OPERATING MANUAL

HD32.3TC

Thermal microclimate

EN

V2.1

senseca

Contents

1 Introduction

HD32.3TC is a portable instrument indicated for the microclimate and Indoor Air Quality (IAQ) analysis.

Depending on the probes connected, the instrument measures:

- **T** dry bulb temperature
- **T_{nw}** natural ventilation wet bulb temperature
- **T_g** globe thermometer temperature
- **RH** relative humidity
- **V_a** air speed
- **CO_2** carbon dioxide
- **P_{atm}** atmospheric pressure
- **PM1.0**, **PM2.5**, **PM10** particulate matter
- **VOC** index (Volatile Organic Compounds)

and calculates:

- **WBGT indoor** (Wet Bulb Globe Temperature) index in absence of solar irradiation
- **WBGT outdoor** (Wet Bulb Globe Temperature) index in presence of solar irradiation
- Mean radiant temperature **Tr**
- **PMV** (Predicted Mean Vote) index
- **PPD** (Predicted Percentage of Dissatisfied) index
- **TU** (Turbulence) index
- **DR** (Draft Rate) index
- **HI** (Heat Index)
- **UTCI** (Universal Thermal Climate Index)
- **TEP** (Perceived Equivalent Temperature)
- Estimation of **SARS-CoV-2** virus natural decay on surfaces

Additional indices can be calculated using **DeltaLog10** software, for example:

- **IREQ** (thermal insulation required)
- **DLE** (exposure time limit)
- **RT** (recovery time)
- **WCI** (wind chill index)
- **PHS** (predicted heat strain) method indices

Instrument main features:

- Data logger with large memory capacity for long measuring cycles.
- Internal camera to store pictures of the monitored environment.
- Rechargeable battery that guarantees an operating autonomy of at least 24 hours.
- Backlit Color 4” graphic LCD (active area 52x87 mm, 800x480 pixel) with capacitive touch.
- Wi-Fi connection for sending the data to an FTP server.

- Three inputs for probes with SICRAM module, which keeps memory of the probe calibration data. The probes can be inserted in any of the inputs: they are automatically recognized when the instrument is turned on.
- RS485 serial port to which auxiliary probes can be connected: e.g., the probe for measuring Particulate Matter (PM).
- OTG Mini-USB port for PC connection and battery charging.

Microclimate applications:

- In **moderate environment** (in compliance with ISO 7730 and ASHRAE 55 standards):
  - Measurement of the **PMV**, **PPD** and $\mathbf{T_r}$ global comfort indices.
  - Measurement of the **DR** local discomfort index.
- In **severe hot environment** (in compliance with ISO 7243 standard):
  - Measurement of the **WBGT** index.

IAQ applications:

- Measurement of comfort conditions and indoor air quality, for example in schools, offices, factories, etc.
- Sick building syndrome analysis.
- Verification of the efficiency of Heating, Ventilation and Air Conditioning (HVAC) systems.
- Building Automation.

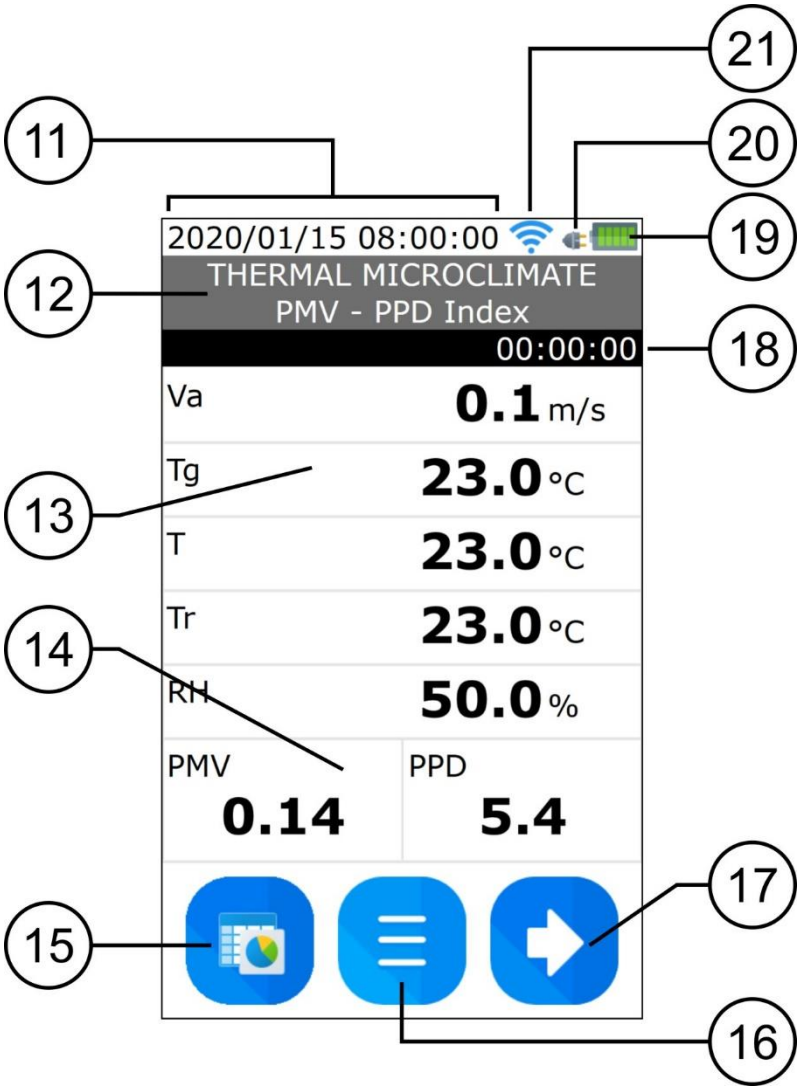
Reference standards:

- **ISO 7726**: Ergonomics of the thermal environment - Instruments for measuring physical quantities.
- **ISO 7730**: Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria.
- **ISO 7243**: Ergonomics of the thermal environment - Assessment of heat stress using the WBGT (wet bulb globe temperature) index.
- **ISO 9886**: Ergonomics – Evaluation of thermal strain by physiological measurements.
- **ISO 8996**: Ergonomics of the thermal environment – Determination of metabolic rate.
- **ISO 11079**: Ergonomics of the thermal environment – Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effect.
- **ASHRAE Standard 55**: Thermal Environmental Conditions for Human Occupancy.
- **ASHRAE Standard 62.1-2019**: Ventilation for Acceptable Indoor Air Quality.

2 Description

1. Input for **SICRAM** probes.
2. OTG mini-USB input for power supply, battery charging, PC connection.
3. Three-color (RGB) LED: indicates the logging status. It blinks green if the logging is not active; it blinks alternately green and blue if the logging is active.
4. Graphic backlit LCD display with capacitive touch.
5. **BACKLIGHT** key: turns the display backlight on and off.
6. **REC** key: starts and stops the data logging.
7. **ON/OFF** key: switches the instrument on and off.
8. Tripod fixing.
9. RS485 serial port for the connection of auxiliary probes (PMsense-P).
10. Camera.

Display



11. Date and time.
12. Type of measurement.
13. Physical quantities measured by the connected probes.
14. Calculated indices.
15. Key for switching from the numerical display of measurements to the graphical display, and vice versa.
16. Key for entering the menu.
17. Key to view the next page (the scrolling is cyclic).
18. Duration of the current logging session (the counter is updated with each acquisition) or of the last logging session, if logging has been stopped.
19. Battery charge level.
20. Indicator of the presence of the external power supply.
21. Status of the Wi-Fi connection. When the connection is active, it indicates the signal level. The symbol is gray when the connection is disabled or there is no signal.

3 Thermal microclimate

Thermal Microclimate refers to the environmental parameters that influence the thermal exchanges between an individual and the environment in confined places, and that determine the so-called "thermal well-being".

The micro-environmental climatic factors, together with the type of work done, condition the worker in a series of biologic responses linked to well-being situations (Comfort) or thermal uneasiness (Discomfort). In fact, the human body tries to keep the thermal balance in equilibrium conditions in order to keep the body temperature on optimal values.

The instrument detects the following quantities:

In **WBGT Index** visualization:

- **T_{nw}**: natural ventilation wet bulb temperature probe
- **T_g**: globe thermometer temperature
- **T_a**: ambient temperature

The **WBGT** index is calculated both in the presence of solar radiation (**outdoor**) and in the absence of solar radiation (**indoor**).

In **PMV - PPD Index**, **UTCI Temperature** and **TEP Temperature** visualizations:

- **V_a**: air speed
- **T_g**: globe thermometer temperature
- **T_a**: ambient temperature
- **RH**: relative humidity

In addition to the PMV, PPD, UTCI and TEP indices, the medium radiant temperature **T_r** is calculated.

In **Turbolence** visualization:

- **V_a**: air speed
- **T_a**: ambient temperature

The local Turbulence intensity **TU** and the Draft Rate **DR** are calculated.

In **Heat Index** visualization:

- **T_a**: ambient temperature
- **RH**: relative humidity

3.1 WBGT index

WBGT (Wet Bulb Globe Temperature) is one of the indices used for determining the thermal stress to which is submitted an individual in a warm environment. It represents the value, with reference to the metabolic waste associated with a particular activity, beyond which the individual is in a thermal stress condition. WBGT index combines the natural ventilation wet bulb temperature measurement **T_{nw}** with the Globe thermometer temperature **T_g** and, in some situations, with the air temperature **T_a**. The formula for the calculation is the following, and refers to an individual with reference cotton work clothing (I_{cl} = 0.6 and i_m = 0.38):

- inside and outside the buildings in **absence of solar irradiation**:

$$\mathbf{WBGT_{indoor} = 0.7\ T_{nw} + 0.3\ T_g}$$

- outside the building in **presence of solar irradiation**:

$$\mathbf{WBGT_{outdoor} = 0.7\ T_{nw} + 0.2\ T_g + 0.1\ T_a}$$

where:
T_{nw} = natural ventilation wet bulb temperature
T_g = globe thermometer temperature
T_a = air temperature

The detected data must be compared with the limit values established by the standard; if they are exceeded, it is necessary to:

- directly reduce the thermal stress in the workplace under consideration;
- proceed with a detailed analysis of the thermal stress.

Table 3.1: limit values of the thermal stress WBGT indicated in the ISO 7243 standard

METABOLIC RATE CLASS	METABOLIC RATE, M		WBGT LIMIT VALUE			
	RELATIVE TO A UNIT AREA OF SKIN SURFACE (W/m^2)	TOTAL (FOR AN AVERAGE AREA OF SKIN SURFACE OF 1.8 m^2) (W)	INDIVIDUAL ACCLIMATED TO HEAT (°C)		INDIVIDUAL NON- ACCLIMATED TO HEAT (°C)	
0 (RESTING)	M ≤ 65	M ≤ 117	33		32	
1	65 < M ≤ 130	117 < M ≤ 234	30		29	
2	130 < M ≤ 200	234 < M ≤ 360	28		26	
3	200 < M ≤ 260	360 < M ≤ 468	STAGNANT AIR 25	NON- STAG-NANT AIR 26	STAGNANT AIR 22	NON-STAG-NANT AIR 23
4	M > 260	M > 468	23	25	18	20
NOTE: THE VALUES HAVE BEEN ESTABLISHED TAKING AS A REFERENCE A MAXIMUM RECTAL TEMPERATURE OF 38 °C.						

To calculate the WBGT index, the following probes must be connected:

- **HP3201.2**, **HP3201** or **TP3204S** natural ventilation wet bulb temperature probe.
- **TP3276.2** or **TP3275** globe thermometer probe.
- **TP3207.2** or **TP3207** dry bulb temperature probe if the detection is made in presence of solar irradiation.
  Alternatively to the TP3207.2/TP3207 temperature-only probes, a combined probe, e.g., HP3217.2R/HP3217R or HP3217B4/HP3217BV4, can be used.

For the measurement of the WBGT index, reference is made to the standards:

- **ISO 7726**
- **ISO 7243**

3.2 Predicted mean vote PMV and predicted percentage of dissatisfied PPD

The thermal comfort is defined by ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers INC) as a condition of psycho-physical well-being of the individual with reference to the environment in which he lives and works.

The evaluation of such subjective state can be objectified and calculated using integrated indices that consider the ambient microclimatic parameters (T_a, T_r, V_a, RH), the energetic waste (metabolic waste MET) associated with the working activity and the clothing typology (thermal insulation CLO) usually used.

The index that more accurately reflects the influence of the physical and physiological variables is the **PMV** (Predicted Mean Vote) index.

In summary, it comes from the equation of thermal balance whose result is related with a psycho-physical well-being scale and expresses the mean vote (predicted mean vote) on the thermal sensations of a sample of individuals that are in the same environment.

From the PMV index is derived a second index called **PPD** (Predicted Percentage of Dissatisfied) which quantifies in percentage the "dissatisfied" individuals in relation to certain microclimatic

conditions.

ISO 7730 standard suggests the PMV index use in presence of the following ranges of variations of the variables influencing the thermal balance:

- Energetic waste = 1 ÷ 4 met
- Clothing thermal impedance = 0 ÷ 2 clo
- Wet bulb temperature = 10 ÷ 30 °C
- Mean radiant temperature = 10 ÷ 40 °C
- Air speed = 0 ÷ 1 m/s
- Vapour pressure = 0 ÷ 2.7 kPa

The PMV index is therefore an index particularly suitable for the evaluation of **working environments with moderate microclimate**, such as houses, schools, offices, laboratories, hospitals, etc.; it is useful in detecting limited degrees of thermal discomfort in residents of such environments.

ISO 7730 standard suggests PMV values between +0.5 and -0.5 for the thermal comfort, which corresponds to a percentage of dissatisfied with the thermal conditions (PPD) less than 10% (see the following table).

Table 3.2: thermal sensation scale

PMV	PPD (%)	THERMAL SENSATION
+3	100	Very Hot
+2	75.7	Hot
+1	26.4	A little bit warm
+0.85	20	Acceptable thermal environment
-0.5…+0.5	< 10	Thermal well-being
-0.85	20	Acceptable thermal environment
-1	26.8	A little bit cold
-2	76.4	Cold
-3	100	Very Cold

For the calculation of PMV and PPD indices it is necessary to know:

- The working charge (energetic waste);
- The thermal impedance of clothing.

The working charge can be quantified using the following units of measurement:

- **kcal/h (1 kcal/h = 1.163 W):** with this unit it is expressed the average power per hour supplied by an individual during the working activity;
- **MET (1 MET = 58.15 W/m^2):** with this unit it is expressed the total power per hour supplied by an individual during the working activity divided by the body surface of the individual.

Clothing thermal impedance:

The clothing thermal impedance is measured in CLO.

1 CLO = thermal gradient of 0.18 °C on a 1 m^2 area crossed by 1 kcal/h thermal flow.

The following tables can help to establish the thermal impedance values of the clothing and the working charge (metabolism).

Table 3.3: thermal impedance values of some typical clothes combinations (ISO 9920)

Clothing	CLO	m^2 K/W
Work clothing		
Pants, overalls, socks, shoes	0.70	0.110
Pants, shirt, pants, socks, shoes	0.75	0.115
Pants, shirt, overalls, socks, shoes	0.80	0.125
Pants, shirt, pants, jacket, socks, shoes	0.85	0.135
Pants, shirt, pants, aprons, socks, shoes	0.90	0.140
Lingerie with short sleeves and legs, shirt, pants, jacket, socks, shoes	1.00	0.155
Lingerie with short sleeves and legs, shirt, pants, overalls, socks, shoes	1.10	0.170
Lingerie with long sleeves and legs, thermal jacket, socks, shoes	1.20	0.185
Lingerie with short sleeves and legs, shirt, pants, jacket, thermal jacket, socks, shoes	1.25	0.190
Lingerie with short sleeves and legs, overalls, thermal jacket and trousers, socks, shoes	1.40	0.220
Lingerie with short sleeves and legs, shirt, pants, jacket, thermal jacket and trousers, socks, shoes	1.55	0.225
Lingerie with short sleeves and legs, shirt, pants, jacket, padded jacket with heavy overalls, socks, shoes	1.85	0.285
Lingerie with short sleeves and legs, shirt, pants, jacket, heavy jacket and track suit, socks, shoes, cap, gloves	2.00	0.310
Lingerie with long sleeves and legs, thermal jacket and pants, thermal outer jacket and trousers, socks, shoes	2.20	0.340
Lingerie with long sleeves and legs, thermal jacket and pants, parka with heavy padding, padding with heavy overalls, socks, shoes, cap, gloves	2.55	0.395
Daily clothing		
Pants, shirt, shorts, light socks, sandals	0.30	0.050
Slip, slip, stockings, dress with light sleeves, sandals	0.45	0.070
Pants, shirt with short sleeves, light trousers, light socks, shoes	0.50	0.080
Panties, stockings, short-sleeve shirt, skirt, sandals	0.55	0.085
Pants, shirt, light trousers, socks, shoes	0.60	0.095
Slip, slip, stockings, dress, shoes	0.70	0.105
Underwear, shirts, trousers, socks, shoes	0.70	0.110
Underwear, complete racing (shirt and trousers), long socks, running shoes	0.75	0.115
Slip, slip, blouse, skirt, thick knee socks, shoes	0.80	0.120
Pants, shirt, skirt, a sweater necklace, thick knee socks, shoes	0.90	0.140
Pants, blouses with short sleeves, pants, sweater with a V-neck, socks, shoes	0.95	0.145
Pants, shirt, pants, jacket, socks, shoes	1.00	0.155
Panties, socks, shirt, skirt, vest, jacket	1.00	0.155
Panties, stockings, blouse, long skirt, jacket, shoes	1.10	0.170
Underwear, blouses with short sleeves, shirt, pants, jacket, socks, shoes	1.10	0.170
Underwear, short sleeve blouses, shirts, trousers, waistcoats, jackets, socks, shoes	1.15	0.180
Lingerie with long sleeves and legs, shirt, pants, sweater with a V-neck, jacket, socks, shoes	1.30	0.200
Lingerie with long sleeves and legs, shirt, pants, vest, jacket, coat, socks, shoes	1.50	0.230
Knitted underwear		
Panties	0.30	0.047
Long Panties	0.10	0.016
Blouse	0.04	0.006
Short-sleeve shirt	0.09	0.014
Long-sleeve shirt	0.12	0.019
Panties and bra	0.03	0.005
Jerseys - blouses		
Short-sleeve	0.15	0.023

Clothing	CLO	m^2 K/W
Light, with long sleeves	0.20	0.031
Normal, with long sleeves	0.25	0.039
In flannel, with long sleeves	0.30	0.047
Light blouse, with long sleeves	0.15	0.023
Trousers		
Short	0.06	0.009
Light	0.20	0.031
Normal	0.25	0.039
In flannel	0.28	0.043
Clothes- skirts		
Light skirt (summer)	0.15	0.023
Heavy skirt (winter)	0.25	0.039
Light dress, with short sleeves	0.20	0.031
Winter dress, with long sleeves	0.40	0.062
Overall	0.55	0.085
Sweaters		
Gilet	0.12	0.019
Light sweater	0.20	0.031
Sweater	0.28	0.043
Heavy sweater	0.35	0.054
Jackets		
Light , summer jacket	0.25	0.039
Jacket	0.35	0.054
Apron	0.30	0.047
High thermal insulation, synthetic fur padding		
Suit	0.90	0.140
Trousers	0.35	0.054
Jacket	0.40	0.062
Waistcoat	0.20	0.031
Outdoor clothing		
Coat	0.60	0.093
Under-jacket	0.55	0.085
Parka	0.70	0.109
Suit	0.55	0.085
Accessories		
Socks	0.02	0.003
Heavy ankle socks	0.05	0.008
Heavy long socks	0.10	0.016
Nylon socks	0.03	0.005
Shoes (thin soles)	0.02	0.003
Shoes (thick soles)	0.04	0.006
Boots	0.10	0.016
Gloves	0.05	0.008

Table 3.4: metabolic rate – classification according to the job

Job		**Metabolism** (W/m^2)
Craftsman	Bricklayer	110 ÷ 160
	Carpenter	110 ÷ 175
	Glazier	90 ÷ 125
	Painter	100 ÷ 130
	Baker	110 ÷ 140
	Butcher	105 ÷ 140
	Watchmaker	55 ÷ 70
Mining	Trasporter worker	70 ÷ 85
	Coal miner	110
	Coke oven worker	115 ÷ 175
Steel industry	Blastfurnace worker	170 ÷ 220
	Electrical oven worker	125 ÷ 145
	Trainer by hand	140 ÷ 240
	Trainer by machine	105 ÷ 165
	Melter	140 ÷ 240
Metallurgical industry	Blacksmith	90 ÷ 200
	Welder	75 ÷ 125
	Turner	75 ÷ 125
	Milled operator	80 ÷ 140
	Precision mechanic	70 ÷ 110
Graphical jobs	Composer by hand	70 ÷ 95
	Bookbinder	75 ÷ 100
Agriculture	Gardener	115 ÷ 190
	Tractor Conducer	85 ÷ 110
Traffic	Car Conducer	70 ÷ 100
	Bus Conducer	75 ÷ 125
	Tram Conducer	80 ÷ 115
	Crane Conducer	65 ÷ 145
Different jobs	Laboratory assistant	85 ÷ 100
	Teacher	85 ÷ 100
	Sales assistance	100 ÷ 120
	Secretary	70 ÷ 85

Table 3.5: Metabolic rate – classification by category

Class	M variation range		Examples
	W/m^2	W	
0 At rest	65 (55 ÷ 70)	115 (100 ÷ 125)	Rest
1 Low metabolic rate	100 (70 ÷ 130)	180 (125 ÷ 235)	**Comfortable seated**: light manual work (writing, typing, drawing, cutting, accounting), working with hands and arms (small tools, inspection, assembly or sorting of material), with arms and legs (driving a vehicle under normal conditions, operation of a pedal or a switch with the feet). **Standing**: work with drill (small pieces), milling machine (small pieces), winding bobbins, winding small armatures, work with low power machines, walk (speed up to 3.5 km/h).
2 Moderate metabolic rate	165 (130 ÷ 200)	295 (235 ÷ 360)	Moderate work with hands and arms: (hammering nails, filing), work with arms and legs (driving off-road trucks, tractors or building machinery), work with arms and trunk (with jackhammer, tractor assembly, plastering, intermittent handling of moderately heavy materials, weeding, hoeing, picking fruits and vegetables), push or pull light wagons or wheelbarrows, walk at speeds between 3.5 and 5.5 km/h; forging.
3 High metabolic rate	230 (200 ÷ 260)	415 (360 ÷ 465)	Intense work with arms and bust, bringing heavy material, digging with shovel; working with hammer, saw, chisel or plane hardwood; shearing the grass by hand, digging, walking at a speed between 5.5 and 7 km/h. Pushing or pulling wagons and wheelbarrows with heavy loads; debarring castings; placing cement blocks.
4 Very high metabolic rate	290 (> 260)	520 (>465)	Very intense work at a fast to maximum pace; working with the ax, digging so intense, climbing the stairs, ramps, walking quickly in small steps, running, walking at speeds greater than 7 km/h.

Table 3.6: metabolic rate – classification by specific activity

Activity	W/m²
Flat walk along the path	
At 2 km/h	110
At 3 km/h	140
At 4 km/h	165
At 5 km/h	200
Walking uphill at 3 km/h	
Slope of 5°	195
Sope of 10°	275
Slope of 15°	390
Walking downhill at 5 km/h	
Slope of 5°	130
Slope of 10°	115
Slope of 15°	120
Climb a ladder (0.172 m/step)	
80 steps per minute	440
Down a scale (0.172 m/step)	
80 steps per minute	155
Carry a cargo at 4 km/h	
Mass 10 kg	185
Mass 30 kg	250
Mass 50 kg	360
Relaxing	
Sleeping	41
Standing	46
Sitting relaxed	58
Relaxing	65
Standing relaxed	79
Various	
Sedentary activity (office, home, lab, light ind.)	70
Light standing activity (shopping, lab, light ind.)	93
standing moderate activity (shop assistant, housework, work on machine)	116
Jobs – Building industry	
Laying bricks (building a uniform wall)	
Full brick (mass 3.8 kg)	150
Hollow brick (mass 4.2 kg)	140
Hollow brick (mass 15.3 kg)	125
Hollow brick (mass 23.4 kg)	135
Prefabrication of concrete elements	
Mounting and unmounting formworks (prestressed concrete)	180
Inserting steel rods	130
Pouring concrete (prestressed concrete)	180
Construction of houses	
Mixing cement	155
Pouring concrete for foundations	275
Compacting concrete by vibration	220
Mounting formworks	180
Load the wheelbarrow with stones and lime	275

Activity	W/m²
Jobs – Steel industry	
Blastfurnace	
Preparing the casting channel	340
Tapping	430
Forming (by hand)	
Forming medium size pieces	285
Hammering with jackhammer	175
Forming small pieces	140
Forming (by machine)	
Pouring castings	125
Forming, ladle with one operator	220
Forming, ladle with two operators	210
Forming from a ladle suspended to a crane	190
Finishing	
Working with jackhammer	175
Grinding. Cutting.	175
Jobs – Forestry industry	
Transportation and working with ax	
Walking and carrying (7 kg) in a forest, 4 km/h	285
Carrying an electric saw (18 kg) by hand, 4 km/h	385
Working with an ax (2 kg, 33 strokes/min)	500
Cutting roots with the ax	375
Chopping down (fir)	415
Sawing - cutting with circular saw operated by two people	
60 double strokes/min, 20 cm^2 per double stroke	415
40 double strokes/min, 20 cm^2 per double stroke	240
Sawing - cutting with electric saw	
Saw operated by a person	235
Saw operated by two people	205
Sawing – cutting	
Saw operated by a person	205
Saw operated by two people	190
Sawing - removing the bark	
Summer average	225
Winter average	390
Job – Agricolture	
Various jobs	
Digging (24 strokes / min)	380
Plowing with horses	235
Plowing with a tractor	170
Hoeing (mass of the hoe 1.25 kg)	170
Fertilizing a field	
Sowing by hand	280
Sowing with spreaders pulled by horses	250
Sowing with tractor	95
Jobs - Sport	
Running	
9 km/h	435
12 km/h	485
15 km/h	550

Activity	W/m²
Skiing - in plan with good snow	
7 km/h	350
9 km/h	405
12 km/h	510
Ice Skating	
12 km/h	225
15 km/h	285
18 km/h	360
Jobs – Home jobs	
Various jobs	
Cleaning	100 ÷ 200
Cooking	100 ÷ 200
Cleaning dishes, standing	145
Hand washing and ironing	120 ÷ 220
Shaving, washing and dressing	100

To calculate the PMV and PPD indices, the following probes must be connected:

- **TP3276.2** or **TP3275** globe thermometer probe.
- **HP3217.2R** or **HP3217R** combined relative humidity and temperature probe (or alternatively HP3217B4/HP3217BV4).
- **AP3203.2** or **AP3203** hot wire air speed probe.

For the measurement of the PMV and PPD indices, reference is made to the standards:

- **ISO 7726**
- **ISO 7730:2005**

3.3 Mean radiant temperature

The medium radiant temperature $\mathbf{T_r}$ is defined as the uniform temperature of a fictitious black cavity in which an individual would exchange the same amount of radiant thermal energy that it exchanges in the real non-uniform environment.

To evaluate the mean radiant temperature, we must detect: the globe thermometer temperature, the air temperature and the air speed measured close to the globe thermometer.

The formula for calculating the mean radiant temperature is the following:

- In case of **natural convection**:

$$\mathbf{T_r} = \left[\left(\mathbf{T_g} + 273\right)^4 + \frac{0.25 \times 10^8}{\varepsilon_{\mathbf{g}}} \left(\frac{\left|\mathbf{T_g} - \mathbf{T_a}\right|}{\mathbf{D}} \right)^{1/4} \times \left(\mathbf{T_g} - \mathbf{T_a}\right) \right]^{1/4} - 273$$

- In case of **forced convection**:

$$\mathbf{T_r} = \left[\left(\mathbf{T_g} + 273\right)^4 + \frac{1.1 \times 10^8 \times \mathbf{V_a}^{0.6}}{\varepsilon_{\mathbf{g}} \times \mathbf{D}^{0.4}} \left(\mathbf{T_g} - \mathbf{T_a}\right) \right]^{1/4} - 273$$

where:

$\mathbf{D}$ = globe thermometer diameter
$\boldsymbol{\varepsilon_g}$ = 0.95 globe thermometer presumed emissivity
$\mathbf{T_g}$ = globe thermometer temperature
$\mathbf{T_a}$ = air temperature
$\mathbf{V_a}$ = air speed

The mean radiant temperature does not coincide with the air temperature: if within a room there are areas which have a temperature much higher than that of the air (think, for example, of the flame of a fireplace), the mean radiant temperature is an average significantly affected by the presence of this very hot area.

The mean radiant temperature is detected with the globe thermometer, which is a temperature probe consisting of a copper sphere painted with matt black, with emissivity $\boldsymbol{\varepsilon_g}$ equal to 0.95 (as required by ISO 7726), with a Pt100 sensor inside.

The temperature of globe thermometer may be significantly higher than the air temperature, as in the case of a mountain hut, where the air is 0 °C, but where the presence of a fireplace produces a medium radiant temperature of 40 °C, ensuring a comfort situation.

Under normal conditions, maintaining a mean radiant temperature significantly higher than the air temperature is an advantage in terms of environmental quality. In homes, where fireplaces or stoves no longer exist, usually the mean radiant temperature coincides with the air temperature, or it is even lower. These situations (the main case is represented by buildings with large glazed surfaces) are not particularly healthy as the warm and wet air facilitates the development of pathogens. From this point of view, the heating with lamps or radiant panels is much healthier. It is more hygienic to ensure the comfort conditions with a mean radiant temperature greater than the air temperature. The legislation erroneously establishes the air temperature rather than the mean radiant temperature as the evaluation parameter for heating systems.

To calculate the mean radiant temperature, the following probes must be connected:

- **TP3276.2** or **TP3275** globe thermometer probe.
- **HP3217.2R** or **HP3217R** combined relative humidity and temperature probe (or alternatively HP3217B4/HP3217BV4).
- **AP3203.2** or **AP3203** hot wire air speed probe.

To calculate the mean radiant temperature, reference is made to the **ISO 7726** standard.

3.4 Turbulence intensity TU and draft rate DR

The local turbulence intensity, in percentage, is defined as the ratio between the local air speed standard deviation and the local average air speed (ISO 7726):

$$\mathbf{TU} = \frac{\mathbf{SD}}{\mathbf{V_a}} \times 100$$

where:
V_a = average local wind speed
SD = local wind speed standard deviation

$$\mathbf{SD} = \sqrt{\frac{1}{\mathbf{n}-1} \cdot \sum_{\mathbf{i}=1}^{\mathbf{n}} \left(\mathbf{V_{a_i}} - \mathbf{V_a}\right)^2}$$

From the turbulence calculation, knowing the average values of the local wind speed and ambient temperature, the Draft Rate **DR** is obtained, according to ISO 7730:

$$\mathbf{DR} = \left(34 - \mathbf{T_a}\right) \cdot \left(\mathbf{V_a} - 0.05\right)^{0,62} \cdot \left(0.37 \cdot \mathbf{V_a} \cdot \mathbf{TU} + 3.14\right)$$

The air current discomfort is defined as an undesired local cooling of the body due to air motion. The Draft Rate DR indicates the percentage of people who are dissatisfied due to the air current.

The DR index is calculated when the temperature is between 20 and 26 °C and the average air speed is less than 0.5 m/s.

To calculate the turbulence intensity, the **AP3203.2** or **AP3203** hot wire air speed probe must be connected.

To calculate the turbulence intensity TU and the Draft Rate DR, reference is made to the standards:

- **ISO 7726**
- **ISO 7730**

3.5 Heat Index HI

The heat index **HI** is calculated as a function of the environmental temperature and relative humidity and estimates the physiological discomfort due to high temperatures in the presence of high humidity.

The sultry heat condition in fact limits the dispersion of heat from the human body, hindering the thermoregulation process with possible consequences for the health of the individual, which can even lead to heat stroke.

The heat index is defined for temperatures greater than or equal to 27 °C and for relative humidity rates greater than or equal to 40%.

The "U.S. National Oceanic and Atmosphere Administration (NOAA)" classifies the heat index into four risk levels, highlighted with color coding, as shown in the following tables.

Table 3.7: heat index as a function of temperature and humidity

		Temperature (°C)															
		27	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
Relative humidity (%)	**40**	27	27	28	29	31	33	34	36	38	41	43	46	48	51	54	58
	45	27	28	29	31	32	34	36	38	40	43	46	48	51	54	58	
	50	27	28	29	31	33	35	37	39	42	45	48	51	55	58		
	55	27	29	30	32	34	36	38	41	44	47	51	54	58			
	60	28	29	31	33	35	38	41	43	47	51	54	58				
	65	28	29	32	34	37	39	42	46	49	53	58					
	70	28	30	32	35	38	41	44	48	52	57						
	75	29	31	33	36	39	43	47	51	56							
	80	29	32	34	38	41	45	49	54								
	85	29	32	36	39	43	47	52	57								
	90	30	33	37	41	45	50	55									
	95	30	34	38	42	47	53										
	100	31	35	39	44	49	56										

Table 3.8: risk levels in case of prolonged exposure and/or physical activity

Color	Level	Heat Index HI	Effects
Light yellow	Caution	27 °C ≤ HI < 33 °C	Fatigue possible
Dark yellow	Extreme caution	33 °C ≤ HI < 40 °C	Heat stroke, cramps or exhaustion possible
Orange	Danger	40 °C ≤ HI < 52 °C	Cramps or exhaustion likely and heat stroke possible
Red	Extreme danger	HI ≥ 52 °C	Heat stroke highly likely

3.6 UTCI Temperature

The **UTCI** (Universal Thermal Climate Index) temperature is defined as the air temperature of the reference condition causing the same model response as actual conditions.

The ISB (International Society of Biometeorology) commission on the UTCI has defined the following as reference condition:

- Person walking at 4 km/h.
- Rate of metabolic heat production = 2.3 MET (≈135 W/m^2).
- Air speed (V_a) = 0.5 m/s at 10 m above ground.
- Mean radiant temperature (T_r) = Air temperature (T_a).
- Relative humidity (RH) = 50% (T_a < 29 °C); Partial vapour pressure = 2 kPa (T_a > 29 °C).

The UTCI temperature depends on the actual values of air temperature, air speed and relative humidity.

UTCI is valid in all climates and seasons, and it is independent of the individual's characteristics.

The following table reports the thermal stress as a function of the UTCI temperature.

Table 3.9: UTCI thermal stress levels

Level	UTCI
Extreme heat stress	UTCI > 46 °C
Very strong heat stress	38 °C < UTCI < 46 °C
Strong heat stress	32 °C < UTCI < 38 °C
Moderate heat stress	26 °C < UTCI < 32 °C
No thermal stress	9 °C < UTCI < 26 °C
Slight cold stress	0 < UTCI < 9 °C
Moderate cold stress	-13 °C < UTCI < 0
Strong cold stress	-27 °C < UTCI < -13 °C
Very strong cold stress	-40 °C < UTCI < -27 °C
Extreme cold stress	UTCI < -40 °C

3.7 TEP Perceived Equivalent Temperature

The **TEP** Perceived Equivalent Temperature is defined as the temperature that produce a thermal sensation equivalent to those of the air temperature of a reference environment:

- Standing still person.
- Still air (V_a= 0).
- Mean radiant temperature (T_r) = Air temperature (T_a).
- Relative humidity (RH) = 50%.

The formula for calculating the Perceived Equivalent Temperature is the following:

$$\mathbf{TEP = -3.777 + 0.4828\ T_a + 0.5172\ T_r + 0.0802\ RH - 2.322\ V_a}$$

where:
T_a = air temperature (°C)
T_r = mean radiant temperature (°C)
RH = relative humidity (%)
V_a = air speed (m/s)

4 Volatile organic compounds (VOC) monitoring

Volatile organic compounds (VOC) are polluting chemicals that evaporate easily at ambient temperature and pressure. An excessive concentration of these substances in indoor environments reduces the quality of the air, causing discomfort or, in the most serious cases, alterations in the state of health (irritation, breathing difficulties, etc.) in the people present in the environment. The detection of volatile organic compounds is therefore a factor of primary importance in determining the quality of indoor air.

There are many sources of VOC pollution in indoor environments, for example:

- glues, adhesives, solvents, paints;
- cosmetic products, deodorants;
- cleaning products;
- heating devices;
- printers, photocopiers;
- cigarette smoke;
- building materials;
- furnishings (furniture, coatings);
- the "occupants" themselves (breathing, body surface).

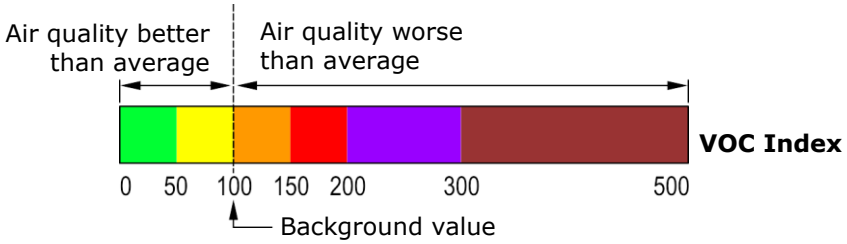
The volatile organic compounds monitoring can be performed by using the **HP3217BV4** probe.

The VOC measurement provided is not an absolute concentration, but it is a measurement:

- relative (compared to the average situation of the monitored environment);
- qualitative (index of better or worse than the average situation).

The probe must therefore "adapt" to the environment to be monitored, so that the average pollution state (background value) of the environment can be determined. For this to happen, **it is necessary to leave the probe operating (connected to the instrument and with the instrument on) in the environment to be monitored for at least 12 hours**.

After the time of adaptation to the environment, the state of VOC pollution is expressed as an index variable from 1 to 500 (dimensionless). The value 100 corresponds to the background value of the environment. Values below 100 indicate that VOC pollution is improving; values above 100 indicate that VOC pollution is worsening compared to the determined background value.



VOC Index	Air quality
VOC Index < 50	Much better than average
50 < VOC Index < 100	Slightly better than average
100 < VOC Index < 150	Slightly worse than average
150 < VOC Index < 200	Somewhat worse than average
200 < VOC Index < 300	Much worse than average
300 < VOC Index < 500	Bad compared to average

The VOC index value is an average referring to the last 24 hours of monitoring.

Not being an absolute indication, the VOC measurement is not suitable for comparing different environments, because environments with a very different degree of pollution could generate similar values of the VOC index, being the index based on the background value of the environment.

5 Operation

Before switching the instrument on, connect the probes to the inputs.

- For the measurement of the **WBGT** index, connect the following SICRAM probes:
  - **TP3207.2** or **TP3207** dry bulb temperature probe (or alternatively a combined HP3217.2R/HP3217R or HP3217B4/HP3217BV4 probe).
  - **TP3276.2** or **TP3275** globe thermometer probe.
  - **HP3201.2** or **HP3201** or **TP3204S** natural ventilation wet bulb temperature probe.
- For the measurement of the **PMV/PPD** indices and mean radiant temperature **T_r**, connect the following SICRAM probes:
  - **HP3217.2R** or **HP3217R** temperature and relative humidity combined probe (or alternatively HP3217B4/HP3217BV4).
  - **AP3203.2** or **AP3203** omnidirectional hot wire air speed probe.
  - **TP3276.2** or **TP3275** globe thermometer probe.
- For the measurement of the **TU/DR** indices, connect the **AP3203.2** or **AP3203** omnidirectional hot wire air speed SICRAM probe.
- For the measurement of the Heat Index **HI**, connect a **HP3217.2R** or **HP3217R** temperature and relative humidity combined probe or a dry bulb temperature probe and a natural ventilation wet bulb temperature probe.
- For the measurement of the **CO_2**, connect the **HP3217B[V]4** SICRAM probe.
- For the measurement of the **VOC** index, connect the **HP3217BV4** SICRAM probe.
- For the measurement of the PM1.0 - PM2.5 - PM10 particulate matter, connect to the RS485 port the **PMsense-P** transmitter.
- For the estimation of **SARS-CoV-2** virus natural decay on surfaces, connect a temperature and relative humidity combined probe.

Notes:

1) **The SICRAM probes must be connected when the instrument is off. If a probe is connected when the instrument is already on, it is not recognized: it is necessary to switch the instrument off and on again.**
2) If more probes of the same type are connected, it will be considered only the first recognized probe: the scan of the probes, for their recognition, starts from input A.

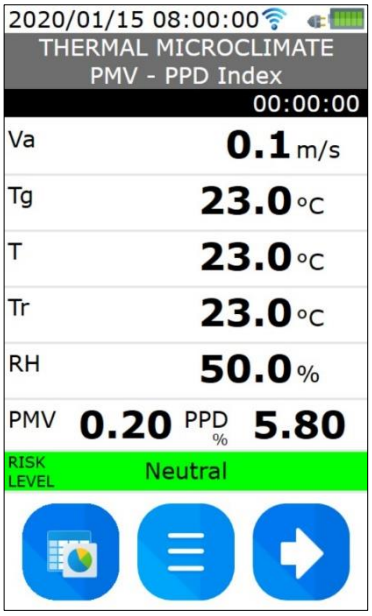
To switch the instrument on and off, press the **ON/OFF** key.

When the instrument is switched on, the instrument model and the firmware revision (at the bottom right) will be displayed for some seconds, then the measurements are displayed.

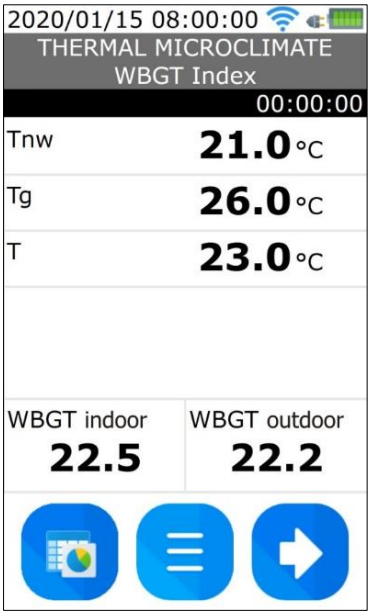
If multiple measurement screens are available, use the "right arrow" key on the display to switch from one screen to another. The scrolling is cyclic.

The various measurement screens are illustrated below (the screens actually visible depend on the instrument measurement settings, see the MENU chapter).

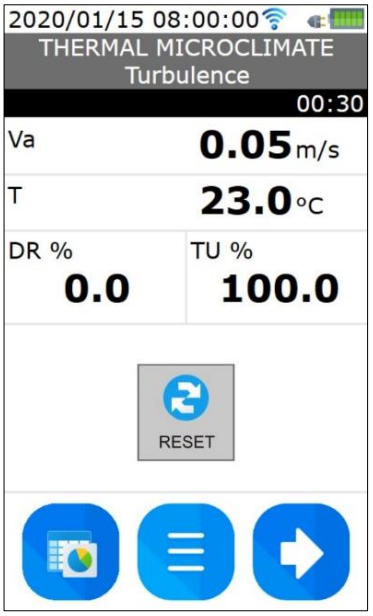
The colored bar in the PMV/PPD index, heat index, UTCI temperature and TEP temperature screens indicates the evaluation of thermal stress.



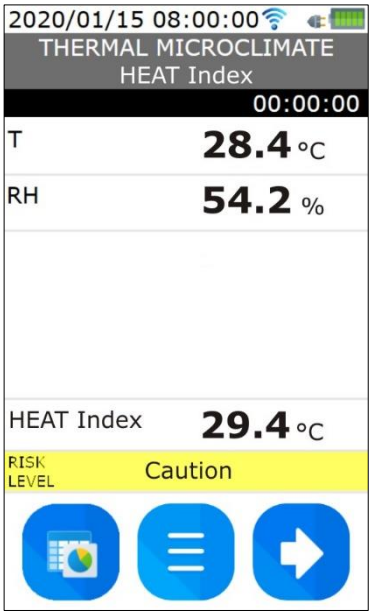
Thermal microclimate PMV – PPD indices



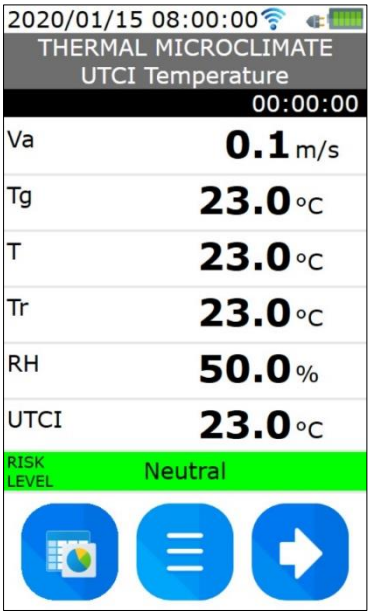
Thermal microclimate WBGT index



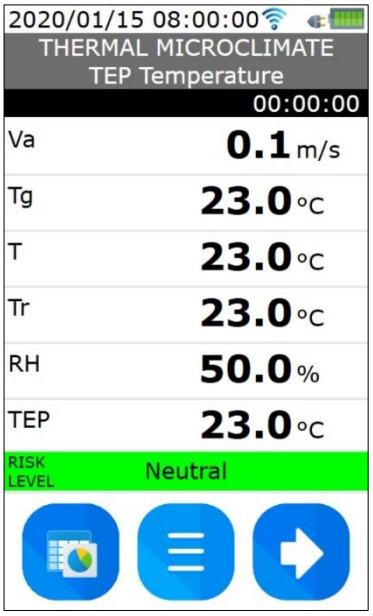
Thermal microclimate DR – TU indices



Thermal microclimate Heat Index



Thermal microclimate UTCI Temperature



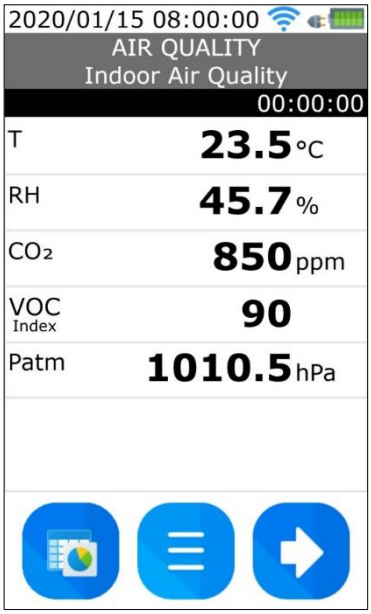
Thermal microclimate TEP Temperature

Measured quantities:

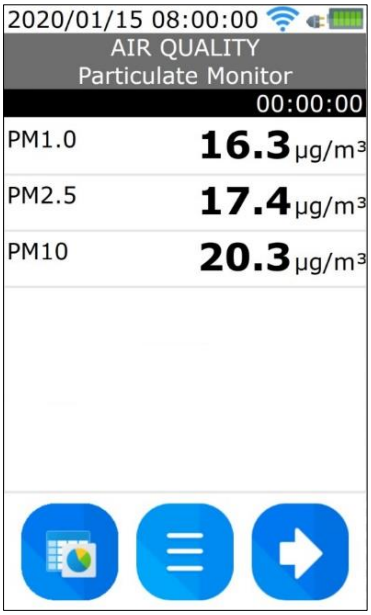
RH = Relative humidity
T = Environmental temperature (dry bulb)
Tg = Globe thermometer temperature
Tnw = Wet bulb temperature
Va = Air speed

Calculated indices:

DR = Draft Rate
HI = Heat index
PMV = Predicted mean vote
PPD = Predicted percentage of dissatisfied
TEP = Perceived equivalent temperature
Tr = Mean radiant temperature
TU = Turbulence
UTCI = Universal thermal climate index
WBGT = Wet Bulb Globe Temperature



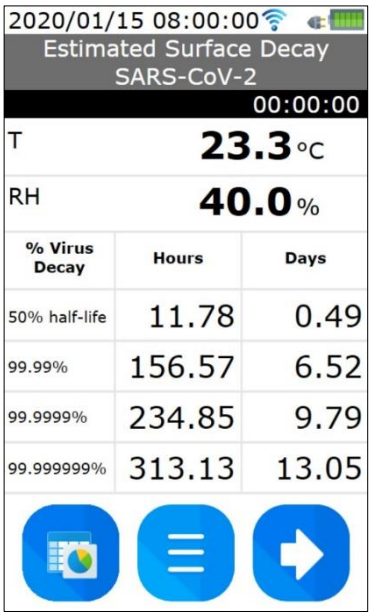
Indoor Air Quality (IAQ)



Air Quality Particulate Matter (PM)

Measured quantities:

CO_2 = Carbon dioxide
Patm = Atmospheric pressure
PM1.0 - PM2.5 - PM10 = Particulate Matter
RH = Relative humidity
T = Environmental temperature
VOC Index = Volatile Organic Compound



Estimation of SARS-CoV-2 time decay on surfaces

Based on the environmental temperature and relative humidity values, the natural decay time of the SARS-CoV-2 virus on surfaces is estimated, according to the equation published by the "U.S. Homeland Security department".

The following decay percentages are considered:

- 50%
- 99.99%
- 99.9999%
- 99.666666%

The time is displayed in both hours and days.

DR and TU indices calculation:

For the calculation of the TU and DR indices, the measurements detected in the previous 30 seconds are considered. Therefore, it is necessary to wait 30 seconds (at the top right, above the measurements, there is a timer) to have the first valid data after switching on the instrument or activating the TU and DR indices screen from the menu. The calculation is continuously updated every second and can be reinitialized by pressing the RESET key.

Logging:

To start a logging session, press the **REC** key.

When data logging starts, the instrument front LED blinks alternately green and blue, the counter of the recording duration is activated and the name of the file (characterized by the logging start date and time) in which the data are stored appears.

The frequency with which the data are stored is set with the "LOGGING" menu item.

To stop the logging, press the **REC** key again. Alternatively, it is possible to stop the data recording automatically by setting the logging session duration in the "LOGGING" menu.

The data of each logging session are stored in different files. The files are stored in the folder corresponding to the active project. Before starting the logging, select or create the desired project in the "PROJECTS" menu (see the MENU chapter). If there are no user-defined projects, the data are stored in the default folder.

The list of the files relating to the active project in the instrument memory is visible in the "PROJECTS >> FILES" menu.

Note: if the REC key is pressed while inside the menu, the instrument automatically exits the menu and returns to measuring mode, then logging is started.

Connecting to PC and viewing the logged data:

The data can be viewed with the **DeltaLog10** software by connecting the instrument to a PC USB port with the **CP31** cable (USB drivers installation is not required).

The instrument is seen as a disk drive containing the various folders corresponding to the projects. It is not necessary to perform connection procedures with the software, simply:

- display the tree of the directories in the main window of the DeltaLog10 software;
- select the desired folder on the disk drive corresponding to the instrument;
- double-click on the name of the data file.

When the instrument is connected to the PC, it is possible to create, rename and delete the project folders in the disk drive corresponding to the instrument directly from the PC by using a file manager (alternatively it can be done via the instrument menu).

Note: the USB connection is disabled when the menu is entered or the logging is started, and it is automatically enabled when the menu is exited or the logging is stopped.

Sending data to an ftp server:

The data files can be sent by the instrument via FTP ("PROJECTS >> FILES >> FTP" menu). To send files via FTP, the instrument must be connected to a Wi-Fi network ("SETUP >> WI-FI" menu).

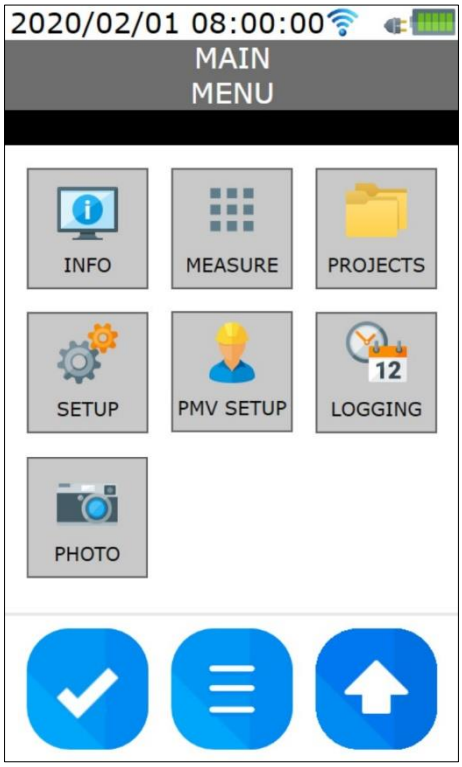
Storing pictures of the monitored environment:

The instrument allows taking pictures of the monitored environment. The images are stored in the folder of the active project. To take photos, see the "PHOTO" menu item.

Note: take photos before or after logging; during logging, the camera function is not accessible, as it is not possible to enter the menu.

6 Menu

From any numerical measurement screen, press the MENU key (central key) on the display to enter the main menu (*Note*: if the logging is running, it is not possible to enter the menu).



INFO: instrument and connected probes general information.

MEASURE: choice of the measurement screens to be displayed.

PROJECTS: management of the folders for data storage.

SETUP: setting of the Wi-Fi and FTP connections, date and time, language and auto-off of the display backlight.

PMV SETUP: setting of the parameters for the PMV index calculation.

LOGGING: setting of the logging interval and duration.

PHOTO: capturing of photos / viewing of the photos of the active project.

Confirms the displayed setting. Blinks to indicate that a setting has been changed but not yet confirmed.

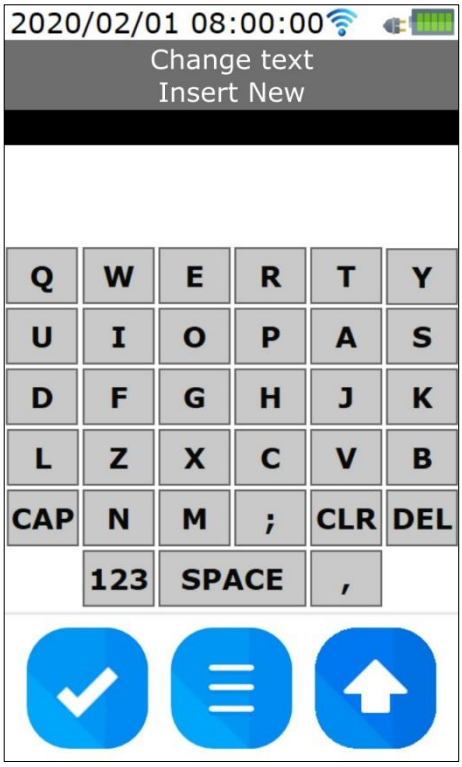
Exits directly from the menu (at any level).

Goes back up one level within the menu.

Note: the instrument automatically exits the menu after 5 minutes of inactivity.

Virtual keyboard:

Some settings require entering a string. In this case, a virtual keyboard appears on the instrument display, as shown in the following image.



- **CAP**: upper case ⇔ lower case.
- **CLR**: clears the string.
- **DEL**: deletes the last character.
- **123**: alphabetic characters ⇔ numbers/symbols.

Press the "check" key to confirm the entered string.

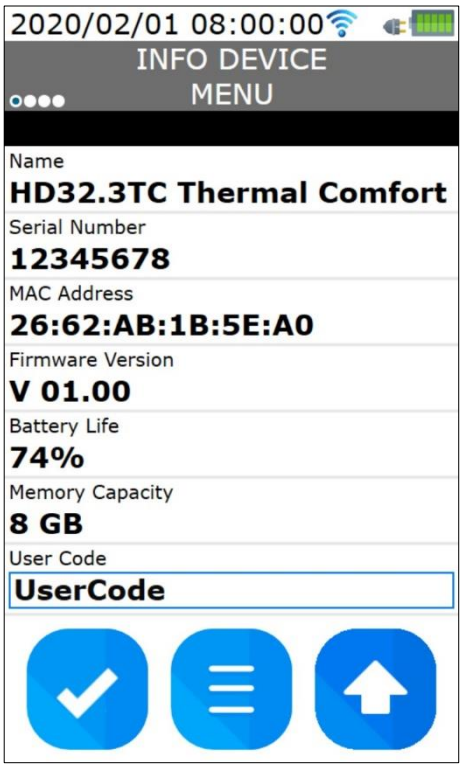
6.1 INFO menu

The INFO Menu shows the instrument and connected probes general information.

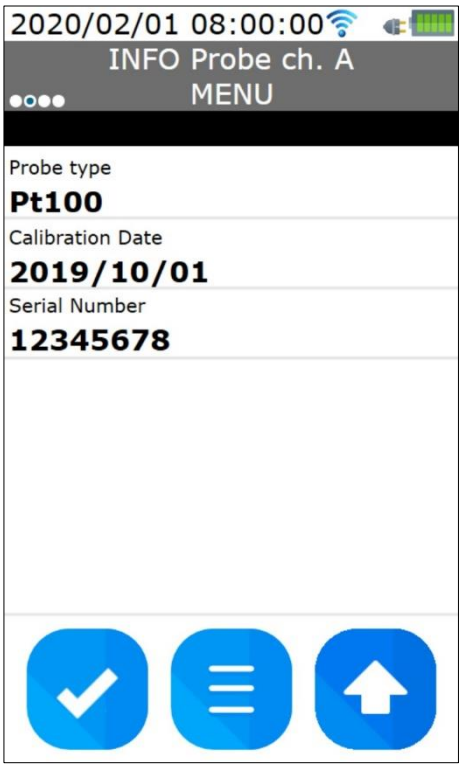
In order to scroll through the information pages, swipe horizontally on the display. The page you are viewing is indicated in the third row of the display, on the left.

Instrument information: model, serial number, MAC address, firmware version, battery charge, memory capacity and user code (editable by pressing on the corresponding field).

Probes information: probe type, calibration date and serial number.



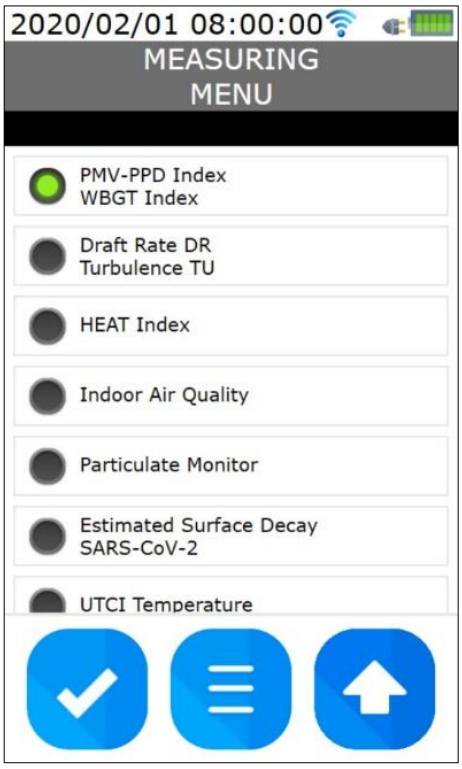
Instrument info



Probes info

6.2 MEASURE menu

The MEASURE menu allows choosing the measurement screens to be displayed.



To save the setting, press the "check" key.

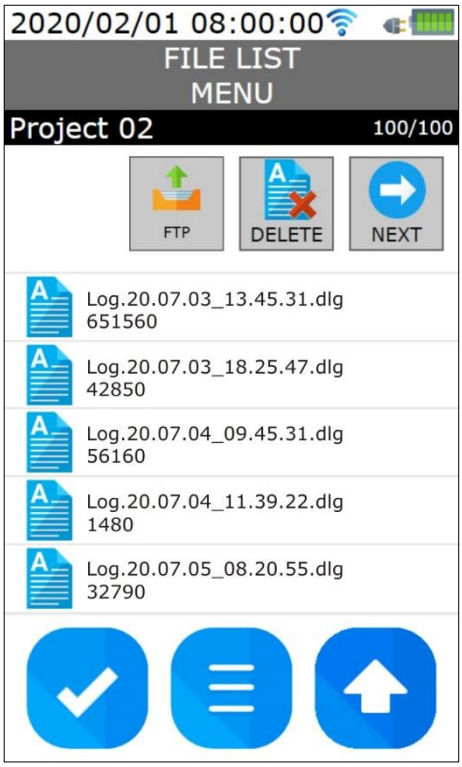
6.3 PROJECTS menu

The instrument allows saving the data of separate loggings in different projects. Each project corresponds to a folder in the memory of the instrument. When a logging is started or a photo is captured, the data are saved in the active project.

Entering the PROJECTS menu, the ACTIVE PROJECT box indicates the name of the active project.

- **PROJECTS**: allows changing the active project and creating, renaming and deleting the project folders.
- **FILES**: displays the list of the files of the active project. Allows sending via FTP individual files.

To view the list of the files of the active project, press FILES.

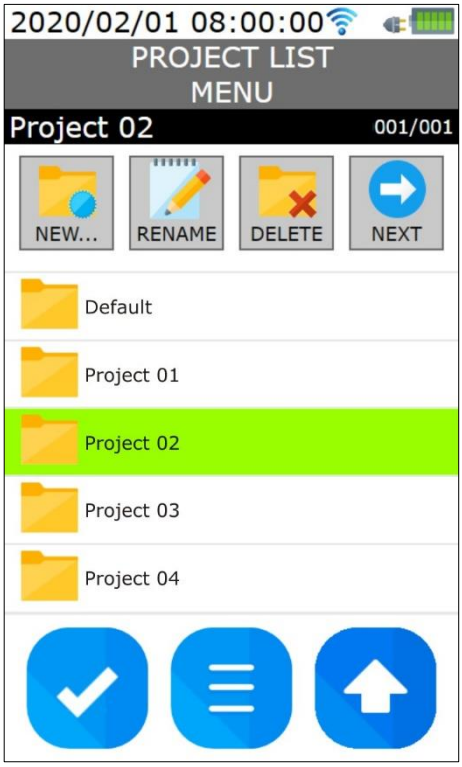


- **FTP**: sends the selected file via FTP (only "dlg" logging files can be sent, not "jpg" photos).
- **DELETE**: deletes the selected file.
- **NEXT**: goes to the next screen of the list (cyclic scrolling).

To select a file, press on the file row. The selected file is highlighted by a blue bar.

When sending a file via FTP, the progress bar, the file size in bytes and the number of bytes sent are displayed. At the end of sending, press OK in the window that has opened. The sending can be canceled by pressing the ABORT key.

To change the active project and to create, rename and delete the project folders, press PROJECTS.



- **NEW...**: creates a new project.
- **RENAME**: renames the selected project (highlighted by a blue bar).
- **DELETE**: deletes the selected project (highlighted by a blue bar). Confirmation is requested before the definitive deletion of a project.
- **NEXT**: goes to the next screen of the list (cyclic scrolling).

To select a project, press on the project row. The selected project is highlighted by a blue bar.

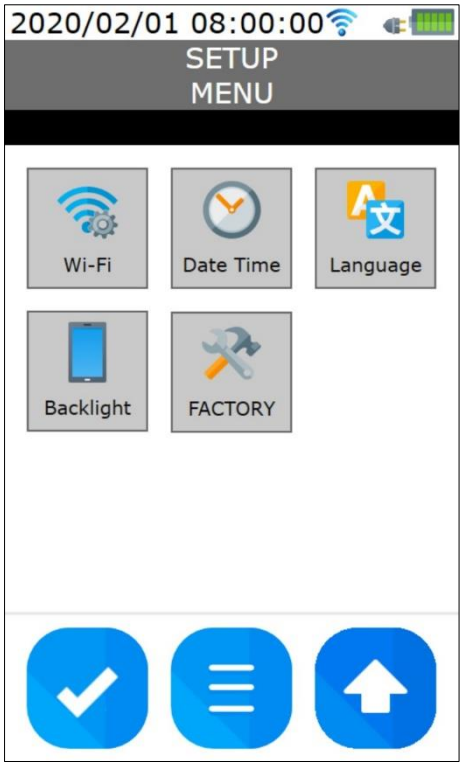
The project highlighted by the green bar is the active project. To change the active project, press on the row of the project to be activated (it will be highlighted by a blue bar) and then confirm with the "check" key.

To rename or delete the active project, first select it (the green bar turns blue).

Note: if the active project is deleted, only the content of the folder is deleted but not the folder.

6.4 SETUP menu

The SETUP menu allows setting the Wi-Fi and FTP connections ("**Wi-Fi**" key), the instrument date and time ("**Date Time**" key), the instrument language ("**Language**" key) and the auto-off of the display backlight ("**Backlight**" key).



The FACTORY sub-menu includes advanced system functions for the technical maintenance of the instrument and is accessible after entering a numeric password.

Wi-Fi configuration:

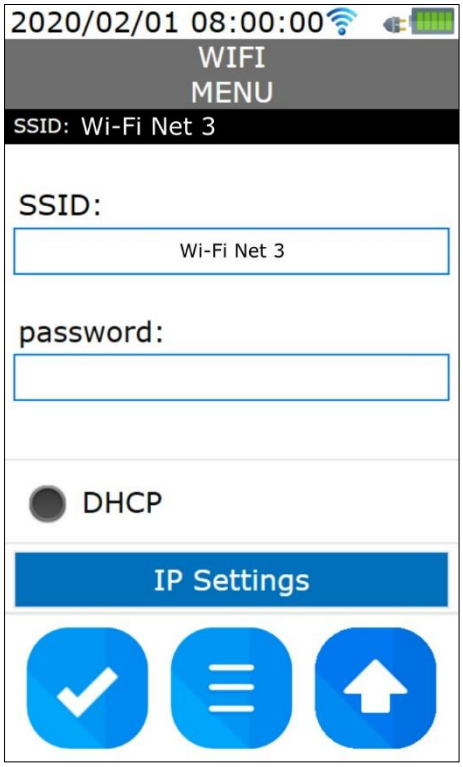
By selecting Wi-Fi you can enable/disable the Wi-Fi connection and configure the FTP connection.

- **ON** or **OFF**: enable or disable the Wi-Fi connection. When the connection is enabled, the key background is green and the indication is ON. When the connection is disabled, the key background is red and the indication is OFF.
- **SCAN**: re-scan for Wi-Fi networks.
- **FTP**: configuration of the FTP connection.
- **NEXT**: goes to the next screen of the list (cyclic scrolling).
- **ADD NETWORK**: allows adding a Wi-Fi network manually, in case it is not detected automatically.

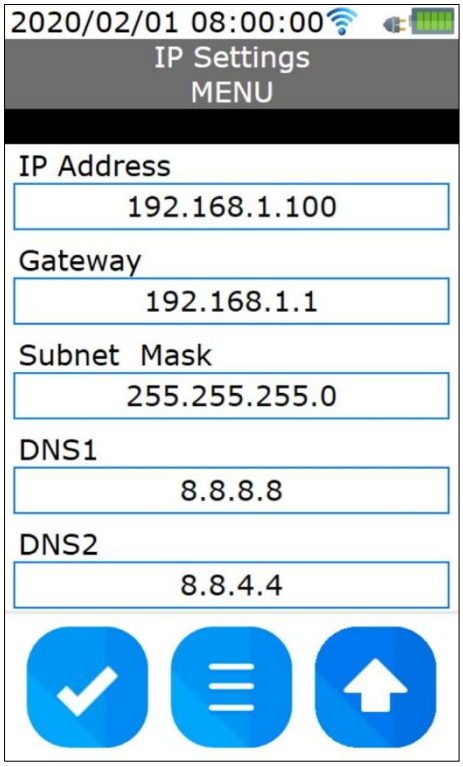
When the Wi-Fi connection is enabled, the instrument automatically scans for available networks and automatically connects to the network with the strongest signal (the signal level is indicated by the symbol next to the network name) among those to which it has the possibility of connect (networks whose password is stored in the instrument). The network to which the instrument

connects is highlighted in blue and is shown in the upper part of the display.

To enter a network password, select the network in the list; in the screen that appears, select the "Password" field, write the password using the virtual keyboard and confirm by pressing the "check" key. The entered network password remains stored in the instrument.

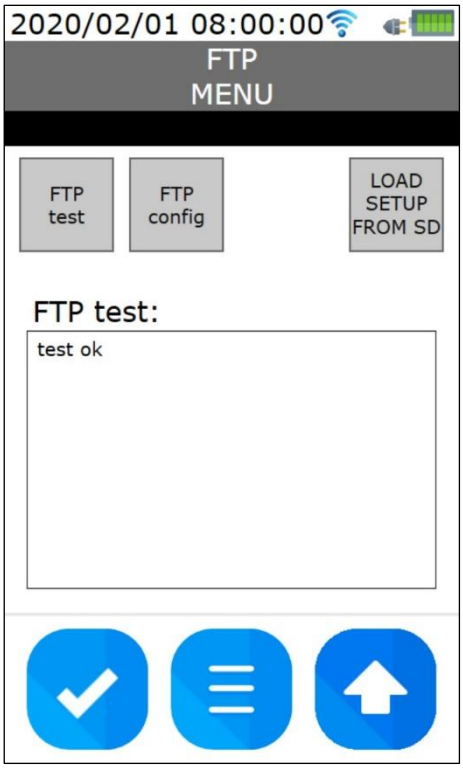


Select DHCP (Dynamic Host Configuration Protocol) to automatically get a dynamic IP address from the network. After connection, the dynamic address assigned by the network to the instrument is visible by pressing "IP Settings". To enter a static IP address manually, deselect DHCP and press "IP Settings", then configure the address and confirm by pressing the "check" key.



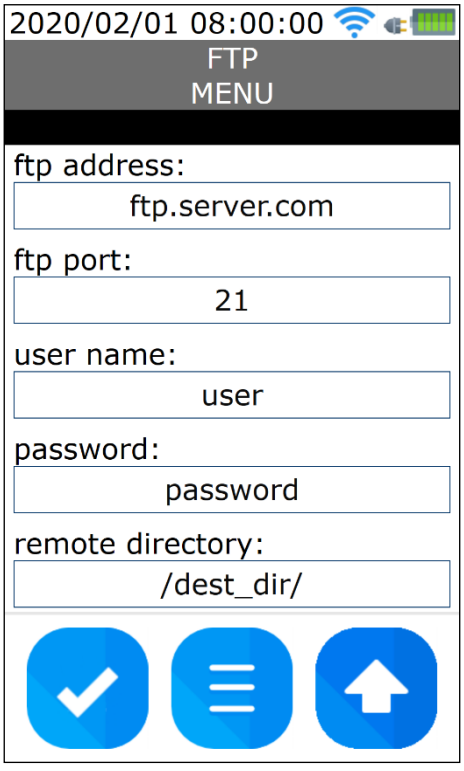
FTP configuration:

Selecting FTP in the Wi-Fi menu, the FTP connection can be configured and tested.



The configuration of the FTP connection can be entered using the virtual keyboard of the instrument or it is possible to load the configuration from a text file present in the instrument memory.

In order to configure the FTP connection, select "FTP Config", then fill in the fields: FTP address, port number, user name, password (by pressing on the word “Password”, the password can be made clearly visible or hidden) and data destination folder. Press the "check" key to confirm.



In order to load the configuration of the FTP connection from a text file present in the instrument memory:

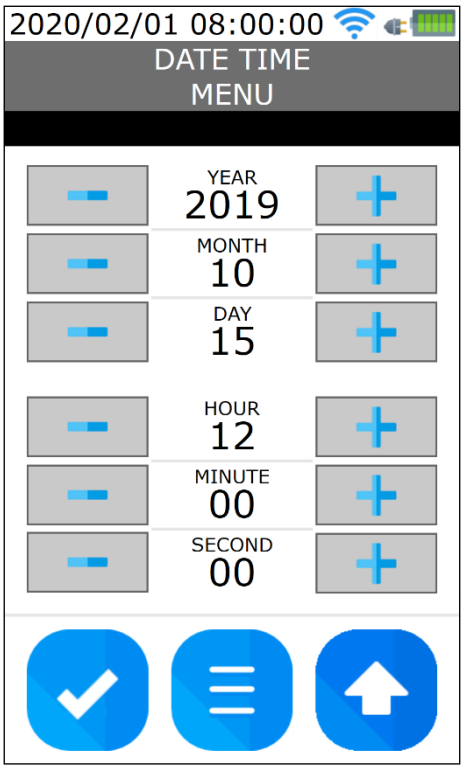
- connect the instrument the PC via USB;
- with a text editor, open the "setup_wifi.txt" file located in the root directory of the disk drive corresponding to the instrument;
- fill in the *ftp_host* (FTP address), *ftp_username* (user name), *ftp_password*, *ftp_folder* (data destination folder) and *ftp_port* (port number) rows;
- close the text file;
- in the FTP menu of the instrument, press the LOAD SETUP FROM SD key.

Note: the Wi-Fi connection, if enabled, is disabled during the uploading of the text file with the FTP configuration; if necessary, re-enable the Wi-Fi connection manually by pressing the ON key in the Wi-Fi menu.

After configuring the FTP connection, select "FTP test" to check the connection: a test "txt" file with the instrument information is sent.

Date and time setting:

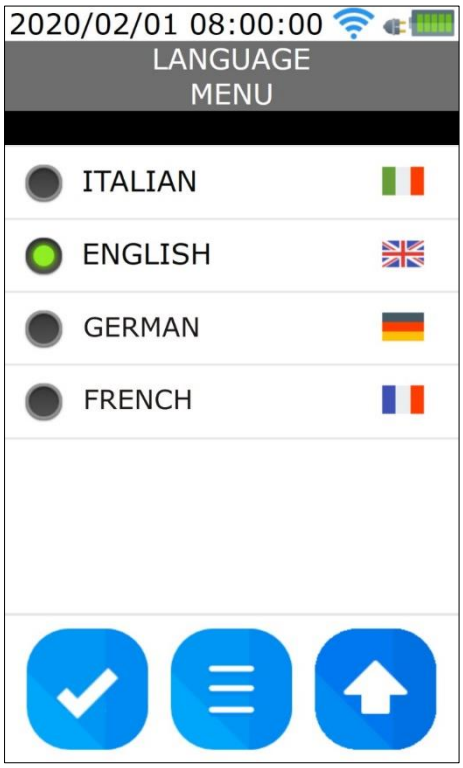
Press "Date Time" in the SETUP menu.



Set YEAR, MONTH, DAY, HOUR, MINUTE and SECOND by using the +/- keys. Press the "check" key to confirm.

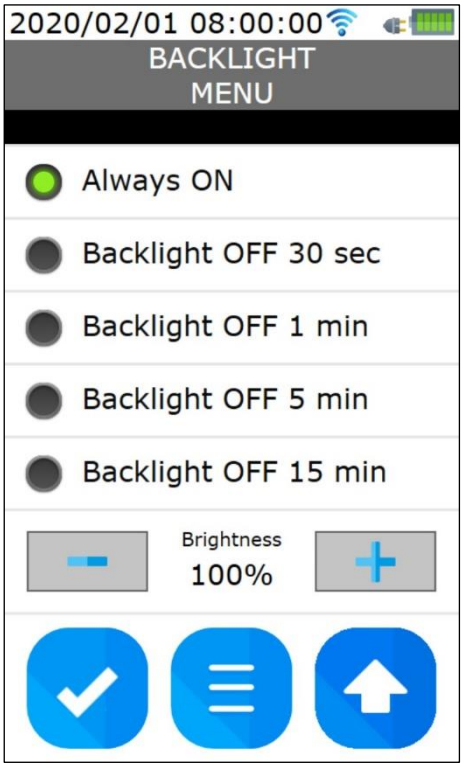
Language setting:

Press “Language” in the SETUP menu, then select the language and press the "check" key to confirm.



Display backlight setting:

Press “Backlight” in the SETUP menu.



Use the +/- keys to adjust the display brightness. The lower the display brightness, the longer the battery autonomy will be.

To set the auto-off after 30 s, 1 min, 5 min or 15 min of inactivity, select the corresponding

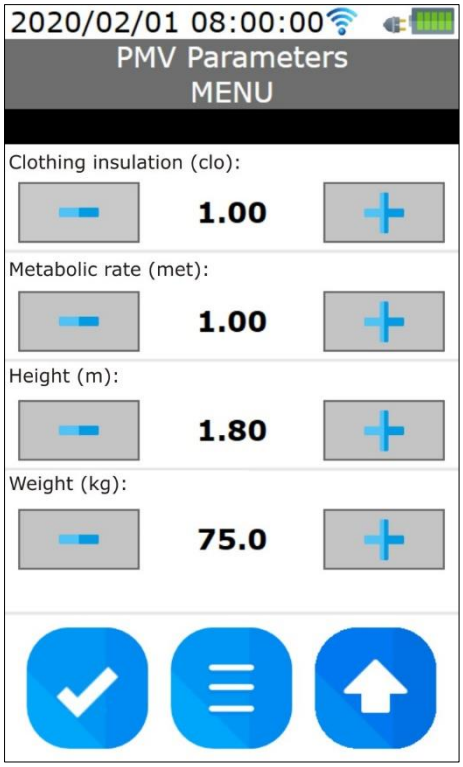
"Backlight OFF ..." item. Select "Always ON" to disable the auto-off.

Note: The display backlight can be turned off and on manually with the BACKLIGHT key on the instrument (key at the bottom right).

Press the "check" key to confirm.

6.5 PMV SETUP menu

The PMV SETUP menu allows setting the parameters for the PMV index calculation.



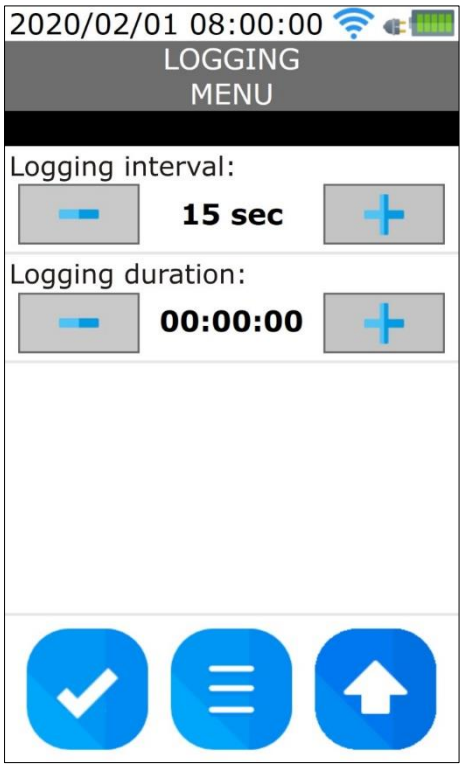
Set the clothing insulation (in CLO), the metabolic rate (in MET), the height and weight of the individual by using the +/- keys.

For the values to set, see paragraph 3.2 "Predicted Mean Vote PMV and Predicted Percentage of Dissatisfied PPD".

Press the "check" key to confirm.

6.6 LOGGING menu

The LOGGING menu allows setting the logging interval and duration.



Use the +/- keys to change the interval an to set any logging duration.

The interval can be set from 1 second to 1 hour.

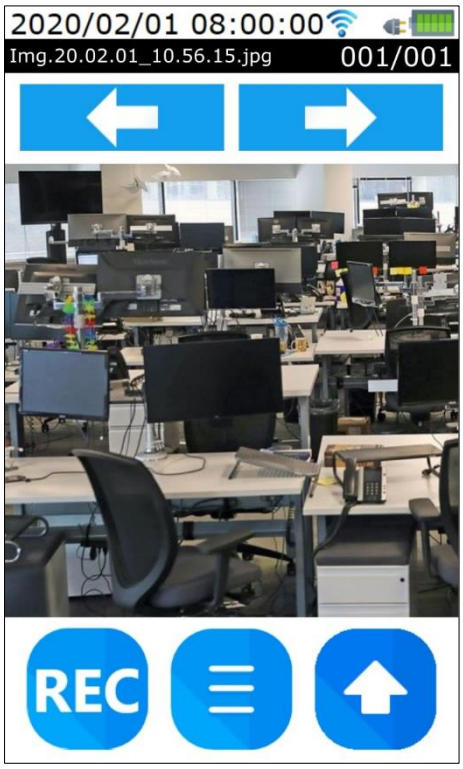
If the logging duration is "00:00:00", the logging stops when the **REC** key is pressed.

If the logging duration is different from "00:00:00", the storage ends when the set time expires (from the start of logging with the **REC** key). The logging can be stopped manually before the set time has elapsed by pressing the **REC** key.

To save the setting, press the "check" key.

6.7 PHOTO menu

The PHOTO menu allows taking photos and viewing the captured photos.



Entering the PHOTO menu, any photos already present relating to the active project are displayed. To scroll through the photos, use the left/right arrow keys. If there are no photos relating to the active project, the message "No Image" appears.

To take a new photo, point the camera of the instrument towards the environment to be taken and press the **REC** key. The photo is saved in "jpg" format in the active project folder.

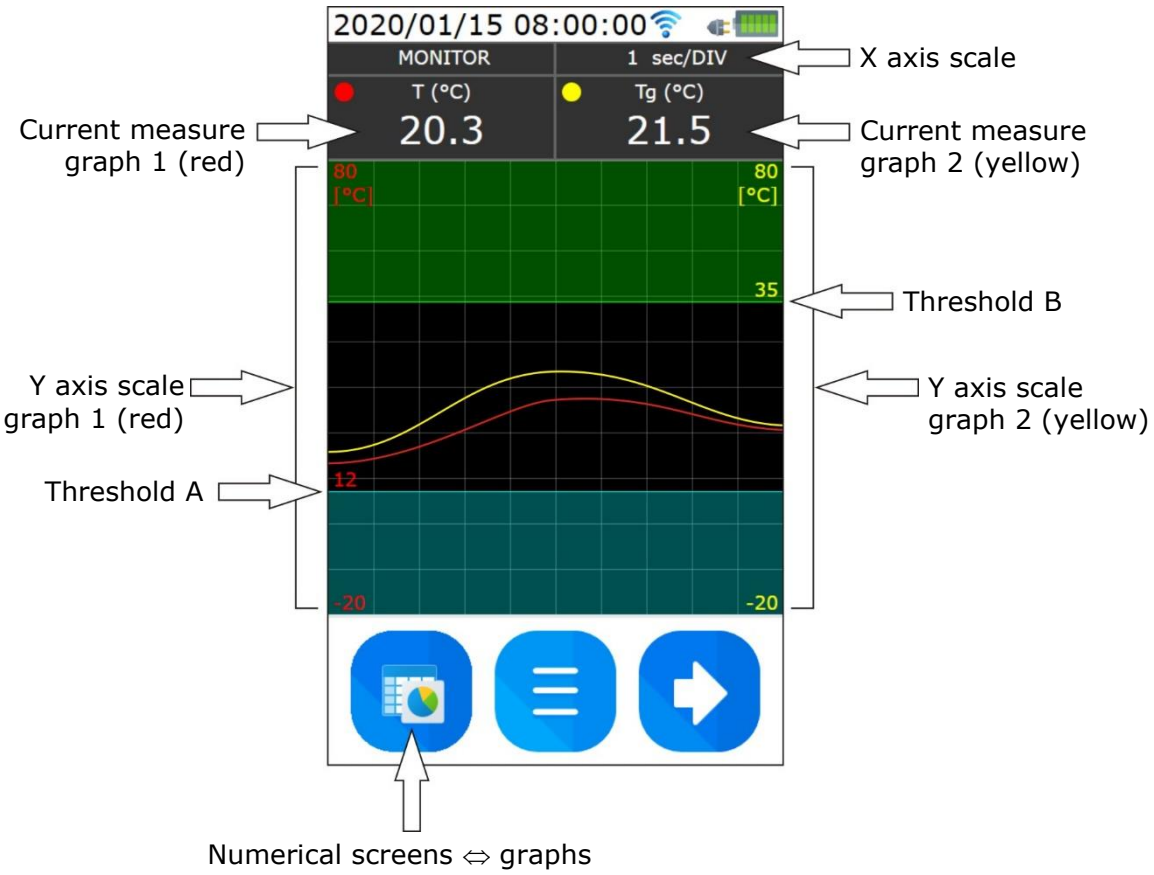
Attention: the preview of the photo to be taken is not displayed; the photo will be visible after pressing the REC key.

7 Graphs

The instrument can simultaneously display the graph of two quantities in real time, as well as a graphic display of the current values of the PMV and PPD indices.

Up to two reference thresholds (visual alarm) can be enabled, each configurable as a low threshold (highlights if the measurement falls below the threshold) or high threshold (highlights if the measurement rises above the threshold). The two thresholds can be associated with the same graph or with different graphs.

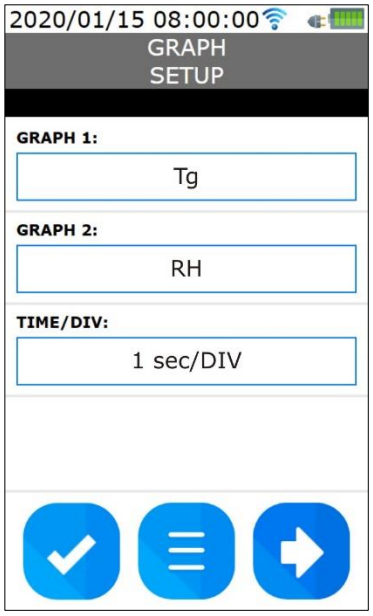
To switch from the numerical display of the measurements to the graphical display (and vice versa), press the key on the bottom left on the display.



The thresholds are represented by a blue line (threshold A) and a green line (threshold B). The value of a threshold is shown on the Y axis of the quantity to which the threshold is associated. The area of the graph that exceeds the threshold values can optionally be highlighted with a shadow.

In order to choose which quantities to represent graphically and to set the graphs area, press the MENU key (central key) on the display during the graphical display. There are four configuration screens, which can be cyclically selected with the "right arrow" key on the display:

1. Screen for selecting the quantities to be graphed and setting the X axis time scale.
2. Screen for setting the Y axis scale.
3. Screen for setting the reference (alarm) threshold A.
4. Screen for setting the reference (alarm) threshold B.

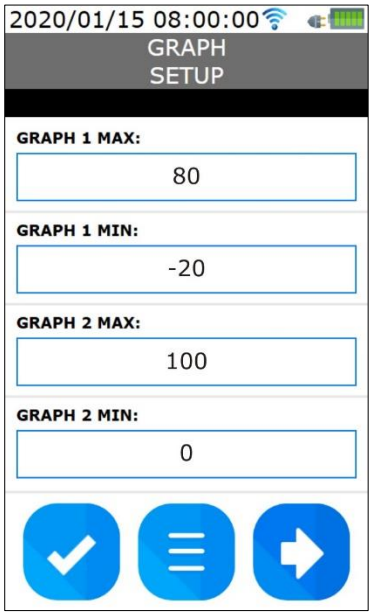


Selection of quantities and setting of X axis:

To associate a quantity to a graph, press on the field corresponding to graph 1 (red) or graph 2 (yellow): the list of available quantities appears. The list can be scrolled by swiping up and down. Press on the desired quantity (press on DISABLED to not associate any quantity), then press the "check" key to confirm.

To set the X axis time scale, press on the TIME/DIV field: the list of available scales appears. The list can be scrolled by swiping up and down. Press on the desired scale, then press the "check" key to confirm. The set time value corresponds to a division (square) of the graph grid.

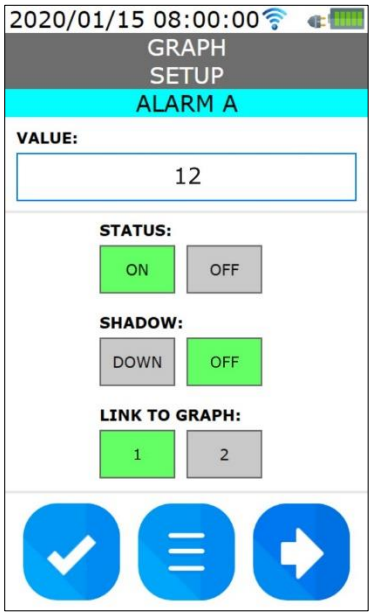
Note: since the instrument measuring interval is always 1 s and the horizontal resolution of the display is 480 pixels (48 pixel/DIV), if a scale greater than or equal to 1 min/DIV is set for the X axis, the points in the graph will be a decimation of the measured values.



Setting of Y axis:

You can set the minimum and maximum of the Y axis scale independently for the two graphs.

By pressing on a field, a numeric keypad appears: enter the value and press the "check" key to confirm. Only integer values can be entered.



Setting of reference threshold A and B:

By pressing on the value field, a numeric keypad appears: enter the value and press the "check" key to confirm. Only integer values can be entered.

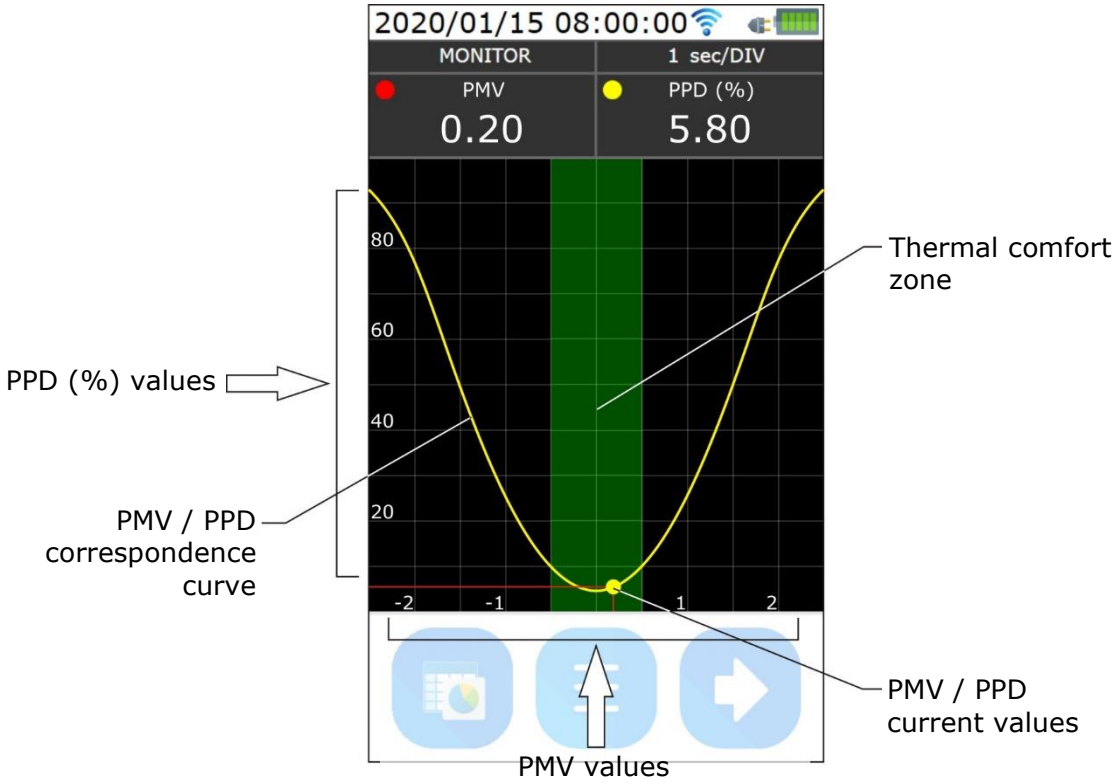
STATUS: press ON to display the threshold on the graph; press OFF to hide it.

SHADOW: to shade the graph area above the threshold (upper threshold), press UP/DOWN to select UP; to shade the graph area below the threshold (lower threshold), press UP/DOWN to select DOWN; press OFF to not display the shading.

LINK TO GRAPH: press 1 to associate the threshold to graph 1; press 2 to associate the threshold to graph 2.

PVM / PPD graph:

From the first graphic screen, press the "right arrow" key on the display to switch to the graphic display of the PMV / PPD indices.



The yellow dot moves on the PMV / PPD correspondence curve and indicates the current values of the indices.

The green vertical band represents the thermal comfort zone: -0,5 < PMV < 0,5 and PPD < 10%.

8 Preparation and maintenance of the probes for the measurement of microclimatic indices

Probes necessary for **WBGT** index measurement:

Probes necessary for **PMV/PPD** indices measurement:

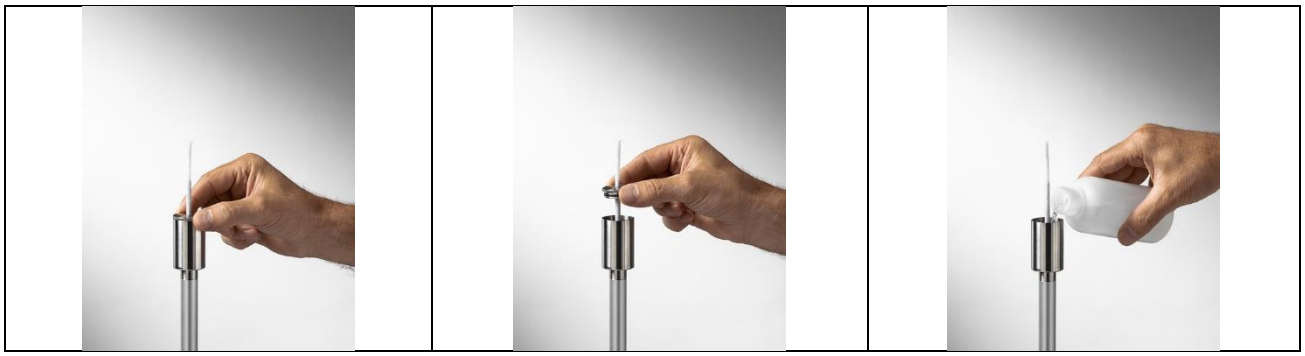
The probes are already factory calibrated. The calibration data are stored in the SICRAM module memory.

TP3575 and TP3276.2 globe thermometer probes:

Screw the globe to probe stem.

HP3201.2 and HP3201 natural ventilation wet bulb probes:

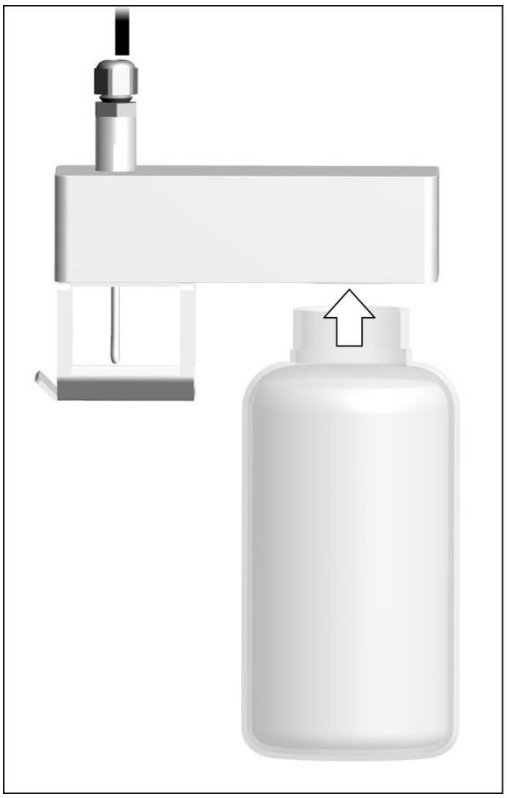
- Remove the sensor cap (the cap is not screwed).
- Insert the cotton wick, previously dipped with distilled water, into the temperature probe. The cotton wick must protrude from the probe for about 20 mm.
- Fill the reservoir up till ¾ with **distilled water**.
- Replace the cap.
- **Warning**: keep the probe vertical to prevent water from leaking.

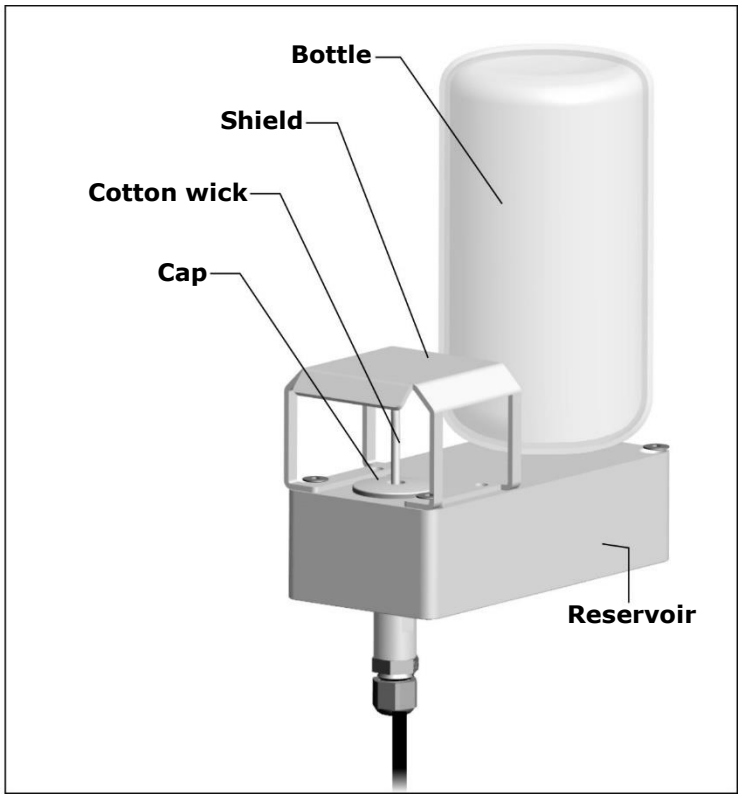


Note: over time the cotton wick tends to calcify (harden): it must be replaced periodically.

TP3204S natural ventilation wet bulb probe:

- Remove the sensor cap (the cap is not screwed).
- Insert the cotton wick, previously dipped with distilled water, into the temperature probe. The cotton wick must protrude from the probe for about 20 mm.
- Replace the cap.
- Fill the bottle with 500 cc of **distilled water**.
- Turn the probe over and firmly screw the bottle to the probe reservoir.
- Turn the probe quickly (to avoid water spillage).
- Secure the probe to the **SP32TC** support.





For measurements in presence of solar irradiation, use the protection shield from solar radiations.

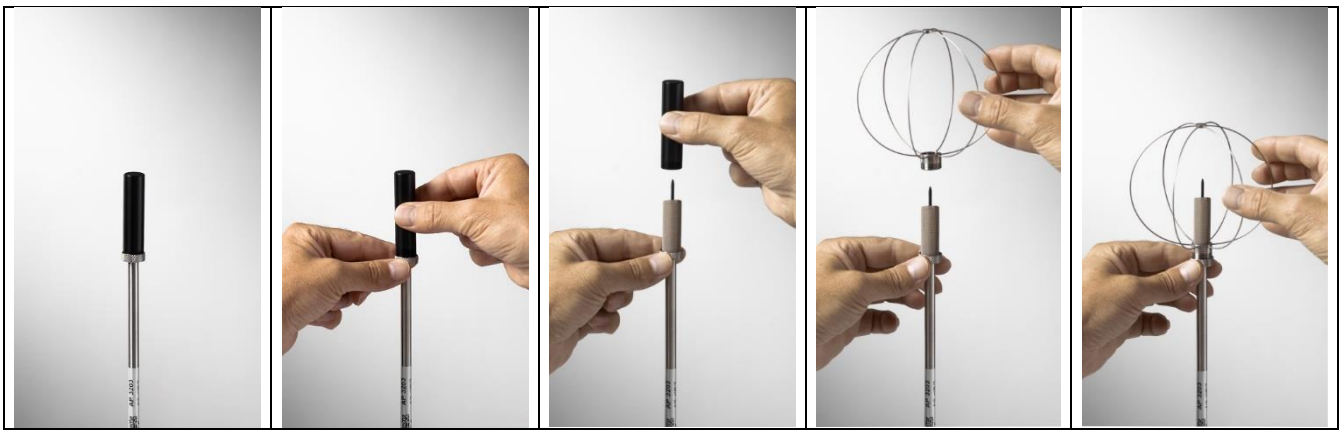
Note: over time the cotton wick tends to calcify (harden): it must be replaced periodically.

HP3217R and HP3217.2R combined relative humidity and temperature probes:

- Do not touch the sensors with the hands; avoid dirtying them with oils, greases or resins.
- The sensors can be cleaned by the dust and pollution by using a very soft brush (e.g. badger) soaked in distilled water.
- To **check** the appropriateness of the relative humidity measurement, the saturated salt solutions **HD75** (75 %RH) and **HD33** (33 %RH) can be used.
- If the measurements are not appropriate, check that the sensors are not dirty, corroded, chipped or broken.

AP3203 and AP3203.2 omnidirectional hot wire air speed probes:

Unscrew the sensor protection cylinder and screw the spherical metal grid.



Danger!

The sensor of AP3203 and AP3203.2 probes is heated. **In case of vapours or gases, a fire or an explosion could be triggered. Do not use the probe in the presence of flammable gases. Make sure that in the environment where the measurement are made there are no gas leaks or potentially explosive vapours.**

Caution!

- **The probe is fragile and must be handled with extreme care**. A simple shock can make the probe unusable.
- After finishing the measurement, the sensor placed on the probe head must be protected with the provided threaded protection cylinder.
- During the use, the probe must be protected with the proper spherical metal grid.
- Do not touch the sensor.

Attention!

For cleaning the probe use only distilled water.

General warnings:

Danger!

Some sensors are not isolated from the outer sheath; take great care not to come into contact with live parts (above 48 V): it could be dangerous for the instrument and for the operator who could be electrocute.

Caution!

- Do not expose the probes to gas or liquids that could corrode the probe material. After the measurement, clean accurately the probes.
- Respect the correct probes polarity.
- When inserting the probes connector into the instrument, do not fold or force the contacts.
- Do not bend, deform or drop the probes: they can be irreparably damaged.
- Avoid measuring in presence of high-frequency sources, microwave or high magnetic fields, as they would be unreliable.

Attention!

- Use the probes suitable for the type of measurement to be performed.
- For a reliable measurement, avoid too rapid temperature variations.

9 Maintenance

Do not use aggressive cleaning agents or incompatible with the materials indicated in the technical specifications. For cleaning, use a soft dry cloth or slightly dampened with clean water.

10 Safety instructions

The instrument proper operation and operating safety can be ensured only in the climatic conditions specified in this manual and if all standard safety measures as well as the specific measures described in this manual are followed.
Do not use the instruments in places where there are:

- Corrosive or flammable gases.
- Direct vibrations or shocks to the instrument.
- High-intensity electromagnetic fields, static electricity.

User obligations

The instrument operator shall follow the directives and regulations below that refer to the treatment of dangerous materials:

- EU directives on workplace safety.
- National law regulations on workplace safety.
- Accident prevention regulations.

Warnings on battery usage

Danger!

To avoid any risk of explosion:

- **Do not short-circuit the battery.**
- Do not expose the battery to high temperature.
- Do not use charging devices different from those indicated.
- Do not overcharge the battery allowing it to charge for a long time after reaching the full charge status.

Attention!

In order to prolong the battery life, do not allow it to discharge excessively: recharge the battery when the battery symbol on the display reaches the minimum level.

Disposal: of batteries

- Dispose of dead batteries in the dedicated bins or deliver them to authorized collection centers. Follow the relevant regulation.
- Do not dispose as household waste.
- Do not throw batteries into fire.

11 Technical specifications

Power supply	**Rechargeable** lithium internal battery External power supply unit (**SWD05**), to be connected to the mini-USB connector of the instrument If connected to PC, it is powered by the computer USB port (500 mA at least)
Battery life	At least 24 hours of continuous operation (starting from a fully charged battery) with display always on
Logging interval	Configurable from 1 second to 1 hour
Storage capacity	8 GB
Inputs	3 inputs with 8-pole DIN45326 connector for probes with SICRAM module 1 input with M12 8-pole connector for the PMsense-P particulate matter transmitter
Display	Backlit color graphic LCD with capacitive touch Active area 52x87 mm, 480x800 pixels
Camera resolution	480x640 pixel
Connectivity	Wi-Fi (2.4 GHz) and USB OTG, Host and Device The USB connection does not requires drivers installation
Uncertainty	± 1 digit @ 20 °C (only the instrument)
Operating conditions	-5…50 °C, 0…90 %RH no condensation
Storage Temperature	-25…65 °C
Materials	ABS, rubber protection band
Dimensions	185x90x40 mm
Weight	500 g
Degree of protection	IP 54

TP3275 AND **TP3276.2** TEMPERATURE PROBES

Sensor	Pt100
Measuring range:	-30…120 °C
Resolution:	0.1 °C
Accuracy:	1/3 DIN
Temperature drift @ 20 °C	0.003 %/°C
Long term stability	0.1 °C/year
Connection	8-pole female DIN45326 connector Cable L=2 m (only TP3275)
Globe dimensions	Ø=150 mm (TP3275), Ø=50 mm (TP3276.2)
Stem dimensions	Ø=14 mm, L=110 mm (TP3275) Ø=8 mm, L=170 mm (TP3276.2)
Response time T_{95} (1)	15 minutes

TP3207 AND **TP3207.2** TEMPERATURE PROBES

Sensor	Pt100
Measuring range:	-40…100 °C
Resolution:	0.1 °C
Accuracy:	1/3 DIN
Temperature drift @ 20 °C	0.003 %/°C
Long term stability	0.1 °C/year
Connection	8-pole female DIN45326 connector Cable L=2 m (only TP3207)
Dimensions	Ø=14 mm, L=140 mm (TP3207), L= 150 mm (TP3207.2)
Response time T_{95} (1)	15 minutes

HP3201 AND **HP3201.2** NATURAL VENTILATION WET BULB PROBES

Sensor	Pt100
Measuring range:	4…80 °C
Resolution:	0.1 °C
Accuracy:	Class A
Temperature drift @ 20 °C	0.003 %/°C
Long term stability	0.1 °C/year
Connection	8-pole female DIN45326 connector Cable L=2 m (only HP3201)
Stem dimensions	Ø=14 mm, L=110 mm (HP3201), L= 170 mm (HP3201.2)
Cotton wick length	10 cm approx.
Reservoir	Capacity 15 cc, autonomy 96 hours @ RH=50% and t=23 °C
Response time T_{95} (1)	15 minutes

TP3204S NATURAL VENTILATION WET BULB PROBE

Sensor	Pt100
Measuring range:	4…80 °C
Resolution:	0.1 °C
Accuracy:	Class A
Temperature drift @ 20 °C	0.003 %/°C
Long term stability	0.1 °C/year
Connection	8-pole female DIN45326 connector, cable L=2 m
Dimensions	L x W x H = 140 x 65 x 178,5 mm (reservoir + bottle)
Cotton wick length	10 cm approx.
Reservoir	Capacity 500 cc, autonomy 15 days @ t=40 °C
Response time T_{95} (1)	15 minutes

HP3217R AND **HP3217.2R** TEMPERATURE AND RELATIVE HUMIDITY COMBINED PROBES

Sensor	Temperature: Pt100 R.H.: capacitive
Measuring range:	Temperature: -40…100 °C R.H.: 0…100%
Resolution:	0.1 °C / 0.1 %RH
Accuracy:	Temperature: 1/3 DIN R.H.: ±1.5% (0…90%RH) / ±2% (90…100%RH) @ T=15…35 °C (1.5 + 1.5% measure)% @ T= remaining range
Temperature drift @ 20 °C	0.02 %RH/°C
Long term stability	0.1 %RH/year
Connection	8-pole female DIN45326 connector Cable L=2 m (only HP3217R)
Dimensions	Ø=14 mm, L=150 mm
Response time T_{95} (1)	15 minutes

AP3203 AND **AP3203.2** OMNIDIRECTIONAL HOT WIRE AIR SPEED PROBES

Sensor	NTC 10 kΩ
Measuring range:	0.02…5 m/s / 0…80 °C
Resolution:	0.01 m/s
Accuracy:	± (0,05 + 5% measure) m/s
Temperature drift @ 20 °C	0.06 %/°C
Long term stability	0.12 °C/year
Connection	8-pole female DIN45326 connector Cable L=2 m (only AP3203)
Stem dimensions	Ø=8 mm, L=230 mm
Protection dimensions	Ø=100 mm

(1) The response time T_{95} is the time needed to reach 95% of the final value. The measurement of the response time is done with a negligible air speed (motionless air).

HP3217B4 E **HP3217BV4** TEMPERATURE, RELATIVE HUMIDITY, CO_2, VOC AND ATMOSPHERIC PRESSURE COMBINED PROBES

Sensor	Temperature/R.H.: CMOS Atmospheric pressure: piezoresistive CO_2: Non-Dispersive Infrared (NDIR) VOC: Metal-Oxide film (only HP3217BV4)
Measuring range:	Temperature: -20…80 °C R.H.: 0…100% Atmospheric pressure: 300…1250 hPa CO_2: 0…5000 ppm VOC index: 1…500 (dimensionless)
Resolution:	Temperature: 0.1 °C R.H.: 0.1 %RH Atmospheric pressure: 0.1 hPa CO_2: 1 ppm VOC index: 1
Accuracy (typical):	Temperature: ±0.1 °C (20…60 °C) / ±0.2 °C (remaining range) R.H.: ±2% (0…80%RH) / ±3% (80…100%RH) @ T=10…50 °C Atmospheric pressure: ±0.5 hPa @ T=25 °C / ±1 hPa (500…1100 hPa) @ T= remaining range CO_2: ±(50 ppm + 3% of the measure) @ 25 °C / 1013 hPa VOC index: relative qualitative measurement (see chapter 4)
Temperature drift	Atmospheric pressure: ±0.75 Pa/°C (0…55 °C / 700…1100 hPa) CO_2: 1 ppm/°C (-20…45 °C)
Long term stability	Temperature: < 0.03 °C/year R.H.: < 0.25 %RH/year Atmospheric pressure: < ±1 hPa/year CO_2: 5% of the measure/5 years
Connection	8-pole female DIN45326 connector
Dimensions	167 x 30 x 19 mm
Response time	Temperature / R.H.: 10 s (T_{63} **(2)** with 1 m/s air flow) CO_2: < 120 s (T_{90} **(3)** with 2 m/s air flow)
Operating conditions	-20…60 °C / 0…95 %RH non-condensing **(4)**
	

(2) The response time T_{63} is the time needed to reach 63% of the final value.

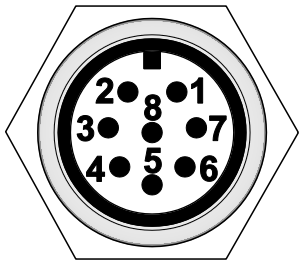
(3) The response time T_{90} is the time needed to reach 90% of the final value.

(4) The sensor shows best performance when operated in 20…80 %RH humidity range. Long term exposure outside the indicated range (especially at high humidity) may temporarily offset the sensor response.

PMSENSE-P PARTICULATE MATTER TRANSMITTER

Measuring principle	Laser scattering
Measured pollutants	PM1.0, PM2.5 and PM10
Measuring range	0…1000 µg/m^3 (for each pollutant)
Resolution:	0.1 µg/m^3
Particle size detection range	∅ 0.3…10 µm
Linearity error	< 5%
Repeatability	< 3%
Sensor warm up time	15 s
Response time	Measurements update rate 1 s
Sensor lifetime	> 10,000 hours of continuous use
Temperature drift	< 0.01 µg/m^3 /°C
Connection	M12 8-pole circular connector
Operating conditions	-20…+70 °C / 0…95 %RH / 500…1500 hPa
Housing material	Polycarbonate
Protection degree	Housing equipped with a rain-proof and UV resistant inlet air filter – IP 53
Dimensions	120 x 94 x 71 (excluding M12 connector)
Weight	330 g

HD32.3TC and PMsense-P M12 connector pin-out



HD32.3TC male M12		PMsense-P male M12	
Pin	**Function**	**Pin**	**Function**
1	GND	1	GND
2	--	2	+Vdc
3	--	3	
4	RS485 A/-	4	RS485 A/-
5	RS485 B/+	5	RS485 B/+
6	--	6	--
7	+Vdc	7	--
8	--	8	--

The PMsense-P transmitter is powered directly by the instrument: do not apply to the transmitter power other than that supplied by the instrument.

Approvals

IEEE 802.11 (Wi-Fi) certifications:

HD32.3TC contains IEEE 802.11b/g/n module FCC ID: 2AC7Z-ESPWROOM02
IC ID: 21098-ESPWROOM02
TELEC certified RF module: [R] 206-000519

R 206-000519

12 Probes and accessories ordering codes

The instrument is supplied with carrying case, rechargeable lithium battery (BAT-30), power supply (SWD05) and USB cable (CP31).

DeltaLog10 software is downloadable from the website.

The probes must be ordered separately.

Probes with SICRAM module for the measurement of microclimatic indices

The probes necessary for **WBGT** index measurement are:

- Dry bulb temperature probe, one of the following:
  - **TP3207.2** Ø 14mm, L=150 mm.
  - **TP3207** Ø 14mm, L=140 mm. Cable 2 m.
    Alternatively, a HP3217.2R/HP3217R or HP3217B4/HP3217BV4 combined probe can be used.
- Globe thermometer probe, one of the following:
  - **TP3276.2** Globe Ø 50 mm. Stem Ø 8 mm, L=170 mm.
  - **TP3275** Globe Ø 150 mm. Stem Ø 14 mm, L=110 mm. Cable 2 m.
- Natural ventilation wet bulb temperature probe, one of the following:
  - **HP3201.2** Stem Ø 14 mm, L=170 mm.
  - **HP3201** Stem Ø 14 mm, L=110 mm. Cable 2 m.
  - **TP3204S** For long-lasting measurements. 500 cc distilled water capacity. Cable 2 m.

The probes necessary for **PMV/PPD** indices measurement are:

- Temperature and relative humidity combined probe, one of the following:
  - **HP3217.2R** Stem Ø 14 mm, L=150mm.
  - **HP3217R** Stem Ø 14 mm, L=110mm. Cable 2 m.
    Alternatively, a HP3217B4/HP3217BV4 probe can be used.
- Omnidirectional hot wire air speed probe, one of the following:
  - **AP3203.2** Stem Ø 8 mm, L=230 mm.
  - **AP3203** Stem Ø 8 mm, L=230 mm. Cable 2 m.
- Globe thermometer probe, one of the following:
  - **TP3276.2** Globe Ø 50 mm. Stem Ø 8 mm, L=170 mm.
  - **TP3275** Globe Ø 150 mm. Stem Ø 14 mm, L=110 mm. Cable 2 m.

The probes necessary for **TU/DR** indices measurement are:

- Omnidirectional hot wire air speed probe, one of the following:
  - **AP3203.2** Stem Ø 8 mm, L=230 mm.
  - **AP3203** Stem Ø 8 mm, L=230 mm. Cable 2 m.

Probes for the measurement of air quality

HP3217B4 CO_2, temperature, relative humidity and atmospheric pressure probe with SICRAM module. Direct connection without cable.

HP3217BV4 CO_2, VOC, temperature, relative humidity and atmospheric pressure probe with SICRAM module. Direct connection without cable.

PMsense-P PM1.0, PM2.5 and PM10 transmitter with RS485 output. M12 connector. 2 m cable. To be fixed on VTRAP30 (not included).

Accessories

VTRAP30	Tripod, height 157 mm.
VTRAP	Tripod, max. height 1310 mm (SP32TC support not included).
SP32TC	Holder for instrument and 4 probes with cable. It can be fixed to both VTRAP30 tripod and VTRAP tripod.
CP31	USB cable with male mini-USB connector on instrument side and male A type USB connector on PC side. **Spare part**.
SWD05	100-240 Vac / 5 Vdc-1 A stabilized mains power supply. Output with A type USB connector. **Spare part**.
BAT30	Rechargeable lithium battery. **Spare part**.
AQC	200 cc of distilled water.

Notes

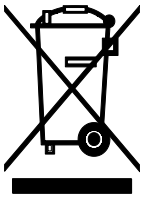
WARRANTY

The manufacturer is required to respond to the "factory warranty" only in those cases provided by Legislative Decree 6 September 2005 - n. 206. Each instrument is sold after rigorous inspections; if any manufacturing defect is found, it is necessary to contact the distributor where the instrument was purchased from. During the warranty period (24 months from the date of invoice) any manufacturing defects found will be repaired free of charge. Misuse, wear, neglect, lack or inefficient maintenance as well as theft and damage during transport are excluded. Warranty does not apply if changes, tampering or unauthorized repairs are made on the product. Solutions, probes, electrodes and microphones are not guaranteed as the improper use, even for a few minutes, may cause irreparable damages.
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales of Goods" apply.

TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.
We reserve the right to change technical specifications and dimensions to fit the product requirements without prior notice.

DISPOSAL INFORMATION



Electrical and electronic equipment marked with specific symbol in compliance with 2012/19/EU Directive must be disposed of separately from household waste. European users can hand them over to the dealer or to the manufacturer when purchasing a new electrical and electronic equipment, or to a WEEE collection point designated by local authorities. Illegal disposal is punished by law.

Disposing of electrical and electronic equipment separately from normal waste helps to preserve natural resources and allows materials to be recycled in an environmentally friendly way without risks to human health.

CE RoHS

senseca.com

Senseca Italy S.r.l.
Via Marconi, 5
35030 Selvazzano Dentro (PD)
ITALY
info@senseca.com

senseca