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ISO 9847 & ASTM G207 CALIBRATION

The world is moving towards indoor calibration of pyranometers

The leading pyranometer manufacturers and many others calibrate pyranometers indoors at normal incidence, according to the ISO 9847 and equivalent ASTM G 207 standards. Compared to outdoor calibration, the method has the fundamental advantage that directional response and temperature response are perfectly reproducible. It works under generally accepted reference conditions: 0 ° zenith angle is the reference for directional error and 20 °C is the reference instrument temperature.

Figure 1 *SRC02 indoor pyranometer calibration system*

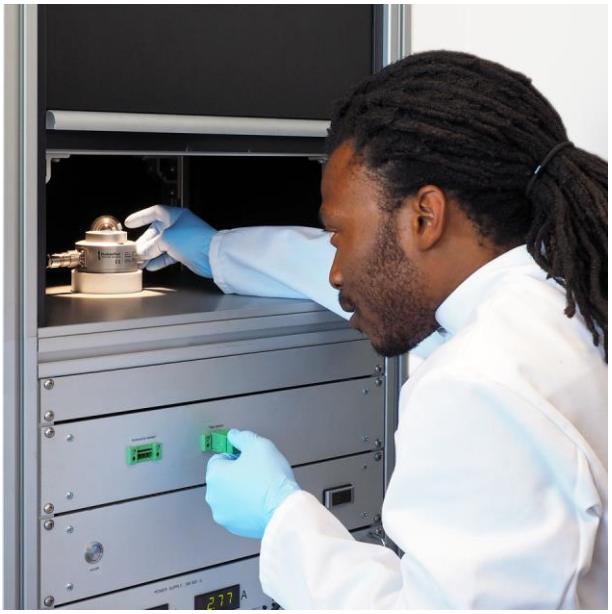

Figure 2 *Application example: sensor being prepared for calibration in an indoor calibration system*

Introduction

The tradition of outdoor calibration of pyranometers was born out of necessity. The directional- and temperature response of the first pyranometers were unreliable and could not accurately be determined. Local calibration at realistic solar angles and temperatures was the way to include the unknown directional error and temperature response into the calibration. Modern instruments are produced within known and narrow performance limits. For these sensors, indoor calibration is best. Calibration reference sensors are still calibrated outdoor under the natural sun to minimise spectral errors.

ISO 9847, IIc indoor calibration

The indoor calibration method of ISO 9847, type IIc works by transferring the sensitivity of a calibration reference sensor to an identical test sensor under a lamp. The reference sensor is calibrated outdoors under the spectrum of the natural sun. The IIc procedure involves an unshaded and a shaded measurement and exchange of the instrument positions in the potentially inhomogeneous beam of the lamp. The procedure also includes a beam-stability verification. The method is a "transfer" between identical instruments and does not rely on intensity or the spectral composition of the lamp.

Requirements

The IIc method requires use of a reference sensor with identical sensor and optics as the test sensor. Sensors of the same model have identical spectral sensitivity and identical non-linearity. Using a different model / brand or higher class sensor leads to errors; if the spectral response or linearity of the calibration reference differs from the sensor under test, the use of a low intensity and low colour-temperature lamp instead of the natural sun introduces linearity- and spectral errors.

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Standards

ISO 9847: Solar Energy – Calibration of field pyranometers by comparison to a reference pyranometer
ASTM G207 - 11 Standard test method for indoor transfer of calibration from reference to field pyranometers

Calibration hierarchy

The calibration reference sensor is traceable to WRR. Typically the calibration reference used in indoor calibration is calibrated following ISO 9846, type 1 outdoor calibration. However, you may also add another step in the hierarchy using reference sensors calibrated indoors.

Calibration reference conditions

If the temperature response, non-linearity and directional response of the calibration reference are known, you may apply corrections from outdoor calibration conditions to the typical reference conditions, or add a general "transfer error" to cover possible differences. Reference conditions are not standardised, but the main manufacturers use:

- irradiance level 1000 W/m^2
- normal incidence irradiance
- instrument temperature 20 °C
- horizontal instrument position
- spectrum: solar irradiance on a clear day

The calibration lamp only serves as a means to compare the calibration reference to an identical sensor under test. The above reference conditions therefore also apply to the indoor calibration result. The calibration remains traceable to the calibration reference conditions (including the spectrum and irradiance level) that were valid for the calibration reference sensor during its outdoor calibration. The lamp typically has a colour temperature of around 3000 K.

Benefits

- calibration at normal incidence, which is the reference condition for directional response
- calibration at 20 ° C which is the reference condition for instrument temperature
- change of sensitivity is directly traceable to sensor / coating degradation
- reference condition comply with IEC Standard Test Conditions for solar energy testing (STC), as applied in Photovoltaic (PV) module and system testing
- fast, independent of weather

Reference users of the same method

- Hukseflux Thermal Sensors B.V., The Netherlands, USA, India, China, Japan, Brazil
- ISOCAL North America Inc., USA
- GeoSUN Africa, South Africa
- TÜV Rheinland, Germany
- DWD Deutscher Wetterdienst, Germany
- KNMI The Netherlands Meteorological Institute, The Netherlands
- EKO Instruments, Japan
- Kipp & Zonen B. V., The Netherlands, UK, Germany, France, Singapore, USA
- Campbell Scientific Canada, Canada
- Meatech, India

Further endorsements

In the new IEC 61724-1:2017 Photovoltaic System Performance Monitoring - Guidelines for Measurement, Data Exchange and Analysis allows calibration according to ISO 9847.

Attainable uncertainty at Hukseflux

Typical contributions to the uncertainty budget are the uncertainty of the calibration reference, 0.75 % uncertainty of the transfer to reference conditions and 0.5 % uncertainty of the method. The calibration reference uncertainty is higher for lower class sensors. The expanded calibration uncertainties (k = 2) we attain at Hukseflux for different pyranometer classes:

- < 1.2 % for secondary standard
- < 1.5 % for first class
- < 1.8 % for second class

Avoiding uncertainty in directional response, these uncertainties are not far from those of high quality outdoor experiments.

About Hukseflux

Hukseflux Thermal Sensors offers measurement solutions for the most challenging applications. We design and supply sensors as well as test & measuring systems, and offer related services such as calibration, engineering and consultancy. Hukseflux is ISO 9001:2008 certified. Hukseflux sensors, systems and services are offered worldwide via our office in Delft, the Netherlands and local distributors.

Interested in our products or services?
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