Quality Assurance in solar thermal heating and cooling technology

Keeping track with recent and upcoming developments

Summary report on durability and reliability requirements and test methods for collectors and components including proposal for changes or complements to current EN 12975

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Deliverable D2.2

1 Summary

Work related to improvement of durability and reliability testing o collectors according to the EN12975 standard was given high priority in work package 2 “Collectors” of the QAiST project. As a result all QAiST partners have taken part in this work and a huge amount of experience has been utilized when the main deliverables of this WP were developed. Table 1 shows the performance indicators related to these deliverables and chapter 3 shows how they were fulfilled in the project. In chapter 4 the main contents of the QAiST reports related to collector durability and reliability that were produced are briefly presented and in chapter 5 the specific inputs to the standard revision on each topic are presented. It also shows how the changes will affect the execution of the standard and the outcome of the tests.

Most inputs have already been integrated in the revised EN 12975 standard during the course of the QAiST project but additional ones will also be added during the currently on-going review/ inquiry process. Some topics have not been possible to cover completely, and additional work will be required before some more optimum solutions for the standards are found. Here, the QAiST project has provided a good platform to build the work on.

2 Introduction

This report presents deliverable D2.2 of the QAiST project. It summarizes the work carried out in subtask 2.1.2 of Work package 2 “Solar collectors”. This subtask has focused on durability testing and assessment of collectors and collector components and the report gives a summary of several detailed technical reports that were produced within the subtask, see chapter 4.

The work of subtask 2.1.1 which focused on performance of tracking and/ or concentrating collectors (mid- temperature collectors) constitutes deliverable D2.1, which is divided into three reports:

- R2.1 Performance testing of Evacuated tubular collectors
- R2.2 Experience from tests on concentrating and tracking collectors (R2.2 was merged with R2.3 which was initially planned as a separate report)
- R2.4 Collector component characterization

These three reports are NOT part of this summary report. Some parts of these reports that relates to durability are however summarized in Table 4. For logistical reasons durability issues related to tracking/ concentrating collectors are included in report R2.4.

As the title of the report indicates, this work was mainly aimed at providing input to the revision of the European standards for testing solar thermal collectors, EN 12975-1 and-2:2006, [1] and [2]. At the start of the QAiST project it was not possible to predict to what extent the project would be able to cooperate with the technical CEN committee CEN/TC 312, responsible for this standard. As it turned out this developed better than what was expected. Not only was the TC reactivated simultaneously to the QAiST start after some years of inactivity and the leader of QAiST WP2 elected convener of the CEN/TC 312/WG1, working

group of collectors. Even more important was the fact that the QAiST project enabled a high level of activity within this working group. This enabled QAiST to provide a substantial contribution to the on-going revision of the standards, partly in terms of delivering the "proposal for changes and complements" as reported here, but also in terms of active contribution to the finalization of the new draft standard.

Furthermore, the QAiST project was successful in its ambitions to reach an international harmonization of these standards. Thus, the draft prEN 12975-2 standard developed within CEN in parallel to QAiST was adopted as a draft ISO standard, prEN ISO 9806 [3], aiming to replace the current ISO 9806 series of standards [4], [5] and [6].

3 Objectives and performance indicators

A number of specific objectives were outlined for QAiST WP 2. They can be summarized as three main objectives:

1. *To extend the scope of the EN 12975 standard* in order to make thorough technical assessment of new collector types possible, thus providing good support for further development and enabling Solar Keymark certification which in turn will facilitate their market access

2. *To improve the test methods for state of the art products* in the standard based on the requirements of the industry and on current market development and experiences. This can be further detailed as:
    a. Improving test methods that were shown to be inefficient, either to make them more time/cost effective or to make them "sharper" to reveal critical weaknesses of collectors that so far could pass undetected
    b. Clarification of requirements for pass and fail
    c. Harmonization of test procedure application among European laboratories and optionally on the international level

3. To improve the presentation of results from the tests

How these objectives were reached through the work in WP2 when it concerns durability and reliability issues is explained in chapters 4 and 5. Reviewing the target performance indicators for WP2, deliverables D2.1 and D2.2, see **Table 1**, it can be concluded that the targets were reached and surpassed. Both deliverables were as already mentioned integrated in the new draft standard and submitted not only to CEN inquiry but to a parallel CEN/ ISO inquiry. Furthermore, despite the fact that consortium members had significantly different views on a number of topics discussed, all proposals delivered were agreed by more than ¾ of the members.

Table 1 Performance indicators for QAiST WP2 "Solar collectors" related to deliverables D2.1 and D2.2

Specific Objectives	Result Indicators:	Target (quantification) of success:
▪ Extending the scope of EN 12975 to fully cover also medium temperature collectors (tracking, concentrating collectors, evacuated tube collectors)	▪ Status of draft of revised standard EN 12975 (D2.1)	▪ Draft agreed by at least ¾ of the project consortium members involved in the relative task (T2.1.1) ▪ Draft submitted to CEN TC 312 for CEN inquiry
▪ Clarification of durability and reliability requirements and test methods in EN 12975	▪ Status of proposal for clarifications (D2.2)	▪ Proposal agreed by at least ¾ of the project consortium members involved in the relative task (T2.1.2)

4 Contents of work carried out

In this chapter an overview of the technical reports that are parts of deliverable D2.2 are presented, see Table 2. Discussions at the first QAiST meetings resulted in a list of priorities and responsible persons and institutions were assigned to the different work tasks. Some tasks, e.g. work on ETCs, impact resistance- and mechanical load testing could be aligned to on-going research at different institutes and could also benefit from liaisons within CEN. Other, e.g. work on rain penetration, stagnation temperature and pressure drop, where performed as stand-alone activities within the QAiST project. Furthermore some tasks were solved by means of discussions and summaries of existing data and knowledge whereas others, being the main part, were further supported by practical inputs.

Table 2 Technical reports forming part of deliverable D2.2

Report name	Report number	Main contents
Summary report on rain penetration tests	R2.10	• Review of evaluation criteria in the current EN 12975 standard • Proposal for a revised method based on AS-NZS-2712-2007 • Proposal for improved evaluation criteria • Report on practical experiences from application of the revised method by five laboratories • ***Inputs to revision of EN 12975***
Summary report on one year exposure[1]	R2.11	• Background to decision to carry out one year exposure test at nine laboratories • Reports on performance measurements on 20 collectors whereof 16 ETCs with heat pipe, before and after the one year exposure plus observations on degradation

[1] See also Table 4

Report name	Report number	Main contents
		• **Input to revision of EN 12975**
Summary report on pressure drop measurements	R2.13	• Background to pressure drop measurements on solar collectors and why a generalized method would be desirable • Review of pressure drop theory • Report from measurements on a flat plate collector using different fluids and temperatures • Proposals for a generalized method and for further work
Summary report on freeze testing of heat pipes	R2.15	• Background explanation of need for freeze testing of heat pipes • Report on practical tests based on two different approaches • Proposal of a new mandatory test method including evaluation criteria • ***Inputs to revision of EN 12975*** • Proposals for further work
Summary report on impact resistance test	R2.16	• Background explanation of need for impact resistance test • Summary of four different methods: IEC test for PV modules, Swiss method and the two EN 12975 methods • ***Inputs to revision of EN 12975*** • Proposals for further work
Summary report on mechanical load tests	R2.17	• Background explanation of what mechanical loads and the related testing is about in practice, how it relates to PV module testing, to CE-marking and to CPD ("Structural safety") and how it is a topic of many different CEN TCs • Short review of shortcomings in the current methods of EN 12975 and 12976 • ***Inputs to revision of EN 12975 and EN 12976 and to the guide to EN 12975*** (Deliverable D2.3) • Review of some on-going work and proposal for further work • Summary of detailed studies of loads on collectors and systems (Annex)
Summary report on absorber surface durability	R2.18	• Background explanation of need for absorber surface durability testing • Short explanation of the "Task X method" which is introduced as a new standard • ***Inputs to revision of EN 12975 and to a new ISO standard on collector components and materials*** • Proposals for further work
Summary report on stagnation	R2:19	• Background explanation of the need for

Report name	Report number	Main contents
temperature determination		stagnation temperature determination on solar collectors • Summary of approaches offered in the EN 12975 including sensor positioning descriptions • Evaluation of a new method for calculating the stagnation temperature based on performance test results • **Inputs to revision of EN 12975**
(Guide to EN12975)	D2.3	• Not summarized in this report but mentioned since it also contains results of an overview of collector failures encountered during testing

5 Inputs to revision of standard EN 12975

Inputs to the revision of the EN12975, effectively to the prEN 12975-1 and to the prEN ISO 9806, which aims to replace EN 12975-2, have been provided on a multitude of topics. The extent of the inputs vary a lot, from thoroughly revised methods and evaluation criteria, as in the case of the rain penetration test, or completely new standards, as in the case of absorber surface durability, to small however important inputs as in the case of the freeze test method where so far only some wording was changed but a whole new method is being developed. **Table 3** summarizes the various inputs, the effects they will have on the practical execution of EN12975/ EN ISO 9806 and on the outcome of the tests.

Table 3 Overview of the inputs to the EN 12975 revision

Report name	Report number	Type and extent of input	How it affects the execution of the standard and the outcome of tests
Summary report on rain penetration tests	R2.10	Clarified test- and evaluation criteria	• Improved harmonization between laboratories • Improved repeatability • Improved accuracy in judgements on pass and fail • Better feedback to manufacturer when products fail
Summary report on one year exposure[2]	R2.11	Recommendation for post exposure performance test of ETC with heat pipe. Concept of exposure severity classes introduced	• Longer testing time for ETCs with heatpipes • Tougher and more relevant testing of ETCs with heatpipes • On an average, at least initially, lower performance reported for these collectors

[2] See also Table 4

Report name	Report number	Type and extent of input	How it affects the execution of the standard and the outcome of tests
			•
Summary report on pressure drop measurements	R2.13	No direct input so far	
Summary report on freeze testing of heat pipes	R2.15	At present only a minor text change making freeze testing of heat pipes using water as heat transfer media mandatory Proposal of a new test method including evaluation criteria is under preparation and will be included in the inquiry phase	• Slightly increased testing costs for ETCs with heat pipes • Freezing problems related to ETCs with heat pipes eliminated or radically reduced
Summary report on impact resistance test	R2.16	Clarified testing criteria. Test proposed to be mandatory but with option for “No hail classification”. Steel ball test ok for pass judgement	• Slightly increased testing costs for some collectors but reduced for others • Improved harmonization between laboratories and to PV module testing • ETCs and FPCs are more equally treated •
Summary report on mechanical load tests	R2.17	Clarified testing criteria. Concept of load classes introduced. Minimum load level increased. Improved reporting format	• Tougher tests as fixing points and a set of mounting equipment are also tested. • Improved harmonization between laboratories and to PV module testing
Summary report on absorber surface durability	R2.18	New EN and ISO standards based on the IEA SH&C Task X method	• Improved harmonization between laboratories • Enables future certification of absorber surfaces and facilitates exchange of absorbers within a given collector certificate
Summary report on stagnation temperature determination	R2:19	Clarified testing criteria. New simplified calculation method introduced for FPCs. Improved reporting format	• Improved harmonization between laboratories • Reduced costs for some collector types • Stagnation temperature required in the installer manual

Table 4 Complimentary information related to durability in the revision of EN12975 supplied in other QAiST reports

Deliverable/ Report	**Type and extent of information**
R2.1 Performance testing of Evacuated tubular collectors	• In conjunction to the one year exposure tests reported by CSTB in R2.11 some performance measurements were repeated already after the normal exposure of minimum 30 days. ISFH and ITW carried out these additional tests which are reported in Annex 2 of R2.1. The conclusion from these tests was that significant degradation, resulting in a reduced power output had occurred already after 30 days of outdoor exposure of ETC:s with heat pipe. • Analysis from ISFH of the effect of heat transfer paste degradation on the performance of ETCs with heat pipes led to the conclusion that this can have a significant negative effect and that the quality of heat transfer paste should be defined by a standardized test. This test is still to be elaborated.
R2.2 Experience from tests on concentrating and tracking collectors	• Based on these experiences a new mandatory annex P was developed and introduced in the revised EN 12975 standards. The annex “Reliability testing of concentrating and tracking collectors” explains particular aspects of durability testing on this type of collectors. E.g. the concept of “active overheating protection” is introduced in the standard.
R2.4 Collector component characterization	• Characterization and durability testing of the main components of medium temperature collectors, the receiver and the reflector is presently attaining a strong focus from the CSP business but still haven’t been implemented in any specific collector component standards. A draft standard for receivers and a guideline for optical characterization of reflectors are available. • CSP technology has recently been taken up by IEC/TC117 and CEN/TC 312 has decided to follow this work rather than trying to develop their own standards for receivers and reflectors. A similar strategy is taken with respect to testing of trackers which is dealt with in IEC/TC82. Here, a technical specification is available as IEC 62727 TS Ed.1: “Specification for solar trackers used for photovoltaic systems”
D2.3 Guide to EN12975	• Additional clarifications on testing practice, evaluation criteria (picture examples of failures) and reporting. This is primarily directed to new test laboratories and based on the experiences from several well established laboratories. It is meant to give new laboratories a good introduction to the work with collector testing and also to improve the harmonization between laboratories. • Directives for in-house testing following as close as possible the EN 12975 standard. Chapter 9 of the guide is directed to manufacturers explaining how many tests can be performed in-house with acceptable accuracy for product development.

6 Discussion and conclusions

The QAiST project has enabled a strong and fruitful collaboration between the European solar thermal industry and institutions involved in research and quality assurance. In the context of this report it has been directed to the further development of test standards for solar thermal collectors and their components and more specifically to their durability and reliability. Maintained performance during a long lifetime is as important as a competitive cost/ performance ratio for the competitiveness of these products. In particular for new innovations it's a prerequisite for market acceptance that these properties can be assessed and somehow guaranteed.

The QAiST reports summarized herein forms a strong basis for the revision of the EN 12975 standard and will result in a number of improvements. Clarified acceptance criteria and improved methods will facilitate harmonization on a European as well as on an International level and open up for new innovations. Most inputs have already been integrated in the new draft standard during the course of the QAiST project but additional ones will also be added during the currently on-going review/ inquiry process. Some topics have not been possible to cover completely, and additional work will be required before some more optimum solutions for the standards are found. Even in this case however, the work of QAiST has provided a good platform to build the work on.

7 References

[1] CEN, European committee for standardization, 2006 “EN 12975-1:2006, Thermal solar systems and components - Collectors - Part 1: Requirements”

[2] CEN, European committee for standardization, 2006 “EN 12975-2:2006, Thermal solar systems and components - Collectors - Part 2: Test methods”

[3] prEN ISO 9806: 2012/ ISO DIS 9806:2012. Solar Energy-Solar thermal collectors-Test methods

[4] ISO 9806-1:1994. Test methods for solar collectors -- Part 1: Thermal performance of glazed liquid heating collectors including pressure drop

[5] ISO 9806-2:1995. Test methods for solar collectors -- Part 2: Qualification test procedures

[6] ISO 9806-3:1995. Test methods for solar collectors -- Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop