Pyrradiometer

Operating instruction 7.1415.20.000

1. Range of Application

The Pyrradiometer is used for exact determination of net radiation in short- and long wave radiation range with two separately working receivers and with built-in Pt 100 resistant Thermometer to determine reference temperature.
The measuring principle of the Pyrradiometer is the measurement of the temperature difference between blackened receiver plates facing up and blackened receiver plates facing down by means of thermocouple elements.

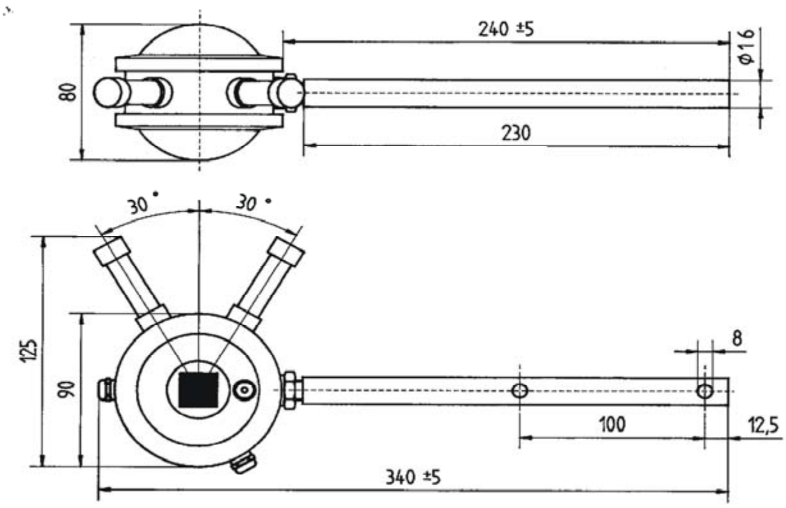
2. Construction and Mode of Operation

Between two blackened receiver plates a sturdy Aluminium heat sink is located in the centre of the instrument. Under each of the two black surfaces are placed 90 thermocouples connected in series. As the radiation flux is transformed thermoelectrically and the measurement is based on temperature differences, the heat sink temperature is determined by means of a built-in Pt-100 resistance Thermometer. When only net radiation is to be determined heat sink temperatures are not to be considered.
The lupolene domes shield the receiver plates from wind and moisture and are fastened waterlight by screw rings and O-rings. Two tubes of desiccant are supplied to remove vapour from inside the housing. Two levels are imbedded in the top and bottom of the instrument. An arm with holes for mounting is included.

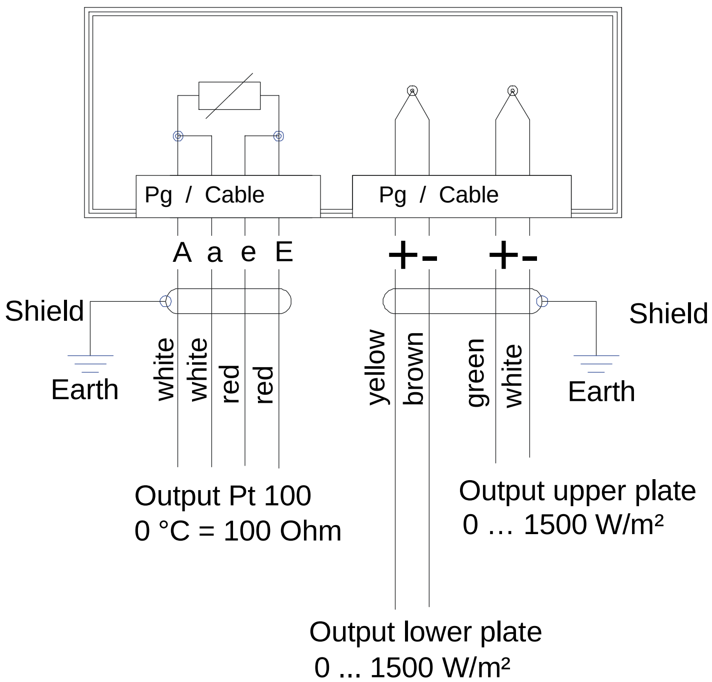
3. Technical Data

Measuring range	: 0 ... 1500 Wm^{-2}
Spectral sensitivity	: 0,3 ... > 3 µm
Output	: about 15 $\mu V/Wm^{-2}$
Impedance	: about 190 Ω / receiver plate
Ambient temperature	: - 40 ... + 60 °C
Resolution	: < 1 Wm^{-2}
Stability	: < 3 % per year (temporary operation)
Cosine response	: < 5 % of the value, zenith angle 0°...80°
Azimuth response	: < 5 % of the value
Temperature effect	: < 2 % of the value between – 20 °C ... + 40 °C
Linearity	: < 2 % in the range 0,5 ... 1330 Wm^{-2}
Response time	: < 25 sec. (95 %)
	: < 45 sec. (99 %)
Cable	: 5 m long, 4-polar shielded
Weight	: 1,25 kg

Scale Drawing



4. Connection Diagram



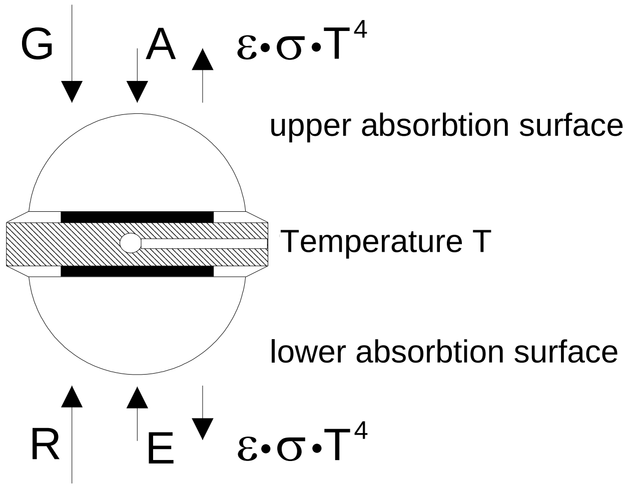
5. Mounting

The place where the instrument is located should not be shaded by high buildings, trees or others and for regular maintenance it should be easily accessible. The distance from the reference surface should be 1 – 1,5 m maximum. Only in case large surfaces are measured the distance can be higher.
The outputs of the cable should be directed to north.
The radiation of the atmosphere should be measured by the receiver with the green and white print.
It is recommended to record the global radiation together with the measurement of the device temperature.
Final levelling is accomplished with the incorporated bull's-eye level on each side of the equipment.

The colour of the cables corresponds to the colour code of the receiver plate

6. Evaluation

When using instruments for long-wave radiation , the radiation caused by the temperature of the instrument itself, and being emitted over the receiving surface of the instrument, must be taken into consideration. Therefore, it is necessary to record the instrument temperature and to correct the measured radiation values accordingly.



The upper receiving surface supplies a voltage, which corresponds to the radiation quantity $S_1 = G + A - \varepsilon \cdot \sigma \cdot T^4$, where **G** is the short-waved global radiation, **A** the long-waved atmospheric radiation (thermal radiation of the atmosphere) and $\varepsilon \bullet \sigma \bullet \mathbf{T^4}$ being the body thermal radiation of the Pyrradiometer into the upper half-space (T = device temp.).

The lower receiving surface supplies a voltage which corresponds to the radiation quantity $S_2 = R + E - \varepsilon \cdot \sigma \cdot T^4$. Where **R** is the short-waved reflection radiation, **E** the long-waved radiation (thermal radiation of the ground) and $\varepsilon \bullet \sigma \bullet \mathbf{T^4}$ being the body thermal radiation of the pyrradiometer into the lower half-space (T = device temp.).

Both values $\mathbf{S_1}$ and $\mathbf{S_2}$ can have a minus sign individually. The radiation quantities from the half-spaces can be calculated to :

$$G + A = S_1 + \varepsilon \cdot \sigma \cdot T^4 \qquad \text{and} \qquad R + E = S_2 + \varepsilon \cdot \sigma \cdot T^4 ,$$

The net radiation is $S = G + A - R - E = S1 - S2$

In $\varepsilon \bullet \sigma \bullet \mathbf{T^4}$ is ε the emmissivity of the atmosphere, respectivly the ground, σ **= 5,669 •10^{-8} W $^{m-2}$ K^{-4}**, the Stefan-Boltzmann constant.

The radiation values of a few temperatures are stated in the following table, the emmissitivity is assumed to be ε **= 1**:

Temp. [°C]:	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40	45	50	55	60
Radiation [W/m²]:	198	215	233	252	272	293	316	339	364	391	419	448	479	511	545	581	618	657	698

The radiation from the upper half-space is composed of the short-waved part global radiation (max. solar constant = 1360 W/m²) and the long-waved part atmospheric thermal radiation (a second radiation source). that is the reason why the value of the radiation can be greater than the solar constant.

Example of measured values

Radiation observatorium Hamburg of the German Weather Service 1965

line	time	selection	G	R	A	E	G+A	R+E	unit
1	June, 0-1 Uhr	min	0	0	279	326	279	326	W/m²
2	June, 0-1 Uhr	max	0	0	390	413	390	413	W/m²
3	June, 12-13 Uhr	min	52	12	291	366	343	378	W/m²
4	Junie 12-13 Uhr	max	942	163	384	448	1326	611	W/m²
5	Dec., 0-1 Uhr	min	0	0	244	302	244	302	W/m²
6	Dec., 0-1 Uhr	max	0	0	378	378	378	378	W/m²
7	Dec., 12-13 Uhr	min	6	0	250	320	256	320	W/m²
8	Dec., 12-13 Uhr	max	221	41	372	378	593	419	W/m²

As the irradiation from the upper half space consists of the short-wave radiation (generally < 1,37 kW/m²) and the long-wave atmospheric radiation (second radiation source), the value of the solar constant can formally be exceeded. The effective irradiation intensity on the receiving surfaces, however, arises in practice only after deducting the emitted black body radiation of the receiving surfaces.

The above table shows already for Hamburg (52° north) in line 4 a value of the radiation sum G + A = 1326 W/m² which attains nearly the value of the solar constant of S = 1,37 kW/m². In more southerly climes, of course, the resulting values are considerably higher.

7. Maintenance

The accurate horizontally levelling should be checked every day as well as the clearness of the lupolene domes. The receiver plates have to be black.

Lupolene domes: Lupolene domes should be cleaned very cautiously from time to time. Light scratches do not influence measurement.

Note: Damaged or perforated domes have to be changed immediately. They can be exchanged very easily by removal of screw rings and fixing rings.

8. Warranty

All instruments are checked carefully during production and before delivery. Our company warrants them to be free from defects in material and workmanship under normal use and service for 12 months from date of delivery. The obligation is limited to repairing or replacing parts which have been returned to the Company and which were defective in material or workmanship at time of manufacture. Costs of shipping are not subject of the warranty.

This warranty shall not apply to instruments which have been subject to misuse, negligence or accident. Cost incurred in removing or reinstalling parts by the customer or others are not reimbursed by the Company as well.

Thies CLIMA

ADOLF THIES GmbH & Co. KG

Hauptstraße 76 37083 Göttingen Germany
P.O. Box 3536 + 3541 37025 Göttingen
Phone ++551 79001-0 Fax ++551 79001-65
www.thiesclima.com info@thiesclima.com