TECHNICAL REPORT

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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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Contents

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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 Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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.

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.

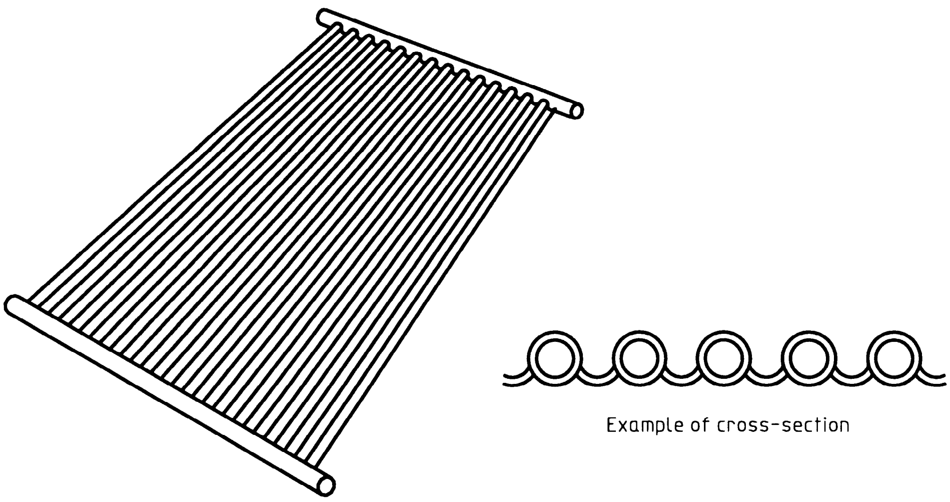


Figure 1 — Example of a plastic/elastomeric panel collector

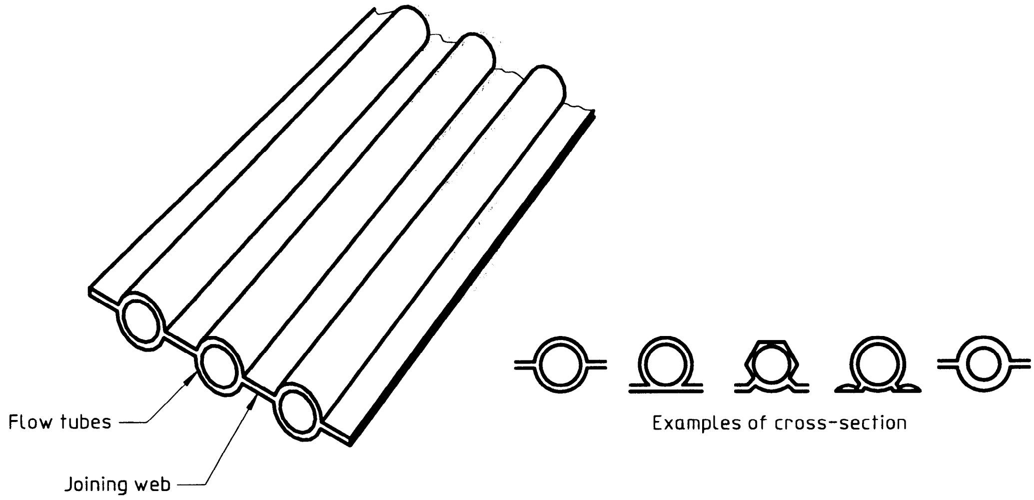


Figure 2 — Plastic strip collector

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.

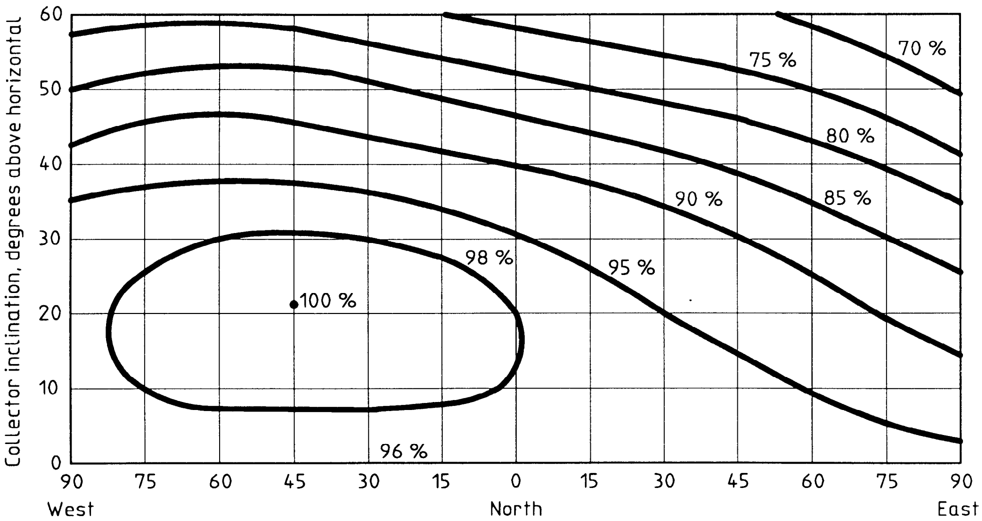
NOTE 3 The example given in figure 3 is for Melbourne, Australia, latitude 38°S, and is based on the useable solar energy received over a 12-month period. It is included as an indication only of the effect of non-ideal installation conditions and should not be used as the basis of calculations in other 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

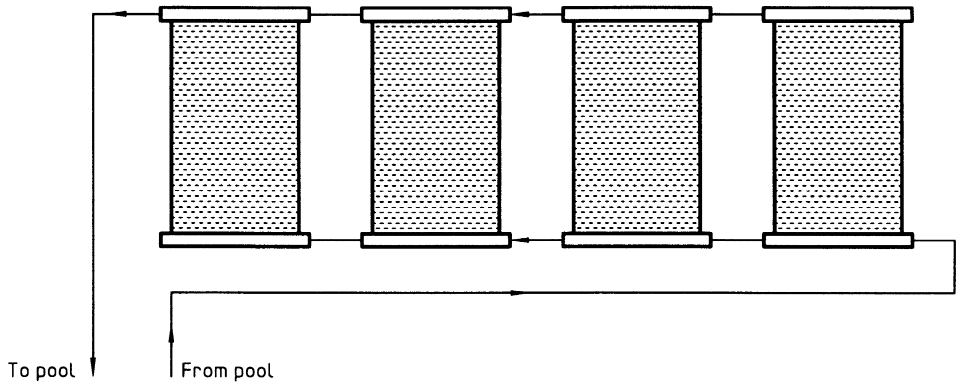
Collectors may be connected in parallel, in series or in a combination of series and parallel units to form an array. The optimal configuration depends on the geometry of available area for collector mounting as well as on the hydraulic characteristics of the collector modules. The objectives are to 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 · m^2) to 140 l/(h · m^2) [0,03 kg/(s · m^2) to 0,04 kg/(s · 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.

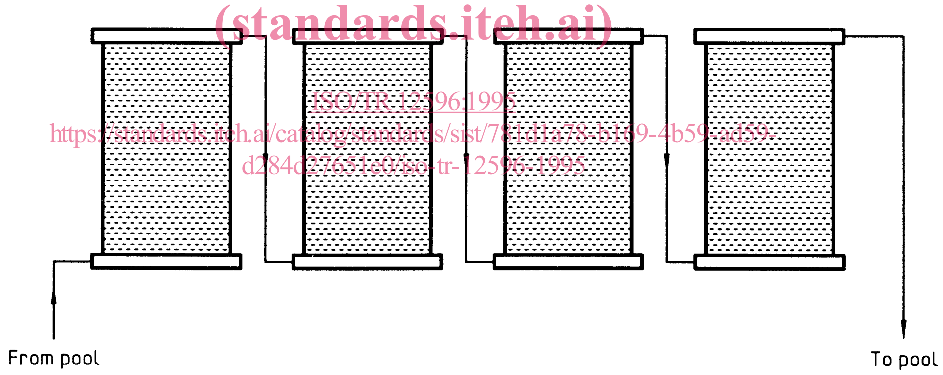
The efficiency of thermal solar collectors decreases with increasing operating temperature, particularly for unglazed collectors. It is therefore important that the flowrate through the collectors is sufficiently high to ensure efficient operation. However, flowrates higher than those specified above 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

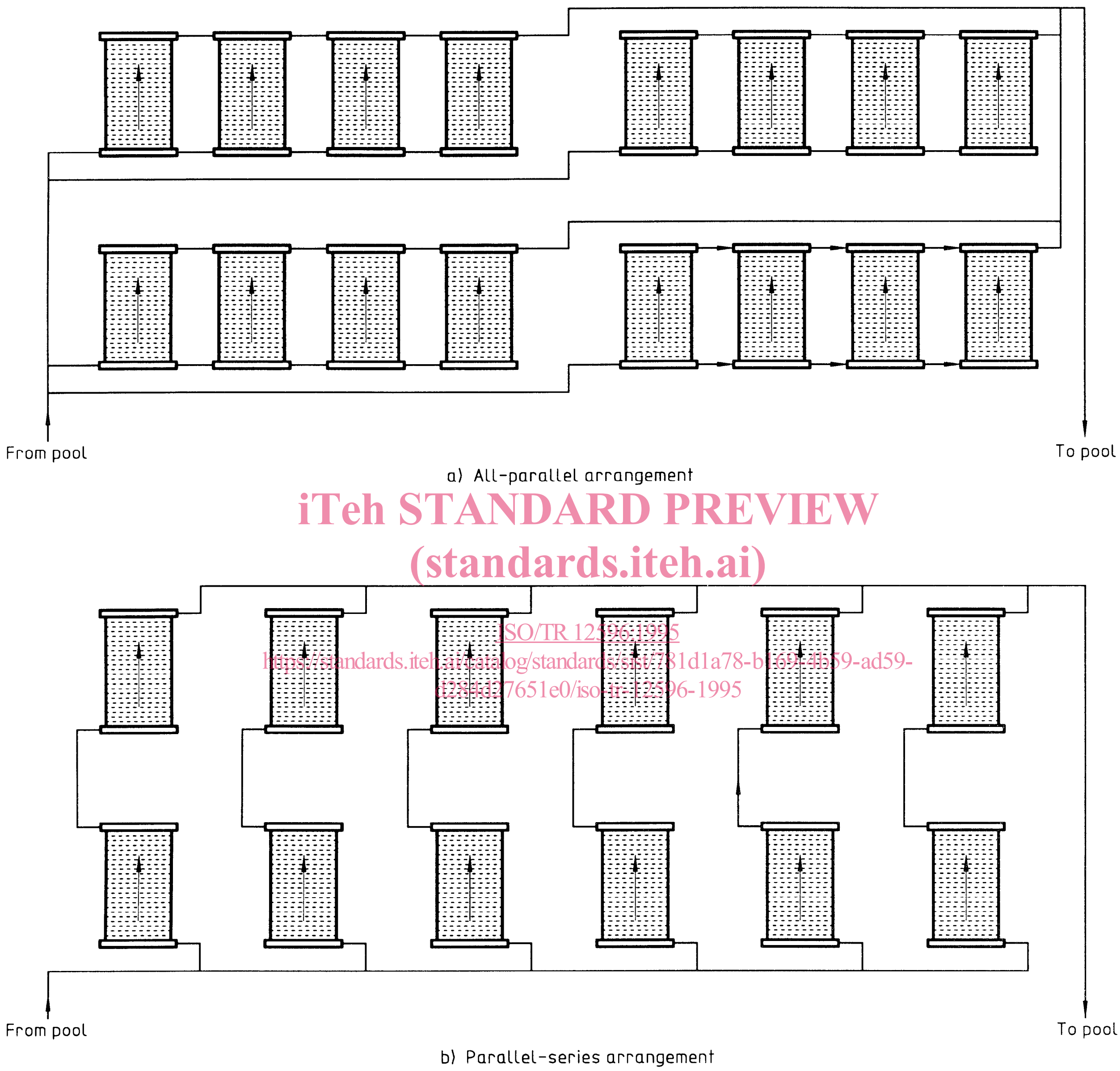


Figure 5 — All-parallel and parallel-series arrangement of panel collectors