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CALIBRATION CERTIFICATE
UPPER AND LOWER PYRANOMETERS

FOUR-COMPONENT RADIOMETER		:	**CNR 1**
SERIAL NUMBER		:	**071421**
SENSITIVITY		:	**10.15 µV/W/m²**
IMPEDANCE	upper sensor	:	37.1 Ohm
	lower sensor	:	36.7 Ohm

CALIBRATION PROCEDURE :

The indoor calibration procedure is based on a side-by-side comparison with a reference pyranometer under an artificial sun fed by an AC voltage stabiliser. It embodies a 150 W Metal-Halide high-pressure gas discharge lamp. Behind the lamp is a reflector with a diameter of 16.2 cm. The reflector is 1 m above the pyranometers producing a vertical beam. The reference and test pyranometers are mounted horizontally on a table, which can rotate. The irradiance at the pyranometers is approx. 500 W/m². During the calibration procedure the reference and test pyranometer are interchanged to correct for any non-homogeneity of the beam. The dark offsets of both pyranometers are measured before and after the interchange and taken into account. The preliminary sensitivity figure is used as input in a spreadsheet which calculates the desired parallel resistors for each pyranometer to trim its sensitivity to a selected value.

REFERENCE PYRANOMETER : Kipp & Zonen CMP 3 sn060193 active from January 1, 2007

hierarchy of traceability :

This pyranometer was compared with the sun and sky radiation as source under mainly clear sky conditions using the "continuous sun-and-shade method". The readings are referred to the World Radiometric Reference (WRR) as stated in the WMO Technical Regulations. The measurements were performed in Davos (latitude: 46.8143°, longitude: -9.8458°, altitude: 1588 m above sea level).

The inclination of the receiver surfaces versus their horizontal position were set to 0.0 degrees, the instrument signal wire to the north. During the comparisons, the instrument received global radiation intensities from 642 to 978 with a mean of 817 W/m². The angle between the solar beam and the normal of the receiver surface varied from 25.5 to 50.0 with a mean of 39.3 degrees. The instrument's temperature ranged from +11.0 to +27.1 with a mean of +20.6 °C. The sensitivity calculation and the single measurements deviation (σ) are based on 1309 individual measurements.
The obtained sensitivity value and its expanded uncertainty (95% level of confidence) are valid for similar conditions and are: 14.51 ± 0.54 µV/W/m² (but is corrected by Kipp & Zonen to 14.88 µV/W/m². See "correction applied" below.)
Dates of measurements: 2006, July 16-19,24,25,27; August 15,18,23,25,31; September 1,4,5,12

Global radiation data were calculated from the direct solar radiation as measured with the absolute cavity pyrheliometer PMO2 (member of the WSG, WRR-Factor: 0.998618, based on the last International Pyrheliometer Comparison IPC-2005) and from the diffuse radiation as measured with a continuous disk shaded pyranometer Kipp & Zonen CM 22 sn020059 with sensitivity 8.91 (ventilated with heated air, instrument-wire to the north).

correction applied : +2.4 %
This correction was necessary to correct for the mean directional error of the reference CMP 3 in Davos. This error is estimated at Kipp & Zonen measuring the cosine error for the mean angle of incidence at azimuth S-30° and S+30°. The reference CMP 3 now measures the vertical beam of the indoor calibration facility more correctly.

IN CHARGE OF TEST : M.Elshout Date: 2007-July-10 Kipp & Zonen, Delft, Holland

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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CALIBRATION CERTIFICATE
UPPER AND LOWER PYRGEOMETERS

FOUR-COMPONENT RADIOMETER		:	**CNR 1**
SERIAL NUMBER		:	**071421**
SENSITIVITY		:	**10.15 µV/W/m²**
IMPEDANCE	upper sensor	:	85.5 Ohm
	lower sensor	:	99.5 Ohm

CALIBRATION PROCEDURE :

The reference and test pyrgeometer are mounted horizontally on a table under an extended warm plate (67°). The table can rotate to exchange the positions of both instruments. The net irradiance at the pyrgeometers is approximately 150 W/m². The indoor procedure is based on a sequence of simultaneous readings. After 30 s exposure to the warm plate, the output voltages of both pyrgeometer are integrated 30 s. Next; both pyrgeometers are covered by a blackened "shutter" with stable "room temperature". After 30 s both signals are integrated again during 30 s. The resulting two "zero" signals are subtracted from the former signals to get comparable responses. In this way is compensated for temperature differences between both pyrgeometers.
Next the pyrgeometer positions are interchanged by rotation of the table and the procedure is repeated. The mean of former and latter responses is compared to derive the sensitivity figure of the test pyrgeometer. In this way asymmetry in the warm plate configuration and IR environment is cancelled out. The preliminary sensitivity figure is used as input in a spreadsheet which calculates the desired parallel resistors for each pyrgeometer to trim its sensitivity to a selected value.

REFERENCE PYRGEOMETER : EKO/Kipp & Zonen CG 3 sn030004 active from March 22, 2007

hierarchy of traceability :

The reference CG 3 has been calibrated to the reference pyrgeometer CG 4 under mainly clear sky conditions during nighttime at Kipp & Zonen, Delft Holland. (On his turn the CG 4 has been calibrated outdoors July to November, 2006, at the IR-centre of the World Radiation Center Davos, to their pyrgeometer reference group.)
The reference CG 3 and CG 4 were placed horizontally side by side. During the calibration period from 15 February 2007 to 16 February 2007 the (outgoing) radiation signal (U_{emf} / S) ranged from -89 to - 51 W/m². The instrument temperatures ranged from +9.2° to +3.3°C. The pyrgeometer thermopile outputs (U_{emf}, U_t) and body temperatures (T_b) were measured every second by a COMBILOG 1020 data logger and averages of 60 measurements have been logged as 1 min. values. Later on the downward radiation (L_d) can be determined with the formula:

$$L_d = \frac{Uemf}{S} + 5.67 \cdot 10^{-8} \cdot T_b{}^4$$

For the (modified) reference CG 4 snFT001 a sensitivity of 13.13 ±0.25 µV/W/m² was applied and with its voltage U_{emf} and temperature T_b data the reference L_d curve is calculated.
For the reference CG 3 a one minute average sensitivity S_t is calculated with the formula:

$$S_t = U_t \cdot \left(L_d - 5.67 \cdot 10^{-8} \cdot T_b{}^4\right)^{-1}$$

The final S_t is the average of one minute S_t's determined in periods with a net IR signal < -40 W/m² (Clear sky). The sum of all periods must be at least 6 hours.
The derived CG 3 sn030004 sensitivity and its expanded uncertainty are: 13.61 ± 0.27 µV/W/m².

IN CHARGE OF TEST : M.Elshout Date: 2007-July-10 Kipp & Zonen, Delft, Holland

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