Quality Assurance in solar thermal heating and cooling technology

Keeping track with recent and upcoming developments

Summary report
Rain penetration test

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1. Introduction

The rain penetration test seems to be a very critical and unreliable test, but the scope of this test is very important in order to ensure the energy output of the collectors for their whole lifetime. The following effects can be assumed to be crucial for the collector behaviour:

- Humidity condensating/fogging the inside of the glass cover, having an effect on the transmission
- Humidity can be "transporter" for other chemicals, like NH_3, Salts,…; and by this speed up aging effects
- Humidity can in combination with heat cause foiling effects (growth of biologic compounds)
- Humidity in combination with heat can decompose materials (PU-Foam, etc.)
- Humidity soaked up in the insulation material can increase the heat transfer rate enormously
- Humidity can condensate in such an extent that it drops down on the absorber surface, which in some cases is not water resistant
- Collectors with humidity condensations on parts of the glass cover do not meet the aesthetic expectations of most people
- Freezing problems can be caused in some constructions if water tightness is not guaranteed
- ETC for example combine often aluminium and copper (Heat transfer sheet and heat pipe) if water is entering and wetting these metals as an electrolyte corrosion is speed up

2. Methods of EN12975:2006

The EN 12975:2006 contains the following methods to do the rain penetration test:

- Visual Inspection
- Weighing the collector
- Humidity measurement
- Measuring the condensation level

All methods are used for different kind of collectors. The limits are defined for the methods "Weighing the collector", "Humidity measurement" and "Measuring the condensation level", but a lot of other influences are not clarified very well.

In general following topics need to be taken into account:

- Critical areas of the collector should be sprayed to ensure that the collector withstands rain impact over his lifetime.

- The rain penetration should be done in the same way by all test institutes. Therefore the procedure needs to be described in detail.
- A wide range of boundary conditions need to be taken into account, because this test is done all over the world.
- A harmonisation with international standards should take place.

Following chapters summarize the advantages and disadvantages of each method.

2.1. Visual Inspection

Advantages	Disadvantages
Easy	Limits not defined
Fast	Result maybe affected by boundary conditions
For every kind of collector	
Cheap	
No changes at collector structure (bore hole)	

2.2. Weighing the collector

Advantages	Disadvantages
Easy	Weighted water inside the collector can be in insulation or absorber?
Fast	Limit of 30 g/m² reliable?
For nearly every kind of collector	Result maybe affected by boundary conditions
Cheap	Measurement tool hard (possible?) to find, with the needed accuracy
No changes at collector structure (bore hole)	Not defined when weighing needs to be done after spraying

2.3. Humidity measurement

Advantages	Disadvantages
	Applicable just for FPC
	Changes at collector structure (bore hole)
	Defined limits reliable?
	Positioning of sensor needs to be specified
	Boundary conditions highly influential

2.4. Measuring the condensation level

Advantages	Disadvantages
Easy	Applicable just for FPC
Fast	Defined limits reliable?
Cheap	Boundary conditions highly influential

3. Activities and main results

3.1. Meetings and telephone conferences

The improvement of a method for testing the rain penetration was discussed in several project meetings of QAiST and in four telephone conferences. In general it was agreed that the measuring of the condensation level should not be used anymore and an improved test method should be harmonized with the standard AS-NZS-2712-2007.
The following topics were discussed in detail:

- Reliable judgement

To get reliable results it is necessary to test a collector which allready was exposed to different weather conditions. The rain penetration test could be done after a complete exposure test. To ensure that a minimum of preconditioning is done before the rain penetration test, it should be described in the revision of the EN 12975.
The most reliable judgement can be done in opening the casing of a collector and analysing the water or trays of water inside the collector. For this reason it makes sense to combine the rain penetration test with the final inspection.
A judgement for ”passed” can be done also by weighing the collector. If the result of this would be ”failed” the final inspection needs to be done for reliable judgement of ”failed”.

- Boundary conditions

The result of a rain penetration test can be influenced by boundary conditions like solar irradiance, ambient temperature or ambient humidity. To reduce the influences the temperature of the absorber should be defined and constant during the test.

- Spraying areas

For common collector types it could be defined which areas should be sprayed with water. The most problematic areas are normally corners and edges of casings or pipe feedthroughs. The positioning of nozzles should be described to ensure that this areas are sprayed. The spraying of the back side of collectors is not necessary.

- Spraying period

For the spraying period several detailes need to be defined. The duration of spraying, amount of water, minimum drop sizes and storage after the spraying are relevant.

3.2. Main outcomes

Based on the discussed topics and agreements a draft for revision of the EN 12975 was developed. Also criteria for passed/failed were summarized (see 3.5) and nozzles are

proposed (see 3.3). Based on the proposed nozzles a comparision of overall amount of water of EN 12975:2006 and draft for revision was done (see 3.4)

3.3. Proposed full cone nozzles

Manufacturer	Type	Technical data	remarks
Spraying Systems http://www.spray.de/	Modell VKE-2	3bar / 1,6 l/min / 60°	LINK, p.38
Schlick http://www.duesen-schlick.de/	Modell 553	65° / 3bar / 1,5 l/min / >400µm 60° / 3bar / 2,4 l/min / >400µm	LINK; S.5 LINK; S.6
Lechler http://www.lechler.de/	Modell 460	60° / 3bar / 1,88 l/min 60° / 3bar / 2,35 l/min	LINK; S.5 LINK; S.5

Table 1: Overview of proposed nozzles

3.4. Comparision between EN 12975:2006 and proposal for revision

A comparison was done between the amount of water sprayed onto the collector when using EN 12975:2006 and when using the method according to the proposal for revision. Table 2 shows the main values of water spraying of both methods. The mass flow per nozzle is shown as 1,5 kg/min. Table 3 shows a calculation based on values of EN 12975:2006. The mass flow per nozzle is comparable to the mass flow of the proposal for revision in Table 2.

EN 12975:2006	Proposal for revision
0,05 kg/(m² s) = 3 kg/(min*m²) 1 m² = 3 kg/min 2 m² = 6 kg/min 4 m² = 12 kg/min 6 m² = 18 kg/min	Type: full cone spray nozzle Spray angle: 60° Pressure: 3bar Number of spray nozzles: 6 to >8 Mass flow: **1,5 kg/min per nozzle** Drop size is not important (Fog = <100µm)

Table 2: Values for spraying water of EN 12975:2006 and proposal for revision

EN 12975:2006			
Collector area	**2 m²**	**4 m²**	**6 m²**
Number of spray nozzles	6 - 8	8	12
Overall mass flow	6 kg/min	12 kg/min	18 kg/min
Mass flow per nozzle	**1 kg/min**	**1,5 kg/min**	**1,5 kg/min**

Table 3: Calculation of massflow per nozzle

3.5. Criteria of passed/failed

This chapter summarizes the discussions of criteria of passed or failed of the rain penetration test.

List of criteria:	passed	failed
Weighing method		
water quantity more than 30 g/m²		X
Final inspection (inside the casings)		
Wet insulation (squeezing, 10ml, wet spot)		X
Water		X
Visible trace of water drops running down glass and absorber		X
Water outside the casing in/at other critical components like tube fixings of ETCs		X

3.6. Gain of experience

To ensure the acceptance of the proposed method for the revision of EN 12975 and to get experience, nine QAiST-partners undertook trial tests. Thus the method was applied as described in the draft, without additional explanation. Some of the trial tests were done on collectors which were tested according to EN 12975-2:2006, to compare the results directly.

The experience of the trial tests can be summarized as follows:

- The same results (passed/failed) were achieved in comparison with tests according to EN 12975-2:2006 (just one different result)
- The proposal for revision should be further improved in the following areas:
    - Explanation of spraying areas, especially for ETCs the number and distance of spray heads could be reduced.
    - Explanation of duration of spraying should be more appropriate. Should the spraying last exactly 4 h? Is there any range?
    - Explanation of hot water circuit should be more appropriate, because spraying and hot water circulation can not be started at the same time.
    - The note for shading in case of outdoor tests should be extended to daytime and night.
    - The pass/fail criteria need to be improved to be in line with EN 12975-1.

    - The detection of ingress of water needs to be improved to cover all relevant collector components.
- The weighing method seems to be suitable to achieve the result “passed”; the removal of water inside absorber pipes and external surfaces should be taken care of.
- The combination with final inspection increases the testing effort for some types of collectors (e.g. in-roof collectors mounted on simulated roof) slightly.
- Testing the back side of collectors could be relevant for collectors which are provided with flat roof frame kits. Collectors mounted on flat roofs are not fully covered by the proposed method.

The gained experience was summarized and discussed in the fourth telephone conference. It will be given directly to CEN within inquiry phase.