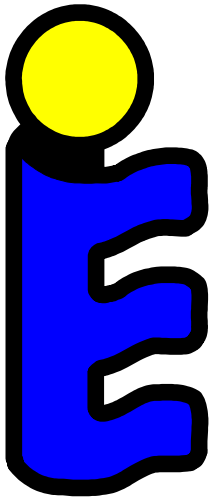

Internal procedures for Solar Keymark WP1.A and input to CEN/TC 312

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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

ESTIF initiated the Solar Keymark project in 2001. An EC supported project within the Altener program, which was finalised in 2003. The project aims to open the European market for producers and dealers of solar thermal products. This has been done by establishing network cooperation between 13 European test laboratories about implementing the new EN standards and establishing a certification mark (a CEN/CENELEC Keymark). This "Solar Keymark" shall ensure compliance with the EN standards for solar thermal products. For the consumers the Solar Keymark act as a common EU quality certificate for solar thermal systems and components. In Work Package 1 part A (WP1.A) have all 13 laboratories, within the established network, implemented the EN 12975-1&2 standards for solar collectors and 6 laboratories were already accredited for performing the tests at the end of the project.

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 get accreditation for performing the tests, 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 aims to:

- act as Solar Keymark internal procedures for the operational procedure of performing the tests
- gives suggestions for revision of the standards to the CEN/TC 312 for the next scheduled revision of the harmonised standards
- gives suggestions of further work needed for future projects within the Solar Keymark network.

Borås, Sweden
2003-03-20
Åsa Wahlström
SP

Abbreviation:

WP1.A: The work package within the Solar Keymark project that working with network for implementing the EN 12975-1, EN 1295-2 standards.
FPSK: Future projects within the Solar Keymark network.
WG1: Work Group 1 that are giving suggestions for revision of EN 12975-1, EN 1295-2 standards to CEN/TC 312.

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.

Comment 2: ***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 3: ***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 4: ***Pass criteria for rain penetration test, 5.3.7***
The pass criteria for weighting the collector in point a) that is stated less than 5 gr/m^2 should be changed to less than 30 gr/m^2. (See ANNEX 1.)

Comment 5: ***Pass criteria for rain penetration test, 5.3.7***
The pass criteria for measurement by humidity in point b) that is stated less than 10 % increase in the humidity value should be changed to any visible droplets inside the collector or humidity that exceeds 20 gr/kg at any time during the test or humidity that doubles from the value measured after stabilisation shall yields to “major failure”. (See ANNEX 2.)

Comment 6: ***Pass criteria for rain penetration test, 5.3.7***
The pass criteria for measured condensation level in point c) that is stated less than 5 % of the transparent cover should be changed to less than 10 % of the transparent cover. (See ANNEX 3.)

Comments to EN 12975-2

Comment 7: ***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 8: ***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 9: ***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 10: ***Symbols and units, page 5*****:**
Coefficient b0 for the incidence angle modifier $K_{\Theta b}$ is missing

Comment 11*: 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. WP1.A suggest that WG1 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 12: ***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 13: ***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 14: ***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) ☐

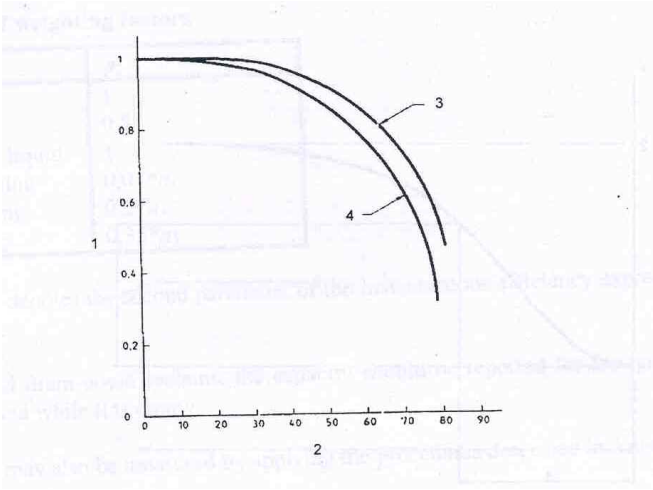
In the table ”Power Output per collector unit (W)” in Annex E it should be indicated that these values are for normal incidence

Comment 15: ***Table number***

In 6.1.5.2. the reference to Table 1 should be to Table 5.

Comment 16: ***Illustrations***

In 6.1.7.1 the Figure 5 is wrong figure and should be the one shown below.

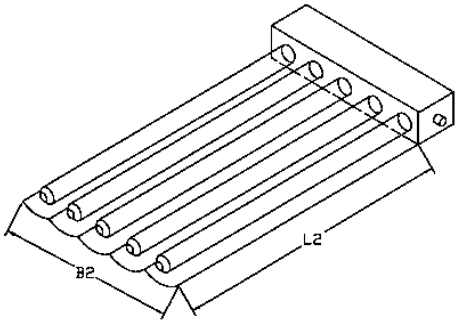


Right Figure 5

Comment 17: ***Illustrations***

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

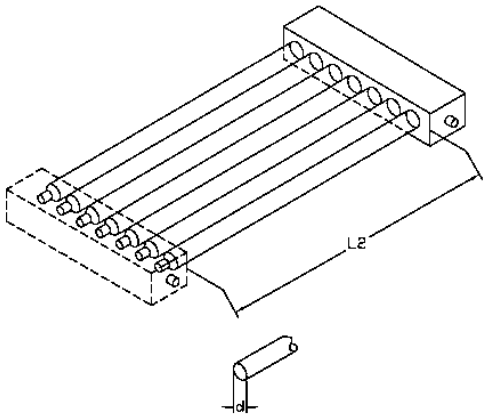
Aperature Area of Tubular Collector



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

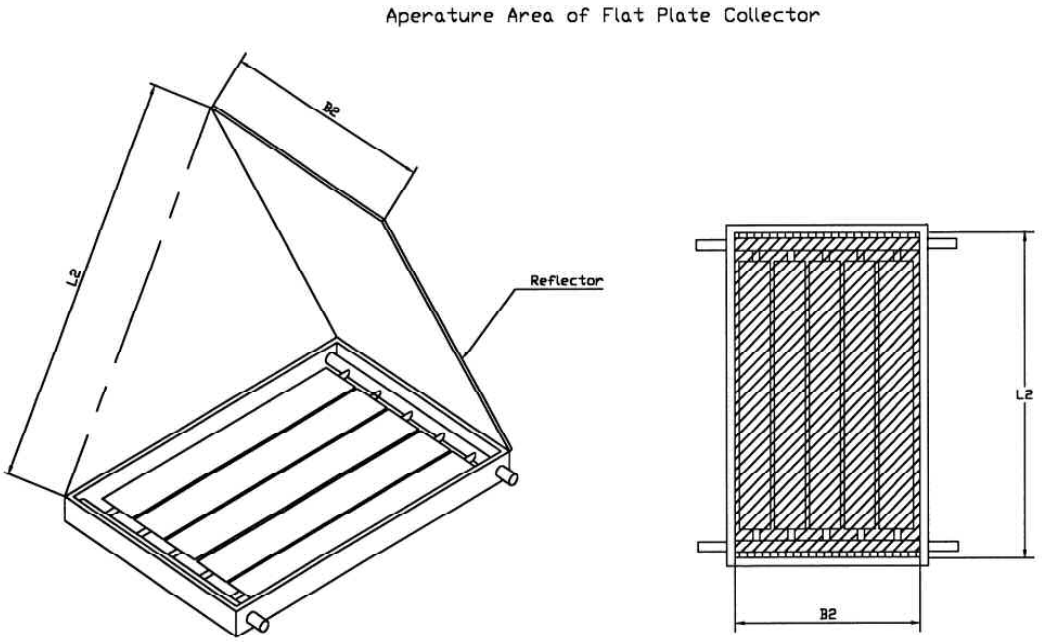


Figure I.5 Figure I.6

Right Figure I.5

Comment 19: ***Maximum Tm* values***
In 6.1.4.4 it says that the maximum temperature shall be at least around 80 °C. WP1.A 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 20: ***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 21: ***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 22: ***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 23: ***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 24: ***Micrometers in Equation 14***
The integration borders have wrong units. It should be micrometers expressed with the Greek "my" and a "m" (μm).

Comment 25: ***Change prEn to EN***
Change to EN 12975-1 in Annex B.2.3 instead of prEN 12975-1.

Comment 26: ***Impact resistance test (5.10)***
The impact resistance 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. The test procedures needs improvements that preferably begin with a comparison on how these test are made for the window industry. These improvements could be done in FPSK or WG1.

The test description, even if it is informal, is needed in the standard as several laboratories are using this test and it is, therefore, important that those laboratories are using the same procedures. However, it might be better to put the test as an informative Annex to clearly show that the test is optional. This investigation could be done in WG1.

Comment 27: ***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 28: ***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 29: ***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 30: ***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 31a: ***Specification of surrounding air speed, 6.3.4.3.***
The question is if the surrounding air speed should be greater than 1 m/s and less than 4 m/s or only less than 4 m/s. Or should the surrounding speed be specified to 4 ± 1 m/s or 3 ± 1 m/s as in the SS test. This could be investigated in WG1.

Comment 31b: ***Editorial of text in Clause 6.3.4.3***
If the investigation in comment 31a concludes that the surrounding air speed should be greater than 1 m/s and less than 4 m/s then the sentence in the middle of the page should be 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 32a: ***Tilt angel of the collector, 6.1.1.3.***
The tilt angel of the collector should be mounted in 45° according to clause 6.1.1.3. This will make comparison of measurements at different laboratories difficult since the incident angel will vary with the latitude. It is not necessarily to specify the tilt angle conditions since it will be specified by the conditions for the angle of incident of direct solar radiation declared in 6.1.4.3. It is, however, beneficial with a specification/recommendation of the tilt angel for easier comparison between different laboratories at similar latitudes. The word "shall" be changed to "should" in the first sentence in 6.1.1.3 and a larger deviation of 45° should be added in the following way "the tilt angel of the collector should be mounted 45° ± 10°.

Comment 32b: ***Tilt angel of the collector, Annex E.***
The mounted tilt angel should also be stated in the test report. Add a line for that in Annex E.

Comment 33: ***Uncertainty of outlet temperature t_e, 6.1.2.3.2.1.***
The collector outlet temperature t_e has no stated uncertainty in the standard. It should have the same uncertainty as the inlet temperature, t_{in}. Change the first sentence in 6.1.2.3.2.1 to "The temperature of the heat transfer fluid of the collector inlet and outlet shall be measured to an accuracy of 0,1 K, but in order …….etc."

Comment 34: ***Class 1 pyranometer, 6.1.2.1.1.1***
It should be added that a Class I pyranometer should have a standard uncertainty of 1 %. Change first sentence in 6.1.2.1.1.1 to "A class I pyranometer with a standard uncertainty of 1 %, as specified in ISO 9060, shall be used ……etc."

Comment 35: ***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 36: ***"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 37: ***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 38: ***Removal of superfluous should-requirement in 6.3.4.6.4 "Evaluation of test data"***
The should requirement on Gd/G>0.5 should be removed.

Comment 39: ***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 40: ***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 41: ***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 42: ***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 43: ***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 in a FPSK or 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 44: ***Spraying of the collector in 5.7.2.1***
The last sentence in 5.7.2.1 should be changed to " The collector shall be sprayed on exposed sides using spray nozzles or showers". This change is necessary both because it is impossible to spray on all sides from above perpendicular to the horizontal and that it should not be needed to spray on the backside since this condition do not occur in practise. This is important particularly for collectors that have a material on the backside that is sensitive for water (e.g. wood).

Comment 45: ***Need of an indoor exposure test, 5.4.***
It would be favourable to have a complete indoor version of the exposure test or to let it be possible to run this test in parallel. An indoor test would decrease the costs for testing and it would therefore be beneficial for the manufacturers if such a method were developed. A development of an indoor exposure test could be done in FPSK or as a new work item in WG1.

Comment 46: ***Accordance with the requirements of EN ISO 17025, Annex D.***
The test report, in Annex D, has to be brought in accordance with the requirements of EN ISO 17025. A specific suggestion on how the Annex should be changed could be dealt with in WG1.

Comment 47: ***Informative procedure for calculating the uncertainty.***
A procedure of deciding the uncertainty of the end result of the testing is needed. The procedure should explain the basic theories in a comprehensive and simple way with recommendations on how to do, step by step, with figures. Maybe it can be convenient with a common excel spreadsheet. The procedure can either be a Solar Keymark document or be included as an informal Annex in the standard. This procedure could be developed in FPSK or as a work item for WG1.

Comment 48: ***For how long and for how many datapoints should the dt_m/dt value exceed +/- 0.005 K/s (6.3.5.2)?***
This could be investigated within the WG1 work.

Comment 49: ***Change of test sequence, 5.1.***
It might be beneficial to change the stated test sequence in the standard, En 12975-2, 5.1. The main reasons for changing the test sequence are:

- The exposure test is not the same in all countries and it will therefore have different influence on the thermal performance test.
- The reliability tests are qualitative tests (expertise of labs) and therefore may give different results at different laboratories while the thermal performance test is quantitative. These different tests should be separated.

When changing the test sequence a few things should be considered:

1 What happens with the collector during the reliability tests, specifically for innovative collectors there the test is not relevant.
2 The test costs should be minimized.
3 When do we have to use the sequence?

Suggestions for how to change the test sequence:

1 Allow using two collectors at the same time. One for thermal performance and one for reliability tests. This will decrease testing time.
2 To do the thermal performance test both before and after the qualitative test. This will increase testing costs.
3 To do the thermal performance test both before the qualitative test and then have an optional second thermal performance test again. This will not necessarily increase testing costs. For example could a manufacturer trust on the first result (for example if the insulation and the coating are well known) while the second test could be used for innovative products.
4 To do thermal performance before the qualitative test.
5 To change shall to should for the test sequence in the standard.

A discussion followed with the arguments that it is a reason for having the stated sequence. Primarily due to that the efficiency should be representative for a used product. An investigation on if it is possible and how to change the test sequence could be done in a FPSK or as a work item in WG1. Additional investigation could be to test if the reliability test really is affecting the efficiency tests.

Comment 50: ***Annex L needs an equation instead of a table.***
Change the table in Annex L with an equation describing the same thing.

Comment 51: ***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 consistst 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.
******

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

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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 10 % of the transparent cover and the collected water shall be less than 20 gr/m^2.