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Solar heating — Swimming-pool heating systems — Dimensions, design and installation guidelines

Chauffage solaire — Systèmes de chauffage pour piscines — Dimensions, conception et guide pour l'installation

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 12596, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 180, *Solar energy*, Subcommittee SC 4, *Systems — Thermal performance, reliability and durability.*

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.4.2.2 of part 1 of the ISO/IEC Directives, 1992), as a "prospective standard for provisional application" in the field of solar heating systems for swimming pools because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

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A review of this type 2 Technical Report will be carried out not later than two years after its publication with the options of: extension for another two years; conversion into an International Standard; or withdrawal.

Annexes A, B and C of this Technical Report are for information only.

Solar heating — Swimming-pool heating systems — Dimensions, design and installation guidelines

1 Scope

This Technical Report gives recommendations for the design, installation and commissioning of solar heating systems for swimming pools, using direct circulation of pool water to the solar collectors. The report does not include electrical safety requirements and does not deal with the pool filtration systems to which a solar heating system is often connected. Annexes A and B are included dealing with calculation of heating load and information concerning pool covers.

The material in this Technical Report is applicable to all sizes of pools, both domestic and public, that are heated by solar energy, either alone or in conjunction with a conventional heating system.

NOTE 1 Many of the recommendations in this Technical Report have been adopted from BS 6785 and AS 3634.

2 Definitions

For the purposes of this Technical Report, the following definitions apply.

2.1 absorber: Device within a solar collector for absorbing radiant energy and transferring this energy as heat into a fluid.

2.2 collector: Device designed to absorb solar radiation and transfer the thermal energy so gained to a fluid passing through it.

2.2.1 collector, flat plate: Nonconcentrating collector in which the absorbing surface is essentially planar.

2.2.2 collector, glazed: Collector in which the absorber is covered by a translucent glazing material.

2.2.3 collector, unglazed: Collector in which the absorber is directly exposed to the environment.

The rear surface may or may not be insulated.

2.2.4 collector, plastic strip: Collector system in which extruded plastic strip embodying fluid passages is arranged to act as an absorber, on a roof or other base.

The strip is typically about 50 mm to 150 mm in width and made of flexible elastomeric or plastic material.

2.2.5 collector, plastic panel: Unglazed collector in which the absorber is made of rigid plastic sheet embodying numerous closely spaced passages for fluid.

2.2.6 collector, plastic piping: Collector system in which plastic piping is arranged to act as an absorber on a roof or other base.

An example of such piping is black polyethylene agricultural piping.

2.3 differential temperature controller: Device that detects a specified difference between two temperatures, and controls pumps and other electrical devices in accordance with this temperature difference.

2.4 direct system: Solar heating system in which the heated water that will be circulated to the pool passes through the collectors.

2.5 drain-down system: Direct solar heating system in which the water can be drained from the collectors to prevent freezing.

2.6 indirect system: System in which a fluid other than pool water passes through the solar collectors.

2.7 reverse return: Arrangement of collector manifolding so that all flow paths through the collector module offer approximately the same resistance to flow.

3 Solar collectors

3.1 Types

Solar collector types commonly used for pool heating vary considerably from those used for providing domestic hot water. The differences arise due to the relatively low temperatures required of swimming pool heating. Also, swimming-pool water is normally more corrosive than domestic potable water.

The use of unglazed, uninsulated collectors for pool heating is now very widespread in the domestic pool field and has been successfully implemented in large public pools. The reason is that conventional flat plate collectors have glazing and insulation to reduce heat losses from the collector. Much of collector design for domestic hot water heaters is devoted to reducing heat losses rather than maximizing heat gain. The losses are essentially proportional to the difference in temperature between the collector fluid and the ambient temperature. Since the collector fluid in a pool heating application is usually much cooler than in a domestic hot water application, the potential losses are proportionately less. Hence the cost of glazing and insulation must be offset by a small reduction of losses at swimming pool temperatures. The performance of glazed collectors may be lower than the performance of unglazed collectors when the pool temperature is close to air temperature, because the glazing reduces the solar input to the collector.

For public pools the situation is not necessarily the same as for private pools, since their temperature requirements may be different, and year-round operation of open-air pools is common in warmer climates. There has been substantial use of both glazed and unglazed collectors in solar heating systems installed on large public and commercial pools. The main features of the various collector types are outlined in 3.2 and 3.3.

3.2 Unglazed collectors

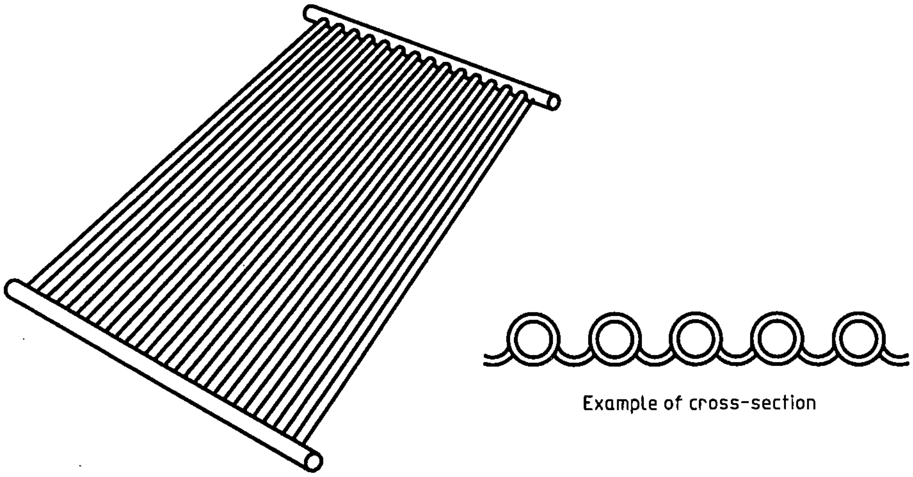
3.2.1 Plastic (or elastomeric) panel collectors

These collectors usually consist of a sheet containing closely spaced passages for fluid, with the top and bottom header pipes integrally attached, normally by welding. An example is shown in figure 1. Materials used for plastic panel collectors include polyolefins (polyethylene, polypropylene, etc.), acrylic and polycarbonate.

3.2.2 Plastic (or elastomeric) strip collectors

These collectors consist of an extruded strip (of width around 50 mm to 150 mm), with a number of fluid passages moulded into the strip. The strips are generally cut to length and connected to header pipes. An example is shown in figure 2. Materials used include ethylene propylene diene (EPDM) rubbers and polyvinyl chloride (PVC).

Strip collectors are designed to be laid on existing roofs or other supports, and their flexibility allows them to follow roof contours and curve around obstacles.



Example of cross-section

Figure 1 — Example of a plastic/elastomeric panel collector

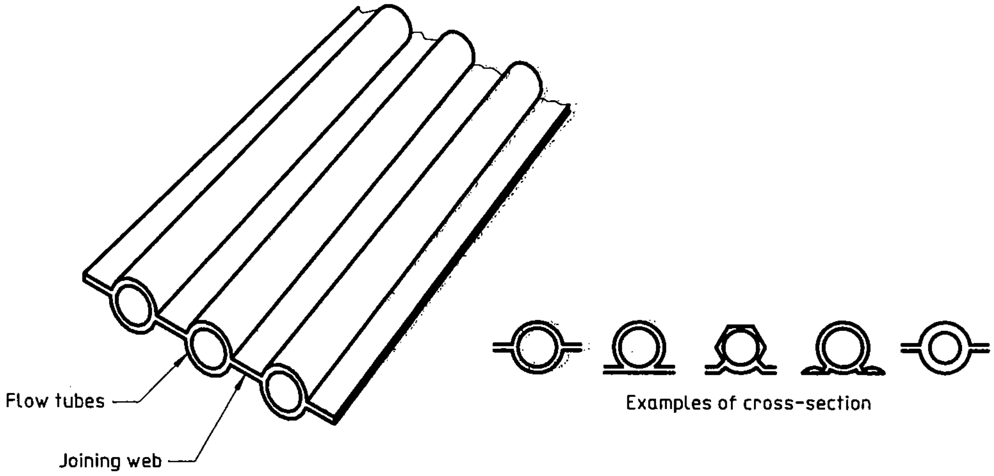


Figure 2 — Plastic strip collector

3.2.3 Plastic pipe collectors

These collectors consist of an arrangement of plastic piping supported on an existing roof or other base. The piping may be arranged in parallel lengths between headers, similar to strip collectors, with appropriate flow balancing. Alternatively the piping may be arranged in a spiral, however with this arrangement it is difficult to achieve both a satisfactory flow and sufficient thermal contact with the roof. Careful design consideration must be given to this style of system due to the need to avoid airlocks and the limited heat gain due to stagnation in long runs of pipe. Consequently, for a given heat output, such a spiral arrangement requires a roof area larger than other arrangements and may have hydraulic difficulties.

3.3 Glazed collectors

These collectors have been developed primarily for domestic water heating. The thermal performance of glazed and unglazed collector systems for pool heating is similar in summer, but glazed systems offer superior performance in winter and accordingly glazed collectors may offer a higher annual solar fraction for applications that operate all year. However, the higher cost of glazed collectors may make them less cost effective than unglazed collectors and the higher temperatures achieved may have detrimental effects on system design and component selection (see 6.1).

3.4 Materials

Materials in contact with pool water should neither contaminate the water nor become corroded under normal service conditions. Special precautions should be observed with respect to the choice of materials in contact with pool water, as this water may contain chlorides or other corrosive minerals. All metals except some chrome-nickel steels should be avoided for these parts of the system. It is important to recognize that not all grades of stainless steel will resist corrosion in these applications; grade 316 is recommended.

Iron and carbon steel are unsuitable for the fluid passages in direct systems because rapid corrosion may occur, resulting in the failure of the passages and rust-staining of the pool walls and fittings.

All components exposed to solar radiation should be resistant to ultraviolet radiation. This is especially important for plastics.

Materials such as EPDM which are able to withstand freezing without damage are preferable for all frost-exposure parts.

3.5 Collector location

3.5.1 General

In order to reduce heat losses and pumping power requirements, collectors should be located so that pipe runs are as short as possible.

3.5.2 Orientation

Whenever possible, collectors should face towards the equator. The range of collector orientations that give output similar to a collector facing the equator will depend on the location, the local climate and the time of year the heating is required. The collector orientation is not significant if the inclination angle is less than latitude 10°. Even at high latitudes this requirement is acceptable for open pools, since such pools are typically only operated in summer.

NOTE 2 Greater deviation from the meridian is allowable in the westerly direction due to the generally higher ambient temperatures in the afternoon.

3.5.3 Inclination

The optimum collector inclination depends on the climate, location and the time of year that heating is required.

For primarily summer heating, the collector should be inclined at an angle not exceeding the latitude angle of the installation site (recommended value: latitude – 10°). For primarily winter heating, the collector should be inclined at an angle greater than the latitude angle by up to 20°.

For systems installed in domestic pools, the inclination (and orientation) will often be dictated by the nature of the roof upon which the collectors are to be mounted. An example of the effect of non-ideal orientation and inclination is given in figure 3, in terms of the collector area required for a given roof orientation and inclination compared with that required for ideal orientation and inclination.

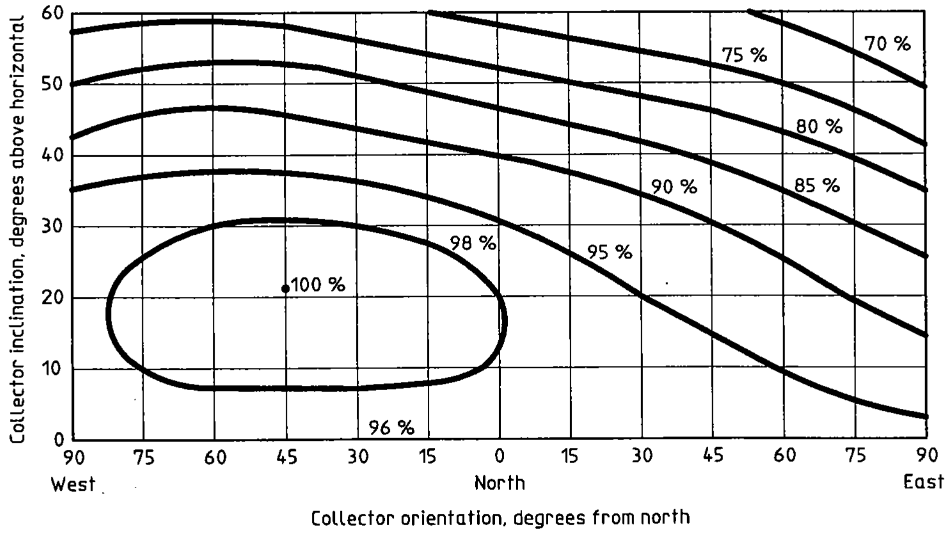
NOTE 3 The example given in figure 3 is for Melbourne, Australia, latitude 38°S, and is based on the useable solar energy received over a 12-month period. It is included as an indication only of the effect of non-ideal installation conditions and should not be used as the basis of calculations in other locations. Similar charts for other locations or other collector types can be determined from an hourly performance evaluation over the required heating season.

3.5.4 Shading

Collectors should be located so as to be clear of shade for at least 3 h either side of solar noon at any time throughout the pool-heating season.

3.5.5 Site exposure

Unglazed collectors are particularly subject to heat losses due to wind. Accordingly, for windy sites, consideration should be given to the use of increased collector area or the provision of windbreaks. Windbreaks will also assist in reducing heat losses from the pool surface.



DATA:

Optimum orientation N – W

Optimum inclination 20 °C

Pool temperature 24 °C

Heating season November – March

Figure 3 — Relative collector output as a function of orientation and inclination (for southern hemisphere)

3.6 Collector dimensions

3.6.1 General

The amount of collector area required is one of the most fundamental aspects of the design of a solar pool-heating system. Collector performance characteristics will normally be available from the collector supplier, and the extent to which a rigorous calculation of collector area is needed will depend on the operational requirements of the pool, including such matters as the following:

a) whether a requirement exists for a specified temperature to be maintained; this may be the case in a public pool used for sporting purposes, or when a varying temperature rise is acceptable, such as in a private pool and in most open-air public pools;

b) whether the swimming season will be all or part of the year;

c) whether there is a conventional heating system to supplement the solar heat delivery to the pool;

d) whether the purchaser wishes to have an indication of the likely performance of the system in regard to temperature and extension of the swimming season.

Factors that need to be considered include:

Location	— local climate
Site-specific conditions	— shading of the roof or pool — roof slope and orientation — colour of pool — wind protection — roof material — roof colour
System configuration	— collector type — plumbing arrangement

In some cases a detailed calculation of pool-heating load and collector output will be necessary, while in others a simple estimation will be adequate. A procedure for calculating the heat requirement for pools is given in annex A. Caution should be exercised when applying these methods for the calculation of heat losses from outdoor pools, as wind speed has a significant effect; however, it is not easy to quantify due to its dependence on the amount of shelter provided around the pool.

Different design philosophies exist and are described briefly in 3.6.2 and 3.6.3. Procedures for the evaluation of the thermal performance of glazed and unglazed solar pool-heating collectors are defined in ISO 9806-1 and ISO 9806-3 respectively.

3.6.2 Pools without auxiliary heating (stand-alone systems)

Where auxiliary heating is not provided, the pool temperature will vary depending upon the local weather conditions and the amount of wind shelter provided. The pool temperature is essentially the equilibrium temperature reached when total pool heat losses are balanced by heat gain due to solar radiation incident on the pool. The addition of collectors to a stand-alone system will lead to an increased but still varying equilibrium temperature. The main objective is to extend the swimming season into spring and autumn.

In these cases, accurate collector dimensions are often not essential and design guidelines, dependent on the climatic region concerned, may be satisfactory. Because the temperature of private pools is normally in the region for which collector energy output is approximately the same for all collector types, the collector area does not depend greatly on the type of the collector. It is acceptable to treat all unglazed collectors as being equivalent for the purpose of choosing collector area in these applications.

As a guide, the following collector areas will generally provide a satisfactory result:

Private pools:	80 % to 100 % of pool area
Public pools:	40 % to 70 % of pool area

For both private and public pools, the collector area may be reduced by 30 % to 40 % if a pool cover is installed (and used). The reason for the larger specific area for private pools is the higher surface area-to-volume ratio and hence higher relative heat loss for small pools.

As an alternative to the use of a simple estimation based on pool area, the pool heat load and collector area needed for a certain equilibrium temperature may be calculated using a suitable computer program. The heat load for a given equilibrium temperature can be calculated (annex A), and the solar system output for the same temperature derived from the collector manufacturer's data and climate data for the site. The two results can be compared and then an iterative procedure used to alter the temperature until the pool load is equal to the output from a given collector system. This will give the equilibrium temperature and can be repeated for all months of interest. Similarly, the effect of different collector areas on equilibrium temperature can also be evaluated.

3.6.3 Pools with auxiliary heating

A common design approach is to calculate the collector area necessary to provide all the heat required in the month for which the requirement is lowest, usually in midsummer. It can then be assumed that the solar system will rarely produce heat that is surplus to requirements. For other months, the conventional auxiliary heater may be used to maintain a specified temperature. The heating load for this month may be known from energy bills for an existing heater, or calculated as outlined in annex A.

For outdoor pools this approach may result in a small collector area, primarily because of the direct solar gain by the pool itself. In such cases, it is generally feasible to install a greater area of collector, to provide higher solar contribution to season load, even though more heat is generated in midsummer than is necessary to maintain the specified temperature.

3.7 Mountings

The method of mounting solar collectors has to be considered carefully, taking into account the considerable forces caused by wind lift to which collectors may be subjected. Manufacturers' recommendations regarding mounting systems should be followed. If mountings are to be fastened to other building structures, special attention should be paid to the design of the mountings and the load that they may place on the building structure. Mountings should not be liable to corrode, cause rainwater leaks or work loose because of wind vibration. Consideration should also be given to the likelihood of vandalism and the means of preventing it, especially if glazed collectors are used.

Provision should be made to ensure adequate drainage either under or over the collectors. Collectors should also be arranged to avoid trapping rainwater or accumulating debris between the collector and the roof. This is particularly important in the case of low-slope unpainted metal deck roofs. For these roof systems, collectors should be run across the ribs rather than along the channels, even though this configuration may result in lower thermal output.

Where collectors are to be mounted on conventional building structures, reference should be made to local building codes to obtain an estimate of the wind loads that may be encountered.

3.8 Interconnection of unglazed collectors

3.8.1 Parallel connection

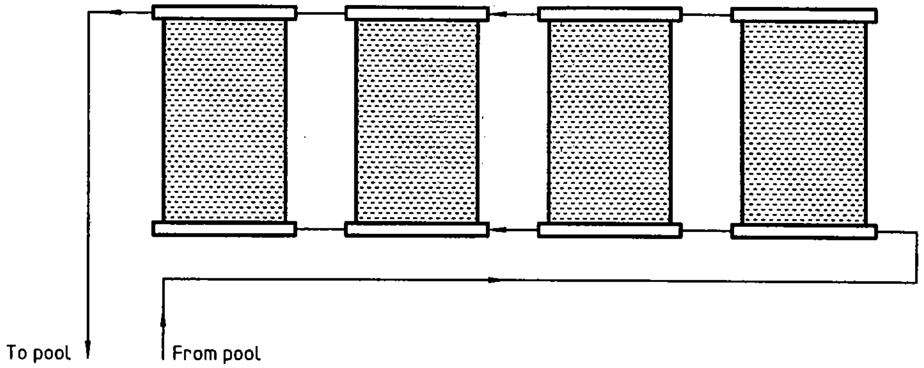
Collectors may be connected in parallel, in series or in a combination of series and parallel units to form an array. The optimal configuration depends on the geometry of available area for collector mounting as well as on the hydraulic characteristics of the collector modules. The objectives are to achieve a low parasitic energy for pumping, usually only 1 % to 2 % of collector heat output, and a uniform heat production by all modules.

The starting point for array optimization is the high-irradiance temperature rise, usually 5 K through each series-connected collector group. This value leads to a specific flowrate requirement of 110 $l/(h \cdot m^2)$ to 140 $l/(h \cdot m^2)$ [0,03 $kg/(s \cdot m^2)$ to 0,04 $kg/(s \cdot m^2)$]. If a separate pump is used for the collector array (see 4.3), the above recommendation is the basis for the hydraulic layout. However, the use of an existing pool filter pump for the collector array as discussed in 4.2 may result in a higher specific flowrate, since the required rate of turnover of the pool water for filtration purposes must be maintained.

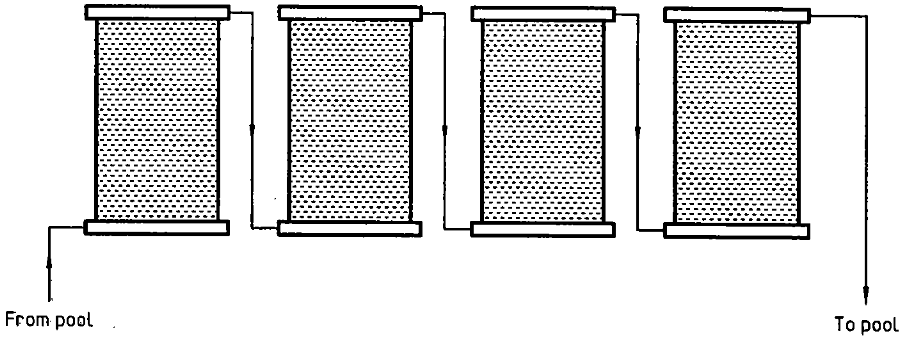
The efficiency of thermal solar collectors decreases with increasing operating temperature, particularly for unglazed collectors. It is therefore important that the flowrate through the collectors is sufficiently high to ensure efficient operation. However, flowrates higher than those specified above will produce little extra benefit and will incur higher pumping energy requirements.

Generally the collector modules should be connected in parallel, as shown in figure 4 a). The use of series connection is not recommended, as this may increase the pumping power requirement and also cause the downstream collectors to operate at higher, less efficient temperatures. Parallel connection, in which the water returns to the pool after passing through one collector, avoids these problems.

However, if the recommended specific flowrate would lead to laminar flow in the modules in the case of all-parallel connection, then several modules should be connected in series to insure turbulent flow in all modules (figure 5). Select the number of series-connected modules to be as low as possible.

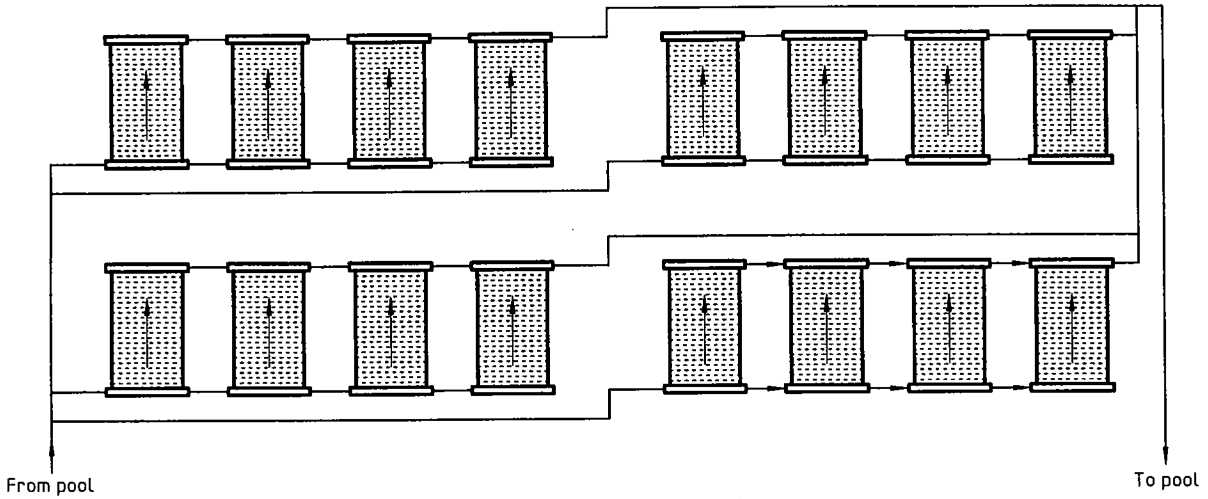


a) Parallel connection

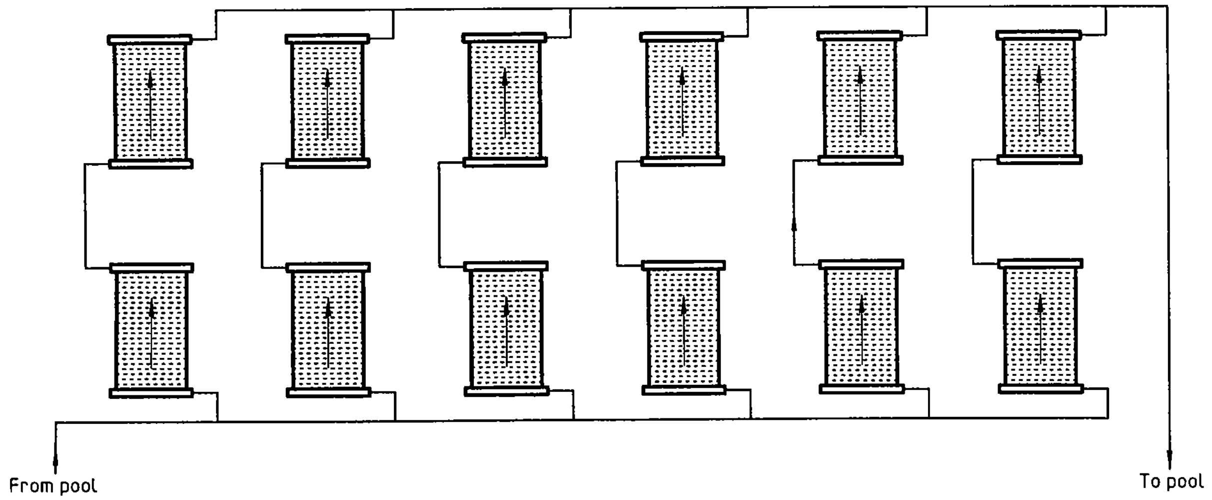


b) Series connection (not recommended)

Figure 4 — Parallel and series connection of panel collectors



a) All-parallel arrangement



b) Parallel-series arrangement

Figure 5 — All-parallel and parallel-series arrangement of panel collectors

In large arrays, an additional reason for connecting some modules in series is the requirement that the pressure drop in the header pipe not exceed 10 % of the pressure drop through a module in order to obtain uniform flow through the parallel-connected collectors. Therefore the number of modules that may be connected in parallel as shown in figure 4 a) is limited.

3.8.2 Interconnection of collector groups

The collector groups should be arranged in parallel in such a way that the length of the flow and return paths is approximately the same for each collector panel, so that flow will be evenly distributed. Figure 5 a) illustrates the recommended arrangement, with the flow line entering the parallel row at one end and the return line being taken from the far end.

Connection of the flow and return lines to the same panel at one end of a parallel row will cause those panels at the near end to short-circuit the flow, while those at the far end will receive less flow and suffer a reduction in performance. Such an arrangement should only be used where the pressure drop in the headers is very much less than that in the fluid passages across the panels.

The flow paths to and from the pool should be designed so that the flow through all passages is balanced and the temperature rise measured near solar noon on a clear day is approximately the same for all collector groups. A qualitative criterion is that the largest temperature rise in the array should be at most twice the smallest rise observed. This may be achieved by the layout of the plumbing (reverse return) or the use of balancing valves.

Balancing valves may be used to obtain uniform specific flow distribution when site requirements make it impractical to balance the flow with simple plumbing arrangements, e.g. when the pressure drop in the pipework at nominal flowrate is significant compared to the pressure drop through the collector array. If required, balancing valves should be installed in the flow line returning water from each group of collectors to the common pool connection. Upon commissioning [see 8.2 e)] the balancing valves should be adjusted to give uniform specific flow through the collectors.

Groups of collectors at different heights should be connected so that they all receive water from the lowest point in the system and return it to the highest point. Figure 6 illustrates a system arranged in this way. If the return lines do not come from a common height, flow through the panels may be uneven, causing a reduction in performance.

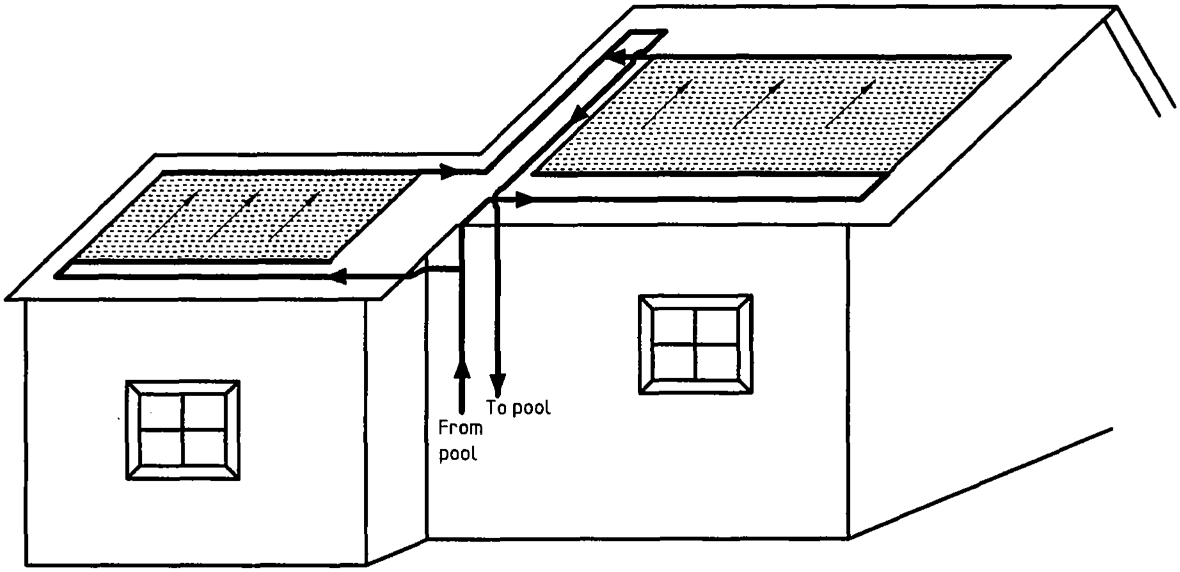


Figure 6 — Recommended plumbing arrangements for collector panels at different elevations

3.9 Connections

Connections between collectors, and between collectors and piping, should be made of a suitable flexible material to accommodate variations in alignment at installation, and movement due to thermal expansion in service. The material of the connections should be no less durable than that of the piping, under the conditions of use.

The arrangement of strip collectors will be largely governed by the nature of the roof or other structure upon which they are installed. Interconnection of strips may be either by a grid layout, or by a loop-return arrangement between two adjacent headers. In all cases, a maximum length of strip of 15 m is recommended.

3.10 Preventions of airlocks

Flow blockage or nonuniform flow in large arrays is commonly caused by airlocks. To avoid this problem, pipework should be installed so that air will naturally rise to a suitable air-bleed device. Air-bleed devices should be located downstream of the collectors.

4 System hydraulics

4.1 Pump capacity

Under normal circumstances the solar system will operate as a closed system, that is, with all components filled with water and no free water surfaces. In this case the static height is of no importance, since the static heights of the supply and return lines are in balance and the head required to raise the water to the top of the supply riser is balanced by the head regained as the water flows down the return leg. Only the frictional losses need be taken into consideration in sizing the pump for normal running conditions. This is not so at start-up if the system has partially or fully drained down. Until the system has completely filled with water, a static head will exist. Thus while the pump may be sized for the normal operating conditions, it must also have sufficient capacity to lift water to the highest point in the system, albeit at a rate lower than the design flowrate.

It is also important to ascertain that an overpressure is established in the whole collector array when the pump is operated. Otherwise the air-bleed device at the output of the collector array may allow air to continuously enter the system. The necessary overpressure condition can be achieved by using a balancing valve in the pool flow line so that the collector output line is filled with water when the pool filtration pump is running (solar pump not running).

4.2 Use of existing pool filter pump

A standard pool filter pump may be used to circulate pool water through the collectors of small systems (maximum 100 m^2 collector area) provided the following conditions are met:

a) the required rate of turnover of the pool water for filtration purposes is maintained;

b) the filter is capable of functioning satisfactorily under the increased pressure that will result from the addition of the collector circuit;

c) the pump has sufficient capacity to handle the static head and frictional losses introduced by the addition of the collector circuit;

d) the collector array is located no more than 6 m above the pool level.

Typical arrangements using an existing pump are shown in figures 7 and 8. With these configurations it may be difficult to adjust the flowrate through the collectors to the required level, as the flowrate depends on variation of pressure drop in the filter. Periodic adjustments may be needed.

4.3 Use of separate pump

A separate pump is necessary in the following cases:

a) small systems of less than 100 m^2 collector area if the collector array is located more than 6 m above the pool water level;

b) small systems if the required rate of turnover of the pool water for filtration purposes cannot be maintained during collector operation using the pool filter pump alone;

c) small systems if the pool filter pump is not able to fill the collector array and establish the required flowrate through it;

d) all large systems (more than 100 m^2 collector area).

If a separate pump is used, and the solar circuit is separate from the filtration circuit, the pump should either be located below the level of the pool water, or be self-priming. If a separate pump is used, and the solar circuit feed line is connected to the filtration circuit downstream from the filter pump, the solar pump will not normally need to be self-priming.

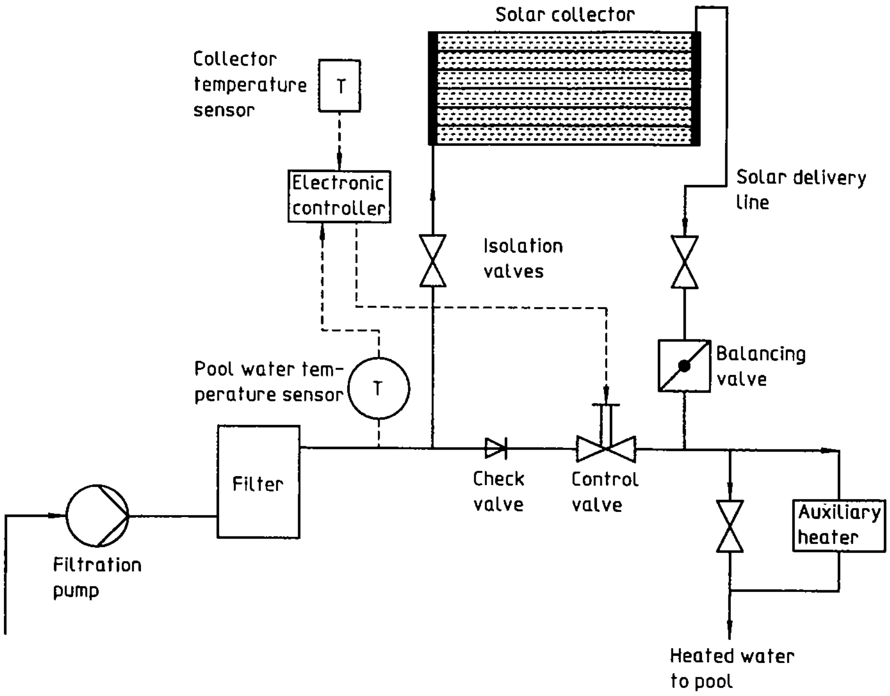
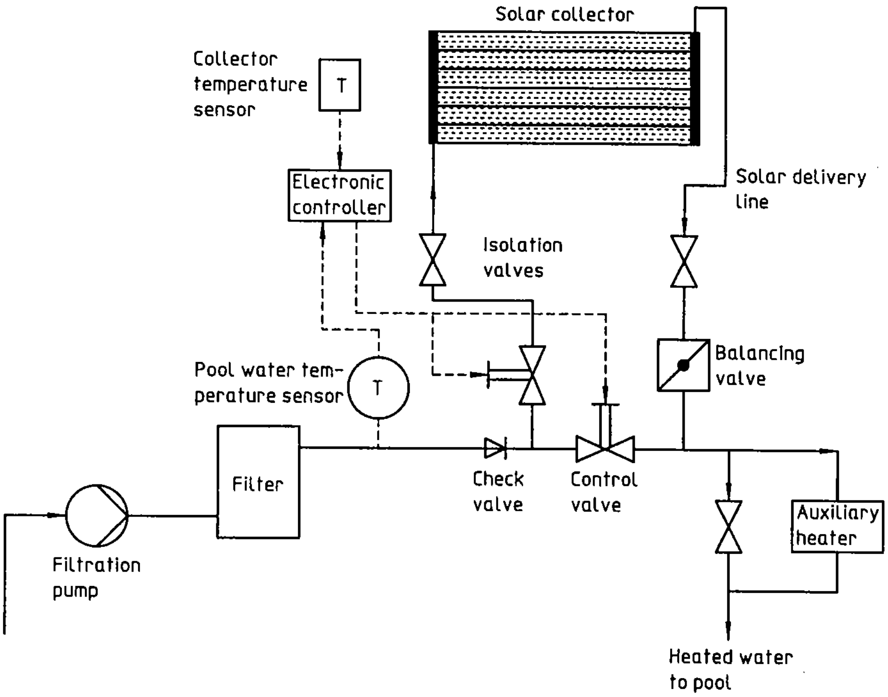


Figure 7 — Use of existing pump, single-valve arrangement



NOTE — A motorized three-way valve may be used in place of the two control valves shown.

Figure 8 — Use of existing pump, two-valve arrangement (collector array located at or below pool level)

NOTE 4 Pumps with flooded suction may need frost protection.

A typical arrangement of a small collector system using a separate pump connected to the filtration circuit is shown in figure 9. Figure 10 describes the case of a large system (more than 100 m^2 collector area).

In the case of a large system, draining the whole collector array each time the solar input is interrupted may cause problems at restart due to:

a) airlocks in some parts of the collector array;

b) air bubbles may be carried away to the pool and disturb swimmers or damage the pool cover;

c) pressure pulses may be created in the collector array when the pump starts and damage the collector.

Hence, the installation of two automatic valves in the return and flow lines of large collector arrays is recommended (see figure 10). These valves and the solar pump should be controlled in the following sequence: the control signal from the pump control unit should be transmitted to the valves and the end contact of one of the valves used to control the pump. In this way the proper sequence is ensured and the collector array is maintained filled with water.

5 Controls and instrumentation

5.1 General

The control system should be automatic in operation and should circulate water through the collectors only when heat can be gained. The operation of the solar circuit should not interfere with the run-on time required for removal of residual heat from any fossil-fuelled pool heater. The use of manual operation, or time switches as typically used to control the operation of the pool filter, will not provide optimum performance.

Circulation of water to the collectors may be either by the filter pump or by a separate pump. The filter pump would, in the absence of a solar heating system, normally operate at times when there may be no solar heat gain. If the filter pump is to be used, the control system should be able to override any time switch that would otherwise prevent the filter pump from operating (see also 7.4). The control system should not adversely affect the operation of other pool equipment, including filters, chlorinators or auxiliary heating system. The filtration period should not be compressed by the operation of the solar pool-heating system.

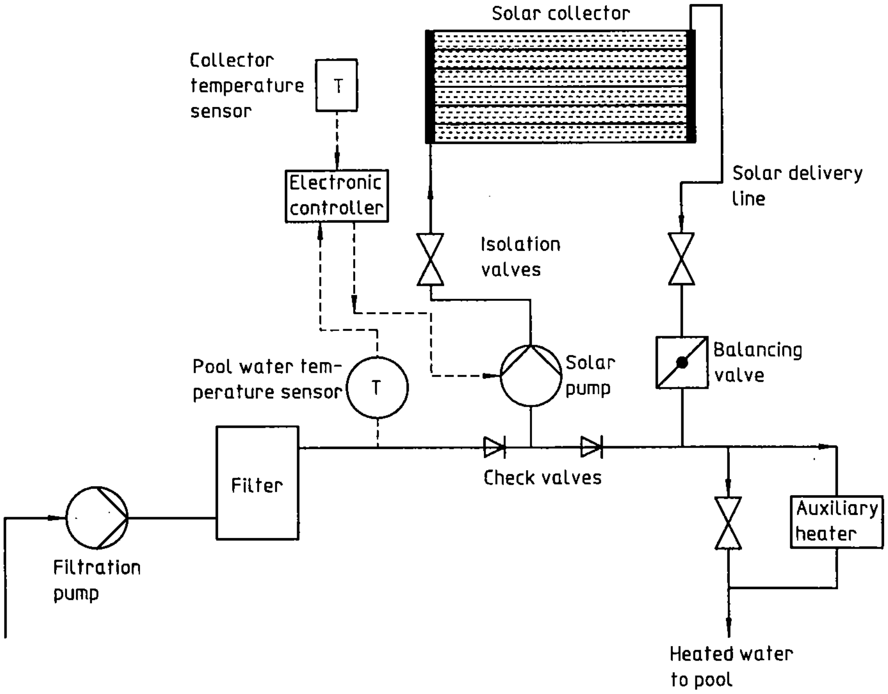


Figure 9 — Use of separate pump and hydraulic system applicable to small systems (maximum 100 m^2 collector area)

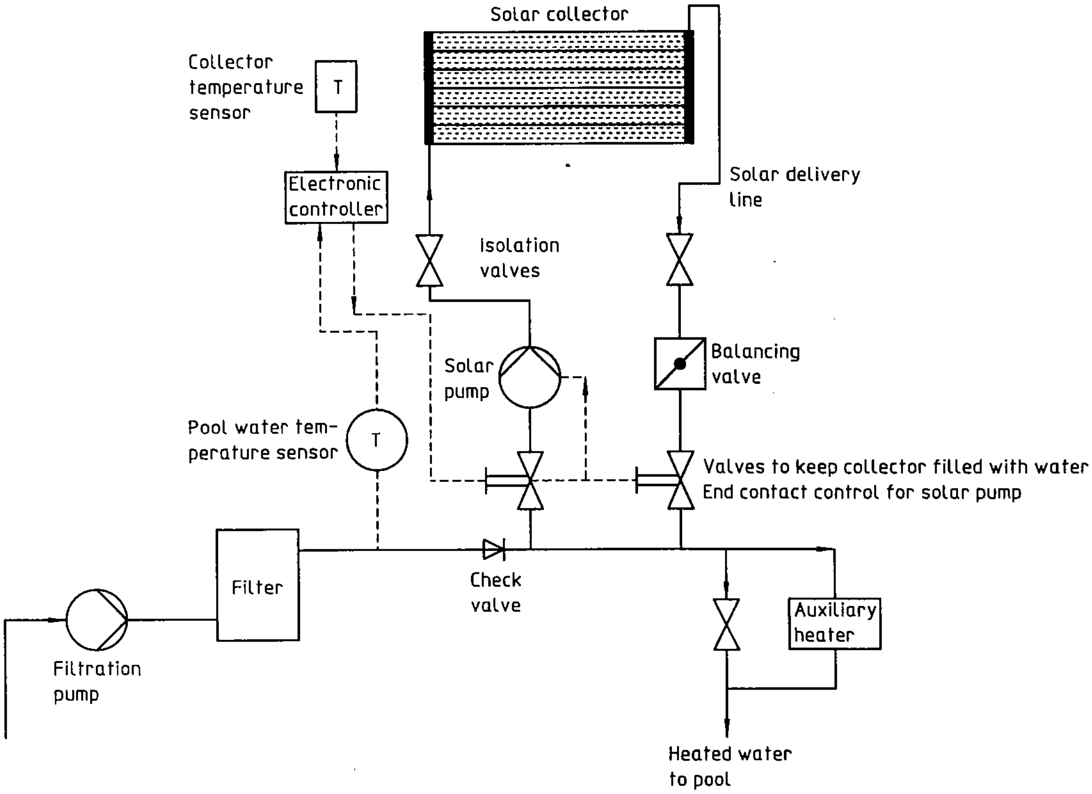


Figure 10 — Use of separate pump and hydraulic system applicable to large systems (more than 100 m^2 collector area)

5.2 Differential temperature controllers

5.2.1 Two-sensor systems

In systems using two sensors, one sensor detects the pool water temperature and the other sensor detects the collector temperature. The pool temperature sensor should be located in the pool recirculation line ahead of the solar circuit. The collector sensor should be located on a section of collector remote from a fluid passage or on a piece of solar absorber material near the collector array but not thermally connected to the hydraulic circuit. For an isolated hot sensor, it is recommended that the temperature difference at which circulation in the solar circuit starts should not exceed 6 K. The temperature difference at which it is stopped should not exceed 3 K. The large temperature differentials generated by this sensor-mounting arrangement can be detected by standard quality differential temperature sensors. Collector temperature sensors located in the collector outlet pipe are not recommended, as this mounting arrangement relies on the detection of very small temperature rises which will require an accurate low-drift detector.

In the context of pool heating, a net benefit is achieved when the value of the energy collected exceeds the energy expended in circulating water to the collectors. The temperature differential at which the controller turns the system off should therefore take account of pump energy consumption. It is also desirable to minimize frequent starting and stopping of the pump.

5.2.2 Four-sensor systems

A system using four sensors offers several control advantages. In such a system, the start differential sensors are located in the pool water and on a section of the solar collector plate near the collector array but not thermally connected to the hydraulic circuit. The stop differential sensors are located in the solar collector inlet and outlet pipes.

Circulation starts when the solar collector plate attains a suitable overtemperature relative to the pool water. After a short time in operation, control of circulation is taken over by the stop differential sensors. Circulation continues until the temperature difference between collector outlet and inlet has fallen to the set stop differential.

The stop differential should be set to a value at which the energy being collected is significantly greater than the energy needed to maintain circulation. The start differential should be set to the lowest possible value at which the stop differential is able to take control.

5.2.3 Temperature sensing in large systems

A temperature sensor located in the outlet of a large system may cause errors at start-up due to nonuniformity in the array heating under no-flow conditions. Also, large arrays are often built with several different collector sections. To avoid incorrect control operations in such systems, a small recirculating pump may be used to mix the water in the collector array(s) so that reliable temperature reading can be obtained for start-up control. Alternatively, the two-sensor arrangement (5.2.1) could be used.

5.3 Photovoltaic controllers

Photovoltaic controllers which sense solar radiation may be used to control the operation of the solar circuit. However, it should be noted that such a means of control is less effective than a differential temperature controller, because it may turn the pump on during times of high radiation and cold windy conditions when an unglazed collector may not function satisfactorily. Intelligent controllers may make use of temperature and radiation sensors. Photovoltaic sensors should be located in a position that receives the same level of solar radiation as the collector array at all times during the operating season.

5.4 System monitoring

For large public pools it is generally desirable to provide a means of monitoring the solar heating system, so that the operators have some feedback on the solar operation. This should include a flowmeter to indicate the flow through the collectors, and a means of measuring the temperature of the pool water and the heated water from the collectors. Temperature indication may be derived from the sensors in the control system.

6 Pipework

6.1 Material

Special precautions should be observed with respect to the choice of materials in contact with pool water, as this water may contain chlorides (either from sea water or from direct salt addition) or other corrosive minerals. All metals except some chrome-nickel steels should be avoided for those parts of the system. All components exposed to solar radiation (collectors, piping, etc.) must be resistant to ultraviolet radiation. This is especially important for plastics; EPDM rubbers have been found to give satisfactory performance.

All pipework must be able to withstand the stagnation temperatures that may be generated in the collectors. The stagnation temperature of unglazed collectors is generally less than 50 °C; however, glazed collectors can reach temperatures of around 110 °C to 150 °C for sealed types and 75 °C to 90 °C for types with significant ventilation. PVC piping will not withstand temperatures above 60 °C and should not be used in such situations.

PVC pipework should not be used in glazed collector systems, or where temperatures greater than 60 °C may be experienced. Black high density polyethylene (HDPE) pipe may be generally suitable. However, both PVC and HDPE pipe must have their working pressures de-rated for operation at high temperatures.

Materials such as EPDM which are able to withstand freezing of water in the passageways are preferable for all frost-exposed parts.

6.2 Installation

Pipework should be installed in accordance with relevant local plumbing codes. Plastics pipework should be supported by clips or hangers at intervals not exceeding those shown in table 1.

The supports should permit expansion movement without imposing undue strain on pipework, valves or fittings. Care must be taken to allow for thermal expansion of plastics pipes, which is significantly greater than that of copper. Additionally, the expansion of HPDE pipe is more than twice that of PVC pipe. For PVC pipe, the provision for expansion should allow for the temperature ranges that will be encountered in normal service, using a coefficient of expansion of 7×10^{-5} K^{-1}.

Individual support should be provided to heavy components such as pumps and motorized valves. Where pipework bears a load, the supports should be positioned so that the load does not cause deformation of the pipework.

Table 1 — Maximum spacing of supports for plastics pipe

Nominal size (DN)	PVC		HDPE	
	Maximum spacing of supports m		Maximum spacing of supports m	
	Horizontal or graded pipes	Vertical pipes	Horizontal or graded pipes	Vertical pipes
40	0,90	1,80	0,43	0,85
50	1,05	2,10	0,45	0,90
65	1,20	2,40	0,50	1,05
80	1,35	2,70	0,60	1,20
90	1,42	2,85	0,67	1,35
100	1,50	3,00	0,75	1,50

6.3 Connections

Connection of pipework to pumps and valves should be arranged so that removal of the device is possible without the need to cut the pipework. Solvent-cement joints of PVC pipe should not be used for these situations.

6.4 Isolating valves

Isolating valves should be fitted to the flow and return lines of the solar circuit, close to the connection to the filter circuit or pool. The purpose of these valves is to facilitate isolation of the solar circuit for maintenance or repair.

6.5 Gradient

All pipework (including collector headers and fluidways) should have a gradient of not less than 1:200, to allow for reliable draining and venting of air.

6.6 Suction outlet from pool

The suction outlet from the pool should be fitted with a protective cover to prevent entrapment of fingers, toes or hair of swimmers. If the velocity of flow at the suction outlet is significant, each pump system should be connected to at least two outlets from the pool by means of a common line. No two outlets to a common line should be closer than 1 m to each other. The purpose of this is to reduce the risk of swimmers being held against the outlet by suction.

6.7 Heated-water return

The line returning heated water from the collectors should be positioned to introduce the heated water ahead of any chemical-dosing equipment, or other heating plant. The inlet returning heated water to the pool should be pointed downwards to reduce losses due to stratification of hot water at the top of the pool.

7 System design

7.1 Water filtration (solar circuit)

Because pool water may be contaminated with suspended solids or other debris that could block solar collectors and pipework, only filtered water should be passed through the solar circuit.

This may be readily achieved where the solar circuit is connected to the filter circuit. However, in solar circuits that are separate from the filter circuit, a suitable mesh strainer should be fitted at the outlet from the pool (see 6.6) or else an in-line strainer fitted elsewhere in the circuit. Such pool outlet connections should be kept clear of the sump of the pool or the water surface, as suspended matter and debris tend to accumulate at these locations.

Provision should be made for cleaning or backwashing any strainer or filter used in a solar circuit separate from the filter circuit.

7.2 Protection against freezing

7.2.1 General

Freeze protection should be provided for systems subject to freezing conditions during part of the year. Some collectors used for swimming-pool heating, such as those made of elastomeric materials (e.g. EPDM rubbers) are tolerant of freezing conditions, but the need for protection of pipework and other components will remain. Freeze protection may be provided either by drain-down of the system or by circulation of pool water.

Drain-down may be either automatic (draining whenever water is not delivered to the solar circuit or when the outdoor temperature falls below a certain threshold value), or manual (requiring action by the pool owner to drain the system, usually at the end of the swimming season).

Circulation of pool water for freeze protection requires a freeze sensor to activate the pump. Additionally, it requires maintenance of power to the controller and pump, and correct operation of the sensor. As protection by this means is obtained at the expense of cooling the pool, this method is not recommended.

7.2.2 Provision for drain-down

In order to achieve satisfactory drain-down of systems mounted above pool level, the following requirements must be met.

a) There should be an unobstructed route for water to return to the pool by gravity. Valves that can prevent drain-down should be convenient for manual operation, or should be interlocked with the operation of the pump.

b) Water should not return to the pool by means of reverse flow through the pool filter, since this may backwash debris into the pool. If the filtration pump is not already fitted with a means of preventing backflow, a nonreturn valve should be fitted between the filter and the solar circuit.

c) Automatic drain-down systems and systems using PVC pipework and fittings should be fitted with a vacuum-relief valve at or near the top of the solar circuit. If a vacuum-relief valve is not fitted, the system components should be capable of withstanding the negative pressures encountered (see 7.3).

d) Any parts of the solar circuit that will not be drained (e.g. due to the pressure head in the filtration circuit) should be otherwise protected against frost damage (e.g. by being located indoors).

e) Automatic drain-down systems should be provided with a means to check whether the system has drained as intended (e.g. by fitting a drain valve that would show the presence of water if opened).

f) If the solar circuit is located at a lower level than the pool surface, an automatic isolation valve should be provided to prevent the draining of the pool through the solar circuit.

7.3 Pressure considerations

Water in the solar circuit above the pool surface level will be at subatmospheric pressure unless maintained at positive pressure by the pump. For heights up to about 1 m above the pool surface level, the entire solar circuit will generally be maintained at positive pressure throughout the system by the filtration pump.

Where collectors are mounted at higher levels, there may be negative pressures in the circuits even with the pump operating. This will generally be the case when there is a drop of more than 10 m. A vacuum-relief valve installed in this situation would lead to air entering the system during pump operation with the consequence of noisy operation, excessive chemical consumption due to bubbling, and possible air locks.

To obviate this possibility, the vacuum-relief valve should be installed at a point where the system is above atmospheric pressure during pump operation. This will require calculation in cases where the collectors are located well above the pool (e.g. on multistorey buildings). Alternatively, an air trap and vent may be installed at the high point in the system, or a restrictor valve fitted downstream of the vacuum-relief valve in order to increase the pressure at the location of that valve. The latter approach has a penalty of increased pumping-energy requirements.

7.4 Arrangement of control valves

Normally, flow control in the solar circuit using the filter pump will be adequately achieved by means of opening or closing a valve in the main filter circuit. If, however, it is desired to positively close the solar circuit when it is not operating, a second valve may be used in the solar circuit (see figure 8) or else a motorized three-port valve used to direct the flow. In such cases however, it will be necessary to provide a means of bypassing the valve when the pump is not running, for the purpose of drain-down.

8 Commissioning

8.1 General

The person responsible for commissioning of the completed system should check that all aspects of the installation have been carried out in accordance with the designer's and the component manufacturer's instructions.

8.2 Commissioning procedure

The following procedures should be carried out.

a) The free movement of all valves and pump impellers should be checked manually where this is possible without dismantling.

b) For systems integrated with the filtration circuit, the solar equipment should be shut off with valves and the filtration circuit checked for correct operation; all pressure gauges should read within manufacturer's/designer's limits. Any defects should be remedied before proceeding.

c) The differential temperature controller or photovoltaic controller should be checked for correct operation. For solar heating systems which make use of the filter pump, the operation of any time switch that controls the filter pump should be checked to ensure that it does not interfere with solar operation.

d) Water should be directed through the solar circuit and the system checked for leaks. The correct operation of any air vents should be confirmed. Adjust any balancing valves on the delivery side of the solar collector in order to obtain the nominal flowrate through the collectors and to ensure that an overpressure is established in the whole array (a condition to allow for correct operation of air-bleed devices).

e) The flowrate through collectors should be checked to ensure that the temperature rise in different parts of the array is within 5 K of the average temperature rise. Flow through collectors may be assessed by one of the following means:

   1) flowmeter;

   2) measurement of the outlet temperature;

   3) measurement of the pressure drop across collectors.

   If balancing valves have been fitted, they should be adjusted in accordance with the manufacturer's instructions. Generally this will be commenced with all valves fully open and appropriate valves gradually closed until the desired flow for each collector group is obtained. It should be confirmed that there is no significant imbalance of flow between collectors. After adjustment, balancing valves (and any isolating valves) should be secured against inadvertent adjustment or tampering, by removing the handles or by other means.

f) If the system is designed for automatic draindown, this function should be checked (see 7.2.2).

g) The solar circuit should be subject to a pressure test to ensure that all components as installed will withstand the operating pressure.

8.3 Documentation

At the time of handover, the pool owner should be provided with an appropriate document certifying that the system has been installed and commissioned satisfactorily.

If the operation of the solar heating system is dependent upon the operation of the filtration pump it should be ensured, in conjunction with the pool owner/operator, that it is set correctly so that the pump will run at least during daylight hours. The system should be handed over either in a fully operational state or decommissioned to an extent appropriate to the time of year and system's design.

The owner's documentation containing the following items should be handed over:

a) the handover document;

b) user's data sheet (see 8.4);

c) warranties issued by the manufacturer(s) of the components or by the installer;

d) operating and preventive maintenance and service instructions describing startup, normal running and shutdown procedures in a form intelligible to the non-technically trained user. These should also include details of protection provided against frost and overheating if applicable. Details of action to be taken in the event of faults should be provided;

e) circuit diagram of any electrical controls.

A separate label should also record the date of the installation and the name and address of the installer.

8.4 User's data sheet

A list of major components should be provided indicating the number, model and make of items of equipment that have been installed. As a minimum, the solar collectors, control system components and pumps should be included in the list.

The method of frost protection should be stated and a clear indication of any need to drain the system manually to provide frost protection should be included, together with instructions for draining.

The method of operation of the control system should be stated, together with any facility for overriding the automatic control system.

Data regarding the need for and frequency of maintenance should be given. Any servicing requirements should also be stated.

Any special hazards to be avoided should be listed, for example, the stagnation temperature that may be attained by collectors when the fluid flow is interrupted.

Annex A
(informative)

Calculation of pool heating load

A.1 General

The pool heating load is the total heat loss less any heat gain from incident radiation.

For outdoor pools there may be a significant gain from radiation directly incident on the pool. Published data for the total radiation incident on a horizontal plane should be used for the purpose of calculations, and it may be assumed that at least 85 % of incident radiation will be absorbed.

The total heat loss is the sum of losses due to evaporation, radiation and convection. Calculation of the losses will require knowledge of air temperature, wind speed and relative humidity or partial water vapour pressure. Other lesser means of heat loss are turbulence caused by swimmers (the calculations below assume a still pool), conduction to the ground (usually considered small enough to be neglected provided there is no ground water surrounding the pool bottom) and rainfall (although not strictly a heat loss, significant rainfall will add to the heating load by lowering the pool temperature). The addition of make-up water should be considered if the temperature differs significantly from the pool operating temperature.

The use of a pool cover will reduce heat losses, particularly evaporative losses. If an allowance for the use of a pool cover is to be made in calculating the heating load, reference should be made to annex B.

A.2 Evaporation heat loss

A.2.1 Outdoor pools (dependence on meteorological wind speed)

Evaporative heat loss from still outdoor pools is a function of the wind speed and of the vapour pressure difference between the pool water and the atmosphere. The following correlation for heat loss due to evaporation is recommended[7]:

$$q_e = (5{,}64 + 5{,}96 v_{0,3})(P_w - P_a) \qquad \ldots \text{(A.1)}$$

where

q_e is the heat loss by evaporation, in megajoules per square metre per day [MJ/(m^2 · d)];

P_w is the saturation water vapour pressure at water temperature t_w, in kilopascals [obtained from figure A.1 or equation (A.4)];

P_a is the partial water vapour pressure in the air, in kilopascals;

$v_{0,3}$ is the wind velocity at a height of 0,3 m over the pool, in metres per second.

If the wind velocity over the pool cannot be measured, it can be inferred from climatic data by the application of a reduction factor for the degree of wind shelter at the pool as follows:

v is $0{,}30 v_{10}$ for normal suburban sites;

v is $0{,}15 v_{10}$ for well-sheltered sites;

v_{10} is the wind velocity normalized to 10 m above clear ground, in metres per second (as recorded in standard climatic data).

Evaporation heat loss from a pool in active use is higher than from a quiet pool, on which equation (A.1) is based. A method for estimating the evaporation rate during periods of pool use is given in A.2.3.

A.2.2 Indoor pools (dependence on air speed at pool water surface)

The low air velocity over indoor pools results in a lower evaporation rate than usually occurs in outdoor pools. For a still indoor pool, the evaporative heat loss q_e is given by the following modification of equation (A.1):

$$q_e = (5{,}64 + 5{,}96 v_s)(P_w - P_{enc}) \qquad \ldots \text{(A.2)}$$

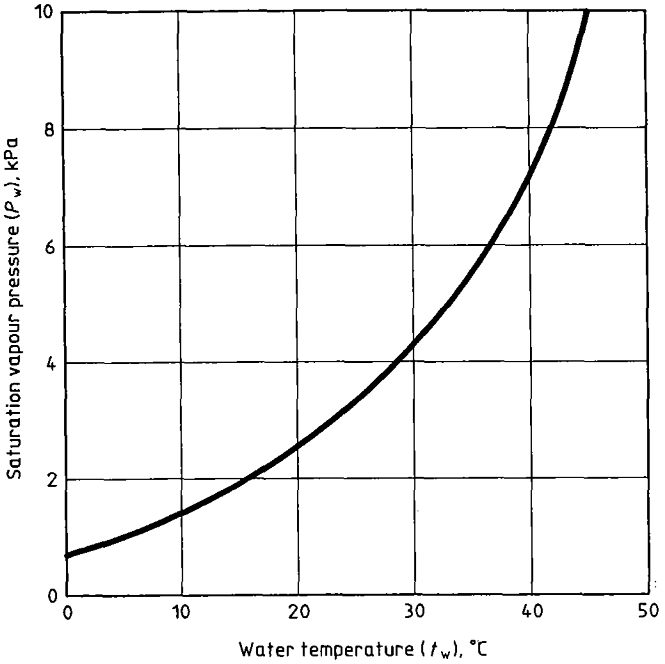


Figure A.1 — Variation of saturation vapour pressure with water temperature

where

P_{enc} is the partial water vapour pressure in the pool enclosure, in kilopascals;

v_s is the air speed at the pool water surface, typically 0,02 m/s to 0,05 m/s.

Partial water vapour pressure (P_a) can be calculated from the relative humidity (RH) by:

$$P_a = \frac{P_s \times \text{RH}}{100} \qquad \ldots \text{(A.3)}$$

where P_s is the saturation water vapour pressure, expressed in kilopascals at air temperature t_a, obtained from figure A.1 or from equation (A.4) with $P_s = P_w$ for $t_a = t_w$:

$$P_w = 0{,}004\,516 + 0{,}000\,717\,8\, t_w - (2{,}649 \times 10^{-6})\, t_w^2 + (6{,}944 \times 10^{-7})\, t_w^3 \qquad \ldots \text{(A.4)}$$

If the water vapour content of the air is expressed in terms of wet bulb temperature, the relative humidity may be evaluated using figure A.2.

A.2.3 Allowance for pool use

The presence of swimmers in a pool will significantly increase the evaporation rate. With five swimmers per 100 m^2, the evaporation rate has been observed to increase by 25 % to 50 %. With 20 to 25 swimmers per 100 m^2, the evaporation rate may be 70 % to 100 % higher than for a still pool.

A.3 Radiation heat loss

Radiation heat loss q_r, expressed in megajoules per square metre per day, may be calculated by means of the following simplified equation:

$$q_r = \frac{24 \times 3600}{10^6}\, \varepsilon_w\, \sigma (T_w^4 - T_s^4)$$

$$= 0{,}086 \varepsilon_w h_r (T_w - T_s) \qquad \ldots \text{(A.5)}$$

where

ε_w is the longwave emissivity of water = 0,95;

σ is the Stefan-Boltzmann constant, equal to 5,67 × 10^{-8} W/(m^2·K^4);

h_r is the radiation heat transfer coefficient, in watts per square metre per kelvin [W/(m^2·K)] (see Note 5);

T_w is the water temperature, in degrees Kelvin;

T_s is the sky temperature, in degrees Kelvin (see Note 6).

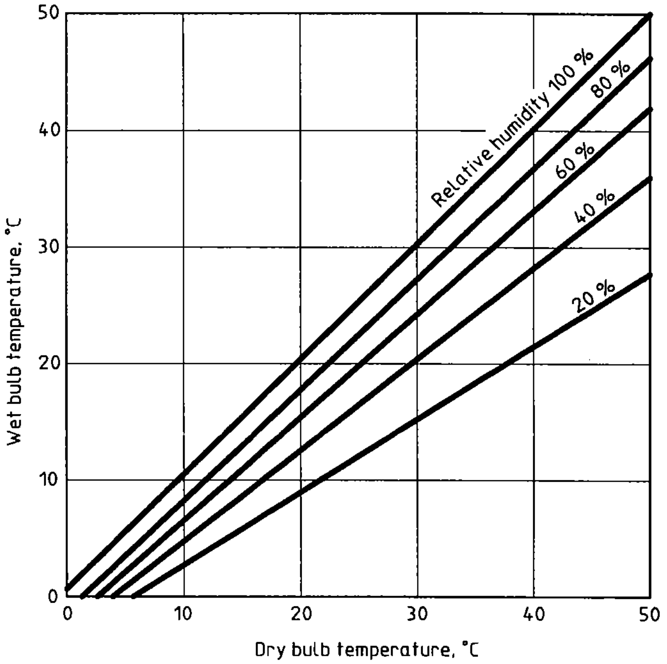


Figure A.2 — Conversion of wet bulb temperature to relative humidity

NOTES

5 The radiation heat transfer coefficient, h_r, may be calculated by:

$$h_r = \sigma (T_w^2 + T_s^2)(T_w + T_s)$$

$$\approx (2{,}268 \times 10^{-7})\left(\frac{T_w + T_s}{2}\right)^3$$

or determined graphically using figure A.3.

6 For an indoor pool

$$T_s = T_{enc}$$

where T_{enc} is the temperature, in degrees Kelvin, of the walls of the pool enclosure.

For an outdoor pool

$$T_s = T_a \sqrt{\varepsilon_s}$$

where sky emissivity, ε_s, is a function of dew-point temperature, t_{dp} (see ISO 9806-3):

$$\varepsilon_s = 0{,}711 + 0{,}56\,(t_{dp}/100) + 0{,}73\,(t_{dp}/100)^2$$

Note that T_s may vary from $T_s \approx T_a$ for cloudy skies to $T_s \approx T_a - 20$ for clear skies.

A.4 Convection heat loss

Heat loss due to convection to ambient air q_c, expressed in megajoules per square metre per day, [MJ/(m^2 · d)], (for an enclosed pool, the room air) is given in AS 3634[4] as:

$$q_c = \frac{24 \times 3600}{10^6}\,(3{,}1 + 4{,}1v)\,(t_w - t_a)$$

$$= 0{,}086\,(3{,}1 + 4{,}1v)\,(t_w - t_a) \qquad \ldots (A.6)$$

where

v is the wind velocity, in metres per second, at 0,3 m above outdoor pools or over the pool surface for indoor pools;

t_w is the water temperature, in degrees Celsius;

t_a is the air temperature, in degrees Celsius.

The convective heat transfer is highly wind-dependent. There will be times, particularly during summer, when this loss will be negative for outdoor pools and the pool will gain heat by convection from the air.

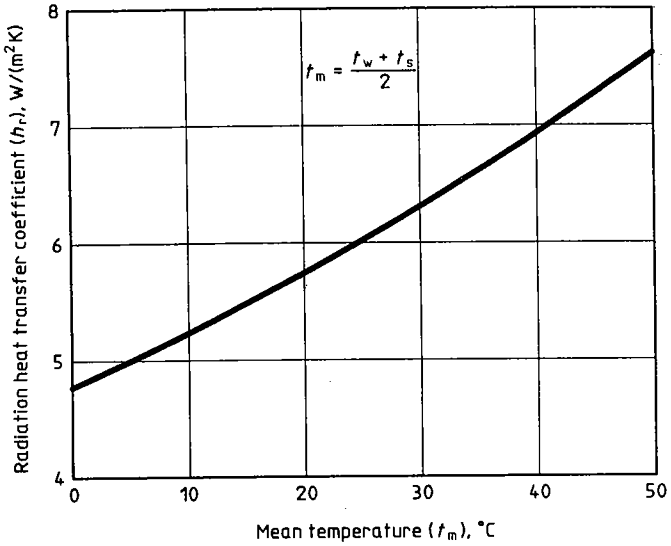


Figure A.3 — Variation of the radiation heat transfer coefficient (h_r) with the mean temperature (t_m)

In above-grounds pools, there will also be significant conduction heat loss through the walls. However, this is approximately balanced by the solar radiation gain over the same surface, and the two heat flows can be assumed to balance and can thus be ignored in most calculations.

A.5 Make-up water

If the make-up water temperature differs significantly from the pool operating temperature, the heat loss, q_{mku}, expressed in megajoules per square metre per day [MJ/(m^2 · d)], due to the addition of make-up water is given by:

$$q_{mku} = m_{evp}\, c_p\, (t_{mku} - t_w) \qquad \ldots (A.7)$$

where

t_{mku} is the make-up water temperature, in degrees Celsius;

m_{evp} is the daily evaporation rate, in kilograms per square metre per day, $= q_c/h_{fg}$, in which

  h_{fg} is the latent heat of vaporization of water, in megajoules per kilogram;

c_p is the heat capacity of water at constant pressure, in joules per kelvin per kilogram.

A.6 Solar radiation heat gain

Heat gain due to the absorption of solar radiation by the pool is given by:

$$q_s = \alpha\, G_i \qquad \ldots (A.8)$$

where

q_s is the rate of solar radiation absorption by the pool, in megajoules per square metre per day [MJ/(m^2 · d)];

α is the solar absorptance (0,85 for light-coloured pools, 0,90 for dark-coloured pools);

G_i is the solar irradiance on a horizontal surface, in megajoules per square metre per day [MJ/(m^2 · d)].

The solar absorptance (α) is dependent on colour, depth and pool usage. For pools with continuous intensive use (such as public pools), an additional reduction of 0,05 should be made to the absorption factor.

If the pool is subject to transient shading, or if a pool cover is used during the day, the solar absorptance will be lower than the values given above.

A.7 Effect of pool covers on heating load

The use of a pool cover can significantly modify the heat flows which define the heating load.

When designing a solar pool-heating system, it is often not possible to know with certainty the times during which a cover will be in place. Also, the cover may not be a perfect fit, and some water will be exposed at the edges. Hence a conservative approach should be taken when allowing for the effect of a cover.

Except when water is lying on top of the cover, a 90 % reduction in evaporative losses may be assumed when a cover is in place. However, allowance should be made not only for the time of day during which the pool is covered, but also for the mean wind speed at that time of day, as diurnal variation in wind speed is often significant.

The reduction in radiation and conduction losses as a result of covering a pool is generally small. Reference should be made to detailed test results for the type of cover concerned before any allowance is made for reduction in these losses. Diurnal variation in sky temperature and air temperature should also be allowed for in the design of large systems.

Annex B
(informative)

Pool covers

Heat losses from swimming pools occur mainly from the water surface. Various types of cover are available to reduce these losses in both indoor and outdoor pools. Covers can be regarded as a useful energy conservation measure with any type of pool and will enable most outdoor pools to function more efficiently as natural collectors of solar radiation.

Various types of floating pool covers can be used, including the following types:

a) double-skin plastic film with encapsulated air bubbles;

b) single-skin plastic film;

c) closed-cell plastic foam laminated to a reinforcing sheet of film or fabric.

Covers are available in either translucent or opaque grades, and plastic foams are frequently supplied laminated onto an opaque woven material. The materials used must be resistant to the effects of swimming-pool water and must not release harmful substances into the water, or facilitate the growth of bacteria.

Covers are moved on and off the pool many times each season. Any pool cover should be sufficiently tough to allow necessary handling without damage. Materials used for covers for open-air pools should be adequately resistant to both ultraviolet radiation and to chemicals normally present in swimming pools.

The main function of a cover is to reduce or eliminate evaporation from the surface of the pool. All cover types are effective in this respect, since they form a vapour barrier across the top surface of the pool. However, any water lying on the top of the cover will reduce its effectiveness. The thermal benefits of using a pool cover on an outdoor pool may be largely nullified in areas of high rainfall in spring to autumn. With covers that are suspended above the water it is important to ensure that the edges are reasonably airtight, otherwise water vapour will escape.

The use of covers at night is particularly important in locations with clear dry night conditions. For such locations, the heat loss from an uncovered pool may be higher than during the day.

Covers are also effective on indoor pools. In cold winter months, covers on indoor pools will also reduce the heating load for ventilation air, because ventilation at night is not usually required when the pool is covered.

A pool cover also reduces heat loss by convection. Single-film covers are the least effective in this respect.

Pool covers also reduce heat loss by radiation from the swimming pool; however, this is the least significant heat loss from the pool.

For a pool that receives direct sunshine, and where the cover may be in place during daylight hours, it is advantageous to select a translucent cover. With such covers there can still be a very significant solar radiation heat gain to the pool. Sunlight that passes through the cover is largely absorbed by the pool water. The water can thus be heated naturally, as with an uncovered pool but with the advantage that the heat losses from the top surface are substantially reduced. It has generally been found that the use of a translucent pool cover is a cost-effective option for an outdoor pool, either in its own right or in conjunction with a solar pool-heating system.

The other benefits of covers are reduced chemical consumption, reduced fouling by leaves, etc. on outdoor pools, and reduced condensation and reduced odour problems on indoor pools.

Safety is an important consideration, as pool covers generally cannot support the weight of a child or pet animal. Due to the risk of drowning, no one should swim beneath a cover. This is particularly important with floating covers.

Annex C
(informative)

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