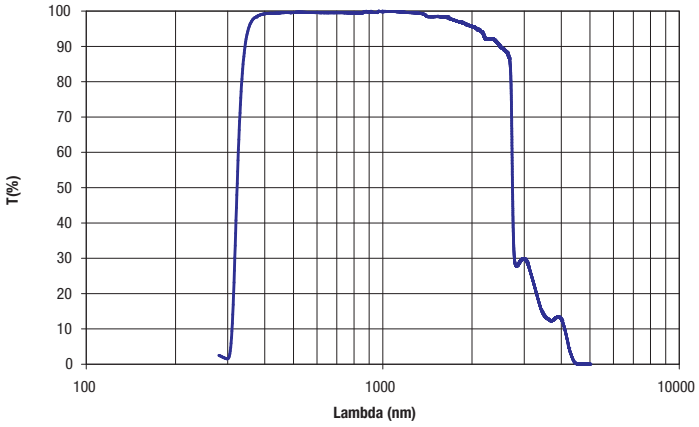
Delta OHM
Member of GHM GROUP

LPNET14.2



LPNET14.2
NET IRRADIANCE METER

LPNET14.2 is a **4-component net-radiometer** for the measurement of the net radiation between 0.3 µm and 45 µm.
The net-radiometer consists of two pyranometers (one for the measurement of the global radiation $E_{sw}\downarrow$ and the other one for the measurement of the reflected solar radiation $E_{sw}\uparrow$) and a pair of pyrgeometers (one for the measurement of the infrared radiation emitted by the sky $E_{FIR}\downarrow$ and the other one for the infrared emitted by the ground surface $E_{FIR}\uparrow$).
The LPNET14.2 is equipped with a temperature sensor (NTC). The measurement of the temperature is needed for the measurement with the two pyrgeometers, in fact, the far infrared is derived by measuring the thermopile output and by the knowledge of the instrument's temperature.
The net radiometer is suitable for outdoor use in all weather conditions and requires little maintenance.



Graph 1 - Relative spectral response of the Delta OHM pyranometers.

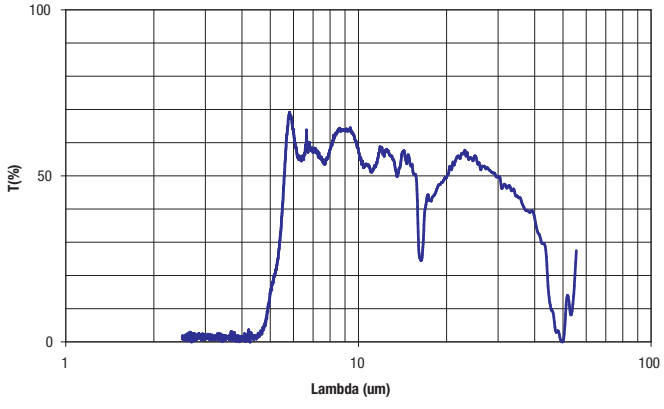
Technical specifications LPNET14.2	
Pyranometer Spectrally Flat Class C according to ISO 9060:2018	
Typical Sensitivity	5 to 15 µV/(W/m²)
Impedance	33 Ω ÷ 45 Ω
Measuring range	0 ÷ 2000 W/m²
Field of view	180°
Non Linearity (albedo sensor)	<1% over full range
Response Time (albedo sensor)	<20 sec
Spectral range (dome transmission)	300 nm ÷ 2800 nm (50%)
	335 nm ÷ 2200 nm (95%)
Working temperature	-40 °C ÷ 80 °C
Pyrgeometer	
Typical sensitivity	5-10 µV/(W/m²)
Impedance	33 Ω ÷ 45 Ω
Measuring range	-300 ÷ +300 W/m²
Temperature Sensor	Thermistor (NTC)
Field of view	180° (upper sensor) 160° (lower sensor)
Non Linearity	< 1% over full range
Response Time	< 20 sec
Spectral range (silicon window transmission)	4.5 µm ÷ 45 µm (50%)
Working temperature	-40 °C ÷ 80 °C

Working principle

The pyranometers that make up the LPNET14.2 measure the radiation for wave lengths between 0.3 µm and 3.0 µm, while the pyrgeometers measure the irradiance in the spectral range between 5.5 µm and 45 µm.

The pyranometers are based on a thermopile sensor which sensitive surface is covered by a matt black paint so to allow the instrument not to be selective at various wavelengths. The pyranometer spectral range is determined by the transmittance of the two glass domes type K5.
Radiant energy is absorbed by the thermopile black surface, creating a difference of temperature between the centre of the thermopile (hot junction) and the pyranometer body (cold junction). Thanks to the Seebeck effect, the difference of temperature between hot and cold junction is converted into a Difference of Potential.

Also the pyrgeometers are based on a thermopile. In this case, to protect the thermopile, silicon discs are used. Silicon is transparent to wavelengths longer than 1.1 µm therefore, on the inside of the window, there is a filter to block radiation up to 4.5-5 µm. The silicon external surface, which is exposed to weathering, is coated with a scratch-resistant coating (DLC) to ensure strength and durability in all weather conditions. The anti-scratch coating offers the advantage of cleaning the surface without risk of scratching the window. Graph 2 reports the transmission of the silicon window according to the wavelength variation.



Graph 2 - Transmission of the silicon window.

Radiant energy is absorbed / radiated from the surface of the blackened thermopile, creating a temperature difference between the centre of the thermopile (hot junction) and the body of pyrgeometer (cold junction). The temperature difference between hot and cold junction is converted into Potential Difference thanks to the Seebeck effect.

If the pyrgeometer temperature is higher than the radiant temperature of the portion of sky framed by the pyrgeometer, the thermopile will irradiate energy and the output signal will be negative (typical situation of clear sky) vice versa if the pyrgeometer temperature is lower than that portion of sky framed, the signal will be positive (typical situation of cloudy sky).

Therefore, for the calculation of the ground infrared ($E_{FIR}\downarrow$), besides the thermopile output signal, is necessary to know the T temperature of the pyrgeometer, as reported under the formula 1:

$$E_{FIR}\downarrow = E_{term.} + \sigma T_B^4$$

Where:

E_{term} = net radiation (positive or negative), measured by the thermopile [W m^{-2})], the value is calculated by the sensitivity of the instrument (C) [μV/ (W m^{-2})] and by the output signal (U_{emf}) from the formula:

$$E_{term.} = \frac{U_{emf}}{C}$$

σ = Stefan-Bolzmann constant (5.6704x10^{-8} W m^{-2} K^{-4});

T_B = pyrgeometer temperature (K), obtained by the reading of the NTC (10kΩ) resistance. The table at the following page reports the resistance value according to the temperature for values included between -25°C and +58°C.

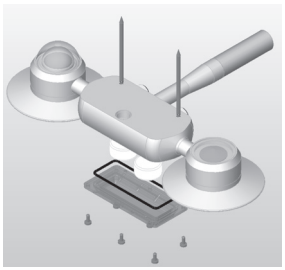
The first term of the formula 1 represent the net radiation, that is to say the difference between ground infrared radiation and the pyrgeometer emission, while the second term is the radiation emitted by an object (taken with submissiveness ε=1) at T_B temperature.

Installation and mounting of the net-radiometer for the infrared radiation measure

Before installing the net-radiometer you need to load the lower compartment with two cartridges containing silica gel crystals. The silica gel has the function of absorbing humidity present inside the instrument; in particular, climatic conditions this humidity can lead to condensation on the inner surface of the silicon window.

While loading silica gel crystals, avoid touching it with wet hands. The operations to perform (as much as possible) in a dry place are:

1. Unscrew the six screws that fix the inner cap of the net-radiometer

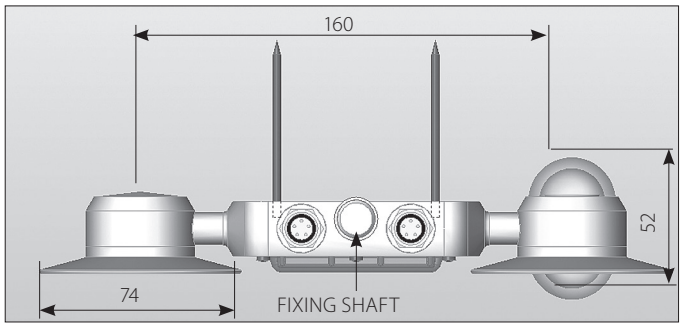


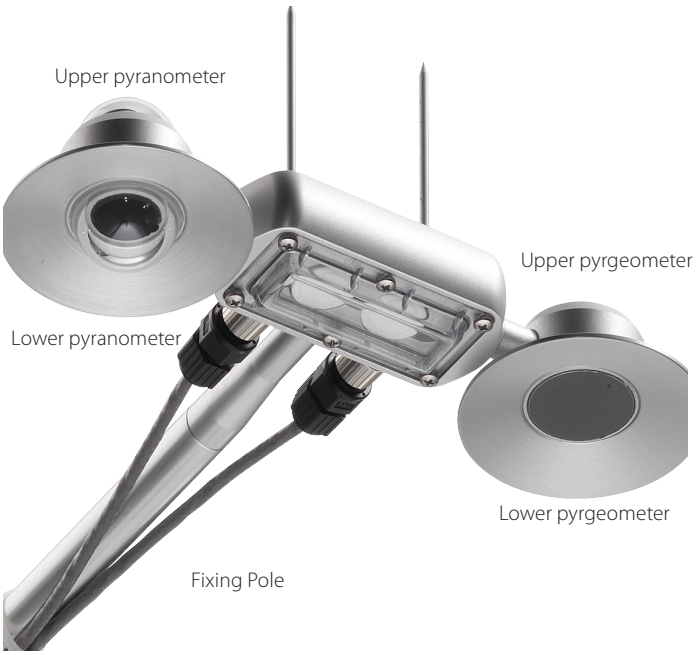
2. Remove (if present) the old cartridge and the marker
3. Open the envelope containing the silica gel and the marker, trim the marker to match the R.H. indicator 10% (make sure that the dimensions are appropriate to the salts compartment)
4. Insert the cartridge in the salts-compartment
5. Insert the marker so that it can easily be checked without opening the salts compartment
6. Thighten he six screws on the lid, make sure that the seal is positioned correctly.
7. The net-radiometer is ready for use

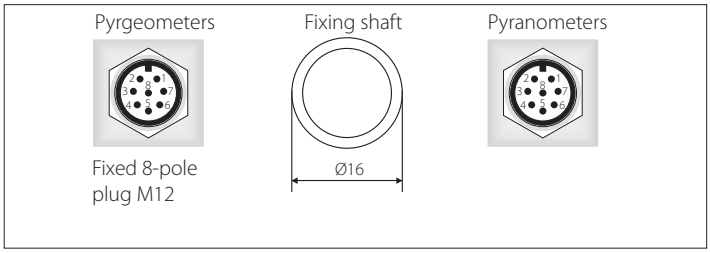
The LPNET14.2 has to be installed in a location easily accessible for periodic cleaning of the silicon window. At the same time, you should avoid buildings, trees or obstacles of any kind exceed the horizontal plane on which the instrument lies. In case this is not possible it is advisable to choose a location where the obstacles are lower than 10 °.

Usually, the instrument is placed so that the cable comes out from the side of the NORTH pole, when it is used in the NORTHERN hemisphere; from the side of the SOUTH pole when it is used in the SOUTHERN hemisphere, according to the standard ISO TR9901 and other WMO recommendations. In any case, it is preferable to comply with these recommendations also when the screen is used.

For an accurate horizontal positioning, the LPNET14.2 has to be fixed on a support pole by using the fixing bracket.







Electrical connections and requirements for electronic reading:

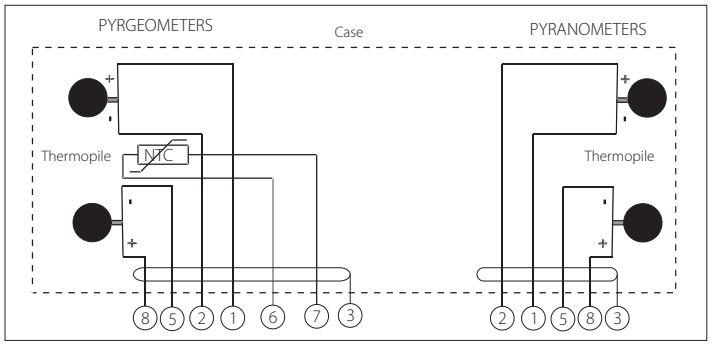
- The net-radiometer LPNET14.2 does not need any power supply.
- The instrument is equipped with two M12 8-pole connectors.
- The optional cables end with an 8-pole connector on one side and open wires at the other side. The cable is UV-resistant and shielded. The diagram with the correspondence between wire colours and connector poles is the following:

Connector	Function		Colour
	Pyrgeometers	Pyranometers	
1	V_{out} (+) $E_{FIR}\downarrow$	V_{out} (+) $E_{SW}\downarrow$	Red
2	V_{in} (-) $E_{FIR}\downarrow$	V_{in} (-) $E_{SW}\downarrow$	Blue
3	screen (⏚)	screen (⏚)	Screen
4	NOT CONNECTED		
5	V_{out} (-) $E_{FIR}\uparrow$	V_{out} (-) $E_{SW}\uparrow$	Brown
8	V_{in} (+) $E_{FIR}\uparrow$	V_{in} (+) $E_{SW}\uparrow$	Green
6	NTC	NOT CONNECTED	White
7	NTC	screen (⏚)	Black

In order to obtain a measure, it is necessary to acquire simultaneously the signal of the four thermopiles and the NTC.

To measure the output signals of the four thermopiles, the four channels have to be connected to a millivoltmeter or a data logger. In order to fully exploit the features of the net-radiometer, the recommended resolution of the reading instrument is 1μV.

Moreover, it is necessary to read the NTC resistance so to determine temperature of the two pyrgeometers.
In the figure below, the electrical connections necessary to read the signal of the four thermopiles and the NTC are reported.



Maintenance

In order to ensure a high measurement accuracy, it is necessary to always keep clean the silicon window and the glass domes of the net-radiometer, so the higher the frequency of cleaning is the best measurement accuracy will be. Cleaning can be done with normal maps for cleaning photographic objectives and water, if not possible, simply use pure ethyl alcohol. After cleaning with alcohol, it is necessary also to clean the window again in silicon with water only.

Due to the high temperature fluctuations between day and night, it is possible that you get some condensation inside the pyrgeometers and pyranometers (especially on the window in silicon); in this case the reading is done wrong. To minimize condensation inside the pyrgeometers, a proper cartridge with absorbent material is inside: Silica gel. The efficiency of silica-gel crystals decreases over time with the absorption of moisture. Typically, the duration of silica gel ranges from 4 to 12 months depending on environmental conditions the instrument operates in. In order to evaluate easily the efficiency status of the salt, within each charge there's a marker added, to be placed at the bottom of the salt compartment so that it can be seen. When it indicates the presence of humidity, it is necessary to replace the salts. Hail of particular intensity or dimension may damage the silicon window, therefore, after an intense storm with hail, it is recommended to check the status of the window.

Calibration and measurements

Each pyranometer and pyrgeometer that composes the instrument is calibrated individually. The calibration factor **S** is given in μV/(Wm^{-2}).
Once the potential difference (DDP) has been measured at sensor ends E_e flux is obtained through the following formula

$$E_e = DDP / S$$

where:
E_e - indicates the radiant flux expressed in W/m^2,
DDP - indicates the potential difference expressed in μV and measured by the multimeter
S - indicates the calibration factor expressed in μV/(W/m^2) and shown on the net radiometer label (calibration factor is also mentioned in the calibration report).
Each LPNET14.2 comes factory calibrated and has its own calibration factor.
The measurement with the two pyrgeometers has to be performed as follows: according to the NTC R_{NTC} [ohm] resistance it is possible to trace the pyrgeometer temperature (T_b) back by using the formula

$$\frac{1}{T_b} = a + b \cdot \log\left(R_{NTC}\right) + c \cdot \log\left(R_{NTC}\right)^3$$

Where:
a=10297.2x10^{-7}; **b**=2390.6x10^{-7}; **c**=1.5677x10^{-7}.
Temperature is expressed in Kelvin.
The values between -25 ° C to +58 ° C are tabulated in the following table,

T [°C]	R_NTC [Ω]	T [°C]	R_NTC [Ω]	T [°C]	R_NTC [Ω]
-25	103700	3	25740	31	7880
-24	98240	4	24590	32	7579
-23	93110	5	23500	33	7291
-22	88280	6	22470	34	7016
-21	83730	7	21480	35	6752
-20	79440	8	20550	36	6499
-19	75390	9	19660	37	6258
-18	71580	10	18810	38	6026
-17	67970	11	18000	39	5804
-16	64570	12	17240	40	5592
-15	61360	13	16500	41	5388
-14	58320	14	15810	42	5193
-13	55450	15	15150	43	5006
-12	52740	16	14520	44	4827
-11	50180	17	13910	45	4655
-10	47750	18	13340	46	4489
-9	45460	19	12790	47	4331
-8	43290	20	12270	48	4179
-7	41230	21	11770	49	4033
-6	39290	22	11300	50	3893
-5	37440	23	10850	51	3758
-4	35690	24	10410	52	3629
-3	34040	25	10000	53	3505
-2	32470	26	9605	54	3386
-1	30980	27	9228	55	3386
0	29560	28	8868	56	3271
1	28220	29	8524	57	3161
2	26950	30	8195	58	3055

to obtain the value in Kelvin, use the appropriate conversion.
Once the pyrgeometer temperature in Kelvin (=Temperature in °C + 273.15) and the thermopile output signal U_{emf} [μV] are known, $E_{FIR}\downarrow$ [W/m^2] irradiation is obtained by the formula:

$$E_{FIR}\downarrow = \frac{U_{emf}}{C} + \sigma \cdot T_B^4$$

Where:
C = pyrgeometer calibration factor [μV /(W/m^2)] reported on the calibration report;
σ = Stefan-Bolzmann constant (5.6704x10^{-8} W m^{-2} K^{-4})

Each pyrgeometer is individually calibrated at the factory and is distinguished by its calibration factor. PPyrgeometer calibration is performed outdoors, by comparison with a sample pyrgeometer calibrated by the World Radiation Centre (WRC). The two instruments are kept outdoors for a few days and nights in the presence of clear sky. The data acquired by a data logger is then processed to obtain the calibration factor.
To fully exploit the features of the probe LPNET14.2, it is recommended to perform the calibration verification every one or two years (the choice of calibration interval depends both on the accuracy to be achieved and on the installation location).

ORDERING CODES

LPNET14.2: Net-radiometer equipped with shaft Ø=16 mm length 400 mm, 2 bird spikes, 5 recharges of desiccant (composed of 2 silica-gel cartridges and one marker), levelling device and Calibration Report. The four outputs of the single sensors are directed to two 8-pole M12 male connectors.

ACCESSORIES

LPG2: 5 recharges of dessicant sachets (each composed of 2 silica-gel cartridges and one marker
CPM12AA8N…: 8-pole M12 connector on one end, open wires on the other end. Available lenght 2, 5 or 10 m.