



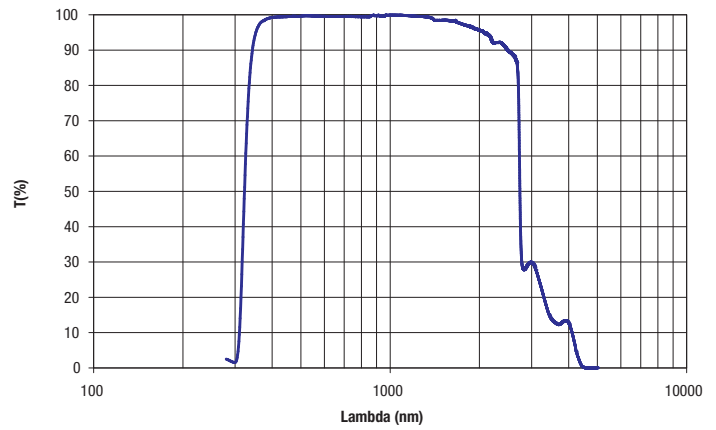
**LP NET 14
NET IRRADIANCE METER**

LP NET 14 is a 4-component net-radiometer for the measurement of the net radiation between 0.3µm 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 LP NET 14 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.

2) Working principle

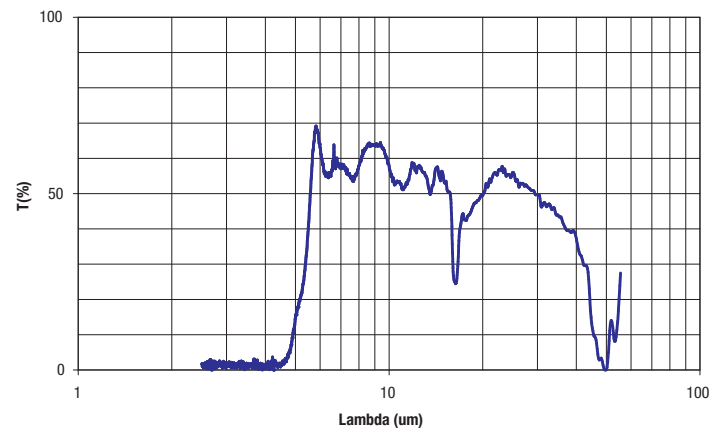
The pyranometers that make up the LP NET 14 measure the radiation for wave lengths between 0.3µm e 3.0µm, while the pyrgeometers measure the irradiance in the spectral range between 4.5µm and 45µm.

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 (See fig. 1). 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.



Graphic 1: Relative spectral response of the Delta Ohm pyranometers.

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. Graphic 2 reports the transmission of the silicon window according to the wavelength variation:



Graphic 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:

$$E_{fir \downarrow} = E_{term.} + \sigma T_B^4 \quad 1$$

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) [$\mu V / (W m^{-2})$] and by the output signal (U_{emf}) from formula 2;

$$E_{term.} = \frac{U_{emf}}{C} \quad 2$$

σ = Stefan-Boltzmann constant ($5.6704 \times 10^{-8} W m^{-2} K^{-4}$);

T_b = pyrgeometer temperature (K), obtained by the reading of the NTC (10k Ω) resistance. In the manual (Table 1) is reported the resistance value according to the temperature for values included between -25°C and +55°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 $\epsilon=1$) at T_b temperature.

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

Before installing the net-radiometer you need to load the cartridge 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
- 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- tighten the six screws on the lid, make sure that the seal is positioned correctly.
- 7- the net-radiometer is ready for use

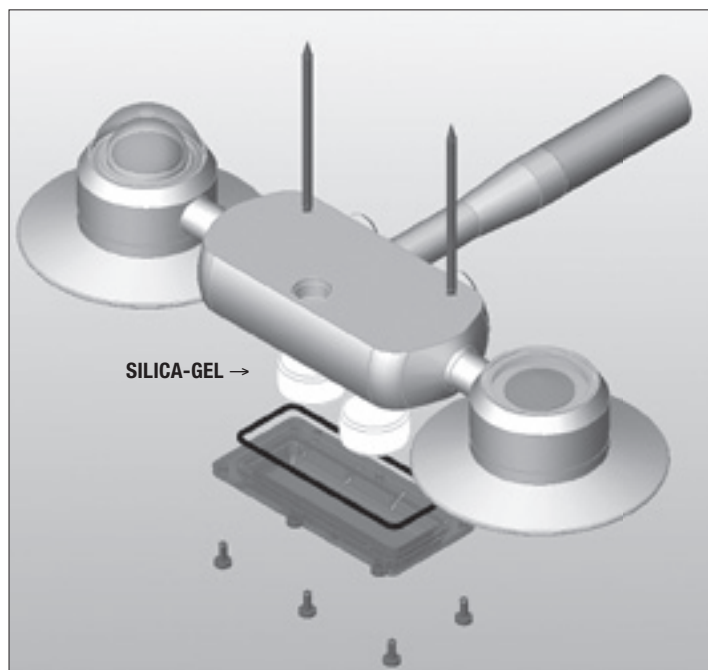


FIG. 3

- The LP NET 14 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 lies the instrument. 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 LP NET 14 has to be fixed on a support pole by using the fixing bracket (see fig. 4).

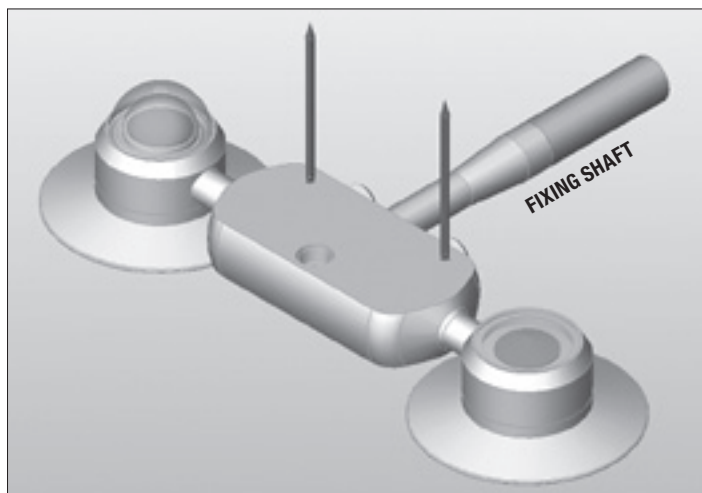
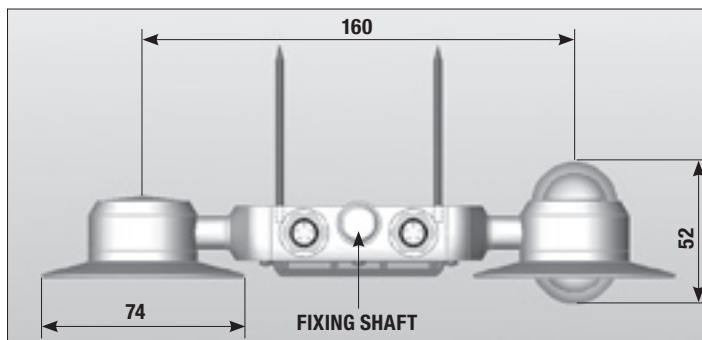


FIG. 4

4) Electrical Connections and requirements for electronic reading:

- The net-radiometer LP NET 14 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 made in UV-resistant PTFE and is provided with 7 wires plus braid (screen), the diagram with the correspondence between wire colours and connector poles is the following (figure 5):

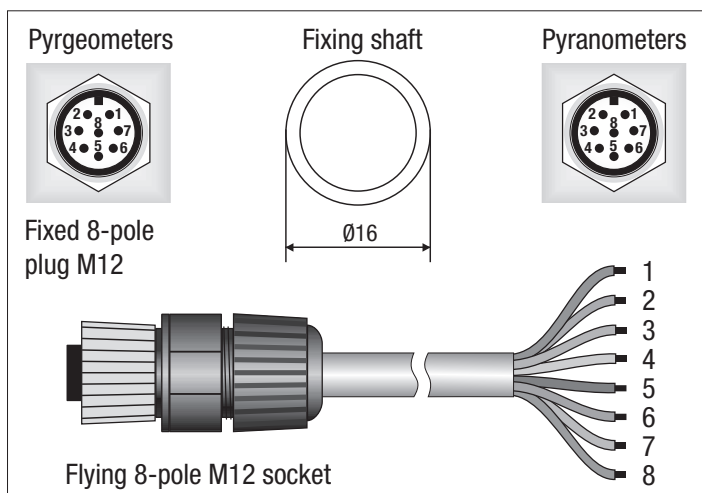


FIG. 5

| 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 (\perp) | screen (\perp) | 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 (\perp) | Black |

Table 1: correspondence pin-function

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.

Under figure 6 the electrical connections necessary to read the signal of the four thermopiles and the NTC are reported.

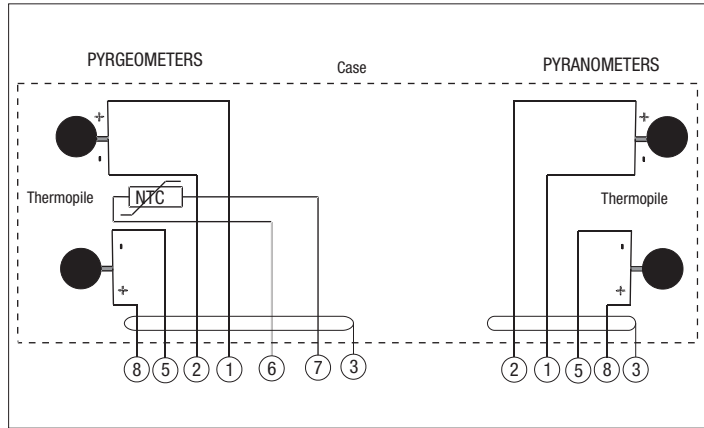


FIG. 6

5) 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 tissues 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 domes again 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 silicon window); in this case the reading is 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.

6) Calibration and measurements:

Each pyranometer and pyrgeometer that composes the instrument is calibrated individually

The calibration factor **S** is given in µV/(Wm²).

- Once the potential difference (DDP) has been measured at sensor ends, E_g irradiance is obtained through the following formula:

$$E_g = \text{DDP}/S$$

where;

E_g: indicates the irradiance expressed in W/m²,

DDP: indicates the potential difference expressed in µV and measured by the multimeter.

S: indicates the calibration factor expressed in µV/(W/m²) and shown on the net radiometer label (calibration factor is also mentioned in the calibration report).

Each net radiometer 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 3:

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

Where:

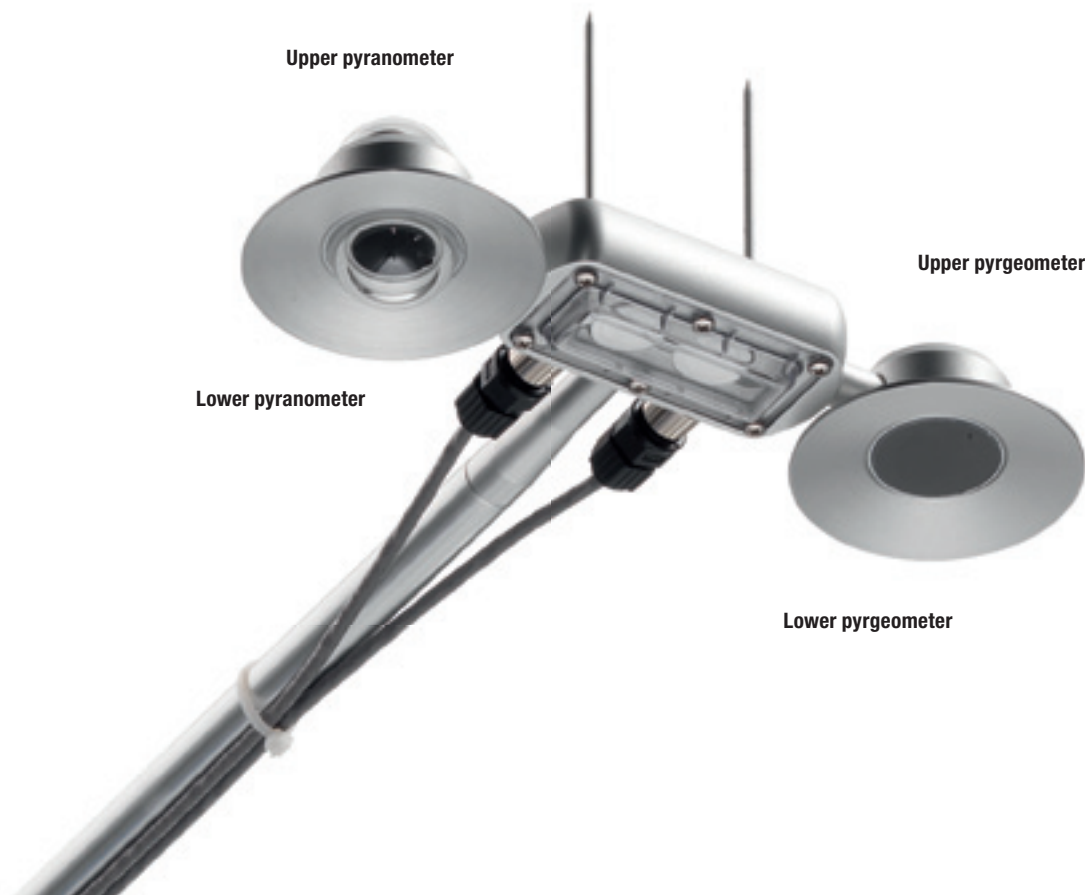
a=10297.2x10⁻⁷;

b=2390.6x10⁻⁷;

c=1.5677x10⁻⁷.

Temperature is expressed in Kelvin degrees.

N.B. The values between -25 ° C to +58 ° C are tabulated in Table 2, to obtain the value in degrees Kelvin, use the appropriate conversion



| 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 |

Table 2: NTC resistance values as a function of temperature.

Once the pyrgeometer temperature in Kelvin degrees and the thermopile output signal are known U_{emf} [μV], irradiance $E_{FIR\downarrow}$ [W/m²] is obtained by the formula 1:

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

Where:

C = pyrgeometer calibration factor [μV / (W/m²)] reported on the calibration report;

σ = Stefan-Boltzmann constant (5.6704x10⁻⁸ W m⁻² K⁻⁴).

Each pyrgeometer is individually calibrated at the factory and is distinguished by its calibration factor.

Pyrgeometer 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 LP NET 14, 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).

7) Technical specifications

PYRANOMETERS

II° Class pyranometer according to ISO 9060

| | |
|----------------------|---------------------------|
| Typical sensitivity: | 10 μV/(W/m ²) |
| Impedance: | 33 Ω ± 45 Ω |
| Measuring range: | 0-2000 W/m ² |
| Field of view: | 2π sr |
| Spectral range: | 305 nm ÷ 2800 nm (50%) |
| (dome transmission) | 335 nm ÷ 2200 nm (95%) |
| Working temperature: | -40 °C ÷ 80 °C |

PYRGEOMETERS

| | |
|-------------------------------|------------------------------|
| Typical sensitivity: | 5-10 μV/(W/m ²) |
| Impedance: | 33 Ω ± 45 Ω |
| Measuring range: | -300 ÷ +300 W/m ² |
| Viewing field: | 160° |
| Spectral range: | 5.5 μm ÷ 45 μm (50%) |
| (silicon window transmission) | |
| Working temperature: | -40 °C ÷ 80 °C |

ORDERING CODES

LP NET 14: Net-radiometer equipped with:

bracket Ø=16 mm length 400 mm, 2 bird spikes, 2 recharges of desiccant (composed of 5 silica-gel cartridges and one marker), level, 2 8-pole M12 connectors and Calibration Report.

ACCESSORIES

LPG2: 2 Recharges composed of 2 silica gel cartridges.

CPM12AA8.5: Cable with 8-pole M12 connector, 5 meters long.

CPM12AA8.10: Cable with 8-pole M12 connector, 10 meters long.

