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ISO/IEC 17025 CALIBRATION CERTIFICATE

CERTIFICATE NUMBER	SRO000001052200195
PYRANOMETER MODEL	SMP21-V
SERIAL NUMBER	200195
CALIBRATION DATE	10 March 2025
INSTRUMENT CLASS	ISO 9060, Class A*
CALIBRATION PROCEDURE	ISO 9847:2023 clause 6, type A1
REFERENCE PYRANOMETER	Kipp & Zonen CMP 21 sn 110734 active from 01 January 2025
REFERENCE PYRANOMETER CALIBRATION PROCEDURE	ISO 9846 par5
CALIBRATION LOCATION	Delft The Netherlands
CUSTOMER	OTT USA 22400 Davis drive suite 100 20164 Sterling United States of America
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, 10 March 2025

J. Mes
(in charge of calibration facility)

Julian Noordhuis
(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 Tabernas, Spain (latitude: 37.0499°, longitude: -2.3908°, altitude: 500m above sea level). Dates of measurements: 4-9 September 2024.
The receiver surface was pointed directly at the sun using a solar tracker. During the comparisons, the instrument received tilted global radiation intensities from 786 W/m² to 1060 W/m² with a mean of 1006 W/m² and tilted diffuse radiation intensities from 86 W/m² to 273 W/m² with a mean of 142 W/m². The ambient temperature ranged from +23.7 °C to +36.4 °C with a mean of +31.6 °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 pyrheliometer PMO6 SN 103. The PMO6 is calibrated against the World Standard Group (WSG), maintained at the WRC Davos every International Pyrheliometer Comparison (IPC). WRR factor of PMO6: 0.998913 (from the last IPC-2021).

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 pyrheliometer PMO2 (member of the WSG, WRR- factor: 0.998623 from IPC-2010) and from the diffuse radiation as measured with a continuous disk shaded pyranometer Kipp & Zonen CM22 SN 020059 (ventilated with heated air).

SENSITIVITY	10.40 µV/(W/m²) at normal incidence on horizontal pyranometer
UNCERTAINTY	0.15 µV/(W/m²) = 1.42 %

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

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.

* Instruments issued before October 2018 are classified conform to ISO 9060:1990.