Solar Keymark II

WP5, Standards – General Acceptance of Standards

Delivery 23 – Recommendations to CEN/TC312 for changes in standard and further work

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Summary

WP5 comprises two different tasks. The first is aimed at the general acceptance of standards and the second is planned to establish a basis for the Key-marking of solar tanks. The progress of these two tasks is briefly summarized below.

Task 1: General acceptance of Standards
The objective is to provide inputs to ongoing and future work of standardisation group CEN/TC 312 “Thermal solar systems and components”, which do revisions of solar thermal standards. The work had its focus pointed either at the EN 12975-2:2006 standard or on new standards to be developed covering related products or sub components. In this respect, the input can be divided in three categories:

- Direct proposals for revisions of EN 12975
- “Resource documents” either to be referenced in EN 12975 as a support to its interpretation and practice, or to be used as drafts for future standards,
- Proposals that indicate that further work are needed.

The work is partly based on a questionnaire made in 2004 that was addressed to industries and research institutes in Europe. It was answered by 7 representatives from the solar thermal industry and by 10 research representatives. Furthermore, it was answered at a work shop in November 2004 arranged by ESTIF (European Solar Thermal Industry Federation) with approximate 25 industrial companies represented. In the questionnaire the respondents were asked to give priority to and comment on different potential working areas within this field.

The results from the questionnaire revealed a particular interest in improved exposure tests for collectors, m^2 to energy conversion, improved characterization of incidence angle dependencies, methods for accelerated testing and determination of optical properties for absorber- and reflector materials. Some of the items above has been further developed within the European project NEGST (New Generation of Solar Thermal Systems) and thereafter passed on as recommendations to TC/CEN 312 (Kovács et al., 2007). As the solar energy field is growing rapidly at present, the conditions and requirements for standardisation are also quickly changing. It is therefore reasonable to assume that some of the products and techniques that were of no interest yesterday will be on top of the list tomorrow. Within the Solar Keymark II project the following topics for improving EN 12975 is considered:

- Annual collector energy output,
- Performance and quality tests for collectors with evacuated tubes,
- Collector components - requirements and test methods,
- Improved exposure - accelerated ageing test of collectors.

After an inquiry among test laboratories and manufacturers and a discussion in WG5 it has been decided to leave the issue of ETC durability out of the scope for a detailed revision proposal for EN 12975.

Task 2: Establish the basis for Keymarking of solar tanks
A proposal to have prEN12977-3 on solar tanks finalized and brought forward to a CEN inquiry was forwarded to CEN at the meeting of TC 312 in April 2006. It was there decided to send prEN12977-3 to the CEN inquiry stage (D24, Done). It is expected that the EN will be available during 2008.

Scheme rules for solar thermal products including tanks (D25) have been drafted. This draft will be proposed to CEN Certification Board when the EN 12977-3 has been approved. Solar Keymarking of solar tanks will then be possible, maybe by the end of 2008.

Annual Energy output

Background

The most important function of a solar collector is its energy performance, the energy output during one year. Based on results from testing according to EN 12975-2:2006 it is possible to calculate an annual energy output. However, the energy output might differ depending on which test laboratories that performs the calculations due to different calculation procedures. Furthermore the energy output will be dependent on where the solar collector will be located and used in practice, i.e. the outdoor climate, the tilt angle and the collector mean temperature. In order to be able compare different kinds of solar collectors from test results, independent of which test laboratory that has performed the test and where the collector finally will be located, it is important to have a standard procedure on how to calculate a comparable energy output.

A common procedure to calculate the yearly energy output is able to replace, for example, the present methods in Germany and Sweden or other special national methods.

A standardised procedure for calculation of the annual collector energy output based on the performance parameters resulting from efficiency tests according to EN 12975 and reference climates has been developed in the Solar Keymark II project. The procedure is programmed into an Excel spread sheet that will be available for all test laboratories and is meant to be an informative annex to EN 12975 in the future. The aim is that it should be easy to perform the calculations while still giving enough sophisticated results that can consider specific features of the most common collectors in the market, it will mainly facilitate performance comparisons for potential buyers.

The Excel spread sheet is based on hour by hour calculation with the input of performance parameters resulting from an efficiency test to calculate the incident angel modifier. Other predefined inputs that should be chosen are the collector inlet temperature (25, 50 or 75 ºC), location (Athens, Davos, Stockholm and Würtsburg) and tilt angels (0, 30, 45, 60 and 90 degrees). An example of results with the Excel spread sheet is given in Fig. 1.

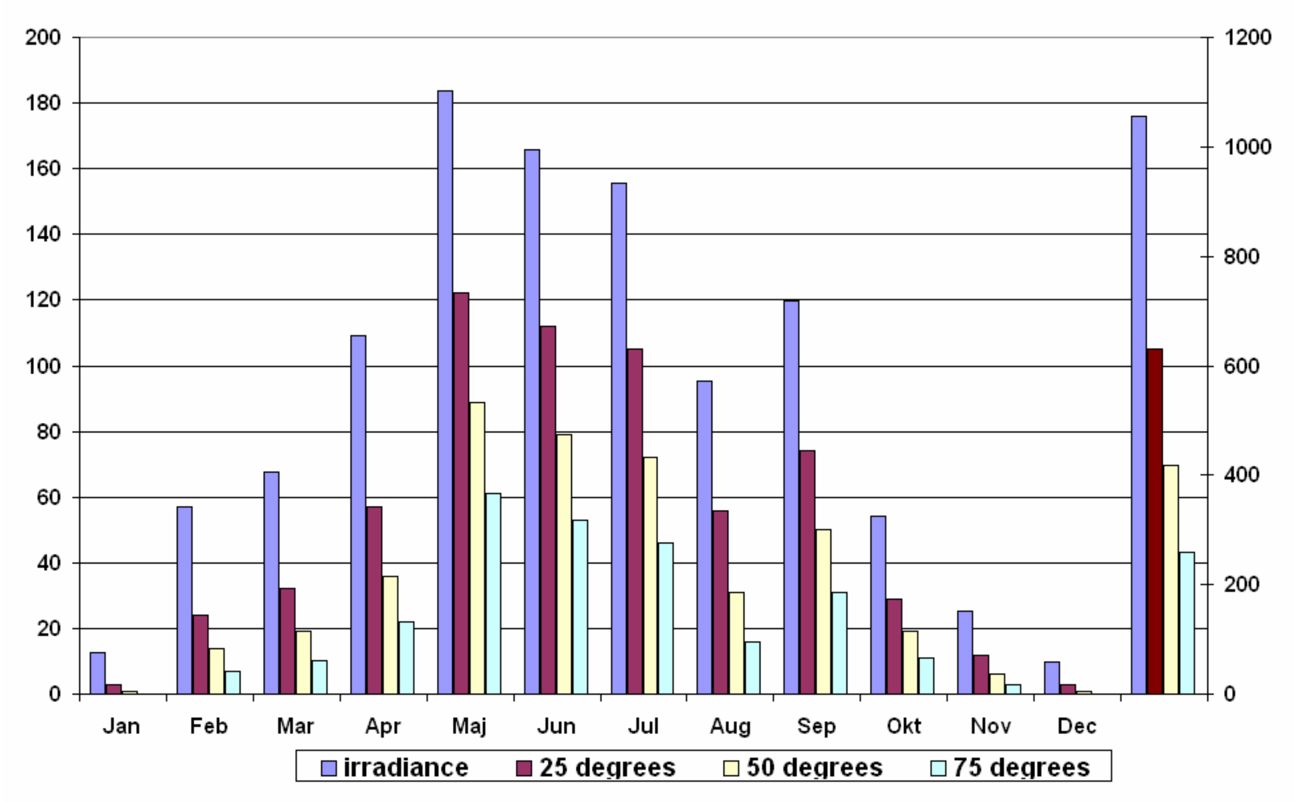

Fig.1. Example of results for monthly and annual energy output for different inlet temperatures calculated with a developed Excel spreadsheet. The left y-axis has the unit kWh per m^2 and month and right kWh per m^2 and year.

Based on the need for a common procedure on calculation of the *energy output from collectors* on the basis of performance test data, it has been decided to develop such a procedure. An inquiry [1] among the participating countries has been carried out and the test laboratories have agreed on the basics of the calculation.
It is assumed that a common procedure for collector output calculations will increase the competition on the market and contribute to an open market for collectors and systems either such figures are used as a base for subsidies, for rating or as a pure consumer information

The outcome from the inquiry led to the following decision about the calculation [1]:

- *Hour by hour calculation with constant collector mean temperature and different climates.*
- *IAM effects should be included and later on even thermal capacitance.*
- *4 climates (Stockholm, Wurzburg, Davos and Athens, preferably from Meteonorm)*
- *3 collector mean temperatures (25, 50, 75ºC), of which 50ºC is chosen as the reference temperature.*
- *To be implemented in Excel.*

It was decided that SP should prepare a draft proposal for such a calculation. The aim was:

- *Should be a part of standard (EN 12975) as an informative annex when ready*
- *Easy to perform but enough sophisticated to take account specific features of most common collectors in the market.*
- *Based on weather data from 4 reference locations in Europe*
- *Relating to the standard for EPBD calculations prEN15316-4-3*
- *Relating to the procedure for m2 to kWh conversion and IEA world statistics*

Short description

A complete description can be found in reference [2]

Inputs

The calculation is based on the following inputs:

- *Collector location (there is possible for the user to add more weather data from more locations): Stockholm, Wurzburg, Davos and Athens*
- *Collector performance data (based on aperture):* η_0 *(weighted as 85% beam (at* $\theta=15°$*) and 15% diffuse),* a_1*,* a_2 *and* $K_{\theta d}$
- *Collector tilt angle (the azimuth is fixed to south): 0, 30, 45, 60 and 90 degrees*
- *Collector mean temperature, variable (25, 50 and 75 is default)*
- *IAM type:*
  - i. *Simple, one direction (e.g. flat plate collector)*
  - ii. *Simple, two directions (e.g. flat plate collector with dependence in to directions or some collectors with reflectors)*
  - iii. *User defined Incidence dependency for every 10 degrees between 0 and 90 both transversally and longitudinally. (e.g. vacuum tubes and collectors with reflectors)*

Calculations

The calculation is based on equation 32 in EN 12975-2:2006 but without dependency of wind, thermal capacitance and sky temperature (and therefore only valid for glazed collectors). The heat delivered to the distribution system (kWh/m^2) is then calculated according to the following equation (see reference [2] or EN 12975-2:2006 for symbols and units):

$$Q/A_a = \eta 0 * K_{\theta b}(\theta) * G_b + \eta 0 * K_{\theta d} * G_d - a_1(t_m - t_a) - a_2(t_m - t_a)^2$$

Where: $\eta 0 = F'(\tau\alpha)_{en} * K_{\theta b}(\theta=15) * 0.85 + F'(\tau\alpha)_{en} * K_{\theta d} * 0.15$

The weather data is taken from Meteonorm 6.0 and hour by hour. No calculations of weather data is made by the program they are all taken from Meteonorm at each tilt and location.

Outputs

The output-sheet is displaying the following data and calculations:

i. A diagram and a table that shows the monthly and yearly calculated energy output for the collector together with global irradiance.
ii. Location, longitude, latitude, tilt angle and time period of the climate data for the chosen location
iii. The collector information, η_0, a_1, a_2, $K_{\theta d}$ together with incidence angle modifier (IAM)

The calculations are not as precise as calculations made in for example TRNSYS or Polysun. The advantages are that the method has a fully transparency. Due to the few parameters it is also easy to use.

Validation and accuracy

The excel-sheet has been compared against two types of commercial software. A TRNSYS model with a solar collector Type 1 and Mode 1 (Presim No. 301) and the "Gross Heat Gain" in Polysun 3.3.

TRNSYS
SP has used the actual model for the annual energy output for calculation regarding the Swedish subsidy since 2003. The inputs for the model have been a reference year (Stockholm 1986 with 1057 kWh/m^2 for a tilt of 45 degrees in south and mean ambient temperature of 6.1 ºC) together with η_0, a_1, a_2 and a table of incidence angle modifier (IAM). For the validation the same climate (Meteonorm) has been used for both TRNSYS and the excel-sheet.

Polysun
The Polysun is develop by SPF in Rapperswil and is also including specific heat capacity. The input for IAM is restricted 50 degrees longitudinally and transversally. There is however possible to choose a model for a flat plate collector or an ETC. The climate for Stockholm has a global irradiance of 1214 kWh/m^2 and a mean ambient temperature of 6.6 ºC. The diffuse irradiance is in Polysun 6.6 % higher than in Meteonorm data.

Result of the validation
The comparison is performed for four types of collectors; one flat plate collector and three types of ETC. The calculations are all done for Stockholm, south, a tilt of 45 degrees, and at the temperatures 25, 50 and 75 ºC. The output has been corrected regarding differences in global irradiance and ambient temperature.

Excel versus Polysun
A positive difference means that the annual energy output is higher for the calculations done with excel and vice versa. The specific heat capacity is in Polysun put to 1 kJ/m^2K. For collectors in the Polysun database

Type of collector / Temperature	**25 ºC**	**50 ºC**	**75 ºC**
Flat plate. Excel with IAM type: Simple, one direction	**0 %**	**1 %**	**-1 %**
ETC double glass, cylindrical absorber and direct connection. Excel with IAM type: Simple, two directions Polysun: Special IAM: No	-4 %	-4 %	-2 %

ETC double glass, cylindrical absorber and heat pipe. Excel with IAM Type: User defined Polysun: Special IAM: No	0 %	4 %	9 %
ETC double glass, cylindrical absorber, flooded. Excel with IAM Type: User defined Polysun: Special IAM: Yes (se Polysun manual)	4 %	6 %	10 %

Excel versus TRNSYS
A positive difference means that the annual energy output is higher for the calculations done with excel and vice versa.

Type of collector / Temperature	25 ºC	50 ºC	75 ºC
Flat plate. Excel with IAM type: Simple, one direction	-6 %	4 %	1 %
ETC double glass, cylindrical absorber and direct connection. Excel with IAM type: Simple, two directions	-11 %	-11 %	-11 %
ETC double glass, cylindrical absorber and heat pipe. Excel with IAM Type: User defined	**-7 %**	**-3 %**	**2 %**
ETC double glass, cylindrical absorber, flooded. Excel with IAM Type: User defined	**-3 %**	**-1 %**	**3 %**

Conclusions of the validation
For flat plate collectors the model is nearly equivalent to the calculations in Polysun and also quite good compared to the TRNSYS model. In calculation with ETC it is recommended to not use the Excel-sheet with "IAM type: Simple, two directions". Excel with IAM Type: User defined and the TRNSYS model gives also a very high conformably in calculations of ETC.

Conclusions

It is recommended to CEN/TC 312 to consider this calculation be a part of standard (EN 12975) as an informative annex.

Further improvements

Add thermal capacitance as an input. Add more locations. It is possible for the user to add more locations but there is maybe desirable to have more locations as normative.

Improved exposure test – accelerated ageing test of collectors

Background

The present European exposure test has been under a lot of debate, mainly due to its inability to maintain uniform test conditions when applied in different parts of Europe. Furthermore it is not considered to reveal the weaknesses of ETCs. Some countries have since long had stricter exposure tests than what is required by EN 12975, and one of the main objectives in the Solar Keymark II project is to eliminate such barriers. Two different methods are now evaluated within the Solar Keymark II project as new candidates for exposure test, but it is not yet clear if any of them will be sufficient enough. The test needs to have the following requirements:

- Main objective is to agree on a standard so that we all do the same test.
- Solve the basic problem of irreproducible test conditions in different locations
- The tests should not be unnecessarily long lasting since it will take to long time to come out with new products and it will give expensive testing.

The present outdoor exposure test was discussed due to the fact that it a) requires a long time to carry out and b) is not proven to give the same results wherever it is applied. Two French and one Australian alternative method have been briefly investigated and the latter is judged as promising. Here, the collector is connected to a heating circuit by which the collector is heated to its stagnation temperature. The collector is then maintained at this temperature for 12 hours per day in 10 days. After that a thermal performance test is carried out at a single test point. A major advantage with this method compared to the CSTB proposal is that the reproducibility of the tests are assured in the way that different national climatic conditions will not at all affect the outcome of the results. The Australian approach is also less time consuming, even compared to the outdoor exposure presently described in EN 12975-2:2006. A drawback of the Australian method is that the cumulative impact of a number of different climate variables such as rain, UV and wind is not assessed.

The Australian method is checked theoretically with the following results:

- Questioned if it will give the result that we expects
- Practical carrying out
    - Difficult to make outdoor in Sweden
    - Expensive in inside in solar simulator
- Australian test works well for flat plate collectors and vacuum tubes without heat pipes. It can also be used for heat pipes if it is done in solar simulator or with hot oil within the piping. It will be more expensive for heat pipes but possible to use.
- The Australian method also requires a retest of thermal performance at one temperature.
- Suggestion that a third method need to be developed
- Check that additional conditions in exposure test will be equivalent with the Australian method.

- When the standard is revised we suggest that more work is needed to agree on a test procedure for this test. The Australian method is a recognized standard that is faster and more repeatable. Solar Keymark therefore believe that all test laboratories will be willing to stand behind one method if a new method is developed with inspiration from the Australian method
- For collectors with an integrated overheating protection the calculation method to get the stagnation is not appropriate

A general acceptance of either the today's method of exposure test in EN 12975, the French's methods or the Australian is not possible to reach within the timeframe of the project.

Conclusions

- NEGST conclusions: Further work on theory and validation needed for a prolonged (6-12 months) outdoor exposure test. Idea of accelerated test on small scale collector was abandoned and FMEA approach not intended for the standard

- ”Australian method” (short term heat cycling) should be more appealing to industry and ”more reproducible”. A proposal based on this method should be developed and discussed in CEN/TC 312 WG 1 as an alternative to the present outdoor exposure.

Performance and quality tests for collectors with evacuated tubes

Most of the work related to development of test methods and quality criteria for solar collectors has been done mainly by considering plate collectors. Only to a minor extent has evacuated tubular collector (ETC) and its specific properties been addressed. ETC collectors today have a remarkable development of the Chinese solar thermal market. In ten years their market shares have grown from 35 to 85 %. The total annual sales of collectors are around 15 million m^2 and growing by an annual 30%. In Europe ETCs have not been the same success so far but their shares are increasing and they have a significantly potential to contribute to a large scale introduction of solar thermal products. In order to meet this market development it is necessary that testing of performance and quality should also take the specific characteristics of ETCs into account. This is considered in the Solar Keymark II project that is developing procedures for quality and performance testing of ETCs.

Items relevant to ETCs with heat pipes:

The heat pipe construction is sensitive in several ways:

- The amount and composition of the evaporating liquid
- The vacuum inside the metal pipe
- The material quality in the pipe and the design of the pipe and the bulb.
- Improper dry connection resulting in low heat transfer capacity.
- Dry out effects during testing under high irradiance
- Risk for freezing, damage due to high temperatures (reflectors), air pockets inside the bulb as a result of improper filling or material……..

These possible failure modes together with the ones resulting from the "metal fin inside double wall glass tube" construction and from the absorber itself makes variable quality and/ or energy performance much more likely for these collectors than for e.g. ordinary flat plate collectors.

The work is based on a questionnaire about ETC testing performed in 2005 among 15 test laboratories, a few manufacturers and importers (Kovács et al., 2007). The purpose of the inquiry was to give a background to an assessment of the need for revised test procedures regarding performance- and quality testing of ETCs. The questionnaire turned out to raise a number of new questions and the ongoing work is based on some of the proposals that were addressed:

- ETCs have comparatively low heat losses which results in higher stagnation- and maximum operation temperatures than compared to flat plate collectors. This means a higher probability for fault to occur during the high temperature- and exposure test that might affect the collector's efficiency. In order to reveal low quality products it is recommended to introduce a test cycle for these collectors. First the collector is measured for efficiency, then to a high temperature- and exposure test and finally for efficiency once again. In order to save costs one of the efficiency tests could be limited to zero loss efficiency, but preferably also the eventual increase in heat losses should be assessed. In order to get knowledge about the affect of introducing a test cycle measurements are ongoing with the test cycle for two types of ETCs.

- Damaging of heatpipes due to freezing can result from improper composition of the working media in the heatpipe or from bad design of the metal tube (material quality, thickness, shape of lower end) and has been reported by several sources (Kovács et al., 2007). As breakage of the metal tube in the case of bad design often doesn't occur until after several freeze cycles, a new procedure for freeze testing has been proposed and will be tested and evaluated within the Solar Keymark II project.

- The EN 12975 standard has today weaknesses of not describing in detail where the stagnation temperature should be measured and with higher stagnation temperatures it will be difficult to determine unambiguous stagnation temperature. Special attention is also required in order to avoid thermal stress on the heat transfer fluid. These problems will be more obvious for ETCs and an investigation is ongoing in the Solar Keymark II project where the stagnation temperatures are measured at different places of the ETC.

- The EN 12975 standard has today weaknesses of difficulties to determine efficiency at high temperatures with good accuracy which will be more obvious for ETCs since they have high operation temperatures. Several laboratories have reported that dry out effects can occur during testing of ETCs with heat pipes during high irradiance conditions and that the present collector model used in the standard was not able to accurately model the thermal capacitance and time constants of the collector. The method available for calculating the thermal capacity of the collector has been reported to underestimate the figures for double glass ETCs. These are also important subject for further research that is needed in near future.

New test cycle for vacuum tubes

Background

In order to reveal low quality products, in particular among ETCs with double glazing's and heat pipes, it was recommended in NEGST to introduce a test cycle for these collectors where the same collector is first measured for efficiency, then subjected to a (possibly revised, tougher) high temperature- and exposure test and then measured for efficiency once again.

A test performed by SP on typical Chinese ETC with heat-pipe did not uncover any difference in performance after a cycle of high temperature test and exposure test with internal and external shock. The industry says in order to show any differences cycles with freezing must be added.

Conclusions

More work is needed before it can be recommended to implement at test cycle for ETCs.

Freezing test with several freeze cycles

The suggested method in NEGST of freeze test of heatpipe has not been carried within Solar Keymark II. The freeze resistance test in EN 12975-2:2006 chapter 5.8 are normally not exposing any problems with ETC

Conclusions

More work is needed before it can be recommended to change the test.

Mechanical load of vacuum tubes:

Background

The mechanical load test in EN 12975-2:2006 is in practice not suitable for tests on vacuum tubes. Due to the round shape of the tubes and the distance between them it is not easy to make a load on the tubes that is corresponding to the reality. The negative pressure test is intended to access the extent to which the fittings between the collector cover and collector box are able to resist uplift forces caused by the wind. This is not relevant for tubular collectors.

The positive pressure of the collector is possible to perform with a plastic folio, but the load on the tube surface is overrated when using 1000 Pa. The negative load is not possible to perform with neither of the procedures described in EN 12975-2:2006 chapter 5.9.2.2.

Today's test at SP

SP is today performing both the negative and the positive load by putting a plastic folio under or on top of the collector. A fan placed under the collector is creating a negative or positive pressure. To make a test better is corresponding to the reality and be able to test the negative load SP are using the plastic folio and a downscaled load. The folio is able to put between the tubes and the foundation or reflectors. The downscaled load is calculated as:

(Area of header + outer tube diameter * length of tubes) / (Gross area of the collector)

This is often resulting in a pressure between 600 and 800 Pa. SP has tested more than 15 vacuum tubes collector with more than 300 tubes for positive and negative load and no one has failed. This is of course not guaranteed that all tubes are resisting this test.

Today's test at INETI

INETI uses the suction cups for the mechanical load test, and in the case of ETC they could perform the negative load using an iron plate where the suction cups were applied. The iron plate is then fixed to the base structure of the collectors. This has only been applied to a collector with reflector.

With this methodology they could only test the fixing of the collector and reflector to the roof and not the collector itself (the tubes and header), which seems to be a problem when there is no reflector behind. They consider that a test should be done if the collector has a reflector and in this case positive and negative pressure would be needed but the form to apply the positive pressure has to be decided.

Conclusion

It is decided to skip the negative pressure test within Solar Keymark right now and wait for any decisions about reversion of EN 12975. It is at the same time recommended to CEN/TC 312 to skip the negative pressure tests in EN 12975 for vacuum tubes. An alternative is to perform the test with plastic folio both for positive and negative load. A third alternative is to only carry out the test for vacuum tubes with reflectors.

Measurements on stagnation temperature on vacuum tubes

Background

According to EN 12975-2:2006 the stagnation temperature shall be measured at two-thirds of the absorber height and half the absorber with (5.3.2). This is not suitable for vacuum tubes. In two notes there are given an opportunity to choose an alternative location and an alternative method of the measurement. The location or method should then be clearly described with the test results.

There is in many ways helpful to straighten out where the highest temperature is expected. For example, this could unveil uneven quality in the performance of the tubes or the whole collector.

Measurements on double-glass vacuum tubes reveal that is likely to find the highest temperature in the top of the bulb at vacuum tubes with heatpipe and near the header in vacuum tubes with U-pipe.

On single glass it is not possible to get access to the absorber and therefore the above location of the temperature sensor is not applicable. A measurement inside the header or riser does not seam to differ much from the temperature inside the actual tubes.

Conclusion

It is recommended to CEN/TC312 to more precise define where the temperature should be measured for vacuum tubes (According to Note 1 in chapter 5.3.2). A suggestion is given below:

Type of collector	Position of measurement	Comments
Flat plate collector	Backside of the Two-thirds of the absorber height and half	As stated in EN 12975 today
Double-glass vacuum tubes with heatpipe	Just below the top bulb inside the tubes - in at least 3 tubes	E.g. thermocouple attached to the cupper tube
Double-glass vacuum tubes with U-pipe	Near the header – in at least 3 tubes	E.g. thermocouple attached to the cupper tube
Single lass vacuum tubes	Inside the header	E.g. thermocouple attached to the cupper tube or a surface sensor
Concentrating collectors (not vacuum tubes)	On the absorber - on a spot in the middle of the absorber with assumed highest concentrating factor	E.g. thermocouple attached to the absorber

Collector components - requirements and test methods

Durability testing of solar absorber coatings, anti reflective coatings, reflector materials and polymer components of solar collectors were early addressed as important subjects for improvement of standards and they have already been accepted as part of upcoming revisions of EN 12975 by the CEN/TC 312 meeting in Canary Islands in April 2006.

The absorber itself, in the collector, is directly or indirectly subjected to a number of tests in the present standard for collector testing EN 12975. Requirements for reliability are also defined. However, for the long term durability of the absorber or more specifically, the absorber coating, there are no requirements. Considering the rapid and continuously ongoing development of new materials, coatings etc. and the increasing specialization among manufacturers, it is assumed that manufacturers of absorbers could benefit from methods that can ”predict” a long service life. Standardised methods and requirements would also benefit their clients, the collector manufacturers, who would then be able to strengthen quality requirements on their suppliers. A new document: “Recommended qualification test procedure for absorber surface durability” (Carlsson, 2004) describes tests applicable to organic and inorganic coatings can more or less be considered ready for inclusion in the standard.

Polymer materials have so far only been used to a limited extent in solar thermal applications. In low temperature applications such as pool heating the introduction has been very successful and in general without problems related to the materials. On the contrary, in medium and high temperature applications where polymers were tried to replace inorganic materials, it has in general failed. As polymers definitely have many potential advantages to offer in solar thermal applications compared to traditional materials, it will be useful to researchers and manufacturers to have a set of common tools and methods to assess their properties and suitability for more demanding applications. The work to include these considerations into the standard is still within the starting phase but there are some methods that can provide an extensive input to this field.

Another subject for improvements of standards is the increasing use of reflectors and anti reflective coatings of cover materials as a cost efficient way of improving the performance. It is a highly exposed component having a high influence on the performance, but is not assessed in the present standard. For example it is a need to be able to assess the long term effects on the collector output. At present no standardised methods are available for this purpose.

Background

With regard to requirements and test methods for collector components (absorber surfaces, polymer absorbers etc.) it has been decided to develop a proposal for revision of EN 12975 mainly based on existing documents from ISO and IEA.

Description

- Absorber coating surface
- Polymer materials
- Reflector and anti reflective coatings of cover materials

Testing solar collectors´ ageing and corrosion characteristics

The test method includes [4]:
Cover of plastic
Absorber surfaces in solar collectors with and without cover sheets

Requirements

Measure the absorption α (weighted with the solar spectrum, air mass 2) and the emissivity ε (at 100 °C) before and after testing. Neither the absorption nor the emissivity may have been reduced or increased respectively by more than 5 percentage points after testing. The samples must not either exhibit any traces of crazing, flaking or cracking, or show changes in color.

However, color change can be accepted if the absorption or emissivity has not reduced or increased respectively by more than 5 percentage points after testing.

Polymeric materials in solar collectors

See reference [5]

Requirements

- The reduction in solar absorptance must not exceed 5 % in absolute terms after ageing.
- The reduction in solar transmittance must not exceed 10 % in absolute terms after ageing.
- Normally a reduction of 50 % of the measured characteristic is accepted after ageing relative the un-aged material.

Together with these methods/recommendations also recommended to look at the work what is ongoing in IE ASH&C Task 39.

References

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[6] *Specification of physical properties for ETC, Ulrik Pettersson, 2007-12-10*