Annex P5.5 In-Situ Testing

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1. Abbreviations

The definitions in the Solar Keymark Scheme Rules apply.

2. Foreword

This document was elaborated by a working group chaired by Stefan Mehnert (Fraunhofer ISE) with the members Stefan Fischer (University Stuttgart), Uli Fritzsche (TÜV Rheinland), Maria João Carvalho (LNEG), Christian Stadler (ARCON-SUNMARK now Viessmann), Katharina Vehring (Din Certco) Carsten Lampe (ISFH)

The present document defines procedures for In-Situ-Certification. In-Situ-Certification is understood as Solar Keymark certification based on in-situ measurement data collected at the “manufacturers' premises”, outside the laboratory at the installed collector (field) under the given operating and installation conditions.

In case of in-situ-tests and measurements it is not possible to be fully in compliance with the requirements of ISO 9806. Some boundary conditions (e.g. installation requirements during performance testing, stability criteria regarding the inlet/outlet temperature, and others) must be adapted to a certain installation. Nevertheless in-situ-testing shall lead to a comparable set of collector parameters / collector power output like laboratory testing.

3. Introduction

The present document defines procedures for In-Situ-Certification. In-Situ-Certification is therewith understood as Solar Keymark certification based on in-situ measurement data collected at the “manufacturers' premises”, outside the laboratory at the installed collector (field) under the given operating and installation conditions.

A “manufacturers’ premises” is herein understood as either the place of production or the operational facility.

At any time of the certification procedure the measurement equipment has to be fully under control of the accredited testing laboratory. The selection, provision, maintenance, calibration and installation of the instrumentation as well as the performance of the measurement, the data storage and data transmission are subjected to the accredited testing laboratory.

“Witness testing” - tests done at the manufacturers’ premises by an employer of an accredited testing laboratory in the presence of another person (from manufacture, certifier,

…) - and/or “supervised manufacturers’ testing" – tests done at the manufacturers’ premises by an employer of the manufacture in the presence of a supervising person from an accredited testing laboratory, are not covered by this document.

In-situ testing must not necessarily be limited to existing applications. It is also imaginable to consider in-situ-testing during the planning and installation of a collector field. Also, in-situ testing is not limited to performance characterization.

4. Scope

In-situ certification is targeting but not limited to collectors which because of their size, power output, weight, operating conditions or on-site production can hardly be tested in a laboratory.

5. Quality and function testing

Quality and function testing shall either be done at the field installation and/or in the testing laboratory using an additional collector / collector component. A minimum requirement is that the full set of function tests of ISO 9806 is to be reported.

6. Thermal performance testing

6.1 Methods

In-situ thermal performance testing has to be performed using QDT with the equation given in ISO 9806. All parameters have to be initially determined. If a parameter is found to be physically implausible or has a T-Ratio of less than 3, it can be excluded.

6.2 Uncertainty determination

Since the boundary conditions during the performance test deviate from the normative requirements an uncertainty determination of the identified parameters is essential and has to be reported in proper manner for each parameter separately

6.3 Fluid heat capacity

Current field measurements / evaluations show that the heat capacity of the heat transfer fluid (can) have a high impact on the uncertainty of the determined parameters. Also, huge deviations between manufacturers' specifications and experimental results regarding the density and the specific heat capacity occurred.

If a heat transfer fluid other than water is used, a sample of the fluid has to be taken, and the density and specific heat capacity of the sample have to be determined experimentally in the temperature range required for in-situ testing.

6.4 Collector mounting and location

ISO 9806 requires that: „The collector shall be mounted such that the lower edge is not less than 0,5 m above the local ground surface."

This requirement is not applicable for In-Situ-Measurements, as collectors are tested in their real state of installation. For this reason the following deviation is permitted for In Situ testing: "In case of in-situ-measurements the requirement defined in ISO 9806:2025, 19.1,"The collector shall be mounted such that the lower edge is not less than 0,5m above the local ground surface." is not applicable. The product shall be tested in its usual installation. A remark shall be included into the test report, describing the installation conditions."

6.5 Shadowing

For efficiency testing collectors shall be chosen, that are not affected by shading from surrounding buildings or other obstacles. If this is not possible, measurement sequences including partial shadowing shall be excluded from the evaluation instrumentation.

6.5.1 Solar radiation measurement

For concentrating (CR>3) collectors the regulations of ISO 9806 apply without restrictions.

For collectors with a CR<3 the regulations of ISO 9806 apply only for the hemispherical irradiance. The share of diffuse irradiance may also be determined with alternative maintenance-free sensors, e.g. the SPN1 pyranometer from Delta-T-Devices Ltd. The determined diffuse share shall then be applied on the irradiance level determined with the class 1 pyranometer. The usage of other then the normative equipment shall be reported and considered for the uncertainty analysis.

The measurement equipment shall be placed at a representative position for the collector(s) under test.

Special attention shall also be paid to the subject of sensor cleaning and maintenance.

Annotation: In a laboratory comparison test on a FPC, the above-mentioned combination of class 1 pyranometer for the determination of global irradiance and SPN1 pyranometer for the determination of the diffuse share, has shown very small deviations of 0,003 in $\eta_{0,hem}$, and 0,01 in K_d. In laboratory as well as in field tests, the usage of the SPN1 pyranometer even for the global irradiance has shown to result in maximum deviations of 0.005-0.02 for η over the complete efficiency curve. The deviations were always to the disadvantage of the collector. The applicability of the SPN1 pyranometer as sole irradiance sensor also for hemispherical irradiance shall be further tested in the future.

6.5.2 Measurement of the heat transfer fluid temperature (Liquid heating collectors)

Placement

To identify parameters that represent the whole set of operating conditions for the field, it may be necessary to combine measurement data from a number of different collectors in the field into one data set for parameter identification. It is recommended to take into account at least the first (cold) and the last (hot) collector of a row.

Sensor types

Previous results show that only immersion temperature sensors lead to useful results. Comparisons with clamp-on temperature sensors have shown large deviations of up to over 10%-points in the efficiency. Only immersion sensors according to normative requirements shall be used.

6.5.3 Surrounding air speed

Wind Speed shall be measured at each collector of the field which is considered for in the efficiency test.

6.5.4 Flow rate measurement (Liquid Heating Collectors)

There shall be no inflow or outflow between the installation point of the flow sensor and the balanced collectors.

In some cases, the installation of an integrated flow sensor in pre-existing collector fields may be impossible. Ultrasonic clamp-on flow meters may be an alternative. For this kind of sensors, in-depth knowledge of the prevailing flow conditions is crucial to obtain reliable results. The use of sensors of this sensor type shall only be allowed if a measurement uncertainty of less than 2% can be assured.

In any case, the method(s) used must be explained and described in detail in the test report.

6.6 Test conditions (ISO 9806:2025, Chapter 22.3)

As operating conditions in the field are typically less stable than in the laboratory longer averaging intervals are helpful to find useful measurement sequences. Averaging intervals of 5 minutes are recommended (as in the former EN 12975) and have shown to be suitable in previous tests.

ISO 9806 requires that: “The flow rate shall be held stable according to Table 6 (steady-state) or to within ±2 % (quasi-dynamic) of the set value during each test period and shall not vary by more than ±5 % of the set value from one test period to another.”

This requirement is not applicable for In-Situ-Measurements, as many installations use flow as control variable for temperature and is replaced by the following: In case of in-situ measurements the limit for the flowrate stability may have to be adapted to the prevailing process conditions to obtain valid measurement sequences. Deviations from the normative requirements shall be mentioned in the test report and must be considered within the uncertainty determination.

Annotation: In previous tests, limits of up to 15% have shown to be acceptable if averaging intervals of 5 minutes are chosen. This value is empirical, and its general validity shall be further examined and substantiated in the future.

6.7 Test sequences (ISO 9086:2025, Chapter 22.4.3)

ISO 9806 requires that: “The inlet temperature shall be kept stable within ± 1 K during each test sequence.“

This requirement is not applicable for in-situ measurements, as the inlet temperatures are less stable in most installations and is replaced by the following: For in-situ measurements, the inlet temperature stability limit may be adapted to the prevailing process conditions to obtain valid measurement sequences. Deviations from the normative requirements shall be stated in the test report and shall be taken into account in the uncertainty determination.

Annotation: In previous tests, limits of up to 3.5K have shown to be acceptable if averaging intervals of 5 minutes are chosen. This value is empirical, and its general validity shall be further examined and substantiated in the future.

6.8 Determination of IAM

For optically symmetric collectors the values of θ_i shall cover angles where the incidence angle modifier does not differ by more than 2 % from the one at normal incidence up to angles of at least 60°.

The determination of bi-axial IAM values is possible using the iterative method described in Hofer et al., 2015. As for this method it is crucial to provide a sufficient variety of incidence angles in both axes, it is recommended to evaluate the largest and smallest achievable incidence angles at the designated test site beforehand. In each axis angles where the incidence angle modifier does not differ by more than 2 % from the one at normal incidence up to angles of at least 60° shall be covered.

If a sufficient range of incidence angles cannot be provided, the IAM shall be evaluated by analytical means and incorporated in the efficiency test as fix values.

In any case, the method(s) used must be explained and described in detail in the test report.

6.9 Accreditation requirement

As the data for a certification process are generated at an external site, the respective laboratory needs accreditation for doing so. This has to include methodological means to provide data security and uncorrupted data transfer.

6.10 Random sampling

The Solar Keymark Scheme rules require random sampling from current production or from the stock of the manufacturer. If this requirement is not applicable for In-Situ testing, the following rules apply:

Case 1: in-situ-tests/-measurements are planed prior the installation of the collector field -> sampling procedure is applicable. The testing laboratory shall randomly select those collectors which are going to be tested within the field and shall define its positions within the field.

Case 2: the field is already installed -> random selection shall be done out of the field by choosing a collector/collector row for installing the measurement equipment.

If neither case 1 nor case 2 are applicable for some reasons (e.g. the field consists of a too small number of collectors), a different solution shall be agreed with the certifier. For example in order to compensate the random selection, more attention can be paid to physical inspection.

In any case, the method(s) used must be explained and described in detail in the test report.

7. References

Hofer A., Buchner D., Heimsath A., Fahr S., Kramer K., Platzer W., Scholl S., 2015. Comparison of Two Different (Quasi-) Dynamic Testing Methods for the Performance Evaluation of a Linear Fresnel Process Heat Collector, Energy Procedia (69) 84-95, ISSN 18766102, URL http://www.elsevier.com/ locate/Procedia