BS EN 12976-1:2017

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Thermal solar systems and components — Factory made systems

Part 1: General requirements

National foreword

This British Standard is the UK implementation of EN 12976-1:2017. It supersedes BS EN 12976-1:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/25, Solar Heating.

A list of organizations represented on this committee can be obtained on request to its secretary.

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European foreword

This document (EN 12976-1:2017) has been prepared by Technical Committee CEN/TC 312 “Thermal solar systems and components”, the secretariat of which is held by ELOT.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2017, and conflicting national standards shall be withdrawn at the latest by July 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12976-1:2006.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

Most significant changes in EN 12976-1:2017 and EN 12976-2:2017 since the 2006 editions of both parts:

The first edition of the EN 12976 series was published in 2000. The standard series provided an important basis for the assessment of the performance as well as the reliability and durability of Factory made solar thermal systems. In the past 15 years or so, several important technological developments and changes of the framework conditions, such as e.g. the aspect of requiring “Energy Labelling”, the EN 12976 series underwent several important changes.

The following modifications are the most important ones that have been implemented in this new edition of EN 12976-1:

— safety valves: new requirement that safety valves shall conform with EN 1489;

— resistance to external influences: consideration that the solar components can impact on the performance and durability of essential building elements, e.g. roofs and facades;

— labelling: harmonisation with ErP;

— Annex C (new): definition of system families; possible range of variations within one system type.

EN 12976, *Thermal solar systems and components — Factory made systems*, is currently composed with the following parts:

— *Part 1: General requirements*;

— *Part 2: Test methods*.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Drinking water quality:

In respect of potential adverse effects on the quality of water intended for human consumption, caused by the product covered by this standard:

a) this standard provides no information as to whether the product may be used without restriction in any of the Member States of the EU or EFTA;

b) it should be noted that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of this product remain in force.

Factory Made and Custom Built solar heating systems:

The standards EN 12976-1, EN 12976-2, EN 12977-1, EN 12977-2, EN 12977-3, EN 12977-4 and EN 12977-5 distinguish two categories of solar heating systems: **Factory Made** solar heating systems and **Custom Built** solar heating systems. The classification of a system as Factory Made or Custom Built is a choice of the final supplier, in accordance with the following definitions.

Factory Made solar heating systems are batch products with one trade name, sold as complete and ready to install kits, with fixed configurations. Systems of this category are considered as a single product and assessed as a whole.

If a Factory Made Solar Heating System is modified by changing its configuration or by changing one or more of its components, the modified system is considered as a new system for which a new test report is necessary. Requirements and test methods for Factory Made solar heating systems are given in EN 12976-1 and EN 12976-2.

Custom Built solar heating systems are either uniquely built, or assembled by choosing from an assortment of components. Systems of this category are regarded as a set of components. The components are separately tested and test results are integrated to an assessment of the whole system. Requirements for Custom Built solar heating systems are given in EN 12977-1; test methods are specified in EN 12977-2, EN 12977-3, EN 12977-4 and EN 12977-5. Custom Built solar heating systems are subdivided into two categories:

— **Large Custom Built systems** are uniquely designed for a specific situation. In general HVAC engineers, manufacturers or other experts design them.

— **Small Custom Built systems** offered by a company are described in a so-called assortment file, in which all components and possible system configurations, marketed by the company, are specified. Each possible combination of a system configuration with components from the assortment is considered as **one** Custom Built system.

Table 1 shows the division for different system types:

Table 1 — Division for factory made and custom built solar heating systems

Factory Made Solar Heating Systems (EN 12976–1 and EN 12976–2)	**Custom Built Solar Heating Systems** (EN 12977–1, EN 12977–2 and EN 12977–3)
Integrated collector storage systems for domestic hot water preparation	Forced-circulation systems for hot water preparation and/or space heating, assembled using components and configurations described in an assortment file (mostly small systems)
Thermosiphon systems for domestic hot water preparation	
Forced-circulation systems as batch product with fixed configuration for domestic hot water preparation	Uniquely designed and assembled systems for hot water preparation and/or space heating (mostly large systems)

NOTE Forced circulation systems can be classified either as Factory Made or as Custom Built, depending on the market approach chosen by the final supplier.

Both Factory Made and Custom Built systems are performance tested under the same set of reference conditions as specified in EN 12976–2:2017, Annex B, and in EN 12977–2:2012, Annex A. In practice, the installation conditions may differ from these reference conditions.

A Factory Made system for domestic hot water preparation may have an option for space heating, however this option should not be used or considered during testing as a Factory Made system.

1 Scope

This European Standard specifies requirements on durability, reliability and safety for Factory Made solar heating systems. The standard also includes provisions for evaluation of conformity to these requirements. Concept of system families is included, as well.

The requirements in this standard apply to Factory Made solar systems as products. The installation of these systems including their integration with roofs or facades is not considered, but requirements are given for the documentation for the installer and the user to be delivered with the system (see also 4.6).

External auxiliary water heating devices that are placed in series with the Factory Made system are not considered to be part of the system. Cold water piping from the cold water grid to the system as well as piping from the system to an external auxiliary heater or to draw-off points is not considered to be part of the system. Piping between components of the Factory Made system is considered to be part of the system. Any integrated heat exchanger or piping for space heating option (see Introduction, last paragraph) is not considered to be part of the system.

2 Normative references

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

EN 806-1, *Specifications for installations inside buildings conveying water for human consumption — Part 1: General*

EN 806-2, *Specification for installations inside buildings conveying water for human consumption — Part 2: Design*

EN 809, *Pumps and pump units for liquids — Common safety requirements*

EN 1151 (all parts), *Pumps — Rotodynamic pumps — Circulation pumps having a rated power input not exceeding 200 W for heating installations and domestic hot water installations*

EN 1489, *Building valves — Pressure safety valves — Tests and requirements*

EN 1490, *Building valves — Combined temperature and pressure relief valves — Tests and requirements*

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

EN 1991-1-3:2003, *Eurocode 1 — Actions on structures — Part 1-3: General actions - Snow loads*

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

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

EN 1999-1-1, *Eurocode 9: Design of aluminium structures — Part 1-1: General structural rules*

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

EN 12975-1:2006+A1:2010, *Thermal solar systems and components — Solar collectors — Part 1: General requirements*

EN 12975–2, *Thermal solar systems and components — Solar collectors — Part 2: Test methods*

EN 12976-2:2017, *Thermal solar systems and components — Factory made systems — Part 2: Test methods*

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

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

EN 13831:2007, *Closed expansion vessels with built in diaphragm for installation in water*

EN 15092, *Building valves— Inline hot water supply tempering valves — Tests and requirements*

CEN/TR 16355, *Recommendations for prevention of Legionella growth in installations inside buildings conveying water for human consumption*

EN 60335-1, *Household and similar electrical appliances — Safety — Part 1: General requirements (IEC 60335-1)*

EN 60335-2 (all parts), *Household and similar electrical appliances — Safety (IEC 60335-2 series)*

EN ISO 9488:1999, *Solar energy — Vocabulary (ISO 9488:1999)*

EN ISO 9806, *Solar energy — Solar thermal collectors — Test methods (ISO 9806)*

ISO 9459-5, *Solar heating — Domestic water heating systems — Part 5: System performance characterization by means of whole-system tests and computer simulation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 9488:1999 and the following apply.

3.1
expansion line
connecting line between the collectors and the pressure expansion vessel in the case of systems with closed expansions vessels; or connecting line between the collector array and the open expansion vessel in the case of systems with open expansion vessels

3.2
safety line
connecting line between the collector array and the safety valve in the case of systems with closed expansion vessels; or connecting line between the collector array and the open expansion vessel in the case of systems with open expansion vessels

3.3
blow-off line
connecting line between the outlet of the safety valve and the environment

3.4
factory-made solar system
packaged solar energy system for the purpose of hot water preparation only, either of the close-coupled or remote-store type, consisting of either one integral component or of a uniform set and configuration

of components, produced under conditions which are presumed uniform, and offered for sale under the same trade name

Note 1 to entry Components used for external mounting on or integration with essential building elements, e.g. roofs or facades, will require additional testing to demonstrate the suitability of application.

4 Requirements

4.1 General

4.1.1 Safety

The system shall fulfil general safety requirements, e.g. care shall be taken to avoid protruding sharp edges on the outside of the system.

4.1.2 Suitability for drinking water

The system shall conform to EN 806-1 and EN 806-2.

NOTE See 4.6.2 c) 7) and 4.6.3 b) 3).

4.1.3 Water contamination

The system shall be designed to avoid water contamination/ or growth of legionella for backflow from all circuits to drinking main supplies following guidelines set forth within the Technical Report CEN/TR 16355, highlighting the effect of temperature, the range in which the legionella is not able to proliferate and heat treatment methods for the purpose of disinfection.

4.1.4 Testing of resistance towards mechanical load

The manufacturer shall define which maximum load the system can withstand. For testing the resistance of not-separable solar thermal systems, EN 12976-2:2017, 5.5 shall be applied.

Test values applied to the cover, the collector box and the fixings between collector box and mounting system should be representative of the maximum loading likely to be experienced in the country where supplied.

4.1.5 Freeze resistance

4.1.5.1 General

The manufacturer shall state a minimal allowed temperature for the system. The parts of the system that are exposed to the outdoors shall be able to withstand freezing to this specified temperature without any permanent damage.

The manufacturer shall describe the method of freeze protection used for the system.

Any indoor components that are to be installed in places where temperatures can drop below 0 °C, shall be protected against freezing.

The freezing resistance shall be tested in accordance with EN 12976-2:2017, 5.1.

4.1.5.2 Freeze protection and safety precautions with antifreeze fluid

The manufacturer shall define the composition of the heat transfer fluid, including additives, allowed for the system.

In general where water vapour is produced in the collector array when the heat transfer liquid containing antifreeze fluid no longer flows through the collector and the sun is shining (stagnation conditions), the whole liquid content of the collector array shall be pushed out of the array within a few

minutes from the beginning of boiling in the collectors. The liquid shall flow out of the array through both the inlet and the outlet connections pipe work. For this purpose, the check valve shall be located in such a way that the expansion line of the collector array is not blocked by the check valve. The design of the collector shall enable the expulsion of the whole liquid content.

The manufacturer shall define the composition of the heat transfer fluid, including additives, allowed for the system. Precautions shall be taken to prevent the antifreeze fluid from deterioration as a result of high temperature conditions. These precautions shall be checked in accordance with EN 12976-2:2017, 5.2.

NOTE 1 If the expulsion of the whole liquid content of the collector array is not possible, water vapour is produced for a long period and condensates somewhere in the collector loop. This is a considerable heat transfer that can damage the parts on which vapour condensation occurs. Also, vapour production in large quantity in the collector arrays leads to higher concentrations of the antifreeze fluid and this fluid may become corrosive. Finally, some antifreeze fluids may solidify when concentration increases at high temperature. This may hinder any further fluid flow after stagnation has ceased.

NOTE 2 In general, the lowest allowed temperature of the system is equal to the freezing point of the antifreeze fluid. If the concentration of some antifreeze fluids - like glycols - exceeds a certain limit, they can freeze without damaging the system. In this case the lowest allowed temperature can be lower than the freezing point of the antifreeze fluid.

4.1.6 Over temperature protection

4.1.6.1 General

The system shall have been designed in such a way that prolonged high solar irradiation without heat consumption does not cause any situation in which special action by the user is required to bring the system back to normal operation.

When the system has a provision to drain an amount of drinking water as a protection against overheating, the hot water drain shall be constructed in such a way that no damage is done to the system or any other materials in the house by the drained hot water. The construction shall be such that there is no danger to inhabitants from steam or hot water from the drain (see 4.6.2).

When the overheating protection of the system is dependent on electricity supply and/or cold water supply, this shall be stated clearly in the instructions and on the system (see 4.6.3 and 4.7).

NOTE For detailed information on the stagnation behaviour of solar thermal systems, please refer to a report of IEA SHC Task 26 on Solar Combisystems, prepared by Robert Hausner and Christian Fink, November 2002, http://task45.iea-shc.org/data/sites/1/publications/IEA-SHC-T45.A.2-INFO-Collector-loop-reqs.pdf.

4.1.6.2 Scald protection

When the system is tested in accordance with EN 12976-2:2017, 5.2, no steam shall escape from any draw-off point. When this test has been performed with other than the highest irradiations this shall be mentioned in the documentation for the user (see 4.6.3).

For systems in which the temperature of the domestic hot water delivered to the user can exceed 60 °C, the assembly instructions shall mention that an automatic cold water mixing device or any other device to limit the tapping temperature to at most 60 °C ± 5 °C shall be installed on the solar heating system or elsewhere in the domestic hot water installation (see also 4.6.2).

This device shall be able to withstand the maximum possible domestic hot water temperature from the solar heating system.

4.1.6.3 Over temperature protection for materials

The system shall have been designed in such a way that the maximal allowed temperature of any material in the system is never exceeded.

Care should be taken in cases where under stagnation conditions steam or hot water can enter the collector pipes, pipe work, distribution network or heat exchanger.

4.1.7 Reverse flow protection

The system shall contain provisions in order to prevent increased heat loss resulting from reverse flow in any circuit. This shall be checked in accordance with EN 12976-2:2017, 5.11.

4.1.8 Pressure resistance

The storage tank and heat exchangers in this tank shall withstand 1,5 times the manufacturer's stated maximum individual working pressures.

When tested in accordance with EN 12976-2:2017, 5.3, of to the above pressures, there shall be no visible permanent damage or leakage of the system components and interconnections. After the waiting period in the test, the hydraulic pressure shall not have dropped more than 5 % from the value measured at the start of the waiting period.

The drinking water circuit shall withstand the maximum pressure required by national/European drinking water regulations for open or closed drinking water installations.

The system shall have been designed in such a way that the maximum allowed pressure of any materials in the system is never exceeded.

Every closed circuit in the system shall contain a safety valve. This safety valve shall withstand the highest temperature that can be reached at its location. It shall conform to EN 1489. If thermostatic valves are used, these shall conform to EN 1490.

4.1.9 Electrical safety

If the system contains any electrical devices, these shall conform to EN 60335-1 and EN 60335-2 (all parts).

4.2 Materials

Any parts of the system to be mounted outdoors shall be resistant to UV radiation and other weather conditions over the prescribed maintenance interval. When any maintenance or replacement of system parts is required in order to maintain the system’s working order over a period of 10 years, this shall be clearly stated in the documents for the user.

With respect to the materials used in the collector loop, Annex B gives information to assist manufacturers in selecting them to avoid corrosion.

Bi-metallic corrosion risk to components used in the solar system, including those exposed externally, should be avoided.

Where mounting may influence the integrity of building structures, testing to CEN/TR 15601 should be applied.

Materials used in the system externally (where mounted in/on roof or façade) shall not reduce or degrade performance and durability of the essential building element where fixed.

4.3 Components and pipework

4.3.1 Collector

For systems whose collector can be tested separately, the collector shall conform to EN 12975-1, with the exception of:

- internal pressure tests for absorber (see EN 12975-1:2006+A1:2010, 5.3.2),
- freeze resistance test (see EN 12975-1:2006+A1:2010, 5.3.10),
- thermal performance measurement (see EN 12975-1:2006+A1:2010, 5.3.9).

For systems whose collector cannot be tested separately (for instance integrated collector storage systems), the whole system shall conform to EN 12975-1, with the exception of:

- internal pressure tests for absorber (see EN 12975-1:2006+A1:2010, 5.3.2),
- exposure test (see EN 12975-1:2006+A1:2010, 5.3.4), on the condition that the installation manual for the system specifies that the empty system shall be protected against prolonged exposure to solar radiation,
- internal thermal shock test (see EN 12975-1:2006+A1:2010, 5.3.6),
- freeze resistance test (see EN 12975-1:2006+A1:2010, 5.3.10),
- thermal performance measurement (see EN 12975-1:2006+A1:2010, 5.3.8),
- mechanical load resistance test (see 4.1.4).

A collector cannot be tested separately if it is not possible to perform all function testing and performance testing according to EN ISO 9806 on the collector when separated from the storage tank.

4.3.2 Supporting frame

Manufacturer shall state the maximum possible loads for their supporting frame, in accordance with EN 1993-1-1 (steel) and EN 1999-1-1 (aluminium).

This shall be mentioned in the documents for the installer.

Allowance of installing the system is depending on national requirements. Guidelines can be found in EN 1991-1-3 and EN 1991-1-4.

Where the supporting frame is integrated with or penetrates through an essential building element e.g. roof or façade, performance and durability of the essential building element should not be reduced.

4.3.3 Piping

The design and materials in the system shall be such that there is no possibility of deforming, clogging or lime deposit in its circuits that will drastically influence the system performance and safety.

With regard to corrosion, Annex B give information to assist manufacturers in selecting the materials used in the collector loop.

Circulation pumps in the system shall conform to EN 809 and the EN 1151 series.

4.3.4 Heat Exchangers

If the system is intended for use in areas with high water hardness and at temperatures above 60 °C, heat exchangers in contact with drinking water shall be designed such that scaling is prevented or there shall be a facility for cleaning.

NOTE High temperature difference between the metal surface of the heat exchanger and the surrounding drinking water mainly causes scaling. This can be avoided by increasing the heat exchanger area.

4.3.5 Control system

When present, the collector temperature sensor shall withstand stagnation conditions as specified in EN ISO 9806 without drifting by more than 1 K.

When present, the store temperature sensor shall withstand 100 °C without reduction of the accuracy by more than 1 K (see EN 12977-5:2012, 6.3.1.4).

The location and installation of all temperature sensors shall ensure a good thermal contact with the part of which the temperature shall be measured. The temperature sensors shall be insulated against high ambient temperatures.

4.4 Safety equipment

4.4.1 Safety valves

Each section of the collector array, which can be shut off, shall be fitted with at least one safety valve. Integrated collector storage (ICS) systems shall be fitted with at least one safety valve, which may be integrated with an inlet combination. The safety valve shall resist the temperature conditions which it is exposed to, especially the highest temperature that can occur. The safety valve shall resist the heat transfer medium. The safety valve shall be dimensioned such that it can release the highest flow of hot water or steam that can occur. The dimension of the safety valve(s) shall be proved by suitable means.

The safety valves shall conform to EN 1489.

4.4.2 Safety lines and expansion lines

If the system is equipped with a safety line, this safety line shall not be capable of being shut off.

If the system is equipped with a safety line and an expansion line, the safety line and expansion line shall be dimensioned such, that for the highest flow of hot water or steam that can occur, at no place in the collector loop the maximum allowed pressure is exceeded due to the pressure drop in these lines. The dimension of the safety line and expansion line shall be proved by suitable means.

The expansion line and the safety line shall be connected and laid in such a way that any accumulations of dirt, scale or similar impurities are avoided.

4.4.3 Blow-off lines

If the system is equipped with blow-off lines, these blow-off lines shall be laid in such a way that they cannot freeze up and that no water can accumulate within these lines. The orifices of the blow-off lines shall be arranged in such a way that any steam or heat transfer medium issuing from the safety valves does not cause any risk for people, materials or environment.

The system shall be checked according to EN 12976-2:2017, 5.6.3.

4.4.4 Expansion vessels

In Europe the design and the construction of expansion tanks are ruled by EN 13831.

NOTE EN 13831:2007 was made under Pressure Equipment Directive (PED) 97/23/EC.

4.5 Resistance to external influences

Performance and durability of components that are mounted on or integrated with an essential building element, e.g. roof or façade, should be proved by testing to be comparable to those of the element. Testing to CEN/TR 15601 should be undertaken. In case, performance and durability of essential building elements, e.g. roofs and facades, is effected by the solar components, life of both external collector and components of system (mounted on or integrated with roof) should be determined. The solar system components shall not reduce or degrade the performance and durability of essential building elements e.g. roofs or façades if integrated or used as a fixing substrate.

For on-roof collector installations, the mounting and fixings which penetrate through an essential building element shall be subject to a weather tightness test. If bracket, hanger or similar fixings for on-roof mounting do not create greater gapping than that of the roof covering, they may not require testing.

Solar pipe penetrations should not reduce or degrade the performance and durability of an essential building element, where they occur.

4.6 Documentation

4.6.1 General

With each Factory Made solar heating system, the manufacturer or official supplier shall deliver documents for assembly and installation (for the installer) and documents for operation (for the user). These documents shall be written in the official language(s) of the country of sale. These documents shall include all instructions necessary for assembly and operation, including maintenance, and draw attention to further requirements and technical rules that are concerned.

4.6.2 Documents for the installer

The assembly instructions shall be appropriate to the system and include information concerning:

a) technical data, at least with respect to:

   1) layout of the system, including combinations and configurations;

   2) location and nominal diameters of all external connections;

   3) an overview with all components to be delivered (such as solar collector, storage tank, support structure, flashings, fixing, collector loop pipework that penetrate into the building, hydraulic circuit, back-up provisions, control system and accessories), with information on each component: type, electrical power, dimensions, weight, marks and mounting;

   4) maximum operating pressure of all fluid circuits in the system, such as the collector circuit, the domestic hot water line and the auxiliary heating circuit;

   5) working limits: admissible temperatures, pressures, etc., throughout the system;

   6) type of corrosion protection;

   7) type of heat transfer fluid;

b) packing and transport of the whole system and/or components and way of storage (outdoors, indoors, packed, not packed);

c) installation guidelines with recommendations concerning:

   1) pre installation survey,

2) risk assessment survey,

3) declaration of roof types suitable for use with solar collector and installation method/s,

4) mounting surfaces,

5) location of collector:

   i) distances from walls, roof edges, ridge, eaves, projections or abutments (such as chimneys or parapets),

   ii) reasonable and safe access for maintenance, cleaning, repair or replacement,

6) procedure for insulation of collector loop pipework (indoors and outdoors):

   i) thickness, labelling, securing, temperature resistance, UV and weather resistance, etc.,

   ii) distances to walls and safety with regard to frost,

7) the way the entrance of piping into the building shall be finished (resistance against rain and moisture),

8) seal for a pipe penetration in a roof underlay in connection with collector loop pipework,

9) performance specification and durability of collector and mounting system (in-roof or on-roof) and compatibility with fixing substrate,

10) assessment and suitability of fixing substrate to accommodate collector and mounting, e.g. on/in roof or façade,

11) the roof integration of the collector (for each roof type) – which should cover as a minimum, roof type suitability declaration, assembly instructions, design details, flashings, fixings (type, number, position, spacing, resistance to design loads, etc.), brackets, penetrations and weather proofing as a minimum (where applicable) for drain-back or drain-down systems, the minimal pipe slope and any other instructions necessary to ensure proper draining of the collector circuit,

12) offset distance of collector above roof (on-roof),

13) weather tightness, detailing and description:

   i) integrated collectors and flashings (in-roof),

   ii) fixings, brackets, etc. through essential building element (on-roof),

   iii) collector loop pipework penetration (system circuit),

14) bi metallic corrosion prevention (collector, mounting system, collector loop and solar system components),

15) verification of requirements of EN 806-1 and EN 806-2,

16) recommendations about lightning protection;

NOTE In EN 12976–2:2017, Annex E, a test method based on EN 62305–3 is given for solar domestic water heating systems.

d) If a support frame that is normally mounted outdoors is part of the system, the maximum values of s_k (snow load) and q_p (peak velocity pressure) according to EN 1991-1-3, EN 1991-1-4 and a statement that the system may only be installed in locations with lower values of s_k and q_p, should be provided. Both the permissible and the maximum positive and negative pressure (wind and snow load) for both the collector and supporting frame should be declared.

Recommendations for the calculation of design loads:

1) The calculation should be done by a Structural Engineer or a specialist with equivalent skill;

2) The calculation should be done in accordance with the relevant Eurocodes and National Annexes;

3) Self-weight shall be calculated in accordance with EN 1991-1-1 / NA;

4) Minimum imposed roof loads shall be calculated in accordance with the snow load map featured in EN 1991-1-3:2003, Annex C; and

5) Wind loads shall be calculated in accordance with EN 1991-1-4 / NA;

e) Method for pipework connections:

1) design and Sizing of Solar Thermal System (collectors, pumps, store tanks, etc.)

2) internal space and access requirements (cylinder, pumps, controls, store, safety vessels, etc.);

f) Types and sizes of the safety and security devices and their draining: the assembly instruction shall demand that any pressure relief valves from which steam can escape during normal or stagnation conditions shall be mounted, in such a way that no injuries, harm or damage can be caused by the escape of steam. When the system has a provision to drain an amount of drinking water as a protection against overheating, the hot water drain shall be constructed in such a way that no damage is done to the system or any other materials in the building by the drained hot water;

g) The necessary control and safety devices including the wiring diagram, including the need for:

1) assembly instructions for each system design and configuration;

2) solar pipework layout (shortest distances, fall, supports, fixing intervals, penetrations, contact, protection from high temperature, etc.);

3) if required. a thermostatic mixing valve which limits the draw-off temperature to 60 °C, according to 4.1.5.2 and is in accordance with EN 15092;

4) adequate means for preventing backflow from all circuits to drinking main supplies;

h) Reviewing, filling and starting up of the system;

i) Commissioning of the system:

1) operational/functioning details of solar thermal system;

2) design details of collector, mounting system and exposed components (integrated or on the roof);

3) system signage following installation (installer and commissioning details, maintenance, potential risks, etc.); signage, refers to the design or use of signs and symbols that may be classified according to their functions such as information, identification and safety and regulatory;

4) installer qualifications and training;

NOTE Additional information may also need to be included in respect to specific performance requirements that may be covered.

5) primary transmission level indicator (where applicable);

6) flow rates for optimum heat transfer of solar energy;

7) wiring;

8) regulations that prevail in the country where sold;

9) works only by suitably qualified and trained persons;

j) a checklist for the installer to check proper functioning of the system;

k) the lowest temperature at which the system can withstand freezing;

l) if the installation of the system is limited to special climatic zones, it shall be mentioned in the documentation.

NOTE The test in EN 12976–2:2017, 5.2 cannot be regarded as a full test for the suitability for climatic zones.

4.6.3 Documents for the user

The operating instructions shall include information concerning:

a) existing safety and security components and their thermostat adjustment where applicable;

b) implementation of the system drawing particular attention to the facts that:

1) prior to putting the system in operation it shall be checked that all valves are properly working and the system is filled with water and/or antifreeze fluid completely or according to the manufacturer's instructions;

2) in the event of any failure condition a specialist shall be called in;

3) verification of requirements of EN 806-1;

c) regular operation of safety valves;

d) precautions with regard to the risk of freezing damage and/or overheating;

e) the manner of avoiding failure when starting the system under frost or possible frost conditions;

f) decommissioning of the system;

g) maintenance of the system by a specialist, including frequency of inspections and maintenance and a list of parts that need to be replaced during normal maintenance;

h) performance data for the system (see also 4.8):

   1) the recommended load range for the system (in l/day) at specified temperature;

   2) the thermal performance and solar fraction of the system according to EN 12976-2:2017, 5.9, for loads in the specified recommended load range;

   3) the annual electricity consumption for pumps, control systems and electrical valves of the system for the same conditions as specified for the thermal performance, assuming a yearly pump operating time of the collector pump of 2 000 h;

   4) if the system contains devices for freeze protection that cause electrical consumption, the electrical power of these devices (in W) and their characteristics (e.g. switch-on temperatures);

   5) for a "solar-plus-supplementary system", the maximum daily hot water load which can be met by the system without any contribution from solar energy, according to EN 12976-2:2017, 5.10;

i) if the installation of the system is limited to special climatic zones, it shall be mentioned in the documentation;

j) when the overheating protection of the system is dependent on electricity and/or cold water supply and/or the system being filled with drinking water, the requirement to never switch off the electricity supply and/or the mains water supply, or that the system is not drained when there is high solar irradiation;

k) the fact that drinking water may be drained from the system during high irradiation situations, if this method is used to prevent overheating;

l) the lowest temperature at which the system can withstand freezing;

m) type of heat transfer fluid;

n) in case of solar heating systems with emergency auxiliary heaters, instructions shall be issued that this emergency heater shall only be used for emergency heating purposes;

o) recommendations on measures to reduce risk of Legionella proliferation;

p) primary transmission level indicator (where applicable).

4.7 Energy Labelling

To determine the Energy label according to the "EU tapping cycles", as defined in CEN Mandate M/324 concerning Energy labelling necessary for labelling of water heater systems according to the European Directive.

Every system shall have the following information durably marked on a plate or label to be visible at installation, i.e.:

— the label is included in the documentation supplied with the system and in the documentation it is stated that the label (or corresponding page of the documentation with the label) shall be placed at the systems or the site where the system is installed and

— an appropriate way for providing a durable fixing and display of the label is provided.

a) Name of manufacturer or responsible supplier of the system;

b) system type indication;

c) manufacturing number or serial number;

d) year of manufacture - this may be included in the production or serial number in coded or clear form;

e) gross and aperture area of the collector in m^2;

f) nominal capacity of the storage vessel in l;

g) maximum operating pressure of the drinking water line;

h) collector heat transfer medium to be used;

i) maximum operating pressure of the collector heat transfer medium or, in case the system has an open or vented collector circuit, a statement to this effect;

j) when the overheating protection of the system is dependent on electricity or cold water supply and/or the system being filled with drinking water, a warning to this effect shall be marked on the system; in case of dependency on the electricity supply, the mains plug of the system shall also be clearly marked to this effect;

k) electrical power of all electric components.

4.8 System performance

The thermal performance of the system shall be tested according to one of the two test methods specified in EN 12976-2:2017, 5.9. The performance shall be reported to the user in the format as specified in EN 12976-2:2017, Annex A (see also 4.6.3).

Annex A
(informative)

Conformity assessment

Guidelines to assess whether one or more tests should be repeated in order to ensure that the changed product is still in conformity with the requirements are given in Table A.1.

Table A.1 — Guidelines for repetition of tests in case that components have been changed

Component test	Anti-freeze fluid	Control unit	Collector [a]	Store [a]	Heat exchanger	Supporting frame	Collector piping or installation
Freeze resistance	X	X [b]	X [c]	X [d]			X [c]
Over temperature		X [b]	X	X			X
Pressure resistance			X	X	X		X
Collector			X				
Lightning protection			X	X [d]			X [e]
Mechanical strength						X	
Thermal performance [f]	X [g]	X	X	X	X		X [h]
Ability to cover load [f]	X [g]	X	X	X	X		X [h]

[a] For "integrated collector storage systems (ICS)", a change on the system implies a change on both the collector and the storage.

[b] If the control unit is involved in frost or overheating protection.

[c] Mainly for drain-back systems.

[d] If the tank is placed outdoors.

[e] If the material is changed (especially non-metal to metal-containing materials)

[f] When, in the judgement of the second/third party, changes have a minor character or will improve the performance of the system, retesting of the performance and the ability to cover the load is generally not necessary and the old results can be used.

[g] Usually not affected, except when the viscosity of the fluid changes.

[h] Mainly for thermosiphon systems

Annex B
(informative)

Material combination with regard to corrosion

All materials used in the collector loop should conform to Tables B.1 and B.2 (closed systems) and Table B.3 and B.4 (open systems), respectively.

Legend

	Acceptable condition (if any limitations indicated are respected)
¤	Special study or test necessary
X	Unacceptable condition

Table B.1 — Material/fluid combination for closed systems

Fitting (coupling) Material	**Material of absorber tube / connecting line / valve / pump / tank / gasket**						
	Aluminium	Galvanized steel	Steel	Stainless steel	Copper	Ceramics	Polymer
Brass	[a]						¤[b]
Aluminium		X					¤[b]
Steel							¤[b]
Stainless steel							¤[b]
Copper		X					¤[b]
Polymer [c]							¤[b]

[a] Brass fittings shall not be connected directly to the aluminium collector, whether on the side of the absorber or the connecting line. But may be used elsewhere in the system. Fittings connected directly to the aluminium absorber are recommended to be in aluminium or stainless steel.

[b] Polymer used shall avoid oxygen diffusion even at much higher temperatures.

[c] For collector output fitting, take into account the stagnation temperature of the collector.

Table B.2 — Material/fluid combination for closed systems

Material in system	**Heat Transfer Fluid**					**Operational limitations**		
	Water	Water with inhibitor [a]	Water with glycol	Water with inhibitor and glycol [a]	Organic	Velocity [m/s]	pH	Temperature [°C]
Brass								
Aluminium	[b]		X		[c]	< 1,22	6,5 < pH < 8,5	[e]
Galvanized steel				no H_2O			8,0 < pH < 12,0	[d] < 55
Steel					no H_2O	< 1,83	8,5 < pH < 9,5	
Stainless steel	¤ [f] Cl^- < 50ppm		¤ [f] Cl^- < 50ppm					
Copper	Maximum 0,5 mg/l NH_4^+					< 1,22		
Ceramics [g]								
Polymer					¤ [h]			¤ [i]
Inhibitor shall be approved/feasible with the materials in the system loop.								
"No xxx" means that the amount of "xxx" shall not be detectable by usual laboratory analytical equipment.								

[a] Inhibitor shall be tailored to the materials in the system.
[b] Can be used in facilities that consist entirely of aluminium with deionized water.
[c] Not tested.
[d] This condition effectively excludes galvanized steel
[e] The glycol is the limiting component. Guidelines from the glycol producer's shall be followed.
[f] The stainless steel grade shall resist all types of corrosion. Special attention shall be paid to welding zones.
[g] Guidelines from producer's shall be followed.
[h] Check the chemical compatibility between absorber and fluid.
[i] Maximum service temperature of the polymer shall withstand the stagnation conditions of the collector.

Table B.3 — Material combinations for open systems (related to internal surfaces)

Fitting (coupling) Material	**Material of absorber tube / connecting line / valve / pump / tank / gasket**					
	Aluminium	Galvanized steel	Steel	Stainless steel	Copper	Polymer
Copper	X	X				
Steel	¤ [a]					
Polymer	¤ [b]	¤ [b]	¤ [b]	¤ [b]	¤ [b]	¤ [b]

[a] Avoid direct contact in fittings. Use the appropriate inhibitor.

[b] For collector output fittings, take into account the stagnation temperature of the collector.

Table B.4 — Material combinations for open systems (related to internal surfaces)

Material in system	**Heat Transfer Fluid**				**Operational limitations**		
	Drinkable water	Untreated	With inhibitor	Organic fluid	Velocity [m/s]	pH	Temperature [°C]
Aluminium		X	No Cu^{2+} No Fe^{2+} No Cl^-	No H_2O	< 1,22	6,5 < pH < 8,5	
Galvanized steel	X	X	No Cu^{2+}	No H_2O		8,0 < pH < 12,0	[d] < 55
Steel	X	X		No H_2O	< 1,83	8,5 < pH < 9,5	
Stainless steel	¤ [a,b] Cl^- < 50ppm	¤ [a] Cl^- < 150ppm	¤ [a] Cl^- < 50ppm				
Copper	maximum 0,5 mg/l NH_4^+	maximum 0,5 mg/l NH_4^+			< 1,22	> 5	
Polymer				¤ [c]			¤ [e]

"No x" means that the amount of "xxx" shall not be detectable by usual laboratory analytical equipment.

[a] The stainless steel grade shall resist all types of corrosion. Special attention shall be paid to welded zones.

[b] Check safety and health regulations.

[c] Check the chemical compatibility between absorber and fluid.

[d] This condition effectively excludes galvanized steel.

[e] Maximum service temperature of the polymer shall **withstand** the stagnation **conditions** of the collector.

In case, materials used in the collector loop does not conform with Tables B.1 and B.2 (closed systems) and Table B.3 and B.4 (open systems) respectively - notice is given in the test report (together with notice a reference to documentation showing that the material combinations used are OK should be given).

Annex C
(normative)

System families

C.1 System family, system subtype

A system family is a family of different system configurations / sizes of the same system subtype.

- Requirements for considering the systems as being of the same subtype are given in C.2.
- Requirements for testing are given in C.3.
- Procedure is given in C.4.

The term 'reference' in connection with the collector efficiency parameters refers to the definition of either 'aperture' or 'gross' area of the collector. Depending on the availability of the collector efficiency parameters (η_o, a_1, a_2 and IAM), based on 'aperture' (EN 12975–2) or the 'gross' (EN ISO 9806) area, the associated definition of the collector area shall be used.

C.2 Requirements for grouping different system configurations into one system family

The members of a system family comply with the following requirements:

a) For the hydraulics principles:

   1) solar thermal loops shall be of the same hydraulic principle,

   2) load loops shall be of the same hydraulic principle.

b) The heat transfer fluid shall be of the same type of liquid (same brand and water mixing percentage).

c) The heat exchanger(s) (if any):

   1) shall be of the same type of heat exchanger (mantel / spiral / external);

   2) heat transfer coefficient of heat exchanger shall be according to Formula (C.1):

$$(UA)_{hx} > 10 \cdot K_{50} \cdot \eta_{0a} \cdot (A_{col} \cdot a_c + U_{loop.total}) \quad \text{(C.1)}$$

   where

   $(UA)_{hx}$ heat transfer coefficient of the solar loop heat exchanger (determination: see C.4.3) in W/K,

   K_{50} collector incidence angle modifier at 50°,

   η_0 collector zero heat loss efficiency coefficient,

   A_{col} collector reference area of collector array in m^2,

a_c collector heat loss coefficient at T_m - T_a = 40 K, in W/(K m²);

with

$$a_c = a_1 + a_2 \cdot 40$$

where

T_a air temperature in °C,

$T_{m:}$ collector mean temperature in °C,

a_1 first order collector loss heat coefficient based on reference area in W/(K m²),

a_2 second order collector heat loss coefficient based on reference area in W/(K² m²),

$U_{loop,total}$ total heat transfer coefficient of the insulated and un-insulated surface of the solar loop in W/K.

The total heat transfer coefficient of the solar loop is calculated by Formula (C.2):

$$U_{\text{loop;total}} = U_{\text{insu}} + U_{\text{un-insu}} \quad \text{(C.2)}$$

where

U_{insu}: heat loss coefficient of the insulated part of the loop in W/K,

$U_{in\text{-}insu:}$ heat loss coefficient of the un-insulated part of the loop in W/K.

The heat loss coefficient of the insulated pipes can be calculated by Formula (C.3):

$$U_{\text{insu;pipe}} = \frac{2 \cdot \pi \cdot \lambda_{\text{insu}} \cdot L_{\text{pipe}}}{LN\left(\left(d_{\text{pipe}} + 2 \cdot t_{\text{insu;pipe}}\right) \Big/ d_{\text{pipe}}\right)} \quad \text{(C.3)}$$

where

λ_{insu} : thermal conductivity of the insulation material in W/(mK),

(estimation: 0,04 W/(K.m)

L_{pipe} : length of the pipe in meters,

d_{pipe} : diameter of the pipe,

$t_{insu;pipe}$: thickness of the insulation in meters.

The heat loss coefficient of a plane surface can be calculated by Formula (C.4):

$$U_{\text{ins-plane}} = \frac{A_{\text{plane}} \cdot \lambda_{\text{insu}}}{t_{\text{insu;plane}}} \quad \text{(C.4)}$$

where

A_{plane} : surface of the plane area in m²,

$T_{insu;plane}$: thickness of the insulation in m.

The heat loss coefficient of un-insulated pipe surface (and other un-insulated surfaces) can be determined by Formula (C.5).

$$U_{\text{un-insu}} = 15 \cdot A_{\text{surface;un-insu}} \quad \text{(C.5)}$$

where

$A_{\text{surface;un-insu}}$: surface area of the un-insulated pipe surface in m².

d) The heat storage tank(s) shall:

1) be of the same brand or declaration from manufacturer that the brands of the tanks are equivalent);

2) be of the same tank orientation (vertical or horizontal);

3) be of the same tank material;

4) be of the same inside coating;

5) comply to the following requirements on heat losses:

i) same insulation material (same material specifications),

ii) additionally, for solar-plus-supplementary systems: the heat loss coefficient shall be lower than:

$0{,}32 \cdot V_{\text{tot}}^{1/2}$,

where

V_{tot} : total volume of the tank in litres;

iii) variation of the tank insulation between the tanks in the family is restricted to:

$(t_{\text{insu,tank,max}} - t_{\text{insu,tank,min}})/t_{\text{insu,tank,min}}) \leq 25\ \%$ (approximately $t_{\text{insu,tank,max}} \leq 1{,}25 \, . \, t_{\text{insu,tank,min}}$)

where

t : insulation thickness,

max : maximum value,

min : minimum value,

or in case test results are available for heat loss according to EN 12977-3 or EN 12897, the requirements on insulation can be expressed as: heat loss coefficient requirement (Wh/l/K/day), with a maximum 40 % relative variation allowed;

6) have an heat exchanger with a similar relative position with a restricted variation of: ± 20 % variation (relative to average positions) allowed in relative positions of lower and higher points of heat exchanger (positions taken relative to tank height);

7) have a restricted variation in total tank volume:

$$\frac{(V_{\text{tot;max}} - V_{\text{tot;min}})}{V_{\text{tot;min}}} \leq 2$$

8) have a restricted variation in relative supplementary heated tank volume, $V_{\text{aux}}/V_{\text{tot}}$:

$$\frac{(V_{\text{aux}}/V_{\text{tot}}),\text{max} - (V_{\text{aux}}/V_{\text{tot}}),\text{min}}{(V_{\text{aux}}/V_{\text{tot}}),\text{min}} \leq 0{,}25$$

where

V_{aux} : volume of the backup heating part of the tank in litres.

e) The collectors shall:

1) be of the same design, with equal thermal performance parameters,

2) have a heat loss coefficient restricted to $a_c < 8$ W/(K m²) (to limit dependence on wind),

3) have a variation in collector reference area of collector array, restricted to:

$$\frac{A_{\text{col; max}} - A_{\text{col;min}}}{A_{\text{col;min}}} \leq 3$$

f) The total heat loss coefficient of the collector loop piping ($U_{\text{loop;total}}$), between collectors and store/heat exchanger), shall be less than 30 % of the total collector heat losses coefficient (=$A_{\text{col}} \cdot a_c$).

g) Controller(s) (if any) shall:

1) be of the same brand, type and settings of controller(s),

2) have the same brand, type and same/similar location of sensors; whereby the relative location of the sensors is restricted to a variation of ± 10 % (relative to average positions) allowed in positions relative to tank height,

3) have an overheating protection / temperature limiting functions of the same principle(s)/functions for all system configurations.

h) Pump(s) (if any) shall:

1) be of the same specifications with respect to operating conditions (temperatures, pressure, fluid, …),

2) have a nominal power consumption (P_{NOM}) for a system with a smaller collector area that is not lower than the power consumption of a system with a larger collector area.

C.3 Testing requirements

The “medium system configuration” is the configuration having the ratio of collector reference area to total storage volume closest to the average value of this ratio calculated for all configurations in the

family. If several configurations are equally close to the average, the configuration with the highest ratio shall be chosen.

The "medium system configuration" shall be tested according to all requirements in the EN 12976 series — except for "Over temperature protection" (EN 12976-2:2017, 5.2) and including the thermal performance characterization is performed according to ISO 9459-5.

Testing the over temperature protection and safety (EN 12976-2:2017, 5.2) shall be carried out on the configuration having the highest ratio of collector reference area to total storage volume.

The collector is tested according to EN ISO 9806.

NOTE 1 Normally two system configurations need to be sampled for (parallel) testing, but in some cases one configuration could at the same time be both the "medium system configuration" and the configuration with the highest ratio of collector reference area to total storage volume. In such case it is possible to sample only one configuration and perform all testing on this configuration.

NOTE 2 Collector reference area is defined in EN 12975-1; total storage volume is declared by manufacturer for all tank sizes in the system family.

C.4 Procedure

C.4.1 General

The method is limited to tests performed according to ISO 9459-5 (=DST) and can be used for both pumped systems and thermo-siphon systems. The method is based on the ISO 9459-5 procedure for performance calculation, which is one of the two methods for performance calculation in the EN 12976 series. The principle of the method is illustrated in the figure below.

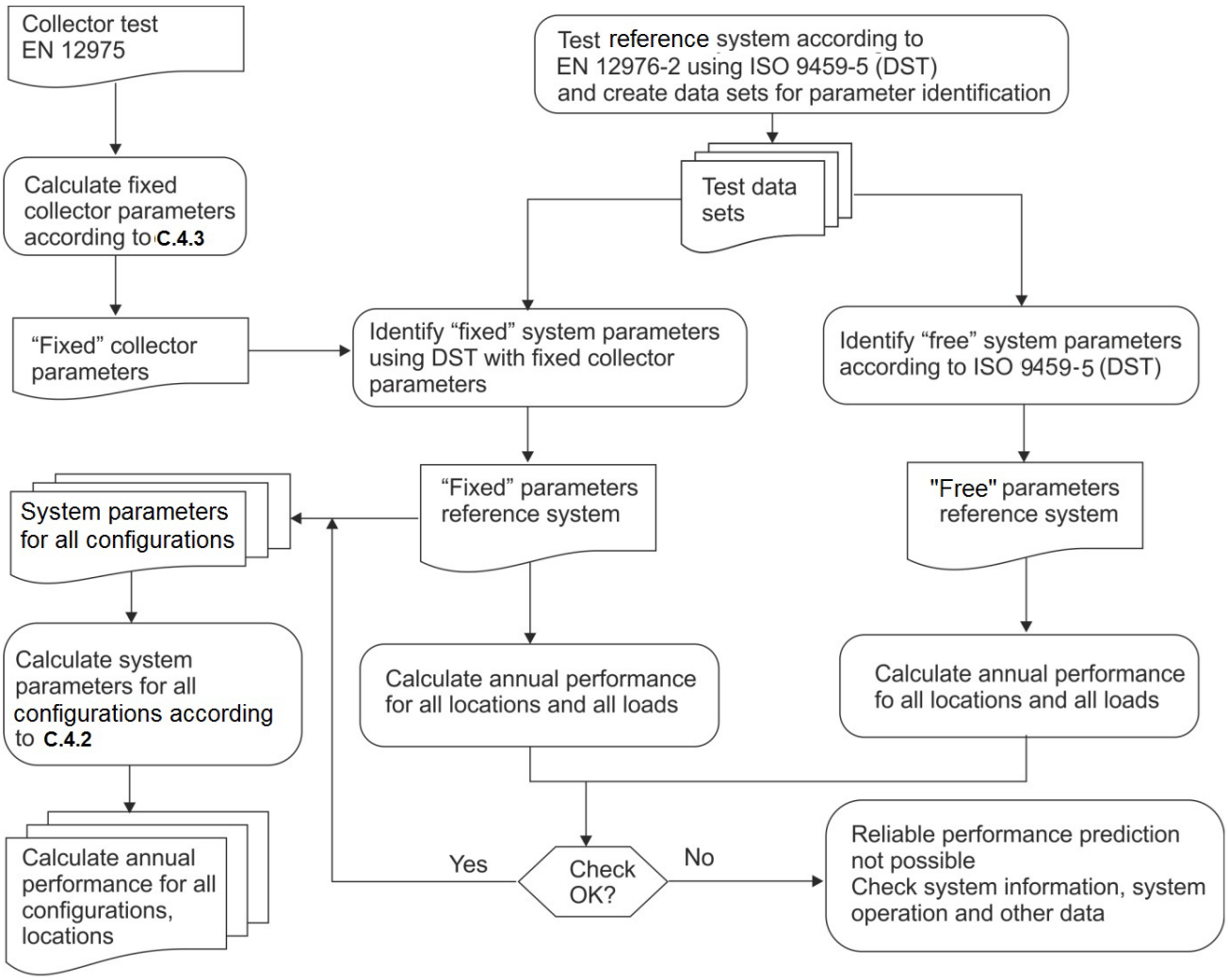

Figure C.1 — Principle of method II (DST)

C.4.2 Evaluation of the validity of the test result

The reference system is chosen and tested (see C.3). Two sets of system parameters are identified:

1) "Free" reference system parameters - these are the parameters determined according to the EN 12976 series/ ISO 9459-5.

2) "Fixed" reference system parameters. These parameters are determined fixing the collector parameters (A_C* and u_C*), according to C.4.3, and identifying the rest of the system parameters using the same test data as used for determination of the "free" system parameters.

The annual performance shall be calculated, for both system parameter sets, and for all climate regions and heat demands.

The test is valid to be applied, if the annual performance for each climate / heat demand combination deviates less than 15 % between data set 1 and data set 2.

C.4.3 Determination of the system parameters

In this phase the system parameters are determined.

Effective collector area A_c*

The effective collector area is determined as:

$$A_c^* = F''' \cdot \eta_0 \cdot K_{50} \cdot A_{col}$$

where

A_{col} total reference collector area in m²,

η_0 optical efficiency

K_{50} incidence angle modifier at 50°.

The heat exchanger factor F"' is defined in the following:

$$F''' = 1 - \frac{\eta_0 \cdot K_{50} \cdot (A_{ref} \cdot a_c + U_{loop,total})}{(UA)_{hx}} \Delta\eta_{hx}$$

with

$$U_{loop,total} = U_{insu} + U_{un\text{-}insu}$$

where

a_c collector heat loss coefficient at T_m - T_a = 40 K, W/(K m²)

T_a air temperature in °C,

T_m collector mean temperature in °C,

$A_c = a_1 + a_2 * 40$,

a_1 first order collector heat loss coefficient in W/(K m²),

a_2 second order collector heat loss coefficient in W/(K² m²),

η_0 collector zero loss efficiency,

K_{50} incidence angle modifier at 50° incident angle,

A_{col} collector reference area in m²,

$(UA)_{hx}$ heat transfer coefficient of the heat exchanger, W/K,

$(UA)_{hx} = U_{hx} * A_{hx}$;

U_{hx} heat transfer coefficient per m² of the heat exchanger in W/(K m²),

A_{hx} total surface area of heat exchanger in m²,

$U_{loop,total}$ heat loss coefficient of the collector loop piping in W/K,

U_{insu} heat loss coefficient for insulated part of collector loop piping in W/K,

$U_{un\text{-}insu}$ heat loss coefficient for the un-insulated part of collector loop piping in W/K.

For external heat exchangers the actual value of $(UA)_{hx}$ is used for the temperature set:

- primary loop 25 °C, 35 °C (collector loop);
- secondary loop 15 °C, 25 °C (tank loop).

For tanks with internal heat exchangers a value of 200 W/K per m² heat exchanger surface (average of inner and outer surface) is chosen for U_{hx} if no qualified measurements (e.g. from EN 12977-3 test) are available for the $(UA)_{hx}$ for the heat exchanger. The test value to be used should comply with the conditions given in EN 12977-2:2012, 6.4.6: "*$(UA)_{hx}$ to be chosen for storage temperatures of 20°C, average temperature difference 10 K and a flow rate similar to the one used for the determination of the collector parameters*" (flow rate corresponding to the minimum number of collector modules applied to the tank within the system family).

NOTE The value for U_{hx}: 200 W/(K m²) is based on test of 23 tanks with internal heat exchangers (tests performed at Danish Technological Institute).

Effective collector loss coefficient U_c*

The effective collector loss coefficient is determined as:

$$U_c^* = \frac{A_c + U_{loop,total} / A}{\eta_o \cdot K_{50}}$$

where

$U_{loop,total}$: heat loss coefficient of the collector loop piping in W/K,

U_{insu} : heat loss coefficient for insulated part of collector loop piping in W/K,

$U_{un\text{-}insu}$: heat loss coefficient for the un-insulated part of collector loop piping in W/K.

Total storage heat loss coefficient U_s

The storage heat loss parameter is determined as:

$$U_{s,x} = U_{s,ref,fix} \cdot \frac{A_{x,surface}}{A_{ref,surface}}$$

where

$U_{s,x}$ storage heat loss parameter to be determined for the actual configuration,

$U_{s,ref,fix}$ storage heat loss parameter determined for the reference system using fixed collector parameters,

$A_{x,surface}$ surface area of storage in the actual configuration,

$A_{ref,surface}$ surface area of storage in the reference configuration.

Total storage heat capacity C_s

The storage heat capacity parameter is determined as:

$$C_{s,x} = C_{s,ref,fix} \cdot \frac{V_x}{V_{ref}}$$

where

$C_{s,x}$ storage heat capacity parameter to be determined for the actual configuration,

$C_{s,ref,fix}$ storage heat capacity parameter determined for the reference system using fixed collector parameters,

V_x storage volume in the actual configuration,

V_{ref} storage volume in the reference configuration.

Fraction auxiliary heating f_{aux}

The parameter for back-up volume is in all cases set to the value of $f_{aux,fix}$ already determined using the fixed collector parameters for the reference system.

Mixing constant D_L

The mixing constant is in all cases set to the values already determined using the fixed collector parameters for the reference system.

Stratification parameter S_C

The stratification parameter is in all cases set to the values already determined using the fixed collector parameters for the reference system.

Thermal resistance load heat exchanger R_L

The parameter for load side heat exchanger is determined as:

$$R_{L,x} = R_{L,ref,fix} \cdot \frac{A_{lshx,x}}{A_{lshx,ref}}$$

where

$R_{L,x}$	load side heat exchanger parameter to be determined for the actual configuration,
$R_{L,ref,fix}$	load side heat exchanger parameter determined for the reference system using fixed collector parameters,
$A_{lshx,x}$	surface area of load side heat exchanger in the actual configuration,
$A_{lshx,ref}$	surface area of load side heat exchanger in the reference configuration.

Wind speed dependency u_v

The wind speed parameter is not taken into account.

C.4.4 Calculation of annual performance

Using the system parameters determined in C.4.3, the annual performance is calculated for all climates and heat loads and reported according to EN 12976-2:2017, Annex A.

Bibliography

[1] EN 1717, *Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow*

[2] EN 12977-1, *Thermal solar systems and components — Custom built systems — Part 1: General requirements for solar water heaters and combisystems*

[3] EN 12977-2:2012, *Thermal solar systems and components — Custom built systems — Part 2: Test methods for solar water heaters and combisystems*

[4] EN 12977-4, *Thermal solar systems and components — Custom built systems — Part 4: Performance test methods for solar combistores*

[5] CEN/TR 15601, *Hygrothermal performance of buildings — Resistance to wind - driven rain of roof coverings with discontinuously laid small elements — Test methods*

[6] EN 62305–3, *Protection against lightning — Part 3: Physical damage to structures and life hazard (IEC 62305–3)*

[7] IEC 61024-1, *Protection of structures against lightning — Part 1: General principles*

[8] ISO/TR 10217, *Solar energy — Water heating systems — Guide to material selection with regard to internal corrosion*

[9] Robert Hausner and Christian Fink, *"Stagnation behaviour of solar thermal systems". A Report of IEA SHC - Task 26 Solar Combisystems, November 2002*, http://task45.iea-shc.org/data/sites/1/publications/IEA-SHC-T45.A.2-INFO-Collector-loop-reqs.pdf

[10] LEGIONELLA and the prevention of legionellosis, World Health Organization 2007

[11] Eero Saikkonen and Pasi Puikkonen, "*Seal for a pipe penetration in a roof underlay". Patent WO2014125169 A1 published on August 21, 2014*

[12] Pressure Equipment Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment

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