ISO 9847 & ASTM G207 calibration

The world is moving towards indoor calibration of pyranometers

The leading pyranometer manufacturers and many others calibrate pyranometers indoors according to the ISO 9847 and equivalent ASTM G207 standards. Compared to outdoor calibration, the indoor method has many advantages; for example, an uncertainty and a processing time that do not depend on the weather and season. The accuracy is sufficient for most PV system performance monitoring - and meteorological applications.

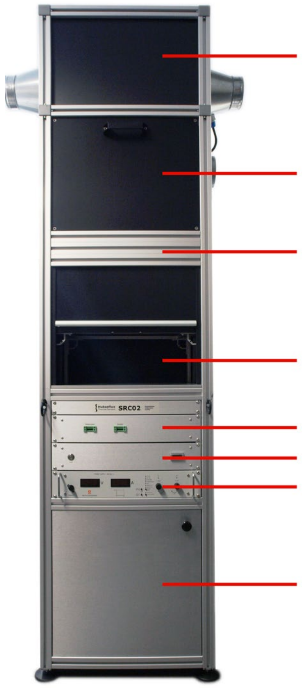

Figure 1 *SRC02 indoor pyranometer calibration system*

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 modern sensors, indoor calibration has become standard practice. Calibration reference sensors are still calibrated outdoor under the natural sun to create traceability to international standards and to minimise spectral errors.

ISO 9847, A1 indoor calibration

The indoor calibration method of ISO 9847:2023, type A1, works by transferring the sensitivity of a calibration reference sensor to a test sensor of the same make and model under a lamp. The calibration is traceable to an outdoor calibration under the spectrum of the natural sun. The A1 procedure involves an unshaded and a shaded measurement and exchange of the instrument positions. The procedure also includes a beam-stability verification. The method is a “transfer” between instruments of the same make and model and should not rely on intensity or the spectral composition of the lamp.

Requirements

The A1 method requires use of a reference sensor of the same make and model. This means with identical sensor, coating and optics as the test sensor. We then may assume, for example, that these sensors have nearly identical spectral selectivity and non-linearity. This leads to an accurate calibration.

By contrast, under a lamp, comparison between sensors of different makes / models leads to errors; if the linearity or spectral response of the calibration reference differs from that of the sensor under test, the use of a low intensity, low-colour temperature lamp instead of the natural sun, introduces linearity- and spectral errors.

Standards

ISO 9847:2023: Solar Energy – Calibration of field pyranometers by comparison to a reference pyranometer.
ASTM G207 – 11:2019 Standard test method for indoor transfer of calibration from reference to field pyranometers.

Calibration hierarchy

The calibration reference sensor is traceable to the World Radiometric Reference, WRR. Typically, the calibration reference used in indoor calibration is calibrated outdoor following ISO 9846. 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 of the calibration reference to the typical reference conditions, or add a general "uncertainty of the transfer" to cover possible differences. Reference conditions are not standardised. Hukseflux uses the following conditions, which ISO TR 9901 specifies as "aligned with ISO 9060":

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

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 conditions closely resemble IEC Standard Test Conditions for solar energy testing (STC), as applied in Photovoltaic (PV) module and system testing
- fast, independent of weather

Who uses this method

- Hukseflux: The Netherlands, USA, India, China, Japan, Singapore, Australia, 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

The new IEC 61724-1:2021 Photovoltaic System Performance Monitoring - Guidelines for Measurement, Data Exchange and Analysis allows calibration according to ISO 9847, and requires an uncertainty of better than 2 %.

Achievable uncertainty at Hukseflux

Typical contributions to the uncertainty budget are the uncertainty of the calibration reference, uncertainty of the transfer to reference conditions and 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 Class A
- < ± 1.5 % for Class B
- < ± 2.4 % for Class C

These uncertainties are similar to those of high-quality outdoor experiments.

About Hukseflux

Hukseflux is the leading expert in measurement of energy transfer. We design and manufacture sensors and measuring systems that support the energy transition. We are market leaders in solar radiation- and heat flux measurement.
Customers are served through the main office in the Netherlands, and locally owned representations in the USA, Brazil, India, China, Southeast Asia and Japan.

Interested in our products and services?
E-mail us at: info@hukseflux.com