![Delta OHM logo - Member of GHM GROUP]

HD32.3, HD32.3A, WBGT-PMV-PPD

HD32.3, HD32.3A
INSTRUMENT FOR THE ANALYSIS OF THE INDICES:
WBGT - PMV - PPD

HD32.3 – WBGT - PMV Index is an instrument made by **Delta OHM** for:
- Analysis of hot environments using **WBGT** index (Wet Bulb Glob 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 standards:

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 is an interface between the instrument and connected sensor and communicates 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 internal 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.
- The display of **maximum, minimum, medium** statistic parameters.
- The data transfer via RS232 or USB serial port.

HD32.3 instrument can detect simultaneously the following quantities:
- Globe thermometer temperature **Tg** with TP3276.2 **(or TP3275)** probe.
- Natural wet bulb temperature **Tn** with HP3201.2 **(or HP3201)** probe.
- Environment temperature **T** with **TP3207.2** probe **(or TP3207).**
- Relative humidity **RH** and environment temperature **T** with **HP3217.2 (or HP3217R)** probe.
- Air speed **Va** with AP3203.2 **(or AP3203)** probe.

Starting from the measured values, HD32.3 can **calculate** and **display,** with **TP3207.2 (or TP3207), TP3276.2 (or TP3275),** and **HP3201.2 (or HP3201)** probes, the following indexes:
- **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.

Starting from the measured values, the HD32.3 instrument can **calculate** and **display,** with **HP3217.2R (or HP3217R), TP3276.2 (or TP3276 or TP3275),** and **AP3203.2 (or AP3203)** probes, the following indexes:
- Medium radiant temperature **TMR.**
- **PMV** Index (Predicted Mean Vote).
- **PPD** Index (Predicted Percentage of Dissatisfied).

WBGT index

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 (or HP3201).**
- **TP3276.2 (or TP3275 or TP3276) Globe thermometer probe.**
- **TP3207.2 (or TP3207) 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 indexes

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 (Ta, Tr, Va, RH), 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 ÷ 4 met
- Thermal resistance of clothing = 0 ÷ 2 clo
- Dry bulb temperature = 10 ÷ 30°C
- Medium radiant temperature = 10 ÷ 40°C
- Air speed = 0 ÷ 1 m/sec
- Water vapour pressure = 0 ÷ 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).

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  %
========================
```

NOTES

Reference standard

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

Table 1: valuation scale of the thermal environment

PMV	PPD %	EVALUATION THERMAL ENVIRONMENT
+3	100	Hot
+2	75,7	Warm
+1	26,4	Slightly warm
+0,85	**20**	**Acceptable thermal condition**
-0,5 < PMV < +0,5	< 10	Comfortable
-0,85	**20**	**Acceptable thermal condition**
-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.
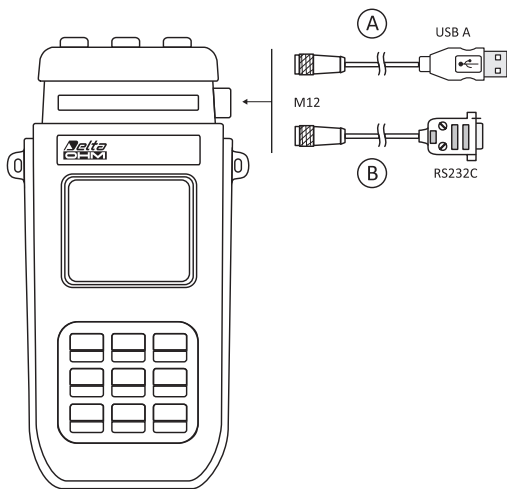
TECHNICAL CHARACTERISTICS	
Instrument technical characteristics	
Power supply	Mains power supply (cod. SWD10) 12 Vdc/1A
Batteries	4 batteries 1.5V type AA
Autonomy	200 hours with 1800mAh alkaline batteries
Power absorbed with instrument off	< 45µA
Inputs for probes with SICRAM module	3 male 8-pole DIN 45326 connectors
Serial interface	
Pin	M12-8 poles
Type	RS232C (EIA/TIA574) or USB 1.1 or 2.0 no-isolated
Baud rate	from 1200 to 38400 baud. with USB baud = 460800
Data bit	8
Parity	None
Stop bit	1
Flow control	Xon-Xoff
Cable lenght	max 15 m
Memory	divided in 64 blocks
Memory Capacity	67600 memorizations for each of 3 inputs
Memorization interval	selectable between: 15, 30 s; 1, 2, 5, 10, 15, 20, 30 min and 1 hour
Safety of the stored data	Unlimited
Logging interval	Configurable from 1 second to 1 hour
Storage capacity	8 GB
Instrument uncertainty	± 1 digit @ 20℃
Operating Conditions	
Working temperature	-5 … 50 ℃
Storage temperature	-25 … 65 ℃
Working relative humidity	0 … 90 %RH no condensation
Protection Degree	IP64
Dimensions (Length x Width x Height)	185 x 90 x 40 mm
Weight	470 g (batteries included)
Materials	ABS, rubber
Display	Back light, dot-matrix 160 x 160 points, visible area 52 x 42mm

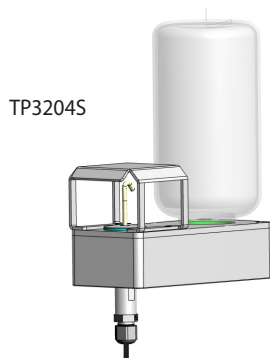| Logging interval	Storage capacity
15 seconds	Approx. 11 days and 17 hours
30 seconds	Approx. 23 days and 11 hours
1 minute	Approx. 46 days and 22 hours
2 minutes	Approx. 93 days and 21 hours
5 minutes	Approx. 234 days and 17 hours
10 minutes	Approx. 1 year and 104 days
15 minutes	Approx. 1 year and 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

Probes technical characteristics	
TP3207 and TP3207.2 - Temperature probes	
Sensor	Pt100
Measuring range	-40…100 ℃
Resolution	0.1 ℃
Accuracy	1/3 DIN
Temperature drift @20℃	0.003%/℃
Long term stability	0.1℃/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}	15 minutes
TP3275 and TP3276.2 - Globe Thermometer Temperature probes	
Sensor	Pt100
Measuring range	-30…120 ℃
Resolution	0.1 ℃
Accuracy	1/3 DIN
Temperature drift @20℃	0.003%/℃
Long term stability	0.1℃/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}	15 minutes
HP3201 and HP3201.2 - Natural Ventilation Wet Bulb probes	
Sensor	Pt100
Measuring range	4…80 ℃
Resolution	0.1 ℃
Accuracy	Class A
Temperature drift @20℃	0.003%/℃
Long term stability	0.1℃/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 lenght	10 cm approx.
Reservoir	Capacity 15 cc, autonomy 96 hours @ RH =50 % and t = 23 ℃
Response time T_{95}	15 minutes
TP3204S - Natural Ventilation Wet Bulb probes	
Sensor	Pt100
Measuring range	4…80 ℃
Resolution	0.1 ℃
Accuracy	Class A
Temperature drift @20 ℃	0.003 %/℃
Long term stability	0.1 ℃/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 lenght	10 cm approx.
Reservoir	Capacity 500 cc, autonomy 15 days @ t=40 ℃
Response time T_{95}	15 minutes

HP3217R AND HP3217.2R - Temperature and RH 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}	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=80 mm

ORDERING CODES

HD32.3 - Thermal microclimate data logger. It includes DeltaLog10 software (with analysis of WBGT, PMV and PPD indices) downloadable from Delta OHM website. The kit is composed of instrument, four AA 1.5 V batteries, instruction manual. The probes and cables have to be ordered separately.

HD32.3A - as HD32.3 but supplied with big carrying case (for probes with cable)

The probes necessary for **WBGT index measurement** are following (in brackets, version with 2 m cable):
- **TP3207.2 (TP3207)** - Dry bulb temperature probe.
- **TP3276.2 (TP3275)** - Globe thermometer probe.
- **HP3201.2 (HP3201)** - Natural wet bulb temperature probe with natural ventilation. For long lasting measurements: **TP3204S**

The probes necessary for **PMV/PPD indices measurement** are following (in brackets, version with 2 m cable):
- **HP3217.2R (HP3217R)** Combined T/RH probe.
- **AP3203.2 (AP3203)** Omni-directional hot wire air speed probe.
- **TP3276.2 (TP3275)** Globe thermometer probe.

ACCESSORIES

VTRAP30 - Tripod, maximum height 157 mm
VTRAP32.2A.3A - Tripod for measurements with probes with cable.
HD32.2.7.1 - Probes support to be fixed to the VTRAP32.2A.3A tripod.
HD2110RS - Connection cable with M12 connector on the instrument side and with 9 pole SubD female connector for RS232C on PC side.
HD2110USB - Connection cable with M12 connector on the instrument, USB 2.0 connector on PC side.
SWD10 - 100-240 Vac/12 Vdc-1 A stabilized mains power supply.
AQC - 200 cc of distilled water.
HD40.1 - Printer (it uses HD2110/RS cable)

A USB connection to PC using type A USB - M12 cable, code HD2110USB. **USB drivers are required.**
B RS232C connection to PC. It allows you to connect the RS232C serial port of a PC or the printer HD40.1 with the cable HD2110RS.

TP3204S

TP3275
HP3201
HP3217R
HD32.2.7.1
VTRAP32.2A.3A