WP3 D7/D8 RECOMMENDATIONS EASILY INSTALLABLE PRODUCTS

Dissemination level: Public

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CONTENTS

SUMMARY

This paper reports on technical solutions to make the installation of solar thermal systems for single-family and small multi-family houses easy.

An easy installable system should be as compact as possible and have clearly marked and a minimum of necessary hydraulic connections. The solar thermal system should be pre-designed and the modules should be delivered in a way that they are easy to mount and connect on the roof. The piping between the collectors and the system in the house should ideally be pre-insulated, pre-designed and easy to connect.

Systems should be designed in a way that they can be installed and put into operation by an installer with only basic knowledge of solar thermal systems.

Introduction

Solar thermal systems for domestic hot water preparation and space heating in single-family houses or small multi-family houses are usually not designed by a planning firm but by installers of residential heating systems. Therefore, the systems should be pre-designed as far as possible by the system manufacturer. An important point for the design of such systems is to simplify the installation process as much as possible. This way installation errors and therefore malfunctions of the systems can be avoided and installation costs are reduced.

When talking about easily installable systems, three topics are of major importance:

1. The system should be designed as compact as possible, leaving only few connections to be installed on-site,
2. the solar collector modules should be delivered in a way that they are easy to mount and connect on the roof
3. and finally, the collector loop between the collectors and the system in the house should be easy to install on-site and ideally be delivered already insulated.

Systems should be designed in a way that they can be installed and put into operation with only basic knowledge of solar thermal systems.

Compact Systems

Solar combisystems (systems for domestic hot water preparation and space heating) consist of many different components. Experiences in the past with systems with two separate storage tanks, many hydraulic connections and electrical connections between controllers of different components (boiler, space heating and collector modules) have shown to lead to mistakes during design and installation. Therefore, the trend is moving towards compact systems where all components are included in a single compact unit. The unit is sold as a pre-designed and pre-fabricated complete package. It is thereby not necessary for the installer to design or size each system and component separately. The optimal, pre-designed systems already contain the optimised piping and pump sizes, the storage tank, solar pump unit, domestic hot water and space heating pump units, auxiliary boiler and controller. The few remaining hydraulic connections are clearly marked to make installation simple: domestic hot water (cold and hot connections), space heating and collector module with flow and return connections and fuel supply for auxiliary heating.

Fig. 1 shows the development of solar combisystem concepts. In this example, the number of hydraulic connections has decreased from 35 to 7, the space requirement from 4.5 to 2 m² and the weight of the system has gone down from 250 to 150 kg.

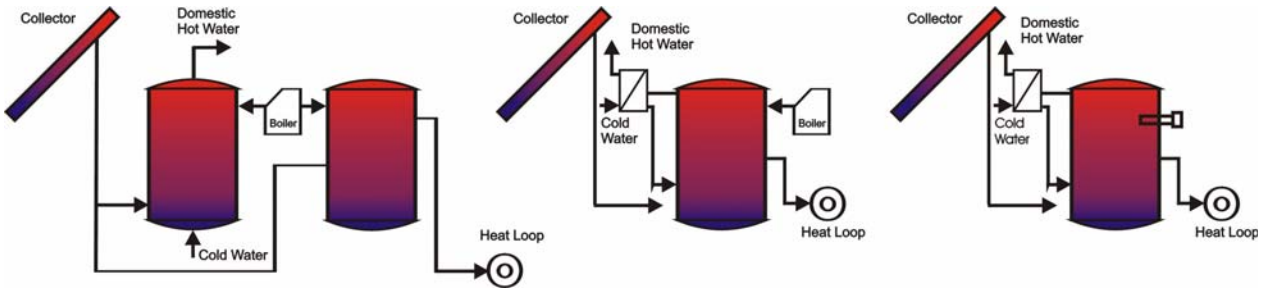

Fig. 1: Development of solar thermal systems towards a compact design

If many separate components have to be connected on-site, there is a high risk for mistakes during installation. With compact combisystems, the number of connections is reduced to a

minimum. The remaining connections should be marked clearly. Another good option is to manufacture the different pipe connections for the system in different shapes - just like connections of external devices to a computer. Plugs come in different shapes and colours so that, for example, the network cable cannot be attached to the outlet for the power cable, see Fig. 2.

Fig. 2: Connections with different shape and colours on a computer

On the left hand side of Fig. 3, a compact solar combisystem is shown. All components are integrated into a single unit. The picture on the right shows a pre-insulated storage tank with clearly marked positions for the collector loop connections.

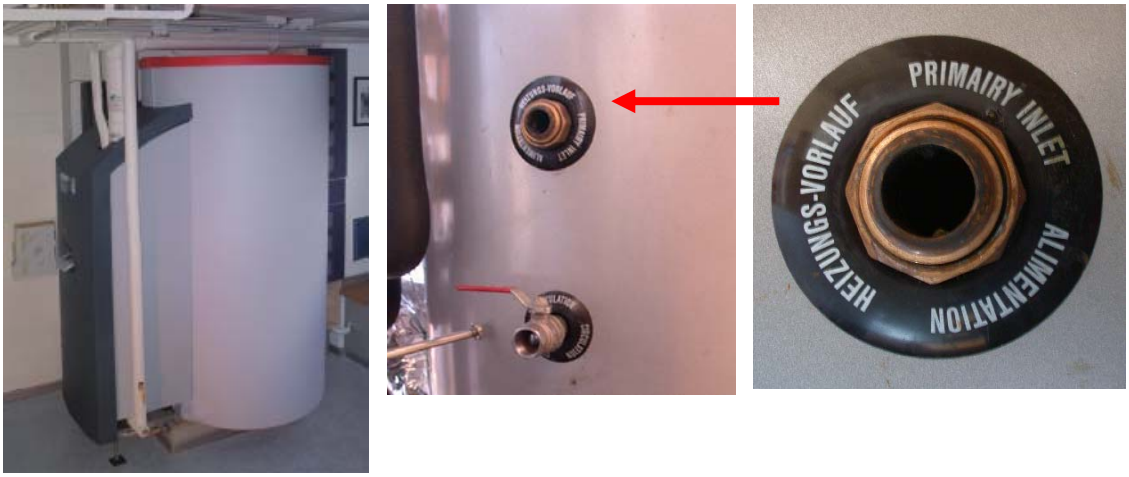

Fig. 3: Compact solar combisystem by the company SOLVIS (left) and pre-insulated storage tank with clearly marked connections by the company Austria Email (centre and right)

Roof Installations

Mounting a collector on a roof is in most cases not the typical work of an installer. It is therefore important that this part is made simple. For smaller systems (domestic hot water preparation), applying lightweight polymer collector is one solution to ease the handling and mounting for an installer. This kind of solar thermal system is present on the market, although not yet largely widespread. Mounting of larger collector modules or heavier collectors can be carried out with a crane, in order to facilitate installation on a roof. Some companies have delivery trucks that are quipped with a crane for this purpose. The installers only have to connect the hydraulics after the mounting. Fig. 4 shows mounting of a large collector field with a crane.

Fig. 4: Mounting collector modules with a crane

A smooth crossover from the roof to the collector frame can be achieved by so called flashing kits for each type of roof covering, if the collector is integrated into the roof. The flashing kits prevent leakage, constitute a good-looking installation on the roof and should be delivered with the collectors by the manufactures to enable the best fit. Many manufactures offer flashing kits that are tailored to different kinds of roof tiles.
If the collectors are installed on top of the roof covering, it is important that the passage of the piping through the roof is constructed in a watertight way

The installer can do preparation work for such mounting by positioning clamps to the roof, to which the collectors are mounted by the manufacturer at the delivery with the means of a crane. Further possibilities for collector installations are ground and flat roof assembly installations.

Collector Loop Piping

The collector loop piping should also be pre-fabricated as far as possible, so that the mounting and installation of the pipes on-site can be done quickly and easily.

Fig. 5: Flow and return pipe, delivered insulated in one package and marked differently (source: Armacell Switzerland AG)

Using corrugated or copper pipes in rather small dimensions makes it possible to deliver the pipes with insulation without losing flexibility for the installation. Flow and return pipes are sometimes delivered together - readily insulated and including an electrical wire for the collector temperature sensor on the roof, see Fig. 5.

With regard to the state of stagnation in the system, it is important that the hydraulic insulation and packing material is resistant to the high temperatures, which can occur. For this reason, it is recommended that all joints on the roof should be soldered rather than made with screw joints or crimp connections. A development by the Austrian company S.O.L.I.D. shows that even systems without an electrical wire to the collector sensor can be realized.
These systems use a pressure sensor in the collector loop, which is installed in the solar hydraulic unit, instead of a temperature sensor on the roof. Pressure variations due to increasing temperature in the collector are detected and the collector loop pump is turned on. Then the temperature sensors in the hydraulic unit are used to verify the flow temperature. The control unit that uses this concept is called ‘cordless control’ and is shown in Fig. 6.

The advantage of the cordless control is not only that it is easier to install but also that maintenance of the sensor is much easier if it is located in the technical room. Sensor failure because of cable breakage (bird picking etc.) can be avoided.

Fig. 6: Cordless control developed by the company S.O.L.I.D. does without a temperature sensor on the roof

Another important aspect is deaeration of the collector loop piping. The collector loop should be deaerated properly when it is filled with heat transfer fluid for the first time. During normal system operation it should not be necessary to deaerate the system again. Therefore it does not make sense to use automatic deaerators. The manual deaerator can be installed on the roof at the highest point of the system. The disadvantage is that the deaerator is hard to reach when installed on the roof. As a solution to this, the deaerator can be placed in the hydraulic unit in the technical room. In this case, flow velocities must be relatively high so that the air can be pushed through the collector and does not accumulate at the highest point. To achieve this, a large portion of the absorber piping is typically connected in series. Also, the type of the pump must allow transporting air bubbles through the system. This configuration is typical for so called low-flow operations. In such systems, often gear or sliding vane pumps are used. The disadvantage of this is that pressure drops of these systems are relatively high.

Stagnation in the solar thermal system

The so-called state of “stagnation” in the solar thermal system depends on the hydraulics in the collectors, in the total system and on the liquid in the system. Typical anti-freeze solutions such as propylene glycol mixtures suffer when subjected to high temperatures and especially long periods of evaporation. The state of stagnation is reached when the temperatures in the solar collector exceed a certain temperature (e.g. 120°C). The collector loop pump is switched off automatically if the solar collectors exceed this temperature or if the heat storage tank is above 95°C. Thereby, the heat transfer medium evaporates and is pushed out of the collector modules into the rest of the system. The medium is buffered in the expansion vessel of the solar thermal system. The activation of the collector loop safety valve can be prevented if the system and the expansion vessel are designed correctly.

The emptying properties of the collector and the collector loop are important in determining the stagnation behaviour of the plant. The goal is to design the hydraulics in a way that when evaporation starts in one part of the collector, the entire liquid is pushed out of the collectors immediately.

Collectors with favourable absorber pipe circuits for stagnation are shown in Fig. 7. Either the return or flow line or both should be located at the lowest part of the collector, which enables the heat transfer medium to be driven out of the collector. Thereby, the steam in the system reaches only to just below the collector and the corresponding steam power is very low.

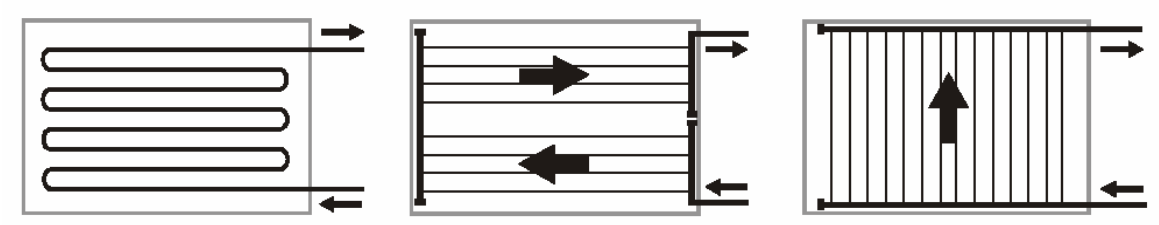

Fig. 7: Collector hydraulics with good emptying behaviour

If the piping in and between the collector modules is not carried out to ease drainage, this can inhibit the overall drainage of the collector field.

Fig. 8 shows examples of unfavourable loops in a collector module. The remaining liquid heat transfer medium is in this case trapped in the u-shaped loop piping and can only be emptied by evaporation which results in high steam power values. In this case the steam reaches far into the system. A repeated overheating of the medium is bad for its properties and shortens its lifetime.

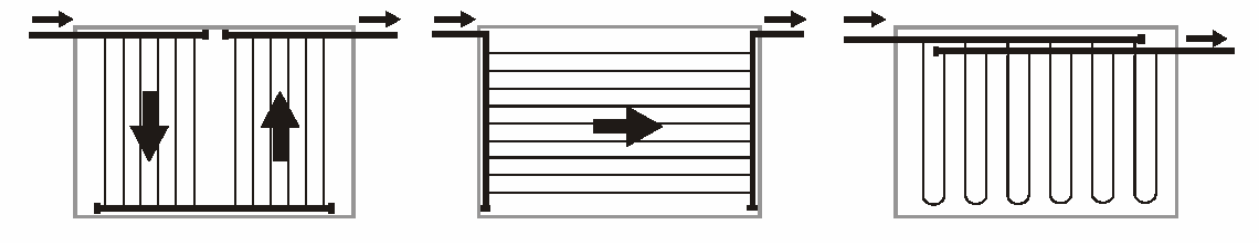

Fig. 8: Collector hydraulics with poor emptying behaviour

The system is designed correctly if the non-return valve is placed so that the collector can be drained from both sides. If the arrangement is inappropriate (see

Fig. 9, left hand side), the non-return valve prevents drainage through the return pipe. In this case only the flow line is available to release the vapour output.

The key issue is the position of the connection to the expansion vessel relative to the non-return valve. The pump can be positioned on either side of the connection to the expansion vessel.

The design of the system and collector hydraulics determines how far the generated steam penetrates into the system. If it is well designed, the steam does not reach the hydraulic components such as pump and expansion vessel that are typically located in the basement of a building.

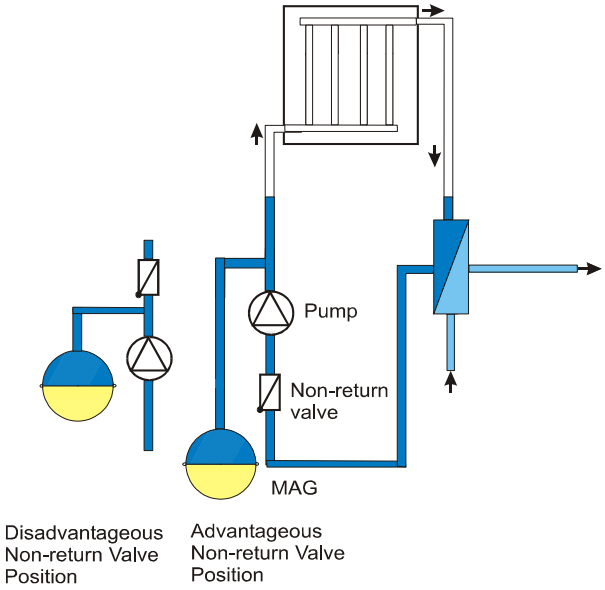

Fig. 9: The stagnation behaviour depends on the non-return valve position

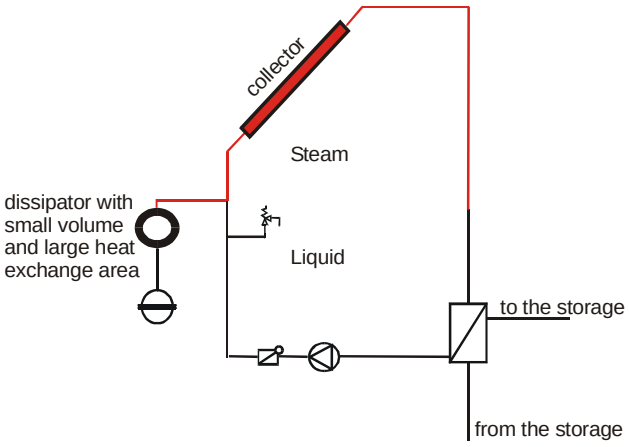

Fig. 10: If the emptying behaviour of the collector cannot be improved, a simple air cooler in the primary solar circuit can limit the steam volume

If the emptying behaviour of the system setup is not as good and steam can penetrate far into the system, action has to be taken to prevent damage of pump and expansion vessel. A possible solution that has proven successful in many existing systems is shown in
Fig. ***10***. A simple air cooler is placed between the expansion vessel and the main collector loop. If this air cooler is installed well above (1.5 - 2 m) the components that should be protected, the steam is condensed here and cannot reach further down in the system. In this case, all components that cannot resist to high temperatures (such as the pump) should be situated below the connection to the expansion vessel to protect it from the steam.

Conclusion

Solar thermal systems for single-family and small multi-family houses should be designed and manufactured in a way that they can be easily installed with a basic knowledge in this area. The goal should be to minimize installation errors and reduce installation costs.

A good approach is compact solar combisystems that have a high degree of prefabrication. These systems keep the amount of connections between the collectors and the technical unit inside the building that have to be made by the installer, at a minimum. These systems are pre-designed. That means that all components are optimised by the manufacturer. They are offered in different sizes. The installer does not have to dimension the different components of the system. The remaining connections to be made by the installer should be clearly marked to avoid installation errors.

Delivery and mounting of collector modules with a crane can facilitate installation, especially for large and heavy collectors. If the collectors are lifted on top of the roof and attached to it by the delivering company, which is experienced working on the roof, the installer only has to make the connections to the system.

An important topic is to avoid problems during stagnation of the system in times when there is more solar energy available than there is heat demand. The hydraulic layout of the system should be designed in a way to make sure that the collector fluid can be drained out of the collector field as soon as evaporation occurs.