Annex Q1 Systems EN 12976 General

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1. Abbreviations

The definitions in the Solar Keymark Scheme Rules apply.

2. Sampling

2.1 From serial production

For compact non-separable systems such as some thermosiphon systems or ICS a series production is assumed when a least 10 samples are produced with the same materials and the same manufacturing technologies in the same way and all major production processes are performed in presence of the inspector.

For separable systems at least 10 collectors and 10 storage tanks are produced with the same materials and the same manufacturing technologies in the same way and all major production processes are performed in presence of the inspector.

2.2 From stock

At least 10 samples (complete systems / collectors / storage tanks as applicable) of the same type more than the number of test samples picked must be available in the stock for picking the sample(s) to be tested.

2.3 Prototype testing

If for any reason the described standard sampling procedures are not applicable and prototypes must be submitted for testing, the CB has to decide on appropriate sampling procedures. In this case, a factory inspection is required after the sampling and before the issue of the certificate to verify the conformity of the sampled product with the planned serial production.

3. Compliance criteria for performance

3.1 General

To compare the thermal performance of two factory made systems in the framework of the Solar Keymark the principles and figures given in this chapter shall be used.

3.2 Solar-plus-supplementary systems

The difference between the calculated $Q_{aux,net}$ (as defined in EN 12976-2, paragraph 5.9.3.2) of two systems shall be less than 10% based on the Würzburg climate data and the design load given by the manufacturer (see: EN 12976-2, Annex B, table B.1).

3.3 Solar-only and solar preheat systems

The difference between the calculated f_{sol} (as defined in EN 12976-2, paragraph 5.9.3.3) of two systems shall be less than 10% based on the Würzburg climate data and the design load given by the manufacturer (see EN 12976-2 Annex B, table B.1).

4. System families

4.1 Factory made system families

If the manufacturer produces the “same” system in different sizes, the different sizes of the system can be considered being the same subtype (within the same system “family”) if they fulfil the design and testing requirements defined in EN 12976-1:2021.

The model parameters determined for systems not physically performance tested according to ISO 9459-2 or ISO 9459-5 have to be stated in the test report and the Solar Keymark data sheet together with the results of the Long-Term Performance Prediction (LTP) resulting from the use of these model parameters for the specific system(s).

4.2 Integrated collector storage and ETC thermosiphon system families

ICS (Integral collector-storage system) is defined as a solar heating system in which the solar collector also functions as a heat(water) storage device. Thermosiphon systems with evacuated tubes can be treated in the same way as ICS, if all the conditions listed in clause 4.2 are met. The term ICS therefore includes also these systems.

Similar ICS systems as defined in 4.2.1 can be grouped into a family using the procedures described in this section. All ICS system of a family shall have the ratio of reference area (m^2) to volume (litres) less than 0.2.

The medium system of the family is defined according to Annex C.3 of the EN 12976-1. If the variation of the ratio of volume to reference area δ is below or equal to 7% (≤ 7%), using as reference the medium system, for all members of the family, then the performance test shall be performed on the “medium system configuration”.

$$\delta = \left| \frac{(R_{V/A,ref} - R_{V/A,x})}{R_{V/A,ref}} \right| \times 100 \ (\%)$$

where

$$R_{V/A} = \frac{V_{s,ref}}{A_{a,ref}} = \frac{V_{s,x}}{A_{a,x}}$$

and:

$V_{s,x}$ Fluid content of the storage tank of the actual ICS system configuration [l]

$V_{s,ref}$ Fluid content of the storage tank of the reference ICS system configuration [l]

$A_{col,x}$ Reference area of the actual ICS system [m^2]

$A_{col,ref}$ Reference area of the reference ICS system [m^2]

If the variation of one system of the family is above this limit δ (>7%), then two systems shall be tested, that with the highest ratio of volume to reference area (S_H) and the one with the lowest ratio of volume to reference area (S_L).

Note: Collector reference area is the aperture area as defined in ISO 9488.The total store volumes are declared by the manufacturer for all sizes in the ICS family. The plausibility of the declared data shall be checked by the testing laboratory.

4.2.1 Requirements for grouping different ICS system into one system family

In order to be considered an ICS family all systems must meet the following

- the same materials shall be used for all components
- the length, width and volume can differ but shall be proportionate
- the members shall have the same external and internal design

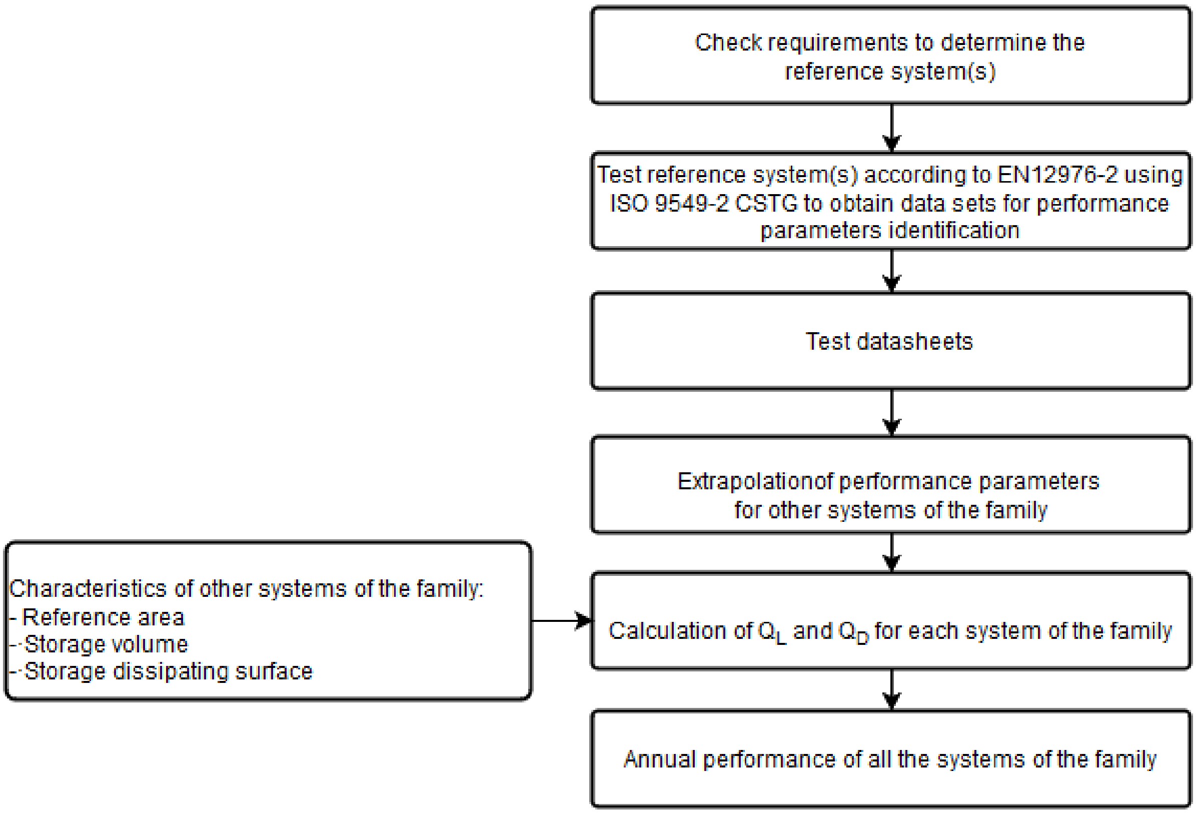
One of the following methods shall be used to determine the performance of each system of the ICS family

- Method III (CSTG), as described in 4.2.2
- Method IV (DST), as described in 4.2.3

If δ≤ 7% the medium system is tested and used as reference system. If δ>7%, for any member of the family δ_L and δ_H are checked. If $\delta_L > \delta_H$ the system S_H is considered as reference system. If $\delta_L < \delta_H$ the system S_L is considered as reference system.

4.2.2 Method III (CSTG)

This method can be used only when an ICS system is tested according to EN 12976-2 using ISO 9459-2. The methodological approach used to extend the test results to other systems of the family is illustrated in the following figure



Where:

Q_D is heat demand (result from EN 12976) [MJ/year]

Q_L is he qat delivered by the solar heating system (according to EN 12976) [MJ/year]

The method is organized in the following four steps:

A) Check requirements to extend test results to other systems of the family

- The reference ICS system shall be tested according to EN 12976-2 using ISO 9459-2 (CSTG method).
- All other systems of the family shall be characterized by a ratio between storage volume and reference area, as required by 4.2.

B) Parameters identification for reference ICS system

From the tests carried out according to ISO 9459-2 (CSTG method), the typical experimental data sets relating to the daily thermal performances is given in Table 1.

Data points	**Data acquired during 12-h test**				**Draw-off**			**Output**
	H *MJ/m²*	$T_{a(day)}$ *°C*	T_{main} *°C*	$T_{a(day)}$-T_{main} *K*	V_d *l*	$T_{d(max)}$ *°C*	$T_{d(max)}$-T_{main} *K*	*Q* *MJ*
1	H_1	$T_{a,1}$	$T_{main,1}$	...	$3\ V_{s,ref}$	$T_{d(max),1}$	...	$Q_{ref,1}$
2	H_2	$T_{a,2}$	$T_{main,2}$	...	$3\ V_{s,ref}$	$T_{d(max),2}$	...	$Q_{ref,2}$
...	...	...	...	...	...	...	...	...
N	H_n	$T_{a,n}$	$T_{main,n}$	...	$3\ V_{s,ref}$	$T_{d(max),n}$	...	$Q_{ref,n}$

Table 1 Experimental data set of reference ICS system

In addition to the previous tests, other test for calculating the mixing draw-off temperature profile and the over-night heat loss coefficient of the storage tank, are performed. Starting from these data, the parameters needed for estimating the annual performance are calculated, as shown in the following parameter table.

Performance parameter description	Symbol	Unit
Coefficients related to daily energy output of the system, obtained according to the following linear correlation: $Q_{ref} = a_1 H + a_2 (T_{a(day)} - T_{main}) + a_3$	a_1	m²
	a_2	MJ/K
	a_3	MJ
Storage tank heat loss coefficient	$U_{s, ref}$	W/K
Normalized draw-off profile, evaluated for H > 16 MJ/m² and H < 16 MJ/m²	*f(V)*	-
Normalized mixing draw-off profile	*g(V)*	-

Table 2 Parameter table – Reference system parameters for annual performance calculation

C) Extrapolation of performance parameters for other ICS systems

The following paragraphs show how to extrapolate the parameters needed for the calculation of annual performance, for all locations and for all loads, for the other systems of the family

- **Daily thermal performance of the system**

For every system of the family a new table x is composed. For each test day, the experimental data set related to the reference system (see Table 1), the daily thermal performance of the generic ICS system, in the same operating conditions as the reference system, are calculated according to the following formula:

$$Q_x = Q_{ref} \frac{A_{a,x}}{A_{a,ref}}$$

where:

Q_x Daily thermal energy output of the actual ICS system [MJ]

Q_{ref} Daily thermal energy output of the reference ICS system, obtained during the experimental tests [MJ]

$A_{col,x}$ Reference area of the actual ICS system [m^2]

$A_{col,ref}$ Reference area of the reference ICS system [m^2]

Data points	Data acquired during 12-h test				Draw-off			Output
	H *MJ/m²*	$T_{a(day)}$ °C	T_{main} °C	$T_{a(day)}$-T_{main} K	V_d *l*	$T_{d(max)}$ °C	$T_{d(max)}$-T_{main} K	*Q* *MJ*
1	H_1	$T_{a,1}$	$T_{main,1}$	…	3 $V_{s,x}$	$T_{d(max),1}$	…	$Q_{x,1}$
2	H_2	$T_{a,2}$	$T_{main,2}$	…	3 $V_{s,x}$	$T_{d(max),2}$	…	$Q_{x,2}$
…	…	…	…	…	…	…	…	…
N	H_n	$T_{a,n}$	$T_{main,n}$	…	3 $V_{s,x}$	$T_{d(max),n}$	…	$Q_{x,n}$

Table 3 Extrapolation of data of system x

Starting from the daily thermal performance data thus obtained, the parameters a_1, a_2 and a_3, related to the actual ICS system x, are calculated.

- **Storage tank heat loss coefficient**

This coefficient is calculated for the actual ICS system, according to the following formula:

$$U_{S,x} = U_{S,ref} \frac{A_{tot,x}}{A_{tot,ref}}$$

where:

$U_{s,x}$ is the storage tank heat loss coefficient of the actual ICS system [W/K]

$U_{s,ref}$ is the storage tank heat loss coefficient of the reference ICS system [W/K]

$A_{tot,x}$ is the surface area of the store in the actual configuration [m^2]

$A_{tot,ref}$ is the surface area of the store in the reference configuration [m^2]

- **Normalized draw-off profiles**

For all members of the family the same normalized draw-off profiles f(V) and g(V), obtained for the reference ICS system, shall be used.

This assumption is based on the hypothesis that the fraction of thermal energy extracted from the reference storage tank, is the same of that extracted from the actual storage tank when the draw-off volume is properly scaled according to the ratio between the reference storage tank volume $V_{S,ref}$ and the actual one $V_{S,x}$.

In particular, it is assumed that:

$$f(V_d/V_{s,ref}) = f(V_{d,x}/V_{s,x})$$

$$g(V_d/V_{s,ref}) = g(V_{d,x}/V_{s,x})$$

where:

V_d is the draw-off volume referred to the reference ICS system [litre]

$V_{d,x} = V_d \frac{V_{s,x}}{V_{s,ref}}$ is the corresponding draw-off volume to be extracted by the actual ICS system, such to have the same value of the normalized draw-off profile. [litre]

D) Annual performance of whole systems family and presentation on the SK datasheet

The annual performance indicators for all locations and loads, according to the requirements of EN 12976-2, are calculated for the tested ICS system and for all members of the ICS family using the derived parameters as described above.

4.2.3 Method IV (DST)

Alternatively, the DST method, according to ISO 9459-5, can be used to determine the performance of an ICS system. In this case the reference system is defined in 4.2. The DST method defines the following parameters:

- Effective collector area A_C^* [m^2]
- Effective collector loss coefficient u_c^* [W/(m²K)]
- Total store heat loss U_S [W/K]
- Total store heat capacity C_S [MJ/K]
- Fraction of store used for auxiliary heating faux [-]
- Mixing constant D_L
- Stratification parameter S_C [-]
- Thermal resistance of load heat exchanger [K/W]
- Volume V [litre]

The extrapolation of the parameters for the different systems of the family is as following:

The effective collector area is scaled with the total surface of the reference area

$$A_{C,x}^* = \frac{A_{C,ref}^* A_x}{A_{ref}}$$

The effective collector loss coefficient u_C^* is scaled with the total surface of the aperture area

$$u_{C,x}^* = \frac{u_{C,ref}^* A_x}{A_{ref}}$$

For ETC Thermosiphon systems, the total store heat loss is scaled up with totals surface of reference area

$$U_{s,x} = \frac{U_{s,ref}\, AS_x}{AS_{ref}}$$

where AS is the total surface area of the storage

The total store heat capacity is scaled up with volumes

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

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

The parameters for stratification (D_L and S_L) are in all cases set to the values already determined using the fixed collector parameters for the reference system.

The parameter for load side heat exchanger (R_L) is determined as:

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

The parameter u_v is not taken into account

The volume is indicated by the manufacturer (see in 4.2).

The annual performance indicators for all locations and loads, according to the requirements of EN 12976-2 clause 5.9.3.2, are calculated for the tested ICS system(s) and for all other systems of the family using the definitions given above.

4.3 Other required tests

Apart from the performance test the mechanical load and the over temperature protection test shall be performed for an ICS family (EN 12976-2, clause 5.2 and 5.5). The mechanical test shall be performed on the model of the family with the highest reference area. The high temperature protection test shall be performed on the model having the highest ratio of reference area (m^2) to volume (litres).

5. Tolerances and Equivalences

5.1 Collectors

A collector in a Solar Keymark certified system can be changed under the following conditions:

- The original test report of the tested system configuration remains the reference for all kinds of modifications, even if a modification was accepted without retest.
- The manufacturer informs the CB about the planned change of collector type.
- The manufacturer delivers the test reports and SK data sheets of both collectors and the system to the CB.
- Both the CB and the TL which has issued the system test report have to approve the system modification.

Note: A collector re-test considered within the certificate (e.g. after 10 years or after modification but with initial registration number) will be treated as changed collector!

A negative decision can also be based on technical consideration out of the following few requirements.

Minimum requirements on the collector:

- The alternative collector is Solar Keymark certified.
- The original collector must be performance tested according to EN ISO 9806
- The test reports of both collectors and the system are available to the CB
- The change of the collector does not cause a change of the system configuration e.g. piping, inlet connections, controller, pump etc.

Both collectors have to be “technical identical”

Definition of “technical identical” Collector” (Data based on test report)

- Tolerance of gross area ± 10 %
- The pressure drop shall not differ by more than ± 10 % for the nominal flow rate as stated by the manufacturer.
- The thermal performance shall be compared as defined in Annex P1, clause 3.2, and shall be within a tolerance ±10 %
- The annual energy output shall not undergo the lower limit of Clause 3.4 Annex P1 for collectors (If the results computed for all 4 locations at 25 °C are within less than -2.5% and at 50 °C within less than -5.0% and at 75 °C within less than -7.5%). For thermosiphon systems, the annual output shall be compared only for the locations Athens and Würzburg.
- W_{peak} ± 10 % (as defined in EN ISO 9806)

No modifications allowed at:

- Hydraulic flow type
- Maximal operating pressure
- Permitted heat transfer fluid

Reporting: The original test report of the tested system remains the reference for all kinds of modifications – cascading modifications are excluded. The original test report remains unchanged and valid. The use of alternative collectors is briefly reported as an addendum to the original test report. The related data sheet shall be revised, if the registration number of the used collector is changed.

5.2 SK certification of a system with a collector certified by another CB

It is not required that a system and the components in the system are Solar Keymark certified by the same CB. In general, a certifier has to perform SK system certification based on collector SK certificates issued by another certification body.

The manufacturer is obliged to inform the CB certifying his system about any changes related to the certification of the collector used in the system - including if the collector certificate is cancelled.

6. Miscellaneous

6.1 Labelling of systems

The requirement stated in EN 12976-1:2021, clause 4.7 “Every system shall have the following information durably marked on a plate or label to be visible at installation” can be considered as fulfilled if: 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) has to be placed at the systems or the site where the system is installed an appropriate way for providing a durable fixing and display of the label is provided

The requirement mentioned above is relevant for the system label required according to EN 12976-1:2021, clause 4.7 and for the Solar Keymark system label.

6.2 Nominal store volume

The nominal store volume stated on the system identification label shall not differ by more than 10 % from the effective store volume determined from the measured thermal capacity. The calculation of the percentage of the difference between the two volumes is based on the value of the effective volume. The effective store volume shall be mentioned in the test report.

6.3 Hot water tapping times

The following taping times shall be used for the performance prediction:

Reference locations	*Longitude*	*Time zone*	*Adjustment of standard time*	*Tapping time (CET)*
Stockholm	*18.07°*	*1*	*-0.20*	*17.80*
Würzburg	*9.90°*	*1*	*0.34*	*18.34*
Davos	*9.82°*	*1*	*0.35*	*18.35*
Athens	*34.70°*	*2*	*0.42*	*18.42*

Table 4 Data of reference locations and adjusted tapping times (Longitude and time as decimal numbers)

6.4 ISO 9459-5 Dynamic System Testing

The preferred test method for solar thermal systems without WISC collectors according to ISO 9459-5 (DST method) is the option v_{ignore} according to clause 6.2.2. The used option must be stated in the report and Solar Keymark data sheet.

The term "average ambient temperature" in clause 6.2.1 of ISO 9459-5 shall be understood as a 24 h average of the ambient temperature of the store, measured in the 24 h before the start of a draw-off.

6.5 Factory made systems using PVT collector

Factory made systems using PVT collectors can be tested and certified under the following conditions:

- The performance testing is done with an MPP tracker
- Durability / Overheating without MPP
- If the PVT collector is already SK certified there are no further criteria for the PVT to be fulfilled, excecpt if the PVT is used in a way that is not included in the PVT certificate.
- If the PVT is not certified then all the requriemtens requried for PVT collectors (Annex P5.1) have to be fulfilled.

All other rules for Factory made systems apply in the same way for PVT as for any other collector.