International Standard

ISO 9846

Solar energy — Calibration of a pyranometer using a pyrheliometer

Énergie solaire — Étalonnage d'un pyranomètre utilisant un pyrhéliomètre

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Foreword

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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).

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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 pyrheliometer. 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 pyrheliometers. 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 pyrheliometers 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 pyrheliometers, 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 pyrheliometer

1 Scope

This document specifies calibration methods for a pyranometer using a pyrheliometer 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 pyrheliometer. The test pyranometer can be horizontal, on a fixed tilt or tracking alongside the pyrheliometer.

b) Continuous sun and shade method. In this method, a shaded calibrated reference pyranometer is used in addition to the reference pyrheliometer. The test pyranometer can be horizontal, on a fixed tilt or tracking alongside the reference pyrheliometer, 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 pyrheliometer 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 pyrheliometers by comparison to a reference pyrheliometer*

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