

ISO/IEC 17025 CALIBRATION CERTIFICATE

CERTIFICATE NUMBER 024987010785

PYRANOMETER MODEL CM 21
SERIAL NUMBER 010785
CALIBRATION DATE 22 November 2021
INSTRUMENT CLASS ISO 9060, Class A (Sec. Standard)*
CALIBRATION PROCEDURE ISO 9847 par5.3.2, A3

REFERENCE PYRANOMETER Kipp & Zonen CMP 21 sn 110734 active from 01 January 2021
REFERENCE PYRANOMETER CALIBRATION PROCEDURE ISO 9846 par5

CALIBRATION LOCATION Delft
The Netherlands

CUSTOMER Equinox Instruments Ltd
Beevor Street
LN6 7DJ
Lincoln
United Kingdom

REMARKS Instrument condition:
The calibration item was received fully functional and did not show any erratic behavior or irregularities during calibration.

Instrument changes after last calibration:
no

Delft, The Netherlands, 22 November 2021


J. Mes
(in charge of calibration facility)R. de Groot
(in charge of test)

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Calibration procedure

The indoor calibration procedure is based on a side-by-side comparison with a reference pyranometer under an artificial sun. A lamp is positioned approximately 1.5 m above the pyranometers producing a vertical beam. The reference and test pyranometer are mounted horizontally on a table which can rotate. The irradiance at the pyranometers is approximately 600 W/m². During the calibration procedure the reference and test pyranometer are interchanged to correct for any non-homogeneity of the beam. Temperature during calibration: 22 °C ± 2 °C.

Hierarchy of traceability

The measurements have been executed using standards for which the traceability to international standards has been demonstrated towards the RvA.

The reference pyranometer was compared with the sun and sky radiation as source under clear sky conditions using the "alternating sun-and-shade method" ISO 9846 paragraph 5. The measurements were performed in Delft, The Netherlands (latitude: 51.9969°, longitude: 4.3863°, altitude: 10m above sea level). Dates of measurements: 22-24 June 2020.

The receiver surface was pointed directly at the sun using a solar tracker. During the comparisons, the instrument received tilted global radiation intensities from 835 W/m² to 1136 W/m² with a mean of 995 W/m² and tilted diffuse radiation intensities from 89 W/m² to 254 W/m² with a mean of 151 W/m². The ambient temperature ranged from +19.0 °C to +29.9 °C with a mean of +23.9 °C.

The direct radiation on the reference pyranometer as obtained with the alternating-sun-shade method was compared to the DNI measured by the absolute cavity pyrhemliometer PMO6 SN 103. The PMO6 is calibrated against the World Standard Group (WSG), maintained at the WRC Davos every International Pyrhemliometer Comparison (IPC). WRR factor of PMO6: 0.99787 (from the last IPC-2015).

This calibration proved that the reference pyranometer has been stable and that the original sensitivity 8.49 µV/(W/m²) ± 0.11 µV/(W/m²) is valid and will be applied (see PMOD calibration details). Observed sensitivity differences between the consecutive years are well within the calibration uncertainty.

PMOD calibration details: The reference pyranometer was compared with the sun and sky radiation as source under mainly clear sky conditions using the "continuous sun-and-shade method". The pyranometer was installed horizontally. During the comparisons, the global radiation ranged from 638 W/m² to 1195 W/m² with a mean of 874 W/m². The solar zenith angle varied from 23.5° to 49.8° with a mean of 32.9°. The ambient temperature ranged from +12.6 °C to +26.2 °C with a mean of +23.7 °C. The sensitivity calculation is based on 436 individual measurements. The readings of the WSG are referred to the World Radiometric Reference (WRR). The estimated uncertainty of the WRR relative to SI is ±0.3%. The obtained sensitivity value and its expanded uncertainty (95% level of confidence) are valid for similar conditions and are: 8.49 ± 0.11 µV/W/m². The measurements were performed in Davos (latitude: 46.8143°, longitude: -9.8458°, altitude: 1558 m above sea level). Dates of measurements: 24, 30 June 1, 2 July 2015. Global radiation data were calculated from the direct solar radiation as measured with the absolute cavity pyrhemliometer PMO2 (member of the WSG, WRR- factor: 0.998623 from the last international Pyrhemliometer Comparison, IPC-2015) and from the diffuse radiation as measured with a continuous disk shaded pyranometer Kipp & Zonen CM22 SN 020059 (ventilated with heated air).

SENSITIVITY 10.85 µV/(W/m²) at normal incidence on horizontal pyranometer

UNCERTAINTY 0.15 µV/(W/m²) = 1.42 %

IMPEDANCE 37 ± 1.5 Ω

Justification of total instrument calibration uncertainty

The combined uncertainty of the result of the calibration is the positive "root sum square" of the following components.

1. The expanded uncertainty due to random effects and instrumental errors during the calibration of the reference CMP 21 is ±0.11/8.49 = ±1.3% (k=2). See traceability text.

2. The expanded uncertainty of the transfer procedure (calibration by comparison) is estimated to be ±0.5% (k=2).

3. The estimated uncertainty of the WRR relative to SI: ±0.3% (k=2).

The expanded uncertainty is: $\sqrt{(1.3\% + 0.5\% + 0.3\%)^2} = \pm 1.42\%$ (k=2).

The resistance measurement uncertainties are due to the PXI 4065 uncertainty in the 100 Ω range: 150ppm of range (=15mΩ) the cable resistance (estimated 0.1 Ω) and due to the electrothermal effect the measurement current in the thermal detector of the pyranometer. This was found to be a resistance error of 1.5 Ω, which results in a total resistance uncertainty of $\sqrt{(0.015^2 + 0.1^2 + 1.5^2)} = 1.5 \Omega$ or 5%.

The PXI 4065 is calibrated by National Instruments Hungary, on 2 september 2020 at a temperature of 23.0 °C, under ISO/IEC 17025:2017 accreditation. This calibration is traceable to NIST and/or other National Measurement Institutes (NMI's).

The reported expanded uncertainty is based on the standard uncertainty of the measurement multiplied by a coverage factor k, such that the coverage probability corresponds to approximately 95%. The standard uncertainty has been determined in accordance with EA 04/2.

Notice

The calibration certificate supplied with the instrument is valid at the date of first use. Even though the calibration certificate is dated relative to manufacture, or recalibration, the instrument does not undergo any sensitivity changes when kept in the original packing.

* from October 2018 the classification conforms to ISO 9060:2018. Instruments issued before that date conform to ISO 9060:1990.

RvA is member of the European Co-operation for Accreditation (EA) and is one of the signatories to the EA Multilateral Agreement (MLA) and to the ILAC Mutual Recognition Arrangement (MRA) for the mutual recognition of calibration certificates.

Reproduction of the complete certificate is allowed. Parts of the certificate may only be produced with written approval of the calibration laboratory.

This certificate is issued provided that the Raad voor Accreditatie does not assume any liability.