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Silicon Solar Inc
Innovative Solar Solutions™

SunMaxx

Evacuated Tube Solar Collector 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 equations to convert many of these units from metric to imperial. If you need assistance, please ask your sales representative or visit us at www.SiliconSolar.com

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1.0 What does Silicon Solar offer?

Solar Energy

Silicon Solar is a leading solar energy company across the United States, and around the world. With three domestic offices/facilities and offshore manufacturing facilities and future expansions in the works, Silicon 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.

Silicon Solar 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, Silicon Solar is dedicated to making Solar Energy affordable to everyone who desires it.

SunMaxx produces numerous Solar Hot Water Collectors, including Evacuated Tube 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 affords Silicon Solar a tremendous amount of flexibility and scalability in our manufacturing process. This scalability, along with our innovative product designs and manufacturing processes, allows Silicon 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 Evacuated Tube 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 Reps and Technicians, 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.

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.

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 pressure of 5 bar (75 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 suitable non-toxic glycol antifreeze (propylene-glycol), not car antifreeze.

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 and the pipe work has been connected.

10. Ensure that Collector Tubes and Heat Pipes are installed in the correct orientation.

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.

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.

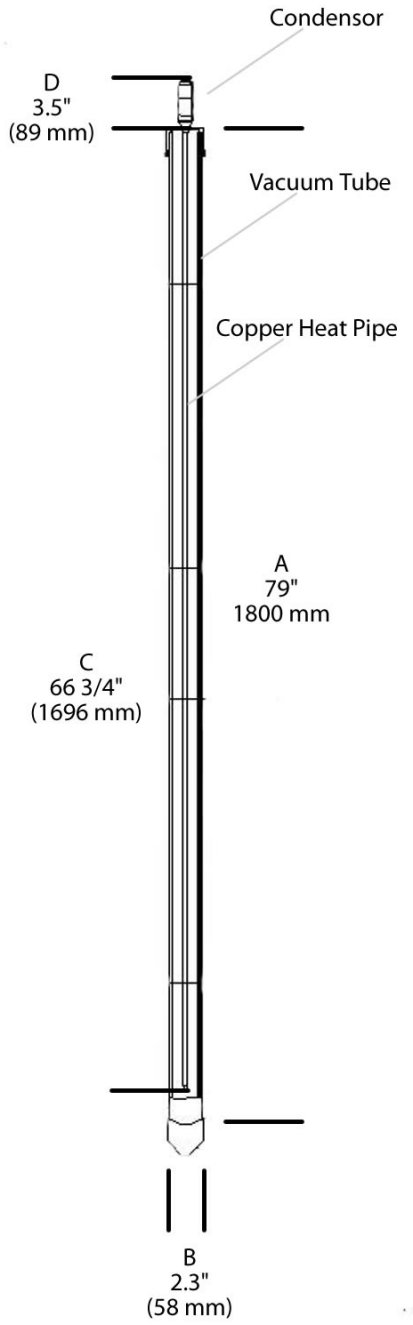
This manual was correct and complete at time of print, but as part of our continuous product improvement and innovation, SunMaxx reserves the right to update and amend specifications without notice.

3.0 How Does a SunMaxx System Work

The two main components of a SunMaxx Solar Collector System are the SunMaxx Evacuated Solar Collector Tube and the SunMaxx Manifold. Complete roof facing kits, as well as pumps, controllers, heat exchangers and storage tanks are available as accessories.

SunMaxx Evacuated Tube Solar Collectors with Heat Pipes feature:

- High Performance
- Low Heat Capacity and High Heat Transfer
- Thermal Diode Operation – Heat flow only in one direction (tube to manifold)
- 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 The SunMaxx Tube

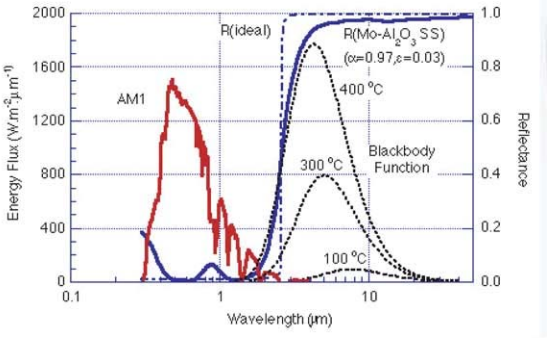
The SunMaxx Evacuated Solar Collector Tube shown in figure 1 combines the technology of the fully evacuated glass tube, industry-leading selective coating absorber, copper heat transfer pipe and the condenser/header.

3.1.1 The Absorber

The main parts of the Absorber are the ABSORBER PLATE (built into the evacuated tube itself) and the HEAT PIPE.

- A: Evacuated Tube Length
- B: Evacuated Tube Diameter
- C: Copper Heat Pipe Length
- D: Condenser Length
- Condenser Diameter: 1" (26 mm)
- Heat Pipe Diameter: 5/16" (8 mm)

The absorber plate is coated with a special, high-efficiency SELECTIVE COATING that ensures maximum radiation absorption and minimum thermal radiation losses. Figure 2 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.



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 Evacuated Solar Collector 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.

3.1.2 The Evacuated Glass Tube

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

The vacuum in the Evacuated Glass Tube ($P<5x10\text{-}3$ 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 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.

3.1.3 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 water 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.

3.2 The SunMaxx Manifold

SunMaxx Manifolds are designed between 7.2 square feet (20 tube) and 10.8 square feet (30 tube). 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.

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. There is a thick, CFC-Free Polyurethane foam insulating jacket inside. The header pipe has a diameter of 1" and the material is 0.08" thick.

The manifold has an approximate depth of 6.1", and a width of approximately 72" (for the 20 Tube Model). Please see chart 1 for overall dimensions of all SunMaxx Evacuated Tube Solar Collector Manifolds. The Collectors' gross area and weight are also listed in this chart.

Model	SM-20	SM-25	SM-30
Dimensions (In)	72"	88"	105"
Dimensions (mm)	1825	2240	2655
Weight (lbs)	175	213	252
Weight (kg)	77	96	114
Gross Area (ft2)	40	49	58
Gross Area (m2)	3.72	4.55	5.39
Aperture Area (ft2)	28.4	35.6	42.8
Aperture Area (m2)	2.64	3.31	3.98

The manifold and all welds are fully processed and pressure tested 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.

3.3 Accessories

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

- Flush Mounting Face Frame Kit
- Manifold/Header
- Evacuated Solar Tubes
- Copper Heat Pipes

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

- 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

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.

Figure 4 shows a completely assembled SUNMAXX Solar Collector.

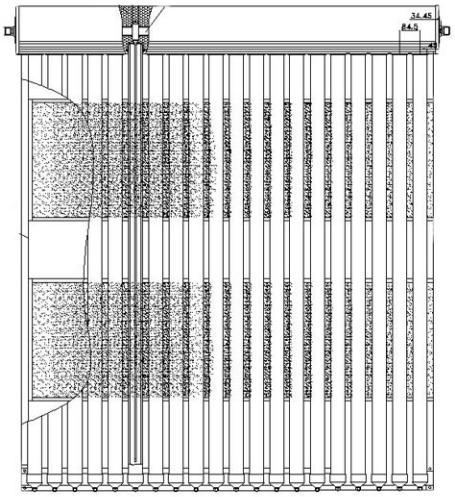


Figure 4.

3.3.1 Mounting Kits

Flush Mounting Face Frame Kit

Every SunMaxx Evacuated Tube Solar Collector comes with our standard Flush Mounting Face Frame Kit. The Flush Mounting Face Frame Kit is suitable for pitched roofs where additional elevation and tilt angle are needed for proper installation.

Flat Roof Adjustable Frame Kits

Adjustable (Tilt) Mount Kits are offered as an upgrade for every SunMaxx Evacuated Tube Solar Collector. This specialized Tilt Mounting Hardware is designed to increase the angle of your SUNMAXX Evacuated Tube 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.*

Upgraded Face Frames

Our upgraded face frames are available for every SunMaxx Evacuated Tube Solar Collector, are Made in the USA. The upgraded face frames are flush mount kits, suitable on their own for appropriately pitched roofs. The upgraded face frames are available in Steel, Aluminum and Stainless.

SunRack 3EV System

The SunRack 3EV is an upgraded mounting system exclusively from SunMaxx and Made in the USA. Each SunRack 3EV will mount up to 3 SunMaxx 20 or 25 Evacuated Tube Solar Collectors. An extension set is available to mount another 1 to 2 SunMaxx Evacuated Tube Solar Collectors. Also, Tilt Mounting Legs for the SunRack 3EV are available in Short and Long models, depending on the slope of the roof and needed installation angle. The SunRack 3EV can also be used for ground mounting SunMaxx Evacuated Tube Solar Collectors.

SunRack Pole

The SunRack Pole is used to pole mount a single SunMaxx Evacuated Tube 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 Evacuated Tube Solar Collectors can be mounted to any type of roof when properly secured. Certain installations may require a noggin – a beam between two rafters.

3.3.2 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.

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). There are two factors (K_1 and K_2) that relate the system's ability to transfer the energy gained. Equation 4.1 combines three empirical values to determine the efficiency of the collector system. (equation 4.1)

$$\eta = \eta_0 - K_1 * \frac{\Delta\iota}{G} - K_2 * \frac{\Delta\iota^2}{G}$$

$\eta = efficiency\ [-]$

$\eta_0 = optical\ effieiency [-]$

$K_1 = linear\ heat\ loss\ factor\ \left[K\frac{m}{W}\right]$

$K_2 = square\ heat\ loss\ factor\ \left[K\frac{m}{W}\right]$

$\Delta\iota = collector\ ambient\ \ temp\ [K]$

$G = global\ solar\ radiation\ [W/m^2]$

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 can be expected, whereas clouds can reduce it to 400 W/m^2 or less.

Due to extremely good insulation properties of the SunMaxx Evacuated Tube 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

All SUNMAXX Evacuated Tube Solar Collectors - the SUNMAXX 10, 20, 25 and 30 use the same Evacuated Solar Tube design. The temperature within the SUNMAXX Evacuated Solar Tubes can reach 304°F, while the exterior of the tube remains cold to the touch. SUNMAXX Evacuated Tube Solar Collectors have a stagnation temperature of 392.5°F.

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

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

The first step to enjoying your SUNMAXX Evacuated Tube Heat Pipe System over a long period of time is to design and specify the collector size and the associated components correctly.

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

5.1 Collector Area

If you are using the installation to provide domestic hot water only, it is strongly recommended that you aim for 100% solar coverage during the summer months only. If the system has to provide additional energy for heating systems in the winter or other applications an option for re-routing the excess heat has to be installed (heat dump, connecting to a swimming pool) to avoid long stagnation periods in the summer.

Figure 7 shows the solar contribution of a correctly sized solar system over the course of a year.

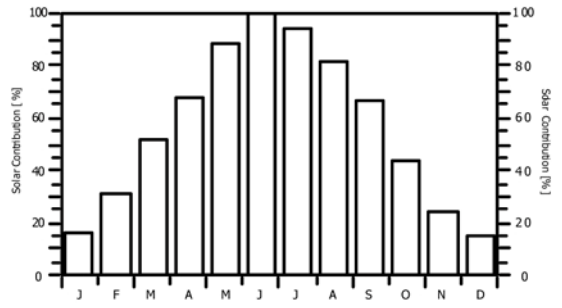


Figure 7

As a guide, you can assume that 1 tube can produce a maximum of 2.2 gallons of hot water per day. Therefore, if you use 40 gallons of hot water a day, a 20 tube system will provide you with approximately 60% solar coverage throughout the year in a mid-north American climate.

Using equation 5.1, a more accurate estimation of the overall system contribution can be made.

$$A_R = R * \eta \quad (5.1)$$

- SC: System Contribution [kWh/m2] or [BTU/h/ft2]
- R: Monthly Solar Radiation [kWh/m2] or [BTU/h/ft2]
- ŋ: Efficiency [-] (*see 4.1)*

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 5.2)

$$A_R = \frac{ED}{SC} \quad (5.2)$$

- 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

As there are only certain collector areas available for SUNMAXX Evacuated Tube Solar Collectors, the collector area for your installation must therefore be chosen accordingly.

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

SunMaxx Model	Aperature Area (m2)	Aperture Area (ft2)
SunMaxx-20	2.64	28.4
SunMaxx-25	3.31	35.6
SunMaxx-30	3.98	42.8

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.

5.2 Flow Rate

The specific Flow Rate per tube is represented by Vt and is measured in [l/min] or [g/min]. This flow rate lines in the range of:

- $0.1 \leqq V_t \leqq 0.25$ [l/min]
- $0.026 \leqq V_t \leqq 0.066$ [g/min]

Some common examples are listed in Table 4.

Area (m2)	Area (ft2)	Flow Rate (l/min)	Flow Rate (g/min)
2	6.6	2.0 - 5.0	.5 - 1.3
3	9.8	3.0 - 7.5	.8 - 1.9
4	13.1	4.0 - 10.0	1.1 - 2.6
5	16.4	5.0 - 12.5	1.3 - 3.3
6	19.7	6.0 - 15.0	1.6 - 4.0
7	22.9	7.0 - 17.5	1.9 - 4.6
8	26.2	8.0 - 20.0	2.1 - 5.3
9	29.5	9.0 - 22.5	2.4 - 5.9

Table 4

By multiplying flow rate of individual tubes by the number of tubes, the system flow rate can be determined as shown in equation 5.3.

$$V_S = V_S * n_t \quad (5.3)$$

- V_S: System Flow Rate [l/min] or [g/min]
- V_t: Flow Rate per Tube [l/min/tube] or [g/min/tube]
- n_T: Number of Tubes (rises in multiples of 10)

You can use the factors listed before Table 4 to convert l/min to g/min.

Or, to convert the system flow rate V_s into the unit [m3/h] that circulation pumps are generally specified in, use equation 5.4.

$$m^3/h = [l/min] * 0.600 \quad (5.4)$$

Or, if you have converted your flow rates in g/min, you can calculate the flow rate in m^3/h using the following conversion factor:

$$m^3/h = [g/min] * 0.227 \quad (5.4)$$

The more tubes 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 90 – 100 tubes 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 taco-setter on the pump control unit.

5.3 Pipe Work

Some recommended pipe sizes are given in table 5.

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	3/4" or 1"
4.6 - 5.9 @ 3.3 ft/s	1"

Table 5

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

1. Installation Costs
2. Energy Costs for Operation

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

$$Ø_i = \sqrt{\frac{4 * V_s}{\Pi * v}} \qquad (5.5)$$

$Ø_i$ = 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)].

5.4 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).

Table 5 gives a rough guide as to which pump should be used in domestic installations depending on the collector area.

	Collector Area [m2 / ft2]	Number of Tubes
16147	2 - 4 / 21 - 43	20 - 40
	5 - 6 / 53 - 65	50 - 60
4690	7 - 9 / 75 - 97	70 - 90

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:

- Solar Collector
- Pipe Work
- Heat Exchanger

The pressure drop of the pipe work ΔP_p in [Pa] 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.

As for the pipe work the pressure drop for the heat-exchanger ΔP_{he} in [Pa] can be found in the manufacturer's information. The same rules apply as with pipe work.

According to the information given above, the overall pressure drop of the system ΔP_s in [Pa] can be calculated using equation 5.6.

$$\Delta P_s = \frac{n_{20} * \Delta P_{c20} + n_{30} * \Delta P_{c30} + \Delta P_p + \Delta P_{he}}{10{,}000} \quad (5.6)$$

Δp_s = System Pressure Drop [m]
n_{20} = Number of 20 Tube Collectors [-]
n_{30} = Number of 30 Tube Collectors [-]
Δ_{pc20} = Pressure Drop of 20 Tube [Pa]
Δ_{pc30} = Pressure Drop of 30 Tube [Pa]
Δ_{pp} = Pressure Drop of Pipe Work [Pa]
Δ_{phe} = Pressure Drop Heat Exchanger [Pa]
10000 = [Pa] to [m]

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 10 shows the relationship between the flow rate and the head pressure of the pump used in SUNMAXX Solar Hot Water Systems.

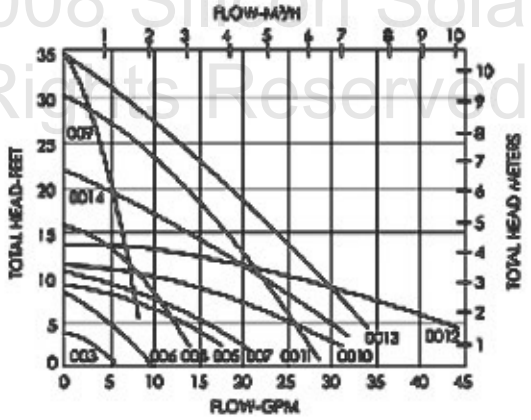


Figure 10

For installations larger than 60 tubes, a larger pump should be chosen [the 18407]. The pump diagram is shown in figure 11.

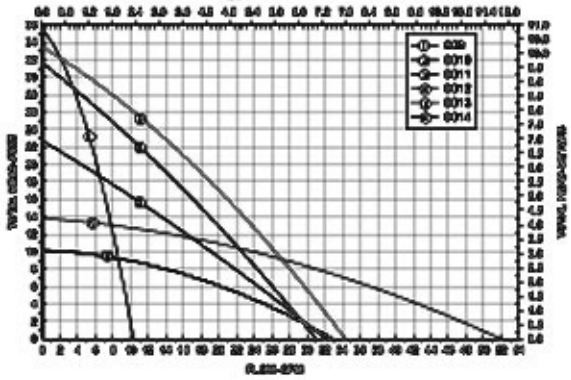


Figure 11

5.5 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. Table 6 gives some sizes for expansion vessels for various collector areas and other parameters

Volume [l]	Total System Content [l]	Static Height [m]	Collector Area [m2]
8 l	</= 25	3	2
	15	</= 8	2
18 l	</= 80	3	3
	15	</= 20	3
	30	</= 16	3
	</= 60	3	4
	20	</= 14	4
	30	</= 12	4
	</= 25	3	6
	20	</= 4	6
35 l	</= 100	3	9
	40	</= 11	9

Volume [g]	Total System Content [g]	Static Height [ft]	Collector Area [ft]
2 l	</= 7	10	21.5
	4	</= 26	21.5
5 l	</= 21	10	32.3
	4	</= 66	32.3
	8	</= 52	32.3
	</= 16	10	43.1
	5	</= 46	43.1
	8	</= 39	43.1
	</= 66	10	64.6
	5	</= 13	64.6
9 l	</= 26	10	96.9
	11	</= 36	96.9

As the values in Table 6 indicate, the lower the static height of the system, the larger the overall system content can be. Therefore, more tubes can be connected to the same size expansion vessel.

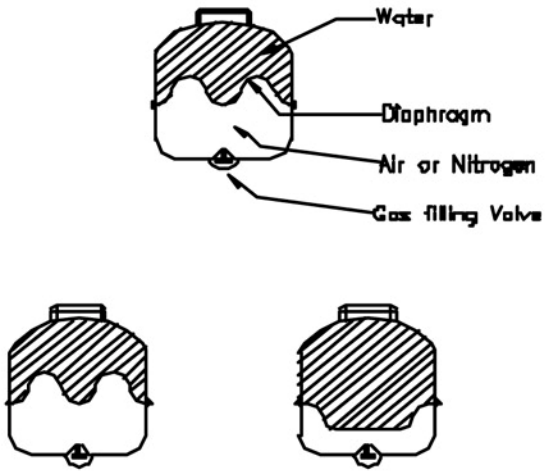


Figure 13

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.

The size of the expansion vessel has to be determined as a function of the total water volume of the solar system, the static height of the system and the water content of the manifold. The following equations (5.7 – 5.11) determine the appropriate size of the expansion vessel.

You can follow the following steps to size the expansion vessel for your SUNMAXX Solar Hot Water Installation.

Before beginning, if you are working in Imperial units, you will need to convert the following measurements to Metric units in order to proceed with the calculations.

Imperial Unit	Conversion Factor	Metric Unit
Height (Ft)	X by .305	Meters
Volume (G)	X by 3.7854	Liters
PSI	X by .06895	Bar

You will need to convert the total volume of your System from Gallons to Liters and the Height of your System (from the collectors to the heat exchanger) from Feet to Meters. You will also need to convert your pressure measurements from PSI to Bar.

For instance, say your installation is a system with:

- Volume: 100 G
- Height: 15 Ft
- Pressure: 100 PSI

Using the conversion factors above your system has the following Metric measurements:

- Volume: 378.5 Liters
- Height: 4.6 Meters
- Pressure: 6.895 Bar

With these factors you can now proceed to size the expansion vessel.

First, we must determine the overall Volume Increase of the water/glycol in the system due to temperature increases. This figure is expressed as $V_{\Delta\ell}$ and is measured in Liters. The calculation to determine $V_{\Delta\ell}$ is as follows (5.7).

$$V_{\Delta\ell} = V_{sys} * \beta \quad (5.7)$$

In this equation, β is the Volumetric Expansion Coefficient of Water or Glycol. These coefficients are as follows:

- Water @ 80 °C / 176 °F = 0.029
- Glycol @ 80 °C / 176 °F = 0.07

Using the $V_{\Delta\ell}$ we can determine the Maximum Operating Pressure of the SUNMAXX Solar Hot Water System. This measurement is known as the P_{max} and is measured in Bar. To determine the P_{max} of your SUNMAXX Solar Hot Water System, you should use the following equation (5.8):

$$P_{max} = P_{rv} - 0.5 \quad (5.8)$$

- P_{max}: System Operating Pressure [bar]
- P_{rv}: Operating Pressure of Relief Valve [bar]

To determine the Set Pressure for the Diaphragm of your Expansion Vessel, we should use the following equation (5.9):

$$P_d = P_h + 0.1 * h \quad (5.9)$$

- P_d: Set Pressure for Diaphragm [bar]
- P_h: Pressure in Highest Point of System [bar]
- 0.1: [m] to [bar]
- h: Static Height of System [m]

Please note that you can convert your Set Pressure for the Diaphragm and convert it back to PSI for setting your Expansion Vessel by multiplying the [bar] value by 14.50236.

To ensure that there is a sufficient volume of water in the system at all times, a minimum volume of water/glycol must be present in the expansion vessel in the cold condition. This value is known as the V_c and is measured in Liters in these equations. You can calculate the V_c of your SUNMAXX Solar Hot Water System using the following equation (5.10):

$$V_c = V_{sys} * 0.015 \quad (5.10)$$

- V_c: Water Volume in the Expansion Vessel in the Cold Condition [l] ***must be 1 liter or higher at minimum***
- V_{sys}: Overall System Content [l]

Please note that you can convert your V_c to Gallons for system setup if you need by multiply the [l] value by 0.26417.

Using the values calculated in equations 5.7 to 5.10, we can determine the actual size of our Expansion Vessel using equation (5.10). The Nominal Size of the Expansion Tank is depicted as V_n.

$$V_n = \frac{(V_c + V_{\Delta\ell} + n_{col} * V_{col}) * (P_{max} + 1)}{P_{max} - P_d} \quad (5.10)$$

- V_n: Nominal Volume of Expansion Vessel [l]
- V_c: Water Volume in Expansion Vessel in the Cold Condition [l]
- $V_{\Delta\ell}$: Volume Increase due to Temperature Increase [bar]
- n_{col}: Number of Collectors Installed
- V_{col}: Water Volume of Single Collector [l]
- P_{max}: Maximum System Operating Pressure [bar]
- P_d: Set Pressure for Diaphragm [bar]

You have now sized the Expansion Vessel for your SUNMAXX Solar Hot Water System. While

most Expansions 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.

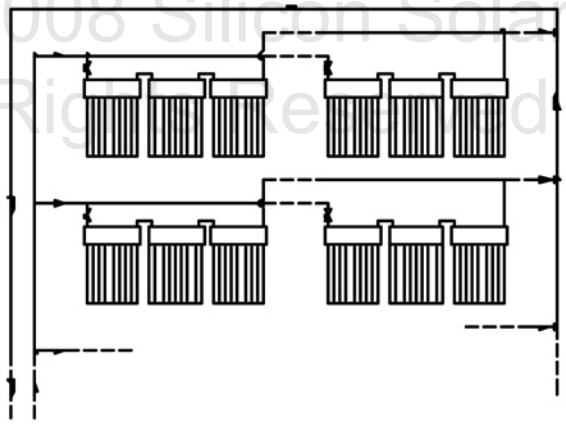


Figure 14

5.6 Hydraulics

5.6.1 Collector System

As mentioned before, the maximum number of tubes installed in series should not exceed 90 to 100 tubes. For bigger installations, the recommended collector connection is shown in figure 14.

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) or by using valves to regulate the flow rate.

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 to 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). *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. Automatic Air

Vents should be fitted with a valve to prevent opening when the system reaches stagnation.

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).

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.

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

5.6.3 Common System Design Layouts

Active System with Double Coil Tank

Figure 15 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.

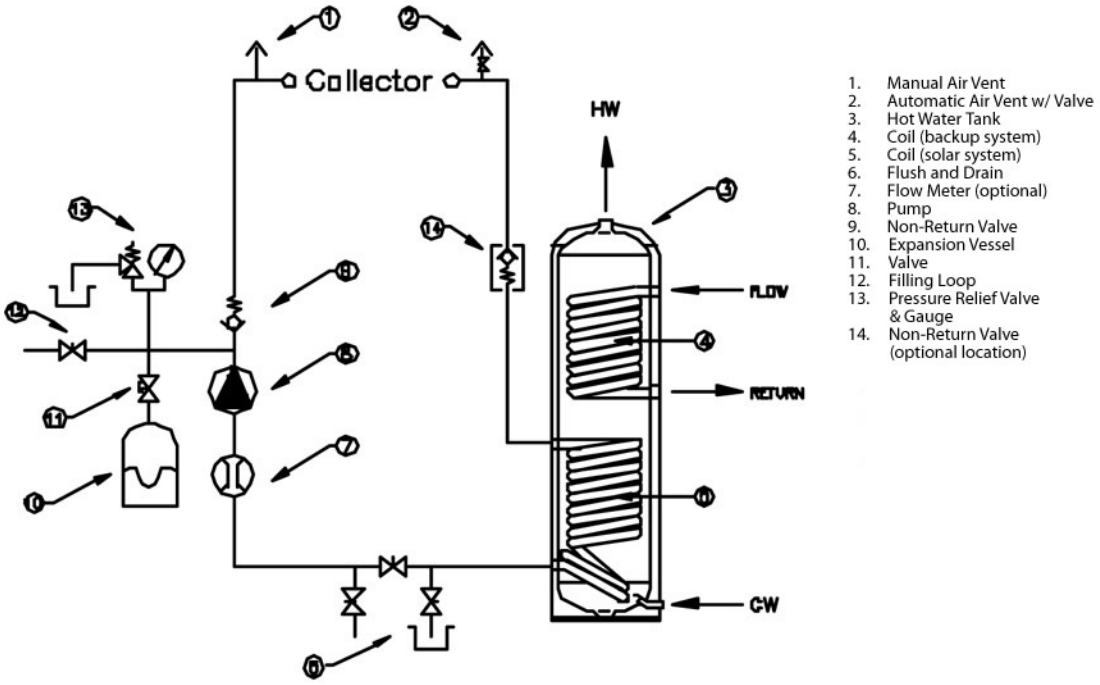


Figure 15

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 16).

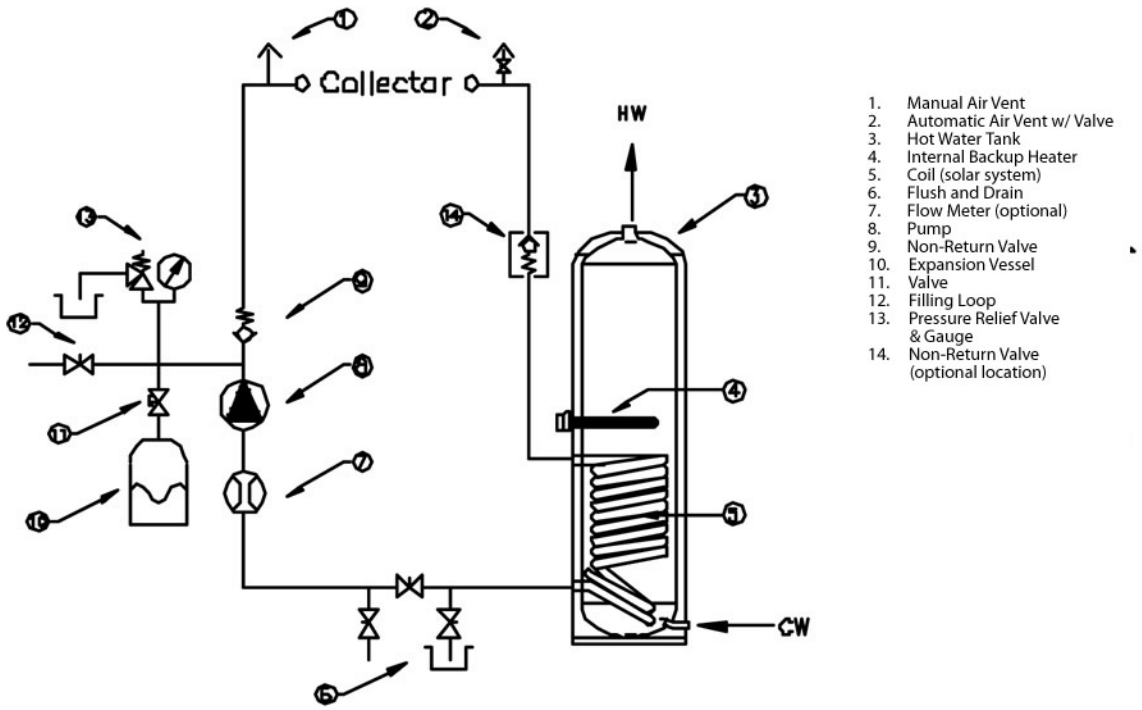
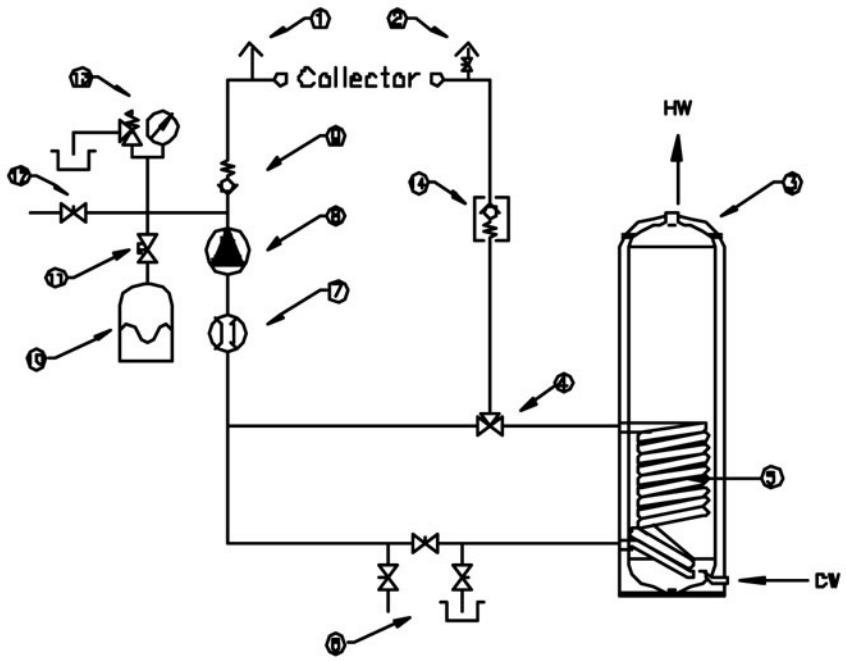


Figure 16

Active System with Short Circuit

Figure 17 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.



1. Manual Air Vent
2. Automatic Air Vent w/ Valve
3. Hot Water Tank
4. 3-Way Valve
5. Coil (boiler system)
6. Flush and Drain
7. Flow Meter (optional)
8. Pump
9. Non-Return Valve
10. Expansion Vessel
11. Valve
12. Filling Loop
13. Pressure Relief Valve & Gauge
14. Non-Return Valve (optional location)

Figure 17

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 18).

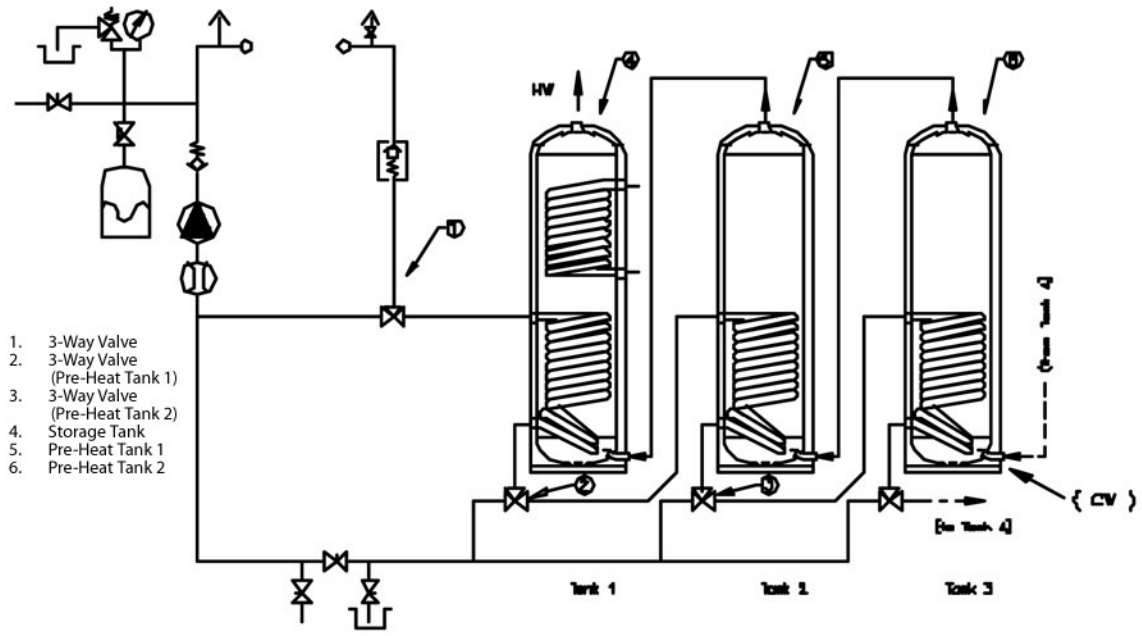


Figure 18

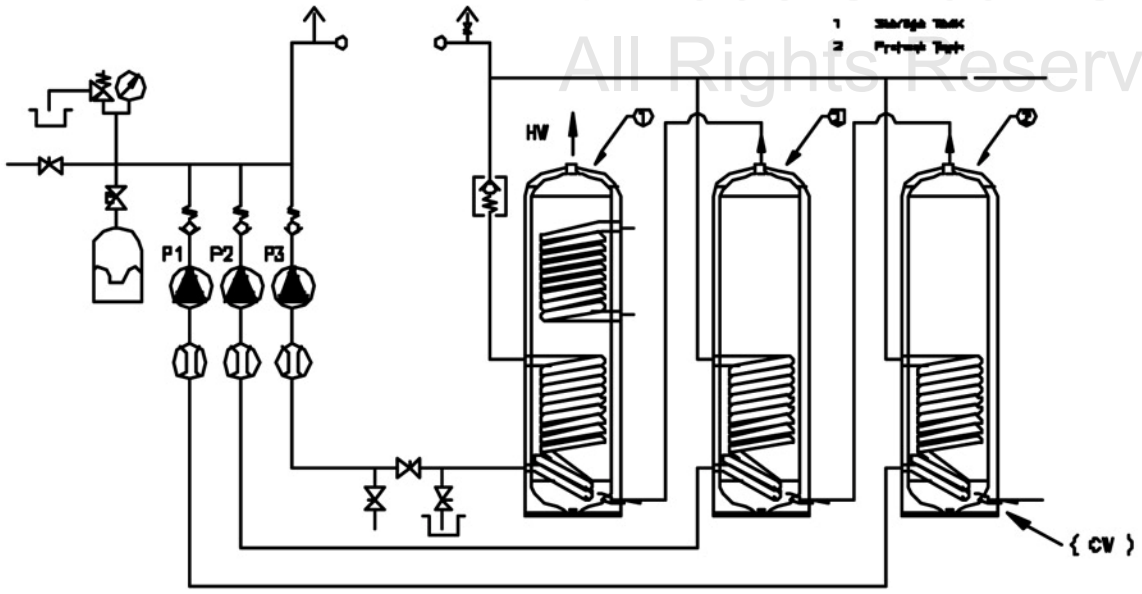


Figure 19

Multiple Tank Installation – Parallel

Figure 20 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.

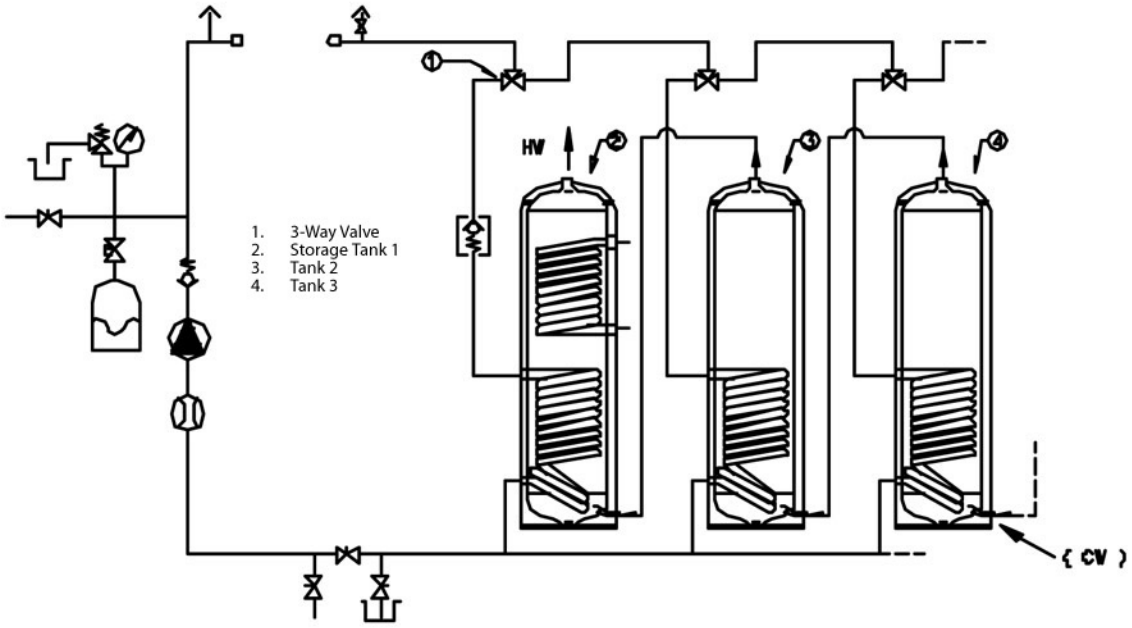


Figure 20

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 21.

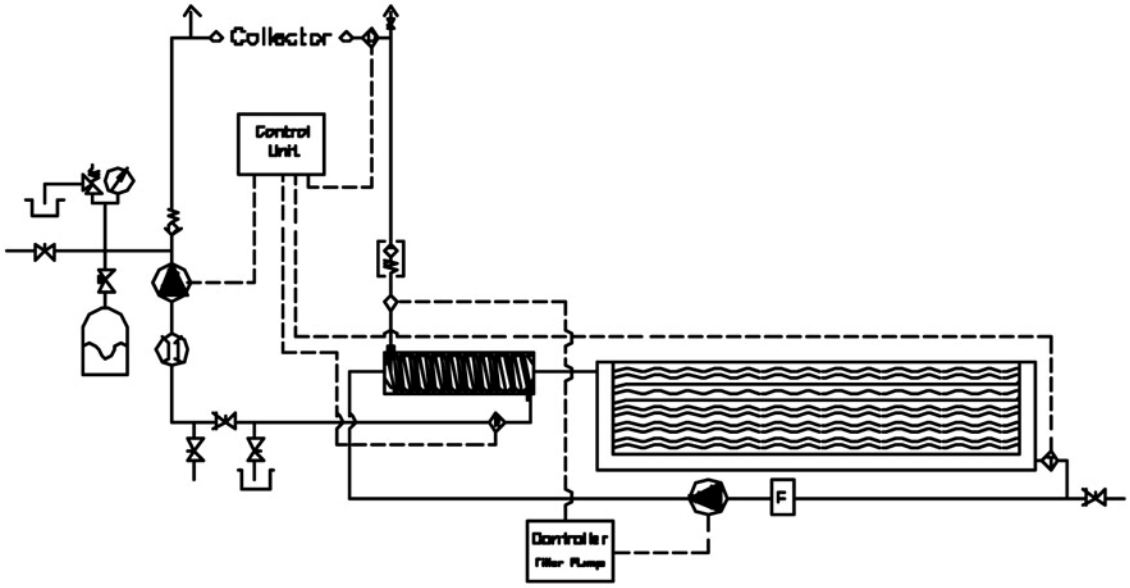


Figure 21

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 Evacuated Tube Solar Collector System with various roof fixing kits. For assembly of SUNMAXX system please refer to you installation manual.

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.

Locate the Solar Collector so that the tubes receive maximum sunshine throughout the day with little or no shading. NOTE: Installation angle should set at the latitude of the location plus 15 degrees, and the collectors should be oriented toward true south, not magnetic south. An azimuth chart can assist you in determining this proper direction.

The Solar Collector System can be mounted at any angle that is >30 degrees and <90 degrees, but the above note dictates the best possible installation angle.

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 evacuated tubes

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. The recommended

manifold connections for installations are shown in Figure 22. Please remember that the maximum number of tubes connected in series should not exceed 90-100.

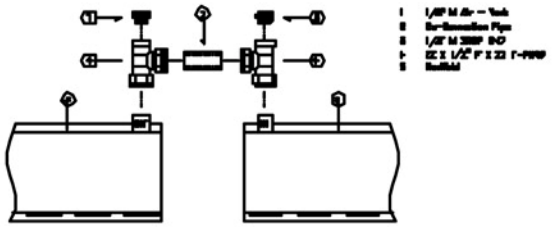


Figure 22.

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.

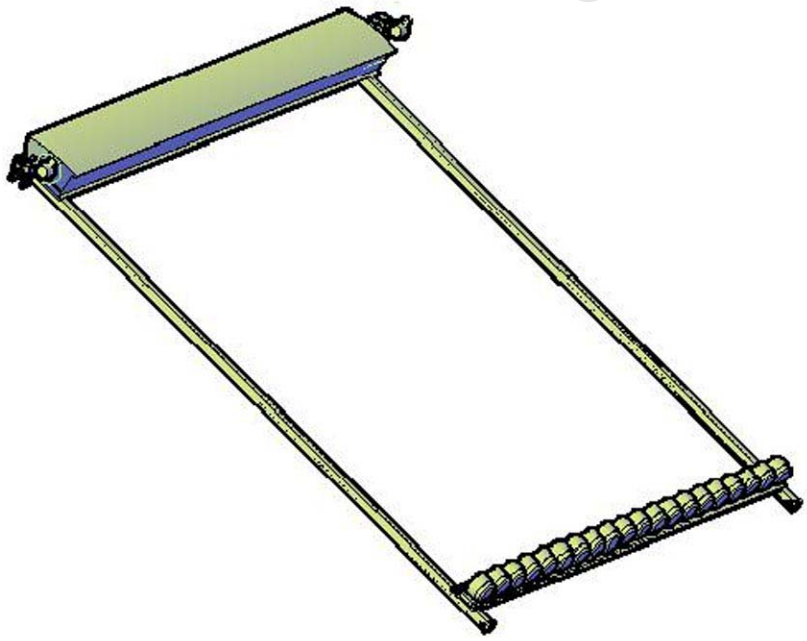
In either case, you should hand-tighten the cap-nut as far as possible. Then, an appropriate spanner should be used to tighten the cap-nut further while a second spanner is used to secure the position of the fitting.

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 Silicon Solar, or your Authorized SunMaxx Dealer.



If you are using any other SunMaxx Evacuated Tube Mounting Hardware, please use the specialized instructions for those systems. This includes:

- SunMaxx Flat Roof Adjustable Frames (Tilt Mounting Hardware Upgrade)
- SunRack 3EVF – Multiple Collector Installation Frames
- SunRack Pole – For Pole Mounting of SUNMAXX Evacuated Tube Solar Collectors

7.0 How to Maintain a SUNMAXX System

7.1 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.

7.2 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.

7.3 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.

8.0 Troubleshooting

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

drops in system	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	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 condensor	1. Replace broken tubes (this does not need to be done immediately to maintain operation) 2. Replace damaged parts 3. Drain and clean system throuroughly

9.0 Appendix

9.1 Products & Spare Parts

Products

	Description	Product Number
Evacuated Tube Collectors	SunMaxx 10 Collector	SunMaxx-10
	SunMaxx 20 Collector	SunMaxx-20
	SunMaxx 25 Collector	SunMaxx-25
	SunMaxx 30 Collector	SunMaxx-30
	Replacement Tubes (set of 10)	6599
	DEMO Kit	16643
Thermosyphon Solar Hot Water Kits	SunMaxx 40 Gallon Thermosyphon	SunMaxx-TS20
	SunMaxx 80 Gallon Thermosyphon	SunMaxx-TS30
Mounting Hardware	Flat Roof Adjustable (Tilt) Frame	18079
	SunMount Upgrade Face Frame	SunMount-25
	SunRack Multi-Collector Mount	SunRack-3EV
		SunRack-3EV10 (extension)
		SunRack-SB (Short Back Support)
		SunRack-LB (Long Back Support)
	SunRack Pole Mount Kit	SunRack-POLE
		SunRack-POLE-B (Base Support)

		SunRack-POLE5 (Steel Pole)
	Roof Mounting Bracket (Flush Mount)	18037
	Standoff Bracket	18036
Solar Hot Water Storage Tanks	40 Gallon Stainless Steel, 1 HE	16146
	40 Gallon Painted Steel, 1 HE	16146-P
	80 Gallon Stainless Steel, 2 HE	16149
	80 Gallon Painted Steel, 2 HE	16149-P
Heat Exchangers	10 Plate, Brazed Plate	39-0010
	20 Plate, Brazed Plate	39-0020
	30 Plate, Brazed Plate	39-0030
Controllers & Circulator Pumps	Differential Temperature Controller	GL30DTC
	Standard Flow Circulator Pump	16147
	large Flow Circulator Pump	4690
	DC/PV Circulator Pump	SID5PV (PV)
		SID10B12 (12V/Battery)
		SID10B24 (24V/Battery)
		SID20R12 (PV or Battery)
	DTC & Standard Pump Package	18046
	DTC & Large Pump Package	18047

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 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

Table 2: Hotel/Restaurant/Guesthouse

Application	Water Temp (C)	Water Temp (F)	Consumption (L)	Consumption (G)
Restaurant				
Per Menu	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

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.

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

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

Building Type	Floor Space m2	Insulation		Units
		Loft Only	Loft & Walls	
Small Detached	100	220	110	kWh/(m2 a)
large Detached	150	210	110	
Bungalow	65	240	140	
Large Semi	90	180	100	
Small Semi	75	180	100	
Semi Bungalow	65	220	130	
Terrace	90	145	90	
End Terrace	90	180	100	

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 Insulation - 3 kWh/m2/day
- Heating Period - 180 days
- Energy Needed - 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 m2 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 m2.

Table 6: Latent Heat

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

Table 7: System Sizing

Number of People	Number of Tubes	~ 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)

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

9.5 SRCC Certification Report – SunMaxx-20

SOLAR RATING & CERTIFICATION CORPORATION

AWARD OF COLLECTOR CERTIFICATION

The solar collector listed below has been evaluated by the Solar Rating and Certification Corporation (SRCC) in accordance with SRCC Document OG-100, *Operating Guidelines and Minimum Standards for Certifying Solar Collectors*, and has been certified by the SRCC as specified in SRCC Standard 100-94, *Test Methods and Minimum Standards for Certifying Solar Collectors*. Certification and thermal performance ratings are based on the successful durability and performance testing of a sample unit where said tests have been conducted by an independent laboratory accredited by the SRCC.

Collector Certification Number: **100-2006011A**

Date Certified: **April 1, 2008** Expiration Date: **August 30, 2019**

Test Laboratory: **Bodycote** Report Number: **06-08-0540** Report Date: **August 30, 2007**

Product: **Tubular** Certified Model: **20EVT** Model Tested: **20EVT**

Supplier: **Silicon Solar Inc.**
2917 State Highway 7
Bainbridge, NY 13733 USA
(800) 746-5508

Description: **Aluminum frame. Glass Vacuum Tube glazing. Aluminum absorber with Sputtered aluminium nitride coating. Vacuum side insulation and Polyurethane and glass wool back insulation. Water was the fluid for performance tests. Gross Area: 3.44 m^2 (37.04 ft^2). Aperture Area: 3.16 m^2 (34.00 ft^2)**

GLAZED COLLECTOR THERMAL PERFORMANCE RATING

Megajoules Per Panel Per Day				Thousands of Btu Per Panel Per Day			
Category (Ti-Ta)	CLEAR 23 MJ/m^2-d	MILDLY CLOUDY 17 MJ/m^2-d	CLOUDY 11 MJ/m^2-d	Category (Ti-Ta)	CLEAR 2 $kBtu/ft^2$-d	MILDLY CLOUDY2 1.5 $kBtu/ft^2$-d	CLOUDY 1 $kBtu/ft^2$-d
A (-5 °C)	33	25	17	A (-9 °F)	31	23	16
B (5 °C)	32	24	16	B (9 °F)	30	22	15
C (20 °C)	30	22	13	C (36 °F)	28	20	13
D (50 °C)	25	17	9	D (90 °F)	23	16	8
E (80 °C)	19	11	4	E (144 °F)	18	10	3

A-Pool Heating (Warm Climate) **B**-Pool Heating (Cool Climate) **C**-Water Heating (Warm Climate) **D**-Water Heating (Cool Climate) **E**-Air Conditioning

Efficiency Equation [Based on Gross Area and (P) = Ti-Ta] **Y Intercept** **Slope**

S I Units: $\eta = 0.371 - 0.8252\ (P)/I - 0.0076\ (P)^2/I$ 0.376 -1.32 $W/m^2 \cdot °C$

I P Units: $\eta = 0.371 - 0.1454\ (P)/I - 0.0007\ (P)^2/I$ 0.376 -0.233 $Btu/hr \cdot ft^2 \cdot °F$

Incident Angle Modifier [NOTE: (S) = 1/cos θ - 1]

$K_{\alpha\tau} = 1.0 + 1.2177\ (S) - 0.7479\ (S)^2$ $K_{\alpha\tau} = 1.0 + 0.44\ (S)$ (Linear Fit)

This award of certification is subject to all terms and conditions of the Program Agreement and the documents incorporated therein by reference. It must be renewed annually. Any change in collector design, materials, specifications, parts, or construction must be reported to SRCC for evaluation of continued certification.

Technical Director April 1, 2008

OG-100 SRCC COLLECTOR CERTIFICATION

Solar Rating and Certification Corporation, c/o FSEC, 1679 Clearlake Road, Cocoa, FL 32922