

BS 5918:2015



BSI Standards Publication

Solar heating systems for domestic hot water – Code of practice for design and installation

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Published by BSI Standards Limited 2015

ISBN 978 0 580 61963 2

ICS 27.160, 97.100.99

The following BSI references relate to the work on this standard:

Committee reference RHE/25

Draft for comment 12/30177610 DC, 13/30274184 DC

Publication history

First published January 1980

Second edition, February 1989

Third (present) edition, January 2015

Amendments issued since publication

Date	Text affected
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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 January 2015. It was prepared by Technical Committee RHE/25, *Solar heating*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 5918:1989, which is withdrawn.

Information about this document

This is a full revision of the standard.

This standard is intended to help with the design and installation of solar heating equipment for domestic hot water (DHW). It is especially intended to help fill the gap for fitted systems that have not been tested to BS EN 12976 or BS EN 12977. Note that the use of the term “custom systems” in these standards tends to refer to a functional system provided by a single final supplier or manufacturer. An assembly comprising solar energy collection and storage components, and supplied or assembled by multiple providers, can be considered an “ad-hoc” system which is considered in this standard.

The documents available as downloads from the sites referenced in the Bibliography were last accessed on 19 January 2015.

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

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Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

The word “should” is used to express recommendations of this standard. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

This code of practice applies to solar domestic water heating systems that incorporate a primary circuit that is indirect, such that the collected solar energy is transferred through a heat exchanger into storage that includes a volume dedicated to solar input. This applies to most systems that are available in the UK at present.

There are other system designs on the market that fall outside the scope, but the code of practice does not restrict or limit the installation of such designs. The methods and algorithms presented in this document that estimate the system performance do not apply to such designs. Nevertheless, several clauses are also relevant to system designs outside the scope. These include the clauses relating to the mounting of solar panels, safety issues and those relating to the provision of information to customers.

1 Scope

This British Standard gives recommendations and guidance for the installation of common indirect solar domestic hot water (SDHW) systems for all types of building in the UK. It includes recommendations and guidance for design, handling, installation, commissioning, handover, maintenance, decommissioning and fault-finding.

NOTE 1 SDHW is domestic hot water (DHW) that has intentionally received heat derived from solar radiation via a solar collector.

The standard covers systems:

- a) in which solar radiation is converted to heat that is primarily intended for domestic hot water preparation;
- b) that contain solar collector(s) intended to transfer heat using an aqueous-based liquid medium;
- c) whose solar collectors conform to BS EN 12975-1 and BS EN ISO 9806;
- d) which contain collectors that provide up to 20 kW instantaneous peak power output measured leaving the collector, when tested in accordance with BS EN ISO 9806 at 800 W/m² perpendicular to the collector aperture plane;

NOTE 2 Depending on the characteristics of the system, this typically equates to a gross collector area of up to approximately 30 m².

- e) in which heat is primarily stored in aqueous-based liquid media; and
- f) in which the primary circuit is indirect with a heat exchanger that is internal to the solar storage vessel and which separates the primary heat transfer fluid that passes through the collector from the DHW.

This British Standard does not cover:

- 1) applications that are primarily intended to provide heat for applications such as space heating, cooling or swimming pools and any other than DHW preparation;
- 2) solar primary system layouts that use solar storage vessels that are outside the building;
- 3) solar primary system layouts with multiple collector fields;
- 4) DHW systems that comprise multiple solar or multiple DHW storage vessels; or
- 5) solar primary system layouts that incorporate a heat pump or other device that utilizes the Carnot cycle.

NOTE 3 It is assumed in the calculations in this British Standard that there is user-disinterest in the DHW settings, i.e. that default factory timer and thermostat settings are present. Extra heating required for bacterial disinfection is not assumed in these calculations.

NOTE 4 Where stated in the standard, the pressure is that exceeding atmospheric pressure at sea level.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1566 (both parts), *Copper indirect cylinders for domestic purposes*

BS 4213, *Cisterns for domestic use – Cold water storage and combined feed and expansion (thermoplastic) cisterns up to 500 l – Specification*

BS 6213, *Selection of construction sealants – Guide*

BS 6920, *Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water*

BS 7671, *Requirements for electrical installations – IET Wiring Regulations*

BS 8000 (all parts), *Workmanship on building sites*

BS 8000-15, *Workmanship on building sites – Part 15: Code of practice for hot and cold water services (domestic scale)*

BS 8558, *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806*

BS 8580, *Water quality – Risk assessments for Legionella control – Code of practice*

BS EN 806 (all parts), *Specification for installations inside buildings conveying water for human consumption*

BS EN 1990, *Eurocode – Basis of structural design*

BS EN 1991-1-1, *Eurocode 1 – Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings*

BS EN 1991-1-3, *Eurocode 1 – Actions on structures – Part 1-3: General actions – Snow loads*

BS EN 1991-1-4, *Eurocode 1 – Actions on structures – Part 1-4: General actions – Wind actions*

BS EN 1993-1-1, *Eurocode 3 – Design of steel structures – Part 1-1: General rules and rules for buildings*

BS EN 1995-1-1, *Eurocode 5 – Design of timber structures – Part 1-1: General – Common rules and rules for buildings*

BS EN 12897, *Water supply – Specification for indirectly heated unvented (closed) storage water heaters*

BS EN 12975-1, *Thermal solar systems and components – Solar collectors – Part 1: General requirements*

BS EN 12977, *Thermal solar systems and components – Custom built systems*

BS EN 12977-3, *Thermal solar systems and components – Custom built systems – Part 3: Performance test methods for solar water heater stores*

BS EN 12977-5:2012, *Thermal solar systems and components – Custom built systems – Part 5: Performance test methods for control equipment*

BS EN 14437, *Determination of the uplift resistance of installed clay or concrete tiles for roofing – Roof system test method*

BS EN 60730-2, *Automatic electrical controls for household and similar use*

BS EN 60730-2-9, *Automatic electrical controls for household and similar use – Part 2-9: Particular requirements for temperature sensing controls*

BS EN ISO 11600, *Building construction – Jointing products – Classification and requirements for sealants*

BS EN ISO 9488, *Solar energy – Vocabulary*

BS EN ISO 9806, *Solar energy – Solar thermal collectors – Test methods*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS EN ISO 9488, BS EN 12977 and the following apply.

3.1 active area

either the absorber or aperture area chosen dependant on collector type

NOTE 1 An active area is used for calculating or estimating system performance in the design stage.

NOTE 2 Some concentrating collectors with large reflective aperture areas do not work as well in predominately diffuse irradiation as found in the UK.

NOTE 3 Aperture area is the preferred option for a collector which concentrates solar radiation.

3.2 cold feed

pipe that contains cold water intended to be eventually heated as DHW

3.3 cold water storage (CWS)

cistern located at a high location in the building filled with cold water via a float valve

3.4 compound parabolic concentrator (CPC) collector

non-imaging collector that uses parabolic reflector segments to concentrate solar radiation

3.5 dedicated solar storage

vessel or part of a vessel that is normally only intentionally heated by the solar primary system

3.6 delivery or draw-off temperature

temperature at which water is drawn off at an outlet intended to supply DHW

3.7 DHW-only vessel

vessel that contains only DHW storage

3.8 differential temperature controller

electronic device that detects a temperature difference and controls pumps and other electrical devices accordingly

3.9 direct system

system in which there is no heat exchanger between the primary and secondary systems

NOTE The water passing from the cold feed can also pass through the solar collector.

3.10 domestic hot water (DHW)

water intended for sanitary bathing and cleansing that has been fully treated by heat or other processes making it suitable as domestic hot water

3.11 downstream

towards the draw-off points of the DHW

3.12 drainback system

system that, as part of the normal working cycle, automatically drains and refills the collector with heat transfer fluid, retaining the fluid within the system

NOTE A drainback system is different from a drain-down system, which is a system that drains the collector to waste, either manually or automatically, when freezing conditions are likely to occur.

3.13 effective solar storage

sum of the dedicated solar storage plus a proportion of volume that is available for additional solar storage where this volume is normally heated by other intermittent heat sources

3.14 flow

section in a circuit where the movement of heat is away from the source, i.e. the hottest part of the circuit

3.15 frost protection

protection offered by a heat transfer fluid at the final setting temperature for a fluid

3.16 heat transfer fluid (HTF)

fluid in the primary circuit which transports heat from the collector to the solar storage vessel

3.17 hydraulically secure

condition such that there can be no release of heat transfer fluid under any foreseeable conditions, with no user intervention required to reinstate system function after electrical power failure under all weather conditions

3.18 indirect system

system in which there is a heat exchanger between the primary and secondary systems

NOTE The water passing from the cold feed does not pass through the solar collector in an indirect system.

3.19 open-vented system

system that allows its liquid contents to be freely in contact with atmosphere

3.20 preheat storage vessel

vessel that stores heat prior to further heating downstream

3.21 primary

assembly of components that contain fluid acting as the source or generation of heat

3.22 return

section in a circuit where the movement of heat is away from the load, i.e. the coolest part of the circuit

3.23 sealed system

circuit that seals the heat transfer fluid from the atmosphere

3.24 secondary system

assembly of components that contains water to be heated as DHW and then discharged or consumed

NOTE This can include the storage vessel with a cold feed unless the DHW instead passes through a heat exchanger.

3.25 solar fraction

quotient between the energy supplied by the solar primary circuit to the storage tank and the total energy intentionally arriving at the storage tank, given by the following formula:

$$\text{solar fraction} = \frac{Q_{\text{sol}}}{Q_{\text{sol}} + Q_{\text{a}}} \quad (1)$$

where:

Q_{sol} is the solar yield, i.e. the net thermal energy gain entering the solar storage tank from the solar primary circuit; and

Q_{a} is the backup energy at point of transfer to DHW.

NOTE See also Figure 1.

3.26 solar heating

process by which heat above the stated reference temperature in a material is primarily derived from solar radiation transfer

3.27 solar primary system

assembly of components that allows passage of heat from a solar collector and transfers it to a storage vessel

NOTE This includes the heat exchanger, but not the storage vessel itself.

3.28 solar storage

volume of water held within a vessel or part of a vessel that is intentionally used to store heat from the solar primary system

NOTE This can include vessels or volumes that store heat from other sources. Non-aqueous methods of storage are outside the scope of this standard.

3.29 stagnation temperature

temperature of the collector during periods of no useful heat removal from the collector with high solar radiation and ambient surrounding temperatures

3.30 storage temperature

temperature at which water is stored in a vessel

3.31 thermosyphon circulation

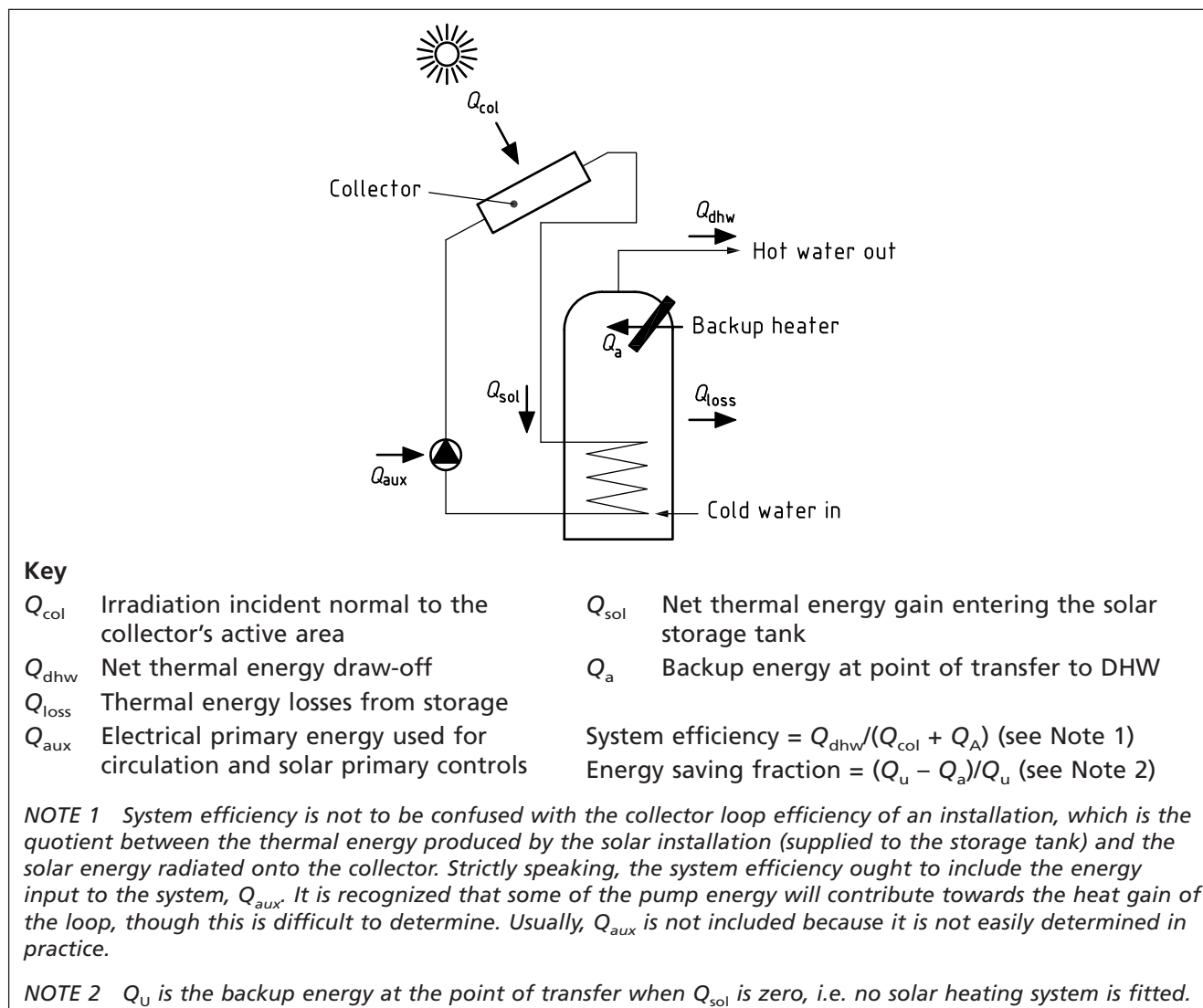
system or process in which circulation of the heat transfer fluid is achieved by natural buoyancy or convection

NOTE Also known as "gravity circulation".

3.32 treated area

area that is intended to be habitable

Figure 1 Schematic showing energy flows through the system



3.33 upstream
towards the source of the cold feed

3.34 vaporization temperature
temperature at which the liquid boils, which varies according to the system pressure

3.35 volatile corrosion inhibitor
corrosion inhibitor which is able to protect system components when the heat transfer fluid is in either a liquid or vapour state

4 General recommendations

4.1 Climatic considerations

NOTE All areas of the UK are at risk of freezing temperatures for some part of each typical climatic year.

Water-carrying components should be protected from frost damage without the need for user intervention or electricity. All rigid components in a SDHW system that are outside the treated area of a building and at risk of frost damage should be protected with an inhibited heat transfer fluid (HTF) that has frost protection for the local climate; in all cases a minimum of -20°C . Where practicable, components that are expected to carry heat should be well insulated and located internally where possible.

4.2 General layout of main components

NOTE The source of energy of a SDHW system is solar radiation, which first enters the system via a solar collector. A solar collector is mounted external to the building to optimally receive the solar radiation. The heat generated from the solar collector is stored in water-filled vessels inside the treated areas of the building.

The combination of pressures and volumes intended for a system determine whether the Pressure Equipment Regulations [1] apply, which might require further tests of the design by a third party. Further information is given in Pressure equipment – Guidance notes on the UK Regulations [2].

The storage vessels should be chosen based on their intended location in a treated area of a building, with consideration to reducing pipe lengths to the collectors and a backup heat source for DHW, as well as proximity to the principal draw-off locations. A compromise on the chosen location of the main components should be made that results in the best overall performance of the whole system.

4.3 General considerations for layout of solar collectors

For best performance, a solar collector should be located where it is least shaded, tilted up from horizontal and facing towards south, and at the shortest practicable distance from the heat storage. Collectors may be located in or on a variety of building components, such as roofs, facades, balustrades and canopies. Access for inspection or maintenance should be provided without detrimentally affecting the building's appearance or aesthetics. Locations near to trees should be avoided where possible as these are likely to suffer from significant overshadowing, with the added potential for leaves and tree sap to build up on the collector glazing. Consideration should be given to future tree growth. Locations in valley areas and near to high-rise buildings should be carefully assessed for the potential for shading.

NOTE Reflective landscape features located in front of inclined collectors can improve annual performance. Such surfaces might be relatively large, such as glazed facades or water features.

4.4 Mitigation of bacterial growth

The potential for the accumulation and growth of microorganisms, such as *Legionella*, should be determined by a risk assessment and appropriate mechanisms for microbial control identified, e.g. periodic heating of storage vessels, pipes to disinfection temperatures or/and continuously to the cold feed source such as by ultraviolet (UV) disinfection or other treatment, in accordance with Annex A.

NOTE In a place of work, there is a mandatory requirement for controls under the Control of Substances Hazardous to Health Regulations [3, 4]. Further guidance on controlling Legionella is given in HSE publications L8 [5] and HSG 274 Part 2 [6].

4.5 Layout of storage vessels

The design should take into account the strong effect of solar storage on the performance of the whole solar heating system, principally by the size of solar storage and stratification.

The effective solar storage, V_{eff} , is equal to the dedicated solar storage, V_s , only in the case of a separate preheat storage vessel. In combined stores, V_{eff} should be calculated in litres (L) using the following equation:

$$V_{\text{eff}} = V_s + (F \times V_b) \quad (2)$$

where:

F is a factor of stored water available in a combined cylinder for solar storage, given in Table 1;

V_b is the volume of standby or stored heat from backup heat sources, in litres (L); and

V_s is the volume of the dedicated solar storage, in litres (L).

Table 1 Backup heat factor, F , for calculating effective solar storage

Usage	F
Permanently switched on	0.1
Overnight (off-peak)	0.3
Timed twice daily	0.3

NOTE Default timer settings for loading stored DHW systems are assumed to be 08:00 to 10:00 and 18:00 to 23:00. The characteristics of an average DHW usage profile are shown in Annex B (see also 7.4.2).

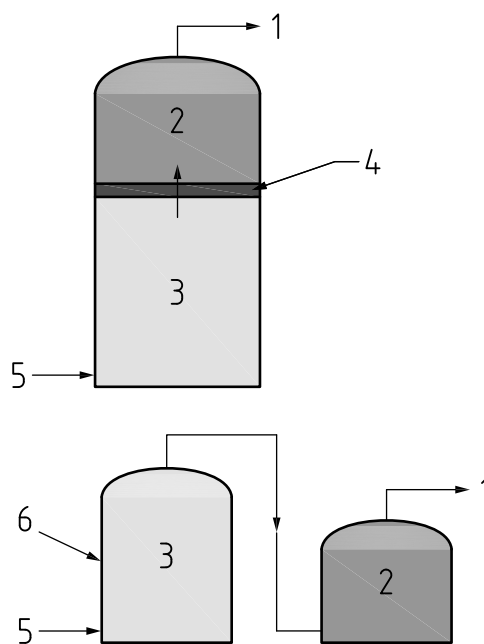
A SDHW system should include a means of storing heat in a volume of water dedicated to transferring heat to the secondary system. This dedicated solar storage should be located upstream of the DHW backup heat source so as not to be heated by other heat sources (see Figure 2) and may either be in a separate sole-purpose vessel or at the base of a vessel with other heat sources.

NOTE 1 The latter is often known as a “twin-coil storage vessel” when a lower coil is dedicated to solar heat and the upper coil from a backup heat source or suitable immersion heaters located in a similar position (e.g. on a horizontal axis). The second coil creates the backup heater volume and this is created more reliably with side entry heating as convection currents are evened out.

NOTE 2 The purpose of dedicated solar storage is to allow energy that comes in at any time of day to be stored by preheating incoming cold feed water. The preheated water is passed to the backup DHW heater. The volume that contains this preheat storage vessel is termed “dedicated” only when there is no other backup heat source normally heating in this volume. The functioning principle of an SDHW system is shown schematically in Figure 3.

NOTE 3 A SDHW system can be divided into two strategic functions of heating. The primary system is the source and transportation of heat from the point of collection to the point of heat exchange, whereas the secondary system uses the heat exchanged as part of the process to treat DHW.

Figure 2 Two types of storage vessel layout

**Key**

- 1 Total daily DHW draw-off, V_d
- 2 Volume of stored water that the backup heat source can heat, V_b
- 3 Volume of stored water dedicated for heat transferred from the solar primary loop, V_s
- 4 Theoretical additional volume available for heat transferred from the solar primary loop when backup heating is timed = $F \times V_b$

$$V_{\text{eff}} = V_s + (F \times V_b)$$

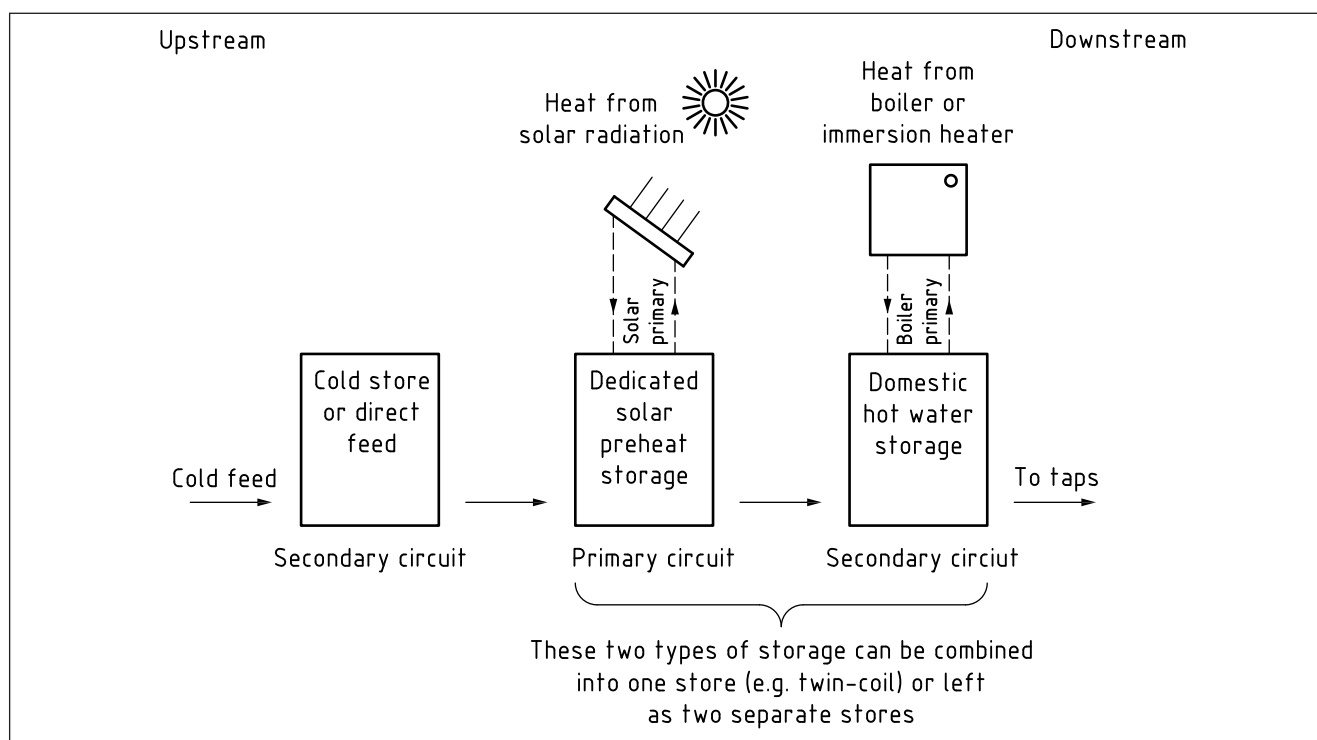
- 5 Cold feed

- 6 Separate preheat storage vessel

$$V_{\text{eff}} = V_s$$

NOTE There are two types of storage vessel layout, spatial and thermal. Therefore, the term "storage" if used alone might require clarification.

Figure 3 Schematic of the functional principle and fluid movements in a typical solar hot water system



4.6 Integration of the dedicated solar storage and the backup DHW heating appliances

Any dedicated solar storage should be integrated with the backup DHW appliance in one of four ways:

- dedicated solar storage and DHW storage contained in a single vessel, as shown in Figure 4a);

NOTE 1 The vessel contains separate heat exchangers for each heat source. This is often known as a "twin-coil cylinder".

- dedicated solar storage and DHW storage contained in two separate vessels, as shown in Figure 4b);
- dedicated solar storage with no DHW storage, as shown in Figure 4c), with the water supplied to the appliance limited to the temperature recommended by the manufacturer; or

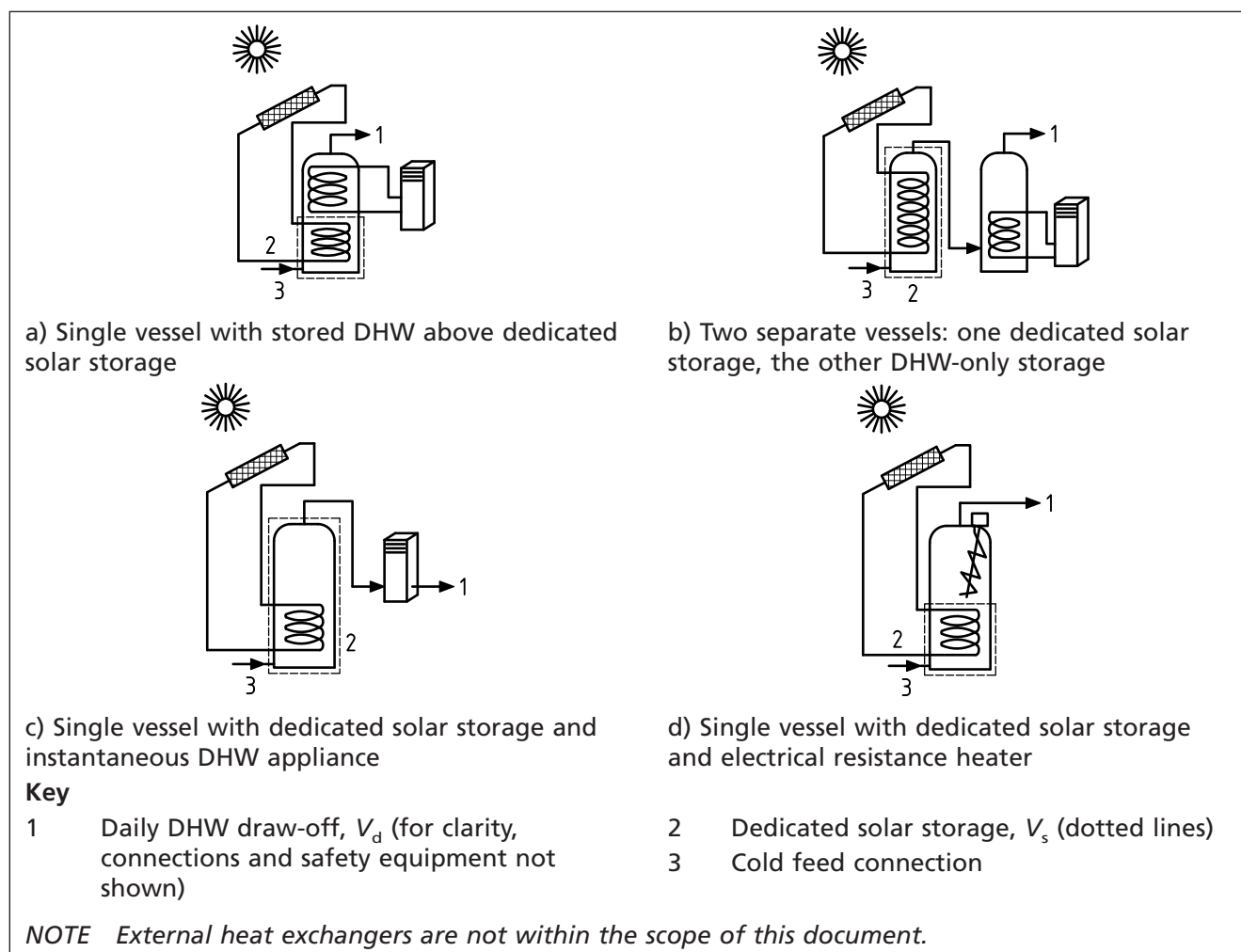
NOTE 2 DHW is provided by an instantaneous or storage hot water appliance with integral backup heat source.

- dedicated solar storage and DHW storage contained in a single vessel, as shown in Figure 4d).

NOTE 3 The vessel contains one heat exchanger for solar and one electrical resistance heater.

In all cases, the format of the secondary system may include vented, unvented and DHW thermal stores using an internal heat exchanger.

Figure 4 Example layouts illustrating dedicated solar storage within common DHW systems



4.7 Primary system design

NOTE Many different designs of solar water heating systems are possible and they can be classified in several ways. For examples of primary system layouts, see Annex C.

The solar water heating primary system should:

- have provision for expansion of HTF without risk of long-term evaporation;
- include control devices to provide limitation in case of over-pressure;
- have a control mechanism to limit over-temperature in the solar storage vessel;
- prevent any damage or malfunction due to freezing of fluid in the solar collector and other parts of the primary circuit;

NOTE This may be done by using an antifreeze solution or by ensuring that all parts of the circuit are freeze tolerant.

- prevent the accumulation of limescale, dirt, silt and other debris which could impede circulation, reduce heat transfer, or compromise the operation of safety vents or expansion pipes; and
- not permit deformation of pipes or vessels which drastically influences performance and safety.

4.8 Secondary system design

Regardless of the particular design of solar water heating, there should be reliable:

- a) prevention of backflow or thermosiphoning of heated water into a cold water cistern containing wholesome water;
- b) prevention of steam or scalding water from reaching hot water distribution pipes or terminal draw-off locations;
- c) maintenance of water quality when in contact with materials and fittings, especially during high stagnation temperatures and pressures;
- d) retention of storage heat capacity to maintain a system efficiency close to optimum assuming a typical DHW profile with a disinterested user;
- e) prevention of overflow or evaporation of fluids from storage cistern;
- f) prevention of disturbance due to pumps of the stratification in the solar storage vessel which unduly increases the solar primary return temperature;
- g) prevention of discharge or waste of water; and
- h) retention of system fluid levels without user intervention.

4.9 Primary protection from frost damage and corrosion

Primary system components should be protected from frost damage and corrosion by the use of, or a practical combination of, either:

- a) HTF containing volatile corrosion inhibitors with antifreeze offering frost protection to at least -20°C ;
- b) system layouts that automatically default to drainback the HTF containing volatile corrosion inhibitors from all components located in untreated areas of the building, including the collector; or
- c) in systems that otherwise accommodate freezing, a HTF containing a volatile corrosion inhibitor, unless otherwise specified by the system manufacturer.

Protection from frost damage should not:

- 1) require user intervention;
- 2) compromise safety;
- 3) use electrical power;
- 4) cause loss of water; or
- 5) cause loss of useful heat from inside the treated area of the building.

NOTE Some collectors are designed as freeze tolerant, which can be tested in accordance with BS EN ISO 9806.

4.10 Service life

Each SDHW system should be designed to have a service life exceeding 25 years when correctly installed, without major component replacement.

NOTE 1 Some components might require replacement during the system life cycle.

NOTE 2 Further information on life cycle analysis can be found in BS EN ISO 14040.

4.11 Reducing loss of primary heat transfer fluid

The risk of fluid loss should be minimized by all of the following:

- a) using a sealed system;
- b) using pipe materials displaying material identification (see 7.10);

- c) using adequate pipe supports (see 7.10);
- d) using joint materials that are pressure-tested after installation (see 7.10 and 9.2);
- e) providing adequate accommodation for fluid expansion with a suitably-sized vessel; and
- f) using metallic materials or other materials of equivalent performance of tear resistance, pressure tolerance, deformation strength, temperature limit, resistance to UV (where external), stability against work-hardening (cracking) and chemical leaching/corrosion.

NOTE For further details, see BS EN 1057 for copper requirements; BS EN 10255 for threaded medium weight steel; BS 7431 for assessing solar water heaters; ISO 9553 for testing preformed rubber seals and sealing compounds used in collectors; BS ISO 3302 for rubber tolerances for products; BS 903-0 for physical testing of rubber; BS 6920 for suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of water; and ISO/TR 10217 for guidance on material selection with regard to internal corrosion.

4.12 Circulation of primary heat

NOTE 1 The principal means of heat circulation in solar primary circuits is by electric pump circulators typically located as shown in Figure 5. Here the HTF is moved through the collector fluid passages in order to transfer useful heat towards the dedicated storage.

Where practicable, a pump, particularly if it is made from rigid components, should be located in the treated area of the building to:

- a) protect against frost damage;
- b) allow ease of access for maintenance and commissioning; and
- c) allow benefit from heat losses to the internal room air during the space heating season.

A control device, such as a differential temperature controller, and system layout should be used to ensure that the pump circulates fluid through the dedicated storage only when there is a net energy increase in the storage and the average temperature of the stored water is raised within each pump cycle. The pump control or system layout should be designed such that, when the solar storage reaches its intended maximum temperature, the pump does not continue to increase this temperature or remove useful heat from the building. The pump should not be located to obstruct the pipes between multiple collectors or between collectors and any safety components. The pump should be chosen and adjusted to meet the minimum necessary system circulation characteristics for the least electrical demand.

The control device should ensure that the pump is not operated when the collector has reached its vapourization temperature since a vapour lock will form, preventing circulation. This in turn can cause unnecessary electrical consumption at the pump. When in use, the pump circulator should be inaudible in any other room in the building save for the room where it is installed, and should not exceed 20 dB where measured 1 m from the pump under any normal operating condition in normal service.

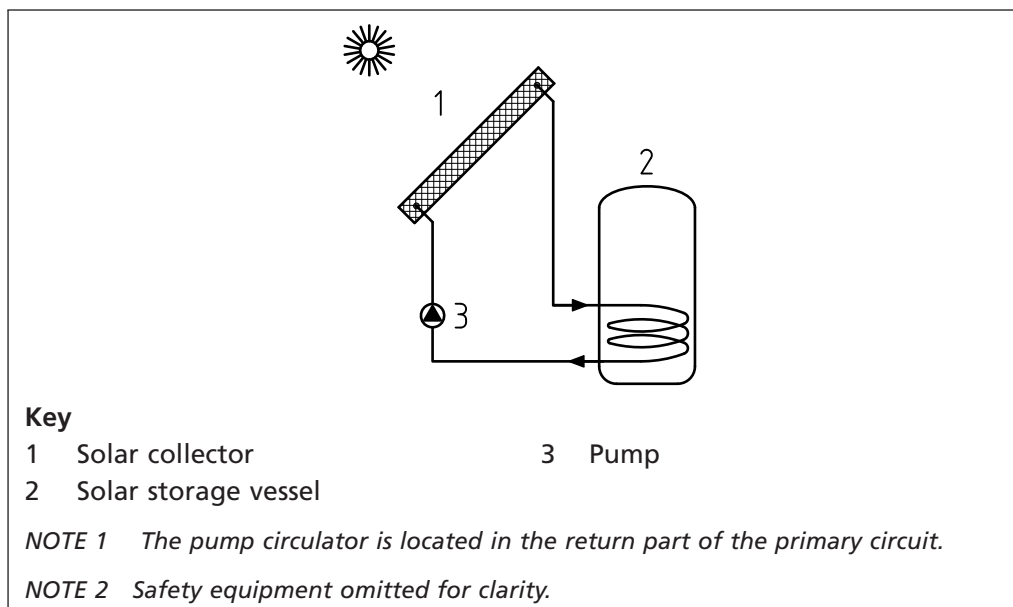
The HTF and system layout should be chosen in combination to achieve protection from frost damage to rigid components, have effective heat capacity and viscosity to reduce pump requirements, minimize internal corrosion, have low toxicity, and be resistant to stagnation temperatures, as well as minimize limescale build-up.

Where the pipes to the collector normally remain fully filled overnight, a non-return valve should be fitted in either or both of the flow and/or return pipes to prevent unwanted natural reverse circulation at night. These should have a low resistance (pressure drop) to minimize pump requirements.

A pump circulator should be fitted in the system pipework to best de-aerate itself, at a location at which it is least likely to suffer cavitation at its inlet or to encounter steam from the collector during stagnation.

NOTE 2 The pump circulator is normally located in the return part of the primary circuit.

Figure 5 Means of primary circulation



4.13 Accommodating primary temperatures

The maximum stagnation temperature can briefly appear in other parts of the solar primary system dependant on the design, which should be selected accordingly.

NOTE The maximum temperature in the SDHW primary system is limited only by the design of the collector. This temperature is measured in the BS EN ISO 9806 test conditions at irradiance of 1 000 W/m² and is known as the maximum stagnation temperature.

Where there is any component in or touching the primary system that is not rated for the maximum stagnation temperature of the collector, additional protection should be provided to that component by locating it on the return pipe so that at least 50% of the primary circuit volume is between the collector outlet and the component, using auxiliary vessels where required.

4.14 Heat efficiency

NOTE Although solar radiation can be considered abundant and freely available, once this energy is transferred into heat in the HTF it becomes indistinguishable from heat that comes from any other heat source.

4.14.1 Conservation of heat and avoidance of loss/waste

4.14.1.1 Heat in the solar primary circuit should be conserved and efficiently transferred to the solar storage with minimum losses. The system should be designed to avoid the following principal losses of heat:

- a) excessive collector temperatures during circulation;
- b) pipes that are external or in untreated areas of the building;
- c) circulation of useful heat from within the building with the intention of a net export in the primary system, including at the collector; and
- d) losses from the solar storage vessel.

4.14.1.2 The risk of loss of useful heat should be minimized by such measures as:

- a) temperature control between the collector absorber and the solar storage;
- b) insulation of pipes and fittings on the primary circuit;
- c) automatic isolation of at least one pipe between the solar storage vessel and collector when no heat gain is available (typically achieved by spring-loaded valves, electrical-operated valves or drainback of liquid at night);
- d) insulation of the solar storage vessel, including non-electrical vessel tappings and all adjoining pipes; and
- e) sufficient solar storage volume (see 7.4).

4.14.1.3 A SDHW system should be designed to avoid wastage of water for the purpose of removing heat in normal operation. Once the heat demand inside the building has been met and can no longer be effectively stored, further heat should not be circulated into the building from the solar collector.

4.14.1.4 Where there is no other hot water storage, a temperature interlock should be provided between the dedicated solar storage vessel and the backup heat source which switches off the backup heat source when sufficient temperature has been achieved. Where there is additional hot water storage, and the layout is designed to allow higher temperature heat in the dedicated storage to rise or be pumped to the additional storage, then the temperature interlock should be provided between the additional storage and the backup heat source.

4.14.1.5 A temperature interlock should be provided between the vessel that contains the dedicated solar storage volume and the backup heat source which switches off the backup heat source where sufficient temperature and volume has been achieved.

4.14.1.6 The heat efficiency measures should not compromise the insulation, weather-tightness, air tightness or fire resistance of the building.

4.14.2 Energy efficiency, disinfection and safety issues

NOTE Solar performance can be significantly reduced by other heat sources attempting to heat the dedicated solar storage. Incorrect location of secondary return circulation in dedicated solar storage, rather than the backup heated volume, has a similar effect.

The interaction of backup heating control, circulation pump control and any disinfection of the dedicated solar storage, and the impact of these on energy efficiency should be taken into account (see Annex A).

4.14.3 Backup heating control

Backup heating using stored water may be controlled using a time clock and thermostat, with a sensor located in the backup heated volume of the tank. The default switching time period (e.g. 07:00 to 09:00 and 16:00 to 22:00) with the temperature conditions (e.g. switch on $<50^{\circ}\text{C}$, switch off $>60^{\circ}\text{C}$) should be adjusted to enable the backup heating to meet the intended DHW demand, which by default for domestic households should be assumed to be the UK average unless clear evidence is found to the contrary (see Annex B).

NOTE 1 Timing of the backup DHW heater has a significant impact on extra effective solar storage additional to that dedicated to solar storage. The period of the day that has the least effect is when there is the smallest effect on solar gains. Typically, this is between 16:00 and 18:00, immediately before the peak evening draw-off and when the solar energy is starting to decline in its daily cycle.

NOTE 2 Where the backup heated volume is correctly specified for the expected DHW load and there is sufficient insulation, DHW can be made available for many domestic load patterns with only one backup heating period, which can improve backup system efficiency due to reduced primary pipework losses.

4.14.4 DHW secondary return (DHWSR) circulation control

NOTE Incorrect connection of any DHWSR can de-stratify the dedicated solar storage and raise its temperature to a point where the solar collector loses efficiency. In extreme cases, e.g. where a DHWSR connection enters the cold feed, the solar system is effectively disabled.

Any DHWSR should not normally enter the dedicated solar storage, taking account of any internal dip pipe arrangements. Separate arrangements should be made for store disinfection (see A.2.2).

4.15 Limiting maximum primary pressure

NOTE The absolute pressure measured in a primary SDHW system varies according to original filling pressure, height above sea level, relative height of components, position and activity of the pump circulator, temperature of the HTF and means of accommodating expansion of the fluid. Under a fault condition, the system pressure can start to approach the design limits of components. If any component catastrophically fails under high temperatures and pressure conditions there is a significant risk of explosion.

A control device should be fitted in the primary circuit to prevent the system pressure exceeding the design limit. This device should be accessible for maintenance and fitted without potential obstruction between it and the solar collectors. The device should be terminated so that, where operated, the discharge cannot cause personal injury or damage to the building (see 7.7.7). The device should not permit passive evaporation of HTF, particularly during summer, or a build-up of moisture inside the building. The device should be capable of operating even in freezing conditions, since solar radiation can still heat up the solar collector.

4.16 Accommodating primary expansion

NOTE The volume of aqueous liquids increases by typically 8% from freezing conditions through to the maximum stagnation temperature in the solar collector.

The primary expansion should be accommodated by a method that does not rely on or allow the discharge of HTF or contamination or loss of water, or require user intervention. There are two common methods of expansion which may be used to meet these design criteria:

- a) a metallic vessel encasing a flexible polymer membrane which retains a volume of gas to absorb expansion without mixing with the HTF; and

- b) a metallic vessel retaining a volume of gas to absorb expansion which mixes with the HTF normally only used in a drainback primary system.

Either vessel should be capable of tolerating higher temperatures than might be experienced in a SDHW system, and be compatible with any HTF used.

4.17 Warnings and indicators of system status

NOTE During high solar radiation conditions, a SDHW system is capable of generating high-temperature pressurized liquids or gases that can appear unexpectedly in any part of the primary system, particularly during fault conditions or during maintenance, servicing or commissioning.

The risk of high-temperature liquids or gases being generated by a SDHW system should be minimized by the installer providing a suitably durable warning notice adjacent and within sight of the solar storage vessel. The warning notice should confirm the risk of high temperatures, identify the location of the solar collector and confirm the type of HTF. Further information should also be provided to:

- a) confirm the level or pressure of HTF in the primary circuit;
- b) display when the control system requires the pump to operate;
- c) confirm the rate of primary circulation; and
- d) confirm the collector (fluid in the absorber) temperature and the solar storage vessel temperature adjacent to the heat exchanger.

5 Site inspections and technical pre-installation surveys

A risk and structural assessment of load-bearing surfaces should be carried out before work commences on a site. A bacterial growth risk assessment should also be carried out to identify the measures required to minimize risk (see 4.4 and Annex A).

A technical survey should be conducted, either on site or remotely, using drawings or photographs. However, an on-site visit should be made for existing buildings. The assessment should be completed by a competent, experienced technical person.

The site visit should involve an assessment of the shading and reflectance. Where possible, this should be established from the viewpoint and same height as the intended collector fixing surface.

NOTE 1 An accurate recording of such information is essential for future validation of a design, such as where performance predictions are disputed. For larger areas, multiple measurements from representative parts of the intended array can be averaged.

The measurement and recording of the collector fixing area, such as on a pitched roof, should include the area dimensions, compass orientation and pitch angle.

NOTE 2 Electronic techniques can allow personnel to take all measurements from the ground level and make adjustment for height in computer software. Site information may be digitized for computer use in simulation software to obtain more accurate predictions of performance.

NOTE 3 An example survey form is shown in Annex D.