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P4000 Particulate Matter Probe

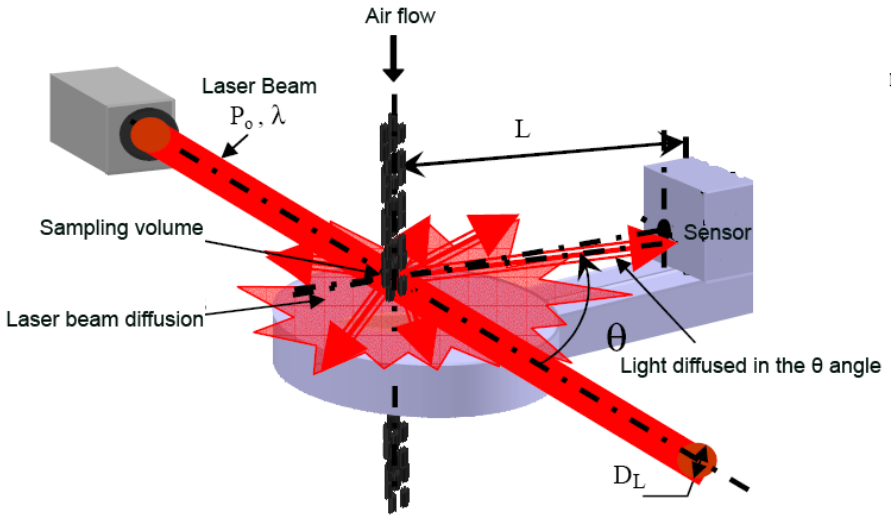
Definition
The Particle Materials, "also known as" Particulate matter "or PM, is a complex mixture of extremely small particles and liquid droplets. Particulate pollution is made up of a number of components, including acids (such as nitrates and sulphate), organic chemicals, metals, and soil particles or dust.
Particulate pollution is responsible for 42,000 premature deaths per year in France and many diseases (asthma, allergies, respiratory diseases and cardiovascular diseases, lung cancer).
The coarsest (larger than 2.5 micrometers) fall fast enough, their residence time in the air is of the order of 1 day, while the finest can stay up to 1 week in suspension and travel thousands of kilometers . Once deposited, the particles can then be re suspended by the wind or in urban areas under the action of traffic.

Principle of detection
The P4000 uses laser diffraction technology (Light Scattering)

The principle is the following: when a laser beam passes through pure air, the beam is invisible. When the beam is visible, this is because the beam is diffracted onto particles along its path. If you look at beam from the side, the more the beam is visible, the more the particle density.

This particle probe uses a sensor with a near-infrared source (laser diode). The sensor is an avalanche photodiode with amplifier. Infrared is used to avoid interference with the day light entering the chamber.

The detection principle looks like this:



The dust density depends mainly on the air flow.

The laser and the sensor and the collimator lenses are looking downward to prevent dust from depositing on the optical when the upward air flow source is turned off.
(Note that a small heater warms the upstream air of the sensor and the lighter hot air generates a constant flow).

The optimum angle between the source and sensor is the result of experiments.

Each particle which passes the laser beam diffracts a part of this beam to the photodiode and the air flow being constant, the pulse width measured is used to classify the particles by size.

A running average of the quantities of particles by category is performed over a period of 30 seconds.

As large particles do not affect health, although present in the indoor environment (especially cloth fibers), particles larger than 10 microns are not counted.

The measurement is made according to the standard classification.

PM (Particle Matter) refer to the total weight of particles per volume of air. It is a vestige of the time when the available technology was not able to detect individual particles. For each particle size a typical mass is attributed to express the result on standardized unit in $\mu g/m^3$.
Monitoring equipment such as modern P4000, count the individual particles in three size classes that are correlated with PM10, PM2.5 and PM1. The hypothesis for the calculation of mass is that the particles are spherical which is not always the case.

Standard values
The size of particles is directly linked to their potential danger vis-à-vis health. Environmental organizations are concerned that the particles have a diameter less than or equal to 10 micrometers because they are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.

The particles are classified into four categories:

- "**PM10**" coarse inhalable particles such as those found near roadways and dusty industries, are less than 10 micrometers in diameter and include fine particles, very fine and ultrafine particles.

- "**PM2.5**" fine particles such as those found in smoke and haze, are less than or equal to 2.5 micrometers in diameter. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air. Diesel engines are the main source. Include very fine and ultrafine particles.

- "**PM1**", very fine particles (most hazardous for health) are less than or equal to 1 micron in diameter. They are virtually eliminated by precipitation and have time to accumulate in the air. Include ultrafine particles.

- "**PM0.1**" ultrafine particles with a diameter less than 0.1 micrometer, also called "nanoparticles" Their residence time is very short, on the order of minutes to hours.

PM2.5 and PM1 can go into the deepest part (alveolar) of the lung where gas exchange occurs between air and blood. These are the most dangerous particles because the alveolar portion of the lungs has no effective means to eliminate and if the particles are water soluble, they can pass into the bloodstream within minutes. If they are not soluble in water, they remain in the alveolar lung for a long time. Soluble elements may be of PAHs (**P**olycyclic **A**romatic **H**ydrocarbons) or residues of benzene classified as carcinogenic.

Standards:

	Europe (2010)	WHO	USA
	PM10 (<10 µm)		
P50* daily limit	50 µg/m^3 (less than 35 times/Y)	50 µg/m^3	150 µg/m^3
Annual limit	30 µg/m^3	20 µg/m^3	Cancelled in 2006
	PM2.5 (<2.5 µm)		
P50* daily limit		25 µg/m^3	
P98* daily limit			35 µg/m^3
Annual limit	25 µg/m^3 in 2010 20 µg/m^3 in 2020	10 µg/m^3	15 µg/m^3

*: The value must not exceed 50% (98%) of the time.

PM1 are not yet regulated.

Performances

Interface:

- RS485 Modbus digital output (see document on Modbus protocol for details)
  ASCII or RTU Modbus mode (to be chosen when ordering)
  Compatible with E4000 probe for interfacing with EnOcean, LON or KNX
  20 selectable BUS addresses (1 to 10 in RTU + 1 to 20 in ASCII with a jumper).
- EnOcean
  EEP : 4BS : A5-09-07
  Pairing with the push button (less than 1 second)

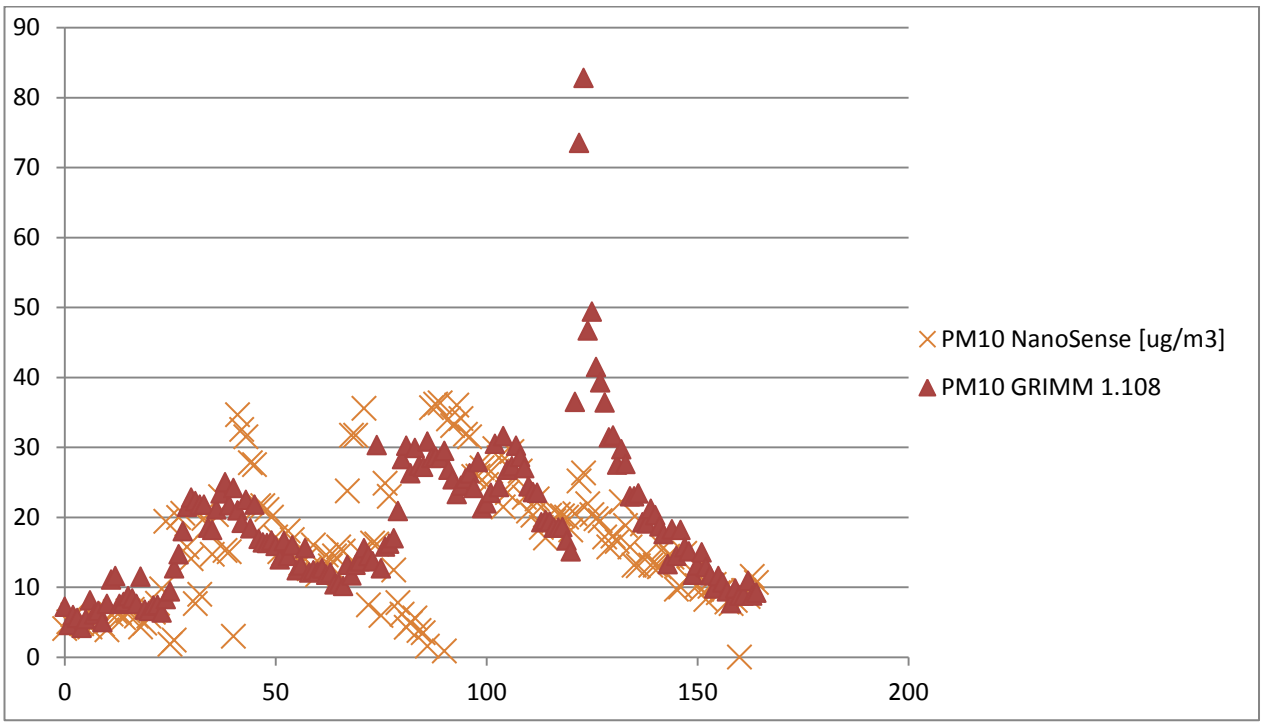
Densities of PM1, PM2.5 and PM10 expressed in µg/m3
Density of PM1, PM2.5 and PM10 also expressed in number/m3
Measuring range 0-950 µg/m^3 and 0-65 535 000 particles /m^3
Resolution 1µg/m3 and 1000 particles per m^3
Running average on 30 seconds
The sensor cannot see particles below 0.5µm
Power supply 12 to 24V DC or AC
Power: 1W
Operating Temperature: 0 to 45 °C.
Storage temperature: -30 to 60 °C

Calibration

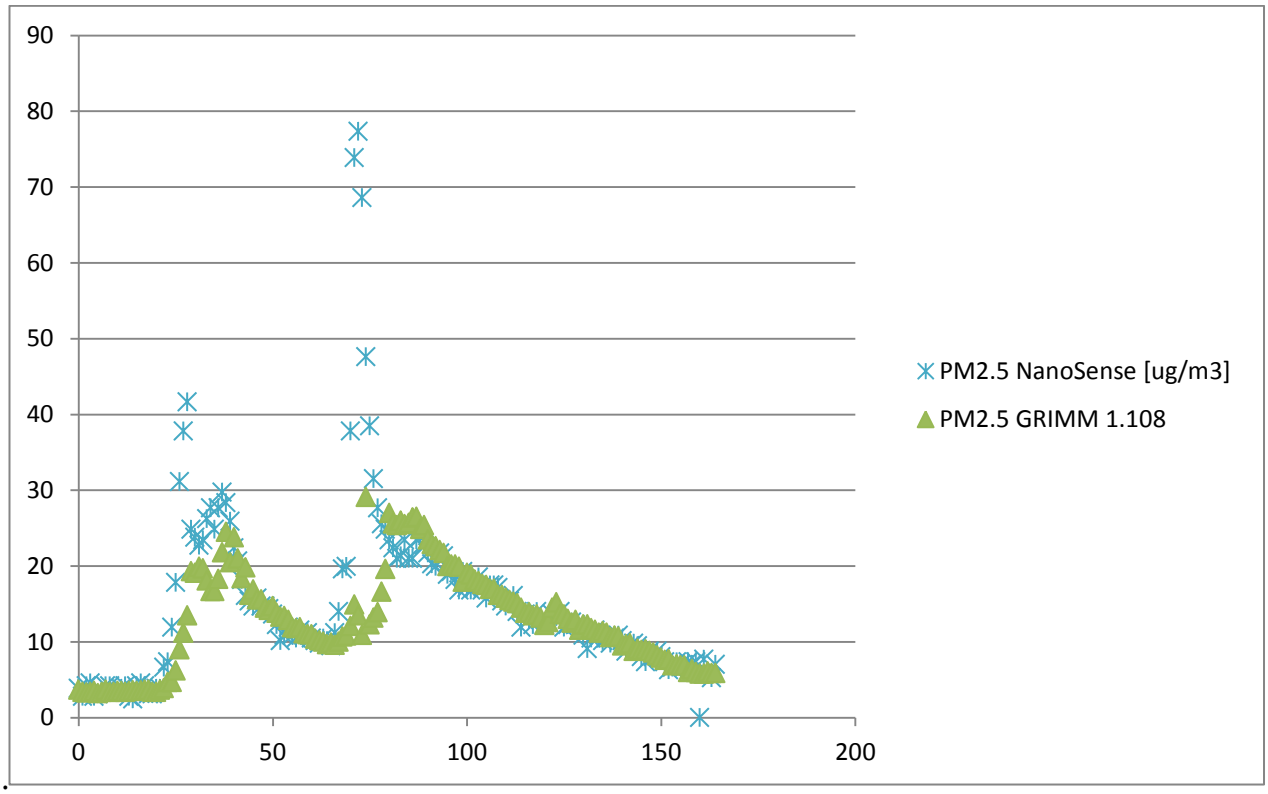
Performed at factory. Do not touch the potentiometer. No recalibration required if preventive maintenance is performed according to the rules

Comparison with a reference measuring device

The curves below show the P4000 probe measurements are quite close to the unit of reference. (Tests performed with an incense stick).



The peaks seen by the E4000 probe are probably due to an integration time steps shorter than the reference Device



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The measures are similar in PM1 counting but insignificant mass.

Examples

Public works are one of many sources of particulate matter (here compounded by the use of compressed air to clean the substrate).

Here is a portable blower who, under pretext of cleaning, dispersed in the atmosphere of a populated city dust particles including bird droppings and dog feces.

Swirling dust off toxic lead (source of lead poisoning), Metaleurop North Plant, shortly before its closure.

Indoor air pollutant particles (diesel fumes and soot type), left on the ceiling around an air inlet.