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# (1.0) What does THERMOMAX offer

## Solar Division

Thermomax Ltd. is a leading manufacturer of high efficiency equipment for efficient and economical conversion of solar radiation into thermal energy. Based in two locations in the United Kingdom, and a unit in Italy, Thermomax occupies over 10,000m² of purpose built factories on 10 acres (40,400m²) of land. The operation is complete with engineering and administration offices, manufacturing plants, development laboratory and testing facilities. Thermomax has a staff of professional, technical and production personnel with a high degree of dedication and competence.

The evacuated heat-pipe solar collector is the result of extensive research, development and testing. These high performance, reliable and cost effective solar modules use advanced technology and new materials.

Thermomax's manufacturing operations are geared to volume production and high quality assurance. The plants are well equipped with modern machinery and specialised tooling for efficient and reliable production. Thermomax's engineering factory in northern Italy is involved in manufacturing some of the unique and sophisticated equipment needed for production purposes as well as specialised components.

## Electronic Division

An electronic division, established in 1990, produces microprocessor controllers for the solar heating systems as well as sophisticated controllers and data loggers for commercial refrigeration applications.

## The Market

The market for Thermomax solar products is worldwide and is managed through a network of distributors, dealers and independent agents. These firms provide application and installation assistance to users, architects, engineers and contractors.

Thermomax is currently sold to over 40 countries with Western Europe, Far East and the United States as its main markets. The number of Thermomax collector tubes in service throughout the world is now in the millions. Satisfied Thermomax users achieve considerable savings in their fuel cost as well as contributing towards a reduction in $CO_2$ emissions.

Installations in extreme climates such as Africa and the Antarctic clearly show the exceptional design characteristics of the Thermomax systems.

Thermomax solar collectors are used to produce clean energy for domestic and industrial hot water, space heating and cooling. Projects such as the solar water heating at Singapore Airport are the largest of their kind, confirming international acknowledgement and full confidence in the Company and its products.

## Assured and approved Quality

Thermomax solar manufacturing plants are fully registered to the internationally recognised ISO Quality Management Systems; the Company has obtained ISO 9001 certificate.

Thermomax collectors are tested and certified by major independent testing authorities in Germany, Switzerland, United States, Great Britain and Australia. Thermomax has received 10 major awards, the first being a 1982 Technology Award received in Germany and two prestige Queen's Awards for export achievement. The Design Council confirms the Thermomax collector to be **_an outstanding British Product_** and winner of a "Millennium Award".

**Thermomax products and production techniques are protected throughout the world by several patents.**

## (2.0)    How to get the most out of a THERMOMAX® system

We recommend you to read this manual thoroughly before commencing installation and to adhere to the cautions given and to all local authorities regulations and relevant standards.

1.  Thermomax® systems should only be installed by qualified persons. If in doubt about any aspect of the installation contact your Thermomax® dealer.
2.  System sizing and application must be in accordance with recommendations by Thermomax®.
3.  Responsibility for safe and proper installation of a Thermomax® solar water heating system rests with the installer.
4.  Thermomax® manifold systems are designed to work with a maximum operating pressure of 5 bar (75 psi). To guarantee this pressure is not exceeded a pressure relief valve and a pressure gauge must be used.
5.  The chloride content of the water passing through the manifold should not exceed 40 ppm – check with your local water authorities.
6.  In areas with hard water a heat exchanger is strongly recommended otherwise regular cleaning of the system is essential.
7.  In cool regions use suitable non-toxic antifreeze-inhibitor e.g. water/glycol mix (not car antifreeze).

8.  When heating a swimming pool or spa a heat exchanger must be used between the pool and the collector.
9.  Unpack and install the collector tubes only after the manifold unit has been installed and the pipework has been connected.
10. Make sure the COATED SURFACE of the absorber in the tube is uppermost when installed.
11. The collector tubes should be covered if the system has not been filled and the tubes are exposed to the sun for extended periods (more than 1 day).
12. Gloves and eye protection should be worn when handling glass.
    Avoid any sudden 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 these suggestions, however final design of any installation is left to the discretion of the installer.

This manual was correct at the time of going to print but, as part of a continual product improvement, Thermomax® reserves the right to update and amend specifications without notice.

The Thermomax® Solar Collector is patented worldwide.

# (3.0)    How does a Thermomax system work

The two main components of the THERMOMAX® solar collector system are the THERMOMAX® Memotron® Evacuated Solar Collector Tube and the THERMOMAX® Manifold. Complete roof fixing kits and pump control units are available as accessories.

THERMOMAX® MEMOTRON® Evacuated Heat-Pipe Solar Collectors offer the following features:
- High performance
- Low heat capacity and high heat transfer
- Thermal diode operation – Heat flow only in one direction (Tube to manifold)
- Control of 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 THERMOMAX® Tube

The THERMOMAX® Memotron® Evacuated Solar Collector Tube as shown in Figure 1 combines the technology of the fully evacuated glass tube, the specially designed absorber with heat-pipe technology and the unique condenser.

### (3.1.1)    The Absorber

The main assembly parts of the absorber are the ABSORBER PLATE and the HEAT-PIPE.
The absorber plate is coated with a special high efficiency SELECTIVE COATING that ensures maximum radiation absorption and minimum thermal radiation losses. Figure 2 shows the characteristics of the selective coating. The coating undergoes a stringent quality control test with only the materials meeting our required levels of absorption and emittance standards being used in production. A heat-pipe performs like a high conductance thermal conductor. Due to its thermophysical properties, its heat transfer rate could be thousands of times greater than that of the best solid heat conductors of the same dimensions. The heat-pipe employs an evaporating-condensing cycle, which accepts heat from an exter-
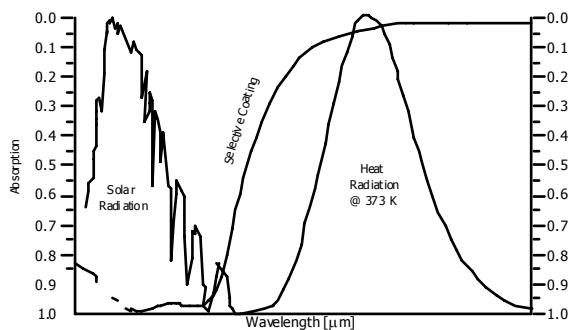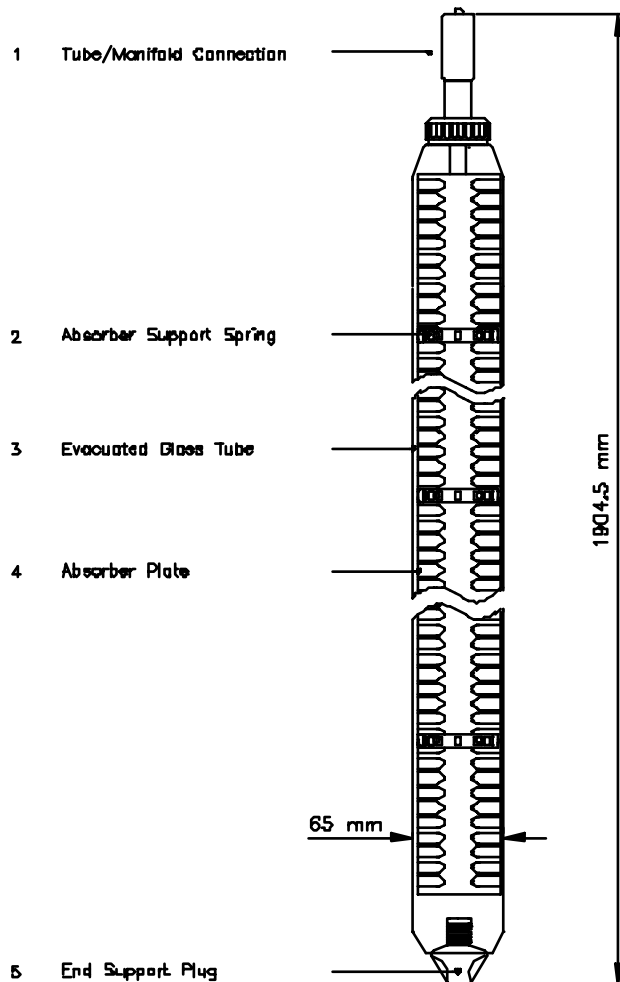


1   Tube/Manifold Connection

2   Absorber Support Spring

3   Evacuated Glass Tube

4   Absorber Plate

1904.5 mm

65 mm

5   End Support Plug

Figure 1



Figure 2

nal source, uses this heat to evaporate the liquid (latent heat) and then releases the latent heat by reverse transformation (condensation) at a heat sink region. This process is repeated continuously as the condensed fluid returns to its original position due to gravity.

Rapid temperature swings produce localised 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 THERMOMAX® Memotron® Evacuated Solar Collector Tube. This patented thermal shock absorber is made of a metal having high thermal resistance and high mechanical strength to completely absorb the temperature swing.

## (3.1.2)    The Evacuated Glass Tube

In a THERMOMAX® collector the absorber plate and its heat-pipe is hermetically sealed within an evacuated glass tube. This protects the high efficiency of the absorber plate from adverse weathering influences as well as airborne pollutants.
The vacuum in the evacuated glass tube is $10^{-5}$ mbar. This can only be reached and maintained over a long period of time through a specialised evacuation process in production resulting in an almost total elimination of convection and conduction losses from the collector.
Due to the 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 as shown in Figure 3. Radiation striking the collector plate is absorbed, then transferred via the heat-pipe as thermal energy to the condenser. Connected into the THERMOMAX® manifold, the condenser efficiently transfers this heat to the water of the connected circuit.
The unique design of THERMOMAX®'s Memotron® condenser assembly provides an edge on 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 vapour in the heat-pipe. This design of the condenser also increases considerably the output of the unit.
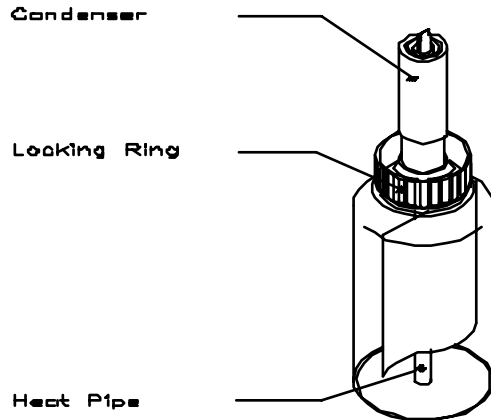


Figure 3

## (3.2)    The THERMOMAX® MS Manifold

The THERMOMAX® MS manifolds are designed in either a 2 m² or a 3 m² tube assembly configuration. A 20 tube manifold adds up to a 2 m² assembly, and the 30 tube manifold to a 3 m² assembly. These can be extended by parallel and serial connection of as many manifolds as required to cover the demanded energy requirement.
The insulated manifolds are supplied completely with the support assemblies and all connection fittings for the pipework required. The manifold chamber is made from high grade stainless steel and is sealed in a weather resistant metal cover. There is a thick CFC - free polyurethane foam insulating jacket, having a U value [W/(mK)] of $0.28 \leq U \leq 0.35$. The stainless steel manifold inlet and outlet pipe has 22 mm diameter.
The manifold section is 115 mm high and 120 mm wide. The approximate overall dimensions, weights, water capacity and absorber area are given in Table 1:

| MS Manifold | 20 tubes | 30 tubes |
|---|---|---|
| Overall dimensions [mm] | 1415 x 2130 | 2124 x 2130 |
| Weight [kg] | 45 | 68 |
| Capacity [l] | 3.3 | 5.0 |
| Net Absorber area [m²] | 2.0 | 3.0 |

Table 1

The stainless steel manifold and all welds and joints are fully processed and pressure tested. Please refer to the CAUTIONS given 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 system various other parts are required. THERMOMAX[®] supplies the following:
- Variety of roof fixing kits
- Flexible hose kits for ease of installation on the roof
- Pump control units for efficient operation and control of the system

THERMOMAX[®] does not normaly supply any plumbing equipment (except the required parts to connect the manifold) or hot water tanks and other commercially available parts. Figure 4 shows an assembled THERMOMAX[®] Solar Collector.
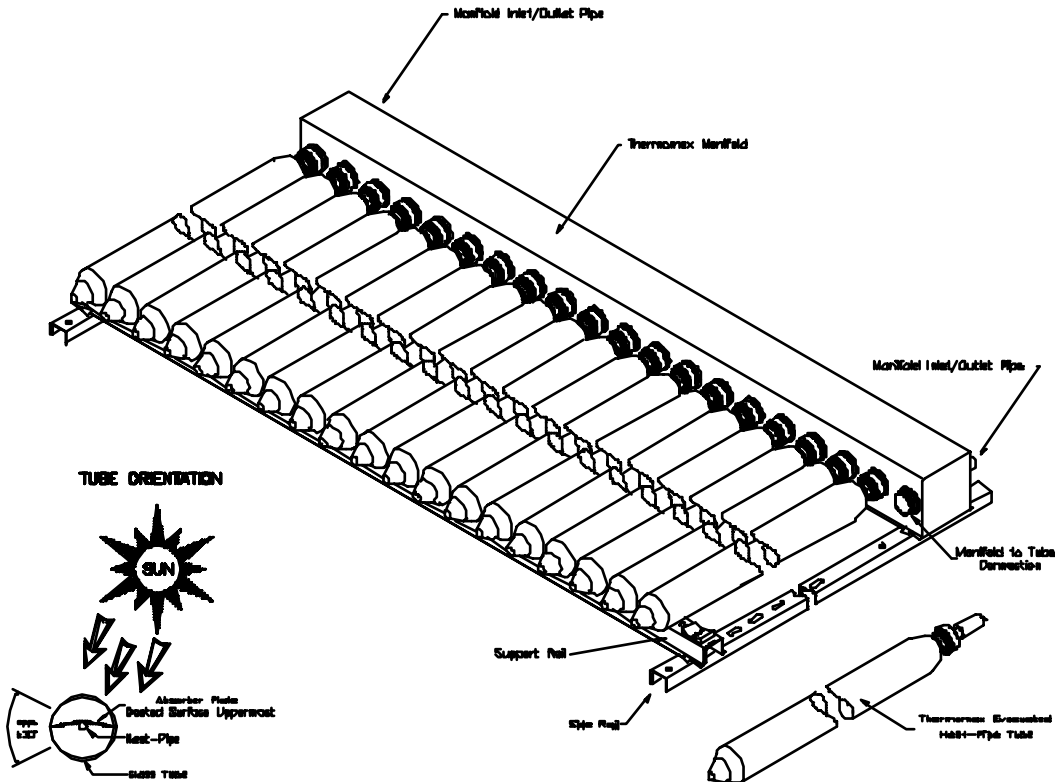


Figure 4

## (3.3.1)    Roof fixing kits

**MS System**

The MS System is supplied as standard with the THERMOMAX® MS manifolds. The patented stainless steel bands provided are suitable for pitched roof tiles, especially slated roofs.

**KS System**

The optional KS System is similar in its application to the MS System. It is also used on pitched roofs with roof tiles. The use of this system is recommended for stone/brick tiles, as a bigger distance has to be overcome between the rafter and the support frame of the THERMOMAX® system.

**FS System**

The optional FS System is to be used for flat roof or ground installations. It contains a complete frame set, manufactured out of stainless steel, allowing the system to be installed under different inclination angles on a flat roof or the ground. Basically the heat-pipe works under angles between 25° and 50° with the optimum angle of the solar radiation being equal to the geographical latitude of the system location.

**Alternative mounting methods**

The THERMOMAX® solar collector system can also be fixed directly to a concrete roof, a solid wall or a copper roof. It is possible to secure the support frame to the rafter using either the MS or the KS system by using a noggin. A noggin is a beam between two rafters. Figure 5 shows one alternative roof mounting option.
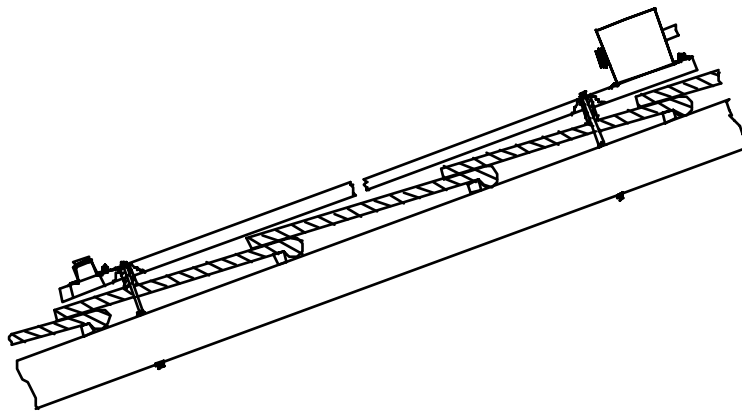
Figure 5

## (3.3.2)    Solar Differential Controller

THERMOMAX® manufacturers a compact and easily installed control device that will regulate the flow of water from the collector to the heat exchanger in the hot water storage tank using microprocessor technology. The control unit will automatically operate the pump according to conditions set by the installer.

**Pump Control Unit**

The pump control unit is a fully assembled group of components mounted on a back plate, enclosed by an insulated cover and includes the following parts:

- Expansion vessel (18 l, 6 bar)
- Pressure relief valve (opening pressure 5 bar) with pressure gauge
- Filling loop including valve, hose connector, flexible hose

**Controllers**

THERMOMAX® manufacturers a range of multi-functional microprocessor units providing complete control for the solar heating system. The microprocessor technology used in the manufacture ensures the collected energy from the sun is transferred efficiently and harnessed under optimum conditions. From the easy to understand SMT 100 to the more sophisticated SMT 400 via a middle of the range SMT 300, the units provide users with valuable information about their THERMOMAX® solar collector system.

**System Kit / Active Pack**

The Active Pack contains all functional parts of the Pump Control Unit, without the back plate and the insulation cover, to allow a more flexible installation where sufficient space for installing a Pump Control Unit is not available.

# (4.0)    How does a THERMOMAX<sup>®</sup> system perform

## (4.1)    Solar Fundamentals

All solar collector systems have the sun as common energy source. The performance depends therefore on the conversion of the solar radiation into useful thermal energy and to transfer it to the hot water system.

The ability to convert solar energy into thermal energy is expressed by the optical efficiency of the system $\eta_0$. The two factors $k_1$ and $k_2$ relate to the system's ability to transfer the energy gained. Equation 4.1 combines the three empirical values to determine the efficiency of the collector system.

$$\eta = \eta_0 - k_1 \cdot \frac{\Delta \vartheta}{G} - k_2 \cdot \frac{\Delta \vartheta^2}{G} \qquad (4.1)$$

with ...  $\eta$ ... efficiency [-]
  $\eta_0$ ... optical efficiency [-]
  $k_1$ ... linear heat loss factor [Km²/W]
  $k_2$ ... square heat loss factor [K²m²/W]
  $\Delta \vartheta$ ... collector–ambient temp. [K]
  $G$ ... Global solar radiation [W/m²]

The global solar radiation G 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. Figure 6 shows the efficiency of the TMO 500 S and TMO 600 S collectors in comparison with a flat plate collector.

Due to the very good insulation properties of the evacuated solar tubes the "only" heat loss is via the THERMOMAX<sup>®</sup> manifold with it's small surface area and the thick layer of high quality polyurethane foam insulation. The correlation between the level of vacuum and the losses can be seen in Figure 7 for e.g. $\vartheta_{Col}$ = 150 °C and $\vartheta_{Amb}$ = 20 °C.

Figure 6

## (4.2)    Thermal Performance

Two types of THERMOMAX<sup>®</sup> MEMOTRON<sup>®</sup> Evacuated Heat-Pipe Tubes are available, differing only in their maximum working temperature.

### TMO 500 S

The model TMO 500 S has a design cut-off temperature of 85 °C (185 °F) and is recommended for applications up to 75 °C (~105 °F).

### TMO 600 S

The model TMO 600 S has a cut-off temperature of approximately 130 °C (~270 °F) and is recommended for applications up to 120 °C (~250 °F).
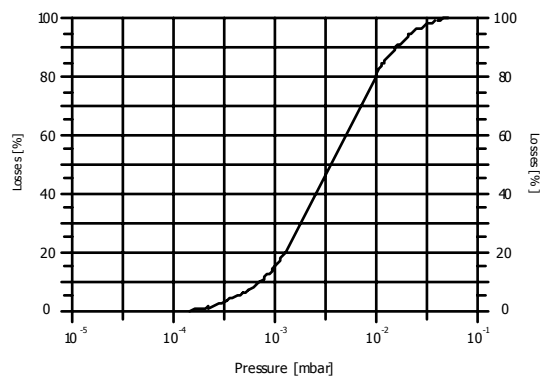
Figure 7

On all models the specially coated absorber has an absorption of better than 0.96 and an emittance of less than 0.1.

The THERMOMAX<sup>®</sup> MEMOTRON<sup>®</sup> Evacuated Heat-Pipe collectors supply heat at temperatures significantly higher than those achieved by flat-plate collectors. This comparison is particularly relevant in cold, windy and cloudy climates.
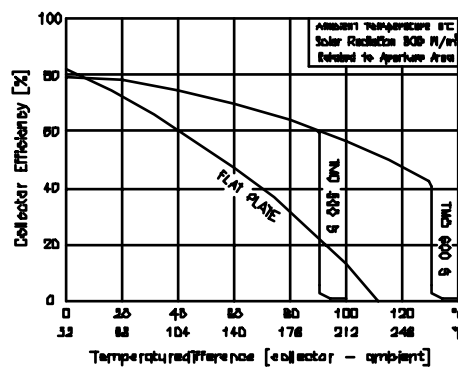
Even though the condenser valve assembly cuts of at 85 °C or 130 °C, heat transfer occurs via the metal assembly and a maximum stagnation temperature of approximately 155 °C (~310 °F) can be reached by both types.

Table 2 summarizes some of the recommended applications of the THERMOMAX® MEMOTRON® Evacuated Heat-Pipe Tubes.

| Tube recommended for ... | TMO 500 S | TMO 600 S |
|---|:---:|:---:|
| Domestic and industrial hot water | ✓ | ✓ |
| Swimming Pool | ✓ | |
| Space Heating | ✓ | ✓ |
| Air Conditioning | | ✓ |
| Sea Water Desalination | | ✓ |
| Power ranking machines for irrigation purposes | | ✓ |
| Industrial process heat | | ✓ |

Table 2

# (5.0)    How to design a THERMOMAX® system

The first step to ensure enjoyment of your THERMOMAX® MEMOTRON® Evacuated 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 up to 9 m² (90 tubes) of collector area. 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 hot water only it is strongly recommended to aim for 100% solar coverage during the summer months only. If the system has to provide additional energy for heating systems in the winter time or other applications an option for re-routing the excess heat has to be installed (i.e. heat-sink, connecting to a swimming pool) to avoid long stagnation times in the summer.

Figure 8 shows the solar contribution of a correctly sized solar system over the year.



Figure 8
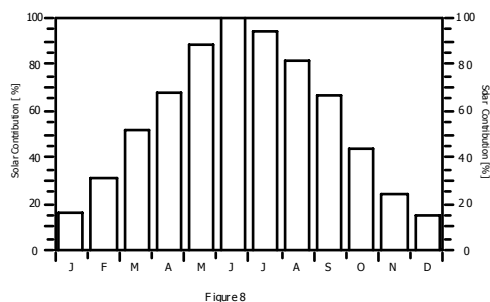
- As a guide you can assume that 1 tube can produce maximum 10 litres of hot water, e.g. your hot water consumption is 200 l per day, a 20 tube manifold system would give you an approximate 60% solar contribution over the year in Middle European climates.

- Using equation 5.1, a more accurate estimation of the overall system contribution per square meter can be made. For some cities the average daily global solar radiation per month is given in appendix 1.

$$SC = R \cdot \eta \qquad (5.1)$$

with ...   SC ... System Contribution [kWh/m²]
R ... Monthly Solar Rad. [kWh/m²]
$\eta$ ... Efficiency [-] (see 4.1)

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

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

with ...   $A_R$ ... Required collector area [m²]
ED ... Energy Demand [kWh]
SC ... System Contribution [kWh/m²]

As THERMOMAX® modules are only available in 2 and 3 m² sizes, the actual collector area A in [m²] has to be chosen accordingly.

- For more precise predictions of the overall performance of the solar system THERMOMAX® offers the SolarMaster® simulation software. Using a statistical method, the calculation of the daily divergent total radiation is based on the combination of theoretical solar radiation data and measured solar radiation data, the collector inclination and the azimuth angle. Integrating the 15 minute calculation intervals over each month simulates the system performance over the year.

## (5.2)    Flow rate

The specific flow rate per tube $V_T$ in [l/(min Tube)] lies in the range of $0.1 \leq V_T \leq 0.25$ [l/(min Tube)]. Some examples are given in Table 3.

| Collector Area [m²] | Flow rate [l/min] |
|---|---|
| 2 | 2.0 – 5.0 |
| 3 | 3.0 – 7.5 |
| 4 | 4.0 – 10.0 |
| 5 | 5.0 – 12.5 |
| 6 | 6.0 – 15.0 |
| 7 | 7.0 – 17.5 |
| 8 | 8.0 – 20.0 |
| 9 | 9.0 – 22.5 |

Table 3

Multiplied with the collector area respectively the number of tubes, where 10 tubes equal 1 m², the system flow rate can be determined as shown in equation 5.3.

$$V_S = V_T \cdot n_T \qquad (5.3)$$

with ... $V_s$ ... System flow rate [l/min]
$V_T$ ... Flow rate per tube [l/(minTube)]
$n_T$ ... Number of tubes [-] (rises in multiples of 10)

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

$$V_S[\frac{m^3}{h}] = V_S[\frac{l}{\min}] \cdot \frac{6}{100} \qquad (5.4)$$

The more tubes that are connected in series, the higher the specific flow rate $V_T$ should be. THERMOMAX<sup>Ⓡ</sup> strongly recommends not to connect more than 90 to 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 in the system on and off. The longer the pipework in the installation, the bigger ΔT should be to avoid toggling of the pump. Through observation and some experience the flow rate can be easily altered after completion of the installation if necessary using a ball valve installed in the pipework or the taco-setter on the pump control unit.

## (5.3)  Pipework

Some recommended pipe sizes are given in Table 4.

| Flow rate [l/min] | Copper pipe size [mm] |
|---|---|
| 2 – 6 @ ν=1m/s | Cu 15 x 1 |
| 7 – 10 @ ν=1m/s | Cu 18 x 1 |
| 12.5 – 17.5 @ ν=1m/s | Cu 22 x 1 |
| 17.5 – 22.5 @ ν=1m/s | Cu 28 x 1.5 |

Table 4

The sizing of the pipe has to be seen under two aspects. First under the aspect of the installation cost, secondly under the aspect of the costs caused by running the system (energy consumption of circulation pump).

As the antifreeze causes approximately 1.3 times higher pressure drop passing through the installation compared with water, the velocity ν in [m/s] of the fluid passing through the system should be 1.0 ≤ ν ≤ 1.25 [m/s]. Equation 5.5 gives the required pipe inside diameter $\emptyset_i$ in [mm].

$$\emptyset_i = 4.6 \cdot \sqrt{\frac{V_S}{\nu}} \qquad (5.5)$$

with ... $\emptyset_i$ ... Pipe inside diameter [mm]
$V_S$ ... System flow rate [l/min]
$\nu$ ... Velocity of fluid [m/s]

The pipe size best matching the calculated inside diameter $\emptyset_i$ has to be chosen. THERMOMAX<sup>Ⓡ</sup> recommends the use of copper pipe but not smaller than 15 mm outside diameter. We do not recommend using plastic pipes in solar installations as high temperatures and the compatibility with the antifreeze can cause failure. The insulation has to be UV stable where exposed to the sunlight and has to be resistant to high temperatures. To prevent high heat losses through the pipe work it is recommended to use insulation with the thickness of at least half the pipe diameter and an U value in [W/(mK)] of U ≤ 0.035 [W/(mK)].

## (5.4)  Circulation 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 the 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 which pump should be used in domestic installations depending on the collector area.

| | | Collector Area [m²] | Number of Tubes |
|---|---|---|---|
| PCU 20-60 | Sys. Kit | 2 - 4 | 20 – 40 |
| | | 5 - 6 | 50 – 60 |
| | PCU 90-240 | 7 - 9 | 70 – 90 (240) |

Table 5

As the flow rate $V_S$ is already determined (see chapter 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 components in the installation connected in series (not parallel). Mainly these are   - Solar Collector,
    - Pipe Work and
    - Heat Exchanger.

The pressure drop of the solar collector $\Delta p_C$ [Pa] can be chosen from Figure 9 as a function of the flow rate $V_S$. As this is for a single collector the value has to be multiplied by the number of collectors n installed in series.
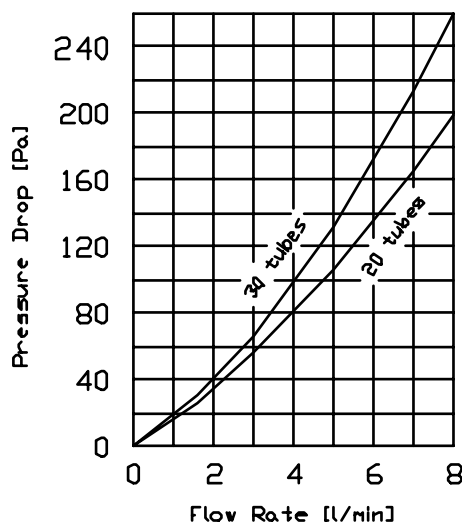


Figure 9

The pressure drop of the pipe work $\Delta p_p$ in [Pa] can be found in standard plumbing tables or in the manufactures information. Please remember to multiply the values in the tables given with 1.3 to take into account that antifreeze and not water is flowing through the system.

As for the pipe work the pressure drop for the heat-exchanger $\Delta p_{he}$ in [Pa] can be found in the manufacturers information. The same as for the pipe work applies in regard to the values given.

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

$$\Delta p_S = \frac{n_{20} \cdot \Delta p_{C20} + n_{30} \cdot \Delta p_{C30} + \Delta p_p + \Delta p_{he}}{10000}$$

(5.6)

with ...   $\Delta p_S$ ... System pressure drop [m]
  $n_{20}$ ... 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]
  10000 ... [Pa] to [m]

Figure 10 shows the relationship between the flow rate and the head pressure of the pump used in the pump control unit PCU 20-60.
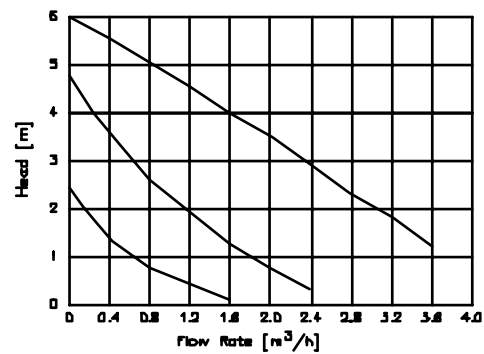


Figure 10

For installations larger than 60 tubes a pump control unit with a bigger pump, the PCU 90-240 PCU, should be chosen. The pump diagram is shown in Figure 11.

In the System Kit / Active Pack a pump with 5 m head pressure is used as shown in Figure 12.
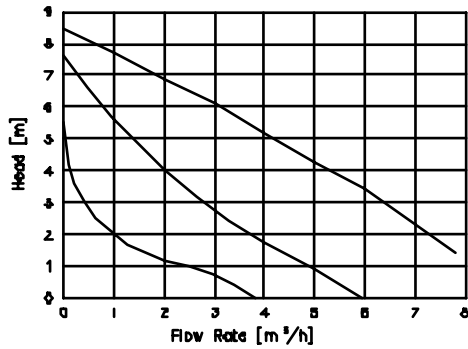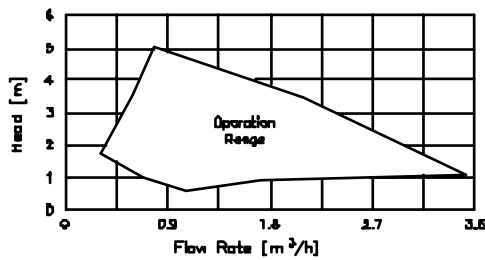
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Figure 11



Figure 12

## (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] | Tot. 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 |

Table 6

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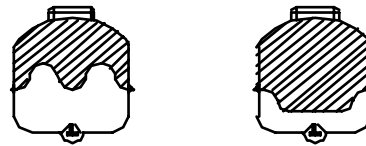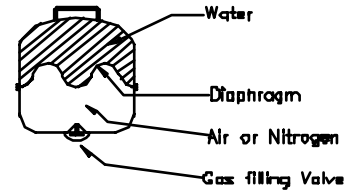


Figure 13

The vessel comprises of two halves. One half connects directly to the water system. The second, separated by a special diaphragm, contains nitrogen or 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 contents of the manifold. The following equations (5.7 − 5.11) determine the appropriate size of the expansion vessel.

The overall volume increase of the water in the system due to temperature increase $V_{\Delta\vartheta}$ in [l] is a function of the overall solar system content $V_{sys}$ in [l] and the expansion coefficient $\beta$ (water @ 80°C $\beta$=0.029, antifreeze @ 80°C $\beta$=0.07).

$$V_{\Delta\vartheta} = V_{sys} \cdot \beta \quad (5.7)$$

The influence of the opening pressure of the pressure relief valve $p_{rv}$ in [bar] and the static height h in [m] is taken into account in equation 5.8

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

with ... $p_{max}$ ... Maximum system operating pressure [bar]

$p_{rv}$ ... Opening pressure of relief valve [bar]

$$p_d = p_h + 0.1 \cdot h \qquad (5.9)$$

with ... $p_d$ ... set pressure for diaphragm [bar]
$p_h$ ... Pressure in highest point of system (e.g. 0.5 bar) [bar]
0.1 ... [m] to [bar]
h ... static height [m]

To ensure a sufficient volume of water in the system at all times a minimum volume $V_c$ in [l] must be present in the expansion vessel in the cold condition. With $V_c$ and the values calculated before the nominal size of the expansion vessel $V_n$ in [l] can be calculated with equations 5.10 and 5.11.

$$V_c = V_{sys} \cdot 0.015 \geq 1 [l] \qquad (5.10)$$

with ... $V_c$ ... Water volume in expansion vessel in cold system condition [l] (minimum 1 litre)
$V_{sys}$ ... Overall solar system content [l]

$$V_n = \frac{(V_c + V_{\Delta\vartheta} + n_{col} \cdot V_{col}) \cdot (p_{max} + 1)}{p_{max} - p_d} \qquad (5.11)$$

with ... $V_n$ ... Nominal volume of expansion vessel [l]
$V_c$ ... Water volume in expansion vessel in cold system condition [l]
$V_{\Delta\vartheta}$ ... Volume increase due to temp. increase [l]
$n_{col}$ ... Number of manifolds installed [-]
$V_{col}$ ... Water volume of single manifold [l]
$p_{max}$ ... Maximum system operating pressure [bar]
$p_d$ ... Set pressure for diaphragm [bar]

Having calculated the nominal size of the expansion vessel $V_n$ the closest available vessel size will be chosen.

# (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 manifold 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.
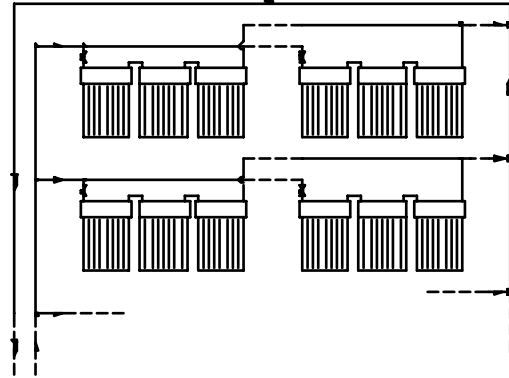


Figure 14

## (5.6.2)  Overall System Design

**Functional description of parts**

The following is a brief description of main parts used in the system.

**Pump** is used to circulate water from the 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 in solar circuit from the tank to the collector when the tank temperature may be greater than the collector temperature (e.g. at night). Be sure to install correctly.
**Air vent** is fitted at the highest point of the system to facilitate removal of air pockets from the system. Air vents should be open when filling the system. Automatic airvents 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 pressurising of the system (max. 5 bar).
**Filling Loop** consists of a flexible hose and stop valve and connects the water mains supply to the hose connector and filling valve.
**Expansion Vessel** is used to contain increased water volume in the system due

to rise in temperature, and hence increased pressure, of water.

**Flush and Drain** assembly is used to flush the system before filling with anti-freeze and to drain it, if necessary.

## 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.



| | |
|---|---|
| 1 | Manual Air Vent |
| 2 | Automatic Air Vent with Valve |
| 3 | Hot Water Tank |
| 4 | Coil (Back-Up System) |
| 5 | Coil (Solar System) |
| 6 | Flush and Drain Assy. |
| 7 | Flow-Meter (optional) |
| 8 | Pump |
| 9 | Non-Return Valve |
| 10 | Expansion Vessel |
| 11 | Valve |
| 12 | Filling Loop |
| 13 | Pressure Relief Valve and Gauge |
| 14 | Non-Return Valve [alternative location] |
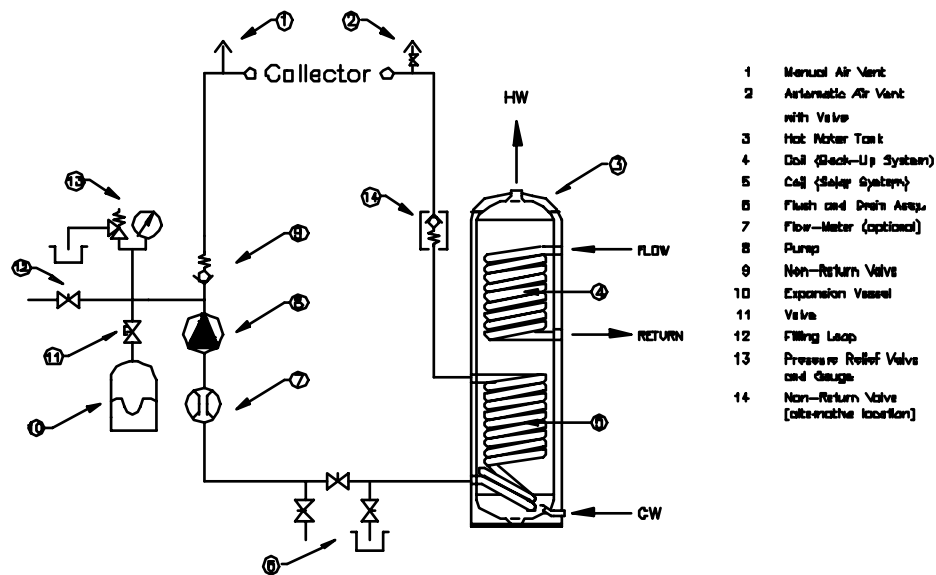
Figure 15

## Active System with Immersion Heater

Similar to the system above an auxiliary electric heater compensates for periods of prolonged cloud or rainfall when the collector cannot operate at full potential (Figure 16).



| | |
|---|---|
| 1 | Manual Air Vent |
| 2 | Automatic Air Vent with Valve |
| 3 | Hot Water Tank |
| 4 | Immersion Heater |
| 5 | Coil (Solar System) |
| 6 | Flush and Drain Assy. |
| 7 | Flow-Meter |
| 8 | Pump |
| 9 | Non-Return Valve |
| 10 | Expansion Vessel |
| 11 | Valve |
| 12 | Filling Loop |
| 13 | Pressure Relief Valve and Gauge |
| 14 | Non-Return Valve [alternative location] |

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 where a long distance is between the collector and the hot water storage tank.
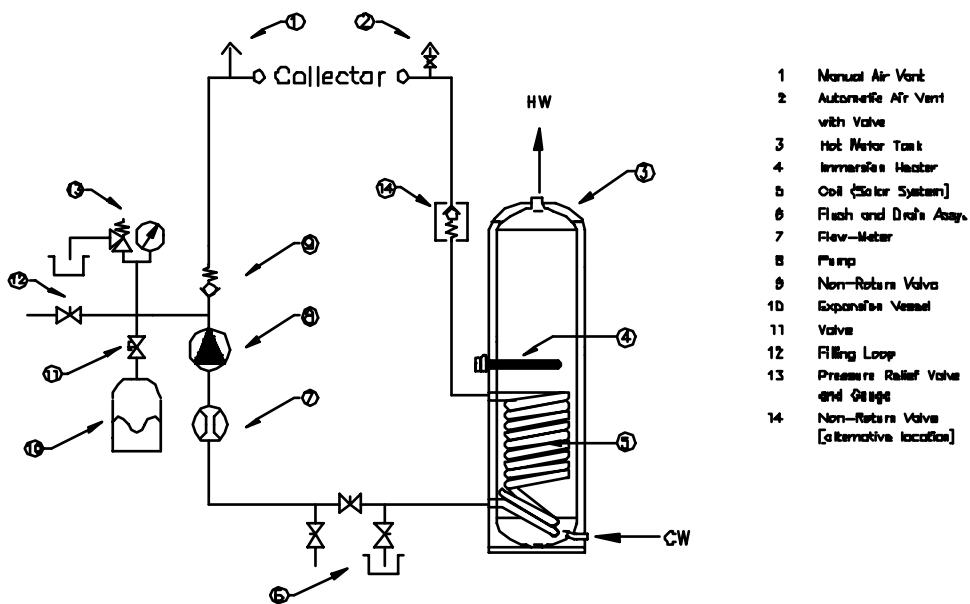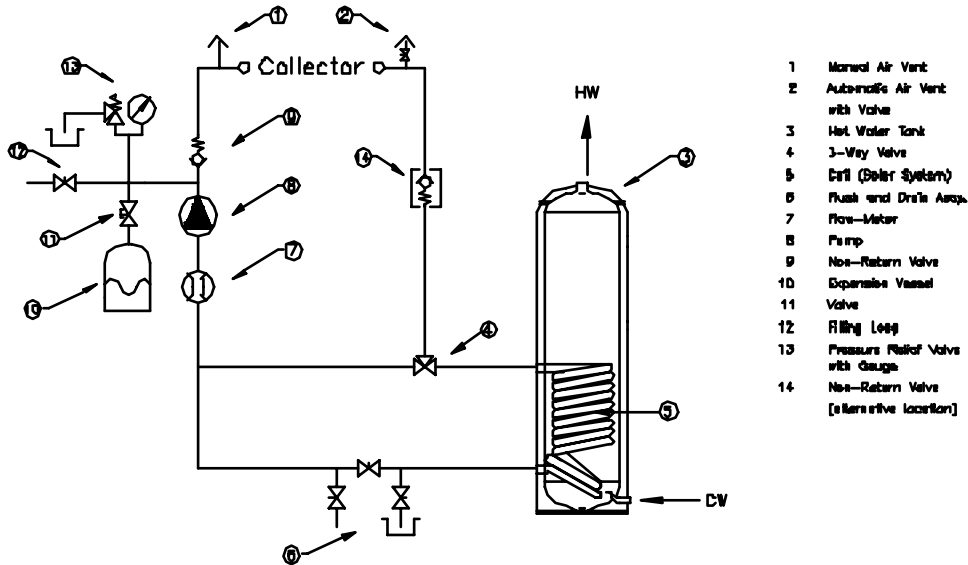


Figure 17

### Multiple Tank Installation - Series

For large installations two or more tanks may be connected to the solar system in series (preheat).

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 to the collector. If water leaving Tank 2 is above a set temperature it is passed to Tank 3 (second preheat tank). This process may be repeated for a number of preheat tanks (Figure 18).



Figure 18

Similar to the previous system the series tank installations can be equipped with a short circuit also. Applications are hotels, hospitals and multi-storey buildings where the distance between the collector and the tank is rather long.

As a cascade function the tanks can be loaded via separate pumps according to the set temperatures as shown in the Figure 19.
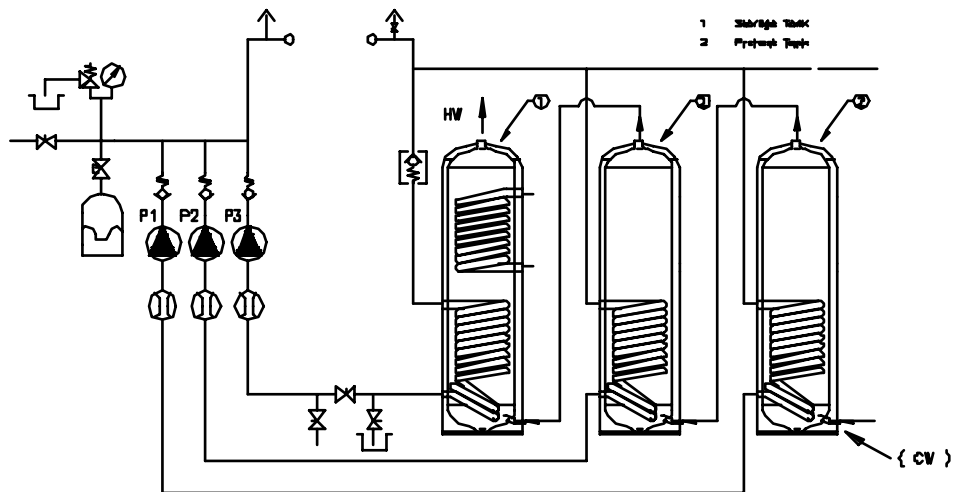
Figure 19

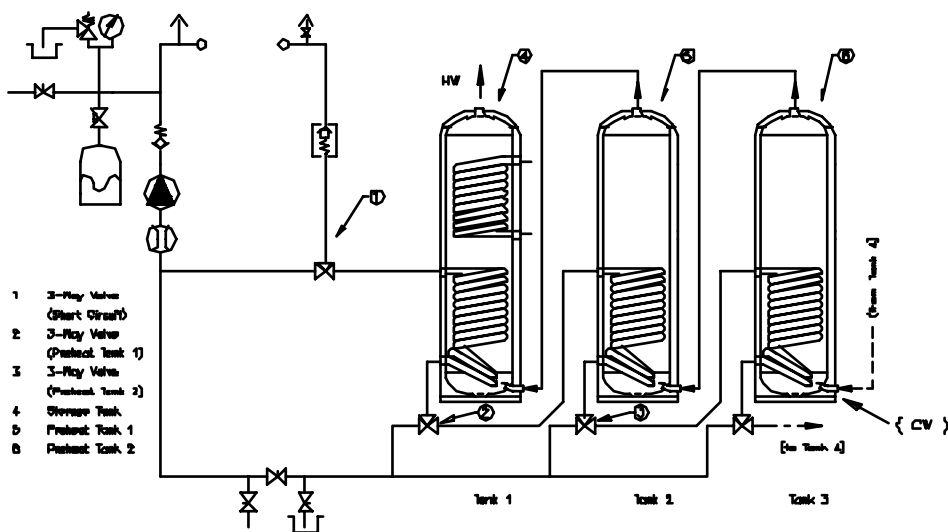## Multiple Tank Installation - Parallel

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 directed via a 3-way valve, controlled by a temperature sensor at Tank 1 to Tank 2. If the water temperature in Tank 1 falls below a set temperature then the water from the collector is redirected through its heating coil.
Once Tank 2 has reached a set temperature the water from the collector is diverted to a third tank and so on. This process can be repeated for any number of tanks. This system is applicable to hospitals, hotels and multi-storey buildings requiring large amounts of hot water.
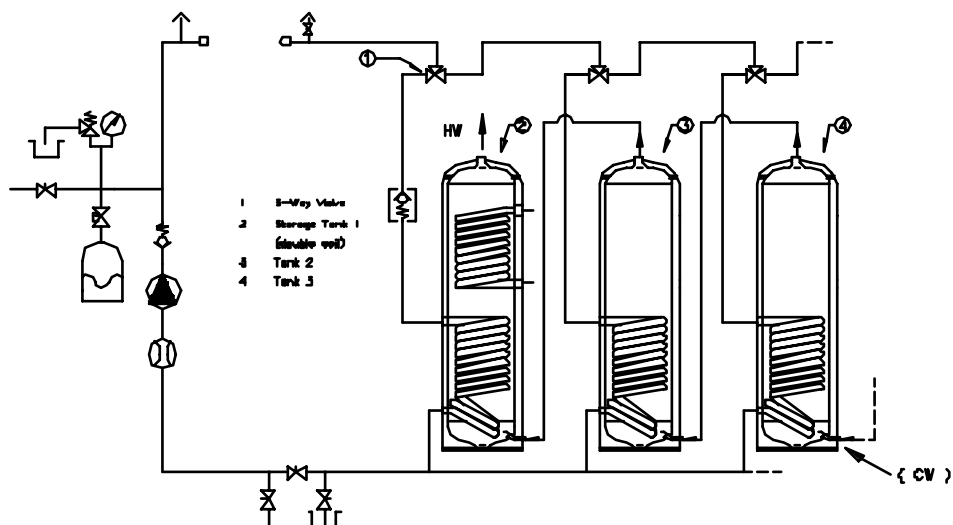
Figure 20

**Swimming Pool**

To incorporate a swimming pool into the system it is essential that a suitable heat exchanger is used between the pool water and the circulating water through the manifold of the solar system (Figure 21).
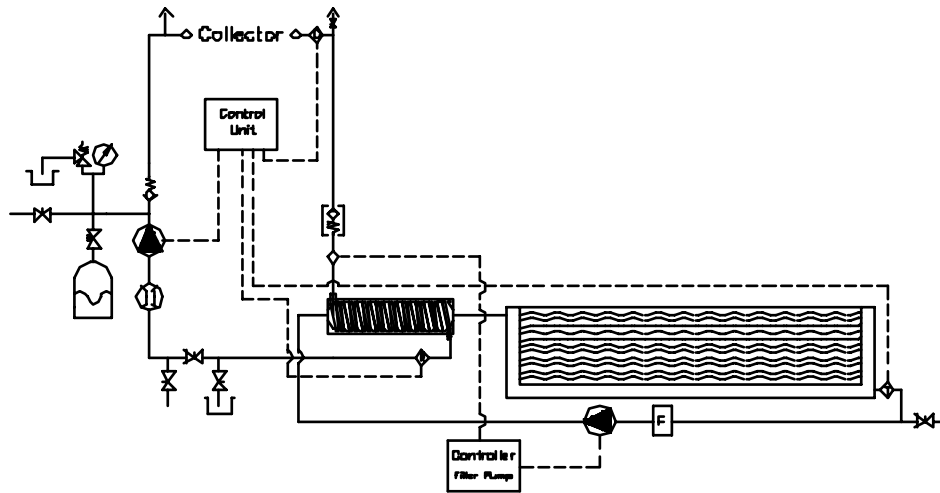


Figure 21

Generally, wound coil heat exchangers should be used as they offer a big exchange area with a low pressure drop on the swimming pool side. This allows a high volume of pool water to be passed through the heat exchanger.
It is necessary that the filtration pump is always ON when the solar collector pump is running to avoid overheating of heat-exchanger and pipework parts on the secondary side of the system.

# (6.0) How to install a THERMOMAX® System

This chapter explains the installation procedures for the THERMOMAX® Evacuated Solar Collector System with the various roof fixing kits.

## (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 THERMOMAX® Solar Energy Collector assembly.

Locate the solar collector system so that the tubes receive maximum sunshine through the day with no or minimum shading. NOTE: The coated surface of the absorber must face uppermost (±30°) and as south facing as possible (Azimuth angle).

The solar collector system can, be mounted at any suitable angle between 25° and almost vertical position (Inclination Angle). The recommended angle is the same as the geographical latitude of the collector location.

In areas where local water is known to be hard or aggressive, a heat exchanger must be used and the use of a water softener is recommended, otherwise regular cleaning of the system will be required.

In areas where the chloride ion concentration is greater than 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 your local water authorities.

**CAUTIONARY NOTES:**
- Make sure sufficient space is left between the manifold and roof apex for ease of working on pipework within the loft span.
- Wear gloves and safety goggles when working with glass tubes.
- Do not use sharp objects to open the covers or the box as this may scratch or damage the glass tube.
- Do not remove the tubes from packaging until ready to assemble.

- Connect the manifold, all the pipework and the pump first before installing the tubes.

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

**Note that when installing the collector and pipe work it is important that all local authority regulations, relevant technical and safety standards are adhered to.**

## (6.2) Manifold Connections

### Series Connections

The manifold flow and return connections are Ø22mm and are designed for use with compression fittings. The recommended manifold connections for installations are shown in Figure 22. Please remember as explained in chapter 5.6.1 that the maximum number of tubes connected in series should not exceed 90 to 100.
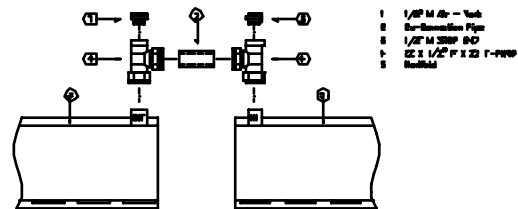


Figure 22.

### Installation of Compression Joints

Compression fittings are renowned for reliability and ease of assembly, as this step-by-step fixing guide amply demonstrates. To make the joint either of two methods may be followed.

- The pipe can be firmly inserted into the compression fitting without removing the cap and the ring. Care should be taken to ensure 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 on to the pipe in logical sequence and the tube fully inserted into the compression fitting.

In both cases, tightening of the cap-nut is effected by hand as far as possible, followed by appropriate turning of the same with a suitable spanner while a second spanner is used to hold the fitting in position.

## (6.3)    MS-System

The following procedure explains the installation of a THERMOMAX<sup>®</sup> Solar System using the stainless steel perforated bands (MS-System).

1.  Select a suitable position for the collector. It should face due south. Recommended angle of tilt is the same as your geographical latitude. The distances between the perforated bands (Pt. No. B0290) are as shown.
2.  Remove tiles.
3.  Secure LOWER band to rafter using the coach screws (Pt. No. A0168) and the plain washers (Pt. No. A0170). Pre-drill holes for screws to avoid splitting of rafter.
4.  Replace tiles.
5.  Locate and secure UPPER band (Pt. No. B0290) to top end of side rail (Pt. No. B0008) using the lower hole. Note: Use the nylon washer (Pt. No. A2158) to hold the bolt (Pt. No. A0175) and the formed washer (Pt. No. A0173) in place in the top hole for later securing of the manifold to the side rails.
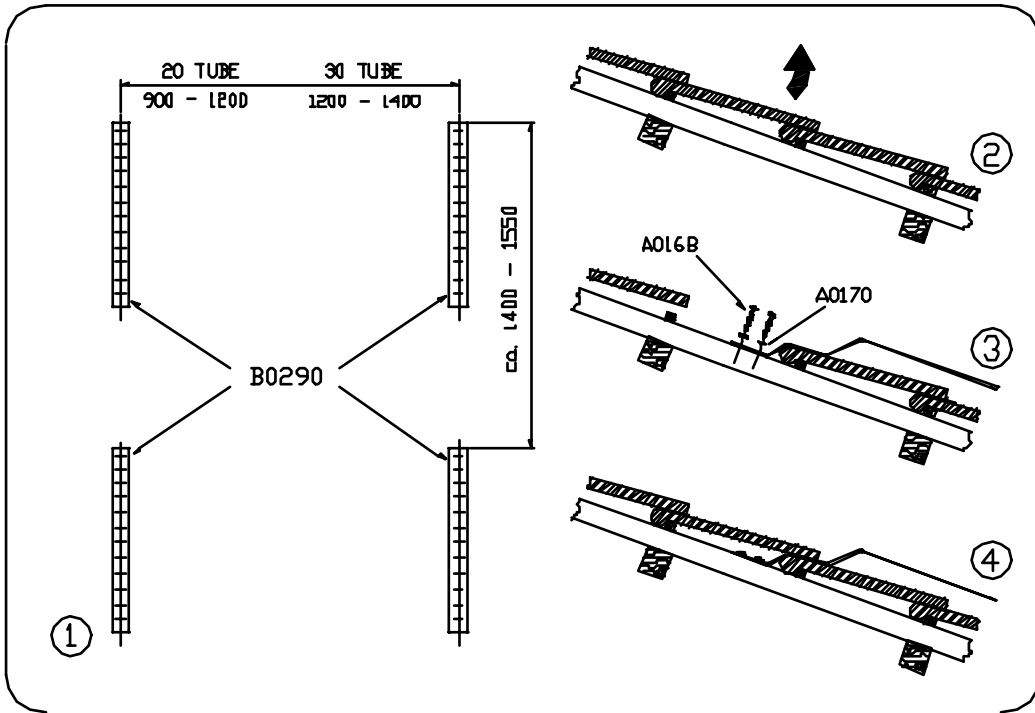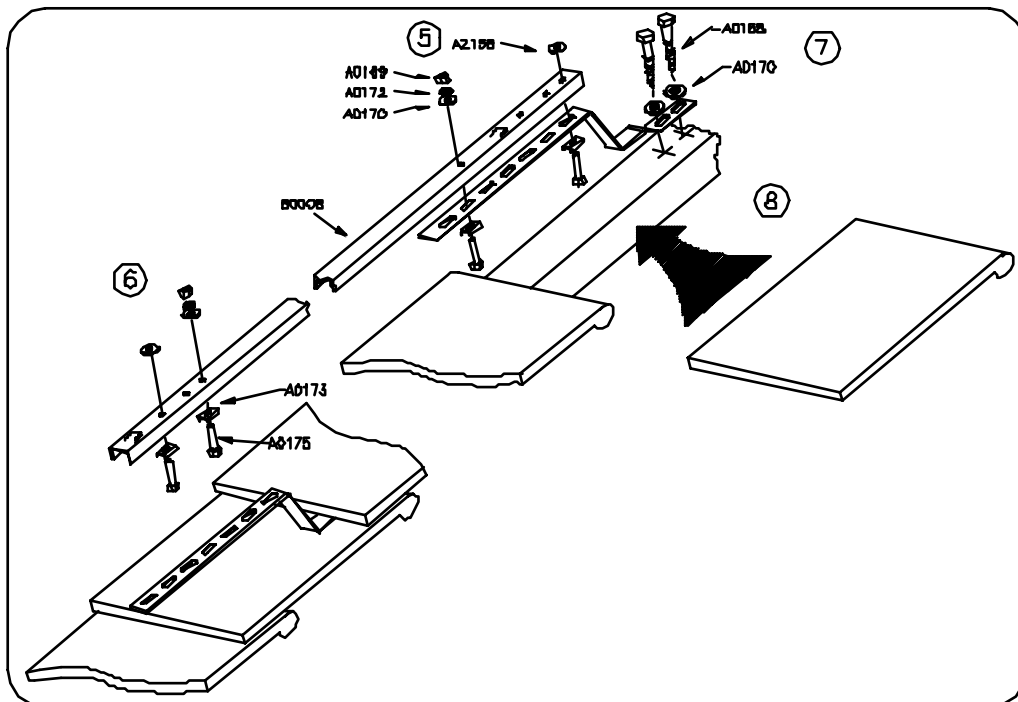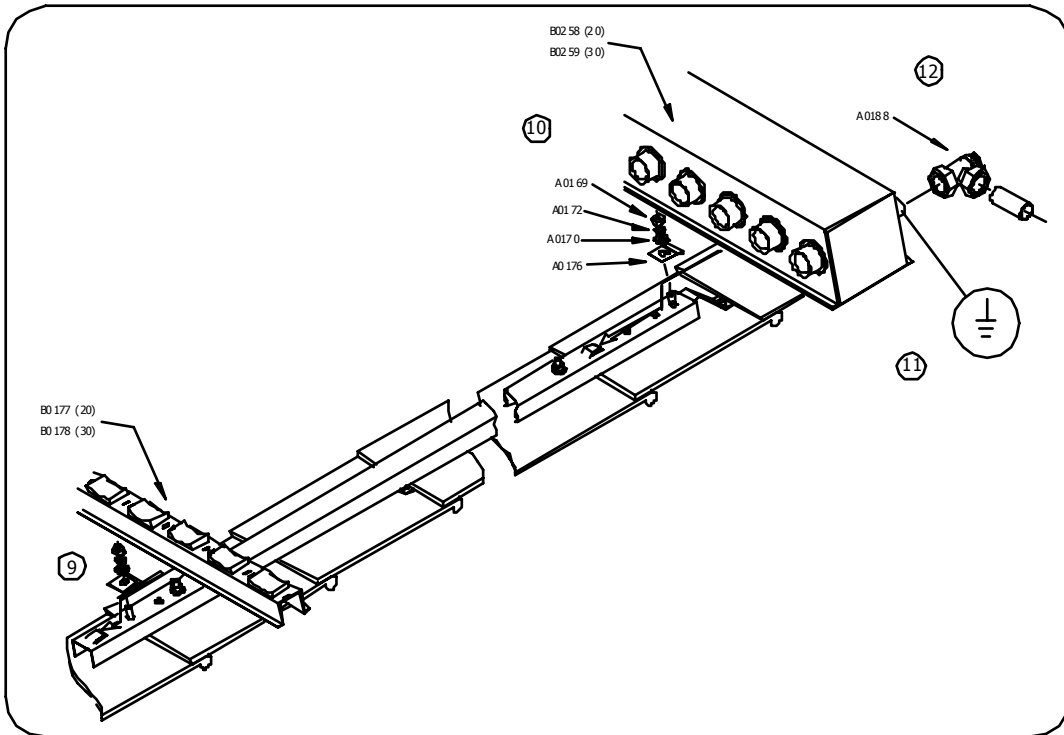6.  Locate and secure bottom end of side rail to LOWER band using the indicated hole of side rail. Note: Use the nylon washer to hold the bolt and the formed washer in place in the bottom hole for the later securing of the bottom support to the side rails.
7.  Secure UPPER band (mounted to side rail) using coach screws and plain washers to rafter.
8.  Tighten all nuts and bolts and replace remaining tiles.
9.  Locate bottom support (Pt. No. B0177 (20) or Pt. No. B0178 (30)) to bottom end of side rail. Remove and discard nylon washer before placing plain washer (Pt. No. A0170), spring washer (Pt. No. A0172), clamping plate washer (Pt. No. A0176), and nut (Pt. No. A0169). The distance from the side rail to the bottom support ends should be equal.
10. Locate manifold (Pt. No. B0258 (20) or Pt. No. B0259 (30)) to top end of side rails. Remove and discard nylon washer before placing plain washer, spring washer, clamping plate washer, and nut. The distance from the side rails to the manifold ends should be the same as those for the bottom support.
11. Earth inlet or outlet pipe of manifold in accordance with local regulations. The same applies to the framework.
12. Locate manifold fittings (Pt. No. A0188) to the manifold inlet and outlet pipe.
    When using an automatic air-vent note that it must be installed vertically. CHECK ALL plumbing and pipework between collector and hot water storage tank.
13. - Unpack first tube (Pt. No. B2100 (TMO 600 S) or Pt. No. B2101 (TMO 500 S)).
    - Rest bottom end of tube on appropriate rubber pad on bottom support.
      ENSURE COATED SURFACE OF ABSORBER FACES UPPERMOST.
    - Insert condenser into manifold.
14. - Tighten retaining cap to manifold by hand.
    - Make sure coated surface still faces uppermost.
15. - Locate bottom support clip (Pt. No. A0921).
    - Tighten all retaining caps approximately ¼ to ½ turn using a suitable spanner. DO NOT OVER TIGHTEN.
    - Repeat steps 13, 14 and 15 for all other tubes.

Installation steps 1 - 4

Installation steps 5 - 8

B0258 (20)
B0259 (30)

12

A0188

10

A0169
A0172
A0170
A0176

11

B0177 (20)
B0178 (30)

9

Installation steps 9 - 12



14

E2100 (TMO 600 S)
E2101 (TMO 500 S)

13

A0921

15

Installation steps 13 - 15

## (6.4)    KS-System

The following procedure explains the installation of a THERMOMAX<sup>®</sup> Solar System using the stainless steel K-Type roof brackets.

1.  Select a suitable position for the collector. It should face due south. Recommended angle of tilt is the same as your geographical latitude. The distances between the K-Type roof brackets are as shown (Pt. No. B0249).
2.  Remove tiles.
3.  Secure LOWER leg of bracket to rafter using the coach screws (Pt. No. A0168) and the plain washers (Pt. No. A0170). Pre-drill holes for screws to avoid splitting of rafter.
4.  Replace bottom tile.
    Locate and secure UPPER leg of bracket to rafter.
5.  Replace remaining tiles.
6.  Locate and secure side rail (Pt. No. B0008) to roof brackets using the indicated holes in the side rail. The holes used in the roof brackets can vary. Note: Use the nylon washer (Pt. No. A2158) to hold the bolt (Pt. No. A0175) and the formed washer (Pt. No. A0173) in place in the hole for the later securing of the manifold to the side rails respectively the bottom support.
    Tighten all nuts and bolts.
7.  Locate bottom support (Pt. No. B0177 (20) or Pt. No. B0178 (30)) to bottom end of side rail. Remove and discard nylon washer before placing plain washer (Pt. No. A0170), spring washer (Pt. No. A0172), clamping plate washer (Pt. No. A0176), and nut (Pt. No. A0169). The distance from the side rail to the bottom support ends should be equal.
8.  Locate manifold (Pt. No. B0258 (20) or Pt. No. B0259 (30)) to top end of side rails. Remove and discard nylon washer before placing plain washer, spring washer, clamping plate washer, and nut. The distance from the side rails to the manifold ends should be the same as those for the bottom support.
9.  Earth inlet or outlet pipe of manifold in accordance with local regulations. The same applies to the framework.
10. Locate manifold fittings (Pt. No. A0188) to the manifold inlet and outlet pipe.
    When using an automatic air-vent note that it must be installed vertically. CHECK ALL plumbing and pipework between collector and hot water storage tank.
11. - Unpack first tube (Pt. No. B2100 (TMO 600 S) or Pt. No. B2101 (TMO 500 S)).
    - Rest bottom end of tube on appropriate rubber pad on bottom support.
      ENSURE COATED SURFACE OF ABSORBER FACES UPPERMOST.
    - Insert condenser into manifold.
12. - Tighten retaining cap to manifold by hand.
    - Make sure coated surface still faces uppermost.
13. - Locate bottom support clip (Pt. No. A0921).
    - Tighten all retaining caps approximately ¼ to ½ turn using a suitable spanner. DO NOT OVER TIGHTEN.
    - Repeat steps 11, 12 and 13 for all other tubes.

20 Tube    30 Tube
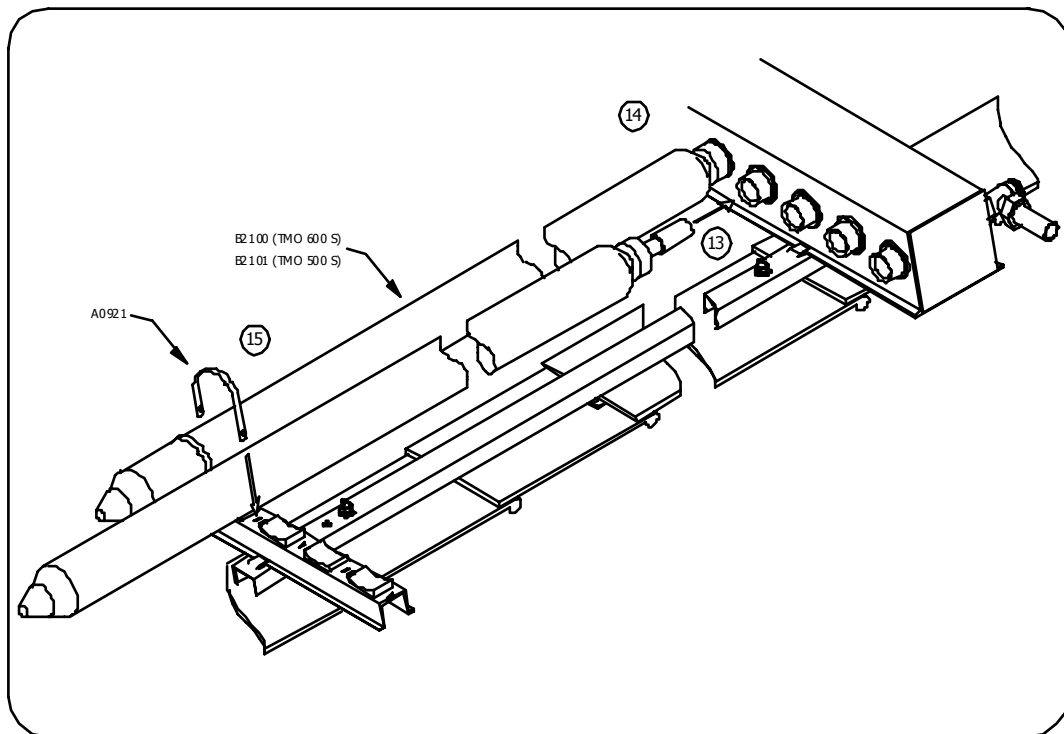900 - 1200    1200 - 1400

app. 1400 - 1500

B0249

① ② ③ ④ ⑤

A0168
A0170

Installation steps 1 - 5

⑥

A2158
A0169
A0172
A0170

B0008

A0173
A0175

Installation step 6

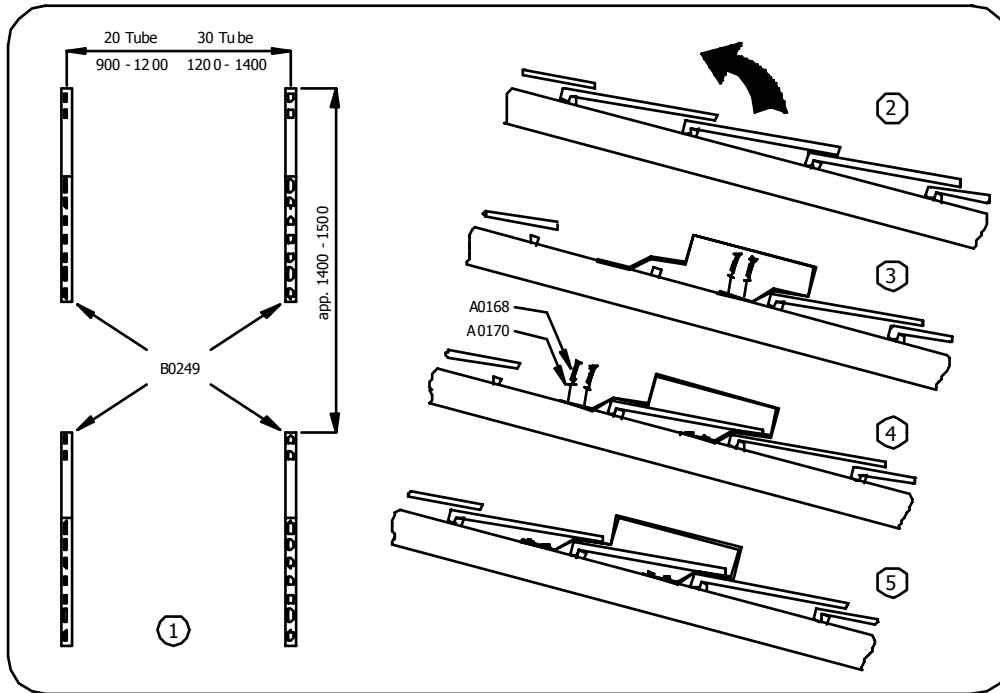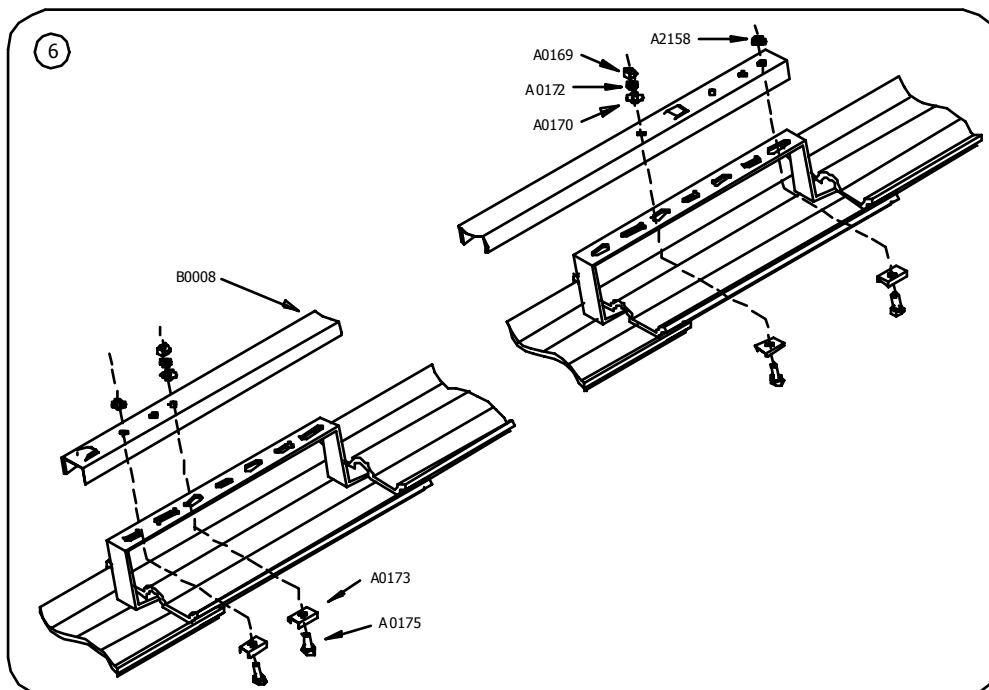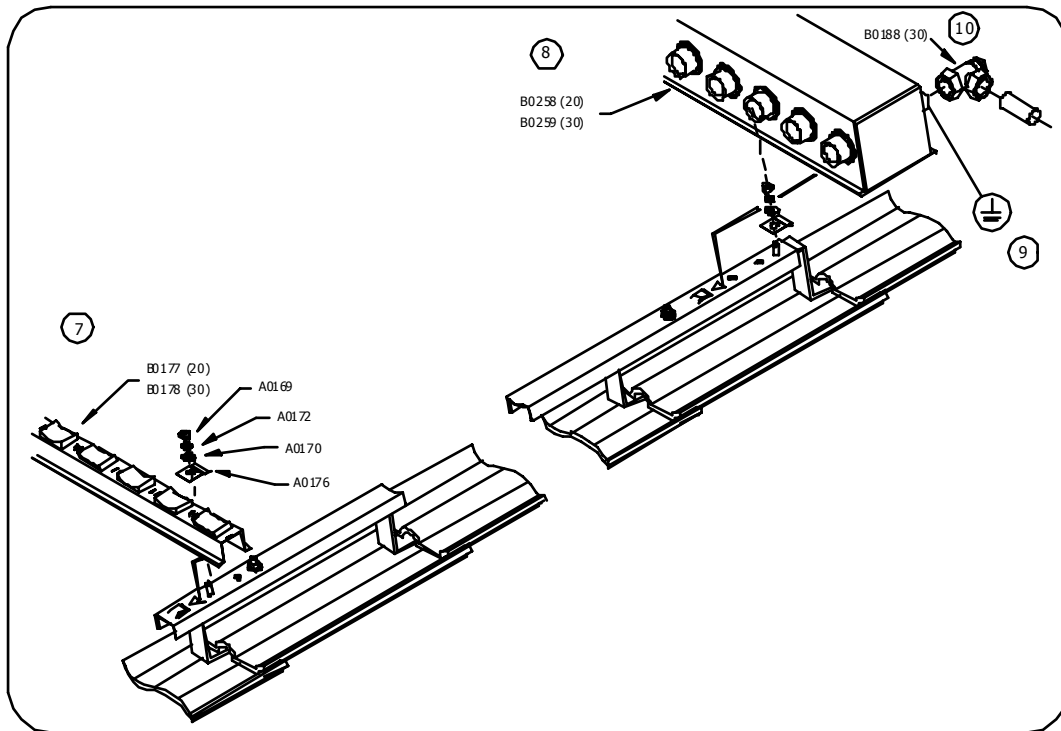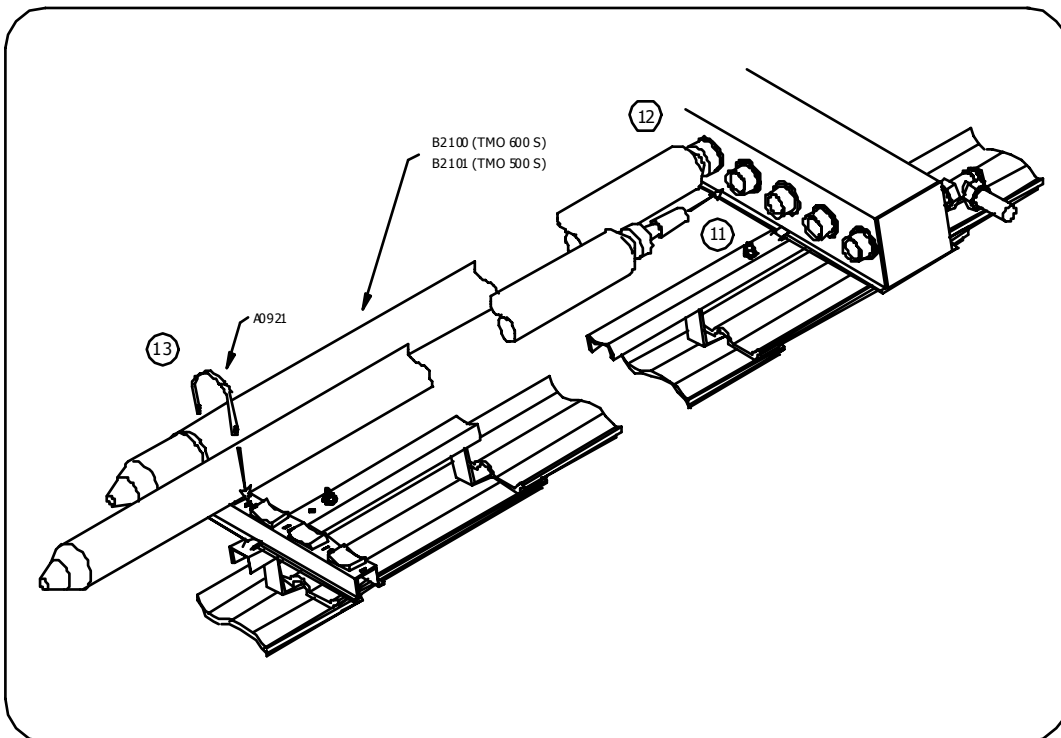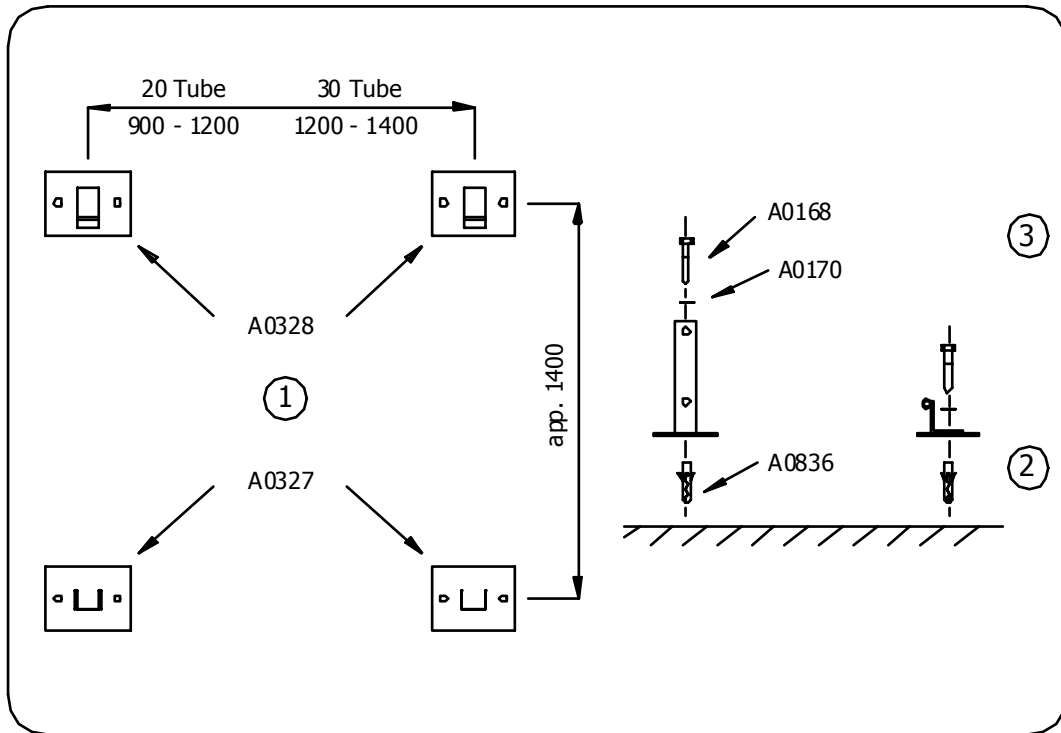Installations steps 7 - 10
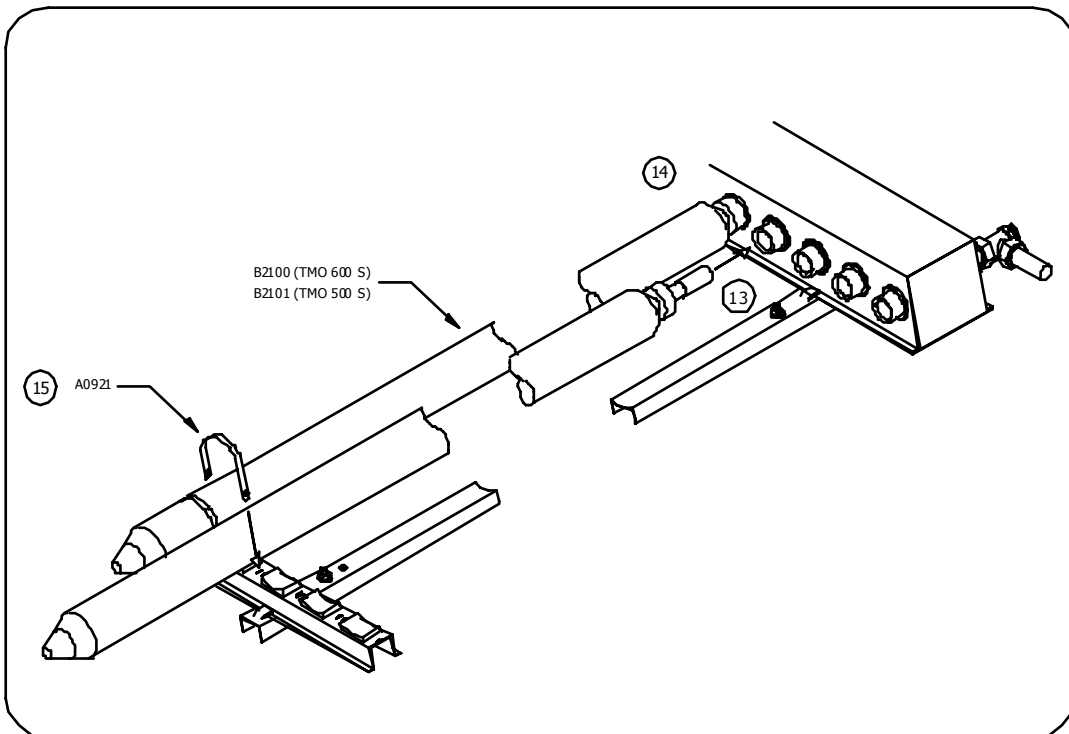


Installations steps 11 - 13

## (6.5)    FS-System

The following procedure explains the installation of a THERMOMAX<sup>®</sup> Solar System using the stainless steel A-Frame for ground and flat-roof mounting.
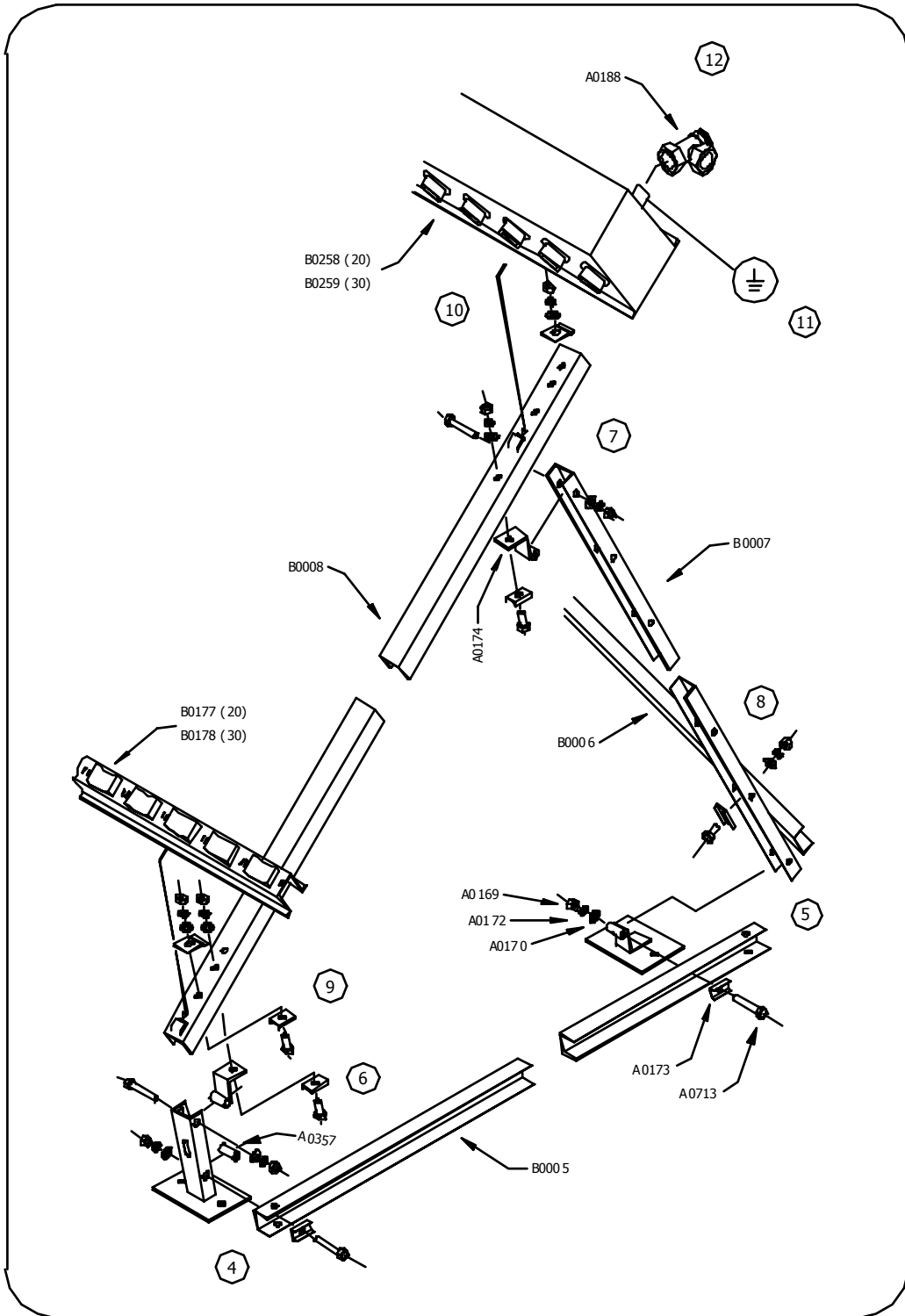
1.  Select a suitable position for the collector. It should face due south. Recommended angle of tilt is the same as your geographical latitude. The distances between the front brackets (Pt. No. A0327) and the rear brackets (Pt. No. A0328) are as shown.
2.  Drill Ø10mm holes for rawl plugs (Pt. No. A0836) and push plugs into holes level with mounting surface.
3.  Locate front and rear brackets in appropriate positions and secure with coach screws (Pt. No. A0168) and plain washers (Pt. No. A0170).
4.  Locate side brace (Pt. No. B0005) to front bracket securing it using bolt (Pt. No. A0713), formed washer (Pt. No. A0173), spacer (Pt. No. A0357), plain washer (Pt. No. A0170), spring washer (Pt. No. A0172) and nut (Pt. No. A0169).
5.  Before securing the side brace to the rear bracket the rear strut (Pt. No. B0007) has to be fitted over the hinge of the bracket. The side brace can also be fitted under various angles to the rear strut depending on the required tilt angle of the system.
6.  Locate and secure bottom end of side rail (Pt. No. B0008) to front bracket using the indicated hole in the side rail.
7.  Use hinge (Pt. No. A0174) to secure top end of side rail to rear strut.
8.  After assembling both side rails reinforce frame by using universal brace (Pt. No. B0006). Secure to both rear struts by diagonal connection (as indicated).
9.  Locate bottom support (Pt. No. B0177 (20) or Pt. No. B0178 (30)) to bottom end of side rail. Remove and discard nylon washer before placing plain washer, spring washer, clamping plate washer (Pt. No. A0176), and nut. The distance from the side rail to the bottom support ends should be equal.
    Tighten all nuts and bolts.
10. Locate manifold (Pt. No. B0258 (20) or Pt. No. B0259 (30)) to top end of side rails. Remove and discard nylon washer before placing plain washer, spring washer, clamping plate washer, and nut. The distance from the side rails to the manifold ends should be the same as those for the bottom support.
11. Earth inlet or outlet pipe of manifold in accordance with local regulations. The same applies to the framework.
12. Locate manifold fittings (Pt. No. A0188) to the manifold inlet and outlet pipe.
    When using an automatic air-vent note that it must be installed vertically. CHECK ALL plumbing and pipework between collector and hot water storage tank.
13. - Unpack first tube (Pt. No. B2100 (TMO 600 S) or Pt. No. B2101 (TMO 500 S)).
    - Rest bottom end of tube on appropriate rubber pad on bottom support.
      ENSURE COATED SURFACE OF ABSORBER FACES UPPERMOST.
    - Insert condenser into manifold.
14. - Tighten retaining cap to manifold by hand.
    - Make sure coated surface still faces uppermost.
15. - Locate bottom support clip (Pt. No. A0921).
    - Tighten all retaining caps approximately ¼ to ½ turn using a suitable spanner. DO NOT OVER TIGHTEN.
    - Repeat steps 13, 14 and 15 for all other tubes.

20 Tube     30 Tube
900 - 1200    1200 - 1400

A0328

A0327

app. 1400

A0168

A0170

A0836

① ② ③

Installation steps 1 - 3

B2100 (TMO 600 S)
B2101 (TMO 500 S)

A0921

⑭ ⑬ ⑮

Installation steps 13 - 15

A0188

12

B0258 (20)
B0259 (30)

10

11

7

B0008

B0007

A0174

B0177 (20)
B0178 (30)

8

B0006

A0169
A0172
A0170

5

9

A0173
A0713

6

A0357

B0005

4

Installation steps 4 - 12

## (6.6)      Alternative Methods

It is possible to secure the side rails to rafter or tiles that are nailed in and cannot be removed using either perforated bands (5.3) or brackets (5.4) a noggin can be installed. A noggin is a beam secured between two rafters.
- Coach screws to noggin or rafter: This method is used only if at least 50mm (2″) of screw thread can be secured into noggin or rafter.
- Stainless steel threaded rod: This method is used if the tile depth or uneven roof prevents use of coach screws, or if collector is to be secured directly to wall.

For further explanation see also Figure 5 chapter 3.3.1.

## (6.7)      Commissioning

Before filling the system with the antifreeze and bringing it up to it's operating pressure the following steps should be carried out.

1. Check all joints have been soldered and all compression joints have been tightened. Open all valves in the system (pump ball valves, check valves, etc.).
2. Make temporary hose connection between mains supply and flush and drain assembly. Close middle valve of assembly and flush system thoroughly via the two other valves to remove all dirt and solder residues.
3. Open the middle valve of the flush and drain assembly, drain the system and close the inlet and outlet valve of the flush and drain assembly. Recheck all joints and connections for leaks.
4. Use a hand pump or a pumped garden spray bottle to fill the required amount of antifreeze/inhibitor into the system through the filling loop. The amount of antifreeze/inhibitor depends on the location of the system and the overall system volume (ratio antifreeze/water = frost protection).
5. Connect hose to water mains supply and fill system to its operating pressure.
6. Open all air-vents and run circulation pump on manual mode. Make sure no antifreeze/inhibitor will be drained through opened air-vents.
   It may be necessary to top up the system pressure in the first few days of operation as dissolved air in the antifreeze/inhibitor is expelled through the automatic air-vent.
7. Adjust system flow rate to the right value. Begin with speed level 1 of circulation pump with fully opened flow-meter and adapt speed level and flow-meter (if used) settings accordingly.
8. Adapt controller settings according to system properties as described in the controller manual.

## (7.0)    How to maintain a Thermomax® System

### (7.1)    Periodic Checks

- Ensure that no physical damage has occurred to the tubes and remove any debris that may have accumulated.
- Check the flow and return pipework between collector and storage tank. Check all connections for leaks and ensure all components are operating correctly.
- Check that the system pressure is maintained at the 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 system as some air will come out of the system solution during the course of the year.
- Check the pressure to see if the set value is still maintained. If top up is necessary connect hose to water mains, fill hose with water to avoid introduction of air into system. Connect hose to filling loop, open valve very slowly until pressure is increased to set value.
- To check antifreeze/inhibitor concentration, draw off a small sample at the drain cock and place in the freezer compartment. Remove when frozen then measure temperature at "slush" stage i.e. when ice and liquid are both present. Temperature should be the same or lower than the minimum expected for the locality.

### (7.3)    Five Yearly Checks

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

# (8.0)    Trouble Shooting

| Problem | Cause | Action |
|---|---|---|
| An 'F' reading on controller LCD display | 1. Loose connections on sensor leads<br>2. Faulty sensor<br>3. Collector sensor at maximum | 1. Check sensor wires for connection<br>2. Replace sensor<br>3. No action required |
| Pump will not run | 1. Mains/pump wiring faulty<br>2. Pump rotor damaged<br>3. The pump control selector P is in manual 'OFF' position<br>4. TC incorrectly set<br>5. TC and ΔT not satisfied | 1. Check wiring at mains/pump<br>2. See pump manufacturers instructions<br>3. Check SMT unit and return pump control P to automatic mode 'AUT'<br>4. Reset to 25°C<br>5. No action required |
| Pump runs continuously | 1. Collector temperature is below TF temperature<br>2. Loose connection or faulty sensor on the collector<br>3. Collector temperature at maximum | 1. No action required TF flashes<br>2. Check connections and sensor wires<br>3. No action required |
| No circulation in system | 1. Pump isolating valves closed<br>2. Automatic air-vent closed<br>3. Air lock at pressure relief valve<br>4. Air lock in the system<br>5. Non-return valve jammed<br>6. Pump is not running<br>7. System in stagnation | 1. Open valves<br>2. Open aut. air-vent and check condition – replace if necessary<br>3. Twist cap at pressure relief valve and vent air<br>4. Check all pipework rises on return side, falls on flow side – clear manual vents<br>5. Free valve or replace<br>6. See above<br>7. Wait until system reaches normal operating conditions |
| Pressure drops in system | 1. Leak at manifold<br>2. Leak in system<br>3. Drain/filling valve not closed<br>4. Aut. air-vent passing water<br>5. Faulty pressure relief valve<br>6. Damaged expansion vessel causes pressure fluctuation and relief valve to open | 1. Check collars on all tubes for leaks tighten if necessary<br>2. Check all joints<br>3. Close fully<br>4. Clean or replace if necessary<br>5. Replace<br>6. Replace |
| Overheating | 1. Pump does not run<br>2. Prolonged period of low hot water consumption | 1. See above<br>2. Divert heat to heat sink |
| Performance loss | 1. Broken tubes<br>2. Damaged insulation<br>3. Build up of lime stone around heat exchanger tube condenser | 1. Replace broken tubes (because of diode function of tube replacement does not have to be done immediately)<br>2. Replace damaged parts<br>3. Drain and clean system thoroughly |

# (9.0)    Appendix

## (9.1)    Products and Spare Parts

**Products**

| | Description | Product Number |
|---|---|---|
| **Tubes** | TMO 500 S (Box of 10) | C0207 |
| | TMO 600 S (Box of 10) | C0206 |
| **Mani-folds** | 20 Manifold + MS Roof Kit | C0001 |
| | 30 Manifold + MS Roof Kit | C0004 |
| **Roof Kits** | KS Roof Kit | C0022 |
| | Biberschwanz Roof Kit | C0024 |
| | Copper Roof Kit | C0056 |
| | FS Roof Kit | C0076 |
| | K-Type Elevation Kit | C0121 |
| **Various** | Blank Insert Assembly | C0052 |
| | Flexible Hose Set (1000 mm) | C0067 |
| | Manifold Connection Kit | C0082 |
| **PCUs and Controllers** | PCU 20/60 SMT100 (18l.-5 bar) | C0179 |
| | PCU 20/60 SMT300 (18l.-5 bar) | C0191 |
| | PCU 20/60 SMT400 (18l.-5 bar) | C0180 |
| | PCU 90/240 SMT300 (5 bar) | C0189 |
| | PCU 90/240 SMT400 (5 bar) | C0190 |
| | Cascade for PCU 20/60 | C0050 |
| | Cascade for PCU 90/240 | C0060 |
| | System Kit SMT100 (8l.-3 bar) | C0173 |
| | Control Unit SMT100 | C0132 |
| | Control Unit SMT300 | C0126 |
| | Control Unit SMT400 | C0128 |

**Spare Parts**

| | Description | Part Number |
|---|---|---|
| **Tubes** | Tube end support plug TMO 600 S | A0634 |
| | Type 2 Support Clips (10 OFF) | A1091 |
| **Manifolds** | 20 Manifold | B0258 |
| | 30 Manifold | B0259 |
| | Manifold Spare Parts | A1093 |
| | Universal Bag of Fittings | A0276 |
| | Bag of Compression Fittings | A0350 |
| | 22 x ½" x 22 T | A0188 |
| | ½" Plug Hex Head | A0189 |
| | ½" Air Vent Hex Head | A0190 |

**Spare Parts continued**

| | | |
|---|---|---|
| **Fittings and Assembly** | 20 Bottom Support Rail + Pads | B0177 |
| | 30 Bottom Support Rails + Pads | B0178 |
| | Support Pads (5 OFF) | A3550 |
| | Side Brace (FS) | B0005 |
| | Universal Brace (FS) | B0006 |
| | Side Rail | B0008 |
| | Front Bracket + Ftgs. (FS) | A0327 |
| | Rear Bracket + Ftgs. (FS) | A0328 |
| | Rear Strut (FS) | A0356 |
| | Coach Screw Kit (8 OFF) | A0351 |
| | M8 Rawl Plugs (8 OFF) | A0858 |
| | 13 mm A/F Box Spanner | A0198 |
| **PCUs** | Return Sensor | A0740 |
| | Collector Sensor | A0741 |
| | Tank Sensor | A0742 |
| | Tank Sensor Pocket | A0332 |
| | Collector Sensor Pocket | A0477 |
| | Return Sensor Pocket | A0683 |

## (9.2)    System Sizing Tables

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

Table survey:    Table 1  -  Average domestic hot water utilisation per household
Table 2  -  Hotel/restaurant/guest house
Table 3  -  Outdoor pool energy requirement [kWh]
Table 4  -  Specific heat loss [kWh] for 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 utilisation per household

| Applications | Water temp. [°C] | Consumption [l/day] |
|---|---|---|
| Sink | 55 | 30 – 50 |
| Wash basin | 35 | 5 – 15 |
| Bath | 40 | 100 – 170 |
| Shower | 40 | 50 |
| Bidet | 40 | 25 |
| Washing m/c cold | 30 – 40 | 60 – 70 |
| Washing m/c hot | 50 – 60 | 60 – 70 |
| Total consumption | | |
| Low | 60 | 10 – 20 |
| Average | 60 | 20 – 40 |
| High | 60 | 40 – 80 |

**Table 2:**  Hotel/restaurant/guest house

| Applications | Water temp. [°C] | Consumption [l/day] |
|---|---|---|
| Restaurant | | |
| per menu | 45 | 6 – 12 |
| per guest | 45 | 12 – 30 |
| Hotel per room | | |
| Room + wash basin | 45 | 15 – 20 |
| Room + shower | 45 | 70 – 120 |
| Room + bath | 45 | 140 – 200 |
| Guest house | 45 | 35 – 70 |

**Table 3:**  Outdoor pool energy requirement [kWh]

| Water temp. [°C] | Swimming season / annum | | | Units |
|---|---|---|---|---|
| | 4 month | 5 month | 6 month | |
| 22 | 150 | 200 | 280 | kWh/(m² season) |
| 24 | 250 | 340 | 480 | |
| 26 | 420 | 560 | 720 | |

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

Assume solar insolation of 5 kWh/(m² day)
4 month season = 120 days/season
Therefore: 5 kWh/(m² day) x 120 days/season = 600 kWh/(m² season)
Collector efficiency = 0.7
Therefore: 600 kWh/(m² season) x 0.7 = 420 kWh/(m² season)

Energy available during a 4 month period from collector.

Energy required to heat pool to 22°C from table 3 is 150 kWh/(m² season) i.e. required ratio of collector surface to pool surface area of 1:3, as 150/450.

**Table 4:** Specific heat loss [kWh] for outdoor pool

Swimming period in months/annum

| Target temp. [°C] | Pool A | | Pool B | | Pool C | | Pool D | |
|---|---|---|---|---|---|---|---|---|
| | 5 | 7 | 5 | 7 | 5 | 7 | 5 | 7 |
| 20 | 0.034 | 0.072 | 0.110 | 0.158 | 0.302 | 0.373 | 0.036 | 0.068 |
| 23 | 0.133 | 0.170 | 0.269 | 0.314 | 0.565 | 0.634 | 0.060 | 0.069 |
| 26 | 0.275 | 0.315 | 0.476 | 0.523 | 0.881 | 0.938 | 0.083 | 0.091 |
| [kWh/m²] | | | | | | | | |

Legend:   Pool A:   Pool with two sides well protected (trees, building or wall), wind speed of 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 coefficient of conductivity of 8.12 W/(mK).

**Table 5:** Average space heating requirements – target temp. 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 ABOVE DATA VARIES ACCORDING TO METHOD OF INSULATION, AGE AND SIZE OF HOUSE, EXTERNAL AND TARGET TEMPERTAURES, ...

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

Assume solar insulation of 3 kWh(m² day)
Therefore: 3 kWh/(m² day) x 180 days/a = 540 kWh/(m² a)
Collector efficiency = 0.7
Therefore:                540 x 0.7 = 378 kWh/(m² season), i.e. energy available over a 6 month period from collector.

Energy required to heat a large detached house, with good loft and wall insulation, floor space 150 m², to a target temperature of 20 °C, is 110 kWh/(m² a).
Require a ratio of collector area to floor space of approximately 110/378 = 0.3, respectively 30 %, giving a collector area of 50 m².

**Table 6:**   Latent heat

1 m² of collector area, with a solar insolation of 1000 W/m² can approximately in one hour ...
...   increase the temperature of 7.8 kg of water from 25 °C to 100 °C or
...   produce 1.0 kg of vapour at 100 °C from water at 100 °C or
...   produce 0.9 kg of vapour at 100 °C from water at 25 °C or
...   produce 0.8 kg of vapour at 140 °C from water at 25 °C.

**Table 7:**   System sizing

| No. of persons | No. of tubes | Approximate storage tank size [l] |
|---|---|---|
| 1 − 2 | 20 | 100 − 150 |
| 3 − 4 | 30 | 200 − 250 |
| 5 − 6 | 40 | 300 − 350 |
| 7 − 8 | 50 | 400 − 450 |

## (9.3)   Solar Radiation Table

The following table gives some values for the solar radiation per month [kWh/m²] for different locations. These values may be used for an estimate as described in chapter 5.2.

| Location | Jan | Feb | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A) Vienna | 0.76 | 1.42 | 2.64 | 3.95 | 5.1 | 5.33 | 5.44 | 4.52 | 3.30 | 2.05 | 1.01 | 0.69 |
| (AUS) Melbourne | 6.67 | 5.92 | 4.89 | 3.70 | 2.64 | 2.28 | 2.39 | 3.04 | 4.03 | 5.95 | 6.51 | 4.42 |
| (CH) Basel | 1.03 | 1.64 | 2.61 | 4.07 | 4.87 | 5.40 | 5.52 | 4.55 | 3.50 | 2.26 | 1.13 | 0.87 |
| (CH) Geneve | 0.94 | 1.79 | 2.97 | 4.47 | 5.26 | 6.07 | 6.29 | 5.03 | 3.70 | 2.23 | 1.07 | 0.74 |
| (CH) Zürich | 0.84 | 1.64 | 2.68 | 4.17 | 5.06 | 5.70 | 5.81 | 4.71 | 3.57 | 2.03 | 0.96 | 0.68 |
| (D) Bremerhaven | 0.58 | 1.22 | 2.42 | 4.02 | 5.00 | 5.84 | 5.18 | 4.60 | 2.98 | 1.62 | 0.70 | 0.44 |
| (D) Freiburg | 1.04 | 1.75 | 2.80 | 4.24 | 5.06 | 5.63 | 5.69 | 4.66 | 3.73 | 2.25 | 1.16 | 0.84 |
| (D) Würzburg | 0.82 | 1.60 | 2.68 | 4.04 | 5.03 | 5.54 | 5.34 | 4.48 | 3.53 | 1.94 | 0.92 | 0.65 |
| (F) Nice | 1.36 | 2.11 | 3.30 | 4.32 | 5.54 | 6.00 | 5.90 | 5.12 | 4.01 | 2.69 | 1.51 | 1.05 |
| (F) Paris | 0.77 | 1.54 | 2.60 | 3.94 | 4.81 | 5.52 | 5.40 | 4.50 | 3.34 | 1.95 | 0.99 | 0.66 |
| (GB) Aberdeen | 0.40 | 1.02 | 2.13 | 3.54 | 4.36 | 5.03 | 4.57 | 3.80 | 2.35 | 1.36 | 0.61 | 0.33 |
| (GB) London | 0.56 | 1.10 | 2.07 | 3.04 | 4.12 | 4.99 | 4.38 | 3.62 | 2.71 | 1.56 | 0.81 | 0.47 |
| (GB) Plymouth | 0.69 | 1.48 | 2.84 | 4.25 | 5.03 | 5.84 | 5.63 | 4.44 | 3.31 | 1.92 | 1.03 | 0.63 |
| (I) Bozen | 1.21 | 1.92 | 3.16 | 4.42 | 4.87 | 5.39 | 5.48 | 4.90 | 3.94 | 2.65 | 1.40 | 1.04 |
| (I) Locarno | 1.44 | 2.14 | 3.58 | 4.71 | 5.19 | 6.02 | 6.30 | 5.20 | 3.95 | 2.85 | 1.53 | 1.32 |
| (I) Pisa | 1.42 | 2.10 | 3.41 | 4.73 | 5.53 | 6.10 | 6.34 | 5.60 | 4.50 | 3.08 | 1.77 | 1.33 |
| (IRL) Dublin | 0.68 | 1.48 | 2.67 | 4.23 | 5.18 | 6.09 | 5.32 | 4.36 | 3.26 | 1.86 | 0.96 | 0.58 |
| (Korea) Seoul | 2.40 | 3.03 | 3.83 | 4.33 | 4.56 | 4.87 | 3.62 | 3.63 | 3.78 | 3.62 | 2.45 | 2.12 |
| (NL) Rotterdam | 0.68 | 1.36 | 2.94 | 3.79 | 4.92 | 5.48 | 5.00 | 4.34 | 3.12 | 1.83 | 0.88 | 0.54 |
| (S) Stockholm | 0.32 | 0.95 | 2.24 | 3.68 | 5.29 | 6.58 | 5.59 | 4.52 | 2.70 | 1.24 | 0.46 | 0.23 |
| (UAE) Dubai | 4.75 | 4.96 | 4.89 | 5.86 | 6.56 | 5.65 | 6.10 | 5.98 | 6.03 | 5.83 | 5.53 | 4.70 |
| (USA) Washington | 0.80 | 1.48 | 2.70 | 4.30 | 5.20 | 6.09 | 5.40 | 4.30 | 3.2 | 1.8 | 0.95 | 0.50 |

## (9.4)      Checklist

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

## (9.5)      Calculation Sheet

The following chart will help to size the expansion vessel, to determine the overall system flow rate and to calculate the minimum inside pipe diameter required. All calculations are based on the explanations and equations in chapter 5.

## (9.6)      Commissioning Sheet

After completion of the installation we recommend to fill in the commissioning sheet and to leave a copy at the location of the solar system for reference.
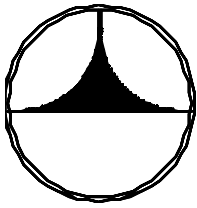
**Thermomax® Solar System**          **CHECKLIST**

## Project Data

Date          _____

Name          _____

Address       _____

Postcode      _____

Tel.          _____

## Consumption

Persons in household_____ Persons

Hot water consumption at _____ °C per person_____ l

Application   ☐   Hot Water          ☐   Swimming Pool

              ☐   Heating            ☐   Other

Expected solar contribution_____ % in _____ month
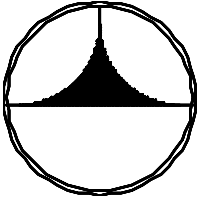
## Building features

Available mounting surface_____ m²    (Length ___ m x Width ___ m)

Inclination angle α _____ °      Azimuth angle β _____°

Roof type     ☐   Sloping Roof         ☐   Flat Roof

              ☐   Other

Static height of system _____ m

## Installation

Installation scheme (chapter 5.6.2)   _____

                                      _____

Tube type     ☐   TMO 500 S

              ☐   TMO 600 S

Control Unit  ☐   SMT 100           ☐   SMT 300

              ☐   SMT 400

Manifold      ☐   20 Tube           ☐   30 Tube

**Thermomax® Solar System**          **CALCULATION SHEET**

## Project Data

Date _____

Name _____

Address _____

Postcode _____

Tel. _____

$$\eta = \eta_0 - k_1 \cdot \frac{\Delta\vartheta}{G} - k_2 \cdot \frac{\Delta\vartheta^2}{G} = \quad - \quad \cdot\!\!-\!\!- \quad - \quad \cdot\!\!-\!\!- = \quad [-]$$

$$A_R = \frac{ED}{R \cdot \eta} = \text{———} = \quad [m^2]$$

$$V_S = V_T \cdot n_T = \quad \cdot \quad = \quad [\frac{l}{\min}] \cdot \frac{6}{100} \cdot [\frac{m^3}{h}] = \quad [\frac{m^3}{h}]$$

$$\varnothing_i = 4.6 \cdot \sqrt{\frac{V_S}{v}} = 4.6 \cdot \sqrt{\text{———}} = \quad [mm]$$

## System pressure drop $\Delta p_S$

Explanation see chapter 5.4

$\Delta p_{C20} = \qquad$ [Pa]

$\Delta p_{C30} = \qquad$ [Pa]

$\Delta p_P = \qquad$ [Pa]

$\Delta p_{he} = \qquad$ [Pa]

$$\Delta p_S = \frac{n_{20} \cdot \Delta p_{C20} + n_{30} \cdot \Delta p_{C30} + \Delta p_P + \Delta p_{he}}{10000} = \frac{\quad \cdot \quad + \quad \cdot \quad + \quad + \quad}{10000}$$

$$= \qquad [m]$$

## Expansion Vessel

Explanation see chapter 5.5

$$V_{\Delta \vartheta} = V_{sys} \cdot \beta = \qquad \cdot \qquad = \qquad [l]$$

$$p_{max} = p_{rv} - 0.5 = \qquad - 0.5 = \qquad [bar]$$

$$p_d = p_h + 0.1 \cdot h = \qquad + 0.1 \cdot \qquad = \qquad [bar]$$

$$V_c = V_{sys} \cdot 0.015 \geq 1[l] = \qquad \cdot 0.015 = \qquad [l] \geq 1[l]$$

$$V_n = \frac{(V_c + V_{\Delta \vartheta} + n_{col} \cdot V_{col}) \cdot (p_{max} + 1)}{p_{max} - p_d} = \frac{(\quad + \quad + \quad \cdot \quad) \cdot (\quad + 1)}{\quad - \quad} = \qquad [l]$$
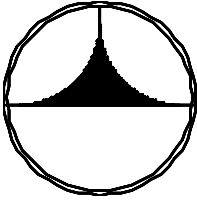
## Summary

Pipe Øi = _____ [mm]

Required head pressure $\Delta p_S$ of circulation pump at $V_S$ = _____ [m]

Expansion Vessel    chosen Volume = _____ [l]

                     Pre-pressure = _____ [bar]

                     Max. sys. operating pressure = _____ [bar]

**Thermomax® Solar System**          **COMMISSIONING SHEET**

## Project Data

Date          _____

Name          _____

Address       _____

Postcode      _____

Tel.          _____

## General Information

Date of purchase     _____     Supplied by _____

Invoice number       _____

Date of installation _____     Installed by _____

## System Information

Tube Prod. Ser. No.   TMO 500 S  C0207 _ _ _ _ _ _  to C0207 _ _ _ _ _ _

                      TMO 500 S  C0206 _ _ _ _ _ _  to C0206 _ _ _ _ _ _

Manifold Prod. Ser. No.  20 Sys.  C0001 _ _ _ _ _ _  to C0001 _ _ _ _ _ _

                         30 Sys.  C0004 _ _ _ _ _ _  to C0004 _ _ _ _ _ _

Solar Controller    Model _____

                    Serial No. _____

                    Settings    TC _____

                                TT _____

                                TF _____

                                $\Delta$T _____

                                TM _____

Expansion Vessel    Volume _____     [l]

                    Pre-Pressure _____ [bar]

                    System filling pressure _____ [bar]

Pump Specification  $V_S$ _____ [m3/h]

                    $\Delta p_S$ _____ [m]

Frost protection down to _____ [°C]