SWC – Towards a new global standard for solar thermal collectors

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1. Introduction

The practical approach to quality assurance in solar thermal heating and cooling technology with regards to components and systems is standardization and testing. It is very important for growth and development that the standards and test methods keep track with recent developments and allow maximum flexibility for future innovations. Good, operational and generally accepted standards are an essential part of the market conditions and the basis for a large and open market. Standards and pre-standards are established, but work is still needed in order to keep track with recent technological developments in the direct use of solar thermal energy (i.e. new materials, concentrating devices,…) and in combination with other technologies (cooling, heat pumps,..). New Member States also bring new opportunities for market development. In order to make this development really strong and quality oriented it's essential that the quality requirements and the public incentives and regulations for solar thermal technologies that rely on them are integrated with and adapted to the current best practice. This Paper gives a review of the current national and international standardization situation as well as standard committees and working groups in the area of solar thermal products. Furthermore it describes the latest changes within the current revision of the European testing standard EN12975.

2. State of the art or standardization situation nowadays

The dismantling of trade barriers and therefore the ensuring of a global market access by unification of the basic requirements is one of the first aims of standardization. Thereby the impact of standardization reaches from cost reduction potential due to rationalization of production processes across the assurance of the quality standard related to the state of the technology up to human safety enhancement. Table 1 gives an overview over the important currently valid European and International Standards which should ensure the quality of solar thermal collectors articulated in application area, standard and short description of their content. Tests of solar thermal collectors according to the valid standards and regulations by independent laboratories should guarantee the quality standard related to the state of the technology, mainly to ensure the continuous growth in order to make a contribution to the sustainable energy supply. Furthermore such tests should ensure the continuous development and should sharpen up the transparency of the European and International market for the consumer. Essential conditions to reach these aims are the general performance of mandatory tests of all solar thermal collectors in the run up to the market entrance. Furthermore useful, which means to the respective state of the technology and the environmental conditions well-adjusted requirements, within the different standards. Even if the most of the standards listed within Table 1 are trace back to the same fundamental standard there are deviations with regard to their requirements which are resulting from the regional enhancement of the several testing standards within the last ten years. Therefore the first aim of standardization, the dismantling of trade barriers as well as the ensuring of a global market access, is failed. For every single market area (Europe, USA, Australia/New Zealand, …) the manufacturers are obliged to commission different test procedures according to national requirements and standards. This retards the implementation of new products and creates additional cost. Beyond that the application of the currently valid national and international standards shows, that neither all currently on the market available collector types nor new products which are trying to enter the market, are covered by. The thermal characterization of concentrating and tracking collectors was, for instance, excluded from the European collector test standard EN12975-1:2006 and also for technologies like solar air heaters and PV-T collectors , which are progressively trying to enter the market, no reliability test procedures were defined until now. As a result the market entrance of advanced collector technologies is prevented or delayed by such exclusions. Also the application of some the described test sequences are currently not possible for common collector technologies like tubular collectors. Examples of these are the not feasible tensile load within the mechanical load test, the missing definition of the impact location within the impact resistance test or the missing criterions of evaluation of the rain penetration test.

Table 1: European and International standards in the area of solar thermal collectors

Application area	Standard	Discription
Europa	EN12975-1,2:2006	Europäische Prüfnorm zur Qualitätssicherung von thermische Solarkollektoren
Australien / Neuseeland	AS/NZS 2712:2007	Australische Prüfnorm zur Qualitätsicherung von thermischen Solarkollektoren
Nordamerika / Canada	ISO 9806-1:1994 ISO 9806-2:1995 ISO 9806-3:1995	Part 1: Thermal performance of glazed liquid heating collectors including pressure drop Part 2: Qualification test procedures Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop
China	GB/T 17049-2005	Thermal performance of all-glass evacuated tube collectors
Südafrika	SANS 6211-1:2003 SANS 6211-2:2003 SABS method 1210:1992 SANS 10106:2006 SANS 1307:2007	Part 1: Thermal performance using an outdoor test method Part 2: Thermal performance using an indoor test method Mechanical qualification test Installation, maintenance, repair and replacement of domestic solar water heating systems Domestic solar water heaters

3. National and International Certification schemes

The allocation of Quality labels is mostly based on a successful performed test and measurement procedure according to national or international Standards as well as national or international certification schemes. While the European Solar-Keymark-Lable for solar collectors is handed on the basis of a test and measurement procedure according to EN12975-1,2:2006 as well as according to the regulations of the "General Keymark Rules" and the product specific "Solar-Keymark-Scheme-Rules", the North American SRCC-Label is handed out on the basis of a measurement procedure according to the ISO9806 or also the ANSI/ASHRAE 93 as well as the regulations of the OG-Standards of the SRCC. This clearly shows that, beyond the above discussed general limits of standardization, additional national deviations concerning the requirements of the several certification schemes are already exists. Beyond the official standards the several certification schemes thereby defines the scope of the test procedures (e.g. which tests of the standard have to be done) as well as the test requirements (e.g. how the tests should be done). Table 2 shows the differences between the normative regulations and the regulations of the certification schemes exemplary for Europe and

North America. This shows once more the complexity resulting from the current requirements. Not only different normative requirements but also different certification schemes have to be taken into consideration for international market entrance.

Table 2.: Differences between the normative requirements and the regulations of national certification schemes exemplary for Europe and North America

	EN12975-1,2:2006	SKM-Rules	ISO 9806	SRCC-Standard OG-100
Factory Inspection	-	+	-	-
Random Selection	-	+	-	+
Static Pressure Test	+	+	+	+
Heat Resistance Test	+	+	+	-
Exposure Test	+	+	+	+
External Thermal Schock Test	+	+	+	+
Internal Thermal Schock Test	+	+	+	+
Rain Penetration Test	+	+	+	-
Mechanical Load Test	+	+	-	-
Freeze Resistance Test	+	+	+	-
Stagnation Temperature	+	+	+	-
Final Inspection	+	+	+	+
Impact Resistance Test	-	-	-	- *
Pressure Drop Test	-	+	+	+
Time Constant	-	-	+	+
Thermal Performance	+	+	+	+

(* mandatory if the transparant cover of the collector is made of not thoughted glass)

4. National and International standard committees and working groups

Table 3 shows on overview about the currently active national and international standard committees and working groups as well as their structural layout and thematic orientation.

Tabel 3.: Standard committees, their structural layout and thematic orientation

Standard Committee	Structural layout	Thematic oriantation
SHC IEA Task 43	• Subtask A: Collectors • Subtask B: Systems	research and develop of new test procedures and characterization methods
ISO/TC180	• WG1: Nomenclature • WG 2: Materials – STANDBY • SC 1: Climate - Measurement and data • SC 4: Systems - Thermal performance, reliability and durability	revision of the ISO 9806-Standards
CEN/TC312	• WG1 – Solar collectors • WG2 – Factory made Systems • WG3 – Thermal solar systems and components; Custom build systems • Labeling	revision of the EN1297x Standards

At international level an expert group of the Solar Heating & Cooling Programm (SHC) of the International Energy Agency (IEA) is currently working within TASK 43 (IEA SHC Rating and Certification Procedures –Advanced Solar Thermal Testing and Characterization for Certification of Collectors and Systems) on the enhancement of established as well as on the development of new test procedures which are urgently needed. This international collaboration researches and develops new test procedures and characterization methods for addressing the testing of both conventional and advanced solar thermal products. Therefore it focuses on research activities The scope of this task includes performance testing and characterization, qualification testing, environmental impact assessment, accelerated aging tests, numerical and analytical modeling, component substitution procedures, and entire system assessment. Task 43 is subdivided into two different Subtasks. The collector related Subtask A as well as the system related Subtask B. The objective of Subtask A is therewith to examine existing testing and certification procedures for low-temperature evacuated tube and flat-plate collectors, air heating collectors, medium- to high-temperature concentrating collectors, to identify weaknesses, inconsistencies in application, and significant gaps. The research will result in new or improved tests that can be communicated to ISO/TC 180 for consideration in updating old standards or developing new standards.

The Technical Committee 180 of the International Organization for Standardization (ISO/TC180) is currently working on the revision of the ISO 9806-Standards. There are three collector standards published as separate parts of ISO 9806 - Test Methods for Solar collectors. Please see table 1. These three parts of the standard ISO 9806 are to be revised. The revision will use the CEN documents EN 12975 Part 1 and 2 – Collectors (Requirements and tests methods). The tests included in these may need refining to adequately cover performance of evacuated tube collectors and other new products.

At the European level the Technical Committe 312 of the European Committee for Standardization (CEN/TC312) is committed to work within different working groups on the actualization of the EN12975. Beyond that the Solar Keymark Network (SKN), a working group which consists of European certification bodies, European testing laboratories as well as representatives from the industry, is continuously working on the enhancement an adoption of the Solar-Keymark-Scheme-Rules. Table 4 shows which collector related European standard are currently under revision. Furthermore it shows their current status as well as their foreseen date of availability.

Table 4.: European Standards under development and their date of publication

Project reference	Title	Current status	DAV
prEN ISO 9488 rev	Solar energy - Vocabulary	Under Drafting	2011-11
prEN 12975-1 rev	Thermal solar systems and componentsThermal solar systems and components - Solar collectors - Part 1: General requirementsGeneral Requirements	Under Approval	2013-10
prEN ISO 9806-2	Thermal solar systems and components - Solar collectors - Part 2: Test methods	Under Drafting	2013-10
prEN 12975-3-1	Thermal solar systems and components - Solar collectors - Part 3-1: Qualification of solar absorber surface durability	Under Approval	2013-05

5. QAiST - Quality Assurance for Solar thermal heating and cooling technologies

In addition the project QAiST - Quality Assurance for Solar thermal heating and cooling technologies – keeping track with recent and upcoming developments – of the Intellegent Energy-Europe (IEE) was set up in 2009. The aim of this project is the accomplishment of the with regard to the content necessary work of the above mentioned standard committees and working groups. This European project gathers 15 participating organizations including the European solar thermal industry and major testing and research institutes in Europe. The project builds on work carried out during the past ten years, since the first European standards for solar thermal products were introduced. QAIST addresses solar thermal systems as well as solar thermal collectors. For these, the introduction of a European certification scheme - The Solar Keymark - has been very successful, now approaching more than 1000 certificates. At the same time a range of new products has been introduced, production has become more industrial and competition is increasing, which altogether increases the need for flexibility and ability to support innovation in the certification process and in the underlying standards. The objective of the project is to enhance the competitiveness of the European Solar thermal industry and further increase consumer confidence through improved standards and certification schemes, harmonization in testing and certification and a wide dissemination of the quality concept throughout Europe. A long term objective for the work is furthermore to support the development process towards a global standard for solar thermal collectors, harmonized to the revised EN 12975 that will be an output from the QAiST project. The work within this project is structured in 7 work packages. WP 1 is for the management of the consortium and the project and includes the usual activities resulting in project meetings and reports. Basic work on standards, procedures and other accompanying measures is done in the WP 2, 3 and 5 as they are dealing with solar thermal collectors (WP2), solar thermal systems (WP3) and new fields for standardisation (WP5). In WP 4 a very important European quality label for solar thermal products is maintained and enhanced – the Solar Keymark. For quality assurance purposes an independent Round Robin on solar thermal collectors and systems is being carried out. In WP 6 all the relevant activities regarding information exchange with national, European and international stakeholders are combined.

6. Achieved results

A first draft revision of the EN 12975 is already done and was concluded by the end of January 2011. Therefore it was necessary to reach consensus among the QAiST project partners and among the members of CEN/TC 312/WG1 on several critical issues. QAiST project objectives related to global harmonization of standards have been fulfilled on several specific items in the EN 12975 revision where discussions with non-European partners in the IEA SH&C Task 43 have given valuable input. The European testing standard EN12975:2006 was thereafter edited into the new prEN including a number of new graphs and figures. Discussions within CEN/TC 312/WG1 and ISO/TC 180 will most likely lead to the decision to go for a common CEN/ISO standard based on this draft and to proceed according to the Vienna agreement. Therefore the review process will be carried out in parallel under CEN lead. As a first step a three month ballot has been launched in ISO to have the New Work Item Proposal approved. This ballot will close by the end of August 2011. Furthermore the ISO CS has announced that there will not be a specific work group on collectors established under ISO/TC 180 as the comments review will be managed on TC level later on processed by CEN/TC 312/WG1. The status for the different parts of the standard is thus:

- prEN12975-3-1 (Materials-absorber surface durability) is currently processed by the CEN CMC, preparing it for public inquiry
- prEN12975-1 and -2 are thus waiting for the result of the ISO ballot on part 2
    - If the answer is positive, the public parallel CEN/ISO inquiry on part 2 will be launched and a CEN inquiry on part 1 will be launched
    - Should the answer be negative, the next step will most probably be to launch a CEN inquiry for part 1 and 2

7. Latest changes within EN12975

7.1 Extension of the Scope of the product standard

An extended scope of the European testing standard EN12975-1 is included into the amended standard EN12975-1,2:2006+A1:2011 since January 2011. Therewith it is now possible to perform efficiency tests on concentrating and tracking collectors on the basis of the European collector test standard. Further adjustments within the scope which enables the applicability of this standard for solar air heaters and PV-T collectors are planed within the ongoing revision.

7.2 Durability and reliability testing

The standard EN 12975, which is specifying test methods for solar thermal collectors, was originally developed with the focus on water-based flat-plate collectors. Other collector designs have been researched in the past, but except for vacuum tube collectors there was no viable market for them in Europe. This has changed in recent years. The overall market has grown to more than 4 million m2 of collector area per year and alternative collector designs are more and more showing up in the market. In various cases, test methods described in EN 12975 are not fully applicable to advanced collector technologies like mid- temperature collectors, PVT-Collectors, solar air collectors and to collectors with new design using largely polymeric materials. On this account established test procedures were developed and, where necessary, new test procedures for advanced collector technologies were designed. For instance for tracking and concentration collectors a new Annex was designed which describes in detail the additional necessary durability and reliability test for such kind of collector modules. One central issue of this Annex is for example the check of the safety installations to avoid stagnation conditions. Further enhancements of the durability and reliability test procedures consists in the reaction of fire, the external fire performance as well as the weather tightness for roof or facade integrated collector modules. Adjustments of established test procedures were done at the rain penetration test, the mechanical load test, the impact resistance test as well as the exposure test.

Rain penetration test

In the past the results of rain penetration tests often showed that, due to the insufficient definition of the boundary conditions, no comparability and reproducibility of tests conducted by one laboratory at different times or even between different laboratories was given. For that reason the test procedure as well as their evaluation criteria was revised with the objective to get a reliable and comparable statement about the water penetration and therefore to ensure a minimum level of quality and durability of the different collector technologies in future times. While up until now the required minimum absorber temperature of 50°C during the rain penetration test could optionally be sustained by solar irradiation or even by an active flow through the absorber of the collector, the revised version only allows the last mentioned. Besides that, the revision of the European testing standard, for the first time defines both. The exact positioning of the spaying nozzles as well as the exact spraying areas related to the collector technology. This step will further harmonize the requirements with the objective to increase the comparability and reproducibility of all conducted rain penetration test in Europe. Figure 1 and Figure 2 shows the positioning of the spraying nozzles and the spraying areas related to the technology. However the major problem of rain penetration tests was the insufficient definition of the evaluation criteria. Also the detection of water penetration by the weighting method prior and after the rain penetration test as well as the direct measurement of the humidity in the gap between the absorber and the transparent cover or the measurement of the amount of water which comes out of the collector casing after drilling a hole, showing inaccuracies. Within the revised standard it will be possible to perform the so called final inspection directly in the connection with the rain penetration test. During the final inspection the collector must be opened. Thus the testing engineer will get a direct impression about the water tightness of the collector module and is no longer depending on defined but insufficient evaluation methods.

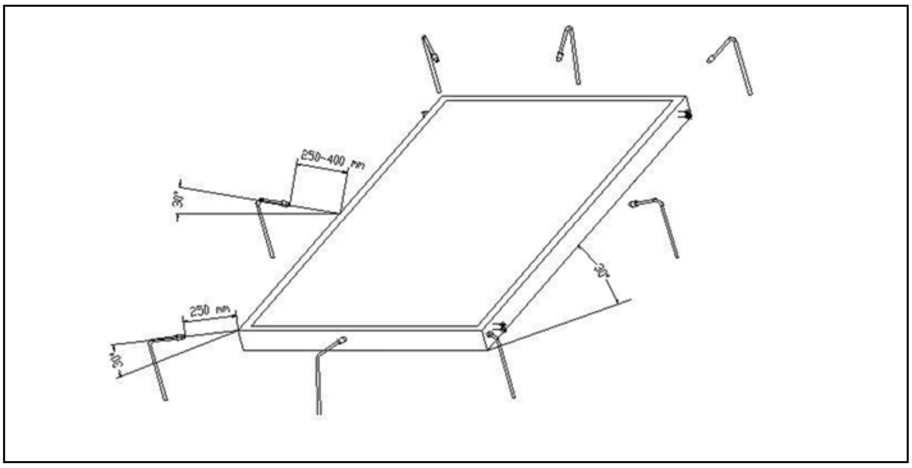

Fig. 1: **Positioning of the spaying**

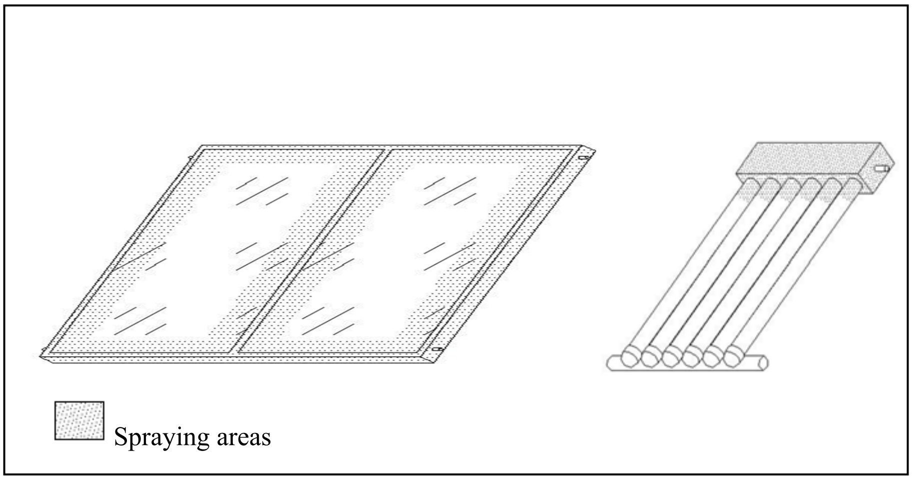

Fig. 2: Spaying areas related to the collector technolog

Mechanical load test

The mechanical load test is one of the requested reliability test according to EN 12975-1,2:2006. It is performed by independent testing laboratories and should deliver adequate results to ensure the mechanical strength to cover the safety issue of collector installations. Up to now it is defined to be performed on a collector, orientated horizontal. Forces which have to be applied according to EN 12975 are minimum 1000 Pa or a value above, when agreed with the manufacturer. By request the test is eventually performed until there is a visible damage. The forces have to be applied in positive and in negative direction. Although recently not requested in the standard the table as well provides information, if angular orientated forces can be applied. At the moment there are different methods used to apply the representative mechanical load. Throughout the different institutes and test centres the methodology to apply these forces varies quite considerably. The lack of information resulting from the limited testing possibilities needs to be closed urgently. Especially for the concentrating technologies an exact knowledge on the conducted/dissipated loads and the resilience of the collector and its devices is necessary. As it is shown in Figure 3, snow does not only sit evenly on the surface but also accumulates at the top and the bottom of the collector. This causes downhill forces and uneven distribution of the pressure, which are not tested according to scheme in EN 12975.

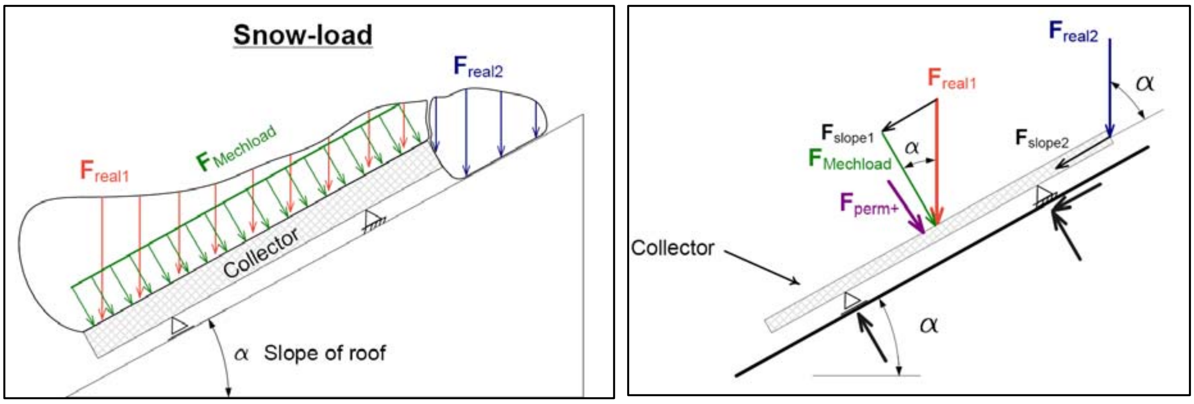

Fig. 3: Snow load and its effects on a flat plate collector

At the moment the FPC and ETC are tested according to EN 12075-1,2:2006 while being positioned in the horizontal. The pressure is raised in steps of 250 Pa, alternating positive and negative directions until 1000 Pa are reached or the collector could not withstand the procedure. ETCs are only tested on positive pressure of the aperture area due to the not applicable test procedure. As figure 3 shows the area load on the collector

F_{real1} resulting of the weight force of the snow is split in to the Cosinus and Sinus ratio resulting from the angle of the slope of the roof. In addition the downhill force of the snow (F_{slope2}) which is accumulated at the top of a single collector will add an auxiliary load which is not represented in the Norm. Moreover dynamic pressure fluctuations caused by different wind loads are not considered until now. Since this is not covered by the current test methods as described in 12975-1,2:2006 for innovative collector constructions (e.g. concentrating collectors using external mirrors, façade modules, …) as well as standard technologies (e.g. tubular collectors), a new adjusted test procedure was implemented into the revision of the European collector test standard. The following adjustments were made:

- Harmonization of the minimum test pressure.
    - In comparison to the previous test procedure, the minimum test pressure shall be 2400 Pa. This is done to reach an unite minimum level all over Europe. Up to now some of the European countries required higher pressure levels than others.
- Further methodologies to apply a mechanical load to the collector are included
    - Using a foil and gravel or water (positive pressure only)
        - On the collector a foil shall be laid and on the collector frame a wooden or metallic frame shall be placed, high enough to contain the required amount of gravel or similar material. The gravel, preferably type 2-32 mm, shall be weighed in portions and distributed in the frame so that everywhere the same load is created (pay attention to the bending of the glass), until the desired height is reached.
    - Using suction cups (positive and negative pressure)
        - The test can also be carried using suction cups. The suction cups shall be distributed as even as possible on the collectors surface. The suction cups shall not hinder the movement of the collector cover caused by the mechanical load. By usage of oval suction cups this is also applicable for tubular collectors.
    - Using air pressure on the collector cover.
        - If sealing towards the ambient is necessary, the sealing shall not hinder the movement induced by the mechanical load in any way.
    - For collectors which have an almost airtight collector box, a negative pressure on the cover is created by pressurising the collector box.
    - For evacuated tubular collectors using ropes to distribute the forces along the tubes might be used as well.

Further investigation will be done in the area of dynamic wind loads. Currently the Fraunhofer Institute for Solar Energy Systems installs within the BMU-funded project MECHTEST different collector types at three locations within Europe. The locations are:

All the collectors will be equipped with force transducers. The aim is to get exact data for different wind and snow situation. The monitoring of the data will help to determine how often which load is applied during one year. Data of the depth of snow, wind strength and its three-dimensional directions as well as temperature and the forces to the collector will be collected.

Additionally it is strongly expected that also the climatic conditions (e.g. Temperature, irradiation level, …) influences the result of mechanical load test. Therefore the Fraunhofer ISE developed a new mechanical load testing facility which is integrated into a climate chamber to perform mechanical load tests in a temperature range of –40°C up to 60°C.

Hail resistance test

Under a closer consideration e.g. of the development of the European standard EN12975-1.2:2006 we will see, that the reliability test to check the impact resistance is, unlikely to older versions, no longer an obligatory test, even though severe hailstorms in Europe definitely increased in the recent years. Also the appliance of other EU-Standards which harmonize the building shell, e.g. for roof lights, is simply not possible for the quality assurance of solar energy systems. By the reason of different requirements concerning the functionality, formulations like "the choice of the used materials should take into account the risk of hailstorms" are not transferable. To change this insufficient situation the Fraunhofer ISE developed a testing facility to simulate hail impacts with ice balls with the objective to perform impact resistance tests of solar thermal collectors according to the valid standards. This testing facility has been set-up in 2009 and gives us the possibility to perform experimental research as well as tests commissioned by the industry. Different studies have shown that the impact resistance test with ice balls can be conducted with a high level of repeatability. Beside that the studies have shown which are the weak points against impacts of hailstones depending on the collector technology (flat plate or tubular collectors) as well as for typical materials (mirrors, aluminum sheets, …) which are normally used for collector constructions. The results of these studies had been used for the current revision of the collector test standard. The amendments are:

- The impact resistance test will become an obligatory test procedure within the revised EN12975-2
- Even if the impact resistance test can further be done by one of two methods, i.e. by using ice balls or steel balls, the current amendment of the standard notes that it is assumed that, as the steel ball does not lose any energy due to its deformation at the impact, this method is the more severe if the two methods are carried out with balls giving the same kinetic energy. Therefore method 2 (Steel ball) shall, in comparison with the previous standard, only be used for "pass" judgments. If method 2 results in a failure, this must be confirmed by a test according to method 1.
- In comparison with the previous standard the usage of different ice ball diameter according to Table 5 (adapted from the IEC 61215: 2005-4) will be possible.
- The impact locations are adapted to different collector types:
    - Glazed flat plate collectors:
        - The impact point needs to be maximum distance of 5 cm from the edge and maximum distance of 10 cm from the corner of the collector cover. Within this area the most critical point (e.g. edge of the glass) should be used.
    - Unglazed collectors:
        - The same definitions as for the glazed collectors are valid. Furthermore it needs to be assured that also the tubes containing the fluid are hit. Other reasonable impact points need to be considered if it is not possible to hit the fluid containing tubes due to geometrical reasons. Unglazed collectors need to be filled with water or with an adequate solar fluid. The collectors shall be tested under at least atmospheric pressure.
    - Vacuum tube collectors:
        - The impact point needs to be in a distance less than 10 cm from the upper or lower end (visible aperture). If the clamps between the inner and outer glass tubes are not covered also this area shall be used. Two tubes are being shot at the upper end („up"). Two tubes are shot at the lower end ("down"). The shooting angle is perpendicular to the tube axis.
    - If the collectors that cannot be classified clearly into the category a.) b.) or c.)
        - The impact points need to be distributed evenly across the whole collector area. The coordinates of the impact points need to be defined before the testing, mentioned in the testing report and have to be documented with photos. Each test procedure with a certain velocity comprises 4 shots.

- The assessment criteria of the hail resistance test is split into appearance and mechanical aspects
  - Appearance: Aesthetical defects (little dents) affecting negatively neither the function nor the power output of the collector, are minor failures which shall be documented within the testing report.
  - Mechanical aspects: Breaking of the glass or other damage of the cover or other collector parts affecting negatively according to the test laboratory the durability (e.g. leakiness) or power output (due to dissolution of coating, scattering of cover) or influencing negatively the safety of the product are major failures which shall be documented within the testing report. The results of the inspection shall be reported, together with the number of impacts, the velocity and the ice ball diameter if method 1 is used and accordingly the height from which the steel ball was dropped and the number of impacts if method 2 is used.

Table 5.: Ice ball diameter, their mass, velocity, and kinetic energy

Diameter [mm]	Mass [G]	Velocity [m*s^{-1}]	kinetic energy [J]
25	7,53	23,0	2,0
35	20,7	27,2	8,0
45	43,9	30,7	20,7
55	80,2	33,9	46,1
65	132,0	36,7	88,9
75	203,0	39,5	158,4

Exposure test

The big disadvantage concerning the exposure test within the currently valid Standards is the period of time of at least 30 sunny and warm days and 30 sunny hours. According to these requirements it is impossible to do it in winter time in the most countries of Europe and testing also takes long in spring and autumn. To accelerate testing especially in times with bad weather conditions it is permitted to do the 30 hour requirement using a sun simulator. To improve the test method and ensure reliable test results for the industry all relevant influences were checked and the relevant degradation mechanisms of the components were considered. Therefore the following changes were made within the current revision of EN12975-1,2:2006: The exposure test provides a low-cost reliability test sequence, indicating (or simulating) operating conditions which are likely to occur during real service and also allows the collector to "settle", such that subsequent qualification tests are more likely to give repeatable results. For the latter purpose a pre conditioning exposure test sequence with approximately half the duration of the full exposure test were defined. The set of reference conditions are given in Table 6. The class according to which the collector is to be tested is defined by the collector manufacturer. The collector shall be exposed until at least 30 days have been passed and the minimum irradiation dose H shown in Table 6 is reached. The collector shall also be exposed for at least 30 h to the minimum irradiance level G given in Table 6, when the surrounding air temperature is greater than the value shown in Table 6 or conditions resulting in the stagnation temperature of the collector. These hours shall be made up of periods of at least 30 min. Indoor exposure using a solar simulator may be applied to reach the 30 or 15 hours and/ or the irradiation dose once the 30 or 15 outdoor days have been reached. It must not consist of longer cycles than 8 hours and have a minimum of 4 hrs to cool down the collector to close to ambient temperature in between each cycle.

Table 6.: Reference conditions for exposure testing

	Value for climate class		
Global irradiation	**Class C Temperate**	**Class B Sunny**	**Class A Very Sunny**
on collector plane during minimum 30 hours (or 15 hours in case of pre-conditioning), G [W/m²] / minimum ambient temperature, t_a [°C]	850/ 10	950/ 15	1050/ 20

dose on collector plane for exposure test during minimum 30 days, *H* [MJ/m²]	420	540	600
dose on collector plane for pre conditioning sequence during minimum 15 days, *H* in MJ/m²	210	270	300

7.3 Thermal performance testing of fluid heating collectors

Thermal performance measurement of PV-T collectors

The current revision of EN12975-1,2:2006 only stated that the operation mode of the PV-module (MPP tracked, open or short circuit) could have a major influence on the thermal performance and that the chosen method need to be mentioned within the report. Furthermore the PV-T collector should be treated as an unglazed collector module if the absorber of PV-T is close connected to the PV-Module and if there's no extra glazing in front of the PV-Module. Thus presently it is possible to determine the thermal efficiency of PV-T collectors according to the European collector test standard EN12975. Following also the Solar Keymark certification of such technologies is not barred. On the other hand this relieves not from the necessary approval according to the IEC-Standard for PV-Modules.

Thermal efficiency measurement of solar air collectors

The new chapter "6.2 Performance testing of air heating collectors" was implemented to define and regulate the thermal characterization of solar air heaters within Europe. The therefore necessary methodological approaches for the thermal characterization of covered solar air heaters were developed by the Fraunhofer ISE within the scope of the BMU founded project Luko-E as well as the project CostEffective (founded by the 7. Framework program of the European Union).However non covered solar air heaters are not taken into account until now. The reason therefore is that the methodological approaches cannot easily be adapted to uncovered solar air collector. Examples are the influence of the wind velocity over the collector surface or the long wave radiation which should be additionally taken into consideration.

Parallel to the investigation at the Fraunhofer ISE a working group in Canada worked on the revision of the Canadian solar air collector standard (F-Series). The public ballot related to this revision was closed in spring 2011. Thus the CSA F 378.2 should now be available. This Canadian standard defines also the necessary measurements for the thermal characterization of solar air collectors. Thereby the method is adopted from the North American standard ANSI/Ashree 93. The final goal is to bring together the CSA F 387.2 and the EN 12975-1,2 in one CEN-ISO Standard with international acceptance.

Thermal performance measurement of concentrating collectors

The current revision of the European testing standard stated, that the thermal performance measurement of concentrating collectors shall be tested according chapter 6.4., which describes the quasy dynamic test procedure. The reason why only this test procedure will currently be applicable is the consideration of direct and diffuse insolation onto the collector plane. If the steady state method should be used for concentrating collectors the geometric concentration ratio C of the collector has to be considered as follows:

- $C \leq 1$: the standard testing method shall be applied, with an acceptable diffuse fraction of maximum 30 %
- $C > 20$: the diffuse radiation is not taken into account
- $1 < C < 20$: the global and the diffuse radiation are measured. By an iterative process Kta_dif is calculated from Kta_glob with a convergation criterion < 2% of Kta_dif. This method will be applied in the informative Annex.

The applicability of this calculation method is currently under investigation by the Fraunhofer ISE by a direct comparison of the steady state method using the calculation method as described above and a quasy dynamic measurement.

Furthermore the elevated temperature of concentrating and mid-temperature collectors has to be considered within the mass flow measurement. The mass flow $\dot{m}$ can either be measured directly based on the coriolis method or indirectly with a MID. For the indirect case, it has to be calculated from $\dot{v}$ ($\dot{m} = \dot{v} * \rho$, $\rho = f(p,T)$). This polynomial function contains the problem that the factors in EN 12975-1,2:2006 are only valid until 99,5 °C. Therefore a new fit is implemented into annex J.2 and J.4 of EN12975-1,2:2012 being valid until 250 °C. Further adjustments for the thermal characterization according to EN12975 are:

- that tracking and concentrating collectors shall be tested using the tracking device of the manufacturer
- that tracking and concentrating collectors shall be mounted in a way that enables performance testing up to incidence angles of 60°

7.4 Guide to EN12975 standard

The purpose of this guide is to be a complement to the EN 12975 standard, focusing on parts 1 and 2 related to testing of solar thermal collectors. The guide has been divided in two parts, each with a different target group and objective.

A guide to establish and new test laboratories for collector testing. The main purpose here is to give a quick introduction to the standard for new laboratories and in general to contribute to a uniform interpretation of the standard and presentation of results.

A guide to manufacturers and importers of solar thermal collectors. Here, the purpose is to give a very light introduction to the standard and to explain how it is used for type testing as well as for innovation and development support. Tests that can easily be carried out by e.g. manufacturers themselves are briefly explained.

7.5 Energy output calculation tool

Within the new Annex Q of EN12975 the description of an excel-based energy output calculation tool, developed by the Swedish Technical Research Institute SP, is given. This tool is primarily developed to give the end-user a possibility to compare different types of solar collectors. The program shall therefore not be used as a calculation tool for design of solar energy installations. No system is simulated. The calculations assume that there is a load all the time for the energy collected and that the collector is operating at a constant average temperature. The tool is applicable to all kinds of liquid heating collectors, including tracking concentrating collectors, collectors with multi axial incidence angle modifiers and unglazed collectors.

8. References

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