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ISO/IEC 17025 CALIBRATION CERTIFICATE

CERTIFICATE NUMBER	030350241101
PYRHELIOMETER MODEL	CHP 1
SERIAL NUMBER	241101
CALIBRATION DATE	14 February 2024
INSTRUMENT CLASS	ISO 9060, Class A*
CALIBRATION PROCEDURE	Validated indoor procedure as described on page 2
REFERENCE PYRHELIOMETER	Kipp & Zonen CHP 1 sn REF2 active from 17 January 2024
REFERENCE PYRHELIOMETER CALIBRATION PROCEDURE	ISO 9059
CALIBRATION LOCATION	Delft The Netherlands
CUSTOMER	
REMARKS	

Delft, The Netherlands, 14 February 2024

J. Mes
(Calibration Manager)

P. van der Heijden
(Calibration Technician)

OTT HydroMet B.V.
Company registered in Delft

Trade register no.: 27239004
VAT no.: NL0055.74.857.B.01
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Calibration procedure

The indoor transfer calibration is performed in analogy to the ISO 9847 pyranometer calibration; the reference and test instrument are of the same type. In the first step the reference pyrheliometer is placed in the collimated beam of a Xenon lamp. After a stabilization period the irradiance is measured and a dark measurement is performed. Then the reference instrument is replaced by the test instrument, after stabilization its output signal is measured. As a last step the reference instrument is again placed in the beam to validate the beam irradiance has not drifted. The sensitivity is calculated from the irradiance as measured by the reference pyrheliometer and the voltage output of the test instrument. The minimum beam intensity is 650 W/m², room temperature is 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.

This reference pyrheliometer was compared against the absolute cavity pyrheliometer PMO6 SN 103 using the sun as source according to ISO 9059 "Calibration of field pyrheliometers by comparison to a reference pyrheliometer". The comparison was performed in Davos, Switzerland (latitude: 46.8143°, longitude: 9.8458°, altitude: 1588 m above sea level). During the comparisons the reference pyrheliometer received direct solar radiation with intensities ranging from 734 W/m² to 1008 W/m², with a mean of 938 W/m². The ambient air temperature ranged from +16.7°C to +33.2°C with a mean of +24.9°C. The sensitivity calculation is based on 347 individual measurements. The sensitivity and its expanded uncertainty (95% level of confidence) with respect to the WRR are valid for similar environmental conditions and amount to: 7.944 µV/(W/m²) ± 0.04 µV/(W/m²). Date of measurements: 22-26 Aug, 5-9 Sept, 2023

The absolute cavity pyrheliometer PMO6 SN 103 is calibrated against the World Standard Group (WSG), at the WRC Davos, Switzerland (latitude: 46.8143°, longitude: 9.8458°, altitude: 1558 m above sea level). This is done every 5 years at the International Pyrheliometer Comparison (IPC). The readings of the WSG are referred to as the World Radiometric Reference (WRR) as stated in the WMO Technical Regulations.

WRR- factor of PMO6 SN 103: (from the last international Pyrheliometer Comparison, IPC-2021). The estimated uncertainty of the WRR relative to SI is ±0.3%. During the yearly NPC hosted by NREL in Golden, Colorado (latitude: 39.742°, longitude: 105.18°, altitude: 1829 m above sea level) the WRR factor of the reference PMO6 SN 103 is verified.

SENSITIVITY	7.80 µV/(W/m²) at normal incidence
UNCERTAINTY	0.09 µV/(W/m²) = 1.12 %
IMPEDANCE	30 Ω ± 2Ω

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 CHP 1: 0.04 µV/(W/m²) / 7.944 µV/(W/m²) = ±0.50% with respect to the WRR (See traceability text).
2. The estimated uncertainty of the WRR relative to SI: ±0.3% (k=2).
3. The expanded uncertainty of the transfer procedure (calibration by non-simultaneous comparison) is estimated to be ±1% (k=2).

The expanded uncertainty is: $\sqrt{(0.50\%^2 + 0.3\%^2 + 1\%^2)}$= ±1.12% (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.

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

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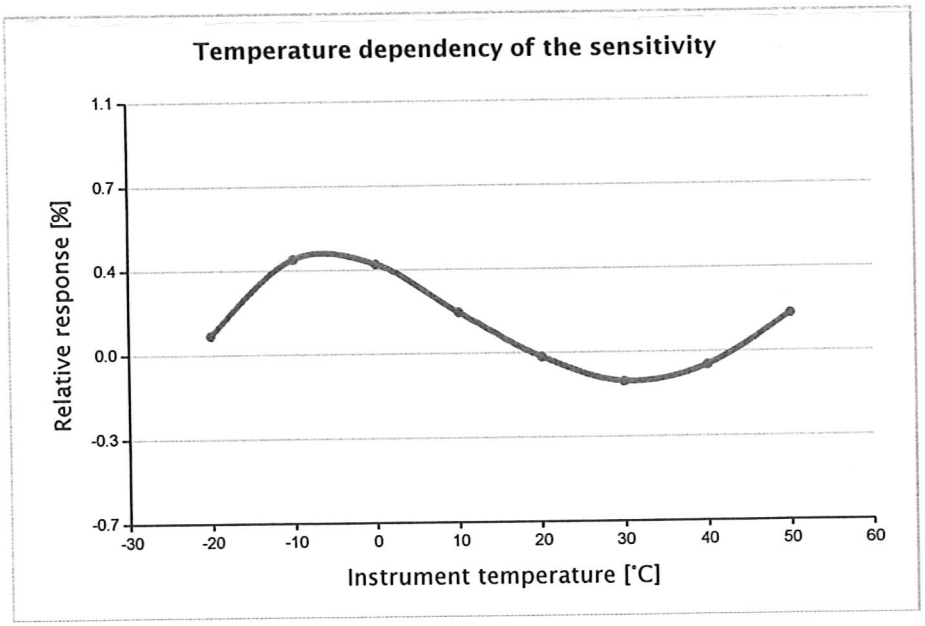
MEASUREMENT REPORT
PYRHELIOMETER

Routine measurement of temperature dependency during final inspection

PYRHELIOMETER TYPE	CHP 1
SERIAL NUMBER	241101
DATE OF MEASUREMENT	02 November 2023
PERFORMED BY	F. de Wit
PROCEDURE	The pyrheliometer is mounted inside the climate chamber and illuminated with a white light source under normal incidence. A CMP22 pyranometer outside the chamber is used to monitor the lamp stability. The pyrheliometer is tested over a temperature range from 50 °C down to -20 °C in steps of 10 °C. The relative temperature dependency is plotted below. The measurement uncertainty of this characterisation is ±0.1% (k=2).



Instrument temperature [°C]	Relative response [%]
-20	0.10
-10	0.43
0	0.40
10	0.19
20	0.00
30	-0.11
40	-0.04
50	0.18