Towards a new global standard for solar thermal collectors

Stefan Mehnert[1], Korbinian Kramer[1], Peter Kovacs[2], Pedro Dias[3], Stephan Fischer[4], Enric Mateu[5], Pilar Navarro[6], Franz Helminger[7]

[1]Fraunhofer-Institut für Solare Energiesysteme ISE, 79110 Freiburg, (Germany)

[2]SP Technical Research Institute of Sweden, S-50115 Boras, (Sweden)

[3]ESTIF - European Solar Thermal Industry Federation, B-1040 Bruxelles (Belgium).

[4]Institut für Thermodynamik und Wärmetechnik (ITW), University Stuttgart, 70550 Stuttgart (Germany)

[5] Centro Nacional de Energías Renovables (CENER), 31621 Sarriguren (Spain)

[6] Instituto Technologico De Canarias ITC, 35119 – Santa Lucia, Las Palmas (Spain)

[7] AIT Austrian Institute of Technology,1210 Vienna, (Austria)

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, etc.) and in combination with other technologies (cooling, heat pumps, etc.). New member states also bring new opportunities for market development. In order to make this development really strong and quality oriented it is 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 EN 12975-1,2:2006.

2. State of the art or standardization situation nowadays

The dismantling of trade barriers and therefore the ensuring of a global market access by harmonisation 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 ensure the quality of solar thermal collectors shown by 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 on all solar thermal collectors in the run up to the market entrance. Furthermore it is the goal to, define the state of the technology and the boundary conditions in well-adjusted requirements, within the different standards. Even if the most of the standards listed within Table 1 are based on the same fundamental standard (ISO 9806) there are significant deviations regarding to requirements, resulting from the regional/national development 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 not reached yet. For every single market area (Europe, USA, Australia/New Zealand, etc.) 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 neither all currently on the market available collector types nor new products which are trying to enter the market are covered by the currently valid national and international standards. 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, 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 of the described test sequences is currently not possible for common collector technologies like tubular collectors. Examples of these are the not applied negative pressure 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

Area of appliance	Standard	Description
Europe	EN12975-1,2:2006	European testing standard for solar thermal collectors
Australia / New Zeeland	AS/NZS 2712:2007	Australian testing standard for solar thermal collectors
North Amerika / 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
South Africa	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

Quality labels are mostly based on a successfully performed test and measurement procedures according to national or international standards as well as national or international certification schemes. While the European Solar Keymark Label for solar collectors is handed on the basis of a test and measurement procedure according to EN 12975-1,2:2006 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 ISO 9806 or also the ANSI/ASHRAE 93 as well as the regulations of the Operation Guideline (e.g. OG 100) 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 already exists. Beyond the official standards the several certification schemes thereby define 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-Certification OG-100
Factory Inspection	-	+	-	-
Random Selection	-	+	-	+
Static Pressure Test	+	+	+	+
High Temperature 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.

Table 3: Standard committees, their structural layout and thematic orientation

Standard Committee and Working groups	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, see table 1. These three parts of the standard ISO 9806 are to be revised. The revision will be based on the current CEN document related to the revision of EN 12975-2. The tests included in this may need refining to adequately cover performance of evacuated tube collectors and other new products.

At European level the Technical Committe 312 of the European Committee for Standardization (CEN/TC312 WG1) 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 and adoption of the Solar-Keymark-Scheme-Rules. Table 4 shows which collector related European and international standards are currently under revision. Furthermore it shows their current status as well as their foreseen date of availability (DAV).

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 components - Solar collectors - Part 1: General requirements	Commenting	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	Commenting	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 – of the Intellegent Energy-Europe Program (IEE) was set up in 2009 - is keeping track with recent and upcoming developments. The aim of this project is the accomplishment of the necessary work in the standard committees and working groups mentioned above. This European project gathers 15 participating organizations including the European solar thermal industry federation (ESTIF) 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 1500 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. Basic work on standards, procedures and other accompanying measures is done, dealing with solar thermal collectors, solar thermal systems and new fields for standardization In order to strengthen the quality assurance of performance testing in European laboratories a proficiency test on solar thermal collectors and systems is carried out

6. Achieved results

A first draft revision of the EN 12975 is already done and was concluded by the end of January 2011. 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 has led 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 by CEN/TC 312/WG1. The status for the different parts of the standard is thus:

- prEN12975-3-1 and 1 are currently in public inquiry phase (ending 15th October 2011)
- The CEN/ISO draft is waiting for the result of the ISO ballot
    - If the answer is positive, the public parallel CEN/ISO inquiry
    - Should the answer be negative, only the Cen inquiry phase will take place

7. Latest changes within EN12975

7.1 Extension of the Scope of the product standard

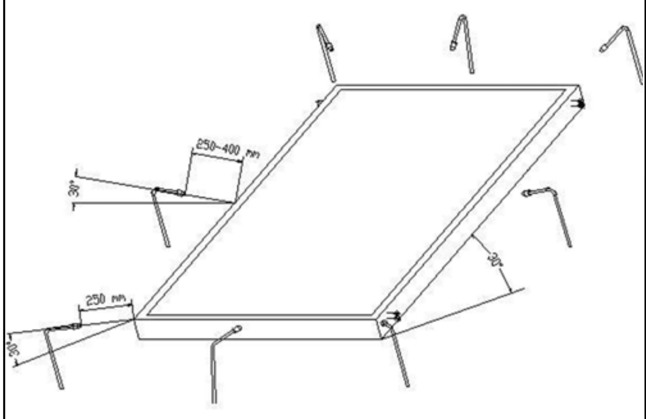
An extended scope of the European testing standard EN12975-1 is included into the amended standard EN12975-1,2:2006+A1:2011 since January 2011. Therewith it is now possible to perform thermal performance tests on concentrating and tracking collectors on the basis of the European collector test standard. 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 m^2 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 concentrating and tracking collectors, PVT-Collectors, solar-air-collectors and to collectors with new designs. 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 consist in the reaction to 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 for the rain penetration test, the mechanical load test, the impact resistance test as well as the exposure test.

<u>Rain penetration test</u>

In the past the results of rain penetration tests showed that, due to not clear definition of the boundary conditions, the comparability and reproducibility of tests conducted at one laboratory at different times or at different laboratories was not reliably 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 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 subsequent the rain penetration test. During the final inspection the collector is opened. Thus the testing engineer will get a direct impression about the water tightness of the collector module and is no longer depending on insufficient evaluation methods.



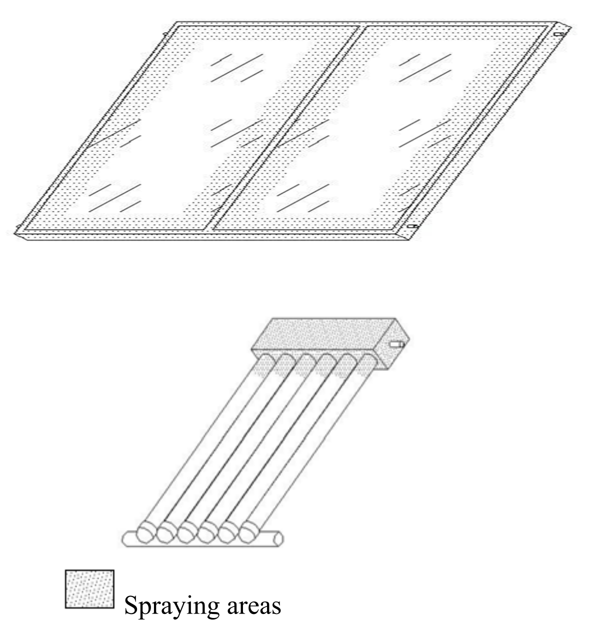


Fig. 1: Positioning of the spraying **Fig. 2: Spraying areas related to the collector technology**

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 1000Pa or a value above, when agreed with the manufacturer. By request the test is eventually performed until there is a visible damage. 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. Even if the forces have to be applied in positive and in negative direction ETCs are only tested on positive pressure due to the not applicable test procedure (and the assumption that negative wind forces are not to take into account as long as there is no reflector). Although recently not requested in the standard a 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. Since this is not covered by the current test methods as described in EN12975-1,2:2006 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 a harmonised 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.

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, etc.) influence 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.

<u>Impact resistance test</u>

The impact resistance test as described in EN12975-1,2:2006 is actually just stated as an informative test procedure even though severe hailstorms in Europe definitely increased in the recent years. This results in a lack of information concerning the impact resistance against hail stones of solar thermal collectors. 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 2008 and gives 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 were the weak points are with respect to impact of hailstones, depending on the collector technology (flat plate or tubular collectors) as well as for typical materials (mirrors, aluminum sheets, etc.) 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 impact resistance test is suggested to become mandatory 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 changes in 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:
        - For unglazed collectors it needs to be assured that 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 (e.g. due to dissolution of coating or 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 6: Irradiation levels according to EN12975

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 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. 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 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 hours and/ or the irradiation dose once the 30 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. With the objective to produce more reliable results in case of subsequence qualification tests a pre conditioning exposure test sequence with approximately half the duration of the full exposure test was defined. The class according to which the collector is to be tested is defined by the collector manufacturer. The set of reference conditions are given in Table 6.

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

	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 ongoing revision of EN12975-1,2:2006 states 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 it will be possible to determine the thermal efficiency of PV-T collectors according to the European collector test standard EN12975 on its thermal behavior. Following also the Solar Keymark certification of such technologies is possible.

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 7th 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. Ongoing work will close this gap.

Parallel to the investigation at the Fraunhofer ISE a working group in Canada worked on the revision of the Canadian collector standard (F-Series). The public ballot related to this revision was closed in spring 2011. Thus the CSA F 378.2 is now 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/Ashrae 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 states, that the thermal performance measurement of concentrating collectors should be tested according chapter 6.4., which describes the quasi dynamic test procedure. The reason why this is the suggested test procedure is the consideration of direct and diffuse insolation onto the collector plane. The applicability of the steady state method is currently under investigation by a direct comparison of the steady state measurement, using an aditional calculation method as described in the following, and a quasi-dynamic measurement. 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 an informative Annex.

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 magnetic inductive flow meter. For the indirect case, it has to be calculated from $\dot{v}$ ($\dot{m} = \dot{v} * \rho$, $\rho = f(p,T)$). The current polynomial function in EN 12975-2:2006 are only valid until 99.5 °C. Therefore a new fit is implemented into the revision of EN12975-2 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 for established 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 for manufacturers and importers of solar thermal collectors. Here, the purpose is to give a 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 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 many kinds of liquid heating collectors, including tracking concentrating collectors, collectors with multi axial incidence angle modifiers and unglazed collectors.

8. Summary/conclusion

The paper shows that there is a significant development on-going right now. Many active protagonists make it possible that the solar thermal branch is moving forward in defining standards and quality means quite quickly. A lot of effort is paid to keep the inter-acting system of standards and labels as transparent as possible and flexible to react on up-coming technologies. The work done within these expert groups is highly valuable for manufacturers and helps to stabilize and back up the market diffusion for solar thermal products. Never the less not all barriers can always be solved in due time, often because of a lack of industry involvement.

Especially to bring together the different global markets will be the interesting challenge within the coming years in sola thermal standardization work.

9. Nomenclature

Quantity	Symbol	Unit
Global irradiation	G	W m-2
Global irradiation dose	H	MJ m-2
Kinetic Energy	E	J

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