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## HD 32.2 INSTRUMENT FOR THE ANALYSIS OF THE WBGT INDEX HD 32.3 INSTRUMENT FOR THE ANALYSIS OF THE PMV AND WBGT INDEX



**HD32.2 – WBGT Index** is an instrument made by Delta Ohm srl for the analysis of WBGT index (Wet Bulb Glob Temperature: wet bulb temperature and globe thermometer temperature) in presence or in absence of solar radiation.

**Reference Regulations:**

**ISO 7243:** Hot environments. Estimation of the heat stress on working man, based on WBGT index (wet bulb temperature and Globe thermometer).

**ISO 8996:** Ergonomics of the thermal environment – Determination of the energy metabolism.

**ISO 7726:** Ergonomics of the thermal environment – Instruments for measuring physical quantities.

The instrument is provided with three inputs for probes with SICRAM module: the SICRAM module interface between the instrument and sensor connected and communicate the sensor parameters and calibration data to the instrument.

All SICRAM probes can be plugged into any of the inputs: they are automatically recognized upon turning the Instrument on.

The main features of the instrument are:

- Logging: data acquisition and logging to the integral instrument memory. Storage capacity: 64 different logging sections, sample interval, user selectable.
- You can set the automatic logging start with auto-start function (Start/Stop time).
- The measurement unit of the temperature: °C, °F, °K.
- Date and time of the instrument.
- The display of maximum, minimum, medium statistic parameters and their deletion.
- The data transfer speed via the RS232 serial port.

**HD32.2** instrument can detect simultaneously the following quantities:

- Globe thermometer temperature **T<sub>g</sub>**.
- Wet bulb temperature with natural ventilation **T<sub>n</sub>**.
- Environment temperature **T**.

Starting from the detected values, HD32.2 can calculate:

- WBGT(in) index (Wet Bulb Glob Temperature: wet bulb temperature and Globe thermometer) in absence of solar radiation.
- WBGT(out) index (Wet Bulb Glob Temperature wet bulb temperature and Globe thermometer) in presence of solar radiation..

**WBGT** (Wet Bulb Globe Temperature – Wet bulb temperature and globe thermometer) is one of the indexes used to determinate the occupational heat exposure.

It represents the value, related to the metabolic expenditure linked to a specific work activity, that causes a thermal stress when exceeded.

WBGT index combines the temperature measurement of wet bulb with natural ventilation  $t_{nw}$  with the globe thermometer  $t_g$  and, in some situations, with the air temperature  $t_a$ .

The calculation formula is the following:

- inside and outside a buildings in absence of solar radiation:  $WBGT_{close\ environments} = 0,7 t_{nw} + 0,3 t_g$
- outside a building in presence of solar radiation:  $WBGT_{outside\ environments} = 0,7 t_{nw} + 0,2 t_g + 0,1 t_a$

where:

$t_{nw}$  = natural wet bulb;

$t_g$  = globe thermometer temperature;

$t_a$  = air temperature.

- The measured data should be compared with the limit values prescribed by the regulations; when exceeded you have to
- reduce directly the thermal stress on the examined work place;
  - proceed to a detailed analysis of the thermal stress.

In order to measure the WBGT index, the following probes should be connected:

- **Natural wet bulb HP3201.2.**
- **TP3276.2 Globe thermometer probe.**
- **TP3207.2 Dry bulb temperature, of the measurement is performed in presence of solar radiation.**

In order to measure the WBGT index, you should refer to the following regulations:

- **ISO 7726**
- **ISO 7243**
- **ISO 8996**

#### Technical features

##### Instrument

Dimensions 185x90x40 mm  
(Length x Width x Height)  
Weight 470 g (batteries included)  
Materials ABS, rubber  
Display back light, with dot-matrix  
160x160 points, visible area 52x42mm

##### Working conditions

Working temperature -5 ... 50°C  
Storage temperature -25 ... 65°C  
Working relative humidity 0 .. 90% RH no condensation

##### Protection Degree IP67

##### Instrument uncertainty $\pm 1$ digit @ 20°C

##### Power supply

Mains power supply (code SWD10) 12Vdc/1A  
Batteries 4 batteries 1.5V type AA  
Autonomy 200 hours with 1800mAh alkaline batteries  
Power absorbed with < 45Ma instrument off

##### Safety of the stored data unlimited

##### Connections

Input for probes with SICRAM module  
3 Connectors 8 male poles DIN 45326

##### Serial Interface:

Pin: M12-8 poles.  
Type: RS232C (EIA/TIA574) or USB 1.1 o 2.0  
not insulated  
Baud rate: from 1200 to 38400 baud.  
with USB baud=460800  
Data bit: 8  
Parity: None  
Flow control: Xon-Xoff  
Cable length: max 15m

##### Memory

divided in 64 blocks.

#### Storage capacity\*\*

67600 memorizations for each of the 3 inputs

##### Logging interval

selectable among: 15, 30 seconds, 1, 2, 5,10, 15, 20, 30 minutes and 1 hour.

##### TP3207.2 Temperature probe

Sensor type: Pt100 with thin-film  
Accuracy: Class 1/3 DIN  
Measurement range: -40 ÷ 100 °C  
Resolution: 0.1°C  
Temperature drift @20°C: 0.003%/°C  
Drift after 1 year: 0.1°C/year  
Connection: 4 wires plus SICRAM module  
Connector: 8 female poles DIN45326  
Dimensions: Ø=14 mm L= 150 mm  
Response time T95: 15 minutes

##### TP3207.2 Temperature probe

Sensor type: Pt100 with thin-film  
Accuracy: Class 1/3 DIN  
Measurement range: -40 ÷ 100 °C  
Resolution: 0.1°C  
Temperature drift @20°C: 0.003%/°C  
Drift after 1 year: 0.1°C/year  
Connection: 4 wires plus SICRAM module  
Connector: 8 female poles DIN45326  
Dimensions: Ø=14 mm L= 150 mm  
Response time T95: 15 minutes

##### HP3201.2 Natural ventilation wet bulb

Sensor type: Pt100  
Accuracy: Class A  
Measurement range: 4 °C ÷ 80 °C  
Resolution: 0.1°C  
Temperature drift @20°C: 0.003%/°C  
Drift after 1 year: 0.1°C/year  
Connection: 4 wires plus SICRAM module  
Connector: 8 female poles DIN45326  
Stem dimensions: Ø=14 mm L= 170 mm  
Braid length: 10 cm. at least  
Tank capacity: 15 cc.  
Tank autonomy: 96 hours with RH=50%, t = 23°C  
Response time T95: 15 minutes

#### \*\* Storage capacity

Logging interval	Storage capacity
15 seconds	Approx. 11 days and 17 hours
30 seconds	Approx. 23 days and 11 hours
1 minute	Approx. 46 days and 22 hours
2 minutes	Approx. 93 days and 21 hours
5 minutes	Approx. 234 days and 17 hours

Logging interval	Storage capacity
10 minutes	Approx. 1 year and 104 days
15 minutes	Approx. 1 year and 339 days
20 minutes	Approx. 2 years and 208 days
30 minutes	Approx. 3 years and 313 days
1 hour	Approx. 7 years and 261 days

**Ordering codes**

**HD32.2 Kit consisting of:**

- HD32.2 WBGT Index instrument, 4 alkaline batteries from 1.5V type AA instruction manual, case.
- DeltaLog10 Software Warm environments: WBGT analysis.

**Probes and cables have to be ordered separately.**

**Required probes for the measurement of WBGT:**

- TP3207.2 Probe of dry bulb temperature.
- TP3276.2 Globe thermometer probe.
- TP3201.2 Natural ventilation wet bulb

**Probes for HD32.2 WBGT Index**

**TP3207.2:** Temperature probe for Pt100 sensor. Probe stem Ø 14mm, length 150 mm. Equipped with SICRAM module.

**TP3276.2:** Globe thermometer probe with Pt100 sensor, globe Ø 50 mm. Stem Ø 8 mm, length 170 mm. Equipped with SICRAM module.

**HP3201.2:** Natural wet bulb. Pt100 sensor. Probe stem Ø 14 mm, length 170mm. Equipped with SICRAM module, spare parts of the braid and case of 50cc. distilled water.

**Accessories:**

**VTRAP30:** Tripod to suit HD32.2 instrument with a maximum height of 280 mm

**HD2110/RS:** Connection cable with M12 connector from the instrument side and with SubD female connector 9 poles for RS232C from PC side.

**HD2110/USB:** Connection cable with M12 connector from the instrument, USB 2.0 connector from PC side.

**SWD10:** 100-240Vac/12Vdc-1A mains voltage stabilized power supply.

**AQC:** 200cc. of distilled water and n° 3 braids for HP3201 or HP3217DM probes

**HD40.1:** printer (uses HD2110/RS cable)

**Example of immediate data print, obtained with HD40.1**

```

-----
      ISO 7243 WBGT Index
-----
Model HD32.2 WBGT Index
Firm.Ver.=01.00
Firm.Date=2008/12/05
SN=12345678
ID=0000000000000000
-----
Probe ch.1 description
Type: Pt100
Data cal.:2008/10/01
Serial N.:08109450
-----
Probe ch.2 description
Type: Pt100 Tg 50
Data cal.:2008/10/01
Serial N.:08109452
-----
Probe ch.3 description
Type: Pt100 Tw
Data cal.:2008/10/01
Serial N.:08109454
-----
Date=2008/11/21 15:00:00
Tnw          21.2 °C
Tg           24.9 °C
Ta           31.3 °C
WBGT {i}     22.3 °C
WBGT {o}     23.0 °C
-----
    
```

Reference regulation

Instrument Model  
Instrument firmware version  
Instrument firmware date  
Instrument Serial Number  
Identification Code

Description of the probe connected to input 1

Description of the probe connected to input 2

Description of the probe connected to input 3

Date and time  
Natural wet bulb  
Globe thermometer ventilation  
Dry bulb temperature  
WBGT in absence of direct solar radiation  
WBGT in presence of direct solar radiation





### HD32.3

**WBGT:** Wet Bulb Globe Temperature Meter

**PMV:** Predicted Mean Vote

**HD32.3 – WBGT - PMV Index** is an instrument made by Delta Ohm Srl for:

- Analysis of hot environments using WBGT index (Wet Bulb Globe Temperature: wet bulb temperature and Globe thermometer) in presence or absence of solar radiation.
- Analysis of the moderate warm environments using PMV index (Predicted Mean Vote) and PPD index (Predicted Percentage of Dissatisfied).

#### Reference Rules:

**ISO 7243:** Hot environments. Estimation of the heat stress on working man, based on WBGT index (wet bulb globe Thermometer).

**ISO 8996:** Ergonomics of the thermal environment. Determination of metabolic rate.

**ISO 7726:** Ergonomics of the thermal environment – Instruments for measuring physical quantities.

**ISO 7730:** Moderate thermal environments. Determination of PMV and PPD index and specification of the condition for thermal comfort.

The instrument is provided with three inputs for probes with SICRAM module: the SICRAM module interface between the instrument and sensor connected and communicate the sensor parameters and calibration data to the instrument.

All SICRAM probes can be plugged into any of the inputs: they are automatically recognized upon turning on the instrument.

The main features of the instrument are:

- Logging: data acquisition and logging In the integral instrument memory. Storage capacity: 64 different logging sections, sample interval, user selectable.
- Start and stop can be set automatically with the auto-start function.
- Selectable measurement unit of the temperature: °C, °F, °K.
- Date and time of the instrument.
- The display of maximum, minimum, medium statistic parameters and their deletion.
- The transfer speed of data via RS232 serial port.

HD32.3 instrument can detect simultaneously the following quantities:

- Globe thermometer temperature  $T_g$  with TP3276.2 probe.
- Natural wet bulb temperature  $T_{nw}$  with HP3201.2 probe.
- Environment temperature  $T$  with TP3207.2 probe.
- Relative humidity RH and environment temperature  $T$  with HP3217.2 probe.
- Air speed  $V_a$  with AP3203.2 probe.

Starting from the measured values, HD32.3 can calculate and display, with TP3207.2, HP3276.2, and HP3201.2 probes, the following indexes:

- WBGT (in) Index (Wet Bulb Globe Temperature: wet bulb temperature and globe thermometer) in absence of solar radiation.
- WBGT (out) Index (Wet Bulb Globe Temperature: wet bulb temperature and globe thermometer) in presence of solar radiation.

WBGT (Wet Bulb Globe Temperature – wet bulb and globe temperature) is one of the indexes used to determinate the occupational heat exposure. It represents the value, related to the metabolic expenditure linked to a specific work activity, that causes a thermal stress when exceeded.

WBGT index combines the measurement of wet bulb temperature  $t_{nw}$  with natural ventilation with the globe thermometer temperature  $t_g$  and, in some situations, with the air temperature  $t_a$ .

The calculation formula is the following:

- inside and outside the buildings in absence of solar radiation:  $WBGT_{close\ environments} = 0,7 t_{nw} + 0,3 t_g$
- outside the buildings in presence of solar radiation:  $WBGT_{outside\ environments} = 0,7 t_{nw} + 0,2 t_g + 0,1 t_a$

where:

$t_{nw}$  = wet bulb temperature with natural ventilation;

$t_g$  = globe thermometer temperature;

$t_a$  = air temperature.

The measured data should be compared with the limit values prescribed by the regulations; when exceeded you have to

- reduce directly the thermal stress on the examined work place;
- proceed to a detailed analysis of the thermal stress.

In order to measure the WBGT index, the following probes should be connected:

- **Natural wet bulb HP3201.2.**
- **TP3276.2 Globe thermometer probe.**
- **TP3207.2 Dry bulb temperature, of the measurement is performed in presence of solar radiation.**

In order to measure the WBGT index, you should refer to the following regulations:

- **ISO 7726**
- **ISO 7243**
- **ISO 8996**

### PMV - PPD

Human thermal comfort is defined by ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers INC) as the state of mind that expresses satisfaction with the surrounding living or working environment.

The evaluation of this subjective condition can be objectified and quantified using integrated index that consider the micro climatic environment parameters ( $T_a$ ,  $T_r$ ,  $V_a$ ,  $r_h$ ), and the work-related energy metabolic expenditure MET, and the typology of clothing (thermal insulation CLO) commonly used.

Among these indexes, the most precise one reflecting the influence of the above mentioned physical and physiological variables on thermal comfort is PMV (Predicted Mean Vote).

Synthetically, it comes from the equation of the thermal balance whose result is compared to a scale of psycho - physical health and expresses the average opinion (average foreseen vote) about the thermal sensations of a group of subjects.

From PMV is derived a second index called PPD (Predicted Percentage of Dissatisfied) that quantifies the percentage of subjects who will be dissatisfied with some micro climatic conditions.

ISO 7730 regulations suggests PMV use in presence of following variables that influence the thermal balance:

- Metabolic expenditure =  $1 \div 4$  met
- Thermal resistance of clothing =  $0 \div 2$  clo
- Dry bulb temperature =  $10 \div 30^\circ\text{C}$
- Medium radiant temperature =  $10 \div 40^\circ\text{C}$
- Air speed =  $0 \div 1$  m/sec
- Water vapour pressure =  $0 \div 2,7$  kpa

PMV is a particularly suitable index for the evaluation of work places with moderate microclimate such as houses, schools, offices, research laboratories, hospitals, and is useful to predict the number of people likely to feel uncomfortably warm or cool.

According to ISO 7730 PMV values range between + 0,5 and - 0,5, provides comfort conditions corresponding to a percentage of dissatisfied (PPD) lower than 10%.

(see table below)..

PMV	PPD %	EVALUATION THERMAL ENVIRONMENT
+3	100	Hot
+2	75,7	Warm
+1	26,4	Slightly warm
<b>+0,85</b>	<b>20</b>	<b>Acceptable thermal condition</b>
<b>-0,5 &lt; PMV &lt; +0,5</b>	<b>&lt;10</b>	<b>Comfortable</b>
<b>-0,85</b>	<b>20</b>	<b>Acceptable thermal condition</b>
-1	26,8	Cool
-2	76,4	Cold
-3	100	Extremely cold

To calculate PMV and PPD indices, it's necessary to know:

- the working load (energy expenditure);
- the clothing thermal insulation.

### Average radiant temperature $T_r$

The average radiant temperature is defined as the temperature of thermally uniform simulated environment that would exchange with a man the same thermal radiation power exchanged in the real environment.

In order to evaluate the average radiant temperature, it is necessary to measure:

the globe thermometer temperature, the air temperature, and the air speed measured close to the globe thermometer.



## Technical features

### Instrument

Dimensions 185x90x40 mm  
(Length x Width x Height)  
Weight 470 g (batteries included)  
Materials ABS, rubber  
Display back light, with dot-matrix  
160x160 points, visible area 52x42mm

### Working conditions

Working temperature -5 ... 50°C  
Storage temperature -25 ... 65°C  
Working relative humidity 0 .. 90% RH no condensation

### Protection Degree IP67

### Instrument uncertainty $\pm 1$ digit @ 20°C

### Power supply

Mains power supply (code SWD10) 12Vdc/1A  
Batteries 4 batteries 1.5V type AA  
Autonomy 200 hours with 1800mAh alkaline batteries  
Power absorbed with < 45Ma instrument off

### Safety of the stored data unlimited

### Connections

Input for probes with SICRAM module  
3 Connectors 8 male poles DIN 45326

### Serial Interface:

Pin: M12-8 poles.  
Type: RS232C (EIA/TIA574) or USB 1.1 o 2.0  
not insulated  
Baud rate: from 1200 to 38400 baud.  
with USB baud=460800  
Data bit: 8  
Parity: None  
Flow control: Xon-Xoff  
Cable length: max 15m

### Memory

divided in 64 blocks.

### Storage capacity\*\*

67600 memorizations for each of the 3 inputs.

### Logging interval

selectable among: 15, 30 seconds, 1, 2, 5, 10, 15, 20, 30 minutes and 1 hour.

## TP3276.2 globe thermometer probe Ø=50 mm

Sensor type: Pt100  
Accuracy: Class 1/3 DIN  
Measurement range: -10 ÷ 100 °C  
Resolution: 0.1°C  
Temperature drift @20°C: 0.003%/°C  
Drift after 1 year: 0.1°C/year  
Connection: 4 wires plus SICRAM module  
Connector: 8 female poles DIN45326  
Stem dimension: Ø=8 mm L= 170 mm  
Response time T95: 15 minutes  
Sonda de bulbo húmedo de ventilación natural  
**HP3201.2 Natural wet bulb**  
Sensor type: Pt100  
Accuracy: Class A with platinum wire  
Measurement range: 4 °C ÷ 80 °C  
Resolution: 0.1°C  
Temperature drift @20°C: 0.003%/°C  
Drift after 1 year: 0.1°C/year  
Connection: 4 wires plus SICRAM Module  
Connector: 8 female poles DIN45326  
Stem dimension: Ø=14 mm L= 170 mm  
Braid length: 10 cm. at least  
Tank capacity: 15 cc.  
Tank autonomy: 96 hours with RH=50%, t = 23°C  
Response time T95: 15 minutes

## HP3217.2 Combined temperature and relative humidity probe

Sensor type: Pt100 with thin film for temperature  
Capacitive sensor for relative humidity  
Temperature accuracy: 1/3 DIN  
Relative humidity accuracy:  $\pm 2\%$ RH (15 ÷ 90 %RH) @ 20°C  
 $\pm 2.5\%$ RH remaining range  
Measuring range: temperature: -10 °C ÷ 80 °C  
relative humidity: 5% ÷ 98% RH  
Connection: 4 wires plus SICRAM Module  
Connector: 8 female poles DIN45326  
Dimensions: Ø=14 mm L= 150 mm  
Response time T95: 15 minutes  
Resolution: 0.1%RH, 0.1% °C

## AP3203.2 Omnidirectional hot wire probe

Sensor type: NTC 10kohm  
Accuracy:  $\pm 0.05$  m/s (0÷1 m/s)  
 $\pm 0.15$  m/s (1÷5 m/s)  
Measuring range: 0÷5 m/s  
0 °C ÷ 80 °C  
Connection: 7 wires plus SICRAM Module  
Connector: 8 female poles DIN45326  
Stem dimension: Ø=8 mm L= 230 mm  
Protection dimension: Ø=80 mm  
Resolution: 0.01 m/s  
Temperature drift @20°C: 0.06% /°C  
Drift after 1 year: 0.12 °C/years

### \*\* Storage capacity

Logging interval	Storage capacity
15 seconds	Approx. 11 days and 17 hours
30 seconds	Approx. 23 days and 11 hours
1 minute	Approx. 46 days and 22 hours
2 minutes	Approx. 93 days and 21 hours
5 minutes	Approx. 234 days and 17 hours

Logging interval	Storage capacity
10 minutes	Approx. 1 year and 104 days
15 minutes	Approx. 1 year and 339 days
20 minutes	Approx. 2 years and 208 days
30 minutes	Approx. 3 years and 313 days
1 hour	Approx. 7 years and 261 days

## ORDERING CODES

### The kit for the analysis of WBGT and PMV consisting of:

- HD32.3 instrument, 4 alkaline batteries 1.5V type AA, instruction manual, case. DeltaLog10 Software for the analysis of WBGT and PMV indexes.

**Probes and cables have to be ordered separately.**

### The probes required for WBGT measurement are:

- TP3207.2 Dry bulb temperature probe.
- TP3276.2 Globe thermometer probe.
- HP3201.2 Natural wet bulb temperature probe with natural ventilation.

### The probes required for PMV measurement are:

- HP3217.2 Combined e temperature and relative humidity probe
- AP3203.2 Omnidirectional hot wire probe.
- TP3276.2 Globe thermometer probe.

### Probes for HD32.3

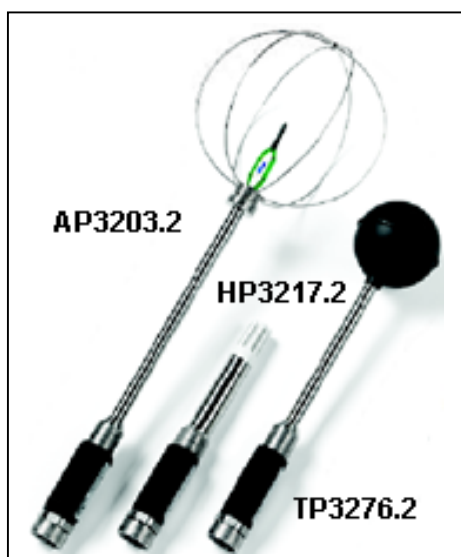
**TP3207.2:** Temperature probe with Pt100 sensor. Probe stem Ø 14mm, length 150mm. Equipped with SICRAM module. **Used for WBGT measurement.**

**TP3276.2:** Globe thermometer sensor Pt100, globe Ø 50 mm. Stem Ø 8 mm, length 170 mm. Equipped with SICRAM module. **Used for WBGT and PMV measurements.**

**HP3201.2:** Natural wet bulb. Pt100 sensor. Probe stem Ø 14 mm, length 170 mm. Equipped with SICRAM module, spares of braid and 50 cc of distilled water. **Used for WBGT measurement.**

**HP3217.2:** Combined temperature and relative humidity probe. Capacitive RH sensor, Pt100 temperature sensor. Probe stem Ø 14 mm, length 150 mm. Equipped with SICRAM module. **Used for PMW measurement.**

**AP3203.2:** Omnidirectional hot wire probe. Measuring range: air speed 0÷5 m/s, temperature 0÷100 °C. Probe stem Ø 8 mm, length 230 mm. Equipped with SICRAM module. **Used for PMW measurement.**



### Accessories:

**VTRAP30:** Tripod to suit HD32.3 instrument with a maximum height of 280 mm

**HD2110/RS:** Connection cable with M12 connector from the instrument side and with SubD female connector 9 poles for RS232C from PC side.

**HD2110/USB:** Connection cable with M12 connector from the instrument, USB 2.0 connector from PC side. SWD10: 100-240Vac/12Vdc-1A mains voltage stabilized power supply.

**AQC:** 200cc. of distilled water and n° 3 braids for HP3201 or HP3217DM probes

**HD40.1:** printer (uses HD2110/RS cable)

### Example of immediate data printing of PMV, obtained with HD40.1 printer

```

=====
ISO 7730  PMV Index
=====
Model HD32.3 WBGT - PMV
Firm.Ver.=01.00
Firm.Date=2008/12/05
SN=12345678
ID=0000000000000000
-----
Probe ch.1 description
Type: Hot wire
Data cal.:2008/10/15
Serial N.:08109460
-----
Probe ch.2 description
Type: Pt100 Tg 50
Data cal.:2008/10/01
Serial N.:08109452
-----
Probe ch.3 description
Type: RH
Data cal.:2008/10/15
Serial N.:08109464
=====
Date=2008/11/21 15:00:00
Va          0.00 m/s
Tg          22.0 °C
Ta          22.0 °C
RH          39.1 %
MET         1.20
CLO         1.00
PMV         0.10
PPD         5.10 %
=====

```

Reference rule

Instrument model  
Version of the instrument  
firmware  
Date of the instrument  
firmware  
Serial number of the  
instrument  
Identification Code

Description of the probe  
connected to input 1

Description of the probe  
connected to input 2

Description of the probe  
connected to input 3

Date and time

Air speed  
Globe thermometer  
temperature  
Dry bulb temperature  
Relative humidity  
Metabolic expenditure  
Resistance of clothing  
PMV – Predicted Mean Vote  
PPD – Predicted Percentage  
of Dissatisfied

