Notice

Please, read this operating instructions before using the net radiometer.

The supplier is not responsible for direct, indirect as well as consequential damages, which were caused by incorrect or not regulation-fair use of the equipment.

Contents

Please note the loss of warranty and non-liability by unauthorised manipulation of the system. You need a written permission of the LAMBRECHT meteo GmbH for changes of system components. These activities must be operated by a qualified technician.

The warranty does not cover:

1. Mechanical damages caused by external impacts (e. g. icefall, rockfall, vandalism).
2. Impacts or damages caused by over-voltages or electromagnetic fields which are beyond the standards and specifications in the technical data.
3. Damages caused by improper handling, e. g. by wrong tools, incorrect installation, incorrect electrical installation (false polarity) etc.
4. Damages which are caused by using the device beyond the specified operation conditions.

1. General information

The net radiometer is an instrument for measuring solar and far infra red radiation balance. This balance is usually called net (total) radiation.

Its up facing sensor measures the solar energy and far infra red energy that is received from the entire hemisphere. Its down facing sensor measures the energy received from the soil surface. The down facing sensor reading is automatically subtracted from the up facing sensor value and converted to one output signal. The resulting output represents the net radiation, which can be interpreted as the radiative energy that is absorbed by the soil surface. The output is expressed in W/m².

The net radiometer is designed for continuous outdoor use. Contrary to most common instruments for measurement of net radiation, it is not equipped with plastic or glass domes. The domes are replaced by a teflon coated sensor surface. This has big advantages for maintenance and sensor stability. By a most particularly higher sensitivity to wind speed the accuracy is limited (see 2.4).

The net radiometer is used for measuring the radiation balance as a meteorological parameter. It can however also be used to measure indoor climate radiative stress.

It is equipped with a level for easy levelling.

The net radiometer fully complies with the CE directive 89/336/EEC.

1.1 Short user guide

Requirements:

1. Net radiometer (16123)
2. Voltmeter with a range from 0...50 mV and an input impedance of more than 5000 Ω
3. A light (illuminant)

- Position the instrument so that the down facing sensor is 1 cm over a surface (e.g. a table) and the upper sensor is facing the illuminant. Please avoid contact between the sensor and your hand. This creates thermal shocks to which the sensor is sensitive. Hold the sensor at the support arm at all times.
- Connect the net radiometer wires to the voltmeter: the red wire to the + pole/ the blue wire to the - pole.
- Set the voltmeter to the most sensitive range.
- Read the sensor signal without illuminant (it takes about a minute for the signal to stabilize).
- Expose the sensor to light. The signal should give a more positive reading.
- Put the illuminant off again, the signal should slowly return to the old signal level. This shows that the sensor is sensitive to light.
- Put the sensor upside down. The signal should reverse sign (+10 mV should become -10 mV), because it measures upper minus lower sensor. Don't worry about a 20 % difference under these conditions! If OK, put the sensor in its original position again and let it stabilize.
- Put your hand over the upper sensor. The signal should give a more positive reading, provided that the sensor temperature is lower than the temperature of your hand. If the temperature of your hand is lower than the temperature of the sensor, the signal will go more negative.
- The sensitivity to thermal shocks can be demonstrated by touching the sensor edge (the blank metal) with your hand for some seconds. The resulting shock will result in a signal drift, or a zero offset that only slowly will settle down again.
- Adjust the voltmeter range in such a way that the expected full scale output of the net radiometer fits the full scale input of the voltmeter. This can be done on theoretical considerations.

  When the maximum expected radiation is +1500 W/m², the minimum is -200 W/ m² and the sensitivity of the net radiometer is 10 µV/ W/m², the expected output range of the pyranometer is 17000 µV = 17 mV. These values are applicable for normal meteorological applications.
- Calculate the radiation intensity by dividing the net radiometer output (17 mV) by the calibration factor (10 µV/ W/m²).
- For permanent installation mounting should be done using the net radiometer mounting rod. The sensor should be mounted in a field which is free from obstructions. Under no condition shadows should be cast upon it.
- Maintenance: The sensor should be kept clean, using water or alcohol. Please treat the surface gently.
- Recalibration is recommended every 2 years.

2. Sensor properties

The net radiometer consists of a thermopile detector, two black teflon coated sensor surfaces, a housing with a build-in level, a cable and a short metal stick.

The thermopile consists of a number of thermocouples that are connected in series. It essentially is a very sensitive differential temperature sensor.

The thermopile generates a voltage output (the sensor is passive, no power supply required). The up facing sensor surface is connected to the upper joints of the thermopile, the down facing sensor is connected to the lower joints of the thermopile. The sensor will measure the temperature difference between the upper and the lower sensor surface. This temperature difference can very accurately be determined (changes of less than 0.001 °C are detectable). The temperature difference is proportional to the net radiation.

Most electrical specifications are determined by thermopile. Spectral specifications are determined by the black teflon coating.

Both the up facing and the down facing sensors have an angle of aperture of 180° and their angular characteristics fulfil the so-called cosine response.

2.1 Electrical properties

The electrical circuit of the net radiometer is drawn in figure 1.

The input impedance of the readout equipment should be > 1 MΩ in order to make an error of < 0.1 %.

Cable can be extended without problems to a length of 100 m, provided that cable resistance is less than 0.1 % of the input impedance of the readout equipment.

The electrical sensitivity of the thermopile changes with the temperature. A nominal value for this is not specified.

Calibration is done at 20 °C.

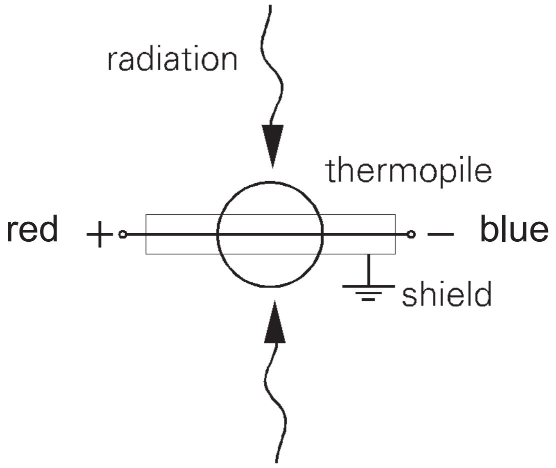


Figure 1: Electrical circuit of the net radiometer (16123)

2.2 Spectral properties

The spectral properties of the net radiometer are determined by the teflon sensor surface. The spectral sensitivity is not specified because it is not considered to be of critical importance.

A sketch of approximate spectral sensitivity is shown in fig. 2.

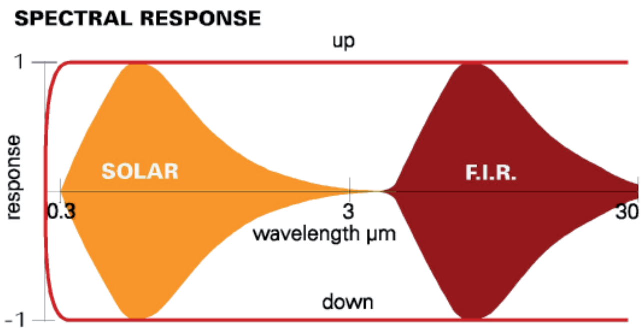


Figure 2: The approximate spectral sensitivity of the net radiometer (16123) combined with the spectrum of the sun under a clear sky, and the spectrum of outgoing far infrared radiation.

The up facing sensor has been calibrated for solar radiation wavelengths. It is assumed that the lower sensor has the same sensitivity. This might not be true; the sensor can have a non perfect symmetry. This however is neglected. Secondly it is assumed that the sensor sensitivity to infrared radiation is the same as for solar radiation.

2.3 Directional/ Cosine response

The measurement of the radiation falling on a surface (also called irradiance or radiative flux) requires two assumptions: that the surface is spectrally black (that it absorbs all radiation from all wavelengths, see previous paragraph) and that it has an angle of aperture of 180°. Another way of expressing these directional properties is to say that the sensor has to comply with the cosine response.

The net radiometer sensor surface has a rather special shape, it is shaped like a cone, in order to have a better compliance with the cosine response.

A perfect cosine response will show maximum sensitivity (1) at an angle of incidence of 0° (perpendicular to the sensor surface) and zero sensitivity at an angle of incidence of 90° (radiation passing over the sensor surface). In between 0° and 90° the sensitivity should be proportional to the cosine of the angle of incidence.

Figure 3 shows the behavior of a typical net radiometer. The vertical axis shows the deviation from ideal behavior, expressed in percentage deviation of the ideal value.

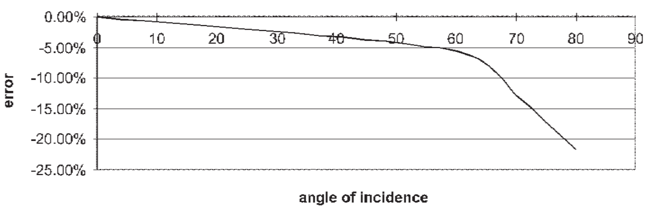


Figure 3: The directional response or cosine response of the net radiometer (16123). On the horizontal axis the zenith angle (0° zenith angle equals 90° angle of incidence). On the vertical axis the percentage deviation from ideal cosine behavior. The specifications of the net radiometer regarding the cosine response are very good because the detector surface is shaped like a cone.

2.4 Sensitivity to wind speed

The net radiometer is calibrated at zero wind speed. At higher wind speeds, the sensitivity and thus voltage output will decrease.

Applying the original sensitivity figure result in too low net irradiances. The design however was made such that this error generally will not be large, so that correction is not necessary. This is achieved by keeping ΔT of the sensor low.

For scientific research to this matter a correction theoretically could be done by multiplying the calculated irradiances with a factor $(1 + v * x^{3/4})$ where v is the wind speed, and x has to be determined empirically (x is found to be 0.01).

3. Calibration

Recalibration is suggested every two years. For it the sensor should be sent in to the supplier.

The checking of the accuracy and sensor performance could be conducted before.

For this purpose a higher standard sensor runs parallel to the sensor, which should be calibrated, during two sunny days. Afterwards the daily values can be compared. The calibration factor can be corrected if the results differ more than 5%. This reference could be a net radiometer with higher accuracy or a net radiometer that is kept safely in the cupboard (sensor stability mainly is a matter of aging of the black sensor surface).

Another way of checking sensor performance during field use, is to put the sensor upside down during stable atmospheric conditions. Theoretically the sensor output should change sign.

Please mind that the sensor response time for stabilizing is about one minute.

This method is no more accurate than 20 % because of the fact that the sensor symmetry is no more accurate than this.

Calibration procedure

The up facing sensor of the net radiometer is the one that is calibrated for solar radiation. It is silently assumed that the sensitivity of the down facing sensor is the same. In reality this might differ. This deviation is accepted because the down facing sensor signal will generally be at least a factor 3 smaller than the signal of the up facing sensor.

Also it is assumed the sensitivity to infra red radiation is the same as for solar radiation. The error caused by this is unknown. It is neglected because the solar radiation will be the dominating factor.

During calibration there is no wind. It is suggested not to correct for this; to improve the accuracy of this instrument would require more than a wind correction.

The up-facing sensor of the net radiometer reference is calibrated against a secondary standard pyranometer (this is a radiometer that is sensitive to solar radiation only) under natural sunlight during clear sky conditions.

Further reference conditions are as follows: temperature 20 °C, irradiance 500 W/m², wind speed <2 m/s.

The primary standard for solar radiation, against which the secondary standard pyranometer is calibrated, is the World Radiometric Reference.

<u>Calibration conditions</u>

- The upper sensor is calibrated for solar radiation.
- Traceable to secondary standard pyranometer
- Normal angle of incidence, 500 W/m², 20 °C, horizontal position, no wind speed.

4. Installation and maintenance

The net radiometer can be attached at a mast using its mounting rod.

Leveling can be carried out by means of the integrated level.

The small metal stick has to be screwed in into the threaded bore at the housing. The stick is used to the protection of the sensor against landings of birds.

When installed on a mast, preferred orientation is such that no shadows are cast on the net radiometer during any time of the day. On the northern hemisphere this implies that the net radiometer should be south of the mast.

It is advised to measure at a height h of at least 1.5 meters above the surface in order to avoid shading effects and to promote spatial averaging.

The down facing sensor signal is representative (99 %) for a circular area with radius 10 h.

The net radiometer is an all weather instrument and it needs after installation low maintenance only. It is recommended to clean the detector regularly, carefully using water or alcohol.

5. Trouble shooting

If your net radiometer does not seem to work at all, please follow the following procedure:

- Check if the net radiometer reacts to light, using the procedure in the „Short user manual".
- No result? Measure the impedance of the sensor across the red and the blue wires. This should be close to 2.3 Ω. If it is infinite, the thermopile is blown.

If the net radiometer shows bigger or smaller results than expected, the following questions might help you out:

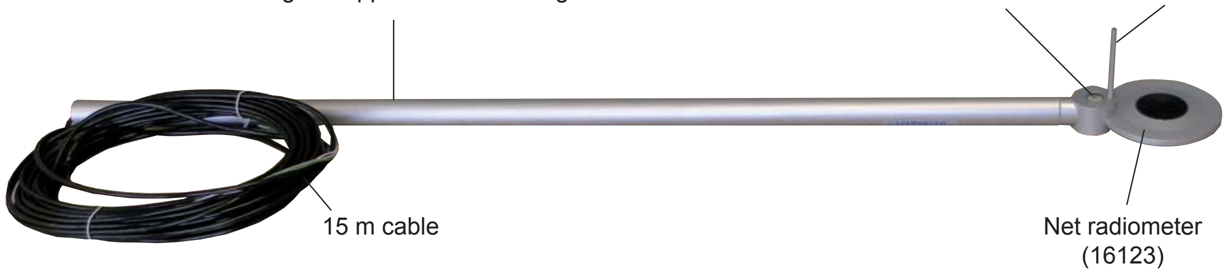
- Are you measuring under natural sunlight?

  If so the maximum expected radiation is 1500 W/m². Under lamps this might be more. For indoor climate studies, smaller values are expected unless solar radiation is present. A typical value for a room when facing a wall and a relatively cold window is 50 W/m².
- Are you correcting for the calibration factor?

  Please note that this factor is an individual property, that is different for each sensor. Do you divide by the factor? This is correct.
- What is the input impedance of your readout equipment?

  It should be > 1 MΩ. If it is significantly smaller you will notice errors.
- Is your readout equipment properly calibrated?

If still no satisfactory answer is found, please contact your supplier.



6. Technical data

Id-No.	**00.16123.100 000**
Measuring element:	Thermopile • conic, teflon-coated absorber (without glass dome)
Measuring range:	-2000...+2000 W/m² • radiation balance within a wide wave range of 0.2...100 µm
Range of application:	-30...+70 °C
Non linearity:	< 1 %
Response time (95%):	< 60 s
Sensitivity:	10 µV/ W/m² (nominal)
Temperature dependence of sensitivity:	- 0.1 %/ °C (typical)
Directional error:	< 3 % at 0...60° angle of incidence at 1000 W/m² • sensor asymmetry < 15 %
Expected signal range:	-25...+25 mV at atmospheric conditions
Housing:	Anodised aluminium
Cable:	Polyurethane • 15 m
Weight:	0.5 kg
Dimensions	See fig. 4

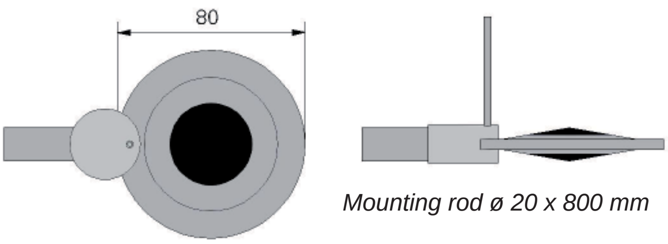


Figure 4: Dimensions of the net radiometer (16123)

Accessories

00.08763.056 002 **(8763 SB) Two-channel transducer**

7. Scope of delivery

1	Net radiometer (16123) with mounting rod and cable
1	Small metal stick (to be installed on the net radiometer)
1	Calibration certificate
1	Operating instructions

LAMBRECHT meteo GmbH
Friedländer Weg 65-67
37085 Göttingen
Germany

Tel +49-(0)551-4958-0
Fax +49-(0)551-4958-312
E-Mail info@lambrecht.net
Internet www.lambrecht.net