

CERTIFICATE NUMBER 123456100333
THERMOPILE CA 2
SERIAL NUMBER 100333
SENSITIVITY 1 22.69 $\mu\text{V}/\text{W}/\text{m}^2$ (of homogeneous irradiance on the front window)
SENSITIVITY 2 0.065 $\mu\text{V}/\mu\text{W}$ (of radiation falling through the window directly on the absorber)
IMPEDANCE 35.9 Ohm
TEMPERATURE 22 ± 2 °C
REFERENCE PYRHELIO METER Kipp & Zonen CHP 1 snREF1 active from January 3, 2011
CALIBRATION DATE 07-Nov-2011 (recalibration is recommended every two years)
IN CHARGE OF TEST Leo van Wely

Calibration procedure

Exact interchange of thermopile CA2 and reference pyr heliometer CHP1 in a horizontal parallel beam of light from a Xenon lamp. Full collimation angle of beam is 0.5°. Irradiance 100 ± 1 W/m². Room temperature 22 ± 2 °C.

Measurement start as thermopile is stabilized and dark voltage is within ± 20 μV .

Then the CA2 with its own window is illuminated by 100 W/m² and the voltage output [μV] after 1 min. divided by 100 is the S1 sensitivity figure.

Subsequently the CA2 is equipped with a window and diaphragm of exactly 10.0 mm² and a dark voltage read out is done when stabilized.

Finally the CA2 is illuminated again with the 100 W/m² beam and now only a pencil of radiation (of 1000 μW) falls directly on the absorber.

The S2 sensitivity figure is calculated from the ratio; "voltage output after 1 min. minus the dark voltage" divided by 1000 μW .

Hierarchy of traceability

This reference pyr heliometer was compared with the reference radiometer PMO2 of the World Radiation Center (WRC) using the sun as source. The reference radiometer is periodically calibrated against the World Standard Group (WSG), maintained at the WRC Davos. The readings are referred to the World Radiometric Reference (WRR) as stated in the WMO Technical Regulations. The originally estimated uncertainty of the WRR relative to SI is $\pm 0.3\%$. The measurements were performed in Davos (latitude: 46.8143°, longitude: -9.8458°, altitude: 1588 m above sea level).

During the comparisons, the reference pyr heliometer received direct solar radiation with intensities ranging from 728 to 1029 Wm², with a mean of 944 Wm². The ambient air temperature ranged from +13.6 to +26.6 °C with a mean of +21.5 °C. The sensitivity calculation is based on 1662 individual measurements. The calculated sensitivity and its expanded uncertainty (95% level of confidence) are only valid for similar environmental conditions and amount: 7.92 ± 0.04 $\mu\text{VW}^{-1}\text{m}^2$.

WRR- factor of PMO2: 0.998618 (from the last international Pyr heliometer Comparison, IPC-2005).

Date of measurements: 2010, July 8, 9, 12, 14 - 16, 19 - 21, 31, August 1

Correction applied 0.0 %

No correction to the Davos sensitivity figure has been applied.

Justification of total instrument calibration uncertainty

The combined uncertainty of the result of the calibration is the positive "root sum square" of two uncertainties.

1. The expanded uncertainty due to random effects and instrumental errors during the calibration of the reference CHP 1 as given by the World Radiation Center in Davos is $\pm 0.04/7.92 = \pm 0.51\%$. (See traceability text).

2. Based on experience the expanded uncertainty of the transfer procedure (calibration by non-simultaneous comparison) is estimated to be $\pm 3\%$.

The estimated combined expanded uncertainty is the positive "root sum square" of these two uncertainties: $\sqrt{(0.51^2 + 3^2)} = \pm 3\%$.

The uncertainty of the transfer procedure is partly due to the lamp instability in time and partly due to the different aperture of reference pyr heliometer (10 mm diam.) and CA2 (25 mm resp. 3.57 mm diam.) in combination with a not perfect homogeneous field of radiation.

Notice

The calibration certificate supplied with the instrument is 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 the moment the instrument is taken from its packaging and exposed to irradiance the sensitivity may deviate with time. See the 'non-stability' value (% change in sensitivity per year) given in the radiometer specifications.