CH 1

Pyrheliometer

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:

Kipp & Zonen B.V.			
Delftechpark 36			
2628 XH		Delft	Holland
P.O. Box 507	2600 AM	Delft	Holland
Phone	+31 (0)15 2755210		
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Email	info@kippzonen.com		
Web	www.kippzonen.com		

Kipp & Zonen reserve the right to make changes to the specifications without prior notice.

WARRANTY AND LIABILITY

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.

Kipp & Zonen shall in no event be liable for incidental or consequential damages, including without limitation, lost profits, loss of income, loss of business opportunities, loss of use and other related exposures, however caused, arising from the faulty and incorrect use of the product.
User made modifications can affect the validity of the CE declaration.

Manual revision: 0706

CE

DECLARATION OF CONFORMITY
According to EC guideline 89/336/EEC

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

Declare under our sole responsibility that the product

Type: **CH 1**
Name: **Pyrheliometer**

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

Imissions	EN 50082-1	Group standard	
	IEC 100-4-2	IEC 801-2	8 kV
	IEC 100-4-3	IEC 801-3	3 V/m
	IEC 100-4-4	IEC 801-4	1 kV
Emissions	EN 50081-1	Group standard	
	EN 55022		

Following the provisions of the directive

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

TABLE OF CONTENTS

1. GENERAL INFORMATION

The pyrheliometer CH 1 is designed to measure the irradiance which results from the radiant flux from a solid angle of 5°. A drawing of the CH 1 is shown in figure 1.1. By aiming the pyrheliometer at the sun, the direct solar irradiance, perpendicular to the detector surface is measured. The CH 1 is designed for continuous outdoor use.

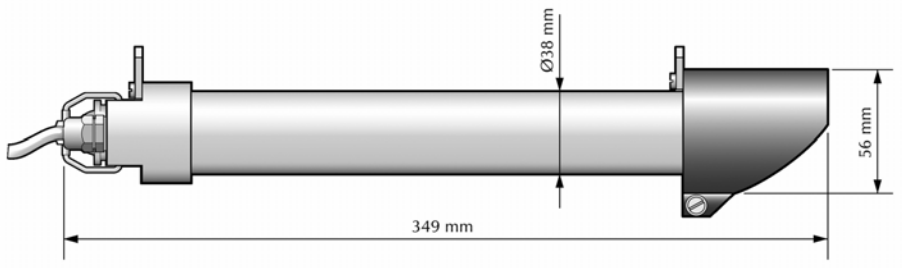

Fig.1.1. Dimensions of the CH 1 pyrheliometer.

In terms of the ISO 9060 standard, which has been accepted by WMO, the CH 1 measuring specifications are in accordance with "first class" pyrheliometers. In order to obtain full first class specification, the pyrheliometer must periodically be compared to a higher standard (ISO 9060, 1990 E, specification and classification of instruments for measuring hemispherical solar and direct solar radiation).

There are, however, specifications that are not within the ISO classification, most notably the opening and slope angle. These are chosen according to WMO recommendations (Revised Instruction Manual on Radiation Instruments and Measurements). The CH 1 is available with a number of options, which are described in Appendix A.

The sight is meant to check proper alignment.
Water vapour can be absorbed in the drying cartridge.

2. SPECIFICATIONS

2.1 ISO SPECIFICATIONS

Response time	95%	7 s
	99%	10 s
Zero offset: Caused by 5 K/H change in ambient temperature		3 W/m².
Non stability		< 1 % per year.
Non linearity		< 0.2 % (< 1000 W/m²).
Spectral selectivity within 0.35 to 1.5 µm.		< 0.5 %.
Temperature response percentage deviation due to ambient temperature (relative to 20 °C)		< 1 %, -20 to +50. < 1.5 %, -40 to +70.
Tilt response		None.
Traceability		To WRR.

OVERALL ISO CLASSIFICATION: FIRST CLASS

REMARK: IN ORDER TO OBTAIN FULL ISO FIRST CLASS CLASSIFICATION, THE PYRHELIOMETER MUST PERIODICALLY BE COMPARED TO A HIGHER STANDARD.

2.2 NON-ISO SPECIFICATIONS

Sensitivity	7-15 µV/Wm^2.
Spectral range	0.2 to 4 µm, 50 % points (see Appendix B.1).
Impedance	50-70 Ω.
Irradiance	0-4000 W/m^2.
Operating temperature	-40 to +80 °C.
Full opening angle	5° ± 0.2° (To WMO Recommendations).
Slope Angle	1° ± 0.2° (To WMO Recommendations).
Sight accuracy	± 0.2° from optical axis.
Materials	Anodised aluminum case, stainless steel screws.
Window material	Infrasil I-301.
Weight	700 grams.
Desiccant	Silica gel.
Cable length	10 m
Absorber coating	Kipp & Zonen carbon black.

3. INSTALLATION

In general the pyrheliometer will be used to measure direct solar irradiance. In this application it will be installed in a tracker, which will either be a manually adjustable mount (see options A.1) or a full- or semi-automatic tracking system.

For installing the CH 1 on a mount or tracking system, a clamp with the suitable 38 mm diameter hole is to be preferred. This clamp must not obstruct the sight. For optimal performance of the tracking system, please ensure that the centre of gravity of the pyrheliometer is in a good position.

If the pyrheliometer is used with a filter wheel, installation of the rain screen is no longer possible.

4. TRACKING

Tracking should have no less accuracy than ± 0.75° from ideal (See B.2). If more than 0.75° deviation occurs the sun starts falling partially outside of the field of view.

5. ELECTRICAL CONNECTION

Figure 5.1 shows the circuit diagram of the CH 1. Cables of up to 200 m are allowed as long as the resistance of the cable remains lower than 0.1 % of the impedance of the readout equipment. A surge arrester is incorporated.

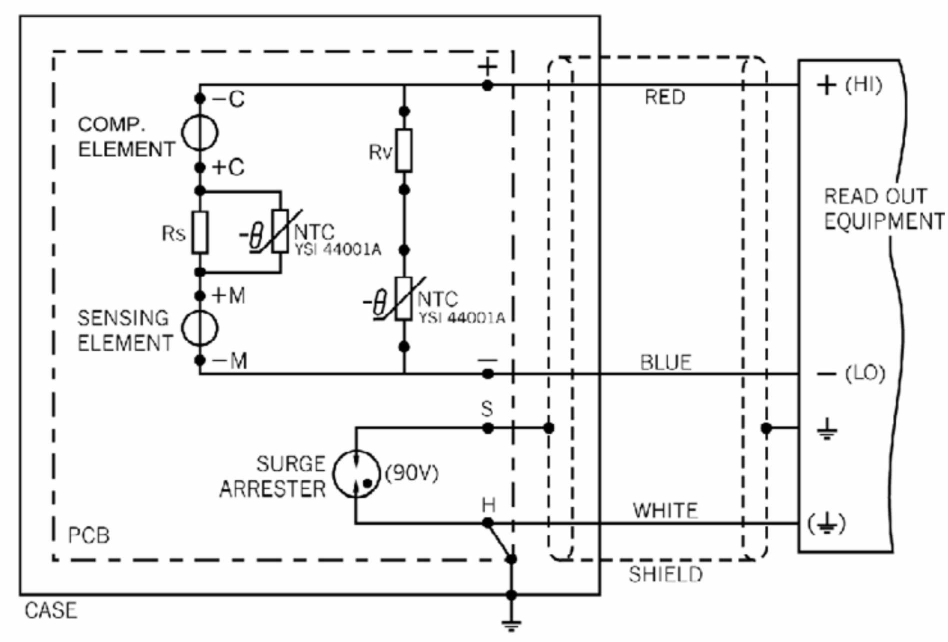

Fig. 5.1. Circuit diagram of the CH 1 pyrheliometer

6. AMPLIFICATION

Assuming that one wishes a measurement accuracy of 1 W/m^2 and the pyrheliometer has a typical sensitivity of 7 to 15 $\mu V/Wm^{-2}$ and an impedance of 70 Ω, this implies certain specifications for amplification and data acquisition.

The amplifier should have a zero offset of less than 1 W/m^2, that is (worst case) less than 7 µV.
Assuming that direct radiation is in the range of 0 to 1200 W/m^2, the amplifier range should be 18 mV.
Non-linearity (of 1 Watt on a scale of 1200) should be less than 0.08%.
In case the signal is digitised, the resolution should be (worst case) smaller than 7 µV or 1 W/m^2.
The impedance of the amplifier should not be lower than 1000 times the output impedance of the pyrheliometer, which is at least 70 kΩ.

7. MAINTENANCE AND OPERATION

For pyrheliometer operation, the most important aspects are:

PROPER ALIGNMENT
PERFECTLY CLEAN WINDOW

As part of the daily routine, inspection of alignment, window and drying cartridge are suggested.

As part of a monthly routine, inspection of leads and connections and replacement of drying cartridge could be performed.

Ensure that the silica gel is still coloured orange. When the orange silica gel in the drying cartridge is turned completely transparent (normally after several months), it must be replaced by active silicagel as supplied in the small refill packs. The content of one pack is sufficient for one complete refill.

On a yearly basis, a check on the calibration factor is advised. This can either be done by letting the pyrheliometer run parallel to a reference, or by performing an indoor calibration.

8. CALIBRATION

At Kipp & Zonen, calibration is performed by indoor comparison with a reference instrument. The reference is not of a higher standard classification. The comparison is made under a xenon lamp at an irradiance level of 800 W/m^2.

The reference has been calibrated at the World Radiation Centre. The accuracy of this calibration is ± 0.5 %.
ISO requests that each pyrheliometer, in order to obtain its classification, must periodically be compared to a higher standard.

APPENDIX A. OPTIONS

A.1 TWO – AXIS 2AP SOLAR TRACKER

The CH 1 is intended for continuous measurement of direct solar radiation used with the Kipp & Zonen two-axis 2AP Solar Tracker.

The 2 AP provides accurate automatic tracking of the sun at all latitudes and in a wide range of environmental conditions. The optional Large Side Mounting Plate allows for the fitment of 1 or 2 direct measurement radiometers such as the CH 1 or CUV A2/B2.

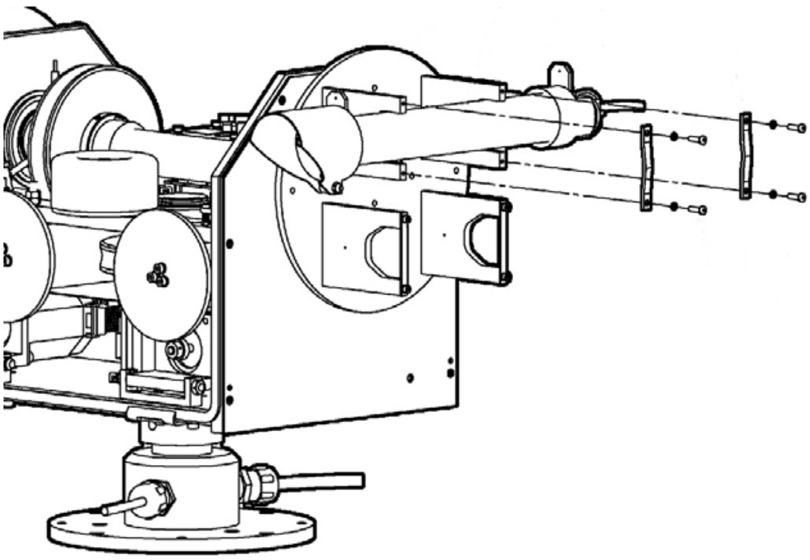

Figure A.1. Kipp & Zonen 2 AP Solar Tracker fitted with optional Large Side Mounting Plate for mounting CH 1.

A.2 FILTER WHEEL CH 1

The filter wheel is meant to allow broadband spectral measurement of direct radiation. Standard Meteorological filters OG 530, RG 630 and RG 695 are incorporated. A drawing is shown in figure A.2.

The filter wheel can be mounted on the CH 1. In this case however, the rain screen cannot be used any more.

With each filter a so-called filter factor can be ordered. This is the ratio of the intensity behind an imaginary filter with unity transmission between the cut-offs, and zero transmission outside, to the intensity measured with the actual filter, using a reasonable terrestrial solar spectrum as input (WMO manual to Meteorological Instruments and Methods of observation 1983). For the spectrum the results of Justus and Paris (Georgia Institute of Technology, Feb. 1987) are used.

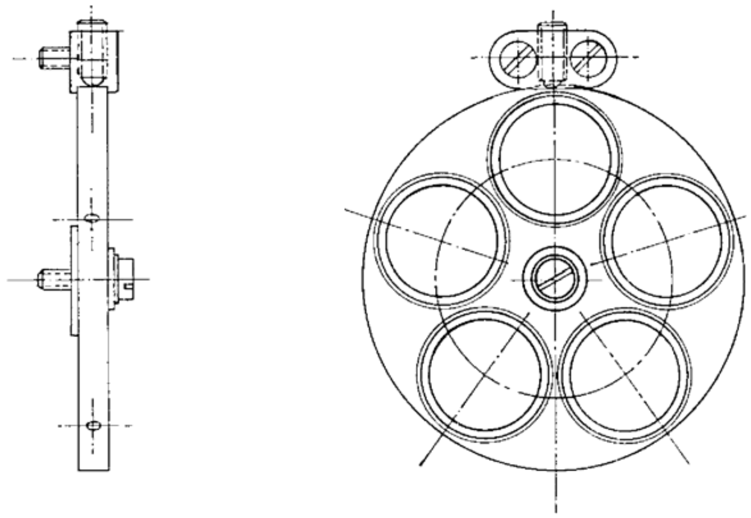

Fig. A.2. Filter Wheel

The filter wheel CH 1 can be mounted on pyrheliometer CH 1. 5 positions for filters are available, while the standard version offers 3 meteorological filters, OG 530, RG 630 and RG 695.

A.3 INTERNAL FILTER

Inside the CH 1 room is reserved for an internal broadband glass filter. This filter can be incorporated according to client specifications. Prices are given on request.

A.4 SENSOR TEMPERATURE MEASUREMENT WITH THERMISTOR 10 K OR WITH PT-100

For reasons of quality assessment of data, it is possible to monitor the sensor temperature of the CH 1. Doing this, temperature dependence of sensitivity and thermal shock effects might be observed and corrected for. Specifications of the thermistor and Pt-100 are in tables A.1 and A.2.

Wiring is specified in fig. A.3. The colour code is:

Red:	Plus thermopile
Blue:	Minus thermopile
Yellow:	Pt-100 (combined with brown) or thermistor
Brown:	Pt-100 (combined with yellow) or not present
Green:	Pt-100 (combined with grey) or thermistor
Grey:	Pt-100 (combined with green) or not present
White	Inner case
Shield	

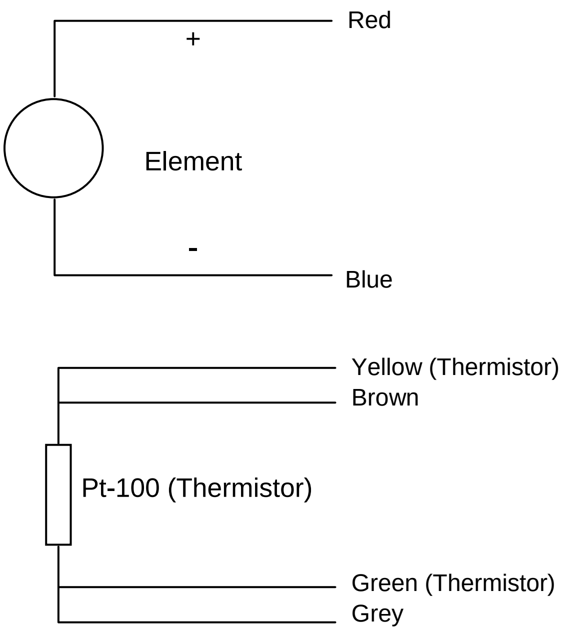

Fig. A.3. Wiring specifications.

Temperature [°C]	Resistance [Ω]	Temperature [°C]	Resistance [Ω]	Temperature [°C]	Resistance [Ω]
-30	135200	0	29490	30	8194
-29	127900	1	28150	31	7880
-28	121100	2	26890	32	7579
-27	114600	3	25690	33	7291
-26	108600	4	24550	34	7016
-25	102900	5	23460	35	6752
-24	97490	6	22430	36	6500
-23	92430	7	21450	37	6258
-22	87660	8	20520	38	6026
-21	83160	9	19630	39	5805
-20	78910	10	18790	40	5592
-19	74910	11	17980	41	5389
-18	71130	12	17220	42	5193
-17	67570	13	16490	43	5006
-16	64200	14	15790	44	4827
-15	61020	15	15130	45	4655
-14	58010	16	14500	46	4489
-13	55170	17	13900	47	4331
-12	52480	18	13330	48	4179
-11	49940	19	12790	49	4033
-10	47540	20	12260	50	3893
-9	45270	21	11770	51	3758
-8	43110	22	11290	52	3629
-7	41070	23	10840	53	3504
-6	39140	24	10410	54	3385
-5	37310	25	10000	55	3270
-4	35570	26	9605	56	3160
-3	33930	27	9227	57	3054
-2	32370	28	8867	58	2952
-1	30890	29	8523	59	2854

Table A.1. YSI Thermistor 44031 Resistance versus Temperature in °C

The Pt-100 is of Heraeus type M-GX 1013 and complies with DIN IEC 751. It has a change in resistance of approx. 0.39 Ω/K.

Temperature [°C]	Resistance [Ω]	Temperature [°C]	Resistance [Ω]	Temperature [°C]	Resistance [Ω]
-30	88.22	0	100.00	30	111.67
-29	88.62	1	100.39	31	112.06
-28	89.01	2	100.78	32	112.45
-27	89.40	3	101.17	33	112.83
-26	89.80	4	101.56	34	113.22
-25	90.19	5	101.95	35	113.61
-24	90.59	6	102.34	36	113.99
-23	90.98	7	102.73	37	114.38
-22	91.37	8	103.12	38	114.77
-21	91.77	9	103.51	39	115.15
-20	92.16	10	103.90	40	115.54
-19	92.55	11	104.29	41	115.93
-18	92.95	12	104.68	42	116.31
-17	93.34	13	105.07	43	116.70
-16	93.73	14	105.46	44	117.08
-15	94.12	15	105.85	45	117.47
-14	94.52	16	106.24	46	117.85
-13	94.91	17	106.63	47	118.24
-12	95.30	18	107.02	48	118.62
-11	95.69	19	107.40	49	119.01
-10	96.09	20	107.79	50	119.40
-9	96.48	21	108.18	51	119.78
-8	96.87	22	108.57	52	120.16
-7	97.26	23	108.96	53	120.55
-6	97.65	24	109.35	54	120.93
-5	98.04	25	109.73	55	121.32
-4	98.44	26	110.12	56	121.70
-3	98.83	27	110.51	57	122.09
-2	99.22	28	110.90	58	122.47
-1	99.61	29	111.28	59	122.86

Table A.2. Pt-100 Resistance versus Temperature in °C

A.5 CALIBRATION BY WORLD RADIATION CENTRE

At Kipp & Zonen calibration is done by comparison to a reference pyrheliometer, which on its turn is calibrated at the World Radiation Centre in Davos (WRC).

Calibration of your CH 1 can also be performed at WRC. At your request this will be arranged by Kipp & Zonen. Please note that this option will affect delivery time. Price is given on request.

APPENDIX B. PHYSICAL PRINCIPLES

B.1 OPERATIONAL PROPERTIES

The basic functions of a pyrheliometer are measuring solar radiation from a certain solid angle within a certain spectral range, with a certain spectral response.

The geometrical response is discussed in B.2.

The sensor in combination with filtering determines the spectral range and spectral response. The detector is a thermal detector with an essentially flat spectral response from 0 to 50 µm.

The filter is either the standard infrasil I or one of the optional filter glasses (see A.2). A combination of these creates a detector with a flat spectral response in a certain wavelength range. Standard range is 0.2 to 4 µm for infrasil I of 2 mm thickness.

The detector is a thermal sensor, based on a thermopile. The incoming radiation is absorbed by the black coating on the detector surface. In order to let a certain amount of energy flow away, a certain temperature gradient across the detector is necessary. This temperature gradient is proportional to the amount of incoming radiation. It is registered by the thermopile which as a result produces a millivolt signal.

The calibration factor is a constant that gives the voltage that is generated for each received W/m^2. Each instrument has its specific calibration factor. This is delivered on a calibration certificate. There are deviations from idealised behaviour, which are summarised in the ISO classification. (See chapter 2)

Typical pyrheliometer specifications are zero-offset, temperature response and tilt response. Other specifications are frequently mentioned instrument specifications.

Zero offset is caused by the transient from one temperature to another. It is due to two causes; first, temperature differences can occur between sensor and housing which causes exchange of infra-red radiation. Secondly, when the sensor changes temperature, this coincides with an energy flow to or from the sensor. An energy flow is only possible with a temperature gradient across the detector. This gradient which can have positive or negative sign is detected by the detector.

The second ISO specification mentioned, temperature response, states the temperature dependence of the sensitivity. Ideally, when a constant amount of radiation comes in, the signal generated by CH 1 would always be the same. In practice however the reading at –20° C constant sensor temperature is different from the reading at +20° C. The maximum deviation is stated under temperature response.
Kipp & Zonen specifies +20° C as a reference.

Tilt response, the third specification that is typically given for pyrheliometers, states the change of sensitivity caused by changes in orientation of the instrument. As should be expected, the CH 1 shows no tilt response.

B.2 GEOMETRICAL RESPONSE

Figure B.1 shows the pyrheliometers optical construction.

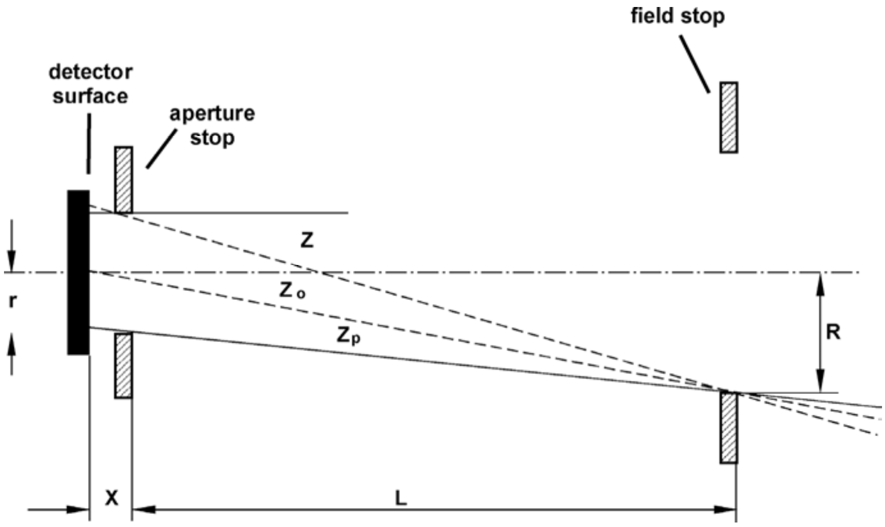

Fig. B.1. Optical construction

The beam of light that reaches the detector is limited by the field and aperture stop. The slope, opening and limit angles are determined by R, r and L. The distance x is negligible.

For the CH 1 the full opening angle is 5°, the slope angle is 1°. The sun, as seen from the detector, occupies a solid angle of 0.5°. A 100% response can be expected only if the sun is entirely within the slope angle. This is the case when tracking accuracy is better than slope angle minus half the solar angle.

Concluding, tracking accuracy should be within 0.75° of ideal.

APPENDIX C. DELIVERY AND SPARE PARTS

C.1 DELIVERY

The CH 1 has part no.: 1334-900
The standard CH 1 is delivered as follows:

- CH 1 pyrheliometer
- Rain screen
- Calibration certificate
- 10 m cable

C.2 OPTIONS

These options can be ordered as separately:

- Filter wheel (Glasses: OG 530; RG 630; RG 695) 0334-101
- CaF2 Window kit 0334-700

The following options can be delivered on request according to customer specifications:

- Sensor temperature measurement with:
  - Thermistor 10 k
  - Pt-100
- Calibration by WRC
- Internal filter

C.3 SPARE PARTS

•	Replacement Drying cartridge Clamp-Spring Drying cartridge (without cover) Cover for cartridge Rubber ring		0305-720
•	Silica gel refill pack		2643-951
•	Rain screen		0014-317
•	Quartz window on metal ring		2125-648
•	Filterwheel filters:	OG 530	2125-768
		RG 630	2125-766
		RG 695	2125-767
•	Manual		0334-300

APPENDIX D RECALIBRATION SERVICE

**Pyranometers, UV-meters, Pyrgeometers &
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 at least 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 your convenience we added three fax forms to schedule the recalibration of your instrument(s) at Kipp & Zonen.

NAME :
COMPANY/INSTITUTE :
ADDRESS :
POSTCODE +CITY :
COUNTRY :
PHONE :
FAX :

☐ **I would like to receive a price list for recalibration**

☐ **I would like to submit my instruments for recalibration**

Type/Model:	Qty:	Requested delivery time
		I intend to send the instruments to Kipp & Zonen on: . . . . . ./. . . . . ./. . . . . .
		I would like to receive the instrument(s) back on: . . . . . ./. . . . . ./. . . . . .

Conformation by Kipp & Zonen
☐ Yes, the dates are acceptable to us ☐ No, unfortunately the dates do not fit into our calibration schedule. We suggest the following dates: . . . . . ./. . . . . ./. . . . ./. . . . . ./. . . . . .

Fax +31-15-2620351

or mail to:

Kipp & Zonen P.O. Box 507 2600AM Delft The Netherlands

NAME :
COMPANY/INSTITUTE :
ADDRESS :
POSTCODE +CITY :
COUNTRY :
PHONE :
FAX :

☐ **I would like to receive a price list for recalibration**

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Fax +31-15-2620351

or mail to:

Kipp & Zonen P.O. Box 507 2600AM
Delft The Netherlands

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 apoyo del cliente se queda a su disposición para cualquier mantenimiento o la reparación, la calibración, los suministros y reserva.

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