SunMaxx
Solar Thermal Systems

Technical Information Manual
ANATOMY OF A SUNMAXX SOLAR COLLECTOR

RETScreen Numbers for SunMaxx Evacuated Tube Solar Collectors
use the following numbers to calculate system sizes and performance in RETScreen Solar Software. You can download RETScreen software from www.SunMaxxSolar.com, or directly from RETScreen.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>10</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>20U</th>
<th>30U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector Gross Area (ft²)</td>
<td>21.73</td>
<td>39.66</td>
<td>47.84</td>
<td>57.60</td>
<td>29.1</td>
<td>43.594</td>
</tr>
<tr>
<td>Collector Aperture Area (ft²)</td>
<td>10.01</td>
<td>20.03</td>
<td>25.03</td>
<td>30.04</td>
<td>19.4</td>
<td>29.063</td>
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<tr>
<td>Fr (tau alpha) Coefficient (W/m²/°C²)</td>
<td>0.34</td>
<td>0.37</td>
<td>0.38</td>
<td>0.38</td>
<td>0.65</td>
<td>0.667</td>
</tr>
<tr>
<td>Fr UL Coefficient (W/m²/°C²)</td>
<td>0.70</td>
<td>0.77</td>
<td>0.80</td>
<td>0.80</td>
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<td>1.057</td>
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<tr>
<td>Temp Coefficient for Fr UL</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.002</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Notes:
Efficiency has been converted from aperture area which is obtained by the Solar Keymark Certification Report. Collector dimensions for factor calculations are based off of collector CAD Drawings.
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1. WHAT DOES SILICON SOLAR OFFER

Solar Energy
Silicon Solar Inc 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, efficient solar energy technologies 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 line 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 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. 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.

- 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.

- System sizing and applications must be in accordance with the recommendations made by SUNMAXX.

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

- 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.

- 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.

- 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.
• In cold regions use a suitable non-toxic glycol antifreeze (propylene-glycol), not car antifreeze.

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

• Unpack and install the collector tubes ONLY AFTER the manifold has been installed and the pipe work has been connected.

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

• 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).

• 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. 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.

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. 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 Evacuated 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 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 Trans-
fer 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<5x10⁻³ 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 CONDENSER, 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.

<table>
<thead>
<tr>
<th>Model</th>
<th>SM-20</th>
<th>SM-25</th>
<th>SM-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>67.9“</td>
<td>84.3“</td>
<td>100.7“</td>
</tr>
<tr>
<td>Length</td>
<td>79“</td>
<td>79“</td>
<td>79“</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>170</td>
<td>212</td>
<td>252</td>
</tr>
<tr>
<td>Gross Area (ft²)</td>
<td>39.66</td>
<td>47.84</td>
<td>57.60</td>
</tr>
<tr>
<td>Aperture Area (ft²)</td>
<td>20.03</td>
<td>25.03</td>
<td>30.04</td>
</tr>
<tr>
<td>Aperture Area (m²)</td>
<td>1.861</td>
<td>2.325</td>
<td>2.791</td>
</tr>
</tbody>
</table>

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.

The image below shows a completely assembled SUNMAXX Solar Collector.

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.

3.3.1 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. 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 ($\eta_0$). 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.

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

- $\eta$: efficiency
- $\eta_0$: optical efficiency
- $K_1$: linear heat loss factor [Km2/W]
- $K_2$: square heat loss factor [Km/W]
- $\Delta l$: collector ambient temp [K]
- $G$: global solar radiation [W/m2]

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 °F to °C
  - $°C = (°F - 32) \times 5/9$
  - $K = °C + 273.15$

The global solar radiation varies considerably from region to region. On a clear summer day approximately 850 W/m2 can be expected, whereas clouds can reduce it to 400 W/m2 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 $\geq 0.94$ and an emissivity of $\leq 0.07$.

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. 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.
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.

\[ A_R = R \times \eta \]

- \( R \): Monthly Solar Radiation [kWh/m²] or [BTU/h/ft²]
- \( \eta \): 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:

\[ 1 \text{ kWh/m}^2 = 317 \text{ BTU/h/ft}^2 \]

To find the required collector area, the energy demand has to be divided by the system contribution (equation 5.2)

\[ A_R = \frac{ED}{SC} \]

- \( SC \): System Contribution [kWh/m²] or [BTU/h/ft²]
- \( ED \): Energy Demand [kWh] or [BTU]
- \( AR \): 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:

\[ 1 \text{ kWh} = 3412.1415 \text{ BTU} \]
\[ 1 \text{ BTU} = 0.00029307108 \text{ kWh} \]

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.

<table>
<thead>
<tr>
<th>SunMaxx Model</th>
<th>Aperture Area (m²)</th>
<th>Aperture Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SunMaxx-10</td>
<td>0.930</td>
<td>10.01</td>
</tr>
<tr>
<td>SunMaxx-20</td>
<td>1.861</td>
<td>20.03</td>
</tr>
<tr>
<td>SunMaxx-25</td>
<td>2.325</td>
<td>25.03</td>
</tr>
<tr>
<td>SunMaxx-30</td>
<td>2.791</td>
<td>30.04</td>
</tr>
</tbody>
</table>

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 \( V_t \) and is measured in [l/min] or [g/min]. This flow rate lies in the range of:

- \( 0.1 \leq V_t \leq 0.25 \text{ [l/min]} \)
- \( 0.026 \leq V_t \leq 0.066 \text{ [g/min]} \)

Some common examples are listed in Table 4.

<table>
<thead>
<tr>
<th>SunMaxx Model</th>
<th>Number of Tubes</th>
<th>Nominal Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SunMaxx-10</td>
<td>10</td>
<td>0.28 GPM</td>
</tr>
<tr>
<td>SunMaxx-20</td>
<td>20</td>
<td>0.56 GPM</td>
</tr>
<tr>
<td>SunMaxx-25</td>
<td>25</td>
<td>0.70 GPM</td>
</tr>
<tr>
<td>SunMaxx-30</td>
<td>30</td>
<td>0.84 GPM</td>
</tr>
</tbody>
</table>

\[ V_s = V_t \times n_t \]

- \( V_s \): System Flow Rate (l/min or g/min)
- \( V_t \): Flow Rate per Tube (l/min or g/min)
- \( n_t \): Number of Tubes (rises in multiples of 10)

You can use the factors listed before Table 4 to convert l/min to g/min, and vice-versa.

Or, to convert the system flow rate, \( V_s \), into the unit
[m³/h] that circulator pumps are generally specified in, use equations 5.4 (be sure to use the proper equation depending on whether your flow rate is measured in l/min or g/min).

\[
m^3/h = \frac{l}{min} \times 0.600
\]

\[
m^3/h = \frac{g}{min} \times 0.227
\]

The more tubes that are connected in series, the higher the specific flow rate (V₁) 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 circulator pumps ON and OFF automatically. The longer the pipework 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 pipework or the taco-setter on the control unit.

### 5.3 Pipe Work

Some recommended pipe sizes are given in Table 5.

<table>
<thead>
<tr>
<th>Flow Rate [l/min]</th>
<th>Pipe Size [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 - 6.0 @ 1 m/s</td>
<td>15 x 1</td>
</tr>
<tr>
<td>7.0 - 10.0 @ 1 m/s</td>
<td>18 x 1</td>
</tr>
<tr>
<td>12.5 - 17.5 @ 1 m/s</td>
<td>22 x 1</td>
</tr>
<tr>
<td>17.5 - 22.5 @ 1 m/s</td>
<td>28 x 1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow Rate [g/min]</th>
<th>Pipe Size [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>.5 - 1.6 @ 3.3 ft/s</td>
<td>1/2”</td>
</tr>
<tr>
<td>1.8 - 2.6 @ 3.3 ft/s</td>
<td>3/4”</td>
</tr>
<tr>
<td>3.3 - 4.6 @ 3.3 ft/s</td>
<td>3/4” or 1”</td>
</tr>
<tr>
<td>4.6 - 5.9 @ 3.3 ft/s</td>
<td>1”</td>
</tr>
</tbody>
</table>

Table 5

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

1. Installation Costs
2. Energy Costs for Operation

As 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 within the following ranges: \(1.0 \leq v \leq 1.25 \text{ [m/s]}\).

- \(1.0 \leq v \leq 1.25 \text{ [m/s]}\)
- \(3.3 \leq v \leq 4.1 \text{ [ft/s]}\)

Equation 5.5 gives the required pipe diameter \(\varnothing\), in [mm] or [in].

\[
\varnothing = \sqrt{\frac{4 \times V_s}{\pi \times v}}
\]

- \(\varnothing\): 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 [\(\varnothing_i\)] has been chosen. *SUNMAXX recommends the used of copper pipe, no smaller than 15mm outside diameter. We do not recommend using PEX or PVC Piping in solar installations (within the solar collector loop) as high temperatures and incompatibility with anti-freeze can cause failure.*

Any insulation used needs to 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 at least half of the pipe diameter and has a U-Value of at least 0.035 [W/(mK)].

### 5.4 The Circulator Pump

The circulator 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 6 give a rough guide as to which pump should be used in domestic installations depending on the collector area.
As the flow rate, $V_s$, is already determined (see section 5.2) the pressure drop $\Delta P_s$ in [Pa] of the system has to be calculated. The system pressure drop, $\Delta P_s$, equals the sum of all single pressure drops of the 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, $\Delta P_p$, 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 (if anti-freeze is used).

As for the pipe work, the pressure drop for the heat exchanger, $\Delta P_{he}$ in [Pa] can be found in the manufacturer’s information. The same rules apply as with the pipe work.

According the information given above, the overall pressure drop of your SUNMAXX Solar Hot Water System, $\Delta P_s$, in [Pa] can be calculated using equation 5.6.

$$\Delta P_s = \frac{n_{20} \times \Delta P_{c20} + n_{30} \times \Delta P_{c30} + \Delta P_p + \Delta P_{he}}{10,000}$$

- $\Delta P_s$: System Pressure Drop
- $n_{20}$: Number of 20 Tube Collectors
- $n_{30}$: Number of 30 Tube Collectors
- $\Delta P_{c20}$: Pressure Drop of 20 Tube Collectors [Pa]
- $\Delta P_{c30}$: Pressure Drop of 30 Tube Collectors [Pa]
- $\Delta P_p$: Pressure Drop of Pipe Work [Pa]
- $\Delta P_{he}$: Pressure Drop of Heat Exchanger [Pa]
- 10,000: [Pa] to [m]

To convert any of your [PSI] pressure ratings to [Pa], you can use the following formula:

$$\text{Pa} = \text{PSI} \times 6.894757 \times 10^3$$

And, to convert the [Pa] pressure rating back to [PSI], you can use the following formula:

$$\text{PSI} = \frac{\text{Pa}}{6.894757 \times 10^3}$$

Figure 5 shows the pump curve for the 007, Standard Circulator Pump from SUNMAXX.

Figure 6 shows the pump curve for the 011, Large Circulator Pump from SUNMAXX.
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 7 gives some sizes for expansion vessels for various collector areas and other parameters.

<table>
<thead>
<tr>
<th>Volume [l]</th>
<th>Total System Content [l]</th>
<th>Static Height [m]</th>
<th>Collector Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>≤ 25</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>≤ 8</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>≤ 80</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>≤ 20</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>≤ 16</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>≤ 60</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>≤ 14</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>≤ 12</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>≤ 25</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>≤ 4</td>
<td>6</td>
</tr>
<tr>
<td>35</td>
<td>≤ 100</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>≤ 11</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume [g]</th>
<th>Total System Content [g]</th>
<th>Static Height [ft]</th>
<th>Collector Area [ft²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>≤ 7</td>
<td>10</td>
<td>21.5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>≤ 26</td>
<td>21.5</td>
</tr>
<tr>
<td>5</td>
<td>≤ 21</td>
<td>10</td>
<td>32.3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>≤ 66</td>
<td>32.3</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>≤ 52</td>
<td>32.3</td>
</tr>
<tr>
<td></td>
<td>≤ 16</td>
<td>10</td>
<td>43.1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>≤ 46</td>
<td>43.1</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>≤ 39</td>
<td>43.1</td>
</tr>
<tr>
<td></td>
<td>≤ 66</td>
<td>10</td>
<td>64.6</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>≤ 13</td>
<td>64.6</td>
</tr>
<tr>
<td>9</td>
<td>≤ 26</td>
<td>10</td>
<td>96.9</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>≤ 36</td>
<td>96.9</td>
</tr>
</tbody>
</table>

Table 7

As the values in the Table 7 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.

The expansion vessel is composed of two halves: one half connects 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 7.

The size of the expansion vessel has to be determined as a function of the volume of the 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 use the following steps to size the expansion vessel for your SUNMAXX Solar Hot Water System installation.

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

<table>
<thead>
<tr>
<th>Imperial Unit</th>
<th>Conversion Factor</th>
<th>Metric Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height [feet]</td>
<td>X by 0.305</td>
<td>Meters</td>
</tr>
<tr>
<td>Volume [gallons]</td>
<td>X by 3.7854</td>
<td>Liters</td>
</tr>
<tr>
<td>Pressure [PSI]</td>
<td>X by 0.06895</td>
<td>Bar</td>
</tr>
</tbody>
</table>

You will need to convert the height of your system, the volume of your system and the pressure of your system...
from imperial and metric. For example:

- 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 your system specifications converted you can now proceed with sizing your expansion vessel.

First, you need to determine the overall volume increase of the water/glycol in the system due to temperature increases. The figure is expressed as \( V_{\Delta l} \) and is measured in Liters. The calculation to determine \( V_{\Delta l} \) is shown in equation 5.7.

\[
V_{\Delta l} = V_{sys} * \beta
\]

In equation 5.7, \( \beta \) 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 \( V_{\Delta l} \) we can determine the maximum operating pressure of the SUNMAXX Solar Hot Water System. This measurement is represented by \( P_{\max} \) and is measured in [Bar]. To determine the \( P_{\max} \) of your SUNMAXX Solar Hot Water System, you should use equation 5.8.

\[
P_{\max} = P_{rv} - 0.5
\]

- \( P_{max} \): System Operating Pressure [Bar]
- \( P_{rv} \): Operating Pressure of Relief Valve [Bar]

To determine the set pressure for the diaphragm of your expansion vessel, \( P_d \) use equation 5.9.

\[
P_d = P_h + 0.1 * h
\]

- \( P_d \): Set Pressure for the Diaphragm [Bar]
- \( P_h \): Pressure in the highest point of the system [Bar]
- 0.1: [m] to [Bar]
- \( h \): Static Height of the System [m]

**Please note that you can convert the set diaphragm pressure to PSI by multiplying 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 state. This value is the \( V_c \) and is measured in Liters. You can calculate the \( V_c \) of your SUNMAXX Solar Hot Water System using equation 5.10.

\[
V_c = V_{sys} * 0.015
\]

- \( V_c \): Water Volume in the expansion tank (cold) [l]  
  * must be atleast 1 Liter
- \( V_{sys} \): Overall System Content [l]

**Please note that you can convert your \( V_c \) to Gallons if needed by multiplying by 0.26417.**

Using the values calculated in equations 5.7 to 5.10, you can determine the actual size of your expansion vessel using equation 5.11. The nominal size of the expansion tank is shown as \( V_n \).

\[
V_n = \frac{(V_c + V_{\Delta l} + n_{col} * V_{col}) * (P_{\max} + 1)}{P_{\max} - P_d}
\]

- \( V_n \): Nominal Value of Expansion Vessel [l]
- \( V_c \): Water Volume in Expansion Vessel (Cold State) [l]
- \( V_{\Delta l} \): Volume Increase due to Temperature Increase [l]
- \( n_{col} \): Number of Collectors Installed
- \( V_{col} \): Water Volume for a 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 commercially available expansion vessels are sized in Liters (metric is standard for the solar industry), you may be able to find one, or more, rated in gallons.

**To convert your \( V_n \) from liters to gallons, multiply by 0.26417.**

The closest available expansion vessel from your supplier should be chosen. However, always go with the expansion vessel that is the next size higher than you need if there is not an exact match. This will keep your expansion vessel from being undersized and possibly damaging the system.
5.6 Hydraulics
5.6.1 Collector System
As mentioned before, the maximum number of tubes installed in series should not exceed 90 - 100 tubes. For bigger installations, the recommended collector connection is shown in Figure 8.

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.

![Figure 8](image)

5.6.2 Overall System Design

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

The PUMP is used to circulate water from the Solar Collectors to the user application.

A FLOW-METER is used to measure/monitor the flow rate of water within the system (optional, but recommended).

A 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 component is installed properly.*

An AIR VENT is fitted at the highest point of the system to facilitate the removal of any air pockets. Air Vents should be open when filling the system. The Automatic Air Vent should be fitted with a ball valve to prevent opening when/if the system reaches stagnation.

PRESSURE RELIEF VALVE & GAUGES are used to monitor the pressure of the system and to serve as a safety measure for preventing over-pressuring of the system. (max = 5 Bar).

The FILLING LOOP consists of a flexible hose and stop valve that connects the water's main supply to the host connector and filling valve.

The EXPANSION VESSEL is used to contain increased water/glycol volume in the system due to increased temperatures, and therefore an increase in volume in order to prevent over-pressuring and system failure/damage.

The FLUSH & DRAIN ASSEMBLY is used to flush the system before filling with anti-freeze and drain it, if necessary for cleaning, maintenance or refilling with new anti-freeze.
5.6.3 Common System Design Layouts

Active System with Double Coil Tank
Figure 9 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.

Components
1. Manual Air Vent
2. Automatic Air Vent w/ Valve
3. Hot Water Tank
4. Coil (Top - Backup System)
5. Coil (Bottom - Solar System)
6. Flush & 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 (Other Location)

Active System with Immersion Heater
Figure 10 incorporates an auxiliary immersion electric heater into the system design of Figure 9. The backup heater compensates for prolonged periods of cloud-cover when the solar collector can not perform at maximum capacity.

Components
1. Manual Air Vent
2. Automatic Air Vent w/ Valve
3. Hot Water Tank
4. Immersion Backup Heater
5. Coil (Bottom - Solar System)
6. Flush & 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 (Other Location)
Active System with Short Circuit

Figure 11 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.

Components
1. Manual Air Vent
2. Automatic Air Vent w/ Valve
3. Hot Water Tank
4. 3-Way Valve
5. Coil (Solar System)
6. Flush & 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 (Other Location)

Multiple Tank Installation - in Series

Figure 12 is 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(s) passes through Tank 1 first, if the return temperature is above a set temperature it passes via 3-Way Valve to Tank 2 - otherwise it is circulated back to the solar collectors. If the water leaving Tank 2 is above a set temperature it is passed to Tank 3 - if not, it circulated back to the solar collectors. After Tank 3, the water is circulated back to the solar collectors. This process may be repeated for any number of pre-heat tanks as needed/desired.

Components
1. 3-Way Valve
2. 3-Way Valve (Tank 2)
3. 3-Way Valve (Tank 3)
4. Main Storage Tank
5. Pre-Heat Tank (Tank 2)
6. Pre-Heat Tank (Tank 3)
Multiple Tank Installation - in Parallel

Figure 13 shows a number of storage tanks connected the collector system in parallel. When the water temperature in Tank 1 reaches a set temperature the water from the collector is diverted via a 3-way valve to tank 2 (controlled by a temperature sensor on Tank 1). If the temperature in Tank 1 falls below the set temperature, water is diverted back to Tank 1 until heating is completed.

Once Tank 2 is heated, the water is diverted to Tank 3. Any number of tanks can be connected in Parallel.

Components

1. 3-Way Valve
2. Main Storage Tank
3. Pre-Heat Tank (Tank 2)
4. Pre-Heat Tank (Tank 3)

Multiple Tank Installation - in Parallel

To incorporate a swimming pool into the solar hot water system, it is essential that a suitable heat exchanger is used (Shell & Tube) is used between the pool and the solar collectors. A Solar Pool Heating System is shown in figure 14. It is necessary that the filtration pump is always ON when the solar collector pump is running to avoid overheating the heat exchanger and pipe work parts on the secondary side of the system.
6. HOW 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 your 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 be set to the latitude of the install location plus 15 degrees and the collectors should be oriented toward the South. An azimuth chart can assist you in determining True South vs Magnetic South.

The solar collector system can be mounted at any angle that is ≥ 30 degrees and ≤ 90 degrees, but the above indicates the best 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 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 the 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 tubes.
- DO NOT remove the glass tubes from their package until you are ready to assemble
- Connect pipe & plumbing before installing tubes

Pipes running horizontally should 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”. Figure 15 shows the typical way to connect to the manifold of a SUNMAXX solar collector.

You should use a 1” x 3/4” (or 1/2”) adapter (depending on the size piping you are using in your SUNMAXX solar system to step down from the 1” connection on the manifold to the system piping.

6.3 Flush Mounting
Please refer to the SunMaxx Heat Pipe Evacuated Tube Solar Collector Installation Guide for instructions on flush mounting. Figure 16 (next page) shows a complete SunMaxx Solar Collector for Flush Mounting.

6.4 Tilt Mounting
Please refer to the SunMaxx Heat Pipe Evacuated Tube Solar Collector Installation Guide for instructions on Tilt mounting. Figure 17 (next page) shows a complete SunMaxx Solar Collector for Tilt Mounting.
7. HOW TO MAINTAIN A SUNMAXX SYSTEM

7.1 Periodic Checks

- Ensure that no damage has occurred to the tubes. Remove any debris that may have accumulated.
- Check the flow and return pipe work between the collector(s) 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 will vary depending on the components and system type.

- 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 needed, connect a hose to the water mains, fill the hose with water to avoid introducing air into 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 anti-freeze/inhibitor concentration, draw off a small sample at the draincock and place in your freezer. Remove from the freezer, and measure the temperature at the slush point (when both ice and liquid are present). Temperature should be the same, or lower, than the minimum expected temperature for the location.

7.3 5-Year Checks

- If using anti-freeze/inhibitor, every five years, the system should be drained, flushed and refilled with new anti-freeze/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.
<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump will not run</td>
<td>1. Main/pump wiring is faulty</td>
<td>1. Check wiring at mains/pump</td>
</tr>
<tr>
<td></td>
<td>2. Pump rotor damaged</td>
<td>2. See pump manufacturer's instructions</td>
</tr>
<tr>
<td></td>
<td>3. The pump control selector P is in the OFF position</td>
<td>3. Check SMT unit and return pump control to automatic mode</td>
</tr>
<tr>
<td></td>
<td>4. TC is incorrectly set</td>
<td>4. Reset to proper temperature</td>
</tr>
<tr>
<td></td>
<td>5. TC and ΔT not satisfied</td>
<td>5. No action required</td>
</tr>
<tr>
<td>Pump runs continuously</td>
<td>1. Collector temperature is below TF Temperature</td>
<td>1. No action required. TF Flashes</td>
</tr>
<tr>
<td></td>
<td>2. Loose connection or faulty sensor on the collector</td>
<td>2. Check connection and sensor wires</td>
</tr>
<tr>
<td></td>
<td>3. Collector temperature at maximum</td>
<td>3. No action required</td>
</tr>
<tr>
<td>No Circulation in System</td>
<td>1. Pump isolating valve closed</td>
<td>1. Open valves</td>
</tr>
<tr>
<td></td>
<td>2. Automatic air vent closed</td>
<td>2. Open auto-air vent/replace if needed</td>
</tr>
<tr>
<td></td>
<td>3. Air lock at pressure release valve</td>
<td>3. Twist cap at pressure relief valve and vent air</td>
</tr>
<tr>
<td></td>
<td>4. Air lock in system</td>
<td>4. Check all pipe work rises on return side, falls on flow side - clear vents</td>
</tr>
<tr>
<td></td>
<td>5. Non-return valve jammed</td>
<td>5. Free valve or replace</td>
</tr>
<tr>
<td></td>
<td>6. Pump is not running</td>
<td>6. See above</td>
</tr>
<tr>
<td></td>
<td>7. System in stagnation</td>
<td>7. Wait until system reaches normal operating conditions</td>
</tr>
<tr>
<td>Pressure Drops in System</td>
<td>1. Leak at manifold</td>
<td>1. Check collars on all tubes for leaks - tighten if necessary</td>
</tr>
<tr>
<td></td>
<td>2. Leak in system</td>
<td>2. Check all joints</td>
</tr>
<tr>
<td></td>
<td>3. Drain/filling valve not closed</td>
<td>3. Close fully</td>
</tr>
<tr>
<td></td>
<td>4. Auto air vent passing water</td>
<td>4. Clean or replace as needed</td>
</tr>
<tr>
<td></td>
<td>5. Faulty pressure relief valve</td>
<td>5. Replace</td>
</tr>
<tr>
<td></td>
<td>6. Damaged expansion vessel pressure fluctuation and relief valve to open</td>
<td>6. Replace</td>
</tr>
<tr>
<td>Overheating</td>
<td>1. Pump does not run</td>
<td>1. See above</td>
</tr>
<tr>
<td></td>
<td>2. Prolonged period of low hot water consumption</td>
<td>2. Divert heat to heat dump</td>
</tr>
<tr>
<td>Performance Loss</td>
<td>1. Broken tubes</td>
<td>1. Replace broken tubes (this does not need to happen immediately)</td>
</tr>
<tr>
<td></td>
<td>2. Damaged insulation</td>
<td>2. Replace damaged parts</td>
</tr>
<tr>
<td></td>
<td>3. Build up limestone around heat exchanger/tube condenser</td>
<td>3. Drain and clean system thoroughly</td>
</tr>
</tbody>
</table>
# 9. APPENDIX

## 9.1 Products & Spare Parts

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Product ID Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evacuated Tube Solar Collectors</strong></td>
<td>10 Tube, Heat Pipe Collector</td>
<td>SunMaxx-10</td>
</tr>
<tr>
<td></td>
<td>20 Tube, Heat Pipe Collector</td>
<td>SunMaxx-20</td>
</tr>
<tr>
<td></td>
<td>25 Tube, Heat Pipe Collector</td>
<td>SunMaxx-25</td>
</tr>
<tr>
<td></td>
<td>30 Tube, Heat Pipe Collector</td>
<td>SunMaxx-30</td>
</tr>
<tr>
<td></td>
<td>20 Tube, U-Pipe Collector</td>
<td>SunMaxx-20U</td>
</tr>
<tr>
<td></td>
<td>30 Tube, U-Pipe Collector</td>
<td>SunMaxx-30U</td>
</tr>
<tr>
<td></td>
<td>20 Tube, Project Collector</td>
<td>SunMaxx-20PC</td>
</tr>
<tr>
<td></td>
<td>50 Tube, Project Collector</td>
<td>SunMaxx-50PC</td>
</tr>
<tr>
<td></td>
<td>DEMO Collector</td>
<td>16643</td>
</tr>
<tr>
<td></td>
<td>10 Replacement Tubes, Heat Pipe (w/o Heat Pipe)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 Replacement Tubes, Heat Pipe (w/ Heat Pipe)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 Replacement Tubes, U-Pipe</td>
<td></td>
</tr>
<tr>
<td><strong>Thermosyphon Kits</strong></td>
<td>20 Tube/40 Gallon Thermosyphon</td>
<td>SunMaxx-TS20</td>
</tr>
<tr>
<td></td>
<td>30 Tube/80 Gallon Thermosyphon</td>
<td>SunMaxx-TS30</td>
</tr>
<tr>
<td></td>
<td>10 Replacement Tubes, Thermosyphon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 Replacement Tubes, Thermosyphon</td>
<td></td>
</tr>
<tr>
<td><strong>Storage Tanks &amp; Heat Exchangers</strong></td>
<td>40 Gallon Tank, 1 Heat Exchanger</td>
<td>16146</td>
</tr>
<tr>
<td></td>
<td>80 Gallon Tank, 2 Heat Exchangers</td>
<td>16149</td>
</tr>
<tr>
<td></td>
<td>10 Plate, Brazed Plate Heat Exchanger</td>
<td>39-0010</td>
</tr>
<tr>
<td></td>
<td>20 Plate, Brazed Plate Heat Exchanger</td>
<td>39-0020</td>
</tr>
<tr>
<td></td>
<td>30 Plate, Brazed Plate Heat Exchanger</td>
<td>39-0030</td>
</tr>
<tr>
<td></td>
<td>12 x 12 Air to Water Heat Exchanger</td>
<td>SMHTL-1212</td>
</tr>
<tr>
<td></td>
<td>16 x 16 Air to Water Heat Exchanger</td>
<td>SMHTL-1616</td>
</tr>
<tr>
<td></td>
<td>18 x 18 Air to Water Heat Exchanger</td>
<td>SMHTL-1818</td>
</tr>
<tr>
<td></td>
<td>20 x 20 Air to Water Heat Exchanger</td>
<td>SMHTL-2020</td>
</tr>
<tr>
<td></td>
<td>22 x 22 Air to Water Heat Exchanger</td>
<td>SMHTL-2222</td>
</tr>
<tr>
<td><strong>Controllers &amp; Circulator Pumps</strong></td>
<td>Goldline GL-30 Differential Temperature Controller</td>
<td>GL30DTC</td>
</tr>
<tr>
<td></td>
<td>Standard Circulator Pump (007)</td>
<td>16147</td>
</tr>
<tr>
<td></td>
<td>Large Circulator Pump (011)</td>
<td>4690</td>
</tr>
<tr>
<td></td>
<td>El Sid 12V/Battery Powered Pump</td>
<td>SID10B12</td>
</tr>
<tr>
<td></td>
<td>El Sid 24V/Battery Powered Pump</td>
<td>SID10B24</td>
</tr>
<tr>
<td></td>
<td>El Sid 12V/Battery / PV Powered Pump</td>
<td>SID20B12</td>
</tr>
<tr>
<td></td>
<td>DTC &amp; Standard Pump Kit</td>
<td>18046</td>
</tr>
<tr>
<td></td>
<td>DTC &amp; Large Pump Kit</td>
<td>18047</td>
</tr>
</tbody>
</table>
9.2 System Sizing Tables

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

Table Guide:

- Table A-1: Average Domestic Hot Water Use per Household
- Table A-2: Hotel/Restaurant/Guest House
- Table A-3: Outdoor Pool Energy Requirement [kwh]
- Table A-4: Specific Heat Loss [kwh] Outdoor Pool
- Table A-5: Average Space Heating Requirements - Target Temperature = 20 °C
- Table A-6: Latent Heat
- Table A-7: System Sizing

Table A-1: Average Domestic Hot Water use per Household (per resident)

<table>
<thead>
<tr>
<th>Application</th>
<th>Water Temp (°C)</th>
<th>Water Temp (°F)</th>
<th>Consumption (L)</th>
<th>Consumption (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sink</td>
<td>55</td>
<td>131</td>
<td>30 - 50</td>
<td>8 - 13</td>
</tr>
<tr>
<td>Wash Basin</td>
<td>35</td>
<td>95</td>
<td>5 - 15</td>
<td>1 - 4</td>
</tr>
<tr>
<td>Bathtub</td>
<td>40</td>
<td>104</td>
<td>100 - 170</td>
<td>26 - 45</td>
</tr>
<tr>
<td>Shower</td>
<td>40</td>
<td>104</td>
<td>50</td>
<td>13</td>
</tr>
<tr>
<td>Laundry (cold)</td>
<td>30 - 40</td>
<td>86 - 104</td>
<td>60 - 70</td>
<td>15 - 19</td>
</tr>
<tr>
<td>Laundry (hot)</td>
<td>50 - 60</td>
<td>122 - 140</td>
<td>60 - 70</td>
<td>15 - 19</td>
</tr>
</tbody>
</table>

Total Consumption

| Low      | 60 | 140 | 10 - 20 | 2 - 5 |
| Average  | 60 | 140 | 20 - 40 | 5 - 11 |
| High     | 60 | 140 | 40 - 80 | 11 - 22 |

Table A-2: Hotel / Restaurant / Guest House

<table>
<thead>
<tr>
<th>Application</th>
<th>Water Temp (°C)</th>
<th>Water Temp (°F)</th>
<th>Consumption (L)</th>
<th>Consumption (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Menu</td>
<td>45</td>
<td>113</td>
<td>6 - 12</td>
<td>1 - 3</td>
</tr>
<tr>
<td>Per Guest</td>
<td>45</td>
<td>113</td>
<td>12 - 30</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Hotel (per room)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room + Wash Basin</td>
<td>45</td>
<td>113</td>
<td>15 - 20</td>
<td>3 - 6</td>
</tr>
<tr>
<td>Room + Bath</td>
<td>45</td>
<td>113</td>
<td>70 - 120</td>
<td>18 - 33</td>
</tr>
<tr>
<td>Room + Shower</td>
<td>45</td>
<td>113</td>
<td>140 - 200</td>
<td>35 - 53</td>
</tr>
<tr>
<td>Guest House</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>113</td>
<td>35 - 70</td>
<td>9 - 19</td>
</tr>
</tbody>
</table>
### Table A-3: Outdoor Pool Energy Requirement [kwh] & [BTU]

<table>
<thead>
<tr>
<th>Water Temp (°C)</th>
<th>Swimming Season</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 months</td>
<td>5 months</td>
</tr>
<tr>
<td>22</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>24</td>
<td>250</td>
<td>340</td>
</tr>
<tr>
<td>26</td>
<td>420</td>
<td>560</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Temp (°F)</th>
<th>Swimming Season</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 months</td>
<td>5 months</td>
</tr>
<tr>
<td>72</td>
<td>31,700</td>
<td>63,400</td>
</tr>
<tr>
<td>75</td>
<td>79,250</td>
<td>107,780</td>
</tr>
<tr>
<td>79</td>
<td>133,140</td>
<td>177,520</td>
</tr>
</tbody>
</table>

**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 Needed: = 600 kwh/m²/season
- Collector Efficiency: 0.7 (70%)
- 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 A-3 is 150kwh/m²/season. In other words, required ratio of collector surface area of 1:3; 150/450.

### Table A-4: Specific Heat Loss [kwh] & [BTU] for Outdoor Pool

<table>
<thead>
<tr>
<th>Target Temp. (°C)</th>
<th>Pool A</th>
<th>Pool B</th>
<th>Pool C</th>
<th>Pool D</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.034</td>
<td>0.072</td>
<td>0.110</td>
<td>0.158</td>
</tr>
<tr>
<td>20</td>
<td>0.133</td>
<td>0.170</td>
<td>0.269</td>
<td>0.314</td>
</tr>
<tr>
<td>23</td>
<td>0.275</td>
<td>0.315</td>
<td>0.476</td>
<td>0.523</td>
</tr>
<tr>
<td>26</td>
<td>0.036</td>
<td>0.068</td>
<td>0.060</td>
<td>0.069</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target Temp. (°F)</th>
<th>Pool A</th>
<th>Pool B</th>
<th>Pool C</th>
<th>Pool D</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>10.778</td>
<td>22.824</td>
<td>34.870</td>
<td>50.086</td>
</tr>
<tr>
<td>68</td>
<td>42.161</td>
<td>53.890</td>
<td>85.273</td>
<td>99.538</td>
</tr>
<tr>
<td>73</td>
<td>87.175</td>
<td>99.855</td>
<td>150.892</td>
<td>165.791</td>
</tr>
<tr>
<td></td>
<td>118.241</td>
<td>200.978</td>
<td>279.277</td>
<td>297.346</td>
</tr>
<tr>
<td></td>
<td>228,240</td>
<td>21,556</td>
<td>21,873</td>
<td>28,847</td>
</tr>
</tbody>
</table>

**Legend:**

- **Pool A:** Pool with 2 sides well protected (trees, building or wall), wind speed = 1 m/2
- **Pool B:** Pool with 2 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)
Table A-5: Average Space Heating Requirements - Target Temperature = 20 °C

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Floor Space (m²)</th>
<th>Insulation</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Loft Only</td>
<td>Loft &amp; Walls</td>
</tr>
<tr>
<td>Small Detached</td>
<td>100</td>
<td>220</td>
<td>110</td>
</tr>
<tr>
<td>Large Detached</td>
<td>150</td>
<td>210</td>
<td>110</td>
</tr>
<tr>
<td>Bungalow</td>
<td>65</td>
<td>240</td>
<td>140</td>
</tr>
<tr>
<td>Large Semi</td>
<td>90</td>
<td>180</td>
<td>100</td>
</tr>
<tr>
<td>Small Semi</td>
<td>75</td>
<td>180</td>
<td>100</td>
</tr>
<tr>
<td>Semi Bungalow</td>
<td>65</td>
<td>220</td>
<td>130</td>
</tr>
<tr>
<td>Terrace</td>
<td>90</td>
<td>145</td>
<td>90</td>
</tr>
<tr>
<td>End Terrace</td>
<td>90</td>
<td>180</td>
<td>100</td>
</tr>
</tbody>
</table>

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

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

- Solar Insulation: 3 kwh/m²/day
- Heating Period: 180 days
- Energy Needed: 540 kwh/m²/day
- Collector Efficiency: 0.70 (70%)
- Energy Out/Period: (540 x 0.70) = 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 of 20 °C = 110 kwh/m²/a.

Required a ratio of collector area to floor space of approximately 110/378 - 0.3 (30%). Giving a total collector area of 50 m².

Table A-6: Latent Heat

1 m² of collector area with solar insolation of 1000 w/m² can...per 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 ft² of collector area with a solar insolation of 1000 w/m² can...per 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>
<thead>
<tr>
<th>Number of People</th>
<th>Number of Tubes</th>
<th>Storage Tank Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>20</td>
<td>100 - 150 l (25 - 40 G)</td>
</tr>
<tr>
<td>3 - 4</td>
<td>30</td>
<td>200 - 250 l (50 - 70 G)</td>
</tr>
<tr>
<td>5 - 6</td>
<td>40</td>
<td>300 - 350 l (80 - 95 G)</td>
</tr>
<tr>
<td>7 - 8</td>
<td>50</td>
<td>400 - 450 l (105 - 120 G)</td>
</tr>
</tbody>
</table>
9.3 Installation Checklist

Project Data:

Date: _______________________________________
Name: ________________________________________________________________________
Address: ________________________________________________________________________
City, State, ZIP: ________________________________________________________________________
Phone: ________________________________________________________________________

Consumption:

People: ____________________
Hot Water @ _____________ C or F @ _____________ L or G / 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 the System: ____________ m² or ft²

Solar Collector: _____ SunMaxx-10    _____ SunMaxx-20    _____ SunMaxx-25    _____ SunMaxx-30

Storage Tank: _____ SunMaxx    _____ Other   _____ 40 Gallon    _____ 80 Gallon

Circulator Pump: _____ Taco 007    _____ Taco 011    _____ El Sid    _____ Other
9.4 Commissioning Sheet

Project Data:
Date: _______________________________________
Name: ________________________________________________________________________
Address: ________________________________________________________________________
City, State, ZIP: ________________________________________________________________________
Phone: ________________________________________________________________________

General Information:
Date of Purchase: _______________ Supplied by: ________________________________________________________________________
Invoice Number: ________________________________________________________________________
Date of Installation: _______________ Installed by: ________________________________________________________________________

System Information:
Collector Model: _____ SunMaxx-10 _____ SunMaxx-20 _____ SunMaxx-25 _____ SunMaxx-30
Solar Controller: Model: ________________________________________________________________________
Serial Number: ________________________________________________________________________
Settings: High Limit _______________ C or F
Low Limit _______________ C or F
On-Differential _______________
Off-Differential _______________
Expansion Vessel: Volume: _______________ L or G
Pressure: _______________ Bar or PSI
Filling Pressure: _______________ Bar or PSI
Pump Specifications: Vs: _______________ m3/h or ft3/h
ΔPs: _______________ M or ft
Frost Protection down to: _______________ C or F
9.5 SRCC Certification Report

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: 06-08-0510
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 aluminum nitride coating. Vacuum side insulation and Polyurethane and glass wool back insulation. Water was the fluid for performance tests. Gross Area: 3.44 m² (37.04 ft²). Aperture Area: 3.16 m² (34.00 ft²)

GLAZED COLLECTOR THERMAL PERFORMANCE RATING

<table>
<thead>
<tr>
<th>Category (T-Ta)</th>
<th>CLEAR</th>
<th>MILDLY CLOUDY</th>
<th>CLOUDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (-5 °C)</td>
<td>33</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>B (5 °C)</td>
<td>32</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>C (20 °C)</td>
<td>30</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>D (50 °C)</td>
<td>25</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>E (60 °C)</td>
<td>19</td>
<td>11</td>
<td>4</td>
</tr>
</tbody>
</table>

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 \(P = T-Ta\)]

\[
\eta = 0.371 - 0.8252 (P)^{0.1} - 0.0076 (P)^{2.1}
\]

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

\[
K = 1.0 + 1.2177 (S) - 0.7470 (S)^2
\]

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
If you have any questions about your SunMaxx Solar Collector, please contact your SunMaxx Dealer or Installer today