CFR

Calibration Facility

Instruction Manual

IMPORTANT USER INFORMATION

Reading this entire manual is recommended for full understanding of the use of this product.

Should you have any comments on this manual we will be pleased to receive them at:

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Kipp & Zonen guarantees that the product delivered has been thoroughly tested to ensure that it meets its published specifications. The warranty included in the conditions of delivery is valid only if the product has been installed and used according to the instructions supplied by Kipp & Zonen.

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Manual version: 0107

Declaration of Conformity
According to EC guideline 89/336/EEC

We **Kipp & Zonen B.V.**
Delftechpark 36
2628 XH Delft

Declare under our sole responsibility that the product

Type: **CFR (version 230 VAC / 50Hz)**
Name: **Calibration Facility for Radiometers**

To which this declaration relates is in conformity with the following standard

Safety standard IEC 1010-1

Following the provisions of the directive.

B.A.H. Dieterink
President
KIPP & ZONEN B.V.

Table of contents

1 Introduction

Dear customer, thank you for purchasing a Kipp & Zonen product. Please read this manual for a full understanding of the use of your Calibration Facility.

The CFR Calibration Facility for Radiometers is designed for the calibration of pyranometers by comparison to a reference pyranometer. As such, it offers a simple and traceable solution for quality control of the stability of pyranometers used in a network.The procedure described complies with Annex A.3 to the international standard ISO 9847 "Calibration of Field Pyranometers by Comparison to a Reference Pyranometer". Annex A.3 is titled "Calibration Devices Using Artificial Sources".

This manual contains information related to the installation, operation, maintenance and calibration of both the 230 VAC / 50 Hz and 115 VAC / 60 Hz versions of the CFR.

If any questions should remain, please feel free to contact your Kipp & Zonen dealer or e-mail

info@kippzonen.com

For information about other Kipp & Zonen products or to check for any update of this manual, go to
www.kippzonen.com

2 Installation and operation

2.1 Delivery

Check the contents of the shipment for completeness (see below) and note whether any damage has occurred during transport. If there is damage, a claim should be filed with the carrier immediately. In this case, or if the contents are incomplete, your dealer should be notified in order to facilitate the repair or replacement of the product.

Contents of delivery:

- Table (including voltage stabilization for 230 VAC / 50Hz version), turntable, shading mechanism
- Lamp with power supply cable
- One spare bulb
- Lamp mounting pillar
- High accuracy voltmeter
- Accessories (stopwatch, cables, tools for installation)
- Manual (2 copies)
- Optional: reference pyranometer(s) with calibration certificate(s)
- Optional: mountings for other Kipp & Zonen radiometers
- Optional: mountings for pyranometers produced by other manufacturers.

2.2 Installation

2.2.1 Environmental conditions

To perform accurate calibrations the calibration facility should preferably be installed in a separate room with temperature controlled and ventilated environment and without spurious light reflections coming from walls and other objects (ideally a dark-room). Kipp & Zonen reference pyranometers are calibrated at approximately + 20 ºC, therefore it is strongly recommended to maintain similar environmental conditions.

2.2.2 Mechanical and electrical set-up

The calibration facility must be built up in the following order. The step-by-step procedure is illustrated in the figures below.

Step 1 Mount the lamp pillar on the table and tightly secure it with the 4 countersunk bolts. The limit cam should be visible at the front side of the lamp pillar.

figure 1 Calibration table with lamp pillar

Step 2 Slide the lamp mounting bracket over the lamp pillar and place the white clamping disk inside the bracket.

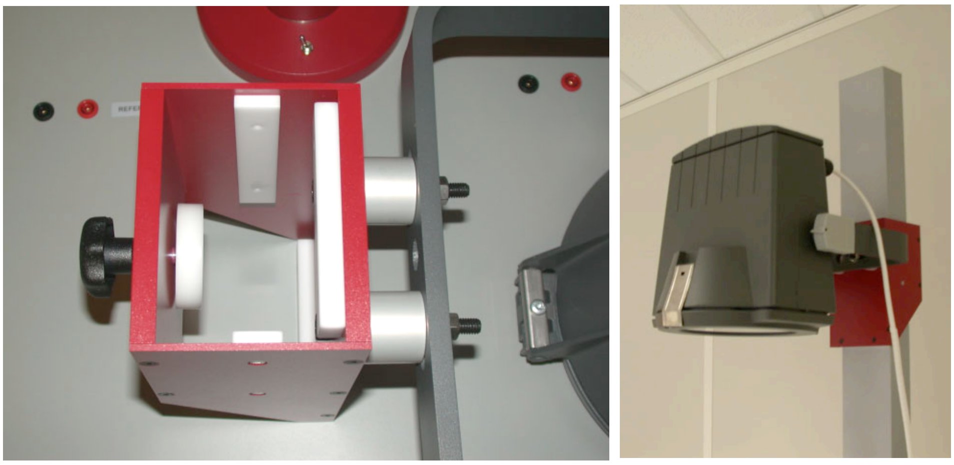


figure 2 Lamp mounting bracket slid over the lamp pillar

Step 3 Remove the mains plug from the lamp housing power cable (if fitted) and pass the cable through the lamp mounting pillar and cable gland.

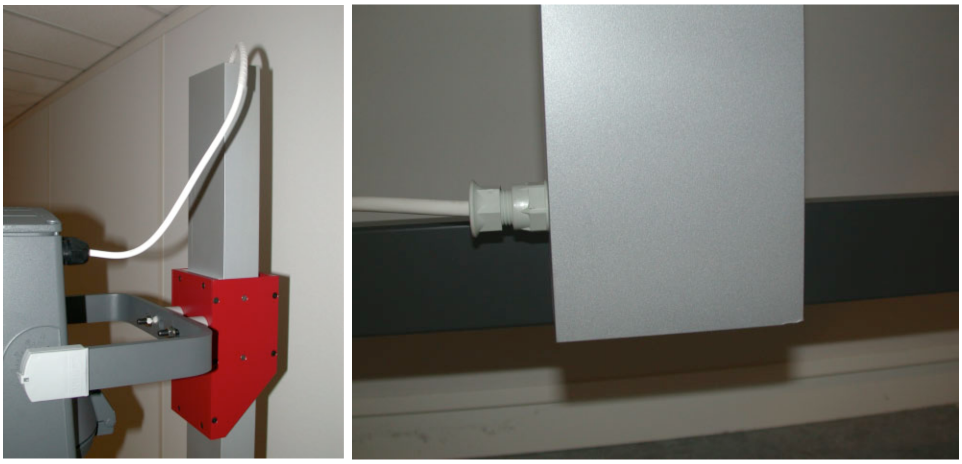


figure 3 Lamp cable passed trough the lamp pillar

Step 4 Electrical connection of the lamp to the voltage stabilizer

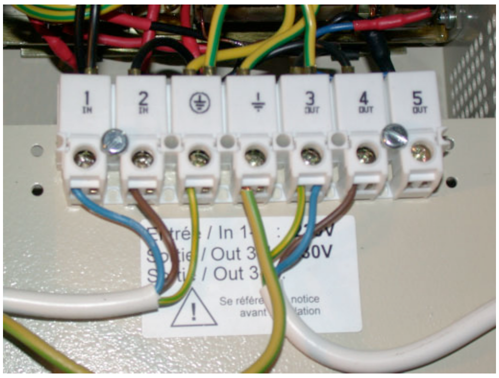
⚠ **Warning: To prevent electric shock during installation, all electrical devices must be disconnected from the mains power.**

115 VAC / 60 Hz Calibration Facility

The 115 VAC / 60Hz version of the CFR has all the electronic components for powering the bulb integrated into the lamp housing. Re-fit the plug and connect directly to a suitable mains outlet socket. Connect the voltmeter power cable to a suitable mains outlet socket.

230 VAC / 50 Hz Calibration Facility

Connect the lamp power cable to the voltage stabilization unit, as shown in figure 4. Fit the metal cover and connect the voltage stabilizer and voltmeter power cables to suitable mains outlet sockets.



Label	Function	Cable	Wire color
1 in	Neutral	Mains	Blue
2 in	Phase 230 VAC	Mains	Brown
(⏚)	Protective Earth	Mains	Yellow/Green
⏚	Earth	Table	Yellow/Green
3 out	Neutral / Earth	Lamp	Blue and Yellow/Green
4 out	Phase 230 VAC	Lamp	Brown
5 out	-	-	-

figure 4 Cable wires connected to the voltage stabilizer terminals

Step 5 Connect the red and black signal measurement cables to either the back or front input terminals of the voltmeter and to the signal output terminals near the lamp pillar.

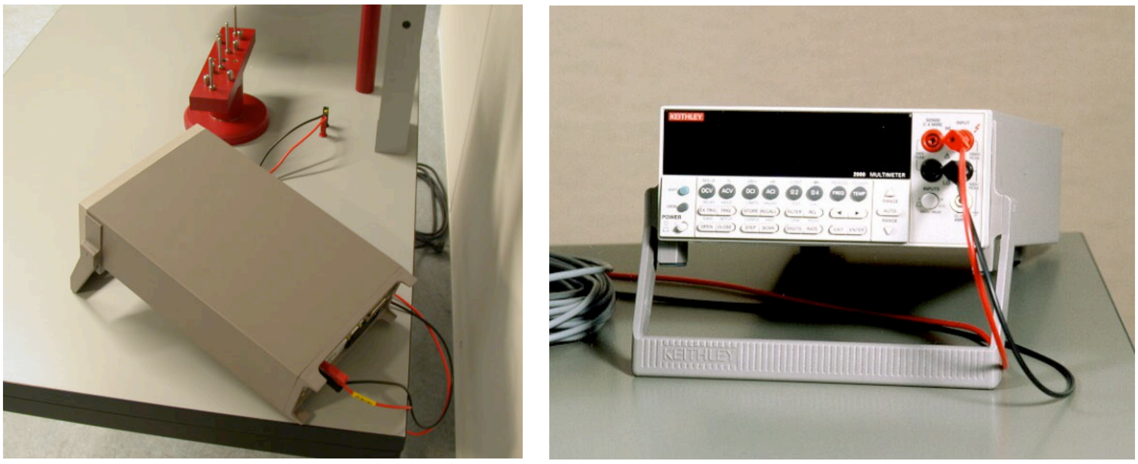


figure 5 Signal cables between voltmeter and signal output terminals

Step 6 The installation will be complete when the mains power cord is connected to an AC power outlet. The lamp of the 230 VAC / 50 Hz Calibration Facility the lamp can be turned on and off using the switch on the power strip.

Finally the correct lamp height should be determined by measuring the irradiance with a reference pyranometer at the left or right position of the turntable. Adjust the lamp height such that the irradiance should be in the range 500 – 600 W/m^2.

figure 6 Complete calibration facility

2.3 Maintenance

In general, the manual calibration facility requires little maintenance apart from keeping it clean and checking that mountings, fittings and electrical connections are secure.

2.3.1 Lamp

⚠

Warning: When cleaning the window or changing the bulb of the calibration lamp for maintenance purposes, the calibration facility should be disconnected from the mains power.
The bulb is pressurized and very hot during operation. Allow it to cool down before handling.

Regular cleaning of both sides of the lamp window is necessary to maintain even illumination.

figure 7 230 VAC/ 50 Hz calibration facility

Open the cover of the lamp by releasing the latches. Remove the old bulb using a piece of soft cloth and dispose of it according to local regulations. Take a new bulb from its package and be sure to only hold it by the base. Handling the quartz envelope may leave permanent marks on the surface, so always use a soft, clean cloth. Fit the 2-pin base of the new bulb into the holder in the middle of the lamp reflector. It only locates in one orientation and should snap into the lamp holder when using a minimum amount of force. Close and secure the lamp cover before switching on the power.

2.3.2 Maintenance and recalibration of the reference pyranometer

On a regular basis the pyranometer dome should be cleaned using alcohol, or clean water. The reference should be kept in a clean, dry and dark place at stable temperature when not in use. The desiccant should be checked regularly and changed when necessary. It can be recalibrated at the World Radiation Centre (Davos, Switzerland), at a Regional Radiation Centre, or at Kipp & Zonen. Addresses of Radiation Centres can be found in Annex III to this manual. The reference pyranometer should be of similar type (construction) to the test pyranometer and of equivalent or higher standard.

It can be convenient to have two of each reference type, so that indoor calibrations can continue whilst the other reference is at a Radiation Centre for recalibration. When the recalibrated reference becomes operational it is advised to document the change of your radiation scale by checking the old reference against the new reference. If the scale change is < 1% you can accept the new value as being the most “fresh” value. If the scale change is more than 1%, critical examination of the radiation centre procedures for old and new references is necessary.

There are several procedures for transferring calibration values from a narrow field of view instrument (pyrheliometer) to a wide field of view instrument (pyranometer). For example the direct component of the solar radiation can be eliminated temporarily from the pyranometer by shading the whole outer dome of the instrument with a disk. However, there is no thermal equilibrium with this method and some models of pyranometer show significant zero-offset drift.

An alternative procedure maintains the test pyranometer in its normal operating condition. This 'component sum' method involves measuring the direct component of the solar radiation with a pyrheliometer and the diffuse component with a shaded pyranometer, and adding together the two values to obtain the global radiation. As, during a clear day, the diffuse radiation is only about 10% of the global radiation, the sensitivity of the second pyranometer does not need to be known very accurately. Both procedures are suitable to obtain a working standard pyranometer. This method is extensively described in international standard ISO 9846.

Transfer from the working standard pyranometer to other pyranometers can be done in sunlight. The pyranometers must be mounted side by side so that each views the same sky dome. It is desirable to integrate, or average, the outputs over a period of time and then compute the calibration constants on the basis of these averages. This reduces the errors due to changing parameters during the day.

Transfer from a working standard pyranometer in the laboratory is only reliable when both pyranometers are of the same construction and have similar optical characteristics. Kipp & Zonen can recalibrate pyranometers according to this method.

2.3.3 Spare Parts Specification

This section provides the article numbers for ordering spare parts for the Calibration Facility.

Part	Description	Part No.
Lamp Housing	: 230 VAC / 50Hz Version	2654116
	: 115 VAC / 60Hz Version	2654117
Bulb (115 & 230 VAC)	: Philips CDM-T 150 W / 942	2603864
Lamp stabilizer (230 VAC)	: MCB Industries , Model 250 VA / 50Hz	2681060
Voltage measurement device	: Keithley Instruments, model 2000	4902212

3 Calibration operation

The indoor calibration procedure, according to ISO 9847 Appendix III, is based on a side-by-side comparison with a reference radiometer under a stable artificial sun. Kipp & Zonen uses a 150 W Metal-Halide high-pressure gas discharge lamp with voltage stabilisation. Behind the lamp is a reflector with a diameter of 16.2 cm. The reflector is 115 cm above the radiometers producing a vertical beam. The irradiance at the radiometers is approximately 500 W/m².

To minimise stray light from the walls and the operator, the light is restricted to a small cone around the two radiometers. The unknown test radiometer 'T' and the reference radiometer 'R' are placed side-by-side on a small table. The table can rotate to interchange the positions (1 and 2) of the radiometers. The lamp is centred on the rotating axis of this table. Actually there is no normal incidence of the radiation, but the angle of incidence is the same for both radiometers (3°) so this cannot give rise to errors. The two radiometers are not levelled with the adjustable feet, but placed on their bases. The effect of the small beam tilt is negligible (compare cos. 3° = 0.9986 and cos. 4° = 0.9976).

Once the Calibration Facility has been installed calibration is quick and simple, but the procedure must be carried out carefully and thoroughly. Section 3.1 describes the procedure and 3.2 gives step-by-step instructions to follow. The philosophy behind the calibration is given in 3.3. In 3.4 an example of a calibration form is given and the form is shown in Annex I.

Wherever output voltages are indicated, R refers to the reference and T refers to the test pyranometer. When dark signals or offsets are indicated, the "*E*" symbol is used. Measurements in position 1 are indicated by "1" (see paragraph on turntable), measurements in position 2 are indicated by "2". The symbol "*S*" refers to sensitivity.

3.1 Description of the procedure

The reference pyranometer and the test pyranometer are placed side-by-side on the turntable in position 1. The table can turn in order to exchange positions. The lamp illuminates both pyranometers with an intensity of approximately 500 Watts per square meter.

After illuminating for one minute, the output voltages of both pyranometers are measured shortly after each other with the voltmeter. The obtained values are called *R* and *T*. Next, a shield covers both pyranometers, so that they do not receive any light. After one minute, the output voltages of both pyranometers are again measured. The values obtained, called ‘zero offsets’, are *RE* and *TE* respectively. The order of magnitude of this offset for a Kipp & Zonen pyranometer is a few W/m^2. For pyranometers from other manufacturers, it could be larger. These zero offsets must be subtracted from the values *R* and *T*. The resulting values are *R1 (equals R-RE)* and *T1 (equals T-TE)*.

The possibility of making errors due to inhomogeneous light is still present. Therefore, the positions of the pyranometers are interchanged, to position 2, by rotating the turntable, and the procedure is repeated. The resulting values of this second measurement are called *R2* and *T2*.
The sensitivity *ST* of the test pyranometer can now be calculated based on the known sensitivity of the reference pyranometer *SR*:

$$ST = SR \cdot \frac{(T1 + T2)}{(R1 + R2)} \qquad \text{(Formula 1)}$$

Finally, a check on errors and lamp stability can be done, using the information of the output of the pyranometers. If the stability is not sufficient, the calibration should be rejected. The rule is that the calibration has not succeeded if the following expression is outside its boundaries:

$$0.98 < \frac{(R1 \cdot T1)}{(R2 \cdot T2)} < 1.02 \qquad \text{(Formula 2)}$$

This expression is sensitive to:

- read-out errors by the operator;
- accidental shading of one pyranometer;
- a non-perfect interchange of position;
- light field instability.

Lamp drift influences the result of the expression, although the effect on the calculated sensitivity *ST* is negligible due to the near simultaneous read-outs.

3.2 Description of the procedure step-by-step

1. **Switch on** the lamp and the voltmeter.
2. Place the reference and test **pyranometers** in the calibration room, **outside the lamplight**, in order to let their temperatures stabilize. Allow 2 hours for the test pyranometer to stabilize if it has been outdoors.
3. Allow **20 minutes** for the lamp to stabilize.
4. Put a test pyranometer and the reference in **position marked with reference**. **Check that the detector surface heights are the same.**
5. Darken the pyranometers with the shading mechanism and wait **2 minutes**.
6. **Expose** the pyranometers to light.
7. After exactly **one minute** note the outputs of the reference and test pyranometers. **Write** them down on the calibration form.
8. **Darken** the pyranometers.
9. Exactly **one minute** after darkening, note the outputs of the reference and test pyranometers. **Write** them down on the calibration form.
10. **Rotate the turntable** so that the pyranometers are in opposite **position**, in the dark.
11. **Expose** the pyranometers to the light.
12. After exactly **one minute** note the outputs of the reference and test pyranometers. **Write** them down on the calibration form.
13. **Darken** the pyranometers.
14. Exactly **one minute** after darkening, note the outputs of the reference and test pyranometers. **Write** them down on the calibration form.
15. **Calculate** the **calibration factor** according to the procedure that is described on the calibration form.
16. **Check** if the **lamp stability** has been sufficient, according to the procedure that is described on the calibration form.
17. For multiple calibrations start again at step 4.

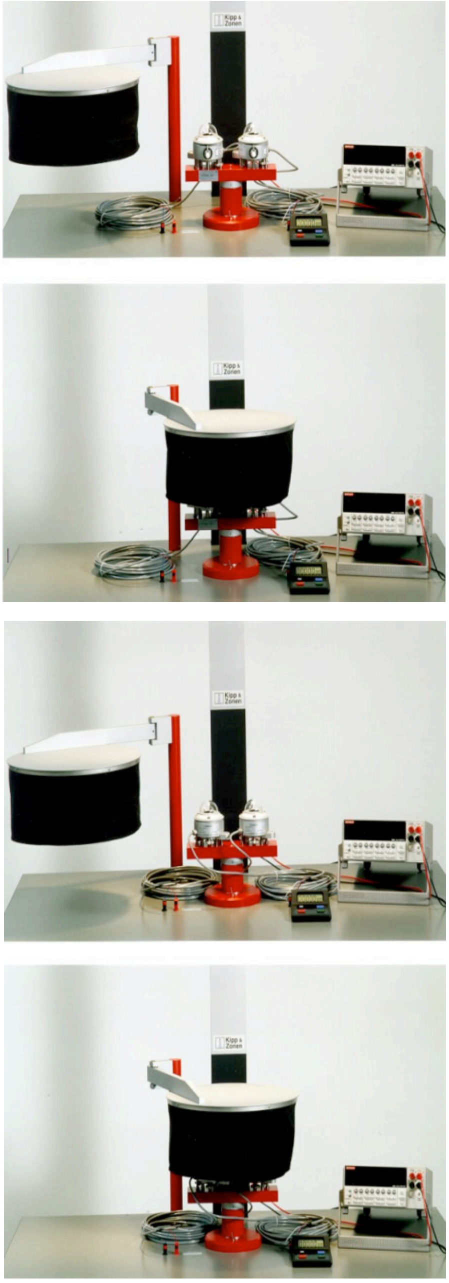


figure 8 Different positions of the turntable and shutter during the calibration procedure

3.3 Calibration uncertainty

The main purpose of the calibration procedure is to perform a one-to-one comparison of the reference pyranometer and the test pyranometer. In order to achieve this, both pyranometers need to be exposed to exactly the same irradiance, under the same circumstances.

There are a number of error sources that could affect the calibration measurement. Potential sources of error are: Lamp instability, pyranometer zero offsets (A and B), voltmeter offset, differences in sensor height and tilting of the pyranometers. These error sources are described below.

The method of performing the calibration, and the subsequent calculations, have been chosen such that the effects of all these error sources have been minimised.

3.3.1 Instability of the lamp output power

Instability of the lamp output power due to mains voltage variations and changes in the light field is fortunately only a secondary source of error. By using formula 2 one can easily assess the total lamp power instability and calibrations where the deviation is greater than 2 % should be rejected.

3.3.2 Pyranometer offsets

Pyranometer offsets cause an output from the instrument, even when no light is present. These offsets are corrected for during the calibration procedure by performing the dark measurements and are taken into account in Formula 1.
ISO 9060 specifies two kinds of offsets; "zero offset a" which results from exchange of thermal radiation between the pyranometer and its surroundings, and "zero offset b" which results from changes in the ambient air temperature.

The offsets are basically caused by the fact that the pyranometer incorporates a thermal sensor, which is sensitive to all heat flows. A high offset can usually be cured by waiting. It will settle down slowly.

Important note!

1. **Pyranometers should be kept out of the lamplight when exposure is not necessary.**
2. **Pyranometers must be operated in a thermally stable environment during calibration.**

More detailed information about zero offsets is explained in the general pyranometer manual.

3.3.3 Voltmeter offset

Theoretically, the voltmeter can cause a zero offset or drift. Short-circuiting the voltmeter input with a resistance equal to the pyranometer's impedance can check the zero offset. The voltmeter might change sensitivity over the years. Generally it should be regularly recalibrated, as for all test and measurement instruments. Because of the fact that the calibration is a relative measurement, the voltmeter sensitivity is cancelled out of the equations. Only the voltmeter linearity and short term drift must be good.

3.3.4 Tilting of the pyranometers

Tilting of the pyranometers, and also the related possibility of light rays that fall in at an angle other than perpendicular, is not a significant error source. This can easily be shown by comparing the cosine values of 0° and 3° angles. These differ by only 0.1%.

3.3.5 Differences in sensor height and geometry

As stated earlier in this chapter, the main purpose of the calibration procedure is to perform a one-to-one comparison of the reference pyranometer and the test pyranometer, which should ideally be of the same model. In that case the height and geometry of both the reference and the test pyranometers are exactly the same. In general, errors in height are the most serious threats to measurement accuracy and should be checked with each calibration.

Note that for side-by-side calibrations outdoors the sensor's heights are less critical because the light source)the sun) is distant and the intensity gradient is small.

3.3.6 Calibration repeatability and overall uncertainty

From experience, the agreement of the calculated values of sensitivity (S) over a number of consecutive measurements of the same test pyranometer shows repeatability within 0.5% percent.
The overall calibration uncertainty of the test pyranometer is estimated to be < 1% compared with the calibrated value of a reference Pyranometer of similar type.

3.4 Calibration Form

An example of a calibration form is given below.

Test pyranometer model: **CMP 6**
Serial number: **060002**

Reference pyranometer model: **CMP 6**
Serial number: **060001**
Sensitivity: *10.00* V/Wm^{-2} (*SR*)

Calibration performed by: *J. Smith*
Date: *20 September 2006* Signature

		Reference pyranometer		Test pyranometer	
Position 1					
	Illuminated	R	*1980*	T	*2980*
	Darkened	RE	*5*	TE	*10*
		R1=R-RE	*1975*	**T1=T-TE**	*2970*
Position 2					
	Illuminated	*R*	*2100*	T	*2820*
	Darkened	*RE*	*2*	TE	*8*
		R2=R-RE	*2098*	**T1=T-TE**	*2812*

Test pyranometer sensitivity

$ST = SR \cdot \frac{(T1+T2)}{(R1+R2)}$ *14.20* V/Wm^{-2}

Lamp stability

$0.98 < \frac{(R1 \cdot T1)}{(R2 \cdot T2)} < 1.02$ *0.994* OK/~~Rejected~~

4 Principle components and specifications of the facility

The Calibration Facility consists of a number of parts. These are described in the following paragraphs.

4.1 Table

The table serves for mounting the lamp, the turntable, the voltage stabilizer (230 VAC version) and the shading mechanism. Additionally, it can serve as a worktable and has clamps for connecting the reference pyranometer signal wires, the test pyranometer signal wires and the voltage meter wires. During calibration, the voltmeter is used alternately to measure both the reference pyranometer signal and the test pyranometer signal.

In order to reduce light reflections, the table has a gray finish.

4.2 Turntable

The turntable serves for mounting the test pyranometer and the reference pyranometer. By rotating the turntable, the positions of these two can be precisely interchanged.
The two available positions are called position 1 and 2. In position 1, the reference is at the left, as seen standing in front of the Calibration Facility. In position 2, the reference is at the right.

The interchange of position during calibration is necessary because the light coming from the lamp is not uniformly distributed across the surface in which the pyranometers are positioned.

In its standard form, the turntable is suitable for installation of Kipp & Zonen pyranometers models CM 6B, 11, 11B, 21, 22 and 31 and the successor models CMP 6, CMP 11, CMP 21 and CMP 22.
Note: there is only one position in which the pyranometers are properly supported by the turntable pillars.

In order to change the voltmeter input signal from the test pyranometer to the reference pyranometer, a switch is incorporated in the turntable base.

For calibration of other Kipp & Zonen radiometers, or pyranometers from other manufactures, a range of adaptors is available.

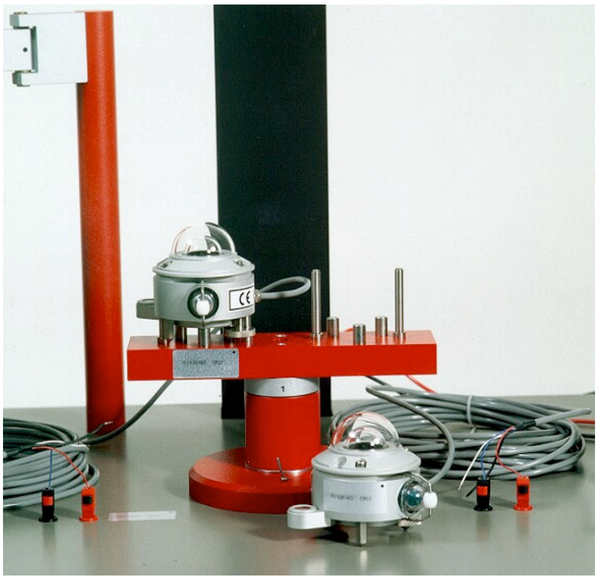


figure 9 Turntable with reference pyranometer

4.3 Shading mechanism

The shading mechanism serves to obtain the dark (zero-offset) signal of the pyranometers and the measurement chain. The shading mechanism blocks all light illuminated from the lamp.

4.4 Lamp mounting pillar

The lamppost serves to position the lamp at a certain height above the pyranometers. In view of the fact that the packaging has to stay within certain limits, the lamppost consists of two parts. The lower part is painted black in order to avoid reflections of the lamp.

4.5 Lamp housing

4.5.1 115VAC/60 Hz Calibration Facility

The 115 VAC / 60Hz calibration lamp is a PAR CDM luminaire, constructed of cast aluminium with non-corroding hardware and fittings.

4.5.2 230VAC/50 Hz Calibration Facility

The 230 VAC / 50Hz calibration lamp is a medium-sized, high-grade, rotation-symmetrical floodlight with a narrow beam.

4.6 Lamp bulb

The lamp serves to generate an input signal for comparing the pyranometer responses. The calibration of the reference is usually done outdoors under sunlight. It should be noted that if the reference and test pyranometers are of the same type, neither the spectrum nor the intensity of the calibration lamp need to exactly simulate sunlight because both pyranometers will be affected similarly.

Product Identification	Philips MasterColor CDM-T 150W/942 G12 T6 1CT
Power	150 W
Average Life	12000 hrs
Lamp Voltage	90 V
Color Description	942 Cool White
Color Temperature	4200 K
Initial Lumens	12700
Design Mean Lumens	8900

4.7 Voltage Stabilization

The voltage stabilizer provides a highly stable voltage to the lamp. For calibration it is necessary to have a reliable voltage because variations in lamp output can affect the result of the calibration slightly. In the final calculation there is a check on read-outs and lamp stability. This is shown in chapter 3. For the 230 VAC / 50Hz version the voltage stabilizer is mounted underneath the table. The 115 VAC / 60Hz facility has the stabilisation circuitry built into the lamp.

4.8 Voltmeter

The voltmeter shown in figure 10 serves to measure the output of the pyranometers. The specific type of voltmeter has been selected for its capability to measure small microvolt signals with high stability and low offsets. In the final calibration calculation, the absolute accuracy of the voltmeter is eliminated as a parameter, as long as the readout is linear and repeatable.

It is recommended to set the voltmeter to measure on the 100 mV scale with an accuracy of 3 digits. To ensure a steady value of the output signal, the sampling rate should be set to medium with a moving average filter over 100 samples.

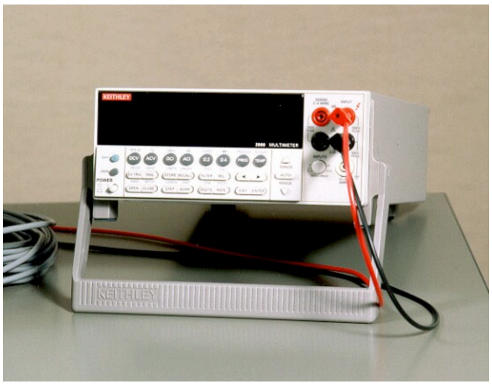


figure 10 Voltmeter

4.9 Switch and clamps

The switch located on the turntable changes the input of the voltmeter from the reference pyranometer to the test pyranometer. The spring clamps located on the table connect the signal wires of the two pyranometers to the switch.

4.10 Reference pyranometer

The reference pyranometer used for calibration is normally delivered with the Calibration Facility, selected from optional list to suit the test pyranometers to be recalibrated. It should normally be of the same type as the test pyranometers or of a higher class but similar construction. The reason for this is that for similar types, there are no errors introduced due to differing instrument characteristics. It is therefore suggested to obtain a reference for each type that is in use.

It is possible to calibrate other types of pyranometers that are not the same as the reference. However, it should be noted that the estimated calibration transfer accuracy could be lower. This has to do with the fact that the surface areas of the detectors, spectral selectivity, non-linearity, time constants and other factors may differ.

The reference pyranometer should be kept in a clean, dry and dark place in order to avoid unnecessary aging and the desiccant checked regularly. Under field conditions, the change in sensitivity should be less than ± 1% per year. Properly stored, the stability should be ± 0.25% per year.
Recalibration can be done either at Kipp & Zonen, at a Regional Radiation Centre, or (with the highest accuracy) at the World Radiation Center (WRC) in Davos, Switzerland.

The Kipp & Zonen reference pyranometers are calibrated at the WRC with the sun and sky as the radiation source. As a consequence, in principle, the calibration values obtained for test pyranometers when using the CFR are related to the same outdoor conditions as in Davos. The specific conditions are given in the extended calibration certificate that accompanies the reference pyranometer. A small correction is applied to convert from the solar elevation angle at the time of the reference calibration, to normal incidence (vertical) radiation, as used in the CFR.

4.11 Mountings for other radiometers

A range of optional turntables and adapters is available for mounting other Kipp & Zonen radiometers and some models of pyranometers from other manufacturers. These can be easily be exchanged with the standard Kipp & Zonen mounting provided with the CFR.

4.12 Stopwatch

The stopwatch provides accurate timing of the calibration. It is necessary to perform the calibration with the steps of the procedure timed as exactly as possible to overcome the fact that the response time of some pyranometers is in the order of magnitude of 2 minutes for 99% response. Good timing is the key to optimal repeatability.

5 Frequently asked questions

□ Can I calibrate pyranometers from different manufacturers with the CFR?

The CFR is a universal calibration facility using a standardized calibration method that can be applied to any other pyranometer model. Although one should take into account the basic principles of uniformity between the test and reference pyranometer and ensuring equivalent detector heights.

□ Can I calibrate a Kipp & Zonen pyranometers using a higher standard Kipp & Zonen reference pyranometer?

Most Kipp & Zonen pyranometers have a similar sensor geometry, therefore can be calibrated with a model of a higher class. Kipp & Zonen offers different mounting adapters to accommodate pyranometers that do not fit to the standard mounting bracket.

Appendix I: Calibration Form for pyranometers

Test pyranometer model : ....

Serial number : ....

Reference pyranometer model : ....

Serial number : ....

Sensitivity : .... V/Wm^{-2} (SR)

Calibration performed by : ....

Date : .... Signature : ....

		Reference pyranometer		Test pyranometer	
Position 1					
	Illuminated	R	:	T	: ....
	Darkened	RE	:	TE	: ....
		R1 = R-RE	:	**T1 = T-TE**	: ....
Position 2					
	Illuminated	R	:	T	: ....
	Darkened	RE	:	TE	: ....
		R2 = R – RE	:	**T2 = T – TE**	: ....

Test pyranometer sensitivity

$ST = SR \cdot \frac{(T1 + T2)}{(R1 + R2)}$ **:** .... V/Wm^{-2}

Lamp stability

$0.98 < \frac{(R1 \cdot T1)}{(R2 \cdot T2)} < 1.02$ **:** .... OK/Rejected

Appendix II: Pyranometer Classification According to WMO Guide 1996

Characteristics	**CMP 22**	**CMP 21**	**CMP 11**	**CMP 6**	**High quality**	**Good quality**	**Moderate quality**
ISO 9060 classification	**Secondary Standard**	**Secondary Standard**	**Secondary Standard**	**First Class**	**Secondary Standard**	**First Class**	**Second Class**
Response time (95 percent response)	5 s	5 s	5 s	18 s	< 15 s	< 30 s	< 60 s
Zero offset: (a) Response to 200 W/m^2 net thermal radiation (ventilated) (b) Response 5 K/h change in ambient temperature	± 3 W/m^2 ± 1 W/m^2	± 7 W/m^2 ± 2 W/m^2	± 7 W/m^2 ± 2 W/m^2	± 15 W/m^2 ± 4 W/m^2	± 7 W/m^2 ± 2 W/m^2	± 15 W/m^2 ± 4 W/m^2	± 30 W/m^2 ± 8 W/m^2
Resolution (smallest detectable change)	± 1 W/m^2	± 1 W/m^2	± 1 W/m^2	± 1 W/m^2	± 1 W/m^2	± 5 W/m^2	± 10 W/m^2
Stability (change per year, percentage of full scale)	< 0.5	< 0.5	< 0.5	< 1	± 0.8	± 1.5	± 3.0
Directional response of beam radiation (The range of errors caused by assuming that the normal incidence responsivity is valid for all directions when measuring, from any direction, a beam radiation whose normal incidence irradiance is 1000 W/m^2)	± 5 W/m^2	± 10 W/m^2	± 10 W/m^2	± 20 W/m^2	± 10 W/m^2	± 20 W/m^2	± 30 W/m^2
Temperature response (percentage of maximum due to any change of ambient temperature within an interval of 50 K)	± 0.5 -20^{0}C-+50^{0}C	± 1 -20^{0}C-+50^{0}C	± 1 -10^{0}C-+40^{0}C	± 4 -10^{0}C-+40^{0}C	± 2	± 4	± 8
Non-linearity (percentage deviation from the responsivity at 500 W/m^2 due to any change of irradiance within the range 100 to 1000 W/m^2)	± 0.2	± 0.2	± 0.2	± 1	± 0.5	± 1	± 3
Spectral sensitivity (percentage of deviation of the product of spectral absorptance and spectral transmittance from the corresponding mean within the range of 0.3 to 3 μm)					± 2	± 5	± 10
Tilt response (percentage deviation from the responsivity at 0° tilt, horizontal, due to change in tilt from 0° to 90° at 1000 W/m^2 irradiance)	± 0.2	± 0.2	± 0.2	± 1	± 0.5	± 2	± 5
Achievable uncertainty, 95 percent confidence level Hourly totals Daily totals	1 %	2 %	2 %	5 %	3% 2%	8% 5%	20% 10%

Appendix III: List of World and Regional Radiation Centres

World Radiation Centres

Davos (Switzerland)
St. Petersburg (Russia) (data centre only)

Region I (Africa)
- Cairo (Egypt)
- Khartoum (Sudan)
- Kinshasa (Dem. Rep. of the Congo)
- Lagos (Nigeria)
- Tamanrasset (Algeria)
- Tunis (Tunisia)

Region II (Asia)
- Pune (India)
- Tokyo (Japan)

Region III (South America)
- Buenos Aires (Argentina)
- Lima (Peru)
- Santiago (Chile)

Region IV (North and Central America)
- Toronto (Canada)
- Boulder (United States)
- Mexico City (Mexico)

Region V (South-West Pacific)
- Melbourne (Australia)

Region VI (Europe)
- Budapest (Hungary)
- Davos (Switzerland)
- St. Petersburg (Russian Federation)
- Norrköping (Sweden)
- Trappes/Carpentras (France)
- Uccle (Belgium)
- Lindenberg (Germany)

Appendix IV: Recalibration service

Pyranometers, Albedometers, Pyrgeometers, UV-Radiometers & Sunshine Duration Sensors

Kipp & Zonen solar radiation measurement instruments comply with the most demanding international standards. In order to maintain the specified performance of these instruments, Kipp & Zonen recommends calibration of their instruments every two years.

This can be done at the Kipp & Zonen factory. Here, recalibration to the highest standards can be performed at low cost. Recalibration can usually be performed within four weeks. If required, urgent recalibration can be accomplished in three weeks or less (subject to scheduling restrictions). Kipp & Zonen will confirm the duration of recalibration at all times. Please note that special quantity recalibration discounts are available for instruments of the same type.

KIPP & ZONEN
SINCE 1830

Our customer support remains at your disposal for any maintenance or repair, calibration, supplies and spares.

Für Servicearbeiten und Kalibrierung, Verbrauchsmaterial und Ersatzteile steht Ihnen unsere Customer Support Abteilung zur Verfügung.

Notre service ‘Support Clientèle’ reste à votre entière disposition pour tout problème de maintenance, réparation ou d’étalonnage ainsi que pour les accessoires et pièces de rechange.

Nuestro servicio de atención al cliente esta a su disposición para cualquier actuación de mantenimiento, reparación, calibración y suministro de repuestos.

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