HANDBOOK ON DESIGN, OPERATION AND MAINTENANCE OF

SOLAR WATER HEATING SYSTEMS

Version 1.1

EMSD

DISCLAIMER

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- Hong Kong Housing Authority
- International Facility Management Association Hong Kong Chapter
- The Association of Consulting Engineers of Hong Kong
- The Hong Kong Association of Property Management Companies
- The Hong Kong Institution of Engineers (Building Services Division)
- The Institution of Engineering and Technology Hong Kong
- Water Supplies Department

TERMS AND ABBREVIATIONS

EMSD	Electrical and Mechanical Services Department
Government	The Government of the Hong Kong Special Administrative Region of the People's Republic of China
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
Licensed Plumber (LP)	A person licensed under the Waterworks Ordinance (Cap. 102) to construct, install, maintain, alter, repair or remove fire services or inside services
OHSAS	Occupational Health and Safety Assessment Series
Registered Electrical Contractor (REC)	An electrical contractor registered under section 33 of the Electricity Ordinance (Cap. 406)
Registered Electrical Worker (REW)	An electrical worker registered under section 30 of the Electricity Ordinance (Cap. 406)
WSD	Water Supplies Department

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1 INTRODUCTION

1.1 About This Handbook

(1) This Handbook recommends the best system design and operational practices in principle for solar water heating systems.

(2) This Handbook covers "General Practice" and "Best Practice" associated with solar water heating system installation and maintenance. "General Practice" refers to general requirements in fulfilling statutory requirements and guidelines as well as aligning common practices in the trade. Whilst "Best Practice" helps to further enhance the safety and system performance of the solar water heating system installations by considering exemplary practices and innovative technologies identified at the time of preparation and revision of this Handbook.

1.2 Target Audience

(1) The target audience of this Handbook includes solar water heating system owners, solar water heating operators, solar water heating maintenance contractors, property management managers and engineering staff.

1.3 Related Ordinances, Regulations and Guidelines

(1) The requirements for the installation, operation and maintenance of the solar water heating system are given in the undernoted ordinances, regulations and codes of practice, etc. Readers may refer to the following documents for further information:

a) Waterworks Ordinance (Cap. 102)

b) Waterworks Regulations (Cap. 102A)

c) Electricity Ordinance (Cap. 406)

d) Code of Practice for Prevention of Legionnaires' Disease, by the Prevention of Legionnaires' Disease Committee, the Government

e) Code of Practice for the Electricity (Wiring) Regulations (CoP), issued by the EMSD of the Government

f) Guidance Notes for Household-scale Solar Water Heating Systems at Village Houses, issued by the EMSD of the Government

g) Building New Territories Exempted Houses, Lands Department of the Government

h) Buildings Ordinance (Cap. 123)

2 DESIGN CONSIDERATIONS

2.1 General

(1) Solar water heating systems can be classified into two main types: direct type (open-loop type) and indirect type (closed-loop type), depending on whether the water for consumption is heated up directly or indirectly via a heat exchanger.

(2) Safety precautions required for installing, operating, and servicing a solar water heater is essentially the same as those for a conventional domestic water heater.

(3) For installation and regulatory requirements on the installation of solar water heating systems, readers shall also refer to the "Guidance Notes for Household-scale Solar Water Heating Systems at Village Houses".

(4) The installation or modification of water supply system for solar water heating systems shall only be carried out by a licensed plumber (LP). The plumbing work of solar water heating systems must meet the requirements of the Water Supplies Department.

(5) Sufficient maintenance access shall be provided for the circuit breaker panels, distribution boards and all electrical work on solar water heating systems shall only be carried out by an appropriate Registered Electrical Worker (REW) employed by a Register Electrical Contractor (REC), and comply with the Code of Practice for the Electricity (Wiring) Regulations (CoP).

(6) The type of piping materials to be used in the water supply system should be specified and shall comply with the Waterworks Ordinance (Cap. 102) and the Waterworks Regulations (Cap. 102A)

(7) The major components of a solar water heating system include solar collectors, heat transfer fluids, thermal storage tanks, circulation pumps, heat exchangers, expansion tanks, ancillary equipment and performance monitoring systems, etc.

2.2 Solar Collectors

(1) Solar collectors are used to capture the solar thermal energy to heat up water, either directly or indirectly. Solar collectors can be classified into two major types: flat-plate collectors and evacuated-tube collectors. The selection of solar collector type for an application depends on the operating temperature range between the collector and the ambient temperature.

(2) The capital cost of evacuated-tube collectors is relatively high when compared with that of flat plate collectors, but evacuated-tube collectors are more efficient, occupying less roof area and are capable of delivering water with higher temperature.

(3) The life expectancy of solar collectors is about 20-25 years and some contractors will provide product warranty depending on procurement requirements. Before replacing a faulty solar collector, its warranty shall be checked.

2.3 Heat Transfer Fluid

(1) The heat transfer of a solar heating system can be divided into two categories, direct type (open-loop type) and indirect type (closed-loop type). For the direct type, the water from the storage cylinder is heated through the solar collectors directly and circulated for consumption while heat transfer fluid is heated through the solar collectors and circulated to heat up the water by using a heat exchanger in the indirect type.

2.4 Thermal Storage Tanks

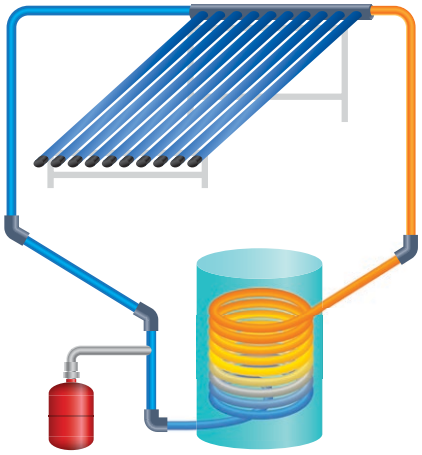
(1) A solar water heating system generally requires a well-insulated thermal storage tank to hold the heated water. The thermal storage tank is often equipped with an auxiliary electric heater (or gas heater) to boost the temperature of the heated water when the thermal output of the solar collectors is not sufficient to meet the heating requirements.

2.5 Circulation Pumps for Heat Transfer Fluid

(1) Circulation pumps are also commonly used in indirect type solar water heating systems to circulate heat transfer fluid between solar collectors and heat exchangers inside the thermal storage tank.

2.6 Heat Exchangers

(1) A heat exchanger is provided for an indirect heating system to transfer the collected solar thermal energy from the heat transfer fluid to the water.



2.7 Expansion Tanks

(1) To prevent the pressure from getting too high due to thermal expansion of the heat transfer fluid, an expansion tank is provided to allow the heated fluid to expand and thus ensure the system's pressure limits are not exceeded.

2.8 Ancillary Equipment

(1) Ancillary equipment includes controllers, safety devices like temperature/pressure (T/P) relief valves, pressure relief valves, and tempering (water mixing) valves. The controller monitors the collector and storage temperatures with temperature sensors, and operates a circulation pump at the appropriate temperature differential. A T/P relief valve releases water (through a discharge pipe to drain) if either the temperature or the pressure inside the storage tank gets too high. A tempering valve is used to control the temperature of the hot water being delivered to the user to prevent burns. The valve mixes the hot water with tap water to ensure that the water delivered to the user is kept below a safe temperature.

(2) Pressure relief must be provided in all parts of the collector array that can be isolated by valves. The outlet of these relief valves should be piped to a container or drain, and not where people could be affected.

(3) Water valves should be provided in the connection between a solar water heating system and the basic plumbing system to isolate the solar heating system under maintenance.

2.9 Application of Technology

2.9.1 General Practice

(1) Temperature sensors, flow meters and pressure gauges should be installed for system operation. Additional instruments such as energy meters for monitoring the power consumption of circulation pumps shall be provided for maintaining system performance.

(2) Thermometers should be located on the collector supply and return pipes so that the temperature difference in the pipes can be determined visually.

(3) Flow meters should be located on the collector supply and return pipes for monitoring the water cycle and checking for low flow condition.

(4) A pressure gauge should be inserted on the discharge side of the pump. The gauge can be used to monitor the pressure that the pump must work against and to indicate if the flow passages are blocked.

(5) Energy meters on circulation pumps should be installed to monitor the power consumption for performance verification.

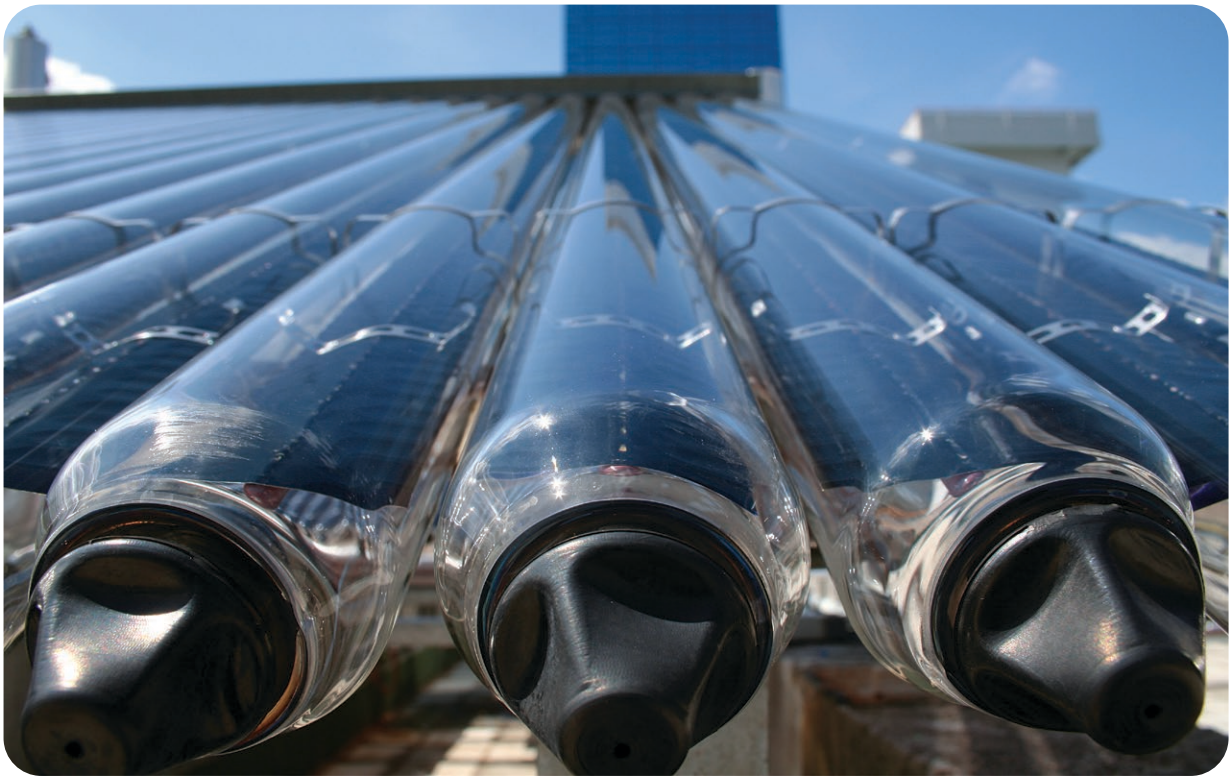
2.9.2 Best Practice

(1) A solar water heating system should be provided with data logging system to record the temperature and energy performance of the system, the monthly mean in-plane solar irradiation, monthly mean solar energy absorbed by the system, and monthly electrical energy consumption of the circulation pump.

(2) Interfacing devices should be provided for connection to the Building Management System (BMS) for:

a) Central monitoring of the operating status, alarm, flow rate, temperature and energy level

b) Controlling the operating set points of the system

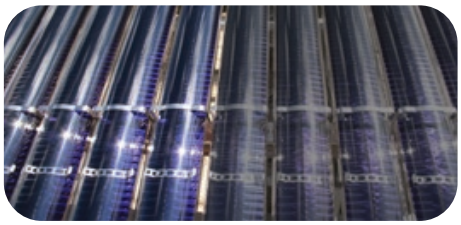


3 OPERATION AND MAINTENANCE

3.1 Factors Affecting System Performance

(1) There are several factors that will affect solar water heating system performance over its operational lifetime:

a) Soiling



Dusty and soiled collectors perform poorly. Soiling is significant especially in the dry season and near construction sites. Periodic cleaning is essential to maintain system performance.

b) Shading

Shading will affect the performance of solar collectors. Vegetation growth or new constructions nearby may induce shading that was not there when the collectors were installed. Regular visual checking for shading during daytime is important.

c) Damage of Solar Collectors

A broken glazing is a major factor affecting the performance of a solar water heating system. Broken glazing may be due to thermal expansion. The interior of the collector, particularly the absorber and insulation, must be protected from inclement weather.

d) Overheating

During periods of high solar irradiance and low hot-water demand, overheating can occur in the solar collectors or storage tanks. Thermal expansion or excessive pressure can burst the associated piping of the storage tank. Overheating may produce steam within the system and make the system inoperable. Therefore, protection against overheating must be considered.

The most common methods to prevent overheating are:

- Stopping circulation in the collection loop until the storage temperature decreases
- Replacing the overheated water with cold makeup water

e) Leakage

Leakage at solar collectors, valves, pipe fittings may occur due to thermal expansion or natural deterioration, making the system inefficient.

f) Scaling

Scaling in a solar water heating system (collectors, pipes, etc.) will affect the system performance in a few ways. In Hong Kong, scaling might occur after a few years of operation though the city's fresh water is soft in nature.

3.2 Operation Procedures

3.2.1 General Practice

(1) The system operator or the Contractor of a solar water heating system should read the operation instructions recommended by the manufacturer/supplier.

(2) The owner can perform simple cleaning work by using clean water on the solar collector surface on a regular basis whilst the waterworks for a solar water heating system shall only be carried out by a LP and the associated electrical work shall be carried out by a REC/REW.

Safety measures against high temperature along the system must be carried out before system inspection and maintenance as the operation temperature of a solar water heating system cannot be controlled.

(3) Before operating the solar water heating system, the system operator or the Contractor should read all instructions for each product. The following procedures for water disconnection and restoration must be carried out prior to and after carrying out any maintenance work of the solar water heating system:

a) Notify the owner/representative of the solar water heating system that the system will be shut down

b) Isolation of the solar water heating system from the main hot water supply system

- Switch OFF the hot water circulation pump. Apply lock and affix appropriate warning notice(s)
- The keys for all isolation points shall be kept by the responsible REC/REW

c) Verification that the system is completely switched OFF

d) After completion of work, the system operator or the Contractor shall inspect, test and certify that the installation is safe for restoration

e) Restoration of the solar water heating system from the main hot water system

- Remove the warning notice(s) and unlock the isolation switch(es) of the hot water circulation pump. Switch ON the isolation switch(es) to restore the solar water heating system
- Notify the owner/representative of the solar water heating system and other relevant parties after work completion

(4) The storage tank is to be completely filled with water and all air is to be vented before energising.

(5) Control of Legionella

To avoid the risk of bacterial growth in water, all solar pre-heated water shall be designed to pass through a local heater or hot water system and heat up to at least 60 °C for at least 5 minutes prior to being discharged to the distribution system under normal loading conditions. The proper design, operation and maintenance of building facilities for prevention of Legionnaires' disease are addressed in the "Code of Practice for Prevention of Legionnaires' Disease". The reader may refer to the technical guidelines for further information.

(6) Proper access tools such as ladders should be provided and with the use of fall arrest systems.

(7) If the fluid of the whole solar heating system has to be drained off for overhaul for a considerable period of time, it is suggested to cover up the solar collectors to avoid high temperature building up on the absorbing surface which may accelerate material ageing and pipe joints leakage.

(8) Idling the solar water heating system for a long period of time should be avoided to prevent stagnant water and if this cannot be avoided, it is recommended that the power to the circulation pump shall be disconnected and that the solar collectors are covered with a blanket or other means to prevent heat gain from the sun leading to system overheating.

3.3 Emergency Preparedness

3.3.1 General Practice

(1) An up-to-date emergency contact list shall be provided and attached at the location near the installation showing the followings items:

- Name of the contact person or company
- Telephone number

(2) In case of emergency, the power to the circulation pump and the valve(s) for shutting off the flow through the collector shall be disconnected to isolate any electricity or fluids from entering the solar water heating system.

3.3.2 Best Practice

(1) Emergency plan/procedures including the communication flow between the solar water heating system owner, system operator and the maintenance contractor, should be provided on site. The emergency plan/procedures should be reviewed on a regular basis.

3.4 Preventive Maintenance

3.4.1 General Practice

(1) All preventive maintenance work shall be read in conjunction with the operation and maintenance (O&M) manual for E&M installations with similar system configuration as the plumbing system as well as the maintenance manual recommended by the manufacturers.

(2) The solar water heating system owner or the system operator shall be notified for the testing or shutdown of the system.

(3) As the operation temperature of a solar water heating system cannot be controlled, safety measures against overheating must be carried out before system inspection and maintenance.

(4) Maintenance of a solar water heating system shall only be carried out by an appropriate LP who shall conduct a risk assessment before commencement of work.

(5) All testing instruments shall be calibrated by an accredited laboratory before use.

3.4.2 Best Practice

(1) The maintenance schedule and procedures shall be regularly reviewed and updated against the latest statutory requirements, international standards and maintenance history.

3.4.3 Preventive Maintenance Schedule

(1) Preventive maintenance schedule for a solar water heating system is recommended as below:

Components/ equipment	Description	Action	Recommended Frequency	General Practice	Best Practice
Solar Collectors	General cleaning	Clean the collectors (when they are cool) to remove dust, debris and other contaminants on the collector surface	Bi-annual to annual	•	•
	Visual inspection	Check the collectors for cracked, broken or deformed glass, shading, deterioration of absorber paint/coating, tubes and insulation	Annual	•	•
		Check the surface temperature of the absorbers for abnormal temperature	Annual		•
		Check for excessive condensation or outgassing under glazing	Annual		•
		Check the frames for corrosion	Annual	•	•
		Check the earthing conductor conditions for collectors with sensors		•	•
	Flow rate	Test the flow rate for compliance with manufacturer's recommendations and the temperature of each collector group in the array	Annual		•
	Leakage inspection	Check the absorbers and pipes for any leakage	Annual	•	•
	Descaling	Remove scaling inside pipework	Every 10 years		•

Components/ equipment	Description	Action	Recommended Frequency	General Practice	Best Practice
Supporting Frames	Mounting system inspection	Check the physical connections and fixing components to make sure the solar collectors and pipework are securely fixed	Annual (Remark 1)	•	•
	Corrosion inspection	Check all hardware for signs of corrosion, remove rust; re-paint and replace if necessary	Annual	•	•
Solar Collector Arrays	Array inspection	Check for abnormal position and movement of solar collectors	Annual (Remark 1)	•	•
		Check hot water flow rate of collector arrays	Annual		•
Heat Transfer Fluids	Heat transfer fluid inspection	Check heat transfer fluid conditions, concentration and degradation for indirect type; refill the heat transfer fluid if necessary	Annual		•
		Check the water quality for direct type		•	•
		Check that provisions are made for draining and filling the system (air vents, drains, pipes correctly graded in-between)		•	•
Pipework	Visual inspection	Check pipework for signs of cracks, defects and leaks, damage, blockage, or degradation of thermal insulation	Annual	•	•
	Hanger inspection	Inspect for signs of defects, sagging, cracks; replace if necessary	Annual	•	•
	Air lock	Check the air locks or blockages of the pipework	Annual		•
	Drainage inspection	Check signs of deformation not holding slopes to drain	Annual	•	•
	Operation temperature inspection	Check for abnormal operation temperature, stop circulation in the collection loop and release the excessive pressure inside pipework if any	Bi-annual to Annual		•
	Descaling	Remove scaling from the pipework	Every 10 years		•

Components/ equipment	Description	Action	Recommended Frequency	General Practice	Best Practice
Valves	Visual inspection	Check valves for any damage, leakage, getting stuck or sign of corrosion; check valve settings and valve position	Monthly	•	•
	Valves functional test	Test valve operation according to the O&M manual and manufacturer's recommendations	Monthly	•	•
Strainers	General cleaning	General cleaning and check for signs of corrosion and getting stuck	Bi-annual	•	•
Heat Exchangers	Visual inspection	Check the heat exchanger for signs of leakage or corrosion and the associated supports	Annual	•	•
	Flow rate	Test the flow rate for compliance with manufacturer's recommendations	Annual		•
	Descaling	Remove scaling from the heat exchangers	Every 10 years		•
Thermal Storage Tanks	Visual inspection	Check storage tanks for cracks, leaks, rust or signs of corrosion	Annual	•	•
		Check the insulation for damage or degradation	Annual		•
	Pressure relief	Check the system pressure and temperature, depressurise the excessive system pressure if any	Annual		•
	Water discharge	Discharge water inside	Bi- annual		•
	Descaling	Remove scaling from the thermal storage tanks	Every 10 years		•
	Reverse heating prevention (if backup heating is provided)	Check that provisions have been made to prevent reverse heating of the solar thermal storage by the domestic hot-water back-up heater	Annual	•	•
	Backup heating (if provided)	Check the thermostat and control of the backup heating element	Annual		•
Expansion Tanks	Leakage check	Check the expansion tanks with diaphragms in by briefly depressing the Schrader valve for leaks of fluid	Annual	•	•

Components/ equipment	Description	Action	Recommended Frequency	General Practice	Best Practice
Pumps	General cleaning	General cleaning and re-paint	Annual	•	•
	Visual inspection	Check that the electrical connections are securely fastened and the earth bonding conductors are properly connected	Annual	•	•
		Check the piping connections for leakages		•	•
	Lubrication	Lubricate the moving parts	Annual	•	•
	Functional and operation test	Check that the pumps are operating correctly without abnormal movement or water leakage	Annual	•	•
		Check the pressure and flow to ensure the operation condition of the pump is in order		•	•
Make-up Water Tanks	General cleaning	Drain and flush out the tank to remove sediment	Annual	•	•
	Visual inspection	Check the water tank for cracks, leaks, rust or signs of corrosion	Annual	•	•
Controls, Sensors and Meters	Visual inspection	Check operational indicators of temperature and pressure to ensure proper operation of the pump and controls	Annual	•	•
		Check the sensor wiring for avoidance of losing connection	Annual	•	•
		Check the accuracy of the sensors and controls, re-calibrate if necessary	Annual		•
	Functional test	Check that controls, water level sensors, temperature sensors are operating sensibly	Annual	•	•
	Pump control panel inspection	Open pump control panel box and check that no fuses/MCBs have blown and all electrical connections are tight	Annual	•	•
		Check for water incursion and corrosion damage	Annual	•	•

Components/ equipment	Description	Action	Recommended Frequency	General Practice	Best Practice
Controls, Sensors and Meters	Pump control panel inspection	Conduct functional tests of the pump panel control	For every five years or as required by PITC		•
		Conduct functional tests of isolation switches and protection devices		•	•
	Dust removal from heat rejection fins	Check ventilation conditions and dust cleaning from heat rejection fins	Annual	•	•
	Pressure relief valves	Check and make sure the valve is not stuck or closed	Annual	•	•
Safety and Warning Notices and Labels	Safety and warning notice inspection	Check for warning signs and labels and replace if necessary	Annual	•	•
	Labels	Check the tags or labels which indicate the positions or flow direction at each valve and pipe	Annual	•	•
Instruments	Instrument inspection	Check the monitoring instruments (e.g., temperature sensors) to make sure they are operational	Annual		•
	Instrument calibration	Calibrate instruments by an accredited laboratory. Replace instruments, temperature sensors, and meters as necessary	Annual		•
System Monitoring and Data Logging System	Operation and performance monitoring	Monitor the operating status, flow rate, temperature, alarms and alert parameters	On-going		•
	Check system monitoring	Check Building Management System for the solar water heating system, check hardware for signal interface and upgrade software as necessary	Annual		•

Components/ equipment	Description	Action	Recommended Frequency	General Practice	Best Practice
System Monitoring and Data Logging System	Log record	Maintain a log of cumulative electrical energy consumption (kWh to date), operating temperature and flow rate against date	Monthly		•
	Performance checking	Check the monthly mean in-plan solar irradiation, monthly mean solar energy absorbed by system and monthly electrical energy consumption of circulation pump	Annual		•

Remark 1:
Precautionary measures against damage to solar collector array, and visual inspection before and after typhoon shall be carried out to make sure the system is in safe condition.

3.5 Corrective Maintenance

3.5.1 General Practice

(1) All plumbing work shall be carried out by an appropriate LP.

(2) Whenever the major components are replaced, the following shall be checked:

a) Specification of solar collectors

b) Water valves

c) Control set point

d) Function and operation

(3) Maintenance records and technical information shall be updated after replacement.

(4) Before the replacement of system components, drain the water from the hot water pipe and make sure the water to the water heater has been completely shut off.

(5) Statutory submission to the WSD may be required if water pipework is changed during maintenance. The reader should refer to the Waterworks Ordinance.

3.5.2 Best Practice

(1) Corrective maintenance carried out during the night or low irradiation hours shall be considered as best practice in avoiding high temperature.

(2) The response time for corrective maintenance or conditions that introduce a safety problem should be addressed and reviewed regularly.

3.6 Spare Parts Management

3.6.1 General Practice

(1) The stocking levels of spare parts depend on the following parameters:

a) Frequency of failure

b) Impact of failure

c) Cost of spare parts

d) Degradation of spare parts over time

e) Equipment reliability

(2) Solar water heating system operators shall maintain an updated list of spare parts suppliers and sufficient spare parts. The minimum spare parts are listed below:

a) Temperature/pressure relief valve

b) Air vent

(3) The solar water heating system operator should formulate the spare part list according to their needs.

3.6.2 Best Practice

(1) The type and quantity of on-site spare parts should be derived from fault history and maintenance records and reviewed regularly.

(2) The obsolescence of spare parts and the availability of substitutes should be reviewed regularly.

3.7 Safety and Environmental Management

3.7.1 General Practice

(1) Prior to any maintenance work of solar water heating system, it is necessary to:

a) Identify all possible risks

b) Determine the work practices that will be undertaken to remove the risks, or to minimise the risks if they cannot be removed altogether

c) Communicate with all staff working on-site about these risks and how they will be removed or minimised

3.7.2 Best Practice

(1) The solar water heating system operator should establish an Environment Management System (e.g., ISO 14001) and a Safety Management System (e.g., OHSAS 18001 or ISO 45001).

3.8 Structure and Qualifications of O&M Teams

3.8.1 General Practice

(1) An organisation chart with the names and contact numbers of the O&M team should be provided. The technical staff for the water supply system shall be LPs while those for the electrical system shall be REWs.

4 RECORD/DOCUMENTATION

4.1 Asset Information

(1) The O&M documents should be kept properly and updated after each modification. The recommended O&M documents are as listed below:

Action	General Practice	Best Practice
Handover reports including but not limited to: - Handover list - Site location and location map with access routes - System capacity - Technical information of solar collector (e.g., manufacturer/ brand, model number, type, size, design flow rate, specific output, maximum operating pressure, heat loss coefficient, efficiency, tube size and material, etc.) - Technical information of heat exchanger, pumps (e.g., design flow rate, etc) - Warranties provided - Project completion date and the end date of defect liability period (DLP) - Spare parts list with makes and model numbers	•	•
Design calculation including the sizing of collector area/storage volume, structural calculation		•
As-fitted drawings including: - Schematic diagramme of solar water heating system and water supply installation showing all components, pipe size, earthing connection and the associated utility metering points/supply points - Layout plans showing major components such as solar heat exchangers, circulating pumps, etc.) - Structural drawings with Registered Structural Engineer reports	•	•

Action	General Practice	Best Practice
WSD submission and approval record	•	•
Certification of Environment Management System (e.g., ISO 14001) and Safety Management System (e.g. OHSAS 18001 or ISO 45001)		•
Testing and commissioning reports	•	•
Operation and maintenance manuals including operation procedures in case of system failure or emergency shutdown and isolation procedures	•	•
Schedule of planned examination and testing		•
Emergency contact list including owner/representative, LPs	•	•

4.2 Maintenance Record Management

4.2.1 General Practice

(1) The owner should keep the preventive maintenance plans, inspection/maintenance records of the installations for a period of not less than 3 years from the date of the inspection/maintenance.

(2) The owner should keep the specification, testing and commissioning reports, operation and maintenance manuals of the installation for future reference by maintenance staff.

(3) Records for major equipment replacements (e.g., location and number of solar collectors replaced) and preventive maintenance records should be kept properly.

(4) The preventive maintenance and overhauls records with clear maintenance schedules and procedures should be kept properly.

(5) A sample checklist for inspection and testing of solar water heating system is attached in Appendix A below, which should be read in conjunction with the previous testing and commissioning reports before inspection and testing are carried out.

4.2.2 Best Practice

(1) The maintenance logbook, preventive maintenance and overhauls records with clear maintenance schedules and procedures shall be digitised and reviewed regularly such that the maintenance contractor is able to predict the trend of material deterioration and formulate a project specific preventive maintenance schedule.

4.3 Information Management

4.3.1 General Practice

(1) The certificates and documentation as per statutory requirements shall be kept properly.

4.3.2 Best Practice

(1) The stored records should be reviewed and audited regularly.

4.4 Stakeholders Management

4.4.1 General Practice

(1) The solar water heating system owner or his representative(s) should be notified about:

a) The schedule of preventive maintenance

b) When the equipment will be shut down for maintenance and the duration

c) Updating of emergency contact list as mentioned in Section 3.3.1

4.4.2 Best Practice

(1) The solar water heating system owner or his representative(s) should be kept informed of the progress of the O&M activities and the obsolescence of spare parts without suitable substitutes.

APPENDIX A: SAMPLE CHECKLIST FOR INSPECTION AND TESTING OF SOLAR WATER HEATING SYSTEMS

Installation Address:	Tested By/Date (N/A if not applicable)
(a) Solar Collectors	
(i) Clean the collectors (when they are cool) to remove dust, debris and other contaminants on the collector surface.	
(ii) Check the collectors for cracked, broken or deformed glass, shading, deterioration of absorber paint/coating, tubes and insulation.	
(iii) Check the surface temperature of the absorbers for abnormal temperature.	
(iv) Check for excessive condensation or outgassing under glazing.	
(v) Check the frames for corrosion.	
(vi) Check the earthing conductor conditions of collectors with sensors.	
(vii) Test the flow rate for compliance with manufacturer's recommendations and the temperature of each collector group in the array.	
(viii) Check the absorbers and pipes for any leakage.	
(ix) Remove scaling inside pipework.	
(b) Supporting Frames	
(i) Check the physical connections and fixing components to make sure the solar collectors and pipework are securely fixed.	
(ii) Check all hardware for signs of corrosion; remove rust; re-paint and replace if necessary.	
(c) Solar Collector Arrays	
(i) Check for abnormal position and movement of solar collectors.	
(ii) Check hot water flow rate of collector arrays.	
(d) Heat Transfer Fluid	
(i) Check heat transfer fluid conditions, concentration and degradation for indirect type; refill heat transfer fluid if necessary.	
(ii) Check the water quality for direct type.	
(iii) Check that provisions are made for draining and filling the system (air vents, drains, pipes are correctly graded in-between).	

Installation Address:	Tested By/Date (N/A if not applicable)
(e) Pipework	
(i) Check pipework for signs of cracks, defects and leaks, damage, blockage, or degradation of thermal insulation.	
(ii) Inspect for signs of defects, sagging, cracks; replace if necessary.	
(iii) Check the air locks or blockages of the pipework.	
(iv) Check signs of deformation not holding slopes to drain.	
(v) Check for abnormal operation temperature; stop circulation in the collection loop and release the excessive pressure inside pipework if any.	
(vi) Remove scaling from pipework.	
(f) Valves	
(i) Check valves for any damage, leakage, getting stuck or signs of corrosion; check valve settings and valve position.	
(ii) Test operation according to the O&M manual and manufacturer's recommendations.	
(g) Strainers	
(i) General cleaning and check for signs of corrosion and getting stuck.	
(h) Heat Exchangers	
(i) Check heat exchangers for signs of leakage or corrosion and the associated supports	
(ii) Test flow rate for compliance with manufacturer's recommendations.	
(iii) Remove scaling from heat exchangers.	
(i) Thermal Storage Tanks	
(i) Check storage tanks for cracks, leaks, rust or signs of corrosion.	
(ii) Check the insulation for damage or degradation.	
(iii) Check the system pressure and temperature; depressurise the excessive system pressure if any.	
(iv) Discharge water inside.	
(v) Remove scaling from thermal storage tanks.	
(vi) Check that provisions have been made to prevent reverse heating of the solar thermal storage by the domestic hot-water back-up heater.	
(vii) Check the thermostat and control of the backup heating element if backup heating is provided.	
(j) Expansion Tanks	
(i) Check the expansion tanks with diaphragms in by briefly depressing the Schrader valve for leaks of fluid.	

Installation Address:	Tested By/Date (N/A if not applicable)
(k) Pumps	
(i) General cleaning and re-paint.	
(ii) Check that the electrical connections are securely fastened and the earth bonding conductors are properly connected.	
(iii) Check the piping connections for leakages.	
(iv) Lubricate the moving parts.	
(v) Check that the pumps are operating correctly, without abnormal movement or water leakage.	
(vi) Check the pressure and flow to ensure the operation condition of the pump is in order.	
(l) Make-up Water Tanks	
(i) Drain and flush out the tank to remove sediment.	
(ii) Check the water tank for cracks, leaks, rust or signs of corrosion.	
(m) Controls, Sensors and Meters	
(i) Check operational indicators of temperature and pressure to ensure proper operation of the pump and controls.	
(ii) Check the sensor wiring for avoidance of losing connection.	
(iii) Check the accuracy of the sensors and controls; re-calibrate if necessary.	
(iv) Check that controls, water level sensors, temperature sensors are operating sensibly.	
(v) Open pump control panel box and check that no fuses/ MCBs have blown and that all electrical connections are tight.	
(vi) Check pump control panel for water incursion and corrosion damage.	
(vii) Conduct functional tests of the pump panel control.	
(viii) Conduct functional tests of isolation switches and protection devices for the pump panel control.	
(ix) Check ventilation condition and dust cleaning from heat rejection fins.	
(x) Check and make sure the valve is not stuck or closed.	
(n) Safety and Warning Notices and Labels	
(i) Check for warning signs and labels and replace if necessary.	
(ii) Check the tags or labels which indicate the positions or flow direction at each valve and pipe.	

Installation Address:	Tested By/Date (N/A if not applicable)
(o) Instruments	
(i) Check the monitoring instruments (e.g., temperature sensors) to make sure they are operational.	
(ii) Calibrate instruments by an accredited laboratory. Replace instruments, temperature sensors, and meters as necessary.	
(p) System Monitoring and Data Logging Systems	
(i) Monitor the operating status, flow rate, temperature, alarms and alert parameters.	
(ii) Check the Building Management System for solar water heating system; check the hardware for signal interface and upgrade software as necessary.	
(iii) Maintain a log of cumulative electrical energy consumption (kWh to date), operating temperature and flow rate against date.	
(iv) Check the monthly mean in-plan solar irradiation, monthly mean solar energy absorbed by the system and monthly electrical energy consumption of the circulation pump.	

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