SOLAR WATER HEATER: MANUAL OF INSTALLATION AND MAINTENANCE

Final Report **2020**

GLOBAL ENVIRONMENT FACILITY
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Acknowledgment 1

Utilizing Solar Energy for Industrial Process Heat in Egyptian Industry (SHIP) project herby express special thanks and gratitude for Sami Marrouki and his team, Tunisian Consultants for developing this document and effectively transferring this knowledge to our team. This manual would not have been possible to undertake without their valuable support and dedication.

This manual of SWH installation and maintenance, was developed under the supervision of the United Nations Industrial Development Organization (UNIDO) within the scope of Utilizing Solar Energy for Industrial Process Heat in Egyptian Industry (SHIP) project. The project is funded by the Global Environmental Facility (GEF) and implemented by UNIDO in cooperation with the Ministry of Trade and Industry of Egypt (MTI).

This manual aims to help SWH technicians and engineers better install and maintain SWH and to disseminate best practices for installation and maintenance of SWH in Egypt, this manual is dedicated especially to qualified SWH installers and maintainers

Executive summary

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The development of quality based market in Egypt for solar water heaters (SWH) is based on two main elements:

- Good quality of the technology, the SWH should be Shamsi labialized in the near future. Controlled by EOS, this measure will allow developing the SWH value chain, well organizing the market and progressing the use of technology through a quality scheme.
- Good quality of services meaning the installation and the maintenance of SWH, this has to be implemented through a certification scheme of personal according to ISO 17024, based on qualification and examination of candidates. Existing and potential installers should be qualified in a first step through an appropriate training program provided by specialized training Centre and certified in a second phase through examination by a certification body.

This manual aims to disseminate best practices for installation and maintenance of SWH, the target groups of this manual are installers expecting to become eligible for providing services in installation and maintenance of different technologies of SWH. This manual is, also, aiming to reinforce the SWH value chain, mainly in services for installation and maintenance.

In a practical way, this manual aims to help SWH technicians and engineers better install and maintain SWH and to disseminate best practices for installation and maintenance of SWH in Egypt, this manual is dedicated specially to qualified SWH installers and maintainers

The manual is elaborated according to four (04) parts:

PART I: DEFINITIONS & PRELIMINARY CONCEPTS

This first part presents basic concepts on Solar Water Heater (SWH) system in the international technical and commercial market contexts. It covers the following topics:

- General definitions
- Comparative analysis of SWH types
- Role of components and accessories of a SWH
- Classification of solar systems
- Sizing elements of solar water heating installations

PART II: SUPPLY & INSTALLATION OF AN INDIVIDUAL SWH

This second part of this manual describes all the steps that an installer needs to follow in order to carry out the installation of an individual SWH. It covers the following steps:

- Customer contact (preliminary visit and installation appointment)

- SWH delivery
- Prepare for installation
- SWH installation
- Commissioning
- Customer acceptance of the installation

This part allows installers to control the technical offer for SWH installation in order to get the compatible choices with the constraints of each installation and users' expectations.

PART III: BEST PRACTICES AND RECOMMNDATIONS FOR PROPER AND CORRECT INSTALLATION

This third part includes 13 practices presented in the form of:

- Proscribed practices: describes the errors that the installer could make during the installation, these practices have to be avoided to guarantee an installation in accordance with the standards and the rules of the art
- Good practices: constitute the solutions to follow to avoid errors and installation anomalies

In addition to the prohibited practices, good installation practices are presented, with a view to optimum commissioning and operation. The operations mentioned constitute an essential complement to the technical specifications to disseminate good practices, ensure user satisfaction and reduce breakdowns and anomalies

PART IV: SOLAR WATER HEATER MAINTENANCE AND REPAIR

This part concerns the maintenance instructions to be followed by the installer and the customer to ensure a better use of the SWH, these maintenances are of three types:

- Systematic maintenance provided by the customer
- Preventive maintenance provided by the installer; during periodic visits carried under the guarantee period
- Corrective maintenance, provided by the installer in the event of a breakdown.

This manual should be followed and respected by the SWH installers and maintainers during the training and the installation and maintenance activities.

Desk review of SWH quality based market development

The experience used as a best practice for the development of the current options is the Tunisian one, the Tunisian PROSOL, known as a famous integrated mechanism aiming to develop in a same time:

- **Demand on SWH**: through the financial mechanism combining public subsidies to soft loan for the SWH procurement
- **Supply of quality based products**: through development of SWH local manufacturing and setting up minimum requirements for products and guarantee
- **Services for installation and maintenance**: through the main following activities:
  - ✓ Qualification of installers and maintainers via specific training
  - ✓ Qualisol label mandatory for operational personal

- ✓ Contract between supplier and installers to make traceability and to materialize the guarantee
- ✓ Manual of installation and maintenance

The multi actor's approach defines precisely the role of each stakeholder through written documents and terms of references, the main roles, are given as an example:

Supplier:

- Respect quality of the products (minimum requirements for SWH)
- Provide testing reports justifying the requested requirements
- Select and train installers on own SWH
- Contract with installers
- Provide guarantee of products for the installers
- Provide manual for installation, operation and maintenance of the SWH system

Installer:

- Provide advice to end user concerning SWH system type
- Respect quality requirements of SWH services
- Install SWH according to contract, quality requirements and "Qualisol " label
- Provide guarantee and manual of system O&M to end user
- Provide continued after sale services "ASS"

End User:

- Operation of SWH according to recommendations
- Preventive maintenance of the SWH system
- Monitoring of SWH system

Public institutions (ANME-STEG):

- Define requirements of the SWH supply (minimum requirements to be respected by suppliers)
- Define requirements of SWH services providers (minimum requirements for installation and maintenance)
- Define qualification criteria of SWH installers and maintainers (Eligibility of installers)
- Validate contract of services and "Qualisol" label for installers
- Approve guarantee conditions of SWH
- Approve manual for installation, operation and maintenance of the SWH system
- Manage the SWH program.

Business association (CSNEnR-Cluster):

- Promotion of the SWH program and quality label for installation "Qualisol"
- Awareness for quality improvement of SWH products and services
- Push for training and promote qualification of installers
- Identify collaborative activities for SWH market development
- Improve competitiveness of SWH systems and services

Training provider:

- Fulfil to requirements and specification of training centers (minimum requirement for training providers)
- Implement the training course developed and provide a certificate

- Contribute to improve the training courses through the monitoring

Due to the success of the Tunisian experience, similar mechanisms are implemented in other countries such as South Africa, Chili, … etc.

International experiences of SWH manual for installation and maintenance

This manual is profiting from the Tunisian experience of SWH quality based market development, the SWH guideline elaborated in the frame of the integrated program (PROSOL) helped to increase the skills of installers and to improve quality of services, the Tunisian experience presents a similar cultural, social and economic conditions.

Similar experiences for SWH manual elaboration are also conducted in some African countries like Kenya and European countries like France, Germany and Spain

Manual for individual SWH installation in Tunisia elaborated by ANME with the support of GIZ and CSNEnR.

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List of Abbreviation

ANME	: national Agency for Energy Conservation Tunisia
CSNEnR	: Renewable Energy Business Association
CSWH	: Collective solar water heater
CV	: Curriculum vitae
EGAC	: Egyptian accreditation
EOS	: Egyptian organization for standardization
FCS	: Forced circulation system
FS	: Forced system
GEF	: Global Environment Fund
GIZ	: German Cooperation
IMC	: Industrial modernization Centre
ISWH	: Individual solar water heater
MCTG	: Maintenance contract and total guarantee
MIT	: Ministry of industry and trade
m^2	: Meter square
NREA	: New and renewable energy authority
PVTD	: Program vocational and training development
SWH	: solar water heater
SWHIM	: SWH installer and maintainer
ToT	: Training of trainers
TS	: Thermosiphon system
TVET	: Technical and vocational education and training
QCM	: Multiple-choice questions
UNDP	: United Nation Development Program
WG	: Working group
mA	: Milliampere

INTRODUCTION:

The project "***Utilizing Solar Energy for Industrial Process Heat in Egyptian Industry***" is financed by the Global Environmental Facility (GEF) and implemented by the United Nations Industrial Development Organization (UNIDO) in cooperation with the Ministry of Trade and Industry.

The objective of the project is to develop the market environment for the local manufacturing and diffusion of solar thermal technologies for industrial process heat. The project focuses on improving the energy efficiency of the industrial heating process system and the introduction of solar thermal technologies mainly in industrial companies with a high fraction of low and medium temperature heat demand in three industrial sectors, namely the food, chemical and textile sectors. Furthermore, the project will support the local manufacturing of quality components of the solar thermal technologies.

The project implementation will result in four main outcomes:

1. Policy instruments for promoting the use of solar thermal technologies for industrial process heat in 3 sectors are developed.
2. Financing for the deployment of solar thermal technologies for industrial process heat is mobilized.
3. The market for the manufacturing, supply and distribution of solar thermal technologies and their components is strengthened
4. The technical capacity of the solar thermal technologies designers, developers, facility managers and service providers for solar energy utilization for industrial heating process is enhanced.

This manual provides the technical approach for SWH installation and maintenance, this manual is necessary training technicians and engineers on solar water heaters (SWH) installation in the frame of Egyptian solar heating promotion program.

The elaborated manual is used for training individual technicians or engineers to be SWH installers/maintainers, who should be the main element of SWH value chain for installation and maintenance, even working for his own individual company to install individual SWH (ISWH) or working for an installation company for collective SWH installation (CSWH) or solar heat processing.

QUALITY CHARTER FOR INSTALLATION AND MAINTENANCE TO BE SIGNED BY THE INSTALLER AND RESPECTED FOR INDIVIDUAL SWH BY THE PERSONAL

As an installer and maintainer of SWH, I hereby undertake to respect the following ten (10) points of the quality charter that lies to:

1. *Have the required professional skills within his own self or his company, attained through a long or a short term training as well as a confirmed practice, and be up to date within the applicable technical requirements*,
2. *Recommend and commercialize only solar systems that meet current standards and specifications and that are eligible for the Egyptian program by EOS, (Solar Key Mark or SHAMCI)*
3. *Provide the client with an advisory role, and assist him in the selection of the best available solutions suited to his needs and considering the local "solar potential", the constraints of the site, the size of the household and the available backup energies*,
4. *After the site visit, a written detailed and complete description of the proposed solar installation must be submitted to the client, setting a deadline for installation, payment conditions and legal guarantee terms, and then propose, for the client, a contract of maintenance for a minimum of 5 years*,
5. *Update the client on any changes and conditions or modalities related to the realization of the SWH installation (type, price, timeline, payment conditions, technical specifications …),*
6. *Once the client's agreement is obtained (technical and financial proposal co-signed), insure to constitute the complete file in conformity with the requirements and carry out the ordered installation in accordance with applicable professional rules, standards and regulations as required*
7. *Set and commission the installation, then proceed to work receipt in the presence of the customer. Give him the instructions and all documents related to the guarantee and maintenance conditions; inform him about the operation of the SWH and its preventive maintenance needs*
8. *Provide the customer, as his counterpart, with a complete detailed and descriptive invoice of the service (that makes out at least the "equipment supply" and the "service fee", in accordance with the initial technical and financial description (with precise designation of installed solar equipment and references certification)),*
9. *In case of customer-reported malfunction or operational incidents on the SWH, commit to responding and to intervene in the site in a short time, and carry out necessary checks and intervention as part of the response obligations attached to the guarantee and maintenance contract*
10. *Following to any notification of the authority, any control operation that the institution would like to carry out on selected installations should be prioritized, in order to examine the SWH and check the conditions of service's implementation*.

Read and approved by
Name:
Surname:
Signature

PART I: DEFINITIONS & PRELIMINARY CONCEPTS

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- General Definitions
- Comparative analysis of SWH types
- Role of components and accessories of a SWH
- Classification of solar systems
- Sizing elements of solar water heating installations

This part allows installers to control the technical offer for SWH installation in order to get the compatible choices with the constraints of each installation and users' expectations.

I. GENERAL DEFINITIONS

A Solar Water Heating (SWH) is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations is available to provide solutions in different climates and latitudes. SWHs are widely used for residential and some industrial applications.

There are two types of solar water heating systems:

- **Active or Forced Circulation (FC) system which need circulating pumps and controls**
- **Passive or thermosiphon System (TS) which need nothing for fluid circulation**

1. Thermosiphon system (TS)

A Thermosiphon system (TS) is a system where the heated water in solar collectors rises up into the storage tank by natural Thermosiphon action. Thermosiphon action occurs when water heated in the collectors, expands as it becomes lighter allowing then the colder heavier water to fall by gravitational force to the bottom of the collector. As the cold water falls to the collector's bottom, it pushes the hotter lighter water back up into the storage tank. This natural action, commonly known as Thermosiphon action, occurs without having any need of moving parts nor any electric backup system energy input to the system (Circulating Pumps)

These systems are easier to maintain, less expensive to install. However, they have installation limits since the storage tank must be placed above the lower part of the collector.

For this SWH type, there are two ways for fluid circulation (Water or Freeze fluid):

- **By direct or open loop system**
- **By indirect or close loop system**

1.1 Direct Thermosiphon "Open loop" system

In a direct system, the potable water circulates from the storage tank to the collector and back to the storage tank. Thus, the heat collecting fluid is the same potable water that is in the water heater as illustrated as following figure 1

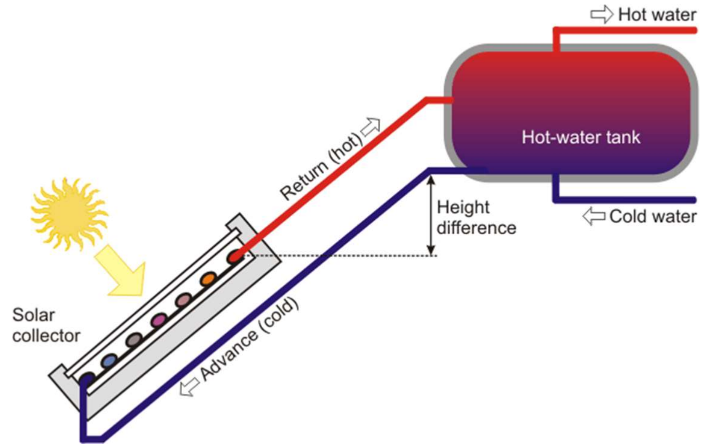


Figure 1: Natural circulation of water in a direct thermosiphon SWH

1.2 Indirect thermosiphon "Closed loop" system

For a Closed-loop system, the heat transfer fluid (anti-freeze solution) circulates through the system's tubes without mixing with the domestic water inside the water storage tank. Closed-loop systems are better-suited for colder climates, since the anti-freeze solution keeps the system from freezing. In places with hard water, the system limits scale development inside the collector's tubes.

Closed-loop systems can operate as Forced System or Thermosiphon System.

For this thermosiphon system, an air vent and an expansion tank are essential to protect the closed circuit from overpressure. The expansion tank is mainly used to compensate for the expansion caused by the water temperature rise in the closed circuit

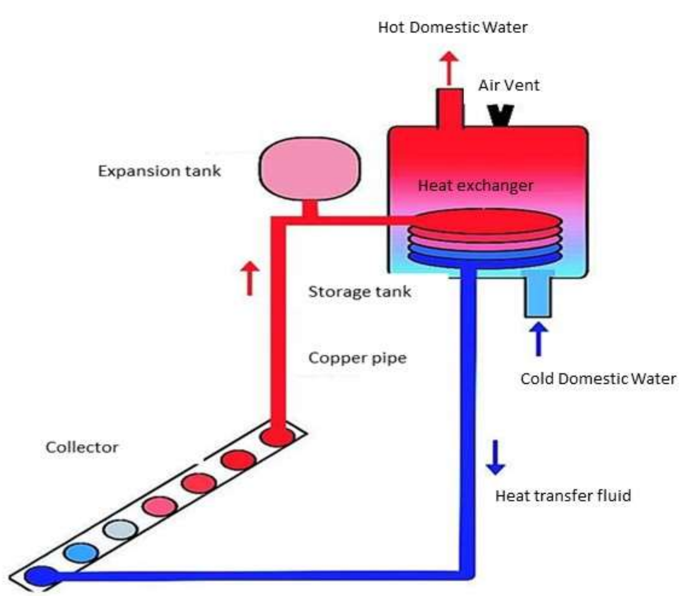


Figure 2: Natural circulation of water in an indirect thermosiphon SWH

2. Forced Circulation System (FCS)

The Forced Circulation system (FC) is an installation requiring the action of an electric pump in order to enable the fluid circulation. Generally, collectors are located on a roof and the storage tank is located in a technical area. The forced circulation system's flow is usually close to twice the thermosiphon system's flow. The system controlling is carried out by means of a differential temperature control between the lower part of the tank and the collectors output, operating the pump when the temperature difference is higher than a determined value (Figure 3)

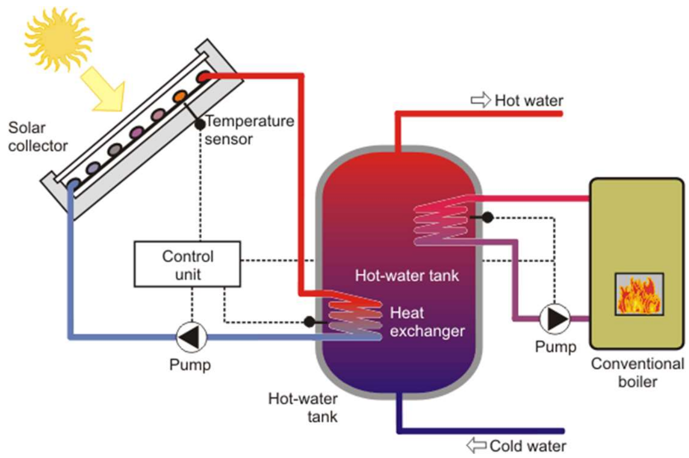


Figure 3: A forced circulation system with back up

FC systems are usually less efficient and more expensive than TS systems however they enable high flexibility in the positioning of the systems' components: storage tanks do not need to be installed above or close to the collectors. Since FC systems use electricity to operate the pump, these systems will not function in a power outage.

3. Collectors type

3.1 Flat plate collector

The flat plate collector is the most commonly used solar collector around the world. Although there are a number of variations in the design of the flat plate collector, a typical flat-plate collector is usually a metal box with a glass or plastic cover (called glazing) on top and a dark-colored absorber plate with embodied fins (pipes) enclosed within. The sides and the bottom of the collector are usually insulated to minimize heat loss. (Figure 4)

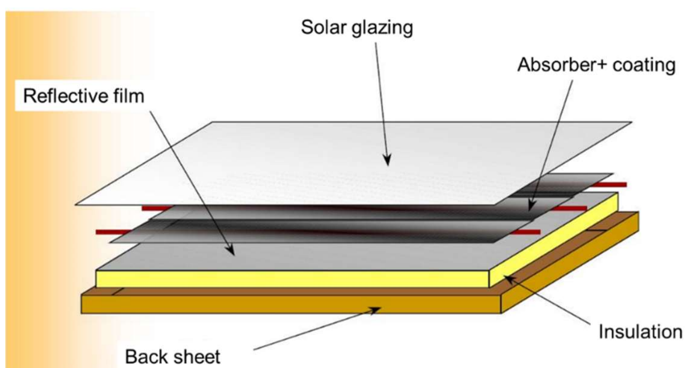


Figure 4: Flat plate Collector

3.2 Evacuated Tube collector

The evacuated tube collectors are made of a series of glass tubes mounted in rows and plugged into a manifold box through which the heat transfer liquid (water or water/glycol) flows (Figure 5). Toxic fluids such as ethylene glycol should not be used in potable water heating systems - only non-toxic propylene glycol may be used. Inside each tube, there is an absorber. The absorber is located inside a double glass tube with a vacuum between the two tubes. The inner glass tube has a selective surface facing outward to absorb the sun's energy. The absorber contains copper tubes or passageways through which the heat transfer fluid flows allowing the heat to be transported away from the absorber.

The loss of heat from the absorber by natural convection is eliminated by the vacuum and, as a result, high operating fluid temperatures of up to 120°C can be achieved. The possibility of higher temperatures is of particular importance for solar industrial process heating application because it increases the number of applications where solar energy can be used

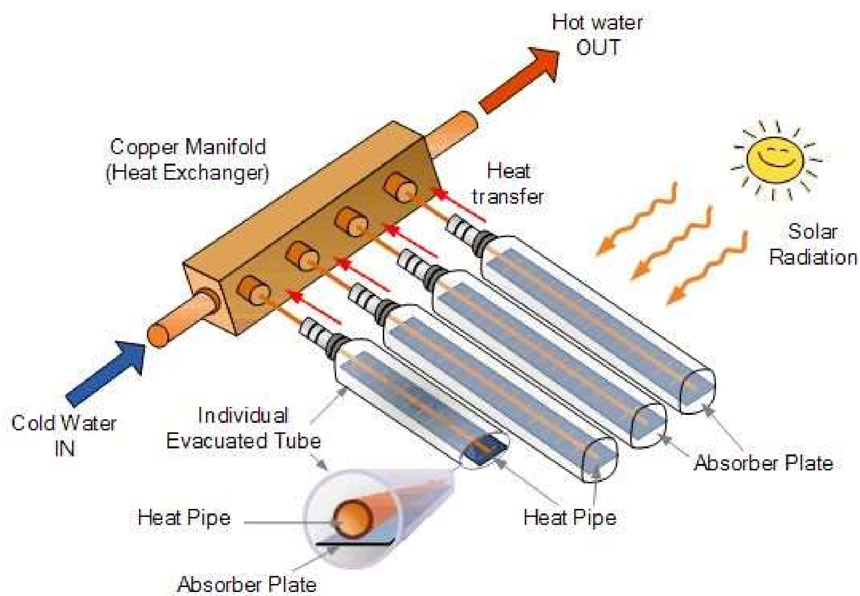


Figure 5: Evacuated Tube collector

3.3 Comparative analysis between the two collector technology's

The following table gives a comparative description of flat and evacuated tube collectors:

	Flat Plate Collector	Evacuated Tube collector
Cost	Less expensive	around 20% to 40% more expensive
Performance	Better in southern climate	Better in colder and/or cloudier conditions
Efficiency	Less efficient	20% more efficient than flat plate
Installation	More sensitive to sun radiation	Less sensitive to sun radiation and orientation
Heat losses	Convection and contacting losses is high	Convection and contacting losses is low
Temperature range	From 60 to 90 °C	From 60 to 120 °c

Table 1: comparative presentation of different types of collectors

3.4 Collectors configuration

Solar collectors can be connected in series as well as in parallel. Ideally, parallel connection of collectors should be limited to four (4) while series connection should be limited to three (3) but manufacturer's recommendation should take precedence.

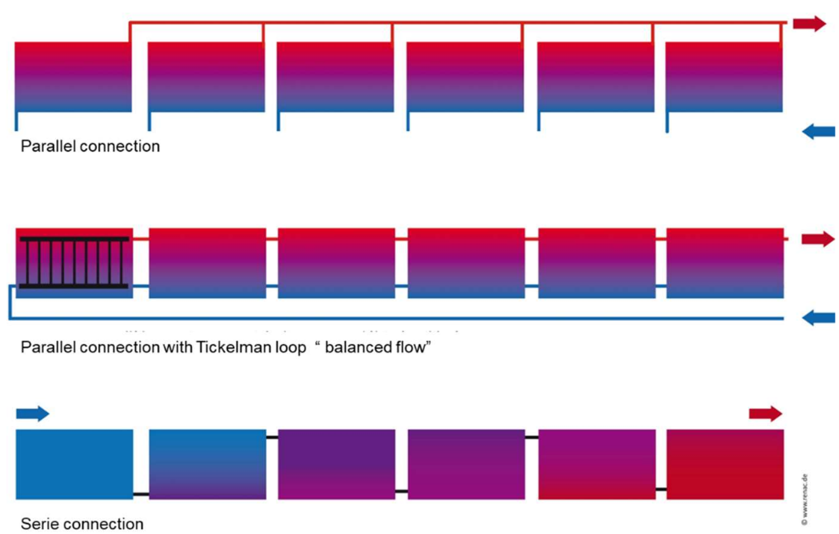


Figure 6: Parallel and series connected collector

II. COMPARATIVE ANALYSIS OF SWH TYPES (ADVANTAGES AND DISADVANTAGES OF CONFIGURATIONS)

1. Thermosiphon system comparison

The following table gives a comparative description of open loop and close loop thermosiphon SWH systems:

	Direct (Open loop) system	**Indirect (Closed loop) system**
ADVANTAGE	Not need heat exchanger	Less limestone in collector tubes
	Simple	Simple
	Low temperature losses	Less corrosion problem
	No need expansion tank and Air vent	More hygienic for domestic hot water
DISADVANTAGE	Corrosion	Need heat exchanger
	Limestone in collector tubes	Need an antifreeze
	Hygienic problem in domestic hot water	More expensive
		High temperature losses

Table 2: advantage and disadvantage of thermosiphon systems

2. Thermosiphon and Forced circulation comparison

The following table gives a comparative description of thermosiphon SWH system and forced circulation SWH systems:

	Thermosiphon system	**Forced Circulation system**
ADVANTAGE	No water pump	Independent location
	No regulation system	Ability to separate tank- collector
	No electricity supply	Large scale system possible
	Simple and independent	Storage tank protected inside
DISADVANTAGE	Storage above the collector	Need a pump
	Storage outside	Need a regulation system
	For small capacities	Need a supply electricity
	Bad system optimization	System interrupted during an electricity shut off

Table 3: advantage and disadvantage of thermosiphon and forced systems

3. Recapitulative table

The following table gives a comparative description of different types of technologies used for SWH systems:

- **Thermosiphon system**
  - ✓ **Direct circuit**
  - ✓ **Indirect circuit**
- **Forced circulation System**

Thermosiphon system				Forced circulation System	
Direct circuit		**Indirect circuit**			
Advantage	Disadvantage	Advantage	Disadvantage	Advantage	Disadvantage
Competitive cost	Constrained architectural integration	No trapped limestone risk in collectors	Constrained architectural integration	Better architectural integration	Higher cost compared to thermosiphon system
No water pump	Sensitive to pressure drops	No freezing risk	Higher cost compared to a direct circuit	Storage tank protected in the inside	Needs a water pump and a regulation system
No regulation system	Limestone stuck in collectors	More adapted to the areas with a high water hardness	Less efficient compared to a direct circuit	Low losses for the storage	The Installation and maintenance are more complex
Simple installation and commissioning	Hygienic problems in domestic hot water	Low sensitivity to pressure drops	Needs more components compared to a direct circuit	The ability to include low temperature heating	Higher Maintenance cost
Easy maintenance	Freezing risk in cold areas	No water pump nor a regulation system	The liquid (antifreeze) level has to be checked yearly and replaced depending on a frequency recommended by the manufacturer	Integration of a more suitable non-electric backup	A more restrictive qualification is needed
Long life		Long life		A Large scale system is possible	A more complex sizing
					The system could be interrupted during an electricity shut off

Table 4: Advantages and disadvantages of each type of SWH

III. COMPONENTS AND ACCESSORIES ROLES

Component	**Photo**	**Role**	**Direct thermosiphon system**	**Indirect thermosiphon system**	**Forced circulation**
Safety group		Protects SWH against overpressure and water return in the system	X	X	
Non-return valve		Prevents reverse thermosiphon phenomenon (taking place especially at night)	X	X	X
Electric resistant (back up)		Increases the preheated water temperature when sun is insufficient	X	X	X

Safety valve		Protects the primary circuit against overpressure			x
Magnesium anode		Protects the tank against corrosion by absorbing the dielectric current	X	X	X
Heat exchanger		Transfers the heat from the collector to the tank with a heat transfer fluid (antifreeze)		X	X

Air vent		Allows air that has entered the system to escape, and in turn prevents air locks that would restrict flow of the heat-transfer fluid circulating in the primary circuit (solar circuit)		X	X
Heat transfer fluid (antifreeze)		Mix of demineralized water and antifreeze circulating in the primary circuit to transfer the heat from the collector to the tank		X	X
Expansion tank		Protects and regulate the pressure of the primary circuit. Absorb an amount of the heat transfer fluid during its expansion (during its overheating)		X	X

Pump/Circulator		Allows the circulation of the heat transfer fluid between the collector and the tank			X
Differential thermal solar control		Controls the pump depending on a temperature differential measured by sensors			X
Sensor		Allows to measure the temperature at different points of the primary circuit			X

Reflector		Increases solar energy collected by the evacuated tube collector			
Manometer		Controls pressure at different points in the hydraulic circuit	X	X	X
Thermostatic mixer		Helps save hot water and prevents overheats and accidental burns to the user	X	X	X

Pressure reducer		Reduces water pressure from the public network	X	X	X
Filter		Removes impurities by lowering the contamination of water	X	X	X
Isolation Valve		Isolates the SWH and facilitates its maintenance	X	X	

Table 5: Components and accessories SWH

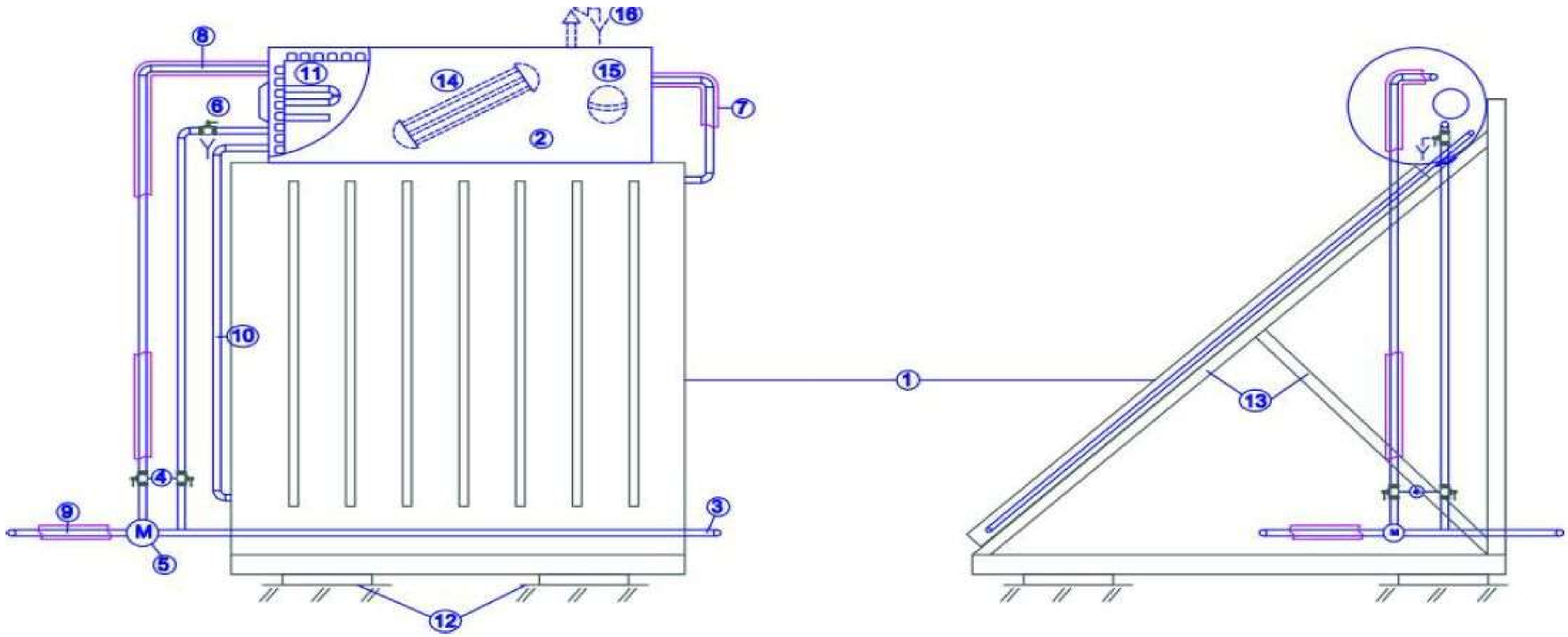


Figure 7: Example of Thermosiphon SWH system (Closed loop system)

Legend:

1) Solar Collector
2) Storage tank
3) Cold water input
4) Isolation valve
5) Thermostatic mixer
6) Safety group
7) Hot water collector outlet (insulated)
8) Solar hot water tank input (insulated)
9) Solar hot water mixed input (insulated)
10) Cold water collector input
11) Electric back up
12) Concrete slabs
13) Support structure
14) Heat exchanger (for Indirect and forced system)
15) Expansion tank (for Indirect and forced system)
16) Air vent

IV. CLASSIFICATION OF SOLAR SYSTEMS

1. Individual Solar Water Heater

The individual Solar Water Heater is a unitary system (Thermosiphon type in general), which ensures the heating of domestic water (Figure 8). The backup system provides the necessary heat to obtain the desired hot water production temperature, especially during periods when there is insufficient solar radiation. The size of these systems is ranging between 150 Liter and 500 Liter of storage tank.

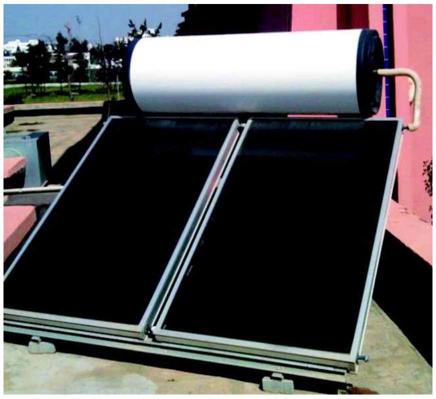


Figure 8: Individual Solar Water heater

2. Compound solar system

It is a system made by assembling individual solar water heater (connection in series and/or in parallel) in order to respond specific needs (Figure 9)

Figure 9: Compound Solar system

3. Individual solar installation

If the compound solar system (connection in series and/or in parallel several individual solar water heater) has a total collector's surface below 7 m2 or has a total storage tank less than 500 liters, it will be considering as an individual solar installation.

4. Collective solar installation

If the compound solar system (connection in series and/or in parallel several individual solar water heater) has a total collector's surface above 7 m2 or has a total storage tank more than 500 liters, it will be classified as a collective solar installation.

5. Classification of solar systems

The program classifies Solar Water Heater installations referring to these two major categories:

- Individual system
- Collective system

Technical specifications	**Solar system classification**		
	Individual system	**Collective system**	
		Small size	Large size
Collector area (m2)	≤ 7	≤ 30	> 30
Storage volume (Liter)	≤ 500	≤ 3000	>3000

Table 6: Solar systems classification

V. SIZING OF SWH INSTALLATION

The small sizing individual installation (collector's area less than 7 m2), are the most used installations in the world. Collective installations are more complex and require more in-depth knowledge and calculations using specific IT tools and software. Suppliers and installers according to local rules and knowledge based on experience often size individual installations.

As with single or mixed individual boilers, the choice is quite limited as the equipment is standard. Indeed, the collector area often varies from 2 to 6 m² and storage from 150 to 500 litters.

It is possible to run into individual SWH of 150 litters with less than 2m2 of collector area.

In current practice, the selection is often presented as follows:

- 150 liters for a small residential apartment
- 200 liters for a normal residential apartment
- 300 liters for a villa/house

This approach can be misleading if the following elements are not taken into account:

- Number of occupants: large family or not
- Number of sanitary equipment: baths, showers, sinks etc.
- Use of secondary or main residence, continuous occupation or seasonal.

The oversizing reflex should be avoided, as it reduces the efficiency and even the profitability of the SWH.

The following table presents the values that can be used as a first estimation:

Occupants number	**1 or 2**	**3 or 4**	**5 or 6**	**7 and +**
Tank volume (1) (liters)	100-150	150-250	250-350	350-500
Tank volume (2) (liters)	150-250	250-400	400-500	550-650
Collector area (m2)	2-2.5	2-3.5	2.5-4.5	3.5-6

(1) : without backup (2): with backup

Table 7: The sizing of elements for Individual SWH

PART II: THE SUPPLY & THE INSTALLATION OF AN INDIVIDUAL SOLAR WATER HEATER

This second part of this manual describes all the steps that an installer needs to follow in order to carry out the installation of an individual SWH. It covers the following steps:

- Customer contact (preliminary visit and installation appointment)
- SWH delivery
- Prepare for installation
- SWH installation
- Commissioning
- Customer acceptance of the installation

I. PRELIMINARY STEPS

The installer has to be able to communicate at least following pieces of general information:

1. **General information:**

   - ✓ Eligible supplier for the Egyptian program and approved by the authority
   - ✓ Presentation of the product variety and advices

2. **Service's limits:**

   - ✓ The achievement of electric and hydraulic expectations required for the commissioning in accordance with SWH standards.
   - ✓ Additional work costs will be covered by the customer. A detailed cost estimate should be communicated to the costumer.
   - ✓ The customer can call upon other specialists to realize the required hydraulic (plumber) and electric expectation (an electrician)
   - ✓ The installer has to give advices, if necessary, to the customer concerning the SWH's adjustment to his needs, to the water quality and to the climate conditions.

The Installer should specify and explain SWH's technical specifications to the customer in order to optimize its performance and ensure the user's safety.

II. PRELIMINARY VISIT

During this phase, the installer has to do these following tasks:

1. **Check the costumer's information:**
   - ✓ Address, access, person to contact, email, phone number….

2. **Explain to the customer these following aspects:**

   - ✓ The SWH requires a periodic maintenance
   - ✓ Maintenance operations are required to assert the SWH's guarantee rights.
   - ✓ No modifications shall be made to the installation without consulting the SWH's installer or supplier in advance.

3. **Carry out investigations on:**

   - ✓ The number of the user who uses frequently the sanitary ware.
   - ✓ The eventual existing sanitary water heating equipment (wall-mounted boiler, electric water heater, etc…) and the distribution scheme.
   - ✓ The energy or fuel used (natural gas, LPG, electricity, ...)
   - ✓ Obstacles that can stop the solar collector from gathering solar radiations
   - ✓ Existing roof connection points for SWH.

4. **Present a technical proposal to the customer**

   - ✓ This technical proposal has to mention the entire range commercialized by the Installer as well as all additional costs
   - ✓ At the customer's request, prepare a detailed cost estimate stating the SWH cost, the installation cost, the maintenance cost and eventually the additional work cost

5. **Agree on financing conditions**

   - ✓ Set the SWH payment terms
   - ✓ Fix a specific date for the SWH installation

III. SWH SYSTEM SITE DELIVERY

Before the delivery to the installation site, the installer has to check the following element, any messed one should be considered:

1. **Costumer's information:**
   - ✓ Address, access, person to contact, email, phone number….
   - ✓ Communicate these pieces of information to the delivery driver
   - ✓ Inform the costumer by the visit date

2. **SWH system pack check**

   - ✓ Collector: no visible damages, no broken glass nor moisture marks (rust)
   - ✓ Storage tank: capacity, type (direct or indirect circuit), no visible damages nor moisture marks (rust)
   - ✓ Accessories: presence of all accessories required for assembly, attachments and joints (hydraulic kit, insulation, fitting, supports, safety valve, magnesium anode, electrical heater, etc….)
   - ✓ Heat transfer fluid (antifreeze liquid) for indirect circuit
   - ✓ Required tools for the installation
   - ✓ Gas drain pipe, manual banding machine, etc…
   - ✓ Proper material handling equipment

3. **Documents to provide to the customer:**

   - ✓ Detailed invoice
   - ✓ SWH technical documents
   - ✓ SWH commissioning form
   - ✓ Supplier warranty card

4. Individual safety equipment

Safety shoes	
Work gloves	
Work clothes	
Safety helmet	
Eye protection	

Table 8: Individual protection equipment

5. Necessary tools and specific equipment

These following tools have to be prepared and carry out by the installer in order to ease his intervention, and make it more competitive and more efficient:

This list is a minimum that the installer should bring with him to the site of installation, this should allow to the installer to save time and to insure his service under quality approach.

REQUIRED MATERIAL LIST **قائمة المعدات اللازمة**

Item	Arabic	Photo	Use
1 Scale set type slide of 2x2.0 m or 2x3.0m	سلم		Access to the roof and installation of things at height
1 Set of rope (diameter 25 mm for ex) and/or any appropriate lifting mean	حبل سميك أو ما يعادله لرفع المعدات		Manipulation of tank, collectors and tools
1 high precision compass	بوصلة ذات فعالية عالية		Definition of orientation and fixing collectors position
1 Digital thermometer	مقياس حرارة رقمى مع حساس حرارة		Measurement of hot water temperature range (from 40 to 150 °C) minimum by sensor
1 Flow meter	مقياس تدفق من 0 إلى 10 لتر/دقيقة		Measurement of water flow for domestic use from 0 to 10 liters per minute
1 Plumbing tool box	صندوق مفاتيح خاص بأشغال التجهيز الصحي		Assempling and mounting components
1 Electric tool box	صندوق مفاتيح خاص بأشغال الكهربائية		Electric intervention and verification of electric issues
1 Set of oxy-flame bottle and/or express-type blowtorches for LPG welding	آلة لحام بالغاز السائل		Welding of pipes, connections and accessoiries Welding pipes during maintenance
1 Banding machine	آلة تقويس الأنابيب		Forming pipes and connection in site

1 Drilling machine (medium model)	آلة ثاقبة متوسطة الحجم		Squeeze metal structures and bolts and screws during installation
1 A larger model of a drilling machine equipped with appropriate strands of different diameters (for drilling walls of 50 cm thick)	آلة ثاقبة من النوع الكبير مختلفة القياسات		Make holes in the wall for the passage of pipes and wires
1 Pump for pressure measurement	مضخة لضغط الهواء		Checking pipes and connection leaks and testing facilities after filling the system
1 A cleaning pump for after-sales services and maintenance	مضخة لصيانة اللاقط لإزالة الكلس		Clean the pipes, collectors, tanks and connection during maintenance work

Table 9: Material list and functions

IV. HANDLING AND TRANSPORT

To fix handling needs, the installer has to check:

1. Intervention conditions:

- ✓ For all roofs commercial residential and industrial: means of access to the roof / terrace (elevator or staircase)
- ✓ Villa house or others: terrace accessible or not

2. Intervention materials:

- ✓ Handling and lifting equipment: scale, rope, pulleys…
- ✓ Personal protective equipment: gloves, shoes, helmet, eye protection glasses

V. INSTALLATION TASKS

Mounting a Solar Water Heater is carried out in several successive steps, which must be observed and followed. These steps are recommended by the manufacturer and documented in an assembly guideline. For both a thermosiphon and/or Forced circulation system with flat collectors or vacuum tubes, the assembly steps are performed in the following order:

Thermosiphon Flat plate collector case:

- Step 1: Support structure (frame) mounting
- Step 2: Collector mounting
- Step 3: Tank mounting
- Step 4: Concrete slabs fixation & overall stability check
- Step 5: Hydraulic and electric connections

Thermosiphon Vacuum tube collector case:

- Step 1 - VT: Support structure mounting
- Step 2 – VT: Reflectors and fixation tubes accessories mounting
- Step 3 – VT: Tank mounting
- Step 4 – VT: Vacuum tubes mounting
- Step 5 - VT: Hydraulic and electric connections

Forced Circulation Case

- Step 1- FC: Support structure (frame) mounting
- Step 2-FC: Collector mounting
- Step 3-FC: Concrete slabs fixation & overall stability check
- Step 4-FC: Tank installation in a technical local
- Step 5-FC: Install Pump station
- Step 6-FC: Install safety devices

- Step 7-FC: Install expansion tank
- Step 8-FC : Hydraulic and electric connections

1. Preliminary works and verifications

Each installation will have different requirements such as site access, solar irradiance, roof tilt & orientation, water quality, availability of trained manpower, customer's requirements for hot water etc.

The installer should ensure that all the above issues are addressed before the system is installed. The customer's information should be used by the installer of the system to ensure that the customer's needs have been addressed and the customer has been made aware of any problems or issues before hand

Important: on arrival at the site, check the installation components with the customer

1. **Check in presence of the customer**

    - ✓ Absence of visible damage from delivery and in particular on the collectors (flat plate or evacuated tube) and the tank

2. **The SWH installation have to comply with the following rules:**

    - ✓ Do not install the SWH directly on the roof waterproofing without mechanical protection. The SWH weight can damage the bituminous cover and cause serious damage (leaks and infiltrations)
    - ✓ Ensure that the safety risks on the site are assessed
    - ✓ A solar access site assessment should be completed and the customer should be made aware of any potential shading issues that might affect the yield of the system.
    - ✓ Avoid waterproofing rising at the acroterion (extension of the façade wall to the roof terrace), and use rigid sleeves for all crossings of foundation walls. (figure 10)

Figure 10: Rising waterproofing damaged by piping passage / Waterproofing roof damaged by steel structure

- ✓ Ensure the presence of expectations in accordance with the preliminary visit recommendations

Figure 11: New SWH connection have to take into account existing piping

- ✓ Choose a SWH location far from obstacles and close to a water evacuation
- ✓ Fix the orientation using a compass (due south)

Figure 12: Location and orientation choice of the SWH

- ✓ Collectors should be unpacked and handled with care. This is a point of particular importance if installing evacuated tubing collectors, as they are more fragile
- ✓ For a thermosiphon system, proper lifting equipment for the collectors and tank should be used as the combined system can be heavy to lift. Always have a work partner on the site for assistance or in case of an emergency situation
- ✓ The collectors should be kept at least 500 mm from all edges of the roof, both from a service and wind loading perspective
- ✓ The collectors should be mounted at the correct tilt and orientation for the particular location so as to ensure the best system yield. If that is impossible, the size of the collector will need to be increased to offset the lower yield due to improper orientation

- ✓ Gloves should always be worn when handling evacuated tubing-based collectors as the pipes inside can reach temperatures of more than 150°C. As a best practice, it is recommended to remove the covering material over the tubes only while commissioning the system

- ✓ Installation of a heat-pipe type evacuated tube collector's heat pipe system generally uses a thermal paste on the heat bulb for efficient transfer of heat and the rubber grommet needs to be moistened with soapy water so that the heat pipe can be inserted easily into the tube. On the other hand, U-tube based collectors come pre-assembled on to the manifold.

- ✓ The waterproof integrity of the roof should not be compromised at any time during or after the installation process. All the drill waste should be removed and the roof should be left in a clean condition

- ✓ It is advisable to photograph the roof space before and after the installation process as a way of verifying that the roof has not been damaged during the installation

- ✓ Installation of collectors should be done as per manufacturer's recommendations and guidelines

Important:

- It is advisable to be at least two people to carry out the installation
- It is advisable to mark the components and pre-assemble on the ground

2. Thermosiphon flat plate collector case

2.1 Step 1: Support structure mounting

Important reminders:

- Zinc or Zn/Al galvanized components should not be installed in direct contact with stainless steel, as galvanic reaction between the two metals can cause premature oxidation.
- Avoid using galvanized or zinc bolts to secure the frame to the root. Instead, use all stainless steel components and EPDM pads if using the angled frame. If standard corrugated iron roofing lag screws are used, they should have a rubber or nylon washer to prevent direct contact with the stainless steel frame


Steel structure is assembled on the floor


Lateral triangular steel structure are assembled on the floor


Structure reinforcement by X back arrangement /Fixing Track collector on triangular steel structure

Figure 13: Support structure mounting steps

2.2 Step 2: Collector mounting

Fixing and positioning the frame

Fixing collector on bottom and top track

Tight the fixation on bottom track

Tight the fixation on top track

Tightening by key and against key the top and bottom collector series connection

Figure 14: Collectors mounting steps

2.3 Step 3: Tank mounting and fixation

Fixing the rear tank steel structure

Fixing tank on the frame

Tank centered and horizontal position

Tightening tank fixation

Figure 15: Tank mounting steps

2.4 Step 4: Concrete slabs fixation & overall stability check

Tightening the X back fixation after tank mounting

Concrete fixing slabs with horizontal alignment verification of entire assembly - Use mortar to fix the slabs on the floor and screws to fix the frame on the slabs

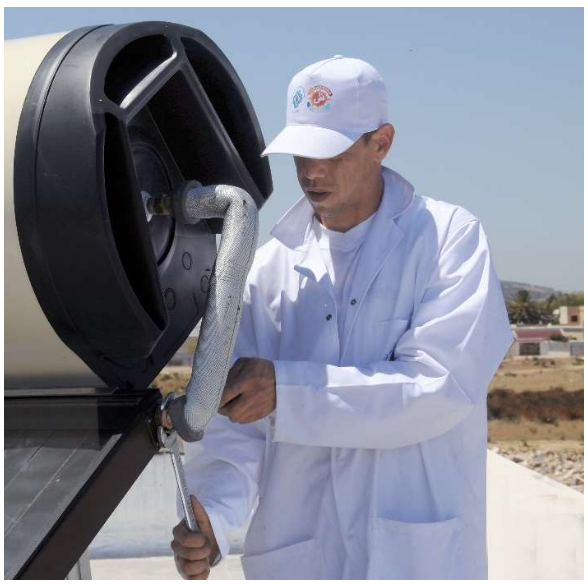
Figure 16: Concrete slabs fixation steps

2.5 Step 5: Hydraulic and electrical connections

Safety valve Installation and connection.

Note: The valve has to be mounted in vertical position to avoid blockage by limestone after operation

Connection and tightening of the Collector-Tank cold-water piping



Connection and tightening of the Collector-Tank hot water piping. It should be insulated by "Armaflex" and protected from the UV from the sun

Filling the tank with water for rinsing, purging and elimination of various waste and left-over.

Let the water run for a few minutes (2 to 5 minutes)

Connection of the electric back-up with compulsory earthing and setting the thermostat to a non-excessive temperature (45 to 50 ° C)

Shaping, cutting and welding of hydraulic connections to existing installation.

The hot water piping must be insulated

Figure 17: Hydraulic and electrical connections steps

3. Thermosiphon evacuated tube collector case:

In evacuated glass tube case, the tank is fixed after the metal support has been mounted. The steps follow one another as follows:

- Fixing the reflectors on the metal support.
- Fixing the tank to the metal support
- Fixing of the aluminum slide in the lower part with the fixing collars
- Insertion of the tubes after application of the thermal paste on the thermos-wells

Steps 1 and 5 are similar between flat and vacuum collectors. They will therefore not be illustrated in this section. We will present steps 2 to 4.

3.1 Step 1- VT: Support structure mounting

Same as Flat plate collector case

3.2 Step 2 – VT: Reflectors and fixation tubes accessories mounting

Fixing the reflectors on the steel structure

Fixing collars insertion

Figure 18: Reflectors and fixation tubes accessories mounting steps

3.3 Step 3 – VT: Tank mounting

Tank mounting and fixation

Figure 19: Tank mounting steps for VT system

3.4 Step 4 – VT: Evacuated tubes mounting

Preparation of vacuum tubes for mounting/application of thermal paste/ fitting of UV Rubber cap

Fixing up vacuum tubes in manifold inside the tank/ Fixing bottom tubes in aluminum slide

Figure 20: Evacuated tubes mounting steps

3.5 Step 5: Hydraulic and electrical connections

The same as flat collectors

4. Forced Circulation Case

Forced circulation systems are to be used whenever the storage tank cannot be installed above the collectors as described in chapter 1. The circulating pump is operated by a differential thermostatic control.

The assembly steps are performed in the following order:

- Step 1-FC: Support structure (frame) mounting
- Step 2-FC: Collector mounting
- Step 3-FC: Concrete slabs fixation & overall stability check
- Step 4-FC: Tank installation in a technical local
- Step 5-FC: Install Pump station (pump, flow meter, differential controller, pressure gauge)
- Step 6-FC: Install safety devices (safety valve, Air vent, expansion tank, thermostatic mixer valve)
- Step 7-FC: Install expansion tank
- Step 8-FC: Hydraulic and electric connections

4.1 Step 1-FC to step 3-FC

The same as flat plate collector case

4.2 Step 4-FC: Tank installation

The storage tank has to be installed in a technical local. The installer must to consider several factors when placing the storage tank. It would ideally be installed as close to the array collectors as practical and should be positioned such that connection to inlets and outlets are easy to complete. The tank has to be placed on a level surface that can adequately support the filled weight of the tank. Make sure that the surface is flat.

The distance between the tank and any wall should be minimum 50 cm, in order to make possible the assembly of various components that are mounted on the tank (electronic control board, electrical element).

It need minimum 60 cm between the ceiling and the top of the tank in order to conveniently replace the magnesium anode rod.

Add an insulating blanket to a tank (a minimum of 2 to 3 inches of fiberglass equivalent is needed)

Figure 21: Storage tank location for forced system

4.3 Step 5-FC: Install pump station

Pump station has been manufactured for forced circulation system. This station incorporates a differential controller, a flow meter, gauges and non-return valves. It must be installed onto the wall and the pump on the cold line, which runs between the lower part of the tank to the lower inlet of the collector(s) and a non-return valve must be installed next to the pump.

Circulation pumps are operated by controllers that measure the temperature at the solar collector and the storage tank to determine whether pump operation is appropriate or not.

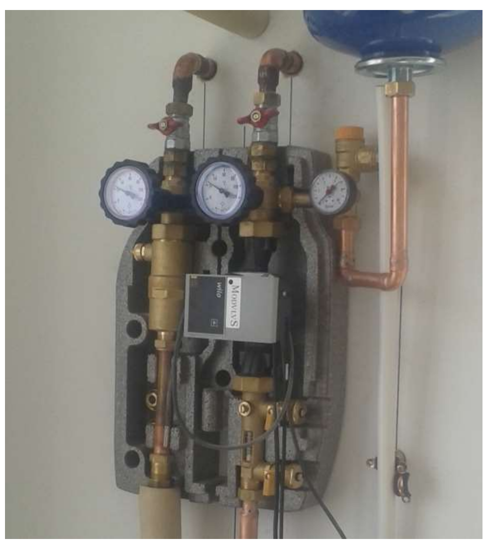


Figure 22: Example of pump station mounting onto wall

Most system manufacturers will provide designated connection points for the temperature sensors. The connection points are typically located near the hot water output at the collector array and near the bottom of the storage tank (Figure 23)

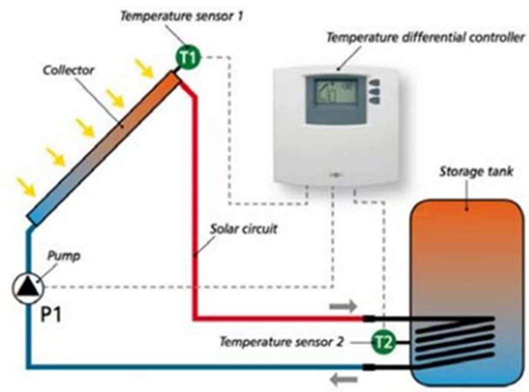


Figure 23: Standard configuration of temperature sensor placement for a differential controller

4.4 Step 6-FC: Install safety devices

All safety devices (safety valve or temperature pressure relief valve, Air vent, Thermostatic mixing valve, isolation valve), should be installed in in their proper locations as shown in figure 24. Also, some of these valves are optional and are only required only under certain circumstances

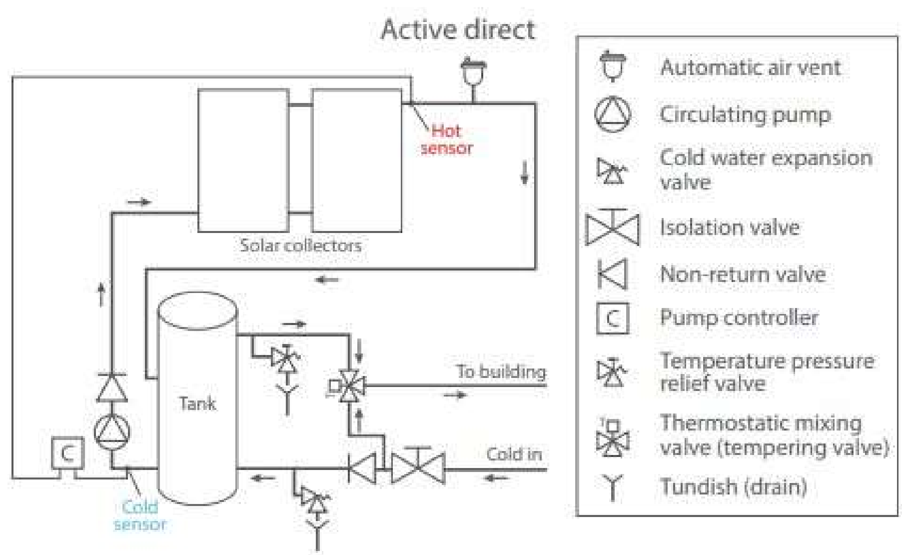


Figure 24: Standard location of safety devices

4.4.1 Air vent

Most solar systems may have valves on the roof for venting, filling, and other aspects of operation. In order to eliminate air traps, air-vent valves must be at all high points in the system where air is most likely to accumulate

If multiple collector arrays are used, an air vent should be installed on each array. The system must be piped to prevent air traps and allow for gravity draining

4.4.2 Safety valve or pressure relief valve

The collector, or tanks with heater elements (connected or not), and even tankless water heaters are pressure producing fixtures, so if any can be isolated, there must be a pressure relief valve somewhere in that portion of the isolated loop that contain them. Most solar water heaters have the pressure relief valve for the collector loop installed at the collector.

4.4.3 Isolation valve

The solar system must have isolation valves – one on each side of the solar loop. An isolation valve should be provided between the pump and the tank on the feed line and between the non-return valve and the tank on the return line.

4.4.4 Drain valves (Filling and rinsing valves)

Drain valves should be provided on both sides of the collector loop. When installed above the non-return valve it can be used to back flush the collector and when installed below the pump it can be used to drain the pump for service.

4.4.5 Thermostatic mixing valve

If a standard "mixing" valve is to be installed, be sure it is below the top of the tank.

Note :

The valves should be installed in such a way that there is ample accessibility for maintenance and troubleshooting

4.5 Step 7- FC: Install expansion tank

Mount the expansion tank in a convenient location close to the pump station (figure 25). Then connect the expansion tank connection line ends to the pumping station and on the cold line.

Figure 25: Expansion tank location close to the pump station

4.6 Step 8-FC: Hydraulic and electric connections

The electric connection in a forced circulation system is wiring the pump and the differential controller. It is recommended that all wiring to the pump and controller is installed in conduit to protect them from damage. If the pump is connected to an outdoor general power outlet, ensure that the connection is waterproof. The thermal sensor cable run from the roof should be secured to beams and along the wall for support.

It is recommended also to put the differential controller in an electrical box with a switch and fuses. The box should be accessible for maintenance and easy to operate. A qualified electrician should perform all wiring according to local codes. The wiring from the differential controller to the sensors carries a very low voltage and is not dangerous when wired correctly.

Concerning hydraulic connection, piping provides the path for fluid transport in the system. The piping must be compatible with system temperatures, pressures and other components. Most systems use copper piping because of its durability, resistance to corrosion and ability to withstand very high temperatures

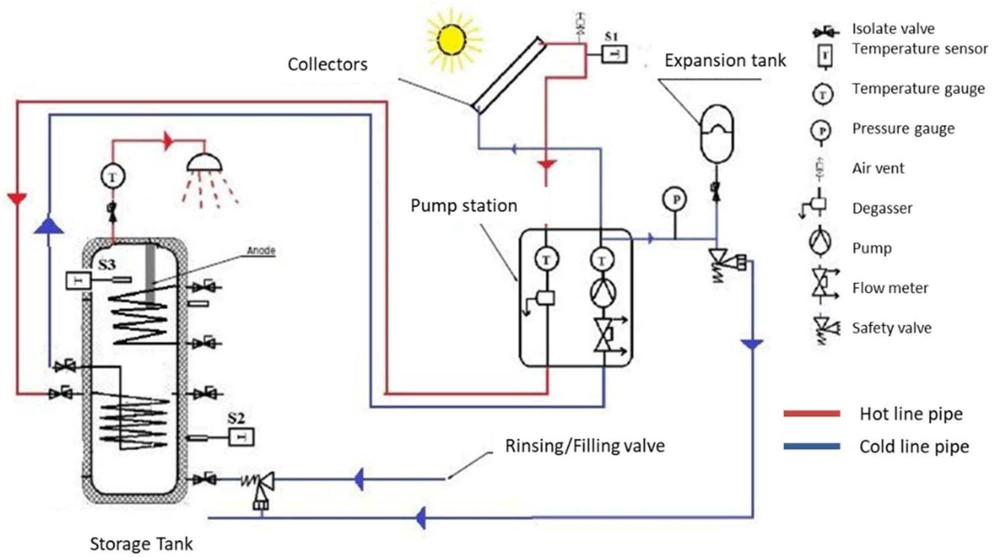


Figure 26: Example of a Forced circulation hydraulic connection

VI. COMMISSIONING

After the system is installed, it must be checked and tested to ensure that it is functioning properly and safe to use. System commissioning involves:

- ✓ Visual inspection of the installation to ensure it is well done
- ✓ Testing of various operational parameters as per the manufacturers' manuals
- ✓ Educating the user
- ✓ Issuing of user-guide or one provided by the manufacturer
- ✓ Completion and signing of the commissioning form and certificate.

It is desirable to commission a SWH system on a sunny day with the collector temporarily covered. The end-user should be advised to let the commissioned system tune up for two days before using it

1. What to check for during commissioning?

The following aspects should be checked properly during commissioning:

- ✓ Visual inspection of the system installation and workmanship to ensure proper installation and that the area is left clean.
- ✓ Ensure that there is no obstacle (building, tree, etc.) shading the solar collector or a part of it.
- ✓ Ensure ladders, scaffolds or safety tapes installed during installation are removed from the site. Any dug outs should also be filled up.
- ✓ Verification of whether the installed components meet the stated specifications
- ✓ The system should be flushed out with cold water to ensure that any dirt inside the piping is removed.

- ✓ Ensure that there is no blockage and that the safety group, safety valve, Air vent and thermostatic mixing valve are properly installed and are easily accessible.
- ✓ Ensure that there is no air trapped inside the collector and the storage tank
- ✓ Testing for leaks should be done by carrying out a test run and pressurizing the system for at least 24 hours before handing over to the owner.
- ✓ Verify that the back-up heater is working as required and confirm the correct operation of the thermostats and safety controls.
- ✓ The controller should also function properly and be able to measure the output water temperature accurately
- ✓ Verify that the system is well insulated to reduce heat losses.
- ✓ Check the fluid level for the closed circuit (indirect systems) and fill it, if necessary.
- ✓ Check all the pipes and ensure they are well placed and adequately secured or clipped.
- ✓ Verify that the various parameters such as the flow rate, pressure and temperature of the various components are as designed. The variable settings critical to the performance of the system are adjusted, set and recorded
- ✓ Verify the electrical backup (if used) connection (Minimum electrical cable section: 2.5 mm2; Compulsory earthing; Protection devices by a 30 mA differential circuit breaker)
- ✓ Ensure that the thermostat is set at a non-excessive temperature (between 45 ° C and 55 ° C) for electrical backup

Note: The electrical back up should be tested after the leak test is done and when the storage tank is full.

2. Thermosiphon case

The hydraulic circuits filling depends on the SWH type (direct or indirect system) and not on the collector type. The following table summarizes the steps to be followed according to the thermosiphon type:

Direct SWH system	Indirect SWH system
1. Open at least one hot water tap in the house 2. Open the safety group cold water inlet to fill the tank and collector 3. Leave the hot water tap open until the air bubbles have completely disappeared, then close and allow the tank to build up pressure 4. Check any leakage on the pipeline 5. Open the hot water tap again to check that all air is purged from the system. 6. Check all tightening connections if necessary	1. Follow the steps 1-4 of the direct system list to purge all air from the storage tank 2. In an indirect system, the working fluid solution that is circulated may need to be filled in depending on the type of system. Follow manufacturer's instructions for filling collector loop with glycol. This generally involves cracking a nut or a fitting at the highest point in the collector loop to allow air to escape while glycol is filled from a low point in the system. Glycol is filled either by a bucket connected via a hose and held at height over the system, or with specialized manual pumps 3. Open the hot water tap again to check that all air has been purged from the system. 4. Check the nominal cold filling pressure

	5. The pressure have to remain constant for a few minutes to ensure the tightness of the closed circuit

Table 10: steps for filling of SWH systems (direct and indirect)

3. Forced circulation case

For Forced circulation the commissioning steps are:

3.1 Purging air from secondary circuit (circuit between storage tank and water tap house)

Follow the steps 1-4 of the direct system list to purge all air from the storage tank.

3.2 Charging the primary circuit (Solar circuit)

1. Before charging the close loop circuit you must make sure that the air vent on the solar panels is not installed. The filling valve is turned on and the close loop line is charged until water starts coming out of the air vent inlet on the solar panel outlet. At the same time the static pressure in the close loop is observed on the manometer on the control board

2. Air vent is installed on the system. The charge valve is turned on again and water is let fill the system completely until the manometer reads 1 bar over the static pressure

3. Observe all fittings to make sure that there is no leakage. In case of leakage, fix all fittings again and do not move on to the next step until you make sure that no leakage occurs

4. Turn on the rinsing valve to discharge the amount of water that will be replaced by heat transfer fluid (antifreeze fluid)

5. Remove the air vent on the roof to pour in the desired amount of heat transfer fluid. Put the air vent again

6. Wait for a while for the diffusion of the heat transfer fluid. Then charge the system through the filling valve until the manometer displays 1 bar + static pressure

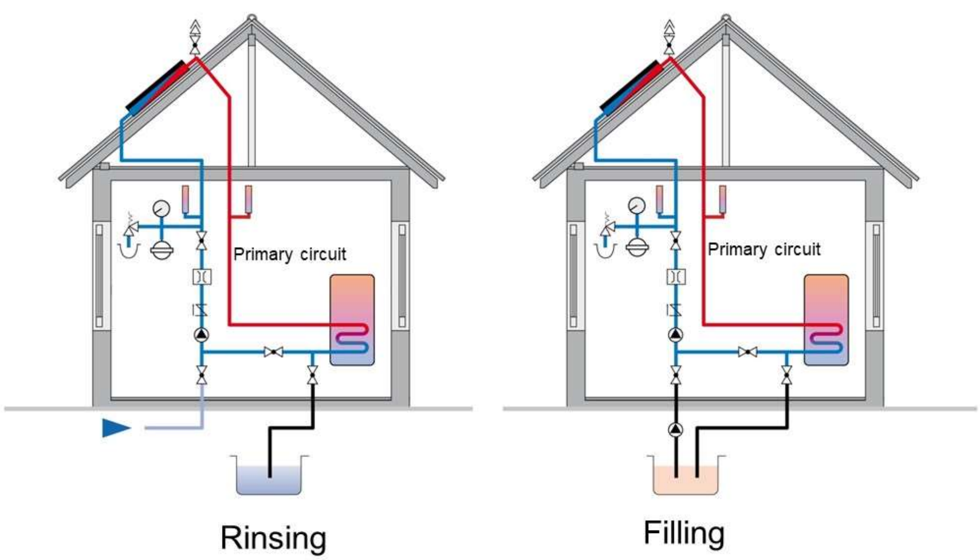


Figure 27: Rinsing and filling process

3.3 Checklist control

The following list gives the points to be checked for a quality control before the commissioning of the SWH installation:

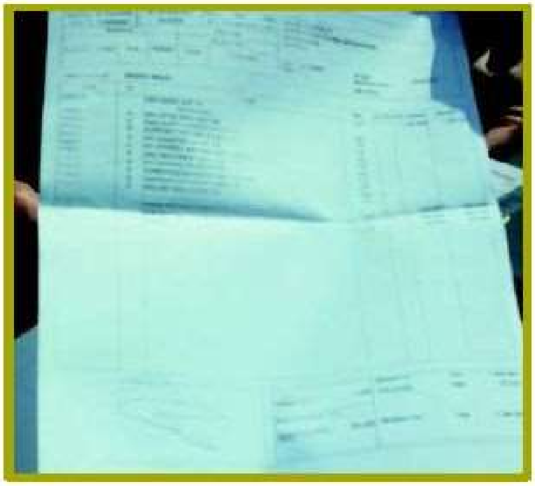
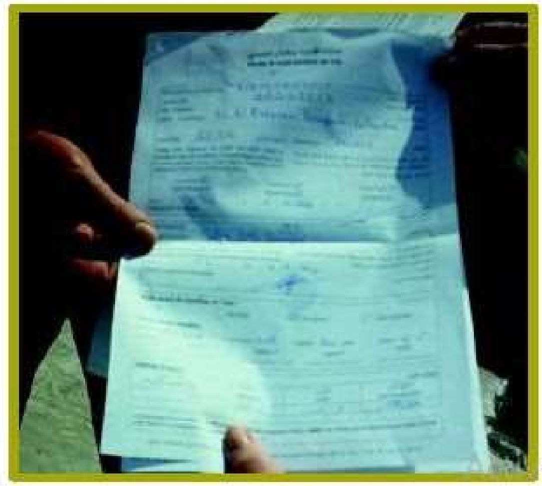
- Set all pumps to a given speed or power settings
- Set the volume flow to a value given in all circuits
- Adjust all pressure settings
- Set all parameters for system regulation
- Calibrate the measurement system
- Test / adjust pressure safety valves (safety valves)
- Check the temperature indicated on all thermometers
- Test all control operations
- Test motorized pumps and valves
- Check the temperature difference at the heat exchangers
- Check for leaks
- Test all fuses, switches and electrical outlets
- Test the warning lights and audible alarms
- Check the antifreeze fluid

VII. MAINTENANCE AND GUARANTEE CONTRACT

The installer has to give the customer a guarantee voucher in the form of a maintenance contract and total guarantee (MCTG), specifying the cost and the schedule of the maintenance operations. The guarantee card must mention, at least the following information:

Customer Name:	Address :
Installer :	Manufacture date :
Collector serial number:	Installation date :
Tank serial number :	Commissioning date :

Table 11: guarantee sheet

Delivery to the customer the detailed invoice and the installation sheet

Presentation of technical sheets

Figure 28: Signature of the maintenance and total guarantee contract by the customer and the installer

PART III: GOOD PRACTICES AND RECOMMNDATIONS FOR PROPER AND CORRECT INSTALLATION

This third part includes 13 practices presented in the form of:

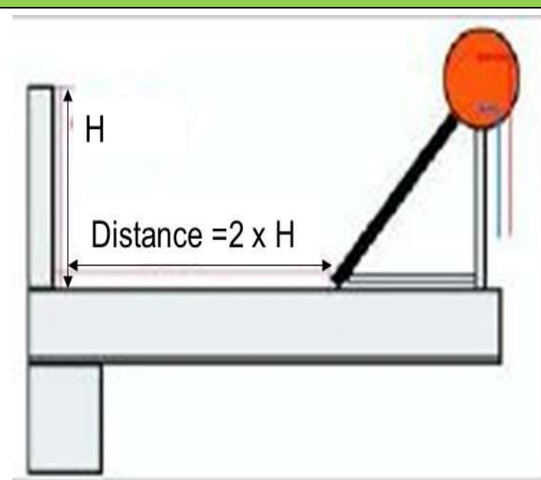
- Proscribed practice: describes the errors that the installer could make during the installation, these practices have to be avoided to guarantee an installation in accordance with the standards and the rules of the art
- Good practice: constitutes the solutions to follow to avoid errors and installation abnormal conditions

In addition to the prohibited practices, good installation practices are presented, with a view to optimum commissioning and operation. The operations mentioned constitute an essential complement to the technical specifications to disseminate good practices, ensure user satisfaction and reduce breakdowns and abnormal conditions

Practice 1: Transport & handling

Proscribed Practice	Good Practice
	
Handling and transport remain the weakest link in SWH installation work, particularly for work at height level. Unsuitable devices are often lacking, which causes damage to components (collector, tank,…) and sometimes serious accidents	the Tank and collector lifting have to be done with an appropriate rope and pulley and not with a scale The installer have to first find out about the access conditions

Practice 2: Shadow and orientation

Proscribed Practice	Good Practice
	
Obstacles reduce considerably the solar energy quantity captured. Particular attention has to be accorded to the surrounding space: vegetation, future extension… With orientation, obstacles are fundamental elements for making a solar installation profitable.	The SWH have to be installed with south orientation and away from obstacles at minimum distance of : 2 x H (obstacle height)

Practice 3: Non-compliance of the electrical connection

Proscribed Practice	Good Practice
	 • Differential Circuit breaker :30 mA • Minimum electrical cable section : 2.5 mm2
The electrical back-up connection of a thermosiphon SWH is often poorly executed. For negligence or ignorance, the back-up is connected directly without prior protection. Failure to respect the electrical cables section and the absence of earthing can cause accidents (fire risk)	The electrical back-up has to be connected to the installation in accordance with the standards. The main requirements are the backup power supply protection, the anode earthing and the cable section (minimum 2,5 mm2). Failure to respect the polarity can cause current leaks in the tank so can accelerate its corrosion

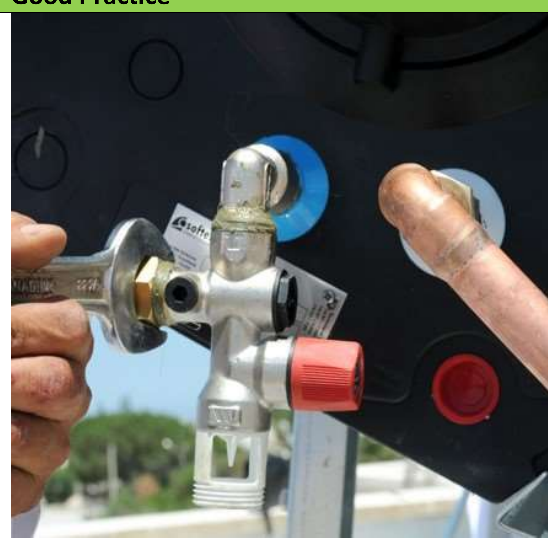
Notice:

Make sure that the grounding point on the magnesium anode is connected to appropriate grounding of the building. The anode must be grounded even if the appliance is not connected to electric power source. Operation with anode not grounded will greatly shorten the life of the tank and will exclude warranty coverage

Practice 4: Hot water piping material

Proscribed Practice	Good Practice
	
Multilayer pipes or other material that cannot withstand temperatures exceeding 90 ° C are to be avoided	The use of insulated copper is the best alternative. Copper has advantageous thermal and sanitary properties and is particularly resistant to the high temperatures

Practice 5: Safety group position

Proscribed Practice	Good Practice
	
A horizontal position of the safety group exposes any SWH user to the burns risk coming from the hot water jet	A vertical position of the safety group eliminates any burns risk coming from hot water jet and avoid blockage by limestone after operation

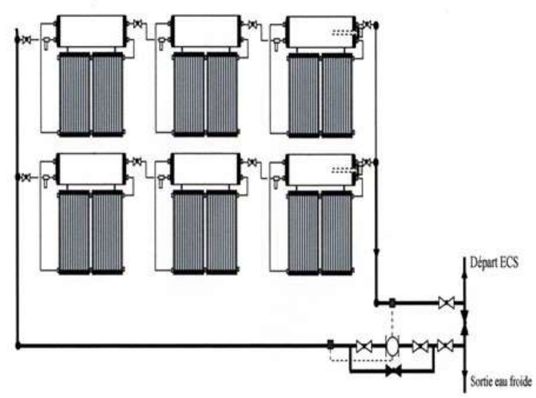
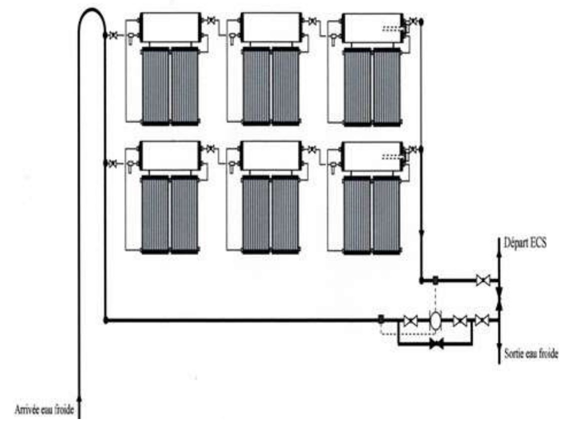
Practice 6: Concrete fixing slabs

Proscribed Practice	Good Practice
	
The SWH fixing to a rigid and stable support is imperative to resist to climatic bores. Inadequate support or bad fixation reduces the SWH stability and can damage the roof waterproofing	The frame structure have to be fixed by appropriate screws in concrete slabs

Practice 7: Waterproofing connection

Proscribed Practice	Good Practice
	
Teflon offers poor sealing because it is not suitable for high temperatures observed in solar circuits	The use of **hemp or tow**, on the solar hot water circuit offers better sealing

Practice 8: Tickelman loop

<table>
<tr><th>Proscribed Practice</th><th>Good Practice: Tickelman loop</th></tr>
<tr><td></td><td></td></tr>
<tr><td>A series-parallel assembly must respect a set of rules, including the hydraulic balancing of the rows. The water passes through the least resistant circuit. So poor irrigation for the most distant rows</td><td>A series-parallel assembly in Tickelman loop way provides a better mass flow balance in circuit even for far rows</td></tr>
</table>

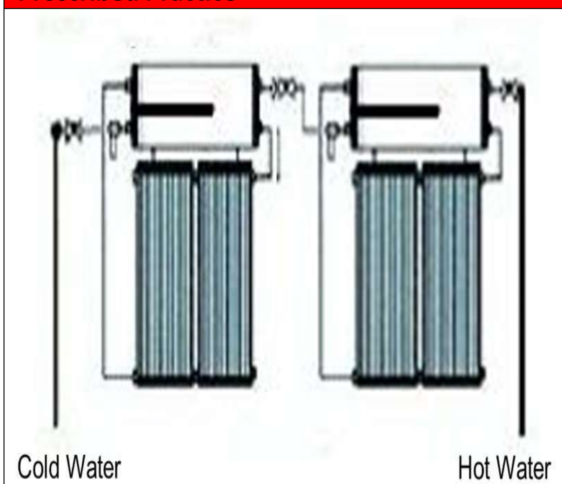
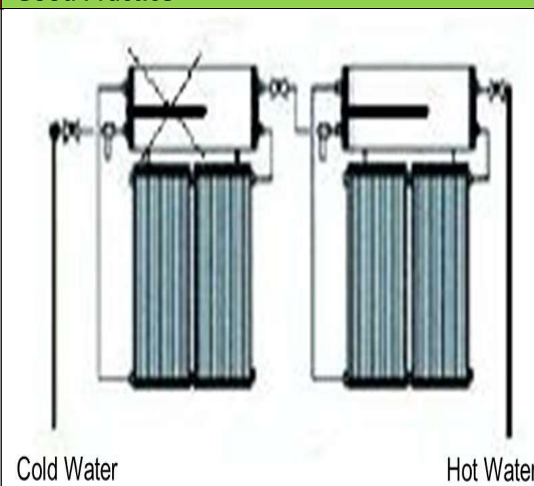
Practice 9: Thermostatic Mixer utility

<table>
<tr><th>Proscribed Practice</th><th>Good Practice</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Solar hot water reach very high temperatures, exceeding 70 ° C. Direct connection to the hot water supplies of sanitary devices exposes users to burns risk</td><td>The alternative is to install a Thermostatic mixer on the hot water outlet circuit. It save hot water and prevent accidental burns</td></tr>
</table>

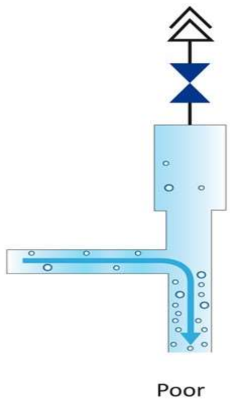
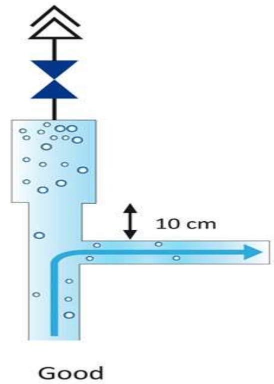
Practice 10: Roof waterproofing

Proscribed Practice	Good Practice
	
The crossing of the waterproofing system against wall capillary rise is an anomaly that is often observed. A perforated seal promotes water infiltration and causes damage	Avoid waterproofing rising at the acroterion (extension of the façade wall to the roof terrace), and use rigid sleeves for all crossings of foundation walls

Practice 11: Electrical backup position for SWH in series case

Proscribed Practice	Good Practice
	
In a series installation, the electrical back-up on each SWH or only on the first SWH will reduce the financial profitability of the installation.	The electrical back-up have to be installed on the last SWH so we will reduce its electrical consumption and ameliorate the installation profitability

Practice 12: Purge valve or Air vent position for indirect system (thermosiphon and Forced circulation)

Proscribed Practice	Good Practice
	
In this case steam or vapor leaves the collector with difficulty (The vapor always tends to rise) because the circulation direction of the heat transfer fluid in primary circuit is from top to bottom. This case is happened when the Air vent is positioned on the last collector in series	When the Air vent is positioned on the first collector in series, the vapor will easily leave the collector because the direction circulation is from bottom to top

Practice 13: Piping insulation

Proscribed Practice	Good Practice
	
The hot water piping thermal insulation is sometimes neglected. Due to ignorance or concern for economy, the installer neglects this fundamental point for a solar installation. The heat losses are significant in particular for long pipes running outside the location. Some installers use thermal insulation that is not very resistant to external hazards (rain, UV, humidity,..)	All the hot water pipe has to be insulated by an insulator which resists to high temperatures, to UV, to humidity, to attacks from rodents and of course, have sufficient thickness (at least equal to the diameter of the pipe). Mechanical protection by aluminum sheet is a good practice for large installations

PART IV: SOLAR WATER HEATER MAINTENANCE

This part concerns the maintenance instructions to be followed by the installer and the customer to ensure a better use of the SWH, these maintenances are of three types:

- Systematic maintenance provided by the customer
- Preventive maintenance provided by the installer; during periodic visits carried under the guarantee period
- Corrective maintenance, provided by the installer in the event of a breakdown.

Eligible solar water heaters require only user monitoring, proper operation, and certain simple maintenance and preventive maintenance operations.

Solar systems are built to last as long as any plumbing system; they have to be designed to withstand bad weather. They are reliable and require little maintenance. This is in particular the case of thermosiphon system type. Routine checks will detect any problems with the solar system in time. Maintaining them will maintain their performance and extend their service life. The installer has to advise his customer, distinguishing between the following interventions:

Systematic maintenance provided by the customer

The installer has to explain, or even demonstrate to the customer, basic maintenance operations which improve the SWH performance and avoid unnecessary costs and travel for minimal interventions, which the customer can provide

Preventive maintenance provided by the installer during the periodic visits insured under the guarantee

The installer has to specify that under the guarantee interventions are paid. A detailed invoice will be communicated to the customer, specifying the supply and installation costs of the repaired or replaced components.

Corrective maintenance, provided by the installer in the event of a breakdown

The installer has to specify to the customer the following points:

- ✓ The maximum intervention time (generally around 72 hours)
- ✓ The intervention costs: diagnostic transport, workforce and components cost

I. SYSTEMATIC COMMON MAINTENANCE PROVIDED BY THE CUSTOMER

- ✓ After bad weather, detect any breakage of glass, piping, or insulation
- ✓ If necessary, clean the solar collectors (flat plate or evacuated tube) with a cloth and soapy water

Figure 29: Cleaning dust from dirty Collector Surface

- ✓ Periodically check the condition and solidity of the supports. Check for any leaks.
- ✓ In flat glass collectors, monitor the appearance of humidity. If so, check the seal between the frame and the glass. It is also necessary to check that the condensation holes placed below the collector are clear

Figure 30: Condensation holes under the glass

- ✓ Check the safety group by turning the purge button. (it is normal for the valve to "drip", in case of high water temperature)

Figure 31: Purge button operation

- ✓ Visually check for shading of the collectors/evacuated tubes during the day (mid-morning, noon, and mid-afternoon) on an annual basis. Shading can greatly affect the performance of solar collectors. Vegetation growth over time or new construction on your house or your neighbor's property may produce shading that wasn't there when the collectors were installed

II. COMMON PREVENTIVE MAINTENANCE PROVIDED BY THE INSTALLER

Proceed to the following elements verification:

Component inspection	**Action(s)**
Flat plate Collector/ evacuated tube glazing and seals	Look for cracks in the collector/ evacuated tube glazing, and check to see if seals are in good condition
Plumbing, pipework, and wiring connections	Look for fluid leaks at pipe connections. Check pipe connections and seals. pipes should be sealed with a mastic compound. All wiring connections should be tight
Piping and wiring insulation	Look for damage or degradation of insulation covering pipes and wiring
Roof penetration	Flashing and sealant around roof penetrations should be in good condition.
Support structures	Check all nuts and bolts attaching the collectors to any support structures for tightness Check the metal condition (anti corrosion paint if necessary)
Safety valves (safety group, safety valve…)	Make sure the valve is not stuck open or closed
Pump (for Forced circulation)	Verify that distribution pump is operating. If you can't hear a pump operating, then either the controller has malfunctioned or the pump has broken
Regulation (for Forced circulation)	Check the regulation is operational Data displayed by the regulation is plausible Temperatures displayed by the regulation are plausible (periodically measure the resistance of temperature sensors)
Antifreeze fluid (for indirect system)	Check and / or change the antifreeze fluid in the closed circuit. The frequency of this operation is often reported in the supplier's manual
Storage tank	Regular drain and clean the Tank storage to prevent the risk of bacterial proliferation Check for cracks, leaks, rust, or other signs of corrosion
Magnesium anode	Check the anode state. When the anode reaches a level of wear, its diameter becomes very small, which causes leaks at the clamping nut. This problem is accelerated by the non earthing of the anode (quite frequent case)
Back up (electrical case)	Check any damage to the sleeves, electrical cables Check that the electrical connections and grounding are in good condition. Check the thermostat setting Check the condition of the electric resistance (scale deposit)

Table 12: preventive maintenance to be provided by installer and maintainer

Important:

In the case of both preventive and curative maintenance or repair, cut off the cold water supply and electricity before making any manipulation or operation

Electric resistant cleaning

Limestone extraction

Tank drain and clean

Magnesium anode control and replacement

Collector orifice drain control

Figure 32: Some Examples of SWH preventive maintenance

III. COMMON CORRECTIVE MAINTENANCE PROVIDED BY THE INSTALLER

Important: Safety provision during maintenance operations

Stagnant collectors can reach temperatures the higher they are efficient. Even a flat plate collector can go into stagnation at a temperature above 100 ° C. There is a danger of burns from contact with metal parts close to the absorber. It is recommended to wear gloves and use a cloth to cover the collectors during the intervention. For the same reasons, in order to avoid thermal shocks which can damage the components and cause burns, it is recommended never to fill or restart a drained system which has just stagnated in direct sunlight

1. Case of low temperature for produced water

Main sources:

- ✓ Strangulation
- ✓ Canalization clogging
- ✓ Heat losses
- ✓ Other sources (bad irrigation, shadow, antifreeze fluid lack,…)

1.1 Strangulation

Clogging between the collector and the tank reduces and prevents circulation between them. Heat transfer to the cold water in the tank is no longer ensured. A blockage check is important. Note that this problem particularly affects thermosiphon direct system. To know it, you just have to put your hand on the collector glass; if the surface temperature of the glazing is high, this means that there may be a blockage. For indirect system (thermosiphon and Forced circulation), this phenomenon is rarely observed since the primary circuit is filled with an antifreeze fluid poor in limestone

1.2 Pipework clogging (Canalization clogging)

- Check if the collector-tank return is blocked even at the level of the tank tip

Figure 33: Pipe clogged with limestone

- Check if a pipe is bent due to improper tightening or bending. Check the Collector-Tank connection

Figure 34: Pipe bent due to incorrect tightening

- Check if the collector is not completely clogged by limestone

1.3 Heat losses

For this case, the produced water temperature is cold despite the absence of water withdrawal. The failure origin can come from limestone formed at the non-return safety group and jam the spring. To resolve this failure, proceed as follows (figure 34):

- ✓ Open the non-return safety group
- ✓ Remove the limestone without damaging the seal or the valve spring.
- ✓ Check that the spring is working properly.
- ✓ A descaler can be used to clean the mechanism. The components will be drowned in a dilute descaling solution, then washed with water.
- ✓ When mounting put a little grease on the joint

Figure 35: Descaling the non-return safety valve mechanism steps

1.4 Other sources

- ✓ Check the good collector irrigation. Improper installation induces improper irrigation of the collector and consequently a natural circulation water blockage.
- ✓ Check the presence of the heat transfer fluid (antifreeze) in the primary circuit (in indirect thermosiphon case)
- ✓ Check the absence of obstacles (New extension, vegetation etc.) which reduce the sunshine radiation received by collectors
- ✓ Vacuum losses for vacuum tube collectors

2. Water leakage cases

2.1 Leak at the safety group

Limestone blocks the safety group causing leaks and more or less continuous flow. These leaks are detrimental to the flat roof in the event of stagnation

Figure 36: Safety group leaking

2.2 Leakage at the connection between collectors

Check if there is a problem when tightening the connecting nipple between collectors. Check the seals at this connection

2.3 Leak under glass (for flat plate case)

Check the collector connections which may be causing this leak. But if the leak is internal and visible, the collector has to be replaced

Figure 37: Under glass collector leaking

2.4 Leak in the tank

Check the tightness of the flange (seal range well tight). If the leak is at the anode, the anode has to be changed. If the leak is at the dust jacket (ferrule leak) change the tank

Figure 38: Tank leaking

3. Electric problem case

In most cases, it needs a simple restart of the thermostat by pushing the red safety button (figure 38), because during summer periods the temperatures in the solar water heater can exceed 90 ° C, which causes the thermostat to react as if the set point has been exceeded. At the return of the cold months the user wanting to start his resistance finds it out of use and concludes with a breakdown

Figure 39: Thermostat rearmament

In some cases, the customer claims that the electric backup works for short periods without heating the water. This proves that the heating element (electric resistant) is completely confined in the limestone. In this case, the electric resistance must be cleaned and the limestone removed

Figure 40: Electric back up covered by the limestone

Note:

Never forget to replace the flange joint. Check that electrical connection box is no longer sealed. This problem is quiet common for boxes placed on the bottom generator tank

IV. BREAKDOWNS AND FAILURES DIAGNOSIS

1. Thermosiphon case

Issue	Thermosiphon Direct System		Thermosiphon Indirect System		Cause (s)	Corrective Action (s)
Collector type	**Flat Plate**	**Evacuated Tube**	**Flat plate**	**Evacuated Tube**		
Leakage at the connections	X	X	X	X	Connections clogged with limestone	Clean/replace connections
	X	X	X	X	Defective joint	Replace joint
Not hot water	X				Tube grid collector clogged with limestone	Descale and clean the tube grid collector
			X	X	Lack of antifreeze fluid	Control the level/add antifreeze fluid
			X	X	Leak at expansion vessel	Replace expansion vessel and add antifreeze fluid
	X	X	X	X	Absence or bad state of pipework insulation	Replace/Insulate hot water canalization
		X		X	Vacuum losses in vacuum tube	Replace defective evacuated tubes
	X	X	X	X	Safety group blocked at open position	Clean/replace safety valve
Not hot water in winter	X	X	X	X	Backup electrical resistance doesn't work	Clean/replace electrical resistance
	X	X	X	X	incorrectly set temperature at thermostat	Set the temperature at 50°C
	X	X	X	X	Defective thermostat	Replace thermostat

Not hot water pressure	X	X	X	X	Safety group blocked at closed position	Clean/replace safety valve
	X	X	X	X	Inlet hot water flow pipe clogged with limestone	Clean/remove limestone
Humidity in collector	X		X		Defective collector joint	Replace defective joint
	X		X		Condensation holes are blocked	Unblock holes
Lack of hot water pressure	X	X	X	X	Significant pressure losses Large scale deposit Pressure fault in network	Descale and purge collectors and Tank Check and clean safety group
High temperature difference between collector and water tank	X				Tube grid collector clogged with limestone	Descale and purge tube grid collector
			X	X	Heat exchanger covered with limestone	Descale and clean heat exchanger
Noisy installation	X	X	X	X	Pressure drop or charged water	Purge and increase pressure if necessary
Back up electrical resistance doesn't work at the cold season start	X	X	X	X	Thermostat switched off for safety (Above 90°C thermostat deactivates electric resistance)	Restart thermostat

Table 13: Corrective maintenance for Thermosiphon systems

2. SWH Forced circulation case

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
No hot water	Auxiliary Heater (electric)	No power to auxiliary back-up heating element	Check high temperature protection and push reset button above thermostat. (Use caution when dealing with electricity.)
	Auxiliary heater (gas)	Failure to ignite	Check pilot light mechanism
		Safety switch malfunctioning	Check and replace
		Defective automatic pilot valve	Check and replace
		Pilot valve defective	Replace
		Loose thermocouple connection	Tighten
		Defective thermocouple	Replace
		Improper pilot gas adjustment	Adjust
	Auxiliary heater thermostat	Thermostat defective	Replace
	Mixing valve	Improper adjustment	Check water temperature at house faucet and adjust valve setting
		Valve defective	Replace or remove from system plumbing
	Distribution piping	Leak (under slab or in walls)	Locate leak and correct
Not enough hot water	Sensors	Improper wiring, cuts, or loose connections	Check and correct

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Not enough hot water	Auxiliary heater	Undersized for hot water demand load	Replace
		Storage tank losses	Insulate tank
		Thermostat set too low	Increase set point temperature
		Element failure	Replace element
		Thermostat failure	Replace thermostat
		Lower element disconnected in conventional rank system	Reconnect element and set thermostat to low temperature
	Non return valve	Heat loss due to defective or improperly installed check valve	Inspect valve and repair or replace
	Collector(s)	Absorber coating degradation	Recoat or replace absorber (Contact manufacturer)
		Area undersized	Increase collector area (See FSEC Sizing Guide)
		Excessive condensation	Inspect and repair glazing seal, pipe gaskets and weep holes and vents at bottom
		Glazing dirty	Clean as required
		Leaks	Repair
		Orientation	Check orientation. Face collector " south
		Outgassing inside collector glazing	Clean surface and contact manufacturer
		Plastic glazing deteriorating	Replace
		Reduction of glazing transmission	Replace glazing

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Not enough hot water	Collectors	Shaded by tree(s) or building(s)	Remove obstacle and shading or relocate collectors(s)
		Improper tilt	Check tilt for geographic area. Set " 15° of latitude
		Improperly plumbed	Compare with system schematic in installation manual
	Differential controller	Improper operation (cycling, late turn on)	Check sensor placement and insulation from ambient conditions
		Faulty sensors or controller	Conduct resistance measurement or check by placing sensors against hot and cold-water glasses and watching pump function. Replace defective units.
		Improper wiring or loose connections	Compare with system schematic. Check for proper connections. Seal all splices against moisture.
		Shorted sensor wiring	Check wiring for breaks, metal contact, water exposure and corrosion.
	Heat exchanger	Sized too small	Replace with properly sized heat exchanger. Insulate.
		Scaling, clogging	Back flush, clean
	Isolation valves	Closed	Open
	Mixing valve	Improperly adjusted	Reset temperature indicator
	Owner	High water usage	Check system size and discuss solar system and owner's lifestyle
	Storage tank	Too small	Install larger tank
		Storage losses	Insulate tank with insulation blanket

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Not enough hot water	Piping	Clogged with corrosion or sediment	Replace excessively corroded components
		Insufficient insulation	Add insulation where required
		High heat losses	Check insulation for splits, deterioration, absence
		Nighttime thermosiphoning	Check for pump operation at night.
		Improperly plumed	Compare with system schematic. Check flow direction.
		Isolation valves closed	Open valves
		Isolation valve failure after closing	Replace valve
		Flow blockage	Flush system. Check effluent for dirt/scaling.
		Low system pressure	Check pressure gauge. Refer to owner's manual for correct pressure.
	Pump	No power	Check breaker, pump, and controller. Repair or replace.
		Flow rate too high or too low	Adjust flow rate
		Defective	Check and replace
		No power	Check breaker, pump cord, controller fuse, if any. Replace if necessary.
		Faulty pump	Listen for irregular noises in pump operation. Feel collector feed and return pipes for temperature difference.
		Runs continuously	Check control system for breaks and shorts
		Improperly installed	Compare with system Schematic

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
No hot water in morning	Non return valve	Stuck open or does not seat	Replace non return valve
	Controller	Sensor wires reversed	Check wiring and reconnect
	Water heater circuit breaker	Water heater circuit breaker shutoff	Turn breaker back on
	Occupants	Excessive consumption	Discuss hot water usage. Check system size and auxiliary heater status.
Water too hot	Auxiliary heater	Thermostat set point too high	Reduce set point temperature
	High limit sensor	Improper calibration	Check, recalibrate and replace
	Occupants	No hot water use (vacation, etc.)	Run hot water to reduce tank temperature
	Mixing valve	Temperature set too high	Adjust
	Mixing valve	Valve failure	Replace valve
No water	Cold-water supply valve	Valve closed	Open valve
Pump does not start	Differential controller	Controller switch in “off” position	Turn to “automatic” or normal operating position.
		Unplugged	Return power to controller
		On and/or off temperature differential set points too high	Reset according to specifications
		Loose contacts	Clean contacts and tighten connections or replace
		Defective components	Replace components or Controller

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Pump does not start	Pump	Motor failure	Check brush holders and other mechanical components that may be loose, worn, dirty or corroded. Replace as appropriate and reasonable. Check for thermal overload.
		Pump motor runs when started by hand. Capacitor failure.	Replace capacitor
		No power	Check breaker, cord and Controller
		Stuck shaft or impeller	Replace
	Sensors	Defective sensor(s)	Replace
		Improper installation	Clean and reinstall properly
		Sensors out of calibration	Recalibrate or replace
	Sensor wiring	Defective sensor wiring	Repair or replace
		Open collector sensor wiring	Check wiring continuity. Repair or replace.
		Shorted tank sensor wiring	Check wiring for continuity. Repair or replace.
	Controller circuitry	Sensors connected to wrong terminal	Correct per manufacturer’s recommendations
	Electrical power supply	On/off switch is “off”	Turn to “on”
		Blown fuse or breaker tripped on overload	Determine cause and replace fuse or reset breaker
		Defective	Check and replace, if required

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Pump starts, but cycles continuously	Differential controller	On and off temperature differential set points are too close together	Reset according to specifications
		Faulty controller	Use controller test set to perform operation check. Repair or replace.
	Piping	Reversed connections to Collector	Reconnect properly
	Sensors	Improper location	Relocate sensors as per system design or manufacturer's requirements
		Not properly secured	Secure properly and insulate from air
		Faulty	Test sensors. Replace if necessary.
Pump cycles after dark	Sensor wiring	Interference from radio or garage door opener, etc.	Use shielded sensor wire
		Radio frequency interference from close proximity to antenna.	Use shielded sensor wire
	Non return valve	Does not seat	Replace
Pump runs continuously	Controller	Off temperature differential set point too low	Reset according to specifications
		Lightning damage	Replace controller
		Controller in "on" position	Turn to "automatic" or normal run position
	Sensor(s)	Sensor(s) out of calibration	Recalibrate
		Defective sensor	Replace
		Improper installation	Reinstall

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Pump runs continuously	Sensor wiring	Interference from radio/garage door opener, etc.	Shielded cable may be necessary
		Shorted collector sensor wiring	Check wiring for continuity. Check wiring connections for weather tightness. Repair or replace.
		Open tank sensor wiring	Check wiring for continuity. Check wiring connections for weather tightness. Repair or replace.
Pump operates but no fluid flows from collector	Air vent	System air-locked. Air vents closed.	Disassemble and clean seat and seal. Replace if necessary.
		Improper location	Install at the highest point. Install at all high points if possible air trap locations exist. Install in true vertical position.
		Air vent cap tight	Loosen ¼ turn
	Non return valve	Installed improperly	Check flow arrow on valve to ensure direction is per system design
	Collector	Flow tubes clogged	Flush collector tubing
	Rinsing valve	Rinsing valve stuck in drain position	Clean cause of sticking. Check power to valve.
	Fluid	No fluid in direct system	Open cold-water supply valve
		Loss of fluid in indirect system	Locate leak and refill
		Loss of fluid in drain-back system	Cool system, locate leak, refill properly
	Isolation valves	Valves in closed position	Open valves
	Piping	Clogged or damaged piping	Unblock piping or repair damaged piping

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Pump operates but no fluid flows from collector	Pump	Broken impeller shaft	Replace shaft
		Impeller broken or separated from shaft	Replace impeller and/or shaft or replace pump
		Improperly installed	Install to ensure correct flow
		Not vented properly	Install in correct orientation
		Undersized	Check pump specifications. Change pump if required.
	Valves	Valves closed	Open valves
Pump cycles on and off after dark	Non return valve	Corroded or defective non return valve	Repair or replace
Pump runs after dark, but eventually shuts off	Sensors	Defective	Change sensor
		Improper location	Relocate
		Sensor not insulated	Insulate
No power to pump with switch on	Controller output relay	Weak or failed relay	Replace relay or controller
Noisy pump	Air vents	Air trapped in system	Open automatic air vent
	Pump bearings	Dry or excessive wear	Lubricate or replace
	Pump impeller	Loose impeller	Tighten or replace impeller
	Pump location	Pump enclosed in small room (closet)	None
		Pump attached to wall – wall acts as amplifier	Relocate pump if noise is unacceptable
	Vent port on pump (if applicable)	Air trapped in pump	Open vent port and/or vent valve and bleed air

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
Noisy system	Pump	Bearings need lubrication (if applicable)	Oil per manufacturer's recommendation
		Air locked	Bleed air
	Piping	Entrapped air (direct systems only)	Purge system by running water up supply pipe and out drain on return line (isolation valves closed)
		Pipe vibration	Isolate piping from walls
Controller does not turn on or off in the "automatic" mode but operates in the "manual" mode	Controller	Defective	Conduct function check and repair or replace
	Sensors	Defective sensors; resistance problem; sensors off scale	Check with multimeter (ohm). Correct or replace sensors.
		Improper contact or insulation	Ensure proper contact is made. Insulate sensors.
		Improper location	Relocate
	Wiring	Short or open	Replace or splice wire
System shuts off at wrong high limit or continues to Run	Controller	Defective	Repair or replace
	Sensors	Defective sensor	Check with multimeter (ohm) and replace
		Improper location	Relocate
System leaks	Collector(s)	Pipe burst due to freeze or defective joint	Repair or replace. Check freeze-protection mechanisms.
	Hose connection	Clamps not tightly secured	Tighten clamps. Replace clamp or hose.
	Valves	Valve gland nuts loose	Tighten nuts. Replace seal or packing if necessary.
		Seats deteriorating	Replace seat washers. Redress seat. Replace valve if necessary.

PROBLEM	CHECK THIS	POSSIBLE CAUSE	CORRECTIVE ACTION
System leaks	Pipe joints	Thermal expansion and contraction.	Replace and provide for flexibility
		Joint improperly made	Reassemble
		Improper seal in system using glycol solution	Make a good seal. Use recommended sealer. Note: glycol will leak through joints where water would not.
	Pressure relief valve (safety valve)	Did not reseal after opening	Replace
		Defective	Replace
		Improper pressure or temperature setting	Reset, if possible, or replace
Water comes off the roof	Pressure relief valve	Defective seal	Replace
		Activates due to no circulation through collector(s)	Check flow in collector loop. (See “Pump does not start” and “Pump operational but no flow to collector.”)
	Collector piping	Defective piping	Repair or replace
	Low-pressure valve installed on collector supply line	Power loss. Pressure loss from well.	No action required.
System does not drain	Piping	Insufficient slope for drainage	Check and ensure piping slopes ¼" per foot of piping
	Event air	Does not open. Defective due to internal mechanism or corrosion.	Clean or replace

Table 14: Diagnosis of problems and corrective maintenance for forced system

V. MAINTENANCE FREQUENCY

Action	Frequency	Performed by	Remarks	Precautions
collectors glass cleaning	Every 3 months for dirty environment	user/technician	with water and brush	Collectors must be cool before cleaning/washing
Safety valve/group functionality	annually	technician	lift and release the lever on the temperature and safety valve to ensure valve operates freely	Discharged water might be hot enough to present a scald hazard and should be directed to suitable drain using a proper hose.
Electric element	annually	technician	testing with electrician's multi-meter	shut off power before accessing and testing the element
Electronic controller	annually	technician	Incoming and outgoing signals check. Connections and terminals	
Hydraulic and piping leak check	annually	user/technician		caution for hot fluid or surfaces
Electrical connections	annually	technician		shut off power
Piping insulation condition	annually	user/technician		
Visual check for collector's glass condition	annually	user/technician		
Stability of collectors support frames	annually	technician		
Stability of water storage tank	annually	technician		
Expansion tank	annually	technician	Leaks check. Pressure check at idle position. (2.5 bar solar circ. 1.5 bar water circ.)	
Thermal fluid level	annually	technician		
Thermal fluid pump/s	annually	technician	Leaks check. Incoming and outgoing signals check. Connections and terminals	
Magnesium anode rod	annually	technician	Magnesium anode rod is designed to prolong the life of the glass-lined tank. It is slowly consumed thereby eliminating or minimizing corrosion of the tank	The tank should be drained to inspect and/or replace the magnesium anode rod.

Table 15: Maintenance frequency

References

This manual of installation and maintenance of SWH is elaborated for the Egyptian market needs; it is inspired from the Tunisian experience and uses the following references:

- ✓ PROSOL Program Tunisia
- ✓ Minimum technical specifications for solar thermal water heating equipment;
- ✓ Minimum technical specifications for suppliers of solar water heating equipment (manufacturers or importers of SWH),
- ✓ Minimum technical requirements for SWH installers and maintainers
- ✓ SWH training and qualification program
- ✓ QUALISOL Charter
- ✓ QUALISOL Procedure Manual
- ✓ QUALISOL Management Manual

Other references:

- ✓ UNDP “Solar Water Heating Training Manual or the Kenyan Industry” – 2017
- ✓ UNDP & GEF “User’s handbook on SOLAR WATER HEATERS” -2010
- ✓ ANME “Guide d’installation des chauffe-eau solaires individuels”-2010
- ✓ Best practices of SWH installation and maintenance: Tunisian case
- ✓ MEGASUN “SYSTEMES A CIRCULATION FORCÉE-M A N U E L T E C H N I Q U E”
- ✓ Journal of Mechanical and Civil Engineering “A Descriptive Study of the Constructional Features of Evacuated Tube Solar Water Heating System” - 2320–334X, PP: 36-41
- ✓ NABCEP “Solar Heating Resource Guide “ -2013
- ✓ SEIDP & World Bank group “SOLAR WATER HEATERS SELECTION AND INSTALLATION GUIDELINES” -2019

Technical references:

- ✓ https://energypedia.info/wiki/Solar_Water_Heater
- ✓ https://www.alternative-energy-tutorials.com/solar-hot-water/evacuated-tube-collector.html
- ✓ http://www.sunflower-solar.com/index.php?act=content&scheduler_id=390
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