an expansion tank is used. It is extremely important that the expansion tank be correctly sized. An incorrectly sized expansion tank will cause the relief valve to open and waste system pressure and fluid.

The expansion vessel is comprised of two halves. One half connects directly to the water system and the second, separated by a special diaphragm, contains nitrogen air. As pressure rises and the volume increases the diaphragm is displaced as shown in Figure 13.

To correctly size an expansion tank, follow the steps below. If you are using metric values, it is necessary to convert them to standard units before starting.

1. Select an appropriate relief valve. There is oftentimes local code that mandates a maximum pressure relief valve setting in solar thermal systems. If there are no code restrictions, determine the relief valve pressure rating using the equation below:

$$P_{static} = P_o + .45 * H$$

Where:

P_{static}	Pressure at the relief valve during normal operation [psi]
P_o	Operating pressure. (The pressure your system is set to when you fill the system). [psi]
H	Vertical distance from the top of the relief valve to the top of the system [ft]

Your pressure relief valve should be rated at 15-20 psi higher than this number

2. Determine the total volume the expansion tank must accommodate. To do this uses the equation below. This formula assumes the vapor form of the water during stagnation while the glycol is pushed out of the collectors.

$$V_a = 1.1\lfloor (V_c + V_p).08 + V_c \rfloor$$

Where:

Va	Expansion volume to be accommodated [gallons]
Vc	Total volume of system piping and heat exchangers excluding collectors [gallons]
Vp	Total volume of collector array [gallons]

The piping volume can be determined by Table 8 below :

Tube type/size	Gallons/foot
3/8" type M copper:	0.008272
1/2" type M copper:	0.0132
3/4" type M copper:	0.0269
1" type M copper:	0.0454
1.25" type M copper:	0.068
1.5" type M copper:	0.095
2" type M copper:	0.165
2.5" type M copper:	0.2543
3" type M copper:	0.3630

Table 7

3. Calculate the minimum required expansion tank volume using formula 5, which is derived from Boyle's Law.

$$V_t = V_a \left(\frac{P_{RV} + 14.7}{P_{RV} - P_{static}} \right)$$

Where:

V_t	Minimum required expansion volume [gallons]
P_{RV}	Maximum Pressure at the relief valve. (generally the pressure relief valve rating minus 3 psi) [psi]

It is recommended that you install a check valve in the collector circuit to allow for swift emptying of the collectors as the evaporation begins.

You have now sized the Expansion Vessel for your SUNMAXX Solar Hot Water System. While most Expansion Vessels are sized in Liters (metric is the standard for the Solar Industry), you may be able to find one rated in Gallons. ***To convert your V_n from liters to Gallons, multiply the [l] value by 0.26417.***

The closest available Expansion Vessel from your supplier should be chosen. But, always go with the next higher size vessel if there is not an exact match. This will keep your Expansion Vessel from being undersized and possibly damaging your system.

5.6 Hydraulics

5.6.1 Collector System

As mentioned before, the maximum number of tubes for vacuum heat pipes installed in series should not exceed 150 tubes (10 flat plates). For bigger installations, the recommended collector connection is shown in figure 11.

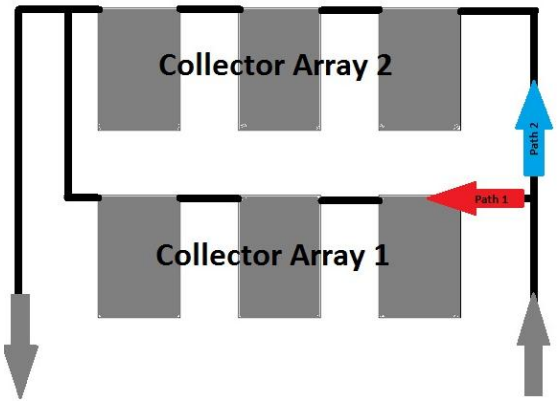


Figure 11

To achieve the highest output of the whole system every manifold needs the correct flow rate. This can be achieved by connecting the manifolds according to “Tichelmann” (the flow and return pipe of each manifold adds up to the same length, also known as reverse return piping). This concept is demonstrated in figure. In order for the flow rate to be equal through both paths, the lengths of path 1 and path 2 have to be equal. Another method to manage the flow rate is by using balancing valves.

5.6.2 Overall System Design

Functional Description of Parts

The following is a brief description of the main parts used in a SUNMAXX Solar Hot Water System.

Pump is used to circulate water from the Solar Collector to the user application.

Flow-Meter is attached near the pump to monitor flow rate of water within the system (optional).

Non-Return Valve is used to prevent gravitational flow of water/glycol in the solar collector loop from the storage tank to the solar collector when the temperature in the tank may be higher than the temperature in the collector (at night) A swing type check valve will function well in this regard. *It is imperative that this valve be installed correctly.*

Air Vent is fitted at the highest point of the system to facilitate the removal of any air pockets from the system. Air vents should be opened when filling the system and then closed using an isolation valve after the system is fully charged and air bubbles have been removed. Automatic Air Vents should be fitted with a valve to prevent opening when the system reaches stagnation. Sunmaxx also recommends using an air scoop or Spirovent near the expansion tank that will act as a continuous air eliminator.

Pressure Relief Valve and Pressure Gauge are used to monitor the pressure of the system and to serve as a safety mechanism to avoid over-pressuring the system (max = 5 bar). This should be activated at no more than 75 psi and piped into a bucket to reuse any spillage.

Filling Loop consists of a flexible hose and stop valve that connects the water main's supply to the hose connector and filling valve.

Expansion Vessel is used to contain increased water volume in the system due to a rise in temperature, and therefore an increase in water pressure. It should be positioned on the suction side of the pump.

Flush and Drain assembly is used to flush the system before filling with antifreeze and to drain it, if necessary.

Controller is used to coordinate the operation of the system. It is in charge of activating/deactivating relays and pumps based on various temperature inputs from sensors.

5.6.4 Common System Design Layouts

Active System with Double Coil Tank

Figure 12 shows a typical solar installation incorporating a double coil hot water storage tank enabling energy input from the central heating system to the top half of the tank and energy input from the solar system to the bottom half of the tank.

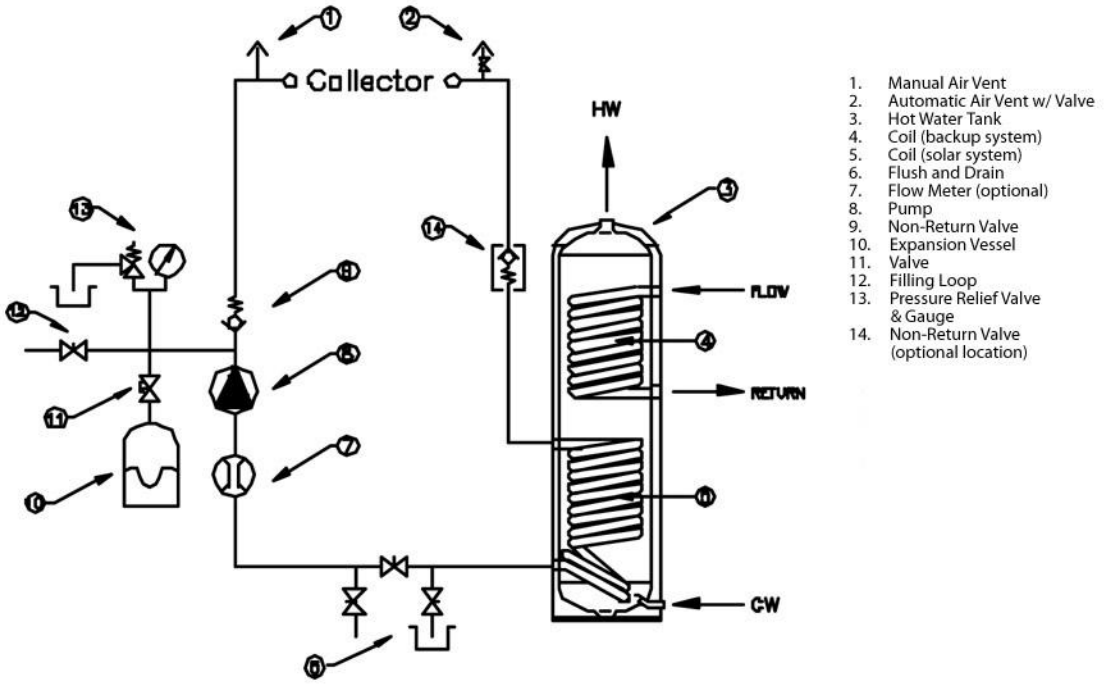


Figure 15

Figure 12

Active System with Immersion Heater

Similar to the system above, an auxiliary electric heater compensates for periods of prolonged cloud or rainfall when the solar collector cannot operate at full potential (Figure 13).

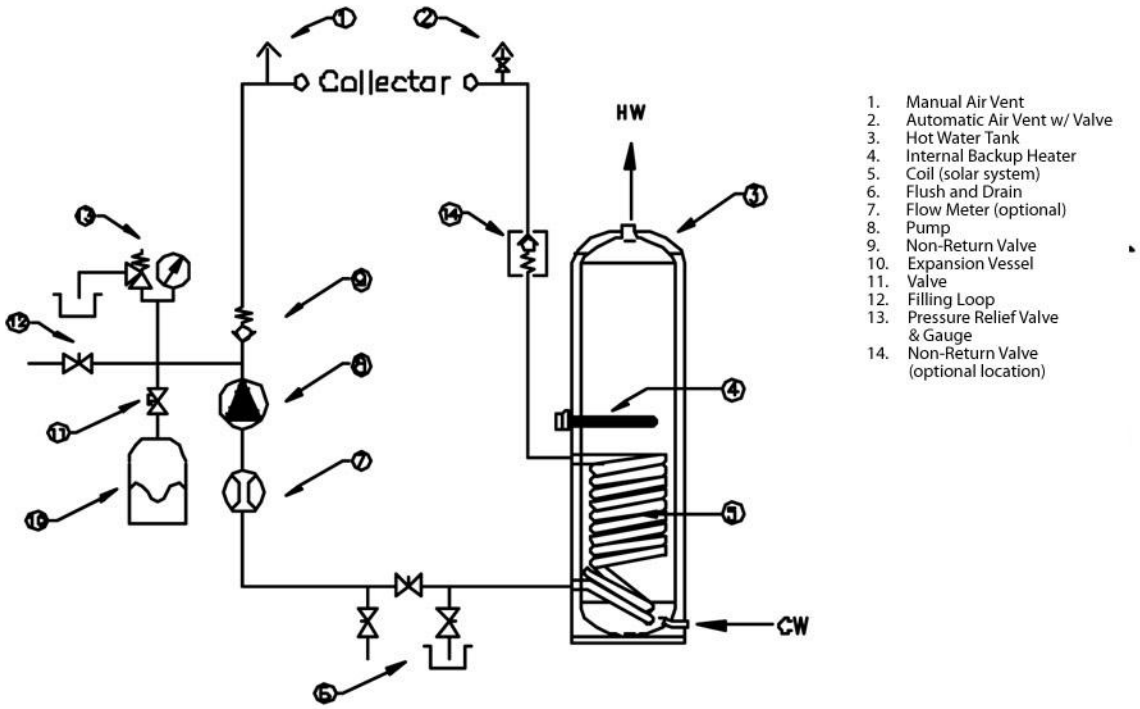


Figure 16

Figure 13

Active System with Short Circuit

Figure 14 shows an active system incorporating a short circuit. Hot water is only directed to the tank if the water temperature from the collector is above a set temperature. If not, the collector water is circulated back through the manifold via a 3-way valve. This type of installation is recommended when there is a long distance between the collector and the hot water storage tank.

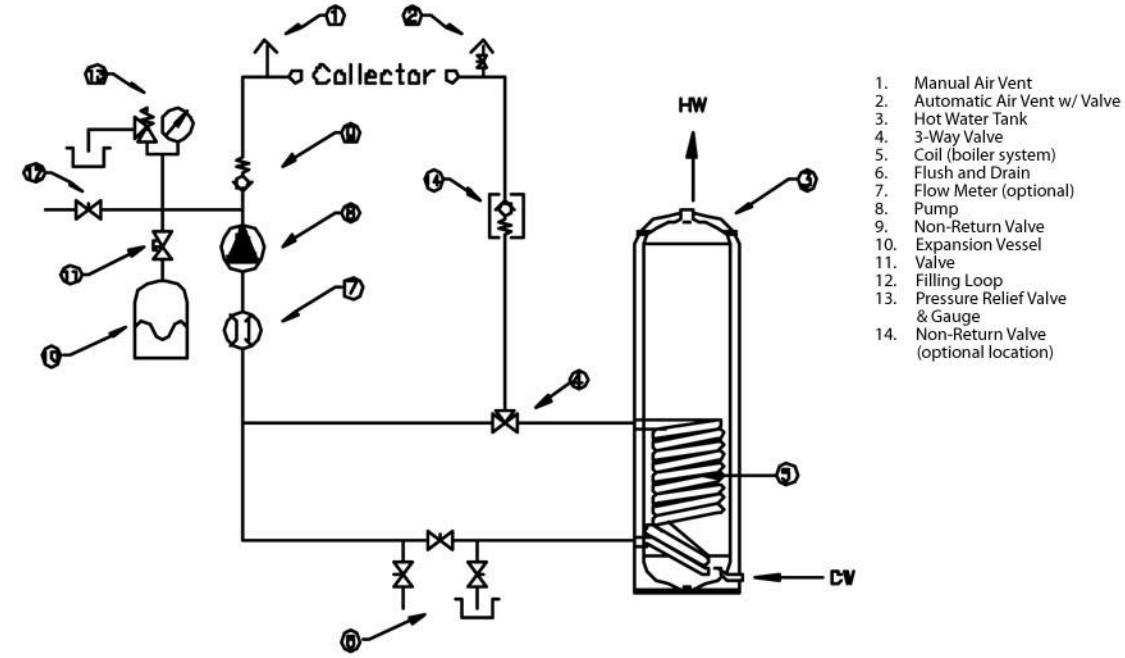


Figure 17

Figure 14

Multiple Tank Installation – Series

For large installations, two or more tanks may be connected to the solar system in series (pre-heat). Using 3-way valves, hot water from the collector passes through Tank 1 first, if the return temperature is above a set temperature it passes via a 3-way valve to Tank 2 (first pre-heat tank) – otherwise it is circulated back through the solar collector. If the water/glycol leaving Tank 2 is above a set temperature it is passed to tank 3 (second pre-heat tank). This process may be repeated for any number of pre-heat tanks as needed/desired (Figure 15).

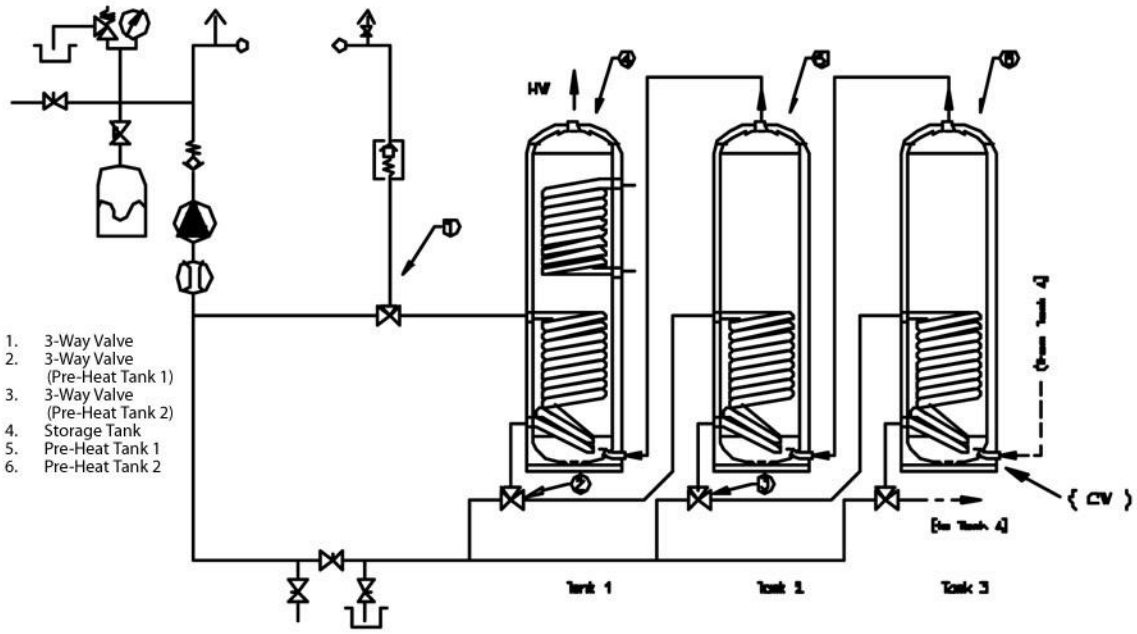


Figure 18

Figure 15

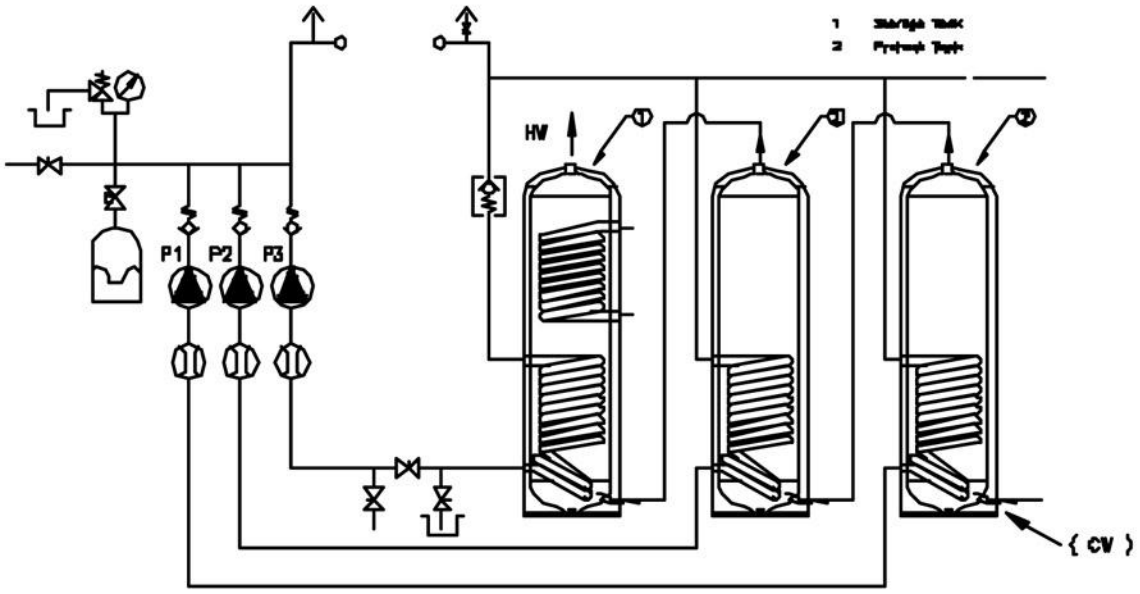


Figure 19

Figure 16

Multiple Tank Installation – Parallel

Figure 17 shows a number of tanks connected in parallel to the collector system. When the water temperature in Tank 1 reaches a set temperature the water from the collector is diverted, via a 3-way valve controlled by the temperature sensor on Tank 1, to Tank 2. If Tank 1 falls below the set temperature the water from the solar collector is diverted back to tank 1.

Once Tank 2 has reached the set temperature the water from the collector is diverted to a third tank, and so on. This method can be used for heating as many tanks in parallel as are needed/desired by your application/design.

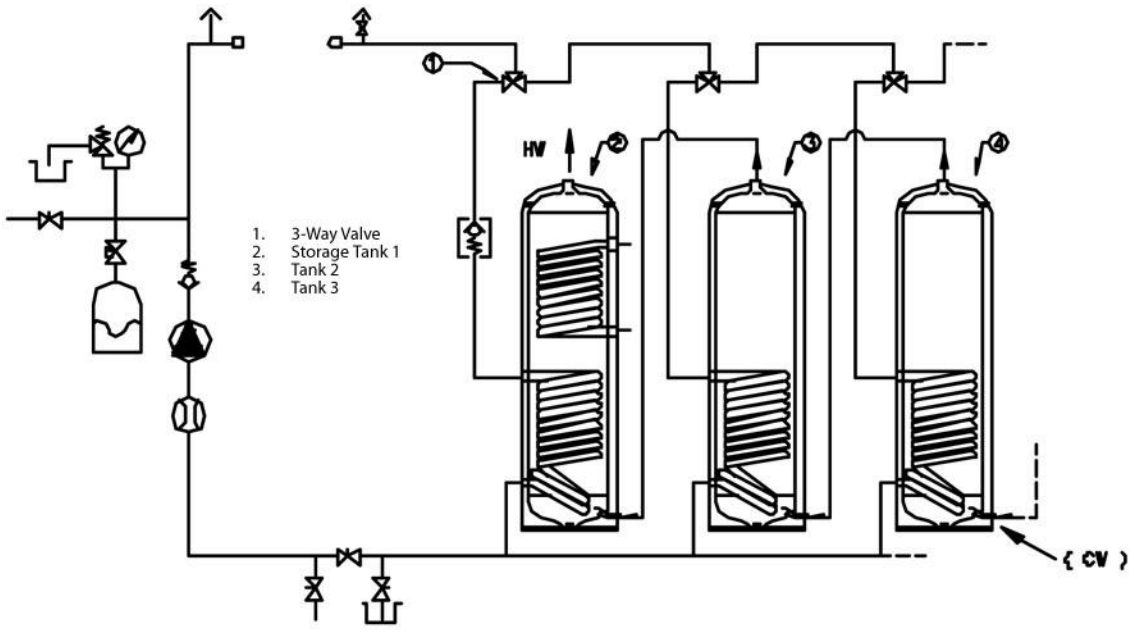


Figure 20

Figure 17

Swimming Pool

To incorporate a swimming pool into the solar hot water system, it is essential that a suitable heat exchanger is used between the water and the solar collector loop. There are a number of different heat exchangers for this application. A SUNMAXX Representative can assist you in determining the proper Heat Exchanger to use for this application. A pool heating system is shown in Figure 18.

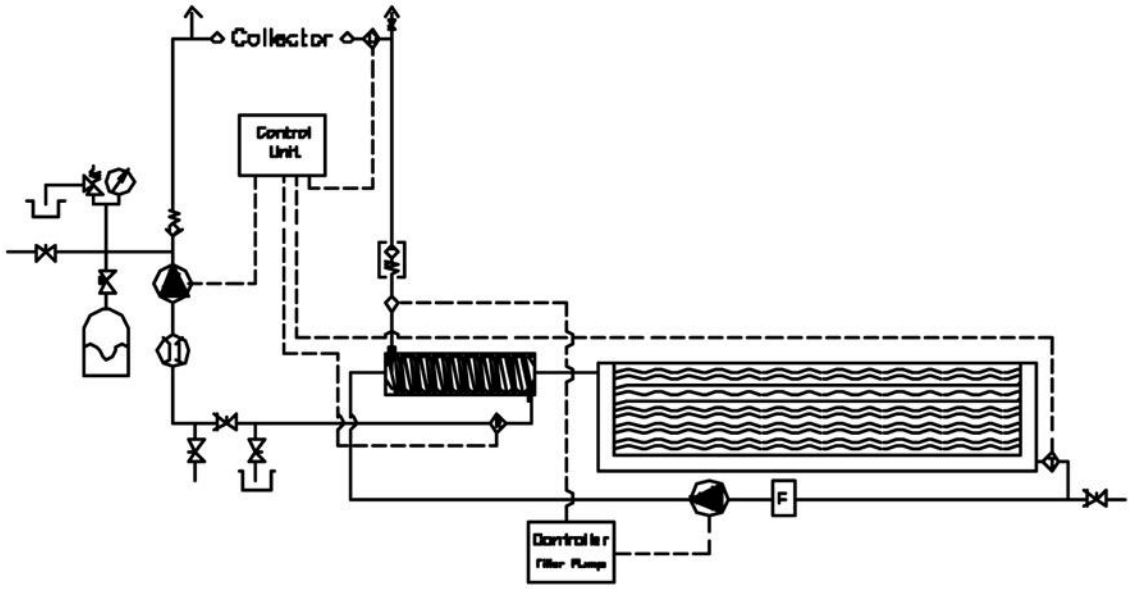


Figure 21

Figure 18

It is necessary that the filtration pump is always ON when the solar collector pump is running to avoid overheating of the heat exchanger and pipe work parts on the secondary side of the system.

6.0 How to Install a SUNMAXX System

This chapter explains the installation procedures for the SUNMAXX Vacuum heat pipe Solar Collector System with various roof fixing kits. See the assembly instructions for each system for more details.

6.1 General

Due to the overall weight of the unit it MUST BE MOUNTED SECURELY TO A STRONG SECTION OF THE ROOF. Please observe the following simple precautions to ensure maximum efficiency from your SUNMAXX Solar Collector assembly.

Positioning the collector in terms of azimuth and inclination angle is described in detail in chapter 2.

In areas where local water is known to be hard, a heat exchanger must be used, and the use of a water softener is STRONGLY RECOMMENDED. Otherwise, regular cleaning of the system will be required to maintain proper operation.

In areas where the Chloride Ion concentration of the water is >40 ppm a heat exchanger must be used in the hot water storage tank. The Solar System should be filled with distilled or dechlorinated water. *Check with the local water authorities concerning the water at the installation location.*

Cautionary Notes

- Make sure sufficient space is left between the manifold and roof apex for easier working on pipe work within the loft span
- Wear gloves and safety glasses when working with glass
- Do not use sharp objects to open the packages. This may scratch or damage the glass tubes
- DO NOT remove the glass tubes from their packaging until you are ready to assemble
- Connect the manifold, all pipe work and the pump before installing the vacuum heat pipes

Pipes running horizontally should always be installed rising slightly to avoid the creation of air pockets.

Please note that when installing the collector and pipe work it is important that all local authority regulations as well as relevant technical and safety standards are adhered to.

6.2 Manifold Connections

The manifold flow and return connections are Ø 1 in and are designed for use with compression fittings. Please remember that the maximum number of tubes connected in series should not exceed 150 (10 flat plates).

Installation of Compression Joints

Compression fittings are renowned for reliability and ease of assembly, as this step by step assembly guide demonstrates. To make this joint, you can follow either of the following two methods.

- The pipe can be firmly inserted into the compression fitting without removing the cap and ring. Be careful that the ring is in the correct position and that the tube makes firm contact with the tube stop in the body of the fitting.
- Or, the cap and the ring can be removed, slipped onto the pipe in the logical sequence and the tube fully inserted into the compression fitting.

In either case, you should hand-tighten the cap-nut as far as possible. Then, an appropriate spanner should be used to tighten the cap-nut further while a second spanner is used to secure the position of the fitting.

6.3 Flush Mounting System

The following procedure explains the installation of the SUNMAXX Solar System using the standard Flush Mounting Hardware Kit

1. Select the most suitable location for the Solar Collector. It should face toward True South, not Magnetic South. The recommended angle of tilt is the latitude of the location plus 15 degrees.
2. Remove roof tiles.
3. Secure LOWER Roof Mounting Brackets (SUNMAXX Part #: SKU18037) to the rafters. Please pre-drill screw holes to avoid damaging the rafters. Install a Left & Right LOWER Mounting Bracket (total of 2).
4. Secure UPPER Roof Mounting Brackets (SUNMAXX Part #: SKU18037) to the rafters. Please pre-drill screw holes to avoid damaging the rafters. Install a Left & Right UPPER Mounting Bracket (total of 2).
5. Once all 4 Roof Mounting Brackets are in place, replace roof tiles.
6. A third set of Roof Mounting Brackets will be needed for SUNMAXX 25 and 30 Tube Solar Collectors – bringing the total for installing these collectors to 6.
7. Bolt Side Support Rails into the Roof Mounting Brackets (2 or 3 rails depending on the collector model you are using).
8. Ensure that all bolts are tightened and all rails are secure and do not move.
9. Attach the bottom support to the BOTTOM of the side support rails. Bolt in place securely.
10. Attach the Manifold to the TOP of the side support rails. Bolt in place securely.
11. Make all plumbing attachments to the manifold – this includes inlet and outlet piping, filling valves, relief valves, etc.

12. Ensure that all plumbing and pipe work (include pump connection) are connected and ready to go.

13. Remove first tube from packaging.

14. Slide top tube through the bottom support strips and secure the condenser into the manifold using the included heat paste.

15. Attach and tighten the tube support cap. Do not over-tighten.

16. Repeat steps 12 to 14 for all remaining tubes in the collector.

17. Repeat this entire process for all collectors being installed until completed.

- Please Note – Mounting Bracket (SKU18037) is not included with the Standard Flush Mounting Hardware Kit. This component is available directly from SunMaxx Solar, or your Authorized SunMaxx Dealer.

7. System Commissioning Guidelines

7.1 Safety First

- **OSHA standards must be observed and practiced.**
- **When handling Glass you must wear protective eye wear and gloves**

7.2 Mounting collectors

- **Evacuated tubes-** refer to assembly guide that comes with collector or (link document)
- **Flat Plates-** refer to assembly guide that comes with collector or (link document)

7.3 Setting Pipe Runs

- **Connecting FlowMaxx Line set**
  - **i)** Be sure that the return side of your piping is the longest, supply side should be the shortest
  - **ii)** You can manipulate the angle and direction as you see fit. That is, you are not restricted with the degree of radius in your turns
  - **iii)** Be sure the supply side is the one with the thermostat wire embedded
  - **iv)** Cut the insulation with a couple inches extra so you can cover the fittings
- **Quick connect fittings-**
  - **i)** All fittings come with ¾ M.I.P. NPT
  - **ii)** Use both Teflon tape and Teflon pipe dope
  - **iii)** Use standard pipe cutter to cut line set
  - **iv)** Flare the end by using the nut included with the coin, discard coin when done.

7.4 Tying Solar Tank to DHW Storage Tank

- **Pressurized-**
  - **i)** Tank must be level and stable
  - **ii)** Be sure locations of ports are accessible
  - **iii)** Bottom coil will be used for the solar loop, always
  - **iv)** Top coil can be used for heat or recirculation
  - **v)** Install PRV on the hot water outlet at top of tank
  - **vi)** Install isolation valves to isolate tank from DHW and solar if needed
  - **vii)** Top sensor port will be sensor three for heat or recirculation
  - **viii)** Bottom sensor port will be sensor two for solar loop
  - **ix)** Install fitting adapters to accept the line set, use Teflon tape AND Teflon pipe dope
- **Non-Pressurized**
  - **i)** Be sure to place bottom of tank on top of added insulation such 2 inch blue foam- this will provide much better performance
  - **ii)** Consult the installation manual for StorMaxx NP
  - iii) Coil assembly
    - (1) Solar loop always coils down into the tank
    - (2) Heating loops should always coil up out of the tank
    - (3) Be sure that when you tie coils in parallel they have equal pipe lengths

7.5 Pump Station Connection

- **Mounting pump station**
  - **i)** When possible- mount at eye level
  - **ii)** Mark bolt locations using the bracket on the back as template
  - **iii)** Secure with lag bolt and washers to wall studs or plate
  - **iv)** Be sure the supply side of solar loop is connected to opposite side as pump
  - **v)** Locate near a power supply (115 v) when possible
- **Connecting expansion tank**
  - **i)** Tank bracket must be placed within 6 inches of the pump station
  - **ii)** Connect fit kit hose to port on pump station directly
  - **iii)** Do not use expansion vessel when using a ButlerMaxx heat dump
- **Connecting Pressure relief valve**
  - **i)** This must be piped to a non-pressure vessel (such as 5 gallon bucket) no more than 6 inches from the ground level

7.6 Controller

- **Sensors connections**
  - i) Insert the **Black pt1000 sensor** into the supply side of your last collector in series using the dry sensor well built in to collector. This will be sensor 1

ii) Insert the **gray pt1000 sensor** into the lower portion of your tank. This will be sensor 2

- **115v lead connection**
  i) If you have a pre-wired controller- simply plug it in. Default settings will work but should be adjusted to meet design criteria
  ii) If you do not have a pre-wired controller- using the ports labeled lead-ground-neutral, wire in your 115v wire. Be sure to strip only a short piece of sheathing- less than ½ inch.
- **Accessories**
  i) Vbus- see manual (link the location)
  ii) Datalogger see manual (link the location)
  iii) Flow meter see manual (link the location)
- **Programming Controller functions**
  i) Default settings- if you plug your controller in, there are pre set parameters that will allow your system to operate properly BUT you should consult the Assembly instructions for the specific controller you are using before attempting to re-program. (link location of manual for BS plus)
  ii) Change your settings to read Fahrenheit as per instruction manual

7.7 Pressurizing Line Set

- **With air**
  i) Using an air compressor of ½ hp pump, you must first pressurize the system, not exceeding 90 psi. Visually inspect lines for leaks, watch pressure gauge.
  ii) convert a hose thread female fitting with a Schrader valve that will allow you to connect your compressor to the fill port. Be sure all valves are closed that would allow air to escape.
- **Determine the system pressure**-
  i) Your system will function between 17-90 psi. Pressure will not affect the collector performance but should not exceed 90 psi.
  ii) To find the proper pressure for your system take the total vertical height and divide by 2.31 and then add 15 psi to that. The result will be your target pressure. Do this before charging your system and remember your target pressure

7.8 Flooding and Purging

- **Mixing glycol**
  i) You must use a 40-50% glycol mixture (for a closed loop glycol system)in most climates north of 35N latitude.
  ii) If you are using a premix solution then you can simply pump the solution in (see filling system section)
  iii) If you are NOT using a premix then you must first determine the total system volume. The simplest way to accomplish this is by filling the system with water (this helps to clean the pipes as well). Then drain the system down and determine the total volume. You can also

determine the volume that you added and subtract the volume that comes out to find total. If you add 100% glycol to the water in the pipe it WILL mix in the loop.

- **Filtering/Flushing** – we advise you to filter your system before closing it in commission. There will be small particulates that can put stress on your system over time. This can be accomplished by using SunMaxx solar filling station with a built in filter.
- **Filling system**- on the return side pump station above and below the pump there are two fill valves with hose fittings and between them a butterfly valve. Together these make up your filling station.
  i) Make sure you know what pressure you are trying to accomplish in your system for reference. See 7.b.ii.
  ii) You must first close the butterfly valve with a flat head screwdriver
  iii) Connect your hoses to each of the hose fittings and open them
  iv) Make sure your solar filling station is full with the appropriate amount of fluid and with the correct concentration.
  v) Turn filling pump on.
  vi) Observe the return and watch as the volume of bubbles decreases.
  vii) When the system is full and bubbles have diminished, then close the return side valve while pump is still on. Watch you pressure gauge until you reach your target pressure.
  viii) Close the supply from filling station and open the butterfly valve as quickly as possible.
  ix) Activate your solar pump to be sure the pump is running. See the controller manual to learn how to manipulate the controller settings in order to activate solar pump
  x) In case of exceeding pressure above target, release pressure via solar filling station until target psi is reached.

7.9 Inserting tubes-

- Inserting heat pipe
  i) With one hand over the top covering the insulation, pull the condenser bulb out with a twisting motion 3 inches
  ii) Unscrew the cap on tail piece and put glass tube through bottom
  iii) Using the high temp heat grease, apply a bead around the top of the bulb
  iv) Grab the heat pipe and insert into manifold with a jiggling motion until it stop, fully inserted
- Inserting glass
  i) Using a non-toxic soapy spray or cloth, wipe the top of glass wet
  ii) With gasket already in place (prior to heat pipe) twist the tube all the way up until it stops
- Securing cap on tail piece
  i) Remove plastic nipple covering the bottom of tube by prying it off
  ii) Secure the cup by threading it in, careful not to cross thread, all the way up
  iii) Move to next tube working from one direction

7.10 Performance assessment

- Find starting temp of tank
  - ***i)*** Write down the starting temp of the tank from reading the controller, this will give us our start point for future calculations
- Determine Solar potential
  - ***i)*** Use retscreen4 (free download at www.retscreen.net)
  - ***ii)*** Find the closest location in the database and write down the insolation data for the month you are commissioning system
  - ***iii)*** Multiply that number by 317.1 to convert to btu/ft/hr
  - ***iv)*** Multiply that product by the total number of tubes in your array
  - ***v)*** Then multiply by the efficiency of the tubes (.73)
  - ***vi)*** This product should be the total btu's produced by your system per day if mounted at true south at the appropriate incline angle
  - ***vii)*** Reduce by 10% if mounting is more than 20 degrees of appropriate incline angle
  - ***viii)*** Reduce by 10% if mounting is more than 15 degrees off of true south
- Find ending temp of Tank after one day of non-use (no load)
- Calculate system output per day
  - ***i)*** Find the difference between start temp and ending temp
  - ***ii)*** Multiply difference (heat gain) by gallons of storage and multiply that # by 8.3
  - ***iii)*** Product will equal BTU production yielded by collector array during that solar day
- Determine heat transfer across collector array
  - ***i)*** Compare difference from collector inlet temp and collector supply temp
  - ***ii)*** Should have 4-7 degrees per collector
- Determine heat transfer across heat exchanger
  - ***i)*** Compare difference in temp across the exchanger. This should equal temp gain across collector. Adjust flow rate accordingly with isolation valve or pump speed

8.0 How to Maintain a SUNMAXX System

8.1 Periodic Checks

- Ensure that no damage has occurred to the tubes and remove any debris that may have accumulated.
- Check the flow and return pipe work between the collector and the storage tank. Check all connections for leaks and ensure that all components are operating correctly.
- Check that the system pressure is maintained at a set value. If the system

pressure repeatedly drops more than 0.5 bar below the set pressure check the system for leaks.

8.2 Optional Checks

The checks listed in this section depend on the components used in the system installation.

- Each spring, vent the system as some air will come out of the solution throughout the year.
- Check the pressure to see if the set value is still maintained. If a top up is necessary, connect a hose to water mains, fill hose with water to avoid introducing excess air to the system. Connect the hose to the filling loop and open the valve very slowly until the system pressure is increased to the set value.
- To check the antifreeze/inhibitor concentration, draw off a small sample at the draincock and place in your freezer. Remove when frozen and measure the temperature at "slush" stage (when ice and liquid are both present). Temperature should be the same, or lower than the minimum expected temperature for the location.

8.3 Five Year Checks

- If using antifreeze/inhibitor, every five years the system should be completely drained, flushed and refilled with new antifreeze/inhibitor.
- Check all insulation of the pipe work and the condition of the temperature sensors, especially the manifold temperature sensor.
- Check the seals where the flow and return connections passing through the roof tiles.

9.0 Troubleshooting

Problem	Cause	Action
Pump will not run	1. Mains/Pump wiring is faulty 2. Pump rotor damaged 3. The pump control selector P is in the manual OFF position 4. TC is incorrectly set 5. TC and ΔT not satisfied	1. Check wiring at Mains/pump 2. See pump manufacturer's instructions 3. Check SMT unit and return pump control to automatic mode 4. Reset to 25 C 5. No action Required
Pump runs continuously	1. Collector temperature is below TF temperature 2. Loose connection or faulty sensor on the collector 3. Collector temperature at maximum	1. No action required. TF Flashes 2. Check connection and sensor wires 3. No action required
No circulation in system	1. Pump isolating valve closed 2. Automatic air-vent closed 3. Air lock at pressure release valve 4. Air lock in system 5. Non-return valve jammed 6. Pump is not running 7. System in stagnation	1. Open valves 2. Open auto air-vent and replace if necessary 3. Twist cap at pressure relief valve and vent air 4. Check all pipework rises on return side, falls on flow side - clear manual vents 5. Free valve or replace 6. *See above* 7. Wait until system reaches normal operating conditions

Pressure drops in system	1. Leak at manifold 2. Leak in system 3. Drain/filling valve not closed 4. Auto air-vent passing water 5. Faulty pressure relief valve 6. Damaged expansion vessel pressure fluctuation and relief valve to open	1. Check collars on all tubes for leaks - tighten if necessary 2. Check all joints 3. Close fully 4. Clean or replace if necessary 5. Replace 6. Replace
Overheating	1. Pump does not run 2. Prolonged period of low hot water consumption	1. *See above* 2. Divert heat to heat dump
Performance Loss	1. Broken tubes 2. Damaged insulation 3. Build up of limestone around heat exchanger/tube condenser	1. Replace broken tubes (this does not need to be done immediately to maintain operation) 2. Replace damaged parts 3. Drain and clean system thoroughly

9.0 Appendix

9.1 Products

	Description	SKU
Vacuum heat pipe Collectors	10 Tube Vacuum Heat Pipe Collector	SunMaxx-VHP10
	20 Tube Vacuum Heat Pipe Collector	SunMaxx-VHP20
	25 Tube Vacuum Heat Pipe Collector	SunMaxx-VHP25
	30 Tube Vacuum Heat Pipe Collector	SunMaxx-VHP30
	Heat Pipe for Vacuum Tubes	VHP-HP-1
	Vacuum Solar Tube 1800mm x 58mm (Without Heat Pipe)	VHP-TUBE-1
Flat Plate Collectors	TitanPowerPlus-SU2	TitanPowerPlus-SU2
	TitanPower-AL2	TitanPower-AL2
	TitanPower-AU2	TitanPower-AU2
Mounting Hardware	SunMaxx VHP Mounting Frame Flush Mount	ConnectMaxx-VHP-FM1 (1 collector)
		ConnectMaxx-VHP-FM2 (2 collectors)
	SunMaxx VHP Mounting Frame Flush Mount Extension	ConnectMaxx-VHP-FME1 (1 collector)
		ConnectMaxx-VHP-FME2 (2 collectors)
	SunMaxx VHP Mounting Frame Free Standing	ConnectMaxx-VHP-FS1 (1 collector)
		ConnectMaxx-VHP-FS2 (2 collectors)
	SunMaxx VHP Mounting Frame Free Standing Extension	ConnectMaxx-VHP-FSE1 (1 collector)
		ConnectMaxx-VHP-FSE2 (2 collectors)
	TitanPower AL2 Mounting Frame Flush Mount	ConnectMaxx- TPAL2-FM1 (1 collector)
		ConnectMaxx- TPAL2-FM2 (2 collectors)
	TitanPower AL2 Mounting Frame Flush Mount Extension	ConnectMaxx- TPAL2-FME1 (1 collector)
		ConnectMaxx- TPAL2-FME2 (2 collectors)
	TitanPower AL2 Mounting Frame Free Standing	ConnectMaxx- TPAL2-FS1 (1 collector)
		ConnectMaxx- TPAL2-FS2 (2 collectors)
	TitanPower AL2 Mounting Frame Free Standing Extension	ConnectMaxx-TPAL2-FSE1 (1 collector)
		ConnectMaxx- TPAL2-FSE2 (2 collectors)
	TitanPowerPlus SU2 Mounting Frame Flush Mount	ConnectMaxx- TPPSU2-FM1 (1 collector)
		ConnectMaxx- TPPSU2-FM2 (2 collectors)

	TitanPowerPlus SU2 Mounting Frame Flush Mount Extension	ConnectMaxx- TPPSU2FME1 (1 collector)
		ConnectMaxx- TPPSU2-FME2 (2 collectors)
	TitanPowerPlus SU2 Mounting Frame Free Standing	ConnectMaxx- TPPSU2-FS1 (1 collector)
		ConnectMaxx- TPPSU2-FS2 (2 collectors)
	TitanPowerPlus SU2 Mounting Frame Free Standing Extension	ConnectMaxx-TPAL2-FSE1 (1 collector)
		ConnectMaxx-TPAL2-FSE2 (2 collector)
	Adapter for TPAL2	34in12mm
	T Profile Rail 40”	40Rail
	T Profile Rail 80”	80Rail
	HBOLT	HBOLT
	VHP Free Standing Frame	FRAF
Pre-Insulated Linesets	30ft 5/8” Basic Pre-Insulated Line Set	FlowMaxx-5830
	50ft 5/8" Basic Pre-Insulated Line Set	FlowMaxx-5850
	80ft 5/8" Basic Pre-Insulated Line Set	FlowMaxx-5880
	160ft 5/8" Basic Pre-Insulated Line Set	FlowMaxx-58160
	30ft 3/4" Pre-Insulated Line Set	FlowMaxx-3430
	50ft 3/4" Basic Pre-Insulated Line Set	FlowMaxx-3450
	80ft 3/4" Basic Pre-Insulated Line Set	FlowMaxx-3480
	160ft 3/4" Basic Pre-Insulated Line Set	FlowMaxx-34160
	.58” Male Lineset Connector	FlowMaxx-QC58M
	.58” Male Lineset Coupling	FlowMaxx-LG58M
	.58” Female Lineset Connector	FlowMaxx-QC58F
	.58” Female Lineset Coupling	FlowMaxx-QC58F
	.34” Male Lineset Connector	FlowMaxx-QC34M
	.34” Male Lineset Coupling	FlowMaxx-LG34M
	.34” Female Lineset Connector	FlowMaxx-QC34F
	.34” Female Lineset Coupling	FlowMaxx-QC34F
	5/8” Mounting Clips	FlowMaxx-MMSM
	3/4” Mounting Clips	FlowMaxx-MMLG
	3’ Extension (5/8”)	FlowMaxx-583ft
	3’ Extension (3/4”)	FlowMaxx-343ft
Solar Hot Water Storage Tanks	65gal 2 Dual Walled Heat Exchangers	StorMaxxDW-652HX
	80gal 1 Dual Walled Heat Exchangers	StorMaxxDW-801HX
	80gal 2 Dual Walled Heat Exchangers	StorMaxxDW-802HX

	120gal 2 Dual Walled Heat Exchangers	StorMaxxDW-1202HX
	50gal 2 Heat Exchangers	StorMaxxPTec-502HX
	80gal 2 Heat Exchangers	StorMaxxPTec-802HX
	105gal 2 Heat Exchangers	StorMaxxPTec-1052HX
	130gal 2 Heat Exchangers	StorMaxxPTec-1302HX
Heat Exchangers	10 Plate, Brazed Plate	39-0010
	20 Plate, Brazed Plate	39-0020
	30 Plate, Brazed Plate	39-0030
	Shell and Tube heat exchanger 70K BTU	SM-B70
Prepackaged Kits	HelioMaxx Basic 65 Gal Tank	HM-65FPx* (Flat Plate)
		HM-65HPx* (Heat Pipe)
	HelioMaxx Basic 80 Gal Tank	HM-80FPx* (Flat Plate)
		HM-80HPx* (Heat Pipe)
	HelioMaxx Basic 120 Gal Tank	HM-120FPx*(Flat Plate)
		HM-120HPx*(Heat Pipe)
	HelioMaxx Pro 65 Gal Tank	HMP-65FPx* (Flat Plate)
		HMP-65HPx*(Heat Pipe)
	HelioMaxx Pro 80 Gal Tank	HMP-80FPx*(Flat Plate)
		HMP-80HPx*(Heat Pipe)
	HelioMaxx Pro 120 Gal Tank	HMP-120FPx*(Flat Plate)
		HMP-120HPx*(Heat Pipe)
	ButlerMaxx 40 Gal Retrofit Tank	BM-40FP (Flat Plate)
		BM-40HP (Heat Pipe)
	ButlerMaxx 50 Gal Retrofit Tank	BM-50FP (Flat Plate)
		BM-50HP (Heat Pipe)
	ButlerMaxx 80 Gal Retrofit Tank	BM-80FP (Flat Plate)
		BM-80HP (Heat Pipe)
	Combi	HMC-xx*
*x is the number of tubes/square meters of collector area *xx is the square footage of home		

Table 8

9.2 System Sizing Tables

The following tables give an indication for domestic and commercial energy requirements. PLEASE NOTE THAT THESE FIGURES SHOULD ONLY BE USED AS A VERY ROUGH GUIDE.

Table Guide:

- Table 1: Average Domestic Hot Water Use per Household
- Table 2: Hotel/Restaurant/Guest House
- Table 3: Outdoor Pool Energy Requirement [kWh]
- Table 4: Specific Heat Loss [kWh] Outdoor Pool
- Table 5: Average Space Heating Requirements – target temp = 20 C
- Table 6: Latent Heat
- Table 7: System Sizing
- Table 8: Collector Spacing and Back Leg Length

Sizing Table 1: Average Domestic Hot Water Use per Household

Application	Water Temp (C)	Water Temp (F)	Consumption (L)	Consumption (G)
Sink	55	131	30 - 50 l	8 - 13 g
Wash Basin	35	95	5 - 15 l	1 - 4 g
Bathtub	40	104	100 - 170 l	26 - 45 g
Shower	40	104	50 l	13 g
Laundry (cold)	30 - 40	86 - 104	60 - 70 l	15 - 19 g
Laundry (hot)	50 - 60	122 - 140	60 - 70 l	15 - 19 g
Total Consumption				
Low	60	140	10 - 20 l	2 - 5 g
Average	60	140	20 - 40 l	5 - 11 g
High	60	140	40 - 80 l	11 - 22 g

Sizing Table 2: Hotel/Restaurant/Guesthouse

Application	Water Temp (C)	Water Temp (F)	Consumption (L)	Consumption (G)
Restaurant				
Per Meal	45	113	6 - 12 l	1 - 3 g
Per Guest	45	113	12 - 30 l	3 - 5 g
Hotel Per Room				
Room + Wash Basin	45	113	15- 20 l	3 - 6 g
Room + Bath	45	113	70 - 120 l	18 - 33 g
Room + Shower	45	113	140 - 200 l	35 - 53 g
Guest House	45	113	35 - 70 l	9 - 19 g

Sizing Table 3: Outdoor Pool Energy Requirement [kWh] & [BTU]

Water Temp (C)	Swimming Season			Units
	4 Month	5 Month	6 Month	
22	100	200	280	kWh/(m2 season)
24	250	340	480	
26	420	560	720	
Water Temp (F)	Swimming Season			Units
	4 Month	5 Month	6 Month	
72	31700	63400	88760	BTU/h/ft2 Season
75	79250	107780	152160	
79	133140	177520	228240	

Example: Energy requirement to heat the pool for a four month season to 22 C

Solar Insulation: 5 kWh/m2/day
4 Month Season: 120 days/Season
Season Energy Need: = 600 kWh/m2/season
Collector Efficiency: 0.7
Season Out/Collector: = 420 kWh/m2/season
Energy available from the collector during a 4 month swimming season.

Energy required to heat the pool to 22 C from Table 3 is 150 kWh/m2/season. In other words, required ratio of collector surface area of 1:3; 150/450.

Sizing Table 4: Specific Heat Loss [kWh] for Outdoor Pool

Target Temp (C)	Pool A		Pool B		Pool C		Pool D	
	5	7	5	7	5	7	5	7
20	0.034	0.072	0.11	0.158	0.302	0.373	0.036	0.068
23	0.133	0.17	0.269	0.314	0.565	0.634	0.06	0.069
26	0.275	0.315	0.476	0.523	0.881	0.938	0.083	0.091
	kWh/m2							
Target Temp (F)	Pool A		Pool B		Pool C		Pool D	
	5	7	5	7	5	7	5	7
68	10.778	22.824	34.87	50.086	95.734	118.241	11.412	21.556
73	42.161	53.89	85.273	99.538	179.105	200.978	19.02	21.873
79	87.175	99.855	150.892	165.791	279.277	297.346	26.311	28.847
	BTU/h/ft2							

Legend:

- Pool A - Pool with two sides well protected (trees, building or wall), wind speed 1 m/s
- Pool B - Pool with two sides partially protected, wind speed 2 m/s
- Pool C - Pool with no protection, wind speed 4 m/s
- Pool D - Pool with a cover with a conductivity coefficient of 8.12 W/(mK)
- Note, 1 m/s = 3.3 ft/s

Building Type	Floor Space m^2	Floor Space ft^2	Insulation				Units
			Loft Only		Loft & Walls		
Small Detached	100	1075	220	69.74	110	35.97	
large Detached	150	1615	210	66.6	110	35.97	
Bungalow	65	700	240	45.78	140	45.78	kWh/m^2 /a
Large Semi	90	970	180	32.7	100	32.7	&
Small Semi	75	810	180	32.7	100	32.7	$kBtu/ft^2/a$
Semi Bungalow	65	700	220	42.51	130	42.51	
Terrace	90	970	145	45.9	90	29.43	
End Terrace	90	970	180	57.06	100	32.7	

Sizing Table 5: Average Space Heating Requirements – Target Temperature 20 C

NOTE: ALL OF THE ABOVE DATA VARIES ACCORDING TO METHOD OF INSULATION, AGE AND SIZE OF HOUSE, EXTERNAL AND TARGET TEMPERATURES

Example: Energy requirement to heat large detached house, floor space 150 m2.

- Solar Insolation - 3 kWh/m2/day
- Heating Period - 180 days
- Energy Collected - 540 kWh/m2/a
- Collector Efficiency - 0.7
- Energy Out/Period - (540 x 0.7) = 378 kWh/m2/season (energy available over 6 month period

Energy requirement to heat a large detached house with good loft and wall insulation, floor space of 150 m^2 to a target temperature 20 C = 110 kWh/m2/a.

Require a ratio of collector area to floor space of approximately 110/378 = 0.3 (30%). Giving a total collector area of 50 m^2.

Sizing Table 6: Latent Heat

Latent heat refers to the amount of energy released or absorbed by a chemical substance during a state change such as solid to liquid or liquid to gas without changing its temperature.

1 m2 of collector area with a solar insulation of 1000 W/m2 can…/hour:

- Increase the temperature of 7.8 kg of water from 25 C to 110 C
- Produce 1.0 kg of vapor at 100 C from water at 100 C
- Produce 0.9 kg of vapor at 100 C from water at 25 C
- Produce 0.8 kg of vapor at 140 C from water at 25 C

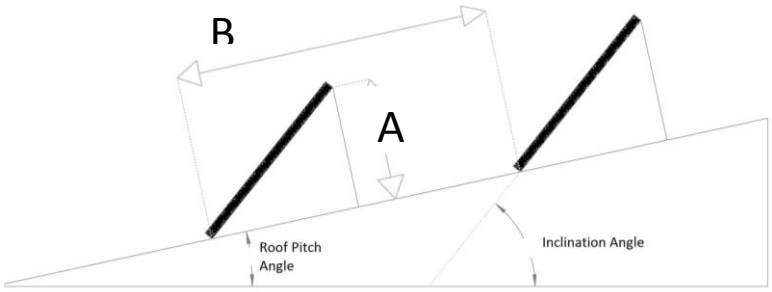
10.8 Sq Ft of collector area with a solar insulation of 1000 W/m2 can…/hour:

- Increase the temperature of 7.8 kg of water from 25 C to 110 C
- Produce 2.2 lb of vapor at 212 F from water at 212 F
- Produce 1.98 lb of vapor at 212 F from water at 77 F
- Produce 1.76 lb of vapor at 284 F from water at 77 F

Sizing Table 7: System Sizing

Number of People	ft^2 of absorber area	~ Storage Tank Size
1 to 2	20	100 - 150 l (25 – 40 G)
3 to 4	30	200 - 250 l (50 – 70 G)
5 to 6	40	300 - 350 l (80 – 95 G)
7 to 8	50	400 - 450 l (105 – 120 G)

Sizing Table 8: Collector Spacing and Mounting Leg



Length

Roof Pitch	Inclination Angle	5°		10°		15°		20°		25°		30°	
		A	B	A	B	A	B	A	B	A	B	A	B
	FLAT	7	82	14	87	20	93	27	100	33	109	39	122
	1/12 (5°)	0	79	7	82	14	87	20	93	27	100	33	109
	2/12 (9°)	0	77	1	80	8	83	15	88	22	94	28	102
	3/12 (14°)	0	75	0	77	1	80	8	83	15	88	22	94
	4/12 (18°)	0	74	0	75	0	77	3	80	10	84	16	89
	5/12 (23°)	0	73	0	74	0	75	0	77	3	80	10	84
	6/12 (27°)	0	72	0	73	0	74	0	76	0	78	4	81
	7/12 (30°)	0	72	0	73	0	73	0	74	0	76	0	79
	8/12 (34°)	0	73	0	72	0	73	0	73	0	75	0	77
	9/12 (37°)	0	73	0	73	0	72	0	73	0	74	0	76
	10/12 (40°)	0	74	0	73	0	72	0	73	0	73	0	74
	11/12 (43°)	0	75	0	73	0	73	0	72	0	73	0	74
	12/12 (45°)	0	76	0	74	0	73	0	72	0	73	0	73

Roof Pitch		35°		40°		45°		50°		55°		60°	
		A	B	A	B	A	B	A	B	A	B	A	B
	FLAT	45	139	51	162	56	198	60	255	65	363	68	640
	1/12 (5°)	39	122	45	139	51	162	56	198	60	255	65	363
	2/12 (9°)	35	112	41	125	46	143	52	168	57	207	61	271
	3/12 (14°)	28	102	35	112	41	125	46	143	52	168	57	207
	4/12 (18°)	23	95	30	103	36	114	42	128	48	147	53	175
	5/12 (23°)	16	89	23	95	30	103	36	114	42	128	48	147
	6/12 (27°)	11	85	18	90	24	97	31	105	37	116	43	131
	7/12 (30°)	7	82	14	87	20	93	27	100	33	109	39	122
	8/12 (34°)	1	80	8	83	15	88	22	94	28	102	35	112
	9/12 (37°)	0	78	4	81	11	85	18	90	24	97	31	105
	10/12 (40°)	0	76	0	79	7	82	14	87	20	93	27	100
	11/12 (43°)	0	75	0	77	3	80	10	84	16	89	23	95
	12/12 (45°)	0	74	0	76	0	79	7	82	14	87	20	93

***All dimensions are in inches**

9.3 Checklist

This checklist will help to collect all the necessary data to designer a solar collector system and give a quotation for it.

See Next Page!

Sizing & Design Checklist

Project Data:

Date: _____

Name: _____

Address: _____

Zip Code: _____

Phone: _____

Consumption:

People in Household: _____

Hot Water @ _____ degrees C or F = _____ G or L/day

Application (check all that apply):

_____ Domestic Hot Water _____ Swimming Pool

_____ Home/Space Heating _____ Other

Expected Solar Contribution: _____ % in _____ (month)

Building Features:

Available Roof Mounting Space = _____ m2 or ft2 (Length=_____ x width=_____)

Inclination (pitch) angle: _____ degrees Azimuth (orientation) angle: _____ degrees

Roof Type: _____ Sloping Roof _____ Flat Roof _____ Other

Static Height of System: _____ m2 or ft2

Installation Scheme (5.6.2): _____

Collector Type: _____ SunMaxx-20 _____ SunMaxx-25 _____ SunMaxx-30

9.4 Commissioning Sheet

After completion of the installation, we recommend that you fill out the commissioning sheet and to leave a copy at the location of the system for future reference.

See Next Page!

Commissioning Sheet

Project Data:

Date: _____

Name: _____

Address: _____

Zip Code: _____

Phone: _____

General Information:

Date of Purchase: _____ Supplied By: _____

Invoice Number: _____

Date of Installation: _____ Installed By: _____

System Information:

Collector Model: _____ SunMaxx-20 _____ SunMaxx-25 _____ SunMaxx-30

Solar Controller: Model: _____

Serial Number: _____

Settings: High Limit _____

Low Limit _____

On-Differential _____

Off-Differential _____

Expansion Vessel: Volume: _____ G or L

Pressure: _____ Bar or PSI

System Filling Pressure: _____ Bar or PSI

Pump Specification: V_s: _____ M^3/h or Ft^3/h

ΔP_s: _____ M or Ft

Frost Protection down to: _____ C or F