
British Standard Code of practice for
**Solar heating systems for
domestic hot water**

Appareils de production d'eau chaude à usages domestiques par énergie solaire — Code de bonne pratique

Leitfaden zu Systemen zur Warmwasserbereitung im häuslichen Bereich mittels Solarenergie

Foreword

This British Standard has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee and is a revision of BS 5918 : 1980 which is withdrawn. It is intended to assist the building services industry to provide well constructed and durable equipment for preheating domestic hot water. Emphasis is placed on general principles rather than on matters of detail concerning particular systems, so that development and innovation in this new field should not be unduly inhibited. At the same time, guidance is given to installers on essential information on the method of operation and expected performance. This information should be furnished to customers in the interests of consumer protection and to provide a greater awareness of the characteristics of these systems. The code provides a basis for estimating the performance to be expected of solar heating systems for domestic hot water used in typical situations in the UK.

This code sets out a framework of recommended practice in the design, construction, installation and commissioning of components and systems for domestic hot water pre-heating. It should be read in association with BS 6757 : 1986, which describes methods of test for solar collectors, and which supplements the information given in this code.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Code of practice

1 Scope

This code of practice provides recommendations for solar heating systems having flat plate collectors with liquid heat transfer media for heating water for domestic purposes in single family dwellings. Design considerations, manufacture, handling, installation, operation and maintenance are included. Applications to space heating and swimming pools are excluded.

NOTE 1. For solar heating of swimming pools reference should be made to BS 6785.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard, the following definitions apply.

2.1 collector (solar collector, solar panel). The general term for the device in which solar radiation is absorbed, converted to heat, and removed by the heat transfer fluid.

2.2 flat plate collector. A collector that employs no concentration of the incident solar radiation, and in which the absorber plate is essentially planar.

2.3 trickle collector. A flat plate collector in which the heat transfer fluid is not contained within passageways in the absorber plate but flows down the plate surface.

2.4 absorber plate (absorber). The element of a collector that receives and absorbs the solar radiation and converts it into heat.

2.5 absorber plate surface coating. A coating the principal function of which is to absorb solar radiation.

2.6 aperture. That part of the outer surface of the collector which admits solar radiation to the absorber plate, including any glazing bars or supports over the absorber.

2.7 aperture area. The maximum area projected by the aperture.

2.8 effective area. The area of the perfect collector that would collect the same amount of solar energy as the aperture area.

2.9 selective surface. An absorber plate surface coating that will decrease the radiative emission from the absorber plate whilst maintaining a high absorptance for solar radiation.

2.10 absorptance. The ratio of the solar radiation absorbed by a surface to that which falls on the surface.

2.11 emittance. The ratio of the thermal radiation from unit area of a surface to the radiation from unit area of a full emitter ('black body') at the same temperature.

2.12 preheat vessel (solar store). A thermal store for the energy transferred from the collector.

2.13 differential temperature controller. A device that is able to detect a temperature difference, and to control

pumps and other electrical devices in accordance with this temperature difference.

2.14 direct system. A system in which the water that will ultimately be drawn from the hot taps passes through the collector.

2.15 indirect system. A system in which a fluid other than the water ultimately drawn from the hot taps passes through the collector.

2.16 open system. A system in which the heat transfer fluid is in extensive contact with the atmosphere.

2.17 vented system. A system in which contact between the heat transfer fluid and the atmosphere is restricted to the free surface of a feed and expansion cistern.

2.18 sealed system. A system in which the heat transfer fluid is completely sealed from the atmosphere.

2.19 gravity system (thermosyphon system). A system in which circulation of the heat transfer fluid is achieved by natural convection.

2.20 pumped system. A system in which the heat transfer fluid is circulated by means of a pump.

2.21 drainback system. A system in which, as part of the normal working cycle, the collector is automatically drained and refilled with heat transfer fluid.

2.22 draindown system. A system in which the collector is drained to waste, either manually or automatically, when freezing conditions are likely to occur.

2.23 draw-off temperature (delivery temperature). The temperature at which domestic hot water is supplied.

3 Legal requirements

3.1 General

This clause refers to legal requirements that have to be observed before the installation of a solar water heating system is undertaken in the UK.

Such requirements are based on the Model Water Byelaws*, prepared by the Department of the Environment, the Scottish Development Department and the Welsh Office, but can vary in different parts of the UK. The local authority and water undertaker for the region in which a proposed installation is to be sited should always be consulted concerning the requirements in respect of planning, building regulations and water supply.

3.2 Planning

A person has generally to obtain planning permission from the local planning authority before carrying out any 'development'. Consequently application should be made to the local planning authority to ascertain whether or not the proposed installation constitutes 'development'.

3.3 Building regulations

General regulations have been enacted concerning the design and construction of buildings in the UK. Solar heating systems incorporated into buildings have to comply with these regulations in so far as they affect such matters as the materials of construction, roof loading, weathertightness, fire resistance, insulation, etc.

* Model Water Byelaws (1986 edition), HMSO, London, 1986.

Advice on some of these matters is given in this code (see clauses 6, 8 and 9 and appendices A, B and C). However, responsibility for the application of the regulations in a particular area rests with the local authority, which may require plans to be deposited, showing how the regulations have been complied with. (See 3.1.)

3.4 Water supply

Water supply byelaws for preventing waste, undue consumption, misuse, or contamination of water supplies have been made by water authorities and water companies in England and Wales and by the Regional and Islands Councils in Scotland. Water regulations for the same purposes have been made by the Department of the Environment, Northern Ireland.

These byelaws require written notice (5 working days if enacted in accordance with the Model Water Byelaws 1986) to be made to the local water undertaker before any installation of, or alteration to, a water fitting is made, if connected to the authority's supply.

Where a water fitting has been installed, that can subsequently be found by the water undertaker to contravene its byelaws, the water undertaker can insist that the occupier remove it. The occupier of the premises will also, on summary conviction of such an offence, be liable to a fine in respect of each offence and, in the case of a continuing offence, to a further fine for each day during which the offence continues after such a conviction. It should be noted that, whilst the various sets of byelaws are identical except in a few minor respects (see 3.1), the interpretation and enforcement of each set of byelaws will vary with the particular water undertaker concerned. Bearing this in mind, it is considered that to attempt to give meaningful general guidance on the application of water byelaws in this code of practice could be misleading.

It is, however, in the interest of prospective purchasers of solar heating systems to obtain the assurance of the installer/manufacture of the system that the recommendations given in 6.3.3 and 6.5 of this code of practice have been followed.

3.5 Other actions

In addition to complying with the legal requirements detailed in 3.1 to 3.4, it is recommended that the occupier/owner inform the lessors, mortgagors, insurers, etc. of the property as applicable.

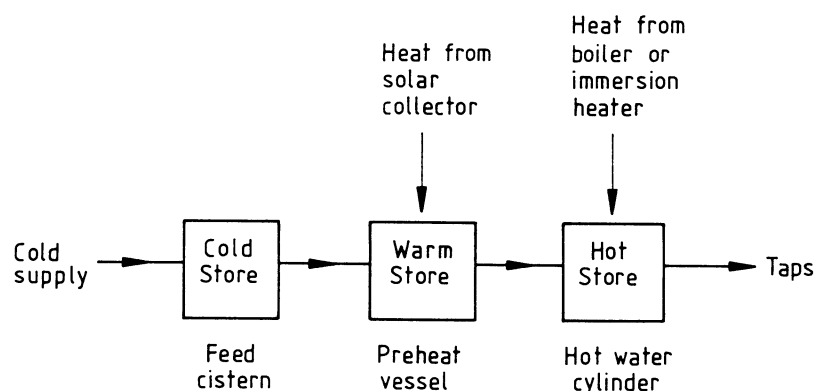
4 Types of system

4.1 General

A hot water system for domestic purposes incorporating solar heating usually contains arrangements for providing heat by other means such as a solid fuel, gas or oil fired boiler or an electric immersion heater. This is necessary because, in the UK, the water cannot be heated to the required draw-off temperature at all times of the year by solar energy alone.

The working principle of solar hot water systems is shown schematically in figure 1. Water from the cold supply is led to the 'cold store' (the feed cistern) whence it passes into the preheat vessel, forming the 'warm store', where it is heated by solar energy. The water passes then to the 'hot store' (the hot water cylinder) which is heated by a boiler or electric immersion heater.

NOTE. To discourage the growth of the organism responsible for Legionnaire's disease, water in the hot store should be kept at a temperature of at least 55 °C. For details, see 'Minimizing the risk of Legionnaire's disease', TM13 1987, obtainable from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.



NOTE. Preheat vessel and hot water cylinder may be combined in one vessel.

Figure 1. Working principle of solar hot water system

In hot weather, solar energy alone may be sufficient to heat the water to the desired draw-off temperature. Arrangements to turn off the boiler or immersion heater automatically are commonly provided, sometimes with a by-pass valve and pipe to allow the water to pass directly from the preheat vessel to the taps. Another arrangement, which is intended to ensure that the hottest water is always available for use, is to employ a cylinder in which the bottom portion (half to two-thirds) of the cylinder functions as the preheat vessel and the top part as the hot store.

4.2 System types

4.2.1 General. Many different designs of solar water heating systems are possible and they may be classified in several ways. Each type has its own advantages and disadvantages, and at the present stage of development it is not considered that a preferred variety has emerged that may be recommended for use in all situations.

To enable the general layout, operation and design limitations of systems to be discussed, three examples are cited here. These differ essentially in the means of obtaining circulation of the heat transfer fluid and of securing protection against damage resulting from freezing in the collectors. They are illustrated schematically in figure 2, where it will be seen that the basis for selecting these as examples is the differing freedom allowed by the various designs in the relative siting of the collectors. For clarity, all detail concerning arrangements for the cold water supply and final heating to draw-off temperature has been omitted, though it is emphasized that adequate provision is required in each case for expansion of the heat transfer fluid, for venting or containing the pressure rise in the event of boiling, both in the collector circuit and in the preheat vessel, and for the prevention of reverse circulation.

4.2.2 Example (a): gravity systems (see figure 2). When a fluid in the collector is hotter than the water in the preheat vessel, flow occurs by natural convection, transferring heat from the collector to the preheat vessel.

System limitations

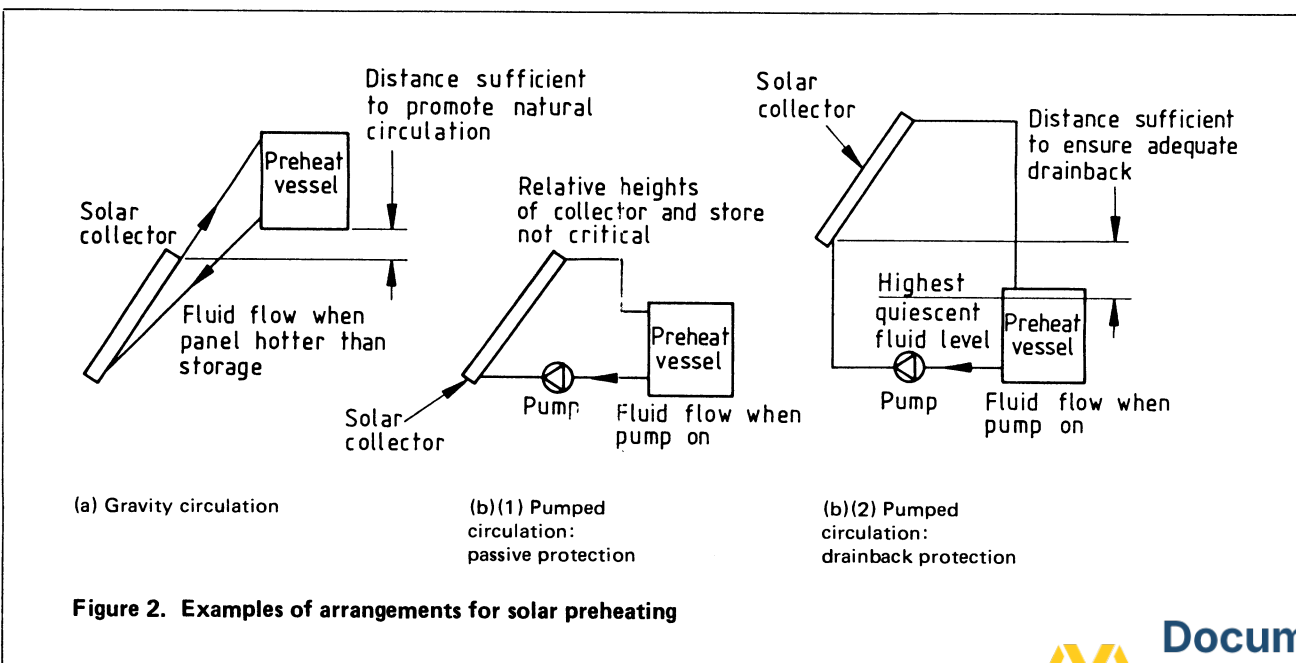
- (a) The collector has to be sited sufficiently below the preheat vessel to promote natural circulation when the collector is hotter than the store.
- (b) Freeze protection in the direct gravity system cannot be readily achieved.
- (c) All pipework should be of minimal length and of sufficient bore to ensure adequate flow.
- (d) There should be sufficient rise on all pipe runs to prevent air locks.
- (e) A non-return valve fitted to prevent reverse circulation would need to have a very low pressure drop for forward flow.

4.2.3 Example (b)(1): pumped systems: passive protection (see figure 2). Transfer of heated fluid from the collector to the preheat vessel is by pumped circulation. The heat transfer fluid fills the absorber plate passages permanently. The relative position of the collector and preheat vessel is generally not critical.

System limitations

- (a) A control system is required to ensure that the pump is operated only when the system can gain energy.
- (b) It is essential that a non-freezing heat transfer fluid be used.

4.2.4 Example (b)(2): pumped system: drainback protection (see figure 2). The arrangement is similar to that described in example (b)(1), except that provision is made to empty the collector fluid when freezing is likely to occur.



System limitations

- (a) Arrangements for venting should be so designed that no escape of the circulating fluid can occur when the pump is operating.
- (b) In a direct system, the lowest part of the collector and of exposed pipework should be above the highest water level in the preheat vessel, after allowing for the rise resulting from drainback. In an indirect system, there is more freedom of layout, but a separate drainback vessel with the same requirements is needed.

5 Components for solar water heating systems

5.1 General

In this clause, descriptions are given of the main features of the principal components of solar water heating systems, to which reference is made elsewhere in the code.

5.2 Collectors

5.2.1 Collectors are of various types, but most of those intended for domestic hot water applications will be of the flat plate variety, the principal components of which are shown in figure 3, illustrating one layout commonly used. In other designs, there may be a single fluid passage in place of the arrangement of headers and risers. The trickle collector has one or more open channels down which the fluid flows by gravity.

Some collectors, as in the example shown in figure 3, are self-contained units intended for attachment to existing roofs or walls. Others are integrated into the structure of the roof, the absorber plate being mounted between the rafters and fitted with a transparent or translucent cover.

5.2.2 The main components of collectors are as follows.

- (a) A blackened or otherwise treated absorber plate the principal functions of which are to absorb the incident solar radiation, to convert it to heat and to conduct the heat to the fluid passages.
- (b) Fluid passages in which a heat transfer fluid flows, in good thermal contact with the absorber plate. Heat conducted from the absorber plate is transferred to this fluid, which subsequently transfers it to water contained in the preheat vessel.
- (c) A transparent or translucent cover or covers the principal functions of which are to help to insulate the absorber plate from the cooler ambient air, and to provide weatherproofing.
- (d) Insulation materials behind the absorber plate the principal function of which is to reduce heat loss from the back of the collector.
- (e) An enclosing box the principal functions of which are to hold the other components of the collector in their correct relative positions and to protect the collector plate and insulation material from the weather. If a collector is integrated into a roof, an enclosing box may not be required.

5.3 Controls

A control system will be a necessary part of pumped solar collector circuits. The purpose of the control is to ensure that fluid is pumped through the collectors only when heat can be gained.

Electronic differential temperature controllers are activated by sensors that detect the temperatures of the collector and

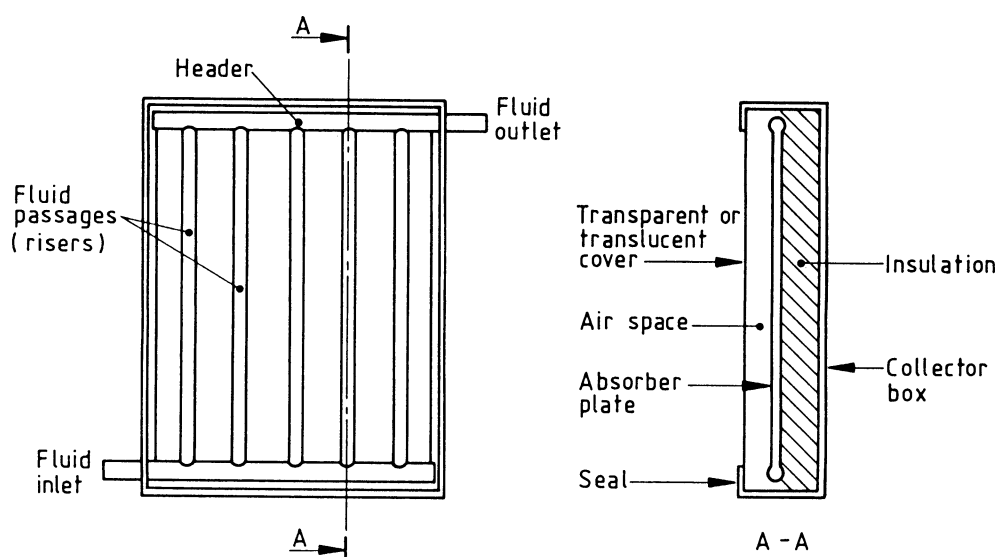


Figure 3. Flat plate collector

the preheat vessel. The main components of a typical control system are:

- (a) *a power source* to provide supplies at the required voltages;
- (b) *an electrically operated switch* to control the supply to the pump;
- (c) *temperature sensors* to provide signals for operating the control;
- (d) *a device, such as a bridge circuit*, to compare the signals received from the sensors and to operate the pump switch.

Control system functions may also include:

- (1) preventing excessive cycling of the pump;
- (2) operating draindown, mixing and by-pass valves;
- (3) limiting water storage temperatures to safe values.

See also clauses 7, 8 and 10.

5.4 Equipment to check system operation

5.4.1 General. It is recognized that faults may occur from time to time in domestic solar water heating systems. Installation of simple checking equipment may prove helpful to both the system owner and service personnel. Since thermosiphon systems are inherently self regulating and may contain no electrical components, there is only limited scope for checking their operation using simple equipment. Correct operation of this type of system is largely dependent upon adherence to good design and installation practice. Unless otherwise indicated, the types of equipment described in 5.4.2 are applicable to pumped systems only.

5.4.2 Types of equipment. No rigid guidelines can be given as to the most appropriate checking devices for use in any particular instance because this will depend upon the detailed design of both the plumbing and control systems. Performance checking equipment installed permanently in the plumbing system should be suitable for use at the maximum working temperature and pressure of the system. Electrical indicators should preferably be operated by a low-voltage supply but, in any case, should be in accordance with clause 8.

Where appropriate, some or all of the following equipment should be considered for inclusion.

- (a) Indicator lights to show that the electrical supply is connected to the control system, to the pump, to any electrically operated valves and to any other electrical equipment forming part of the solar heating system. Where possible, all indicator lights should be grouped in a single frequently-used area of the dwelling (e.g. in the airing cupboard).

- (b) A pressure gauge in sealed primary circuits.

NOTE 1. Item (b) is applicable also to sealed thermosiphon systems.

- (c) An independent indicator for the temperature of the warm store.

NOTE 2. Item (c) is applicable also to thermosiphon systems. Mercury-in-glass thermometers are unsuitable for this application.

- (d) A flow meter to indicate the rate of flow through the solar collector.

NOTE 3. Some designs of meter act as a check valve and may be unsuitable for drainback and draindown systems.

See also clause 10.

5.5 Tanks, pumps, pipework, valves and fittings

These components are broadly similar to those generally employed in low pressure hot water supply systems. References to special requirements for solar water heating systems are given in clause 6.

6 Design considerations

6.1 General

The main requirements of a solar heating system are that it should absorb solar energy efficiently and transmit the heat so generated with a minimum of loss to a storage unit ready for use. In addition, it should be sufficiently durable to have a useful life comparable with that of other building services equipment, and require a minimum of maintenance.

This clause mainly covers those features of component and system design that promote durability and reliability.

Design factors that affect the thermal performance of a system are discussed in clause 7.

System design considerations are similar to those concerning other parts of domestic hot water systems in respect of compatibility of materials, freedom from leakage and air locks, and other matters on which good practice is already well established. Additional considerations that apply to solar heating systems are mainly a consequence of the exposure of parts of them to the outdoor environment and the extremes of temperature that result from this. Freezing and boiling in collectors are hazards to which reference has already been made. A further consequence is the high temperature that may be reached by an absorber at times when there is no fluid flow through it. This may occur on drainback during normal operation, on shut-down for maintenance, or even during installation. Under these conditions the plate temperature may approach 150 °C if it has a neutral black absorbing finish, or 200 °C if the finish is highly selective, and these values are recommended for design purposes. The corresponding temperature for the front cover may approach 100 °C, and when more than one cover is fitted, the inner ones may reach temperatures greater than this.

Having an exposed surface, the collector of a solar heating system is subject to loading by the wind and accumulated snow. The fixings that support the collector should withstand these loads, together with the weight of the collector. They should also transfer the loads safely to the roof members or other foundations without impairing the weathertightness or strength of the structure. (See appendix B.)

6.2 Collector design considerations

6.2.1 Materials. Properties of importance in the selection of materials for collectors are thermal properties, durability and cost. Of the thermal properties, the thermal conductivity determines such design features as the absorber plate

thickness and fluid passage spacing, whilst the heat capacity affects the rate of response to intermittent sunshine (for details see, for example, Duffie, J.A. and Beckman, W.A., *Solar Engineering of Thermal Processes*, Wiley, New York, 1980; see also clause 7). Durability requirements will need to take account of the effects of the outdoor environment (solar radiation, wind loading, hail impact, etc.), thermal effects (expansion and contraction, frost, etc.), corrosion and stressing (in situ and handling during installation, etc.). Capillary fittings employing low temperature soft solders are not suitable for use when directly attached to, or in contact with, collectors. Manufacturers should be consulted on suitable high temperature solders for this duty.

Absorber plates should be leak and pressure tested as described in appendix E. Each absorber plate or collector should be marked with the maximum working pressure in bar (see E.2.1).

Methods of type testing for assessing the resistance of collectors to adverse conditions are described in appendix F.

6.2.2 Heat transfer and flow rates. The collection efficiency of a solar collector decreases with increasing temperature and therefore systems are generally designed to give good heat transfer to the fluid and rapid thermal response.

To ensure adequate efficiency of heat removal, flow rates in the region of 0.01 to 0.02 kg/s per square metre of collector area are found to be satisfactory, when the fluid is water or water based. For other fluids, the flow rate is likely to be higher, and the manufacturer of the fluid should be consulted. (See also clause 7.)

6.2.3 Insulation. The reverse side of an absorber plate often has a bright surface of low emittance, but it is desirable to provide additional insulation to reduce heat loss. Since solar absorber plates can, under shut-down conditions, reach temperatures approaching 200 °C, care should be taken to select insulating materials that will tolerate these temperatures without degradation. Some insulating materials give off vapours at elevated temperatures which can condense on the underside of the cover and reduce transmission of solar radiation.

As a design rule-of-thumb, the total thermal conductance between the back of the absorber plate and the rear of the collector should not be more than 1.5 W/(m²·K); appreciably lower values could be justified for collectors having selective absorber coatings or more than one cover.

Where collectors are built into roof spaces, it may be necessary to provide sufficient back and side insulation to protect the other roofing material (such as wooden roof trusses, boarding and felts) and, in addition, to ensure that the insulation properties of the roof continue to comply with the requirements of the Building Regulations.

6.2.4 Absorber coatings. Paints are often used to provide the surface finish on absorber plates. Some form of pretreatment of the plate surface is usually necessary to ensure satisfactory paint adhesion during the repeated thermal cycling that occurs in service. The paint manufacturer's advice should be sought so that the pretreatment and finish are compatible with the expected

service conditions. Other coatings, including selective surfaces, are usually applied by specialist firms, who should be given full particulars of the intended use of the collector to ensure that a suitable coating is provided.

6.2.5 Collector box. An externally-mounted collector should be weathertight and sufficiently strong and stiff to withstand the forces applied to it in service and during installation without mechanical failure, breakage of glass or damage to weather seals.

Methods of calculating the forces applied to the collector box by wind and snow loads are given in appendix B.

Arrangements for supporting the covers should include adequate provision for thermal expansion, and particular care should be taken to ensure that covers will not be caused to fail from thermal stress due to cooling at the points of support.

The collector box should be so designed as to prevent the retention of excessive quantities of internal condensation, which can impair the effectiveness of insulation and lead to corrosion or degradation of the absorbing surface. Unless special provision has been made to ensure that the collector will remain hermetically sealed throughout its working life, the internal spaces should be vented to the atmosphere by holes situated at the lowest portion of the box, so as to allow drainage of any condensed moisture. In addition to the drainage holes at the bottom, other holes may be required to provide ventilation of the insulation and of the space below the cover. Holes should be so placed or shielded as to preclude the ingress of wind-driven rain or snow.

6.2.6 Covers for solar collectors. The following physical and chemical properties are desirable in materials used for the construction of covers for solar collectors:

- (a) high transmission of visible and near infra-red radiation of wavelength up to 2.4 µm in order to maximize the input of solar radiation;
- (b) low transmission of infra-red radiation of wavelength exceeding 3 µm in order to minimize heat losses;
- (c) good resistance to degradation by sunlight;
- (d) good resistance to chemical degradation and environmental stress cracking when subjected to contact with rainwater, atmospheric pollutants, detergents used for cleaning, or any other materials with which the cover may reasonably be expected to come into contact (e.g. sealant, paint splashes);
- (e) tolerance of high and low temperatures without significant embrittlement or softening;
- (f) hard surface (to facilitate cleaning without surface damage);
- (g) high impact resistance (to resist accidental or malicious damage);
- (h) appropriate fire resistance;
- (i) sufficient strength to withstand wind and snow loads, as indicated in appendix B.

Glass or appropriate plastics materials may be used as cover materials. Many variants of basic plastics have been formulated to satisfy special requirements.

The manufacturers should always be consulted to ensure that materials used for covers are of a suitable type and grade in relation to factors (a) to (i) in this clause.

6.3 System design considerations

6.3.1 Plumbing and flow rates. Some of the components used in a solar preheating system may be selected from existing products developed for other heating applications, but care should be exercised. Help should be sought from manufacturers to ensure that the components will be suitable for the temperatures, pressures and other conditions found in solar heating systems. Particular attention is drawn to the high temperatures that may be experienced by cisterns and float valves connected to the collector circuit.

The system plumbing should be designed to ensure that there is an approximately equal fluid flow through each collector in an array, and that adequate air bleeding facilities are provided.

It is desirable that flow velocities should be less than 1 m/s and in any event they should not exceed 2 m/s, since excessive flow velocity can give rise to noise and erosion.

6.3.2 Pressure relief and venting. Vent pipes, pressure relief valves and automatic air bleeding devices on the collector circuit should be so arranged that vapour or heat transfer fluid escaping from the system can be safely discharged.

A free fluid path from the collectors to a safety valve or expansion vessel should always be provided. This path should not contain a non-return valve, and if it is necessary that it should contain a shut-off device, this should be protected from accidental closure (e.g. by means of a wire and seal).

Sealed systems should be fitted with a pressure relief valve and a pressure gauge.

6.3.3 Components and fittings. All materials, fittings and components used should comply with the requirements of the relevant British Standards, where applicable, or be deemed by the United Kingdom Water Fittings Byelaws Scheme (UKWFBS*) to be no less suitable in relation to the purposes for which water byelaws are made (see 3.4). BS 6700 gives general guidance on the design and installation of systems for supplying water for domestic use. Among the British Standards relating to the potable water side of the system are those listed in table 1, though the list is not exhaustive.

Water byelaws require all water fittings to be adequately protected from frost. Advice concerning frost protection for water services is given in BS 6700.

Manufacturers are recommended to consult the UKWFBS early in the development stage to ensure that materials, components and fittings will comply with the requirements of the local water undertakers.

In direct systems, where the heat transfer fluid is mains water, the metals and connectors used in the solar collector

circuit should be wholly suitable for fresh water applications following the requirements given in BS 6700, and no other less suitable materials should be used.

6.3.4 Collector mounting. Collectors are mounted in various ways, the most common arrangement being mounting above, and parallel to, a slated or tiled roof, with clearance between the bottom of the collector and roof cladding to allow rain to run off normally and to avoid accumulation of leaves and other debris at the upper edge. Mounting in direct contact with tiles and slates may be convenient, but this provides less clearance for the run-off of rain and debris and can impose loads on the cladding which it has not been designed to accept. Sometimes, the cladding is removed or omitted and collectors are mounted with the exposed surface more-or-less flush with the roof. Collectors are also sometimes built into the roof behind patent glazing.

6.3.5 Patent glazing. Where collectors are integrated into roof structures under patent glazing, reference should be made to BS 5516. Particular regard should be paid to minimization of thermal stress in the glass, which will be subject to a wider range of operating temperature than in normal use. Consultation on this point with the manufacturers is advised. (See also 6.2.6(e).)

6.3.6 Weather resistance. Where the system is attached to, or forms an integral part of, a wall or roof, the positioning and method of attachment to the building should be such as not to impair the weathertightness and resistance of the building to moisture penetration into any part that would be adversely affected by such moisture. (See appendix A.)

6.3.7 Structural safety. The method of fixing and the fixings used to attach the system to the building should be adequate for their purpose during the life of the building. The forces that the wind exerts on a collector depend on how it is installed on the roof. Procedures are outlined in appendix B for determining the highest loads likely to be experienced by collectors installed in various ways. It should be recognized that the collector fixings can be subjected to a component of force tending to lift the collector from the roof. However, it will usually be the components acting parallel to the roof that determine the strength and type of fixings required.

It is desirable that fixings should need no maintenance during the service life of the collector. In addition to the primary loads referred to in this clause, they should be designed to withstand other effects such as bending due to variation in wind forces and differential thermal movement, abrasion against roof tiles and other nearby materials, and corrosion due to rain and accumulated debris.

The addition of the system to a building should in no way impair the ability of the building structure to withstand the combined dead load, wind load and imposed loads expected during the building life. (See appendices A and B.)

*. Details of the UKWFBS may be obtained from the Water Byelaws Advisory Service, 660 Ajax Avenue, Slough, Berkshire SL1 4BG.

Table 1. Some relevant British Standards for components and fittings		
Feed and expansion cisterns and expansion vessels BS 417, BS 4213, BS 4814		
Tanks and cylinders BS 699, BS 1565, BS 1566 : Part 1, BS 3198		
Pumps	BS 1394 : Parts 1 and 2	
Valves	BS 5154	
Pipework and fittings		
British Standards applicable to pipes and pipe fittings include the following.		
Form and material	BS designation	Type and application
<i>Tubes</i>		
Copper	BS 2871 : Part 1	Hot and cold water services
Plastics		
ABS	BS 5391	Cold water services
PP	BS 4991	Cold water services
Unplasticized PVC	BS 3505	Cold water services
HDPE	BS 3284	Cold water services
Stainless steel	BS 4127 : Part 2	Hot and cold water services
<i>Fittings</i>		
Copper and copper alloy	BS 864 : Part 2	(capillary and compression) Hot and cold water services (compression)
Malleable cast iron and cast copper alloy	BS 143 and BS 1256	Cold water services (screwed pipe fittings) Hot and cold water services
Unplasticized PVC	BS 4346 : Parts 1 and 2	Cold water services
ABS	BS 5392 : Part 1	Cold water services
In certain areas of the UK specified in the Building Regulations (B3), where softwoods are used in the construction, they are required to be treated, e.g. in accordance with BS 4072, to prevent infestation by the house longhorn beetle.		

6.3.8 Fire resistance. The addition of the system on to the walls or roof of a building should in no way impair the fire resistance of the element to which it is attached.

Where the collector forms an integral part of an element of a building, the following minimum requirements apply.

- When wall-mounted, the collector, together with any back-up walling, is required to have a fire resistance of a specified period.
- When roof-mounted, the collector, in conjunction with any back-up roof construction, is required to comply with the Building Regulations for the type of roof concerned. (For typical type testing procedures, see BS 476 : Part 3.)
- Where pipes pass through a separating wall or floor, protected structure or cavity barrier, they should be adequately fire-stopped, without inhibiting movement due to thermal expansion.

6.3.9 Thermal insulation. Where the system forms an integral part of either the roof or external wall of a building, it should, where possible, be thermally insulated to a standard not less than that of the surrounding parts of the roof or wall in which it is situated.

In addition, where the system is installed in a roof space above a heavily insulated ceiling, the pipe insulation should protect the system from frost conditions that might otherwise cause damage in winter. Requirements for the thickness of thermal insulation for frost protection are given in BS 6700. The insulation should be specified by the designer of the system and should be sufficient to prevent condensation. (See also appendix C.)

All tanks, cisterns, cylinders, pipes, etc. should be well insulated using insulation board, petal jackets, or other conventional or proprietary systems. (See BS 5615.)