Annex P1 Collectors EN 12975 General

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1. Abbreviations

The definitions in the Solar Keymark Scheme Rules apply

2. Specific sampling requirements

2.1 From serial production

A series production is assumed when a least 10 collectors 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 collectors 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 within 6 months after 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 collectors in the framework of the Solar Keymark the principles and figures given in this chapter shall be used.

3.2 Thermal performance

Thermal performance parameters shall be compared based on Σ which corresponds to the area under the measured power curve per m² gross area, i.e. for a collector A:

$$\Sigma_A\left(\Delta\vartheta_{m,\max}\right)=\frac{1}{A_{G_A}}\int_0^{\Delta\vartheta_{m,\max}}\left[\dot{Q}_{BlueSky,SRC,A}\left(\Delta\vartheta_{\mathrm{m}}\right)\right]_{pos}d\Delta\vartheta_{\mathrm{m}}$$

Where $\dot{Q}_{BlueSky,SRC,A}\left(\Delta\vartheta_{\mathrm{m}}\right)$ is the thermal performance under Blue Sky Standard reporting conditions for collector A. The subscript “pos” indicates that only positive values shall be taken into account. Negative values shall be coerced to 0.

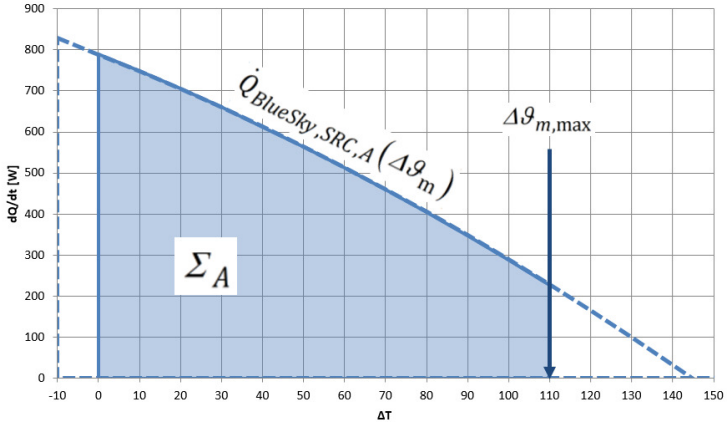

Figure 1: Definition of Σ corresponding to the area under the measured power curve per m² gross area

The thermal performance curve of two collectors shall be compared using $\Sigma_A\left(\Delta\vartheta_{m,\max}\right)$ and $\Sigma_B\left(\Delta\vartheta_{m,\max}\right)$. Care must be taken to select properly the maximum temperature difference

$\Delta\vartheta_{\mathrm{m,max}}$. By definition all thermal performance parameters are valid up to the maximum temperature difference where measured data points are available plus 30°K (see clause 24.3 of ISO 9806:2017). Comparisons of two collector is therefore only possible up to $\Delta\vartheta_{\mathrm{m,max}}$ that is valid for both collectors, i.e. $\Delta\vartheta_{m,\max} = \min\left(\Delta\vartheta_{m,\max}\left(ColA\right), \Delta\vartheta_{m,\max}\left(ColB\right)\right)$

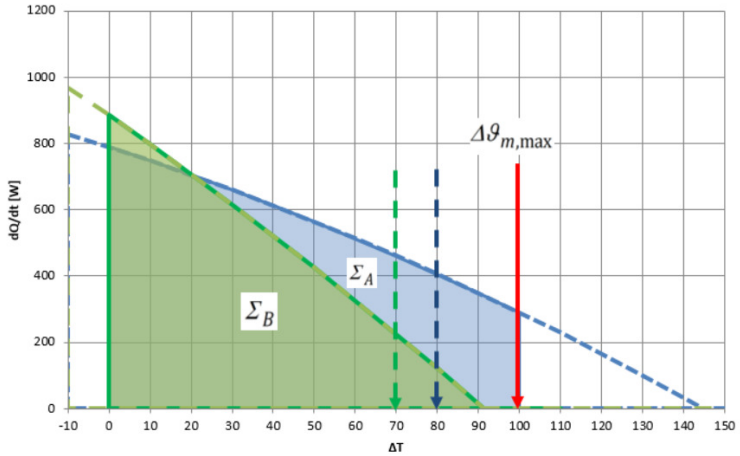

Figure 2: Comparison of thermal performance of two collectors

In the example of Figure 2, Collector A (blue) was measured up to a $\Delta\vartheta_{\mathrm{m}}\left(ColA\right) = 80K$ which would allow to extrapolate up to 110K. Collector B (green) was measured only up to $\Delta\vartheta_{\mathrm{m}}\left(ColB\right) = 70K$ allowing the extrapolation up to 100K. The comparison of the two collectors is therefore only allowed up to $\Delta\vartheta_{\mathrm{m,max}} = 100K$ and of course a certificate including the two collectors can be valid only up to 100K only.

In addition, the power output $\dot{Q}$ of the two collectors under Blue Sky SRC shall not differ by more than 2% of the peak power and not more than 2% of power at a temperature difference of $\Delta\vartheta_{\mathrm{m,max}}/2$ and not more than 5% at $\Delta\vartheta_{\mathrm{m,max}}$.

If not defined differently, the thermal performance of a collector B is then considered the same if

$$\left|\frac{\Sigma_A\left(\Delta\vartheta_{m,\max}\right) - \Sigma_B\left(\Delta\vartheta_{m,\max}\right)}{\Sigma_A\left(\Delta\vartheta_{m,\max}\right)}\right| \leq 0.1$$

3.3 Incidence angle modifier

The incidence angle modifier is compared based on the tabulated values indicated in the test report (ISO 9806:2017 Annex Table A.10) and on the deviation parameter δ: Collector B is considered the same as Collector A with respect to IAM, if for all angles (L and T) from 10° to 80° the IAM of Collector B is within the limits of Collector A defined by formula

$$IAM\left(ColB\left(\theta\right)\right) \in IAM\left(ColA\left(\theta\right)\right) \pm \frac{\delta}{\left(90-\theta\right)} \quad \text{for the standard value } \delta = 0.8$$

A deviation parameter $\delta = 0.8$ results in a “tolerance” of ±2% at $\theta = 50°$

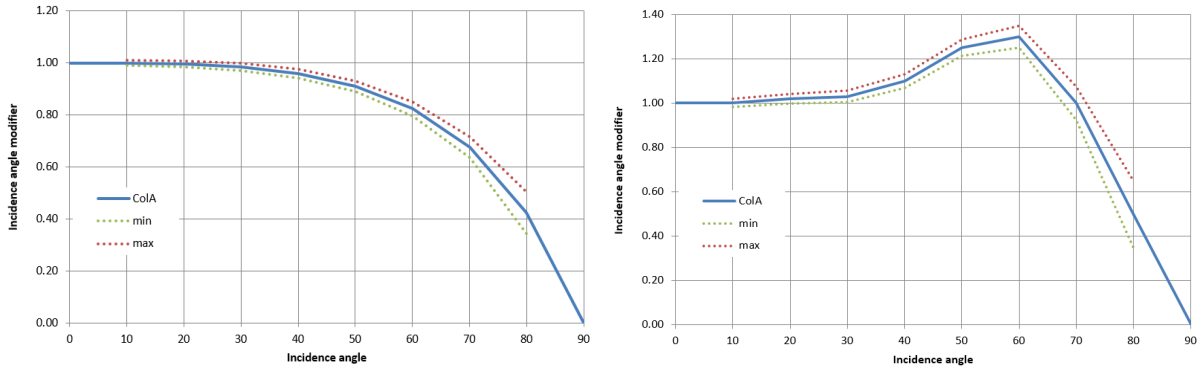

Figure 3: Example of incidence angle modifier variations of $\delta = 0.8$ *(left side) and* $\delta = 1.5$ *(right side)*

3.4 Annual energy output

To compare the annual thermal output of collector A and collector B, the annual output data from the ScenoCalc (Collector data sheet) shall be used. The annual energy output is considered as equal if the results computed for all 4 locations at 25° are within less than ±2.5% and at 50° within less than ±5.0% and at 75° within less than ±7.5%.

	Athens			Davos			Stockholm			Würzburg		
	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
ColA	2'975	2'078	1'342	2'234	1'522	953	1'640	1'053	632	1'794	1'142	675
ColB	3'035	2'203	1'221	2'237	1'533	961	1'639	1'060	638	1'783	1'141	677
%	2.02	6.02	9.02	0.13	0.72	0.84	-0.06	0.66	0.95	-0.61	-0.09	0.30
	OK	X	X	OK	OK	OK	OK	OK	OK	OK	OK	OK

In this case the annual output criteria not fulfilled A and B can't be considered as equivalent if equivalency of the annual energy output is required.

4. Product families

4.1 General

The "Thermal Performance Test" which is the basis for the collector family concept in this section includes the thermal performance AND the incidence angle modifier measurement. The performance figures (including IAM) and the maximum valid temperature range $\Delta\vartheta_{m,\max}$ for the whole family shall be taken form the collector with the lowest $\Sigma\left(\Delta\vartheta_{m,\max}\right)$ of the family as defined in 3.2.

If the criteria of a collector family are met, separate certificates and data sheets with individual performance figures of the different collectors can be issued, provided the thermal performance is determined as required for the certified family.

In this case, reference to all relevant test reports has to be made on each data sheet, even if a product is not mentioned in the family. With regard to the fees, the different collectors are treated as different subtypes.

4.2 Collector size families

If the manufacturer produces the "same" collector in different lengths and/or widths (i.e. the only difference between two collectors is the length and/or the width) the collector is considered the same subtype (within the same collector "family"). In this case only one sample of the smallest and one sample of the largest module shall be taken and tested. The module sizes are compared based on gross area as defined in EN/ISO 9488. The inspector shall inspect all the different sizes of the type to verify conformity.

The largest module shall be subject to all the tests required in EN 12975-1 clause 5.2, and the smallest shall be subject to a thermal performance test (according to EN ISO 9806)

As an exception, the rain test can be done on any member of the family as long as the pre-

exposure requirements of the standard are fulfilled and the major characteristics of the construction are the same.

The durability and reliability tests shall be carried out on collectors representing the major features of the collector family. E.g. collector families with collectors having several glass covers separated by bars. If the largest size of the collector - the test laboratory can test - is smaller than the smallest size of the family representing the weakest point - another testing laboratory shall carry out the respective tests.

The definition of the biggest collector and the smallest collector is done at the initial test. If later a bigger size or smaller size is added to the collector family this is resulting in a new definition for the existing family. If there is a new biggest collector added this will require performance testing and reliability testing of this collector. If there is a new smallest collector added this will require performance testing on the smallest collector.

The performance figures and the temperature range for the whole family shall be determined as defined in 4.1.

It is not admissible to override this regulation by declaring an extended validity of a test report for a collector of a certain size to collectors of other sizes.

If the smallest and/or the biggest collector of a family is/are not produced anymore, the Solar Keymark certificate basically remains valid. The following applies:

a. The published performance parameters remain unchanged, even if the product defining the performance parameters of the family is not produced anymore.
b. The list of models on the data sheet can be reduced accordingly.
c. The test reports mentioned on the data sheet remain unchanged.
d. The physical inspections will be made for the remaining collectors.

4.3 Collector glass thickness families

If the manufacturer produces the same collector with various thickness of the cover glass (i.e. the only difference between two collectors is the thickness of the glass) the collector is considered as the same subtype (within the same collector —family). In this case sample(s) of the collector with the thinnest cover glass and sample(s) of the collector with the thickest cover glass shall be taken and tested. The collector(s) with the thinnest cover glass shall be subject to all the tests required in EN 12975-1 clause 5.2, and the collector(s) with the thickest cover glass shall be subject to a thermal performance test (clause 19-26 of ISO 9086).

The performance figures and the temperature range for the whole family shall be determined as defined in 4.1

4.4 Family of Sydney Type Evacuated Tube Collectors

It is possible to build a Keymark family of Sydney Type Evacuated Tube Collectors where the only difference between the collectors is the material of the absorber tubes such as different types of Steel, Copper and other metals under the condition that

- The nominal heat conductivity of the tube walls is within +/-10% ($\lambda * d \approx const.$, where d is the wall thickness of the tubes) for all members of the family. (Note: To make sure that the thermal performance is not affected by the material)
- An exposure test and internal thermal shock test has been done with one collector of each type of materials.
- To make sure that there are no pressure issues because of the different tube wall thicknesses and the different welding/soldering/connector settings required for different materials, a pressure test is required for all materials with the same pressure rating for all the materials of the family.
- The members of the family have different names depending on the tube material used: The end user has to know what tube material is being used (corrosion in the hydraulic loop).
- In case of heat pipes, a freeze test has to be passed for every material.

4.5 Family of Evacuated Tube Collectors with different tube lengths

It is possible to build a Keymark family of Evacuated Tube Collectors with different tube lengths under the condition that

- All collectors are made of the same tube in terms of diameter(s), material(s), coating(s) and same material strengths. The only difference is the length of the tubes.
- The smallest collector of the family is made of the shortest tubes and the biggest collector of the family is made of the longest tubes. Else it would be possible to make a family where only one length of tube was tested and else it would be possible to make a family where the smallest and the biggest are made of the longest tubes, all in between have shorter tubes. Hence overestimating the performance of the shorter tube collectors due to the aperture-gross area ratio.

The performance figures and the temperature range for the whole family shall be determined as defined in 4.1

5. Tolerances and Equivalences

5.1 Varying absorber materials in same collectors

If a manufacturer produces the “same” flat plate collector using different combinations of materials for the absorber (i.e. Cu/Cu or Cu/Al or Al/Al or Cu/Steel or Al/Steel etc.) in different sizes, the performance of the largest and the smallest collector has to be measured at least for one combination of these materials only. Based on the result that for this collector model either the smaller or the bigger collector has the lowest integral Σ as defined in 3.2, for other combinations of materials only the relevant collector has to be measured again to define the applicable performance figures of this family.

5.2 Collectors with frames in different colours

If collectors differ only by the colour of their frame, only one collector needs to be tested. The test results determined by the test of this collector are valid for all collectors differing only by the colour of their frame from the collector tested. The collector used for testing should be the one that, has according to the manufacturer, the largest market relevance.

5.3 Custom built collectors

Custom built collectors (built in, roof integrated collectors that do not comprise factory made modules and are assembled directly on the place of installation) are handled as described in EN 12975-1, paragraph 1”…a module with the same structure as the ready collector is tested. The module gross area in the case of custom built collectors shall be at least 2 m²”. The manufacturer has to explain the conformity of the test module with the normal production and must provide a detailed description of the components. Very large collector modules may be treated as the custom built ones, see above, if testing of the full size module is not possible.

5.4 Exchangeability of absorbers in flat plate collectors except absorber coating

Flat plate collectors with modified absorbers can be generally considered as the same subtype (same collector family) if 4, 5, 6, 7 and 8 of Table 1 (see below) are modified and if:

- The thermal performance of the modified collector is considered the same as defined in 3.2.
- In the case of a modification of header pipes (clause 7 in Table 1) the exception described in remark 1 shall be taken into account.
- In the case of a modification of the nominal distance between absorber pipes (clause 8 in Table 1) the exception described in remark 2 shall be taken into account.

Collectors with equal absorbers according to the requirements above can just be sold as the same subtype for 1 year.

If the requirement above is not fulfilled or if the collectors with unequal absorbers should be sold in parallel for more than 1 year, separate certificates shall be issued.

It is recommended to do the performance measurement as a comparative measurement of a

collector as originally certified and a collector with the modified absorber.

In the case of existing collector families (e.g. different length and height) the smallest and biggest size need to be taken into account. If the requirement above is not fulfilled for every tested size, separate certificates shall be issued.

Rules for testing

	Shall be tested according to ISO 9806 on the "new" absorber design							
	6. Thermal performance	Determination of the effective thermal capacity and time constant	5.2 Internal pressure tests for absorbers	5.3 High Temperature resistance test	5.4 Exposure test	5.6 Internal thermal shock test	5.7 Rain penetration test	5.11 Final inspection
1. Material of absorber sheet	X	X		X	X	X		X
2. Material of pipes	X	X	X	X	X	X		X
3. Design of absorber plate								
a. Absorber fins to full plate absorber	X	X		X	X	X		X
b. Full plate absorber to absorber fins	X	X		X	X	X		X
4. Nominal thickness of absorber sheet	X	X				X		X
5. Type of connection of absorber sheet and absorber pipes	X		X	X	X	X		X
6. Absorber pipes (nominal diameters, nominal thickness)	X	X	X	X	X	X		X
7. Header pipes (nominal diameters, nominal thickness)	X[1]	X	X	X	X	X	X	X
8. Nominal distance between absorber pipes	X[2]	X[2]	X[2]					

[1] If diameter is changed for "one step" no additional performance test is necessary. "One step" means changes from one listed outer diameter to the next listed larger or smaller outer diameter. The listed diameters are:

12 mm	15 mm	18mm	22 mm	28 mm	32 mm

[2] Retesting is required if the nominal spacing between adjacent absorber pipes is changed by more than ±5%.

Limitations and remarks

- Just absorbers made of copper or aluminium are covered.
- The certification of upright and horizontal format is not covered.
- The proposal shows possible modifications where an agreement was found, other possible modifications are not covered.
- Each not listed modification need to be checked with test labs and certification bodies.
- Flat plate collectors with absorbers with different flow schemes (U-harp, Z-harp and meander) cannot be considered in one collector family.
- If more than one modification is intended (after some time or at new certification process) always the combination of listed tests according to Table 1 is needed.
- The measurement of pressure drop is not included, because of its informative status
- The measurement of the IAM needs not to be done.
- All tests need to be done successfully by a Solar KEYMARK recognized test lab and

reported in test reports.

- For custom built collectors it is essential to use different sizes of header pipes within a collector (clause 7 of Table 1). For this kind of collector this clause is not relevant.

5.5 Procedure for considering selective absorber coatings as equivalent

Different coatings are considered as equivalent provided that

1. They are applied on the same substrate (e.g. copper, aluminium) and
2. The specific test procedures described below have been passed successfully and
3. The equality is accepted by the Solar Keymark Network

Procedure

If a coating is to be considered equivalent to other coatings then the following tests shall be passed and requirements shall be fulfilled:

1. Two identical collectors (apart from the absorber coating) are compared to verify the equality of the two coatings. The absorbers of the two collectors must be made of the same material and must have the same thickness. One of the collectors is coated with one of the reference coatings fulfilling the following requirements: alpha ≥ mean value of alpha values in the group - 1 % point; epsilon ≤ mean value of epsilon values in the group + 1 % point. The mean value shall be given and updated each time a new member is included. The other collector is coated with the new coating.
2. The durability and reliability tests according to ISO 9806 being relevant with regard to the absorber, thus 10 Exposure and 12 Internal thermal shock for the collector with the new coating are successfully passed under climate class A conditions.
3. The thermal performance of the modified collector is considered the same as defined in 3.2.
4. The absorptance and emittance of the different coatings under question shall have - according to the specifications of the manufacturer - equivalent optical properties ($\alpha_1 = \alpha_2 \pm 1\%$ point at most, $\varepsilon_1 = \varepsilon_2 \pm 1\%$ point at most) and the same range of the production variability, e.g. 0.95 ± 2% points.
5. For selective absorber coatings on metal, an IEA SHC Task X (EN ISO 22975-1) test shall be performed successfully
6. The interchangeability is approved by the Solar Keymark Network

The equivalency of the absorber coating can be challenged anytime. In this case the absorber has to be sampled by an accredited third party or by the test lab. The costs for the whole procedure are fully carried by the challenger. Upon presentation of tests that suggest none-equivalency of an absorber coating, the SKN is obliged to request the re-evaluation of the absorber coating the latest until the next SKN meeting. The absorber has to be sampled by a third party.

An updated list of absorber coatings which can be exchanged is found under www.solarkeymark.org.

5.6 Equivalent collector glazing

Note: This procedure applies for thermally toughened safety flat glass only. For all other types of glass, no equivalences can be defined at present, due to a lack of experience. Collector glazing can be considered as equivalent if the following requirements are fulfilled:

1. If material, texture, surface treatment and thickness of the glass remain unchanged,

a. the solar transmittance (AM 1.5) shall be measured and documented for both types of glazing. The solar transmittance (AM 1.5) shall not differ by more than ± 1 percentage point from the one of the glass used for the initial Solar Keymark collector test. These measurements shall be not older than 2 years and shall be made by one of the Solar Keymark test labs or by labs accredited for transmittance measurements;

and

b. if the impact resistance test according to ISO 9806:2017 chapter 16 was performed during the initial test, the impact resistance test shall be passed successfully with equal or better result than in the initial test.

2. If the glass is not identical like described in point 1 above the following additional test has to be done:

a. If the thickness of glass is changed, mechanical load and rain penetration has to be tested.

b. If the thickness of glass is changed by less than 1 mm no transmittance measurement needs to be done, if no other characteristic of the glazing was changed and if the glass is of the same type and from the same glass manufacturer (e.g. Securit Albarino T from Saint Gobain).

c. If texture or surface treatment is changed, the collector performance test incl. IAM has to be done.

Remark: The new test results from collector testing (not glass only testing) have to be documented in an updated test report

6. Miscellaneous

6.1 Determination of gross area for roof integrated collectors

For the determination of the gross area of roof integrated collectors the part of the roof covered by the roof mounting kit surrounding the collector to prevent the ingress of water into the roof (cladding) shall not be taken into account.

6.2 Calculation of thermal power output for solar air heating collectors (SAHC)

For the calculation of thermal power output for solar air heating collectors (SAHC) it is essential to choose a specific mass flow rate, as the performance indicators vary strongly with it. To compare different SAHCs based on the results presented in the SKN Data Sheet, such an "evaluation point" has to be found in a fair and defined manner.
For that purpose the excel tool AirCow has to be used in order to choose this specific mass flow rate or evaluation point from the test results generated according to EN ISO 9806.
Note: The tool cannot find this point for open-to-ambient SAHC, as they cannot be handled with an efficiency curve yet

6.3 Not continuously differentiable performance curve

For solar thermal collectors operating not continuously differentiable performance curve with an efficiency depending on the absolute temperature (e.g. integrated high temperature cut off), ScenoCalc may be calculated with two split curves. A clear switching point between the different curves shall be given in the test report and on the data sheet. The parameters describing the thermal performance below the switching point are eta_0, a1, a2, as usual, the parameters describing the thermal performance above the switching point shall be named with different letters, for example above s0, s1, s2 (or eta_0*, a1*, a2*). The mathematical model for the description of the thermal performance shall be given in the test reports and in the remarks field of the data sheet. It has to be taken into account that the switching point is usually depending on the absolute temperature and not on the relative temperature difference.

6.4 Conversion of unglazed performance parameters (ISO9806:2013, EN12975-2 and earlier) to WISC performance parameters (ISO 9806:2017)

To issue Solar Keymark Datasheets in the latest version, parameters of unglazed collectors (ISO 9806:2013 and earlier) can be converted into WISC parameters (ISO 9806:2018) using the following formulas.

$$a_1 = b_1 + 3b_2$$

$$a_2 = 0$$

$$a_3 = b_2$$

$$a_4 = \eta_{0,hem} \frac{\varepsilon}{\alpha}(1 - 3b_u)$$

$$a_6 = \eta_{0,hem} b_u$$

$$a_7 = \eta_{0,hem} b_u \frac{\varepsilon}{\alpha}$$

$$a_8 = 0$$

$$\eta_{0,b} = \frac{\eta_{0,hem} 1000(1 - 3b_u)}{(850 + K_d 150)}$$