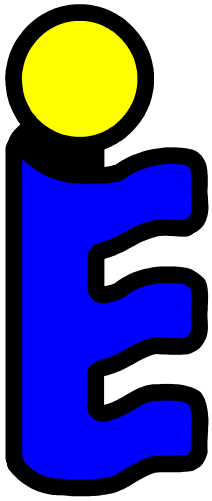

Internal procedures for Solar Keymark WP1.A and input to CEN/TC 312

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Solar Keymark
WP1.A
Network for implementing standards
Solar Collectors

Internal procedures for Solar Keymark WP1.A and input to CEN/TC 312

During the Solar Keymark project comments of the EN12975-1&2 (solar collectors) have been collected and frequently discussed by emails and during the meetings. The main aim with colleting the comments has been to help each other in implementing test procedures for Solar Keymark labelling, to identify difficulties with performing the tests and to interpret the harmonised standards. Some of the most useful comments that have facilitate the implementations of the test procedures and accreditations have been collected in this document. This document primarily aims to act as Solar Keymark internal procedures for the operational procedure of performing the tests and secondly gives suggestions for revision of the standards to the CEN/TC 312 for the next scheduled revision of the harmonised standards.

This is the second version of this document and it is aimed for discussions and acceptance in the 5th Solar Keymark meeting in Portugal in March 2003 as well as input to the CEN/TC 312 (WG1) in Portugal in March 2003.

Comments to EN 12975-1

Comment 1: ***Change prEN to EN***
The standard is referring to prEN 12975 instead of EN 12975, throughout the complete document.

Comments to EN 12975-2

Comment 1: ***Better structure, layout and table of contents***
The standard is not well structured. Required conditions (figures etc.) are often not in a table. This makes it not easy to work with. Also the chapters could be better structured, for instance a new chapter on a new page etc. It's impossible to find something by using the table of contents. The table of contents should include all chapters, from main chapter 1-6 with sub chapters e.g. 6.1.1.1.

Comment 2: ***Mix up of "Uncertainty" and "Accuracy"***
The word accuracy is often used when it supposed to be uncertainty. For example in 6.1.2.3.2.1.

Comment 3: ***Specify properties of coating***
The documentation of test results requires only the name of the material of the absorber coating (given in Annex D.2 and Annex F.2). This makes it difficult to identify the material. It would be beneficial if it is required that the manufacturer must give brand name and values for α and ε for documentation of the coating.

Comment 4: ***Symbols and units, page 5*****:**
Coefficient b0 for the incidence angle modifier $K_{\Theta b}$ is missing

Comment 5*: Second method of identification of parameters in QDT*
Beside the Multiple Linear Regression (MLR) for identification of parameter values in the QDT equation (in 6.3.4.8.1) also other methods should be possible to use. For example algorithms for non-linear models as the Levenberg-Marquart-Algorithm and the DF-program as used for Dynamic System Testing acc. to ISO 9459, Part 5. The work within IEA SH&C Task XIV has indicated that both approaches lead to the same results. The advantage of MLR is the simplicity of the data evaluation, whereas the non-linear model is more flexible with respect to special collector designs. Solar Keymark suggest that Work group 1 (CEN/TC 312) should investigate if the suggested methods lead to the same result. This could be verified in an inter-comparison of test results of QDT measurements. The verification will tell if the alternative methods should be taken into account for the revision of the standard.

Comment 6: ***Heading Annex D and Annex F***
The heading in Annex D and F should be without "… under steady state conditions" since the "performance test reports" are also for reporting tests done according to the quasi dynamic method.

Comment 7: ***Annex E***
The symbol eta0 has become a square in table ”Based on Absorber Area” and table ”Based on Aperture Area” in Annex E. Should be changed. (The same in Annex G.)
It should be clearer if it is mentioned that 6.1 is the steady state method and 6.3 the quasi-dynamic method under “Thermal performance has been tested based on the test methods” in Annex E (as it is done in Annex F)

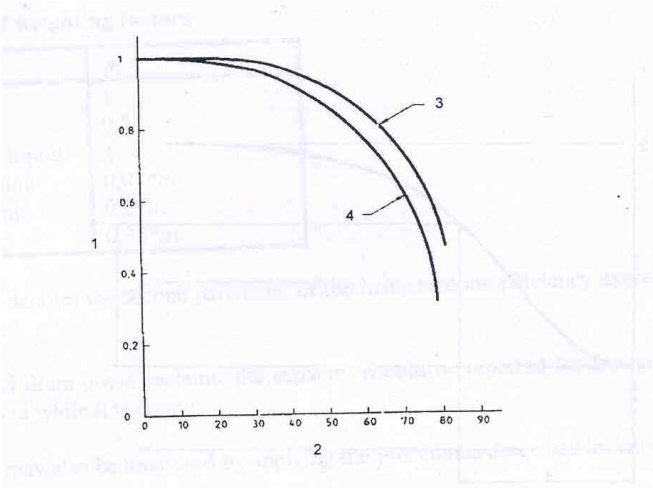
6.1 Outdoor (steady state) ☐ 6.1 Indoor (steady state) ☐ 6.3 Outdoor(quasi-dynamic) ☐

In the table ”Power Output per collector unit (W)” in Annex E it should be indicated that these values are for normal incidence

Comment 8: ***Annex M***
In the standard Annex M is only informative. In Annex G, that is normative, it is stated that if thermal performance has been tested according to 6.3, test results according to Annex M should be attached. Therefore Annex M should be normative in case of testing according to 6.3

Comment 9: ***Table number***
In 6.1.5.2. the reference to Table 1 should be to Table 5.

Comment 10: ***Illustrations***
In 6.1.7.1 the Figure 5 is wrong figure and should be the one shown below.

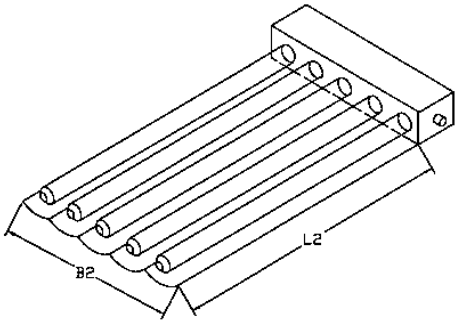


Right Figure 5

Comment 11: ***Illustrations***

In Annex I the Figure I.3 is wrong figure and should be the one shown below.

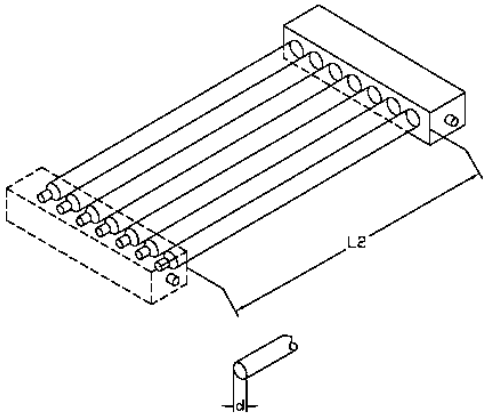
Aperature Area of Tubular Collector



Aa = L2 x B2

Tubular Collector with Reflector
Length: L2; Length of exposed reflector.
Width : B2; Width of exposed reflector.

Figure I.3



Aa = L2 x d x N

Tubular Collector without Reflector
d: Internal Diameter
L2: Length of Parallel and
Transparent Section of the Tube.
(Length of Absorber)
N: Number of Tubes.

Figure I.4

Right Figure I.3

Comment 12: ***Illustrations***
In Annex I the Figure I.5 is wrong figure and should be the one shown below.

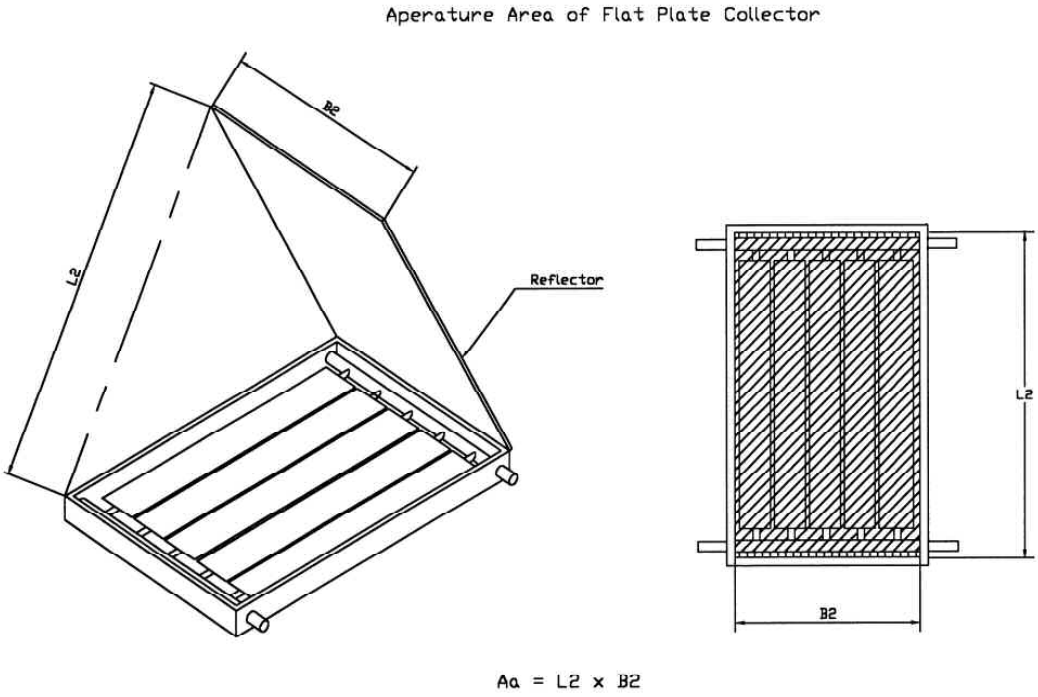


Figure I.5 Figure I.6

Right Figure I.5

Comment 13: ***Maximum Tm* values***
In 6.1.4.4 it says that the maximum temperature shall be at least around 80 °C. The Solar Keymark group recommends that the WG1 group should discuss if this could be changed to "shall be chosen so that maximum Tm* value is at least 0.09 unless the temperature difference become smaller than required in 6.1.4.3."

Comment 14: ***Choice of absorber test***
Four different methods are described for heating the absorber in clauses 5.2.2.2.2 through 5.2.2.2.4. In Annex B.13.2.2, page 96, it should be written which method that has been used. It is not clear which method that should be used under certain conditions or if it is a free choice. Add at the end of 5.2.2.1 "One of the methods described in 5.2.2.2.2 through 5.2.2.2.4 may be chosen.

Comment 15: ***Clarification***
Add at the end of 6.2.4.8.1 "NOTE: Positive EL values are a downward oriented irradiance onto a surface with a temperature of 0 K.

Comment 16: ***Delete per square meter two times***
One can not calculate a value "per square meter" without knowing the reference area to use. Furthermore the effective thermal capacity of collector, C, has the unit (JK^{-1}) and the specific heat capacity, c_i, has the unit ($Jkg^{-1}K^{-1}$) according to page 5 and 6.2.6.2. Therefore, must the mass, m_i, in Equation 29 has the unit kg (that is in consistence with page 5). The sentence in 6.2.6.2 should be "… ,of the product of its mass, m_i, (expressed in kilograms), …". Delete per square meter two times in 6.2.6.2.

Comment 17: ***Observation interval recommendations occurs with two expressions***
In 6.1.2.1.1.3 it says that the condition for the desiccator should be observed both "prior to and following each daily measurement sequence" and "on a regular basis". Delete "prior to and following each daily measurement sequence".

Comment 18: ***Micrometers in Equation 14***
The integration borders have wrong units. It should be micrometers expressed with the Greek "my" and a "m" (μm).

Comment 19: ***Change prEn to EN***
Change to EN 12975-1 in Annex B.2.3 instead of prEN 12975-1.

Comment 20: ***Annex A in 12975-1***
Annex A is informative information on conformity assessment that is described in the Solar Keymark Scheme Rules and will be confusing here. Therefore Annex A should be deleted. Change reference to Annex A.4 in the first sentence of Annex D.

Comment 21: ***Annex D in 12975-1***
Annex D is informative information about tests to be repeated in collector design modification. The recommendation seems to be very week since the Annex is both informative and test repetition is only recommended to be considered. Change in the end of the Table that:

+ Test should be repeated
– Test need not be repeated.

Comment 22: ***Impact resistance test (5.10)***
The impact test includes a non-realistic test. Although it is an optional test, this does give confusion on the market in practice. Also, in practice there was never reason to doubt the impact resistance of collectors. Delete this clause in the standard.

Comment 23: ***Editorial of text on page 37 (6.1.4.8.4.1)***
The last sentence in 6.1.4.8.4.1 should be moved to Clause 6.1.4.3 ("Where diffuse solar irradiance is less than 30 %, its influence may be neglected. The collector shall not be tested at diffuse irradiance level of greater than 30 %.").

Comment 24: ***Editorial of Formulas on page 37 (6.1.4.8)***
Equations (10) is wrong and Equations (8) and (10) should be deleted since they are repetitions of Equations (4) and (6).

Comment 25: ***Editorial of texts on page 37***
The sentence in 6.1.4.8.2 immediately before Equation 4 should be changed to " The solar energy intercepted is AG where the area is A_A when referred to the absorber area of the collector and A_a when referred to the aperture area of the collector, and the collector efficiency is"

$$\eta = \frac{\dot{Q}}{A \cdot G}$$

Comment 26: ***Editorial of Formulas and texts on page 68***
The following sentence should be added directly after Equation (34) in Clause 6.3.4.8.2
- "where the area is A_A when referred to the absorber area of the collector and A_a when referred to the aperture area of the collector (see Annex M)"

Comment 27: ***Editorial of text in Clause 6.3.4.3***
The sentence in the middle of the page is changed to
-" The average value of the surrounding air speed, taking into account spatial variations over the collector and temporal variations during the test period, shall be greater than 1 m/s and less than 4 m/s (1 < Average surrounding air speed < 4)."

Comment 28: ***Tilt angle of the collector***
The tilt angle of the collector should be 45° according to clause 6.1.1.3. This will make comparison of measurements from different laboratories difficult since the incident angle will vary with the latitude. The same specifications as in Clause 6.1.4.3 should be added in the beginning of 6.1.1.3. The first two sentences on page 35: " The angle of incidence of direct solar radiation at the collector aperture shall be in the range in which the incident angle modifier for the collector varies by no more than 2 % from its value at normal incidence. For single glazed flat plate collectors, this condition will usually be satisfied if the angle of incident of direct solar radiation at the collector aperture is less than 20°." Thereafter, the word "shall" should be changed to "should" in the first sentence in 6.1.1.3. (" …..the collector should be mounted such …")

Comment 29: ***Better structure of 6.3 in general and more information in paragraph 6.3.4.6.4 "Evaluation of test data" in particular***
The selection criteria given in the standard are somewhat unclear and they are not efficiently organized in the document. The same applies to the description of test conditions in 6.3.4.3 to 6.3.4.5.

Under paragraph 6.3.4.6.4 “Evaluation of test data” the requirements for selecting data should be repeated/ compiled for clearness reasons. This applies to the following shall-criteria:

- Tout- Tin <1'C
- G<300W/m2
- Tinlet not stable within ±1K during test day or test sequence
- Flow rate not stable within ±1% of the set value during test day or test sequence and may not vary more than ±10 % from the set value from one sequence to another.

And also to the following should-criteria:

- Data recorded during step change in Tin

Comment 30: “Correction” of data should be indicated in paragraph 6.3.4.6.4 “Evaluation of test data”
Some participants in the test data round robin “corrected” measurement data on a routine basis in order to have all inputs physically correct and some did not. So was e.g. beam irradiance set to 0 if, in a datapoint, diffuse irradiance was larger than global irradiance. Similarly the term $(1/\cos(\theta_l)-1)$ was set to zero for angles >85 degrees or set equal to the value at 80 degrees for angles larger than 80. This will in general have some effect on the final results and a check and correction should therefore be indicated in the standard. Preferably in paragraph 6.3.4.6.4 “Evaluation of test data”.

Comment 31: ***Removal of superfluous should-requirement in 6.3.4.3 “Test conditions”***
The should-requirement on power output >0 in 6.3.4.3 should be removed as it is a superfluous requirement since it’s already taken care of by the requirements Tout- Tin <1'C and G<300W/m2

Comment 32: Removal of superfluous should-requirement in 6.3.4.6.4 “Evaluation of test data”
The should requirement on Gd/G>0.5 could probably be removed (see note in paragraph 6.3.4.6.4 of the standard).

Comment 33: ***Mandatory calculation of dt_m/dt in 6.3.4.5.2 “Data acquisition requirements”***
The online calculation of dt_m/dt according to 6.3.4.5.2 shall be mandatory as it has a big impact on the final results if it’s calculated afterwards, from average values instead.

Comment 34: ***Outliner treatment***
It is probably common knowledge that outliners that cannot be explained shall not be excluded from the data set. Nevertheless, this could be indicated in the text, preferably in 6.3.4.6.4 “Evaluation of test data”.

Comment 35: ***Parameter standard deviations in Annex M***
The standard deviations for each parameter resulting from the regression should be reported along with the parameter itself as this gives additional information about the quality of the test result.

Comment 36: ***Maximum load pressure in mechanical load test***
The information about required maximum load pressure is confusing within the different standards EN 12975-1 (5.3.8) and EN 12975-2 (5.9.1.3; 5.9.2.3 and 5.9.3.3).
The description in (5.3.8) EN 12975-1 shall be valid. This information should clearly be repeated in EN 12975-2 (5.9.1.3; 5.9.2.3 and 5.9.3.3). The text should be equal in all paragraphs 5.9.1.3, 5.9.2.3 and 5.9.3.3 (EN 12975-2) and in consentience with 5.3.8 (EN 12975-1). The maximum load pressure shall be at least 1000 Pa for all mechanical load tests, both positive and negative pressures. It should clearly be stated that the manufacturer or national requirements might increase the load pressure above 1000 Pa due to e.g. particular climate conditions.

For "Positive pressure test of the collector cover" (5.9.1.3 EN 12975-2)
The sentence: "-the recommended maximum test pressure, which shall be at least 1000 Pa or optional load test above 1000 Pa up to the value as specified by the manufacturer." should be changed to e.g.: "-the recommended maximum test pressure, which shall be at least 1000 Pa or optional load test above 1000 Pa up to the value as specified by the manufacturer or national requirements."

For "Negative pressure test of fixing between the cover and the collector box" (5.9.2.3 EN 12975-2)
The sentence: "The maximum test pressure may be specified to suit particular climate conditions, otherwise a value of 1000 Pa shall be used." should be changed to e.g.: "-the recommended maximum test pressure, which shall be at least 1000 Pa or optional load test above 1000 Pa up to the value as specified by the manufacturer or national requirements."

For "Negative pressure test of collector mounting" (5.9.3.3 EN 12975-2)
The sentence: "The maximum test pressure may be specified by the manufacturer to suit particular climatic conditions but shall be at least 1000 Pa." should be changed to e.g.: "-the recommended maximum test pressure, which shall be at least 1000 Pa or optional load test above 1000 Pa up to the value as specified by the manufacturer or national requirements."

Comment 37: ***Change of 1000 Pa as maximum load pressure in mechanical load test***
The maximum load pressure, of 1000 Pa, in the mechanical load test (EN 12975-1 (5.3.8) and EN 12975-2 (5.9.1.3; 5.9.2.3; 5.9.3.3)) is to low if the solar collector should be exposed for particular conditions (e.g. high wind pressure or snow load conditions). According to French regulations and the "Eurocode" a higher test pressure load should be required even though it is possible according to the standard that the manufacturer may specify the load pressure and national requirements are prevailing.

A new work item for WG1 could be to investigate if it is possible to harmonize the standard with the "Eurocode" or to further specify in EN-12975 when a higher maximum load pressure is needed.

Comment 38: ***Rain penetration test***

The rain penetration test has been frequently discussed in the Solar Keymark meetings. The standard has three different methods for detecting rain penetration. It has been concluded that all three different methods are needed in the standard, but they need further specifications. Therefore three internal papers that address the difficulties and make suggestions how to clearer define all three methods have been written. These papers are suggested to be the Solar Keymark recommendation for revision of the rain penetration test. The papers are added in Annex 1-3 of this document.

ANNEX 1: Rain Penetration Test, **Weighting the Collector**

Comments and suggestions concerning the rain penetration test defined in 5.7 of EN 12975-2: 5.7.2.2.a: Weighting the Collector

Kostas Voropoulos
NCSR "Demokritos"

Point 1:

The Standard EN 12975-2 suggests three alternative methods of measuring the penetration of water into the collector, after the rain penetration test (5.7.2.2):

- weighting the collector
- humidity measurement
- measuring the condensation level

However, only for the first method it specifies the procedure and the measuring device together with its uncertainty. It says nothing about the other two methods, i.e. the procedure to be followed, instruments, accuracies, e.t.c.

The measurement of humidity inside the collector is a method which introduces many uncertainties due to its nature and it is not mentioned when, how and at which point of the collector this measurement is conducted.

The procedure for the measurement of the condensation level in the inside part of the cover is not also specified. Measuring the area of the condensate is very unreliable since this area does not have regular shapes and is not evenly distributed in the cover.

Our opinion is that the whole procedures for both humidity and condensation level measurements should be mentioned clearly in the test of paragraph 5.7 of EN 12975-2.

Point 2:

In 5.7.2.2 of EN 12975-2, it is stated that the minimum accuracy of scale must be $\pm$ 1gr for the measurement of the collector weight.

Since there are collectors that their weight can reach over 50 kg, it is obvious that the measurement of such a collector with the accuracy of $\pm$ 1 gr presents many uncertainties related to other environmental parameters and requires very expensive balances. It is proposed that the measurement should be conducted with an accuracy of 5 gr/m^2 collector area.

Point 3:

In the Standard there is no specific mention about the several types of collectors that can be tested in rain penetration, concerning their construction materials. However, there are collectors which have wood on their backs.

Our proposal is that an extra paragraph should be included in 5.7 of the Standard, stating clearly that in cases of collectors having wood in the backs (or other special cases), the laboratory must take all necessary measures so that the final result will not be influenced or altered by the special construction of the collector during the conduction of the test.

Comments and suggestions concerning the pass criteria of the rain penetration test defined in 5.3.7 of EN 12975-1

In this paragraph it is stated that the pass criterion for the collector concerning the rain penetration test, and in the case that the weighting method has been used, is that the determined water quantity shall be less than 5 gr/m^2.

According to our opinion, this figure is too small, since in praxis the majority of the collectors present such water penetration. It should also not be forgotten that actually this the only test in which a quantitative pass criterion is set, whereas in all other tests it is the "no major failure". This may cause the unhappy situation that a collector with medium efficiency can pass the rain penetration test due to its "heavy sealing", thus being certified and another collector with very high efficiency can be excluded because it did not meet the 5 gr/m^2 rain penetration criterion.

It is therefore proposed that the acceptance criterion of the rain penetration test for the collector should be 30 gr/m^2.

ANNEX 2: Rain Penetration Test, **Humidity measurements**

Comments and suggestions concerning the rain penetration test defined in 5.7 of EN 12975-2: 5.7.2.2.b: Humidity measurements

Christian Mûller-Schöll
SPF

As far as I see my job,we are looking for something quantitative, which is still not very easily done, and might need some mor e experience and also input from other labs, but I will try something that is on the safe side:

******
For flat plate collectors, an "absolute humidity sensor" has to be placed in the air gap between the absorber and the glazing. Care shall be taken that the sensor does neither touch the glazing nor the absorber. This type of sensor usually consiststs of two elements, a relative humidity sensor and a temperature sensor. Absolute humidity is assessed by calculation. The collector and the sensor shall be connected to the hot fluid loop for at least five hours before the rain is switched on in order to stabilize. When testing outdoors, in order to minimize disturbances of the measurement, the collector shall be shaded during the whole test.

The humidity shall be monitored from five hours before the raining till at least five hours after the raining.

Results
Any visuble droplets in the inside of the collector
or a humidity that exceeds 20 g/kg at any time during the periods described above, or a humidity that doubles from the value measured after stabilization during the periods described above, shall yield "major failure" (a mark of "2").

NOTE: Ingress of water might also be detected at a later stage, during the test "Final inspection", Clause 5.11.

Remarks from the author:
We might also need to add a chapter about humidity sensors, calibrations, uncertainties etc. in the appropriate section.
Numerical figures in the text proposed above are subject to discussion.
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ANNEX 3: Rain Penetration Test, **Measuring of condensation level**

Comments and suggestions concerning the rain penetration test defined in 5.7 of EN 12975-2: 5.7.2.2.c: Measuring of condensation level

Åsa Wahlström, Peter Kovacs and Roger Davidsson,
SP Swedish National Testing and Research Institute

The Standard EN 12975-2 suggests three alternative methods of measuring the penetration of water into the collector, after the rain penetration test (5.7.2.2):

- weighting the collector
- humidity measurement
- measuring the condensation level

This document gives a suggestion on how to clearer define how the test should be performed when using the *measuring of condensation level* for detection of ingress of water.

Improvements of test method

5.7.2.2
The collector shall be mounted and sprayed as explained above while the absorber in the collector should be kept warm (minimum 50 °C). The heating of the collector shall be started at least 30 minutes before the spraying of water and shall continue until it can be ensured that the collector box is dry before testing. This shall be done by circulating hot water (or other transfer fluid) above 50 °C through the absorber before but also during the complete test. The option of keeping the absorber warm by exposing the collector to solar radiation are, therefore, not suitable for detection of ingress of water by *measuring the condensation level*.

For the entire time that the test is in progress the absorber is kept warm and this will evaporate the water that finds its way into the collector. The water will thereafter condense on the inside of the glazing, which is being cooled by cold water on the outside. To ensure that no water has penetrated the collector box without forming condensation on the glazing, the collector shall be tipped on all four sides in turn after the test is terminated.

The penetration of water into the collector shall be determined by measuring the condensation level on the cover glass and by measuring the water that come out of the collector when tipping it.

5.7.3
The collector should be sprayed with water at a temperature between 10-25 °C and with a flow rate of approximately 0,05 kg/s per square meter of sprayed area. The duration of the spraying shall be 4 hours.

After 2 hours an intermediate inspection of condensation of the cover glass shall be done in order to facilitate the reporting of the places where water penetrates. After finishing the spraying the inspection of condensation of the cover glass should be done after a short time for ventilating, in order to distinguish collectors with good ventilation qualifications that are without accumulation of humidity inside the collector. However, the inspection should be done within one minute after finishing the spraying before the collector will make any temperatures changes. The collector shall not be exposed by solar radiation. The condensation area on the glazing shall be measured.

On completion of the measuring the condensation level, dry the collector carefully on all sides. Tip it on to all four sides in turn, standing it on a clean base on which any water that runs out can be collected and/or approximated quantified.

5.7.4
The collector should be inspected for water penetration by the presence of any condensation and the approximate quantity of water that leaked out. The results of the inspection i.e. the extension of water penetration and the places where water penetrated shall be reported.

EN 12975-1
5.3.7
c) the measured condensation level shall be less than 5 % of the transparent cover and the collected water shall be less than 20 gr/m^2.