

Method for

Calibrating field pyranometers by comparison to a reference pyranometer

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Committees responsible for this British Standard

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Association of Consulting Engineers
British Precast Concrete Federation Ltd.
Chartered Institution of Building Services Engineers
Consumer's Association
Copper Development Association
Cranfield Institute of Technology
Department of the Environment
Department of the Environment (Building Research Establishment)
Institution of Gas Engineers
International Solar Energy Society
National Centre for Alternative Technology
Royal Institute of British Architects
Solar Trade Association
Swimming Pool and Allied Trades Association Ltd.
University College Cardiff
University of Ulster
Water Byelaws Advisory Service

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National foreword

This British Standard has been prepared under the direction of the Refrigeration Heating and Air Conditioning Standards Policy Committee and is identical with ISO 9847 : 1992 *Solar energy — Calibration of field pyranometers by comparison to a reference pyranometer*, published by the International Organization for Standardization (ISO) and prepared by Technical Committee ISO/TC 180, Solar heating, in which the UK played an active part.

Cross-reference

The Technical Committee has reviewed the provisions of ISO 9060 : 1990, to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Introduction

Accurate and precise measurements of the irradiance of the global (hemispherical) solar radiation are required in

- a) the determination of the energy available to flat-plate solar collectors,
- b) the assessment of irradiance and radiant exposure in the testing of solar and non-solar-related materials technologies, and
- c) the assessment of the direct versus diffuse solar components for energy budget analysis, geographic mapping of solar energy, and as an aid in the determination of the concentration of aerosol and particulate pollution and the effects of water vapour.

Although meteorological and resource assessment measurements generally require pyranometers oriented with their axis vertical, applications associated with flat-plate collectors and the study of the solar exposure of related materials require calibrations of instruments tilted at a predetermined non-vertical orientation. Calibrations at fixed tilt angles have applications which seek state-of-the-art accuracy, requiring corrections for cosine, tilt and azimuth.

Solar energy — Calibration of field pyranometers by comparison to a reference pyranometer

1 Scope

1.1 This International Standard specifies two preferred methods for the calibration of field pyranometers using reference pyranometers.

1.2 One method, the outdoor calibration or type I, employs solar radiation as the source, while the other method, the indoor calibration or type II, employs an artificial radiation source.

1.2.1 The outdoor calibration of field pyranometers may be performed with the pyranometer in a horizontal position (i.e. zero tilt) (type Ia), in a tilted position (type Ib), or at normal incidence (type Ic) maintaining the receiver surface perpendicular to the sun's beam component.

1.2.2 The indoor calibration of field pyranometers may be performed using an integrating sphere with shaded (type IIa) or unshaded (type IIb) lamp(s), or at normal incidence (type IIc) frequently using an optical bench to present the receiver surface perpendicular to the beam of the lamp.

Types IIa and IIb correspond to an outdoor calibration under conditions of overcast and sunny sky with large light cloud fields, respectively. Type IIc is comparable with the normal incidence calibration of type Ic.

1.3 The methods of calibration specified are traceable to the world radiometric reference (WRR); traceability to the International Pyrheliometric Scale of 1956 is not permitted.

1.4 This International Standard is applicable to most types of field pyranometers regardless of the type of radiation receptor employed. In general, all pyranometers used for long-term monitoring of incident solar irradiance may be calibrated by using the

described methods, provided that the reference pyranometer has been calibrated at essentially the same tilt from horizontal as the tilt employed in the calibration.

NOTE 1 Pyranometers used for collector tests should be calibrated using a reference pyrheliometer (see ISO 9846).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 9060:1990, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*.

ISO 9846:—¹⁾, *Solar energy — Calibration of a pyranometer using a reference pyrheliometer*.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 altazimuth mount: A tracking mount capable of rotation about orthogonal altitude and azimuth axes; tracking may be manual or by a follow-the-sun servomechanism. (See also ISO 9846.)

3.2 global (solar) irradiance: Hemispherical solar irradiance received by a horizontal plane surface. (See also ISO 9060.)

1) To be published.

3.3 Integrating sphere [hemisphere]: A sphere [hemisphere], generally from 1 m to 4 m in diameter, provided with a planar segment (usually a horizontal bottom segment) on which to mount pyranometers (to be compared with an artificial light source), the sphere wall of which is coated with a flat, white paint that is as lambertian as possible to provide uniform illumination.

3.4 pyranometer: Radiometer designed for measuring the irradiance on a plane receiver surface which results from the radiant fluxes incident from the hemisphere above within the wavelength range 0,3 μm to 3 μm . (See also ISO 9060.)

3.5 field pyranometer: Pyranometer usually meeting second class²⁾ specifications or first class specifications, designed for field use and (typically) continuous exposure.

3.6 reference pyranometer: Well-maintained pyranometer, selected for its stability and quality, used exclusively to calibrate other instruments.

3.7 test pyranometer: Pyranometer being calibrated, regardless of its classification or its photoreceptor type.

3.8 tilt angle: Angle between the vertical and the pyranometer axis (which is equal to the angle between the horizontal plane and the plane of the detector surface).

3.9 calibration factor: Multiplier, used to derive the global solar irradiance from the measured output (voltage). The units are those of the reciprocal value of the responsivity (e.g. watts per square metre per microvolt).

4 Apparatus

4.1 Digital electronic readout device

Any digital microvoltmeter having an accuracy of better than $\pm 0,1\%$ may be employed. Data loggers with print-out shall be capable of a measurement frequency of at least two per minute. A data logger having at least a three-channel capacity may be useful.

4.2 Reference pyranometer

The reference pyranometer shall be specially selected, tested and maintained as follows.

2) For the classification of pyranometers, see ISO 9060.

3) Test methods to determine the dependence of the responsivity of a pyranometer on temperature, irradiance, tilt and angle of incidence will form the subject of a future International Standard.

4.2.1 For outdoor calibration (type I)

The reference pyranometer for outdoor calibration (type I) should be typically of a higher class (in accordance with the classification given in ISO 9060) than the test pyranometer, and should exhibit a particularly high long-term stability. The dependence of its responsivity on temperature, irradiance, tilt and angles of incidence shall be determined.³⁾ Within 12 months prior to its use for calibrating field pyranometers, the reference pyranometer should itself be recalibrated outdoors by comparison to a pyrliometer (see ISO 9846). This recalibration should be carried out under conditions typical of those in which the field pyranometer and reference pyranometer will be used. The calibration history of the reference pyranometer should be well documented.

If the measuring conditions during calibration deviate strongly from those during the typical use of the field pyranometer (by more than $\pm 5^\circ\text{C}$ and $\pm 15^\circ$ azimuth angle), a reference pyranometer of the same type that has been calibrated under similar conditions should be used.

4.2.2 For indoor calibration (type II)

The reference pyranometer for indoor calibration (type II) shall be of the same type as the test pyranometer (to avoid errors that may be caused by the artificial radiation employed; these errors may arise mainly from imperfect homogeneity of the source beam or from an imperfect match to the solar spectrum). In addition, the pyranometer shall meet the requirements specified in 4.2.1.

4.3 Integrating sphere or hemisphere

For type IIa or IIb calibration (see 5.3.1), an integrating sphere or hemisphere (see 3.3) is required. Suitable apparatus are described in annex A for information.

4.4 Precision calibration table

A precision calibration table is required for all horizontal and fixed-angle tilt calibrations. It shall be level at 0° tilt (i.e. horizontal) and shall be able to be tilted over a suitable range of angles from the horizontal with an uncertainty of less than $0,3^\circ$.

NOTE 2 The deviation between the tilt angle of the reference pyranometer and that of the field pyranometer should be not more than $0,1^\circ$ which means that the tilt of the pyranometers has to be finely adjusted. If the calibration tables are mechanically and thermally stable it is necessary to check the tilt only after periods longer than a week.