



**Kipp &
Zonen**

Kipp & Zonen B.V.

Röntgenweg 1 2624 BD Delft
P.O. Box 507 2600 AM Delft
The Netherlands

T +31 (0)15 269 8000

F +31 (0)15 262 0351

E info@kippzonen.com

www.kippzonen.com

CALIBRATION CERTIFICATE UPPER AND LOWER PYRANOMETERS

FOUR-COMPONENT RADIOMETER : **CNR 1**
SERIAL NUMBER : **000220**
SENSITIVITY : **11.35 $\mu\text{V/W/m}^2$**
IMPEDANCE upper sensor : 83.0 Ohm
lower sensor : 70.9 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 110 cm 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 : EKO/Kipp & Zonen CM 3 sn014392 active from January 1, 2006

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: 1588m 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 651 to 989 with a mean of 850 W/m². The angle between the solar beam and the normal of the receiver surface varied from 23 to 50 with a mean of 36 degrees. The instrument's temperature ranged from +11.4 to +24.9 with a mean of +18.0 °C. The sensitivity calculation and the single measurements deviation (σ) are based on 656 individual measurements.

The obtained sensitivity and its expanded uncertainty (95% level of confidence) of the CM 3 sn014392 in Davos are valid for similar conditions and are: 17.27 $\pm$ 0.57 $\mu\text{V/W/m}^2$ (but is corrected by Kipp & Zonen to 17.43 $\mu\text{V/W/m}^2$. See "correction applied" below.)

Dates of measurements: June 23, July 14, 20, August 5, 9 and 12, 2005.

Global radiation data were obtained with the absolute cavity pyrhemometer HF18748 (member of the WSG, WRR-Factor: 0.99568, based on the last International Pyrhemometer Comparison IPC-2000) and 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 : +0.9 %

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

IN CHARGE OF TEST : P.v.d.Heijden Date: 2006-January-13 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.



**Kipp &
Zonen**

Kipp & Zonen B.V.

Röntgenweg 1 2624 BD Delft
P.O. Box 507 2600 AM Delft
The Netherlands

T +31 (0)15 269 8000

F +31 (0)15 262 0351

E info@kippzonen.com

www.kippzonen.com

CALIBRATION CERTIFICATE UPPER AND LOWER PYRGEOMETERS

FOUR-COMPONENT RADIOMETER : **CNR 1**
SERIAL NUMBER : **000220**
SENSITIVITY : **11.35 $\mu\text{V/W/m}^2$**
IMPEDANCE upper sensor : 84.3 Ohm
lower sensor : 95.8 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 sn030003 active from July 15, 2004

hierarchy of traceability : The reference CG 3 has been compared against a reference pyrgeometer CG 4 under clear sky conditions at Kipp & Zonen, Delft Holland. (On his turn the CG 4 was calibrated outdoors August 28, 2001, at the World Radiation Center Davos against their reference pyrgeometer PIR 31463F3). The reference CG 3 and CG 4 were placed horizontally side by side. During the calibration period from 18:00 MET (6 November 2003) to 06:00 MET (7 November 2003) the (outgoing) radiation signal (U / S) ranged from - 90 to - 80 W/m². The instrument temperatures ranged from +10° to 0°C. The pyrgeometer thermopile outputs (U_{CG 4}, U_{CG 3}) and body temperatures (T_{CG 4}, T_{CG 3}) 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:
$$L_d = \frac{U_{CG\ 4}}{S} + 5.67 \cdot 10^{-8} \cdot T_{CG\ 4}^4$$

For the reference CG 4 sn010536 a sensitivity S of 9.78 $\mu\text{V/W/m}^2$ has been applied and with its voltage U_{CG 4} and temperature T_{CG 4} data the reference L_d curve is calculated.

For the reference CG 3 a one minute average sensitivity S_{CG 3} is calculated with the formula:

$$S_{CG\ 3} = U_{CG\ 3} \cdot (L_d - 5.67 \cdot 10^{-8} \cdot T_{CG\ 3}^4)^{-1}$$

A final S_{CG 3} is determined only from one minute S_{CG 3}'s determined in periods with a net IR signal < -40 W/m² (Clear sky). The sum of all periods was at least 6 hours.

The derived CG 3 sn030003 sensitivity is: 11.67 ± 0.1 $\mu\text{V/W/m}^2$.

IN CHARGE OF TEST : P.v.d.Heijden Date: 2006-January-13 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.