Delta OHM

HD 32.3
INSTRUMENT FOR THE ANALYSIS OF THE INDICES:
WBGT - PMV - PPD

HD32.3 – WBGT - PMV Index is an instrument made by **Delta Ohm Srl** 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 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 **Tg** with **TP3276.2 (or TP3775)** probe.
• Natural wet bulb temperature **Tn** with **HP3201.2 (or HP3201)** probe.
• Environment temperature **T** with **TP3207.2** probe.
• Relative humidity **RH** and environment temperature **T** with **HP3217.2 (or TP3217)** probe.
• Air speed **Va** with **AP3203.2** probe.
Starting from the measured values, HD32.3 can **calculate** and **display,** with **TP3207.2R (or TP3207), HP3276.2 (or TP3775),** 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 **TP3217.2 (or TP3217), HP3276.2 (or HP3275),** and **AP3203.2 (or AP3203)** probes, the following indexes:
• Medium radiant temperature **Tr**.
• **PMV** Index (Predicted Mean Vote).
• **PPD** Index (Predicted Percentage of Dissatisfied).

WBGT

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) 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

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 below).

AP3203.2

TP3276.2

HP3217.2

HD40.1

RS232 USB

HP32.3

Example of immediate data printing of PMV, obtained with HD40.1 printer
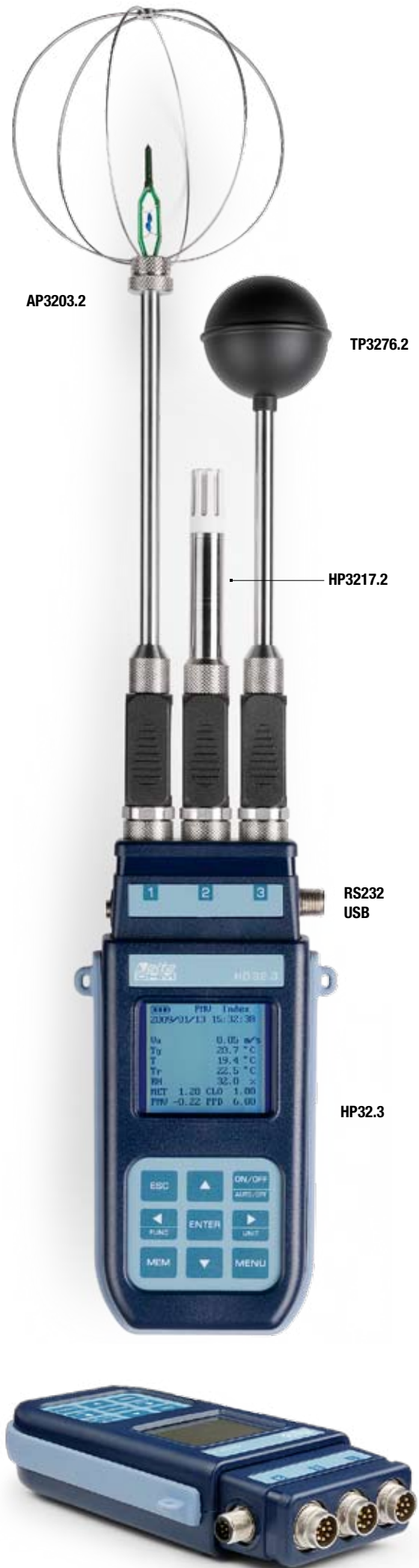
```
=========================
   ISO 7730  PMV Index
=========================
Model HD32.3 WBGT - PMV
Firm.Ver.=01.00
Firm.Date=2008/12/05
SN=12345678
ID=0000000000000000
-----------------------
Probe ch.1 description
Type: Hot wire
Data cal.:2008/10/15
Serial N.:08109460
-----------------------
Probe 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  %
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NOTES

Reference regulation

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 FEATURES
Instrument

Dimensions (Length x Width x Height)	185x90x40 mm
Weight	470 g (batteries included)
Materials	ABS, rubber
Display	Back light, 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	± 1 digit @ 20°C

Power supply

Mains power supply (cod. SWD10)	12Vdc/1A
Batteries	4 batteries 1.5V type AA
Autonomy	200 hours with 1800mAh alkaline batteries
Power absorbed with instrument off	< 45µA
Safety of the stored data	Unlimited

TP3207.2 (TP3207) 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 T$_{95}$:	15 minutes

TP3276.2 globe thermometer probe Ø=50 mm (Ø=150 mm TP3275)

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 T$_{95}$:	15 minutes

HP3201.2 (HD3201) 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 T$_{95}$:	15 minutes

HP3217.2 (HP3217R) 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:	± 2%RH (15 ÷ 90 %RH) @ 20°C ± 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 T$_{95}$:	15 minutes
Resolution:	0.1%RH, 0.1 °C

AP3203.2 (AP3203) Omnidirectional hot wire probe

Sensor type:	NTC 10kohm
Accuracy:	± 0.05 m/s (0÷1 m/s) ± 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

Connections

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

Serial interface:

Pin:	M12-8 poles.
Type:	RS232C (EIA/TIA574) or USB 1.1 o 2.0 no isolated

HD2110/USB

HD2110/RS

SWD10

VTRAP30

| Baud rate: | from 1200 to 38400 baud. |
| | with USB baud=460800 |

Data bit: 8
Parity: None
Stop Bit: 1
Flow Control: Xon-Xoff
Cable length: max 15m
Memory   divided in 64 blocks.
Storage capacity 67600 memorizations for each of 3 inputs.
Logging interval selectable among: 15, 30 seconds, 1, 2, 5, 10, 15, 20, 30 minutes and 1 hour.

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

ORDERING CODES

HD32.3 is composed of:
• Instrument HD32.3, 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.**

HD32.3A is composed of:
• Instrument HD32.3, 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 (TP3207)** Dry bulb temperature probe.
• **TP3276.2 (TP3275)** Globe thermometer probe.
• **HP3201.2 (HP3201) Natural w**et bulb temperature probe with natural ventilation.

The **probes** required for **PMV** measurement are:
• **HP3217.2 (HP3217R)** Combined e temperature and relative humidity probe
• **AP3203.2 (AP3203)** Omni-directional hot wire probe.
• **TP3276.2 (TP3275)** 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: Omni-directional 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 and PPD measurement.**

Probes for HD32.3 version A:

TP3207: Temperature probe with Pt100 sensor. Probe stem Ø 14mm, length 150mm. Cable 2m long. Equipped with SICRAM module. **Used for the calculation of the following indices:**
IREQ, WCI, DLE, RT, PMV, PPD, WBGT, SR.
TP3275: Globe thermometer sensor Pt100, globe Ø 150 mm. Stem Ø 14 mm, length 110 mm. Cable 2m long. Equipped with SICRAM module. **Used for Mean radiant temperature, WBGT.**
HP3201: Natural wet bulb. Pt100 sensor. Probe stem Ø 14 mm, length 110 mm. Equipped with SICRAM module, spare braid and 50 cc of distilled water. **Used for WBGT measurement.**
HP3217R: 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 and PPD measurement.**

AP3203: Omni-directional 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 and PPD 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)
BAT.40: Spare battery pack for HD40.1 and HD40.2 printer with built-in temperature sensor.
RCT: The kit includes 4 thermal paper rolls, wide 57mm, diameter 32mm.

HD32.2.7

TP3275

AP3203

HP3217R

HP32.2.7

HD32.3A