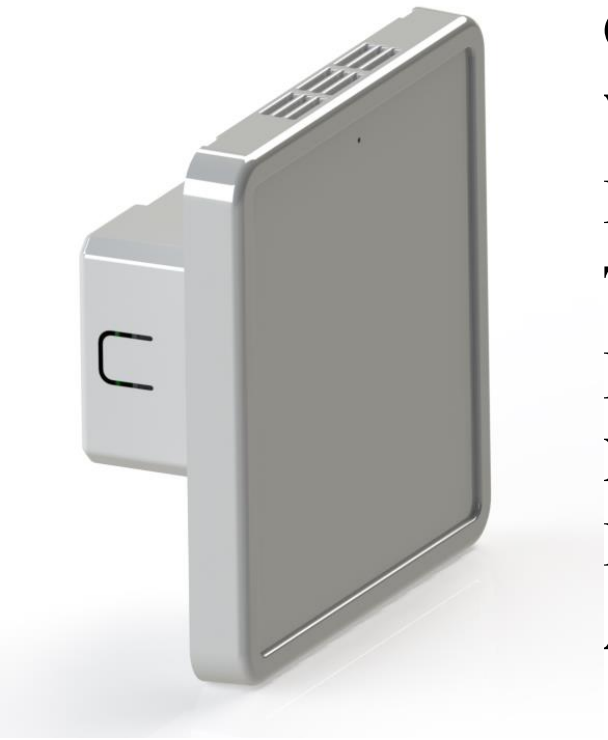
PJD Industries Pty Ltd

Smart Buildings, Processes and Energy Efficiency Solutions

IAQ-5000M

Flush mounted Modbus Indoor Air Quality Probe



CO2
VOC
Particles
Temperature
Humidity
Noise
Light
Atmospheric pressure

Ver	Date	Update
V1	25/05/2020	Initial version
V2	10/08/2020	Details on units
V3	17/09/2020	Control and set points added
V4	01/10/2020	ABC details for single and double bands CO2 sensors

Table des matières

1. Keynote

To comply with in force regulations on buildings energy efficiency, ventilation must be automatically on demand controlled.

2. Measuring indoor Air quality for HVAC control

Energy losses by air renewal in a conventional building are estimated to 30% of the heating and air conditioning cost. Losses become predominant for very isolated buildings even with heat exchanger. The increasing airproofing of buildings also imposes on demand air renewal based on IAQ to ensure productivity, comfort and health.
By controlling the ventilation on human occupancy materialized by the expiration of CO2 (meeting rooms, offices, bedroom) and air quality (VOC, toxic compounds and odors, particulate maters), significant energy savings can be achieved.

3. Multi sensors probe.

This probe is the most comprehensive on the market and can combine the following measurements:

- CO2
- Total VOC
- PM1, PM2.5, PM10
- Humidity
- Temperature
- Light intensity
- Color temperature (in °K)
- Audible Noise
- Flickering (Optional)

4. Easy ecosystems Integration

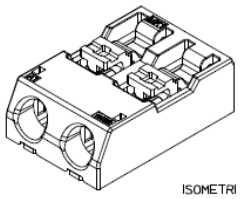
Easy commissioning: there is no need to open the probe to access to a setting button. Address, speed and type of Modbus (RTU or ASCII) can be done via a smartphone and NFC.

5. Power supply

Voltage	12V DC ± 2V
Average current	15mA
Pic current	40mA
Average power consumption	360mW

6. Connection

Power supply:	2 pins (polarized)
Modbus:	2 pins (polarized)
Connector type:	Push In
Release:	Push button
Type of cable:	Solid or Stranded
Diameter of cable:	AWG 18-24 (Solid), 22-26 (Stranded)



7. Maintenance free

Each component of the IAQ probe has been selected and are managed in order to achieve at least 10 years' life span without any maintenance or recalibration.

This probe is designed to work in a ventilated area where sensors have the opportunity to see outdoor CO2 and VOCt concentration at least every 15 days.

The automatic baseline calibration is set on a 2 weeks' period. In order to get a good auto calibration after commissioning, it is recommended to open windows for at least 5 minutes with the probe powered.

8. Durability index

Some countries require indicating the Durability index but calculation is not yet harmonized among counties. As a consequence, we provide raw and detailed information as follow:

The design of the probe is made for a durability of at least 30 years
PM, CO2 and VOC sensors have a 10 years' life span but can be replaced (plug and play) by end user without special tool. See reparability for details.

9. Reparability index

Some countries require indicating the Reparability index but calculation is not yet harmonized among counties. As a consequence, we provide raw and detailed information as follow:

The design of the probe is made of a stack of 5 PCB as follow (mounting order from rear to top)

- Power supply board
- PM sensor
- Inter board interface
- Main board with the following sensors: CO2 (pluggable), TVOC (pluggable), Atmospheric pressure, noise.
- The front board with NFC and the following sensors: T°, RH, light

The main board has a built in test feature for each LRU (Line Replaceable Unit) with a status report through the digital communication and LED interface.
Each above board is designed to be a LRU and each LRU is a SKU (Stock Keeping Unit).
In case of failure each board can be ordered and changed by skilled end user according to the Maintenance and repair manual.
Most of sensors are SMD digital sensor with small drift along the life span of the probe.
Sensor with 10 years' lifespan are pluggable and considered as LRU: PM, CO2, TVOC.
LRU only requires a simple screwdriver for replacement operation. LRU are SKU that can be ordered separately.
Plastic parts are SKU and can be ordered separately in the frame of the reparability and sustainability policy.
Details of SKU part number are given in the "Maintenance and repair manual".

10. Flush-mounting

The flat design of the IAQ probe has been studied to be flush mounted in standard electric boxes. Integrated in the wall, the visible part is just few millimeters thick.
The air is sensed by the air diffusion going between the front panel and the wall (few millimeters).

11. Specifications of sensor after integration in the probe

11.1. Technologies

Protocol	RS485 Modbus, 9600 bauds (See Modbus protocol specification for details). Input protected over 12V.
Power supply	12V to 30V DC, Protection against transient-voltage-over 35V
CO2 sensor	Single band NDIR (Dual bands NDIR in option) with auto zero
TVOC sensor	Digital Metal Oxide pulsed MEMS with auto zero
PM sensor	Laser scattering with laser source
Temperature sensor	Digital MEMS
Relative humidity sensor	Digital MEMS
Atmospheric Pressure	Digital MEMS
Noise sensor	Digital sensor
Light sensors	Digital MEMS

11.2. Lifespan and drifts

Probe: 30 years (MTBF >48 years)
Gas and PM sensors: 10 years under normal conditions of use. Beyond 10 years, a replacement message is activated.
Humidity: Max drift 0.5% RH / year.
Temperature: Max drift of 0.04 ° C per year.
Noise: NA
Atmospheric Pressure: +/- 1mbar/year

11.3. Measurement ranges and accuracies

11.3.1. Single band NDIR CO2 (EP5000XX-YN):

+/- 50ppm and 3% at 25°C and 1013mbar, measuring range: 390 to 5000 ppm, resolution 1ppm.
Automatic Baseline Calibration (ABC): lowest value on 15 days adjusted at 400ppm.
The accuracy of the CO2 measurements indicated above requires that the room be unoccupied and ventilated for some time at least once every 15 days.

11.3.2. Double bands NDIR CO2 (EP5000XX-YD):

+/- 50ppm and 3% at 25°C and 1013mbar, measuring range: 390 to 5000 ppm, resolution 1ppm.
Long Term Adjustment (LTA): lowest value on 45 days adjusted at 400ppm.
The accuracy of the CO2 measurements indicated above doesn't requires that the room be unoccupied and ventilated for some time (Hospital patient room. Etc.).

11.3.3. TVOC:

+/- 0.1mg / m^3 and 15% (Total VOC according to ISO16000-29). Max 65 520 µg / m^3, resolution 28µg / m^3.
Relative measurement: The lowest possible value achievable by ventilation or air treatment becomes the zero on a 15 days' period.
The accuracy of the relative VOC measurements indicated above requires that the probe be associated with an active ventilation.

11.3.4. PM1:

Range of measurement 0 to 1000 µg/m^3
Accuracy: indicative, no accuracy commitment

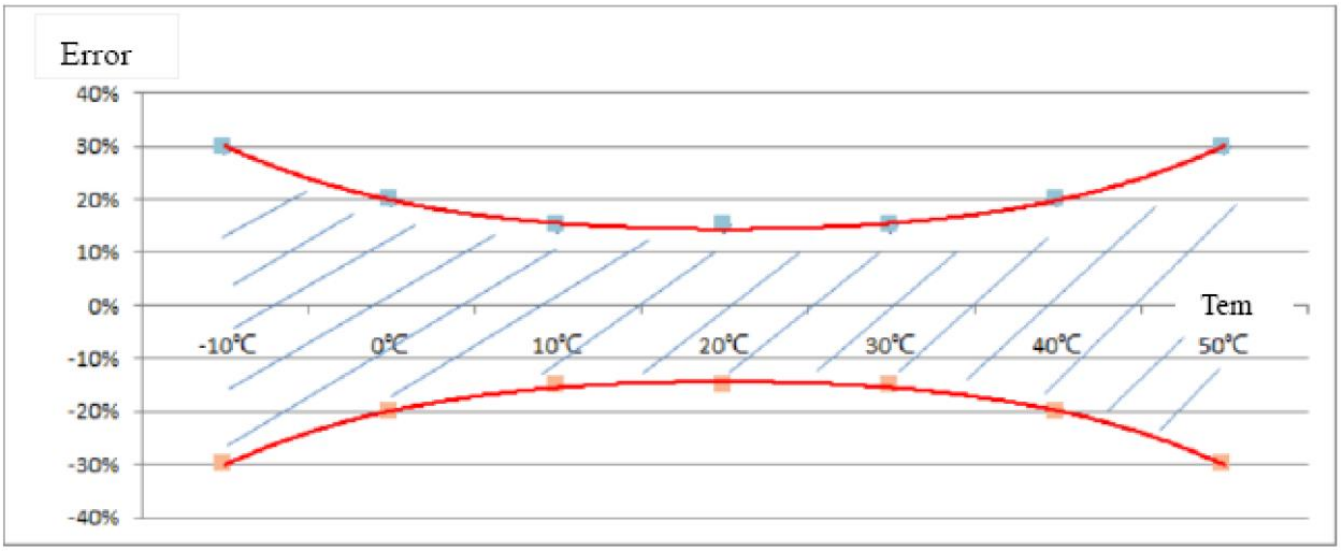
11.3.5. PM2.5:

Range of measurement 0 to 1000 µg/m^3

Accuracy: < 50µg/m³: ± 10µg/m³, 50~100µg/m³： ± 15µg/m³ > 100µg/m³: ± 15% reading
Temperature influence: 0.5 to 1%/°C or 0.5 to 1µg/m³/°C around 20°C, whichever is larger

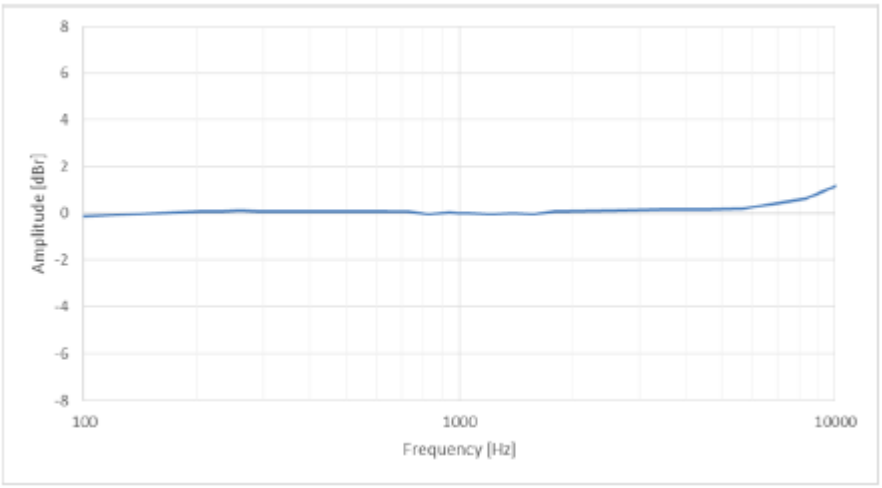
11.3.6. PM10:

Range of measurement 0 to 1000 µg/m³
Accuracy: indicative, no accuracy commitment. Calibration with Arizona sand.



11.3.7. Noise sensor

Range: 122.5 dBA SPL
Pick and average calculated on 30 seconds period
Signal to Noise Ratio: -64 dBA
Omnidirectional sensitivity: -26 dBA FS ±3 dB sensitivity
Drift: not significant.
Frequency response



11.3.8. Atmospheric pressure sensor

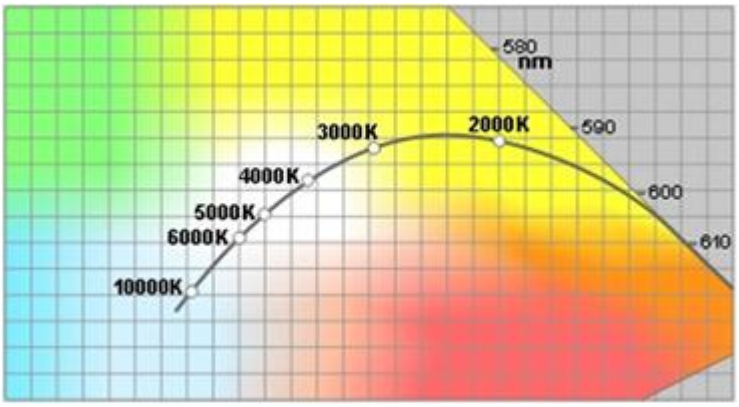
Range: 0 to 1638.4 mbar
Error band, 700 to 1100 mbar,25°C: +/- 1.5 mbar
Error band, 700 to 1100 mbar, 0°C to 50°C: +/- 2mBar
Resolution: 0.1 mbar

11.3.9. Light sensor

Illuminance: Lux computed from RGB and Clear channel.
Color temperature: computed from RGB and Clear channel.
Characteristic of channels:

Parameter	Test Conditions	Red Channel		Green Channel		Blue Channel		Clear Channel			Unit
		Min	Max	Min	Max	Min	Max	Min	Typ	Max	
R_e Irradiance responsivity	$\lambda_D = 465$ nm(2)	0%	15%	10%	42%	65%	88%	11.0	13.8	16.6	counts /µW /cm^2
	$\lambda_D = 525$ nm(3)	4%	25%	60%	85%	10%	45%	13.2	16.6	20.0	
	$\lambda_D = 615$ nm(4)	80%	110%	0%	14%	5%	24%	15.6	19.5	23.4	

Notes:
1. The percentage shown represents the ratio of the respective red, green, or blue channel value to the clear channel value.
2. The 465 nm input irradiance is supplied by an InGaN light-emitting diode with the following characteristics: dominant wavelength λD = 465 nm, spectral halfwidth Δλ. = 22 nm.
3. The 525 nm input irradiance is supplied by an InGaN light-emitting diode with the following characteristics: dominant wavelength λD = 525 nm, spectral halfwidth Δλ. = 35 nm.
4. The 615 nm input irradiance is supplied by a AlInGaP light-emitting diode with the following characteristics: dominant wavelength λD = 615 nm, spectral halfwidth Δλ. = 15 nm.



Range of measurement 0 to 30 000 Lux
Resolution: 1 lux.

11.3.10. Color T°:

Range: 600°K to 10 000°K
Resolution: 1°K

Light Source	Color Temperature (K)
Candle	1900
Sunlight at sunset	2000
Sodium bulb	2200
Incandescent bulb	2500 / 2800
Cold white fluorescent lamp	2700 / 3000
Halogen lamp	3300
Carbon arc lamp	3780
Neutral white fluorescent lamp	4000 / 4200
Sun light plus sky light	5500
Sun at its zenith	5800

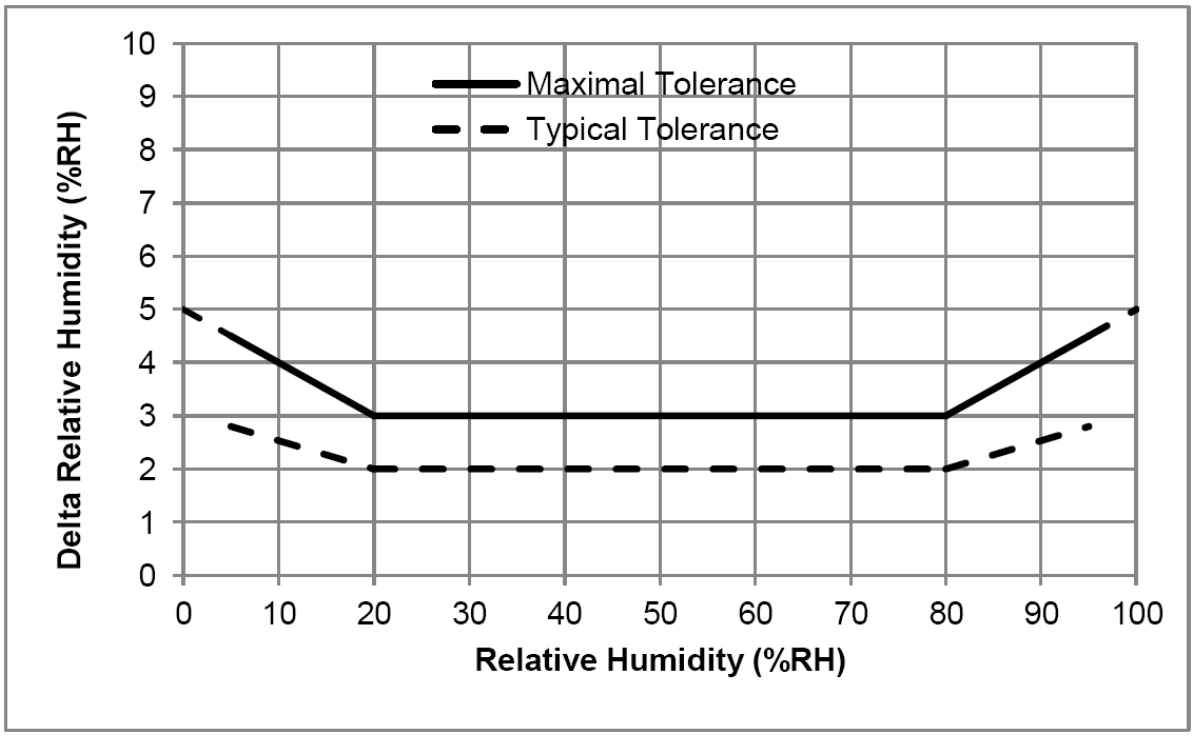
Xenon strobe light	6000
Overcast sky	6500 / 8000
Electric arc	10000

11.3.11. Lux:

Range: 0 to 30 000 lux
Resolution: 1 Lux

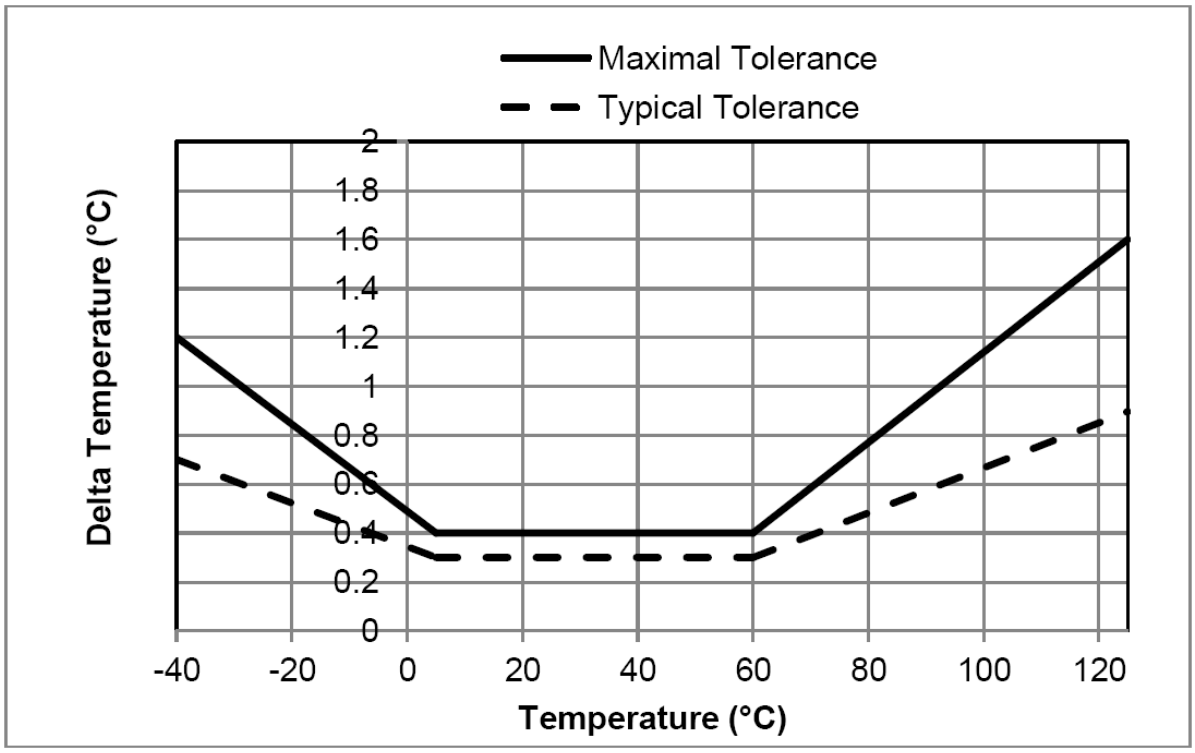
11.3.12. Humidity:

+/- 3% RH, minimum measurement range: 0% to 100% RH, resolution 1%.



11.3.13. Temperature:

+/- 0.3°C, measuring range from 0° to + 50°C, resolution 0.1°C.


Maximal Tolerance
Typical Tolerance
Delta Temperature (°C)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-40
-20
0
20
40
60
80
100
120
Temperature (°C)

12. Improvement of the ABC auto zero

The probe automatically activates an over ventilation (max flow) once every 15 days during a period of vacancy to improve the ABC process which requires a CO2 concentration as close as possible to the outdoor level over a similar period (single band) and a VOC level close to that outdoor. The duration of over-ventilation is not fixed and ends when the change in CO2 is stable for at least 10 minutes (<10ppm).
The probe can receive over-ventilation opportunity data from ecosystem based on occupancy sensors. In the absence of occupancy sensors, the occupancy period is estimated based on a low CO2 value (<500ppm) and a low CO2 variation (<20ppm in 30 minutes).
If the probe has over-ventilated, it no longer takes into account the opportunity information (sufficiently long absence) that it receives during the next 15 days.
To trigger over ventilation on the basis of opportunity information provided by the eco system, the CO2 stability criteria must also be valid.
If the probe does not receive opportunity information from the ecosystem at least once every 24 hours, it will only rely on the unoccupancy estimated via CO2.

13.CO2 manual calibration

A manual CO2 recalibration can be launched via NFC (smartphone App) or Modbus.
A LED will blink during 20minutes. During this time, the windows shall be opened and the room unoccupied to reach the outdoor CO2 level. At the end of the 20 minutes, the CO2 sensor baseline is set at 400ppm and the LED stop blinking.

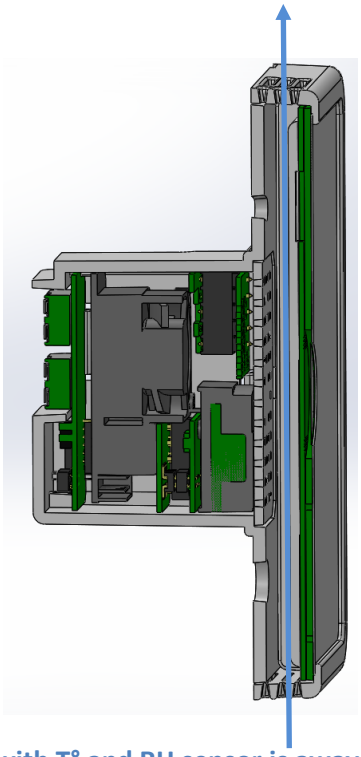
14. Controls

- Ventilation: On Off or Continuous on PI.
- Heating Control: Continuous on Fuzzy logic PID.
- Cooling control: Continuous on Fuzzy logic PID.

15. Set points

- Ventilation: on thresholds or physiological effects objectives
- Heating
- Cooling

16. Air flow



EP5000 probe side view: The front PCB with T° and RH sensor is away from the wall to allow air flow in front of other sensors.

17. Operation and storage conditions

Working temperature range: 0°C to +45°C
Working humidity range: 0 to 95% non-condensing
Storage temperature range -30°C to 60°C
Storage humidity range: 0 to 95% non-condensing

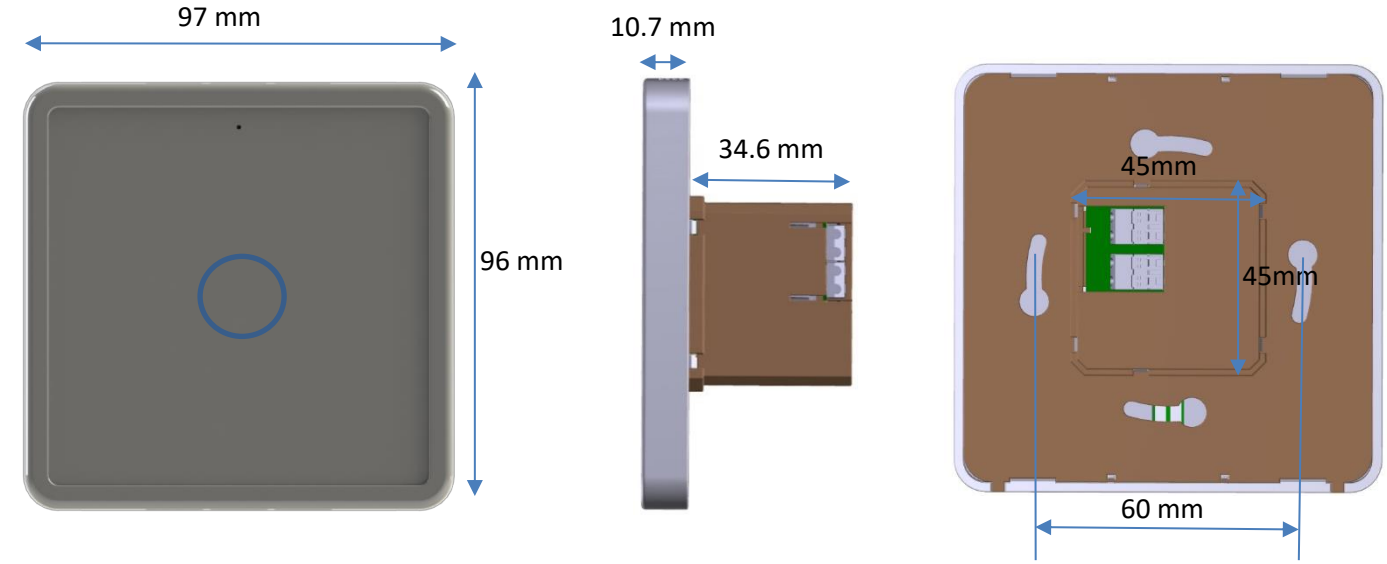
18. Noise

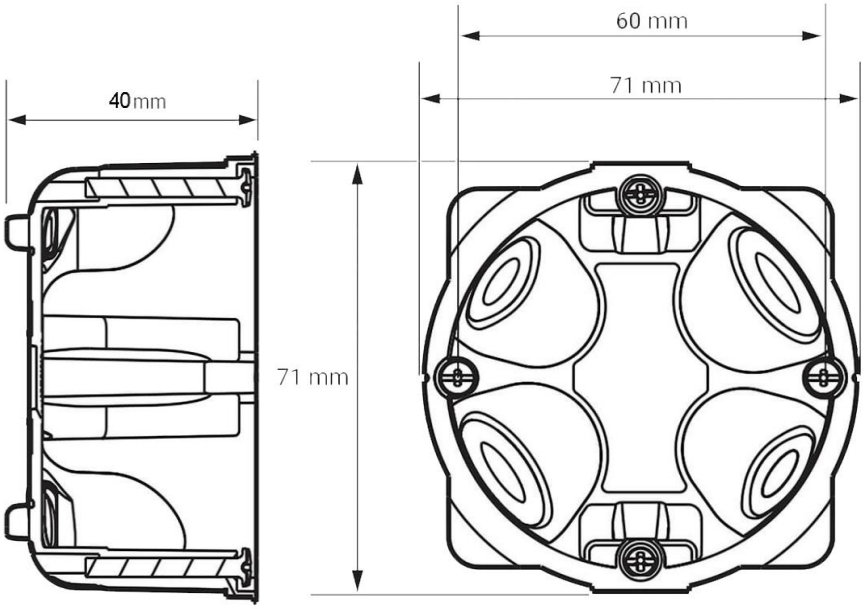
PM sensor fan activated 6 seconds every minutes: < 20dBA at 30cm (background noise < 16dBA)

19. Protection index

Protection class: III
Protection grade: IP 30

20. Dimensions





21. Weight

Probe alone: 120g

22. Packaging

White gift box

23. Packing list

Probe
Wall box
Card with link for online documentation

24. Product Label

The label in the back of the product identify the model.
M termination means **Modbus**.
The serial number is registered in the main MCU and can be read via NFC with a dedicated app for smartphone.

25. Marking

The type of connection (power supply) is indicated in front of each connector as well as polarities.

26. Applicable Standard

EN 60730-1 (electrical controls for household machines and the like)
The unit complies with European Directive 73/23/EEC (Low Voltage Directive) and 89/336/EEC (EMC Directive).

27. Flammability

Flammability class according to UL 94: V0

28. RoHS / Reach compliance

See separate certificate for details

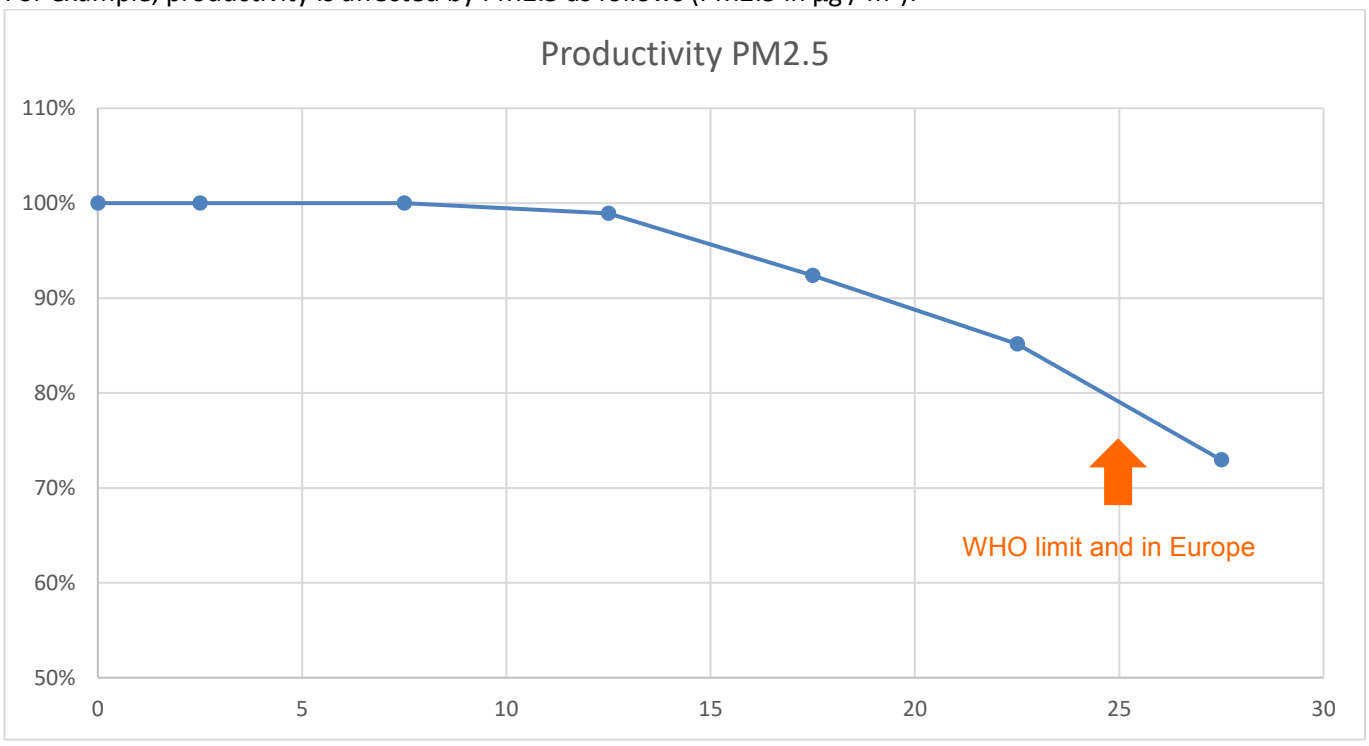
29.Physiological effects

This algorithm is based on international university studies quantifying the physiological impacts of air quality on humans.

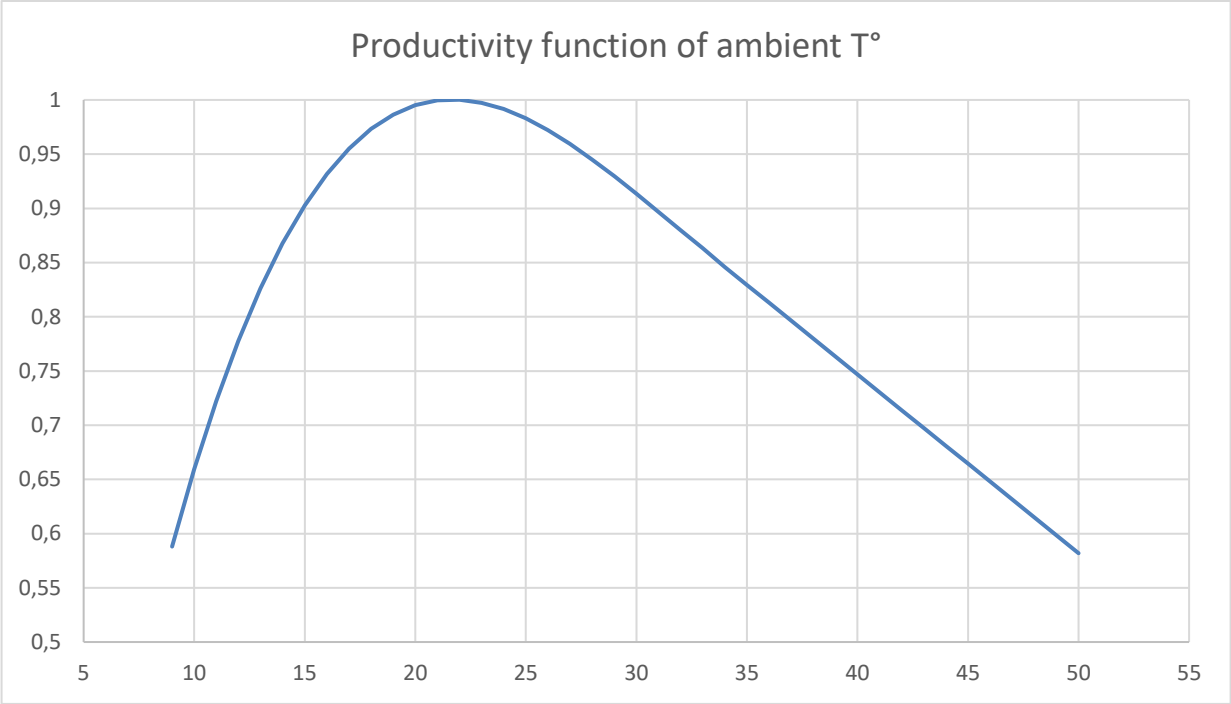
The following table shows the contributors for each physiological impact:

	CO2	COVt	PM	Formaldehyde, Benzene	Radon	Noise	Odors	T°	RH	NOX O3	Lux	Light color	Light flickering
Cognitivity / Productivity	✓	✓	✓			✓	✓	✓			✓	✓	✓
Health		✓	✓	✓	✓	✓		✓					
Quality of sleep	✓					✓		✓			✓	✓	
Asthma attack		✓	✓				✓	✓	✓	✓			
Olfactory Comfort		✓					✓						
Thermal Comfort								✓					
Sound comfort						✓							
Dry air Comfort									✓				
Respiratory tract irritation			✓						✓	✓			
Growth of mold, spores and mites									✓				

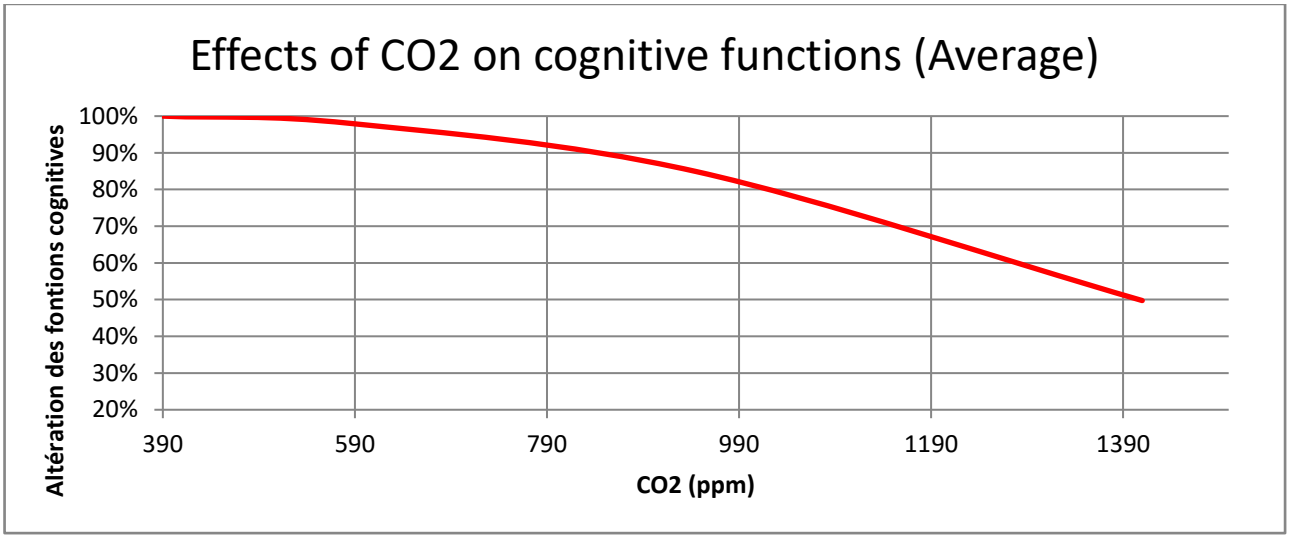
For example, productivity is affected by PM2.5 as follows (PM2.5 in µg / m^3):



Productivity is also affected by extreme temperatures as follows:



Source https://iaqscience.lbl.gov/si/performance-temp-office



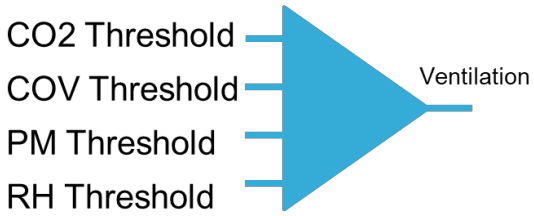
Source NIH National Institute of Environmental Health Sciences

IAQ LEDs summarize health, productivity and quality of sleep indexes and display the lowest.

The ventilation regulation loop is based on settable health, productivity and quality of sleep objectives or by exceeding conventional thresholds.

The comparison between IAQ and AAQ is based on the comparison of physiological effects. An indication by LED for windows on street and backyard.

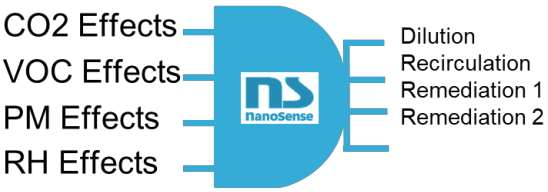
Conventional System



OR Function

Doesn't take into account the combination of effects

Smart IAQ



AND Function

The AND function symbolizes the cocktail effect

30.Index of viral contamination risk

Virus transmitted through the air as well as direct and indirect contact depends of different factors:

Transmission	Temperature	Humidity	UV	Human density	Air flow
Airborne	✓	✓	✓	✓	✓
Contact	✓	✓	✓		

Virus survival conditions are temperature and humidity dependent. Virus are also sensitive to UV. This explain partially why the flu is more prevalent in winter. Crowded environment (confinement) is also a factor of virus spreading. The EP5000 probe can estimate the number of people in a room from the CO2 measurement and the controlled ventilation flow rate. This index evaluates the risk of viral contamination in a building.