



FINAL DRAFT International Standard

ISO/FDIS 9846

Solar energy — Calibration of a pyranometer using a pyrhelimeter

*Énergie solaire — Étalonnage d'un pyranomètre utilisant un
pyrhéliomètre*

ISO/TC 180/SC 1

Secretariat: **SA**

Voting begins on:
2025-05-16

Voting terminates on:
2025-07-11

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

ISO/FDIS 9846

<https://standards.iteh.ai/catalog/standards/iso/277305b3-1ce7-4b45-9997-6b8cc42390e8/iso-fdis-9846>

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

ISO/FDIS 9846

<https://standards.iteh.ai/catalog/standards/iso/277305b3-1ce7-4345-9997-6b8cc42390e8/iso-fdis-9846>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2025

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Selection of methods	7
5 Alternating sun-and-shade method (shade/unshaded method)	8
5.1 Principle	8
5.2 Apparatus	9
5.2.1 Pyranometer	9
5.2.2 Pyrhelimeter	9
5.2.3 Solar tracker	9
5.2.4 Shade device	10
5.2.5 Data acquisition system	11
5.3 Measurement conditions	11
5.4 Measurement site	12
5.5 Installation	12
5.6 Calibration procedure	13
5.6.1 Preparatory phase	13
5.6.2 Measurement phase (single series)	13
5.6.3 Data sampling	15
5.7 Calculation of sensitivity	15
5.7.1 Initial data rejection and filtering	15
5.7.2 Calculation of individual sensitivity values	15
5.7.3 Computation of the sensitivity of the test pyranometer	16
5.7.4 Evaluation of the final results	16
6 Continuous sun-and-shade method (component sum)	17
6.1 Principle	17
6.2 Apparatus	18
6.2.1 Pyranometers	18
6.2.2 Pyrhelimeter	18
6.2.3 Solar tracker	18
6.2.4 Shade device	18
6.2.5 Data acquisition system	18
6.3 Measurement conditions	18
6.4 Measurement site	18
6.5 Installation	18
6.6 Calibration procedure	18
6.6.1 Preparatory phase	18
6.6.2 Measurements	19
6.6.3 Data sampling	19
6.7 Calculation of sensitivity	19
6.7.1 Initial data rejection and filtering	19
6.7.2 Calculation of individual sensitivity values	19
6.7.3 Computation of the sensitivity of the test pyranometer	20
6.7.4 Evaluation of the final results	20
7 Collimation tube method	20
7.1 Principle	20
7.2 Apparatus	20
7.2.1 Pyranometer	20
7.2.2 Pyrhelimeter	20
7.2.3 Solar tracker	20

ISO/FDIS 9846:2025(en)

7.2.4	Collimation tube	20
7.2.5	Data acquisition system	22
7.3	Measurement conditions	22
7.4	Measurement site	22
7.5	Installation	22
7.6	Calibration procedure	23
7.6.1	Preparatory phase	23
7.6.2	Measurements	23
7.6.3	Data sampling	23
7.7	Calculation of sensitivity	23
7.7.1	Initial data rejection and filtering	23
7.7.2	Calculation of individual sensitivity values	23
7.7.3	Computation of the sensitivity of the test pyranometer	24
7.7.4	Evaluation of the final results	24
8	Calibration uncertainty	24
9	Certificate of calibration	25
Annex A	(informative) Shade disc devices and solar tracker alignment	26
Annex B	(informative) Calculation of the sun incidence angle on an inclined plane	29
Annex C	(informative) Motivation on number of measurement days	31
Annex D	(informative) Extended version of the sun-and-shade method	33
Annex E	(informative) Sample averaging of the alternating sun-and-shade method	34
Annex F	(informative) The Forgan alternate method	35
Annex G	(informative) Comparison of the alternating sun-and-shade method (ASSM), continuous sun-and-shade method (CSSM) and collimation tube method (CTM)	37
Annex H	(informative) Uncertainty evaluation for pyranometer calibration	38
Annex I	(informative) Introduction of a new pyranometer sensitivity	41
Bibliography		42

ISO/FDIS 9846

<https://standards.iteh.ai/catalog/standards/iso/277305b3-1ce7-4345-9997-6b8cc42390e8/iso-fdis-9846>

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 180, *Solar energy*, Sub-Committee SC 1, *Climate – Measurement and data*.

This second edition cancels and replaces the first edition (ISO 9846:1993) which has been technically revised.

The main changes are as follows:

- focus on current calibration practices
- addition of a collimation tube calibration method;
- adapted recommendations for mathematical treatment of data;
- revised terminology in line with ISO 9060, ISO 9488 and ISO Guide 99;
- added comments on uncertainty evaluation of the calibration with reference to ASTM G213^[3] and ISO/IEC Guide 98-3.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document aims to promote the uniform application of reliable methods to calibrate pyranometers by comparison to a reference pyrhelimeter. Calibration methods for pyranometers using a pyranometer as a reference are described in ISO 9847.

Calibration of measuring instruments is essential for accurate and reliable measurements. Accurate measurements of the solar irradiance are required for:

- a) determination of the energy input to solar energy systems such as photovoltaic (PV), and solar thermal systems, as a basis for performance assessment;
- b) testing and assessment of solar technologies;
- c) geographic mapping of solar energy resources;
- d) understanding climate change and extreme weather through the surface radiation budget;
- e) applications such as agriculture, building efficiency, material degradation and reliability, health.

Current solar energy performance assessment demands high-accuracy measurements and low measurement uncertainties. To meet this demand, reliable and accurate solar irradiance measurements with synchronized time stamps (see Reference [4]) and a correct uncertainty evaluation are required.

The World Meteorological Organization (WMO) World Radiometric Reference (WRR), which represents the SI units of solar irradiance, is determined by a group of selected pyrhelimeters. For hemispherical irradiance measurements, transfer of this scale to pyranometers has to be accomplished. In order to calibrate pyranometers, which have a field-of-view angle of 2π , with pyrhelimeters that have a limited field of view (typically only 5 degrees) requires additional equipment such as shading discs or collimation tubes.

The pyranometer calibration procedures described in this document are traceable to the International System of Units (SI) through the WRR according to the WMO guidelines Reference [5]. The classification and specification used are prescribed in ISO 9060 Reference [6].

Due to the relatively high accuracy of pyrhelimeters, the methods in this document may lead to lower uncertainties than those obtained by calibration of a pyranometer using a reference pyranometer as given in ISO 9847.

Unless otherwise specified, uncertainties mentioned in this document are expanded uncertainties with a coverage factor $k = 2$.

Solar energy — Calibration of a pyranometer using a pyrhelimeter

1 Scope

This document specifies calibration methods for a pyranometer using a pyrhelimeter as a reference instrument. Three methods are specified in this document.

- a) Alternating sun and shade method. This method uses a shading disc to alternately shade and unshade a pyranometer to compare with the tracking pyrhelimeter. The test pyranometer can be horizontal, on a fixed tilt or tracking alongside the pyrhelimeter.
- b) Continuous sun and shade method. In this method, a shaded calibrated reference pyranometer is used in addition to the reference pyrhelimeter. The test pyranometer can be horizontal, on a fixed tilt or tracking alongside the reference pyrhelimeter, but the reference pyranometer must be mounted in the same plane as the test pyranometer (most often on the horizontal).
- c) Collimation tube method. In this method, the test pyranometer is mounted on a solar tracker and is equipped with a collimation tube designed to allow the test pyranometer to have the same geometric view as the reference pyrhelimeter for a direct comparison of the two instruments.

The methods in this document are applicable for calibration of all pyranometers provided that a proper uncertainty evaluation is performed. Unlike spectrally flat pyranometers, non-spectrally flat pyranometers have a sensitivity that strongly depends on the solar spectrum. Therefore, the calibration result can be valid under a more limited range of conditions.

The result of a calibration is the instrument sensitivity accompanied by an uncertainty. This document includes suggestions for uncertainty evaluation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9059, *Solar energy — Calibration of pyrhelimeters by comparison to a reference pyrhelimeter*

ISO 9060, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*

ISO 9488, *Solar energy — Vocabulary*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9060, ISO 9488, ISO 9059 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>