KIPP & ZONEN
SINCE 1830

MEASUREMENT REPORT

PYRGEOMETER

Routine measurement of temperature dependency during final inspection.

DATE OF MEASUREMENT : 09/02/2018

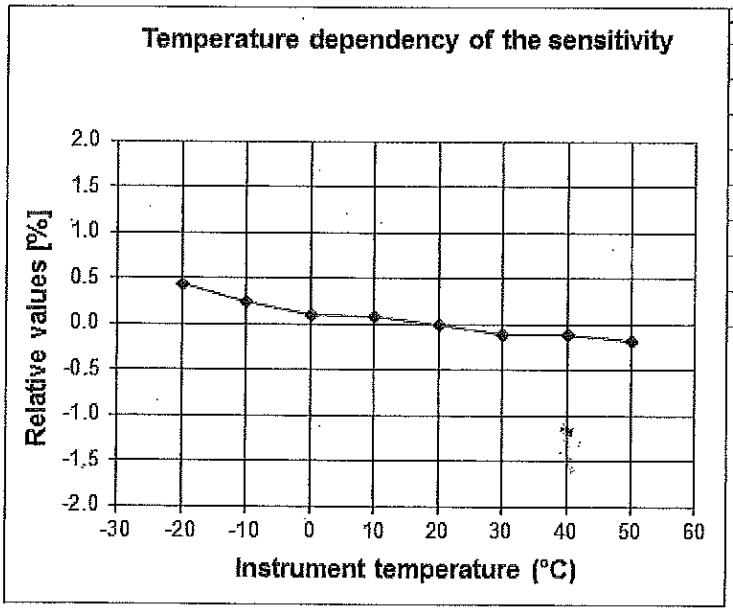
PERFORMED BY : F. de Wit

PYRGEOMETER TYPE : CGR 4

SERIAL NUMBER : 180289

PROCEDURE: The pyrgeometer 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 lamp stability.

The pyrgeometer is tested in a temperature range over 50 °C down to -20 °C in steps of 10 °C. The relative temperature dependency is plotted below



T [°C]	deviation [%]
50	-0.19
40	-0.12
30	-0.11
20	0.00
10	0.08
0	0.10
-10	0.23
-20	0.43

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KIPP & ZONEN SINCE 1830

CALIBRATION CERTIFICATE

CERTIFICATE NUMBER	: 016577180289
CALIBRATION DATE	: 07 February 2018
PYRGEOMETER MODEL	: CGR 4
SERIAL NUMBER	: 180289
REFERENCE PYRGEOMETER	: Kipp & Zonen CG 4 sn 010536 active from January 1, 2018
BODY TEMPERATURE SENSOR	: YSI 44031
SENSITIVITY	: 9.44 ± 0.42µV/W/m²
AMBIENT TEMPERATURE	: Between -4.5°C and -3.7°C, average -4.1°C
IN CHARGE OF TEST:	: A.G. Partosoebroto

CALIBRATION PROCEDURE

The pyrgeometer is calibrated outdoors at Kipp & Zonen under a mainly clear sky during nighttime. The instrument is installed on a horizontal platform next to the reference CG 4. Both the pyrgeometer thermopile output (Uemf) and body temperature (T_b) are measured at one second intervals and compressed to one-minute average values.
The calibration factor of the pyrgeometer is determined by the method of the best curve fit to the CG 4 reference signal. The downward long wave radiation is calculated using the pyrgeometer algorithm (Ld = Uemf /S + σTb⁴). Special measurement criteria are taken into account to calculate the best curve fit, under which:

- The sum of all measurement periods must be at least 4 hours.
- Net radiation exchange with the atmosphere, at least -40 W/m².
- Experimental deviation (2σ) representing absolute values within ±0.2 µV/W/m².
- Experimental deviation (2σ) representing relative values within ±3 %.
- Deviation of downward long wave radiation (Ld) to reference is ±5 W/m² maximum.
- Body temperature (Tb) difference with respect to the reference pyrgeometer is ±0.5 °C maximum.

HIERARCHY OF TRACEABILITY

This reference pyrgeometer was calibrated by an outdoor comparison to the pyrgeometer reference group (PIR 31463F3, PIR 31464F3, CG 4 FT004 and CG 4 010535) of the IR-Centre at PMOD/WRC. The comparison is made during night time with cloudy and cloud-free situations. Radiation and temperature conditions during the calibration:

Long wave downward radiation (Ld):	248 to 319	W/m²
Net radiation:	-98 to -71	W/m²
Pyrgeometer body temperature:	1.4 to 15.9	°C
Integrated water vapour (IWV)	10.1 to 22.0	mm
Measurement period (33 days):	12th of August 2017 to 1st of November 2017.	

From the measurements the sensitivity factor S is determined by using the standard Albrecht et al. relation (see below), which involves the pyrgeometer signal U_{emf} and the body temperature T_b of the pyrgeometer. Body temperature is determined using the Steinhart and Hart equation and the YSI coefficients of the YSI 44031 thermistors.
The Ld irradiance is calculated using the following equation: $Ld = (U_{emf}/S) + \sigma T_b^4$ The retrieved sensitivity S of the reference pyrgeometer and its expanded uncertainty (2σ = 95% level of confidence) are 8.85 ± 0.30 µV / Wm⁻²

JUSTIFICATION OF TOTAL INSTRUMENT CALIBRATION UNCERTAINTY:

The expanded (95%) calibration uncertainty is the root sum square of two uncertainties:

- The systematic uncertainty, this includes uncertainty of voltage (±0.012mV) and temperature (±0.11K) measurement with the data logger. The uncertainty of the sensitivity of the reference sensor (±0.30 µV / Wm⁻²) is also included.
- The statistical uncertainty due to experimental deviations during the comparison outdoors. The magnitude is 2 x the standard deviation of the distribution of the > 240 individual 1-minute averaged observations.

Notice

The calibration certificate supplied with the instrument is valid from the date of shipment to the customer. 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 will deviate with time. See also the 'non-stability 'performance (max. sensitivity change / year) given in the radiometer specification list.

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