Air Quality Measurement Methods

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Main Criteria Pollutants

- US EPA Federal Reference Methods
- US EPA Federal Equivalent Methods

http://www.epa.gov/ttn/amtic/criteria.html

- Sulfur Dioxide (SO_2)
- Carbon Monoxide (CO)
- Nitrogen Oxides (NO_x - NO_2 - NO)
- Ozone (O_3)
- Particulate Matter (PM_{10} – $PM_{2.5}$)

Ambient Air Monitoring Station

Courtesy of SAIC/Port of Long Beach.

Ambient Air Monitoring Station

Courtesy of SAIC/Port of Long Beach and North Coast UAPCD.

How is SO_2 measured?

UV Fluorescence

This method is based on the principle that SO2 molecules absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength. Specifically,

$$2\ SO_2 + h_{v1} \rightarrow SO_2\ ^* \rightarrow SO_2 + h_{v2}$$

SO_2 Measurement

UV Fluorescence

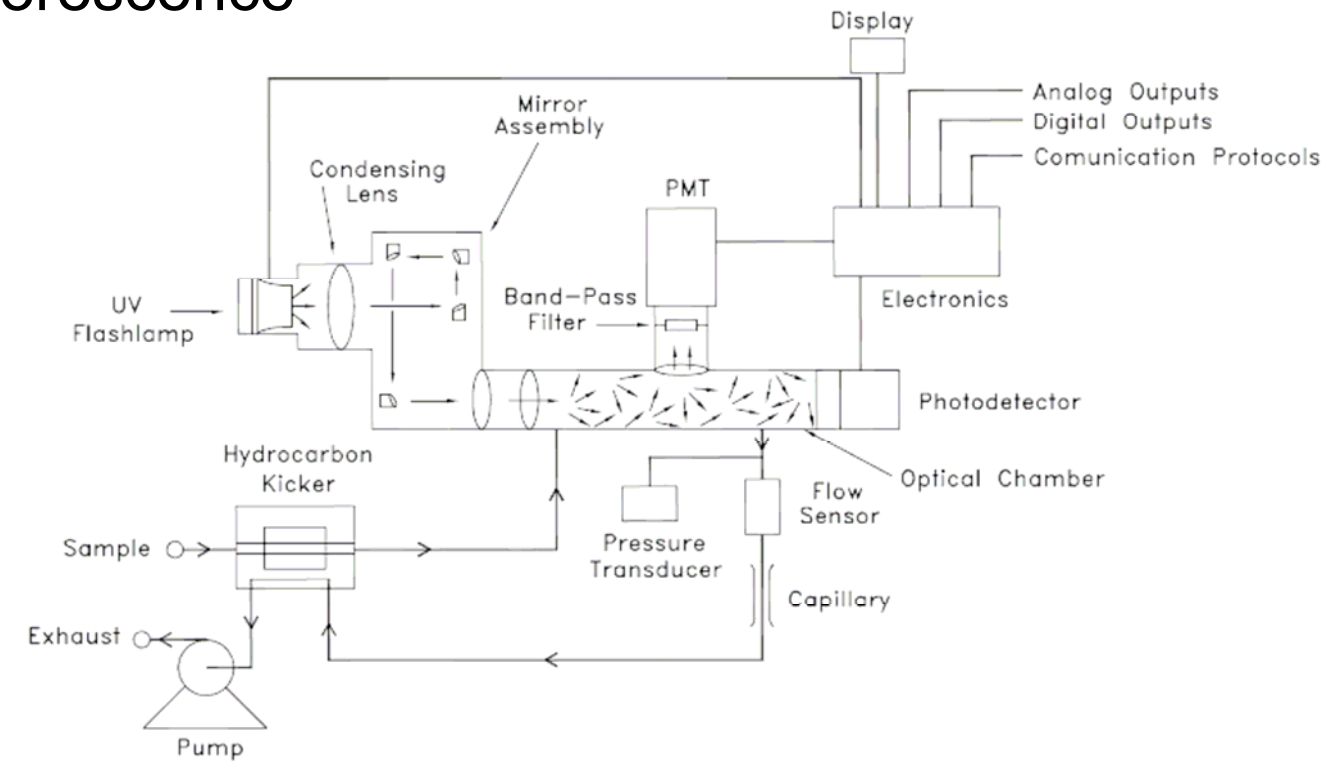


Figure 1. SO_2 Instrument flow diagram

How is CO measured?

Gas Filter Correlation

This method operates on the principle that carbon monoxide (CO) absorbs infrared radiation at a wavelength of 4.6 microns. Because infrared absorption is a non-linear measurement technique, it is necessary to transform the basic analyzer signal into a linear output.

CO Measurement

Gas Filter Correlation

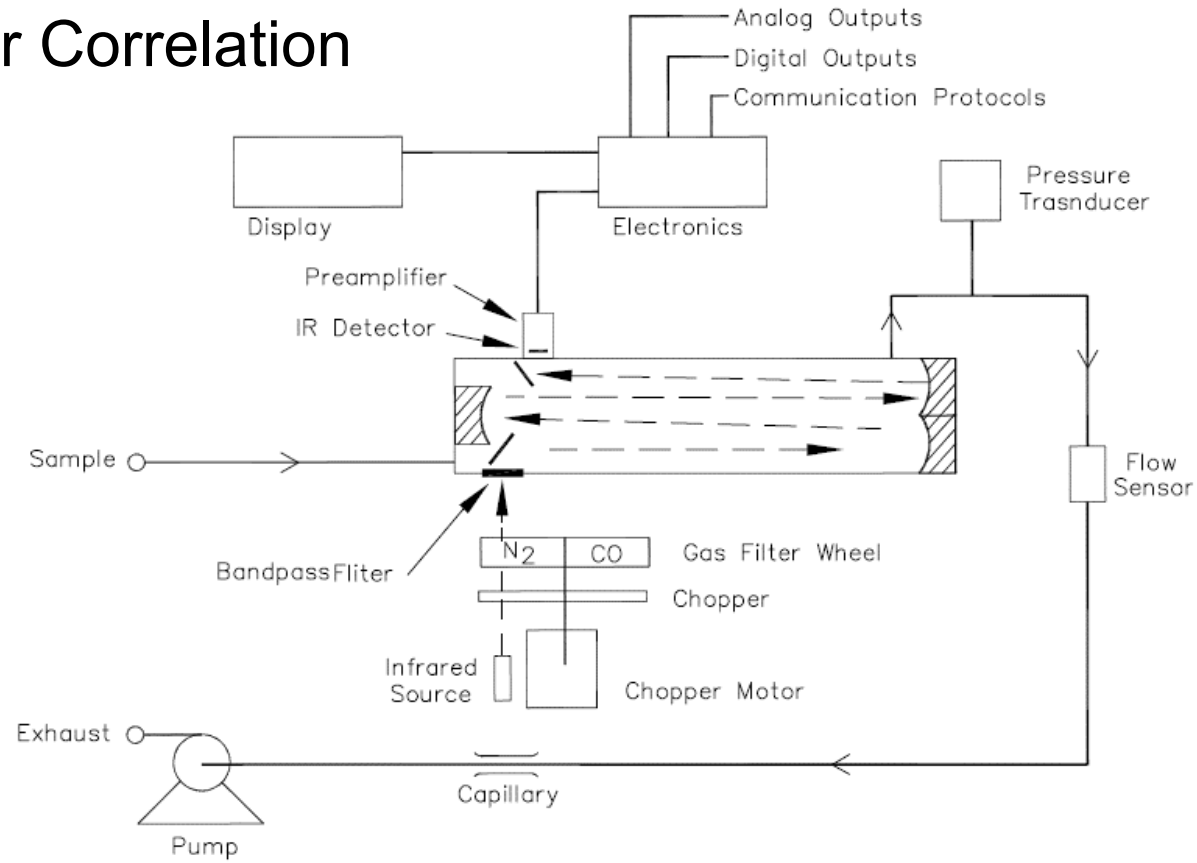


Figure 2. CO Instrument flow diagram

How is NO measured?

Chemiluminescence

The method is based on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to a lower energy states. Specifically,

$$NO + O_3 \longrightarrow NO_2^* + O2$$
$$NO_2^* \longrightarrow NO_2 + h_v$$

How is NO_x measured?

NO_2 reduction to NO

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum converter heated to about 325°C. Stainless steel converters can also be used which are heated to 625°C.

$$3\ NO_2 + Md \longrightarrow 3NO + MdO_3$$

NO_x – NO_2 – NO Measurement

Chemiluminescence

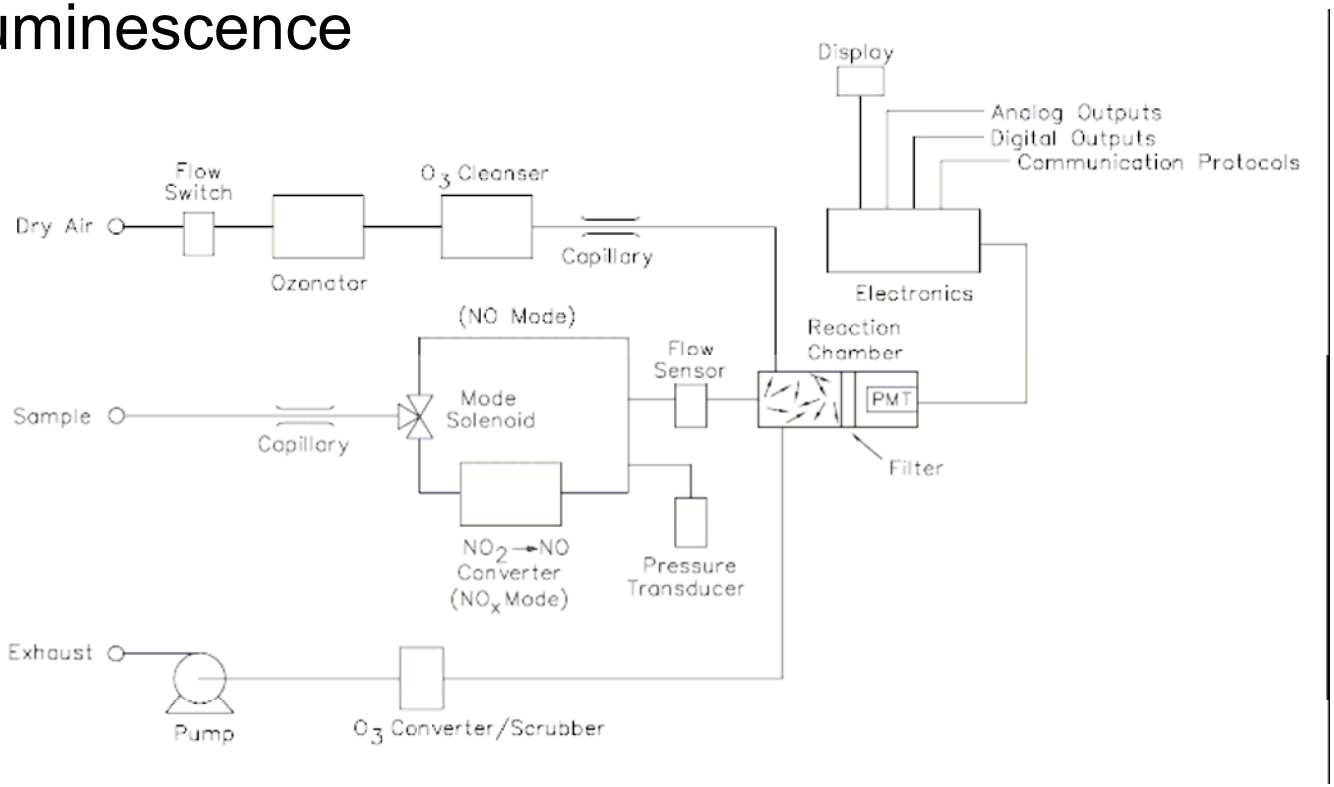


Figure 3. NO_x-NO_2-NO Instrument flow diagram

How is O_3 measured?

UV Photometric

This method operates on the principle that ozone (O3) molecules absorb UV light at a wavelength of 254 nm. The degree to which the UV light is absorbed is directly related to the ozone concentration as described by the Beer-Lambert Law:

$$\frac{I}{I_o} = e^{-KLC}$$

where:
K = molecular absorption coefficient, 308 cm-1 (at 0°C and 1 atmosphere)
L = length of cell
C = ozone concentration in parts per million (ppm)
I = UV light intensity of sample with ozone (sample gas)
Io = UV light intensity of sample without ozone (reference gas)

O_3 Measurement

UV Photometric

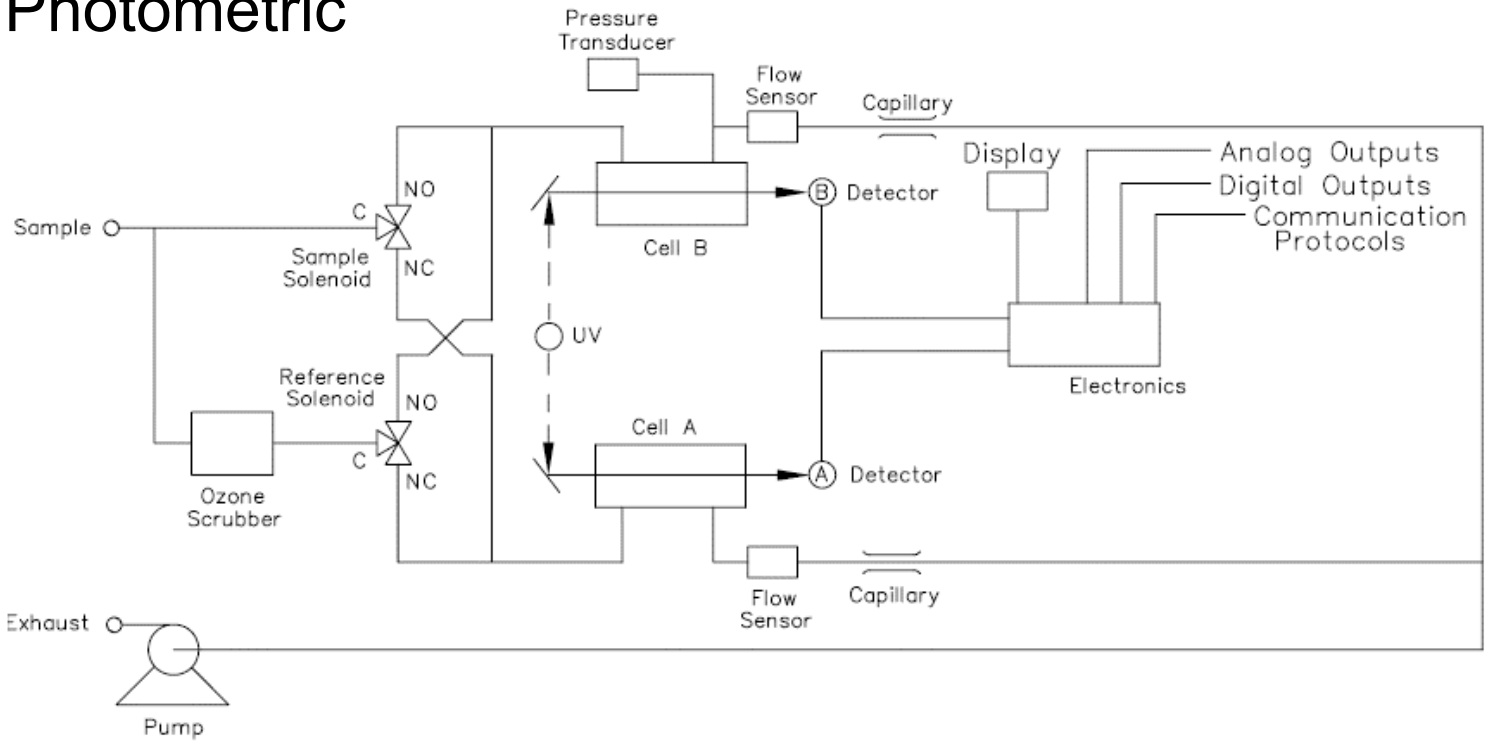


Figure 4. O_3 Instrument flow diagram

Particulate Matter Measurements

$$PM_x = \frac{M}{V}$$

Where:

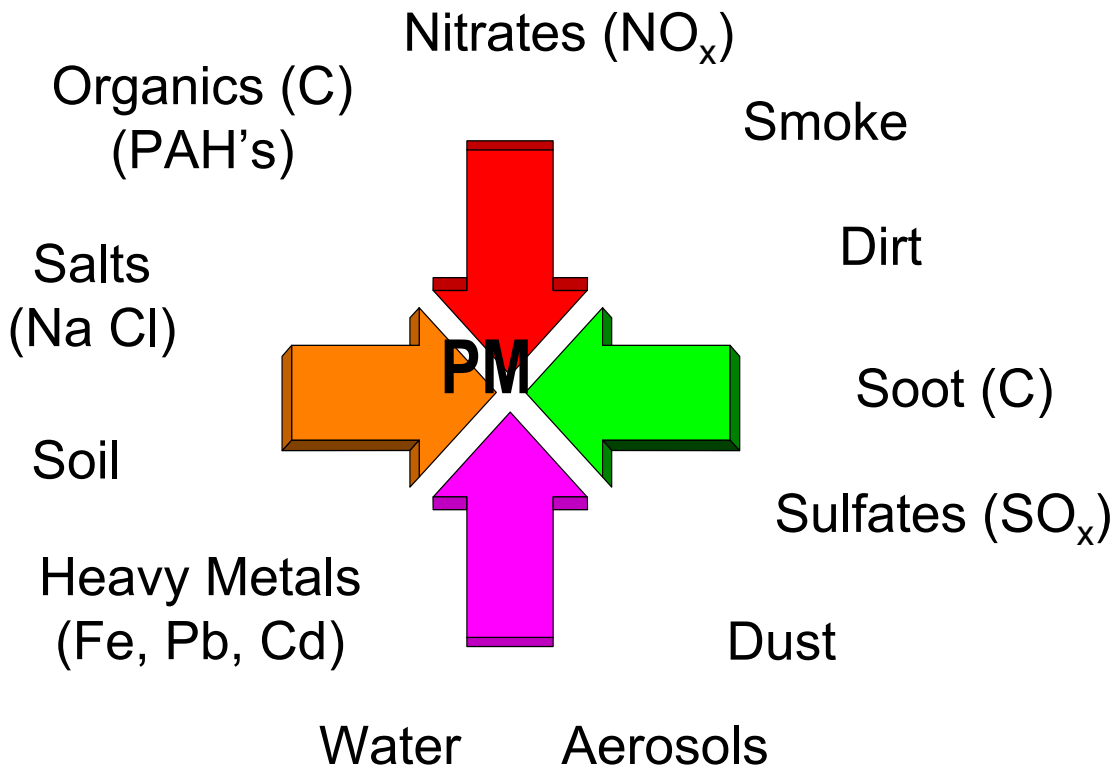
PM = Particulate Matter mass concentration [µg/m³] of particles less than ***x*** microns in diameter

M = ***Mass*** of sampled particles

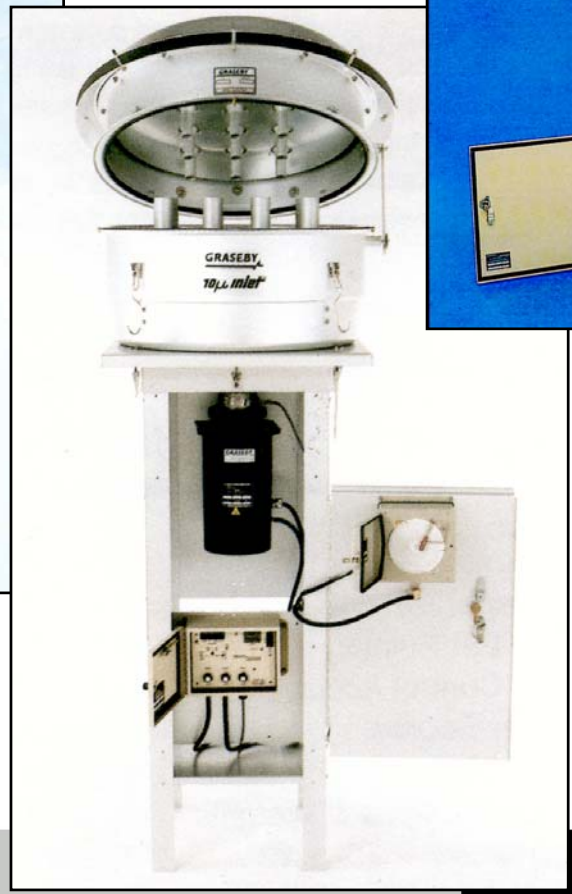
V = ***Volume*** of air sampled

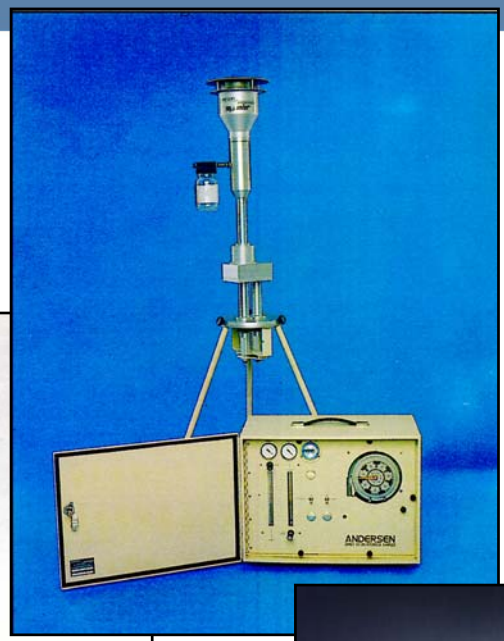
Particulate Matter Measurement

- *Particulate Matter comes in many forms and can be dynamic in the atmosphere.*



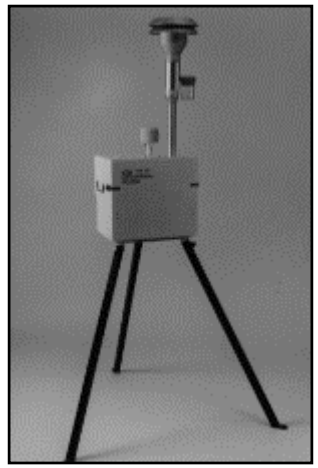
USEPA Designated PM-10 Reference Methods





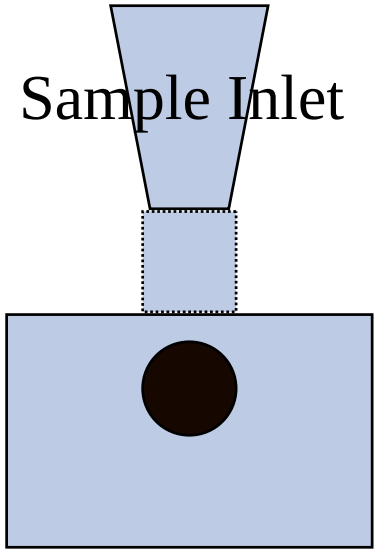
Source: Various manufacturer's literature

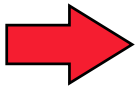
USEPA Designated PM-2.5 Reference Methods

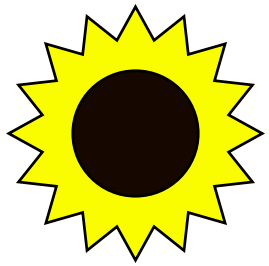


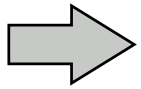
Source: Various manufacturer's literature

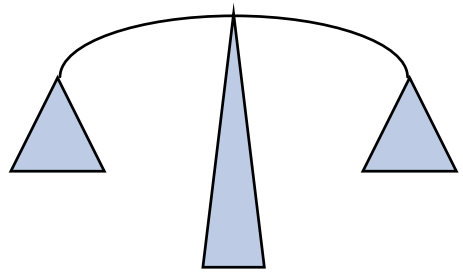
Particulate Matter Measurements







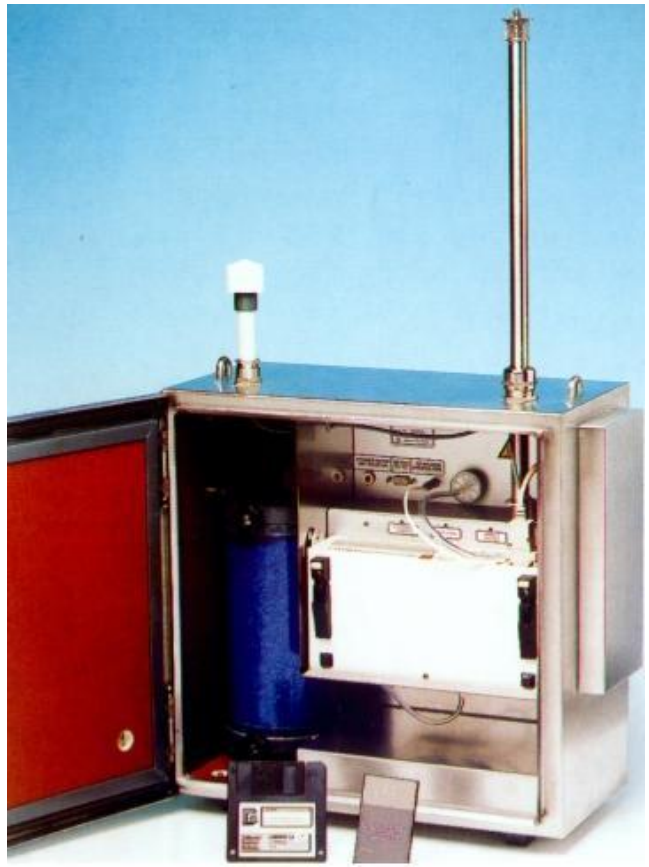




- Sampling being performed at ambient conditions.
- Sample filter is equilibrated to specified T, RH% (pre-sampling equilibration conditions)
- Sample filter is weighed

Continuous Real-time PM Monitors

BAM - Beta Attenuation Monitor

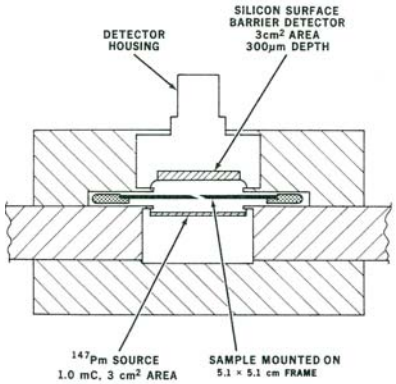


Light Scatter (nephelometer)

TEOM - Tapered element oscillating microbalance

Source: Various manufacturer's literature

Continuous Real-time PM Monitors



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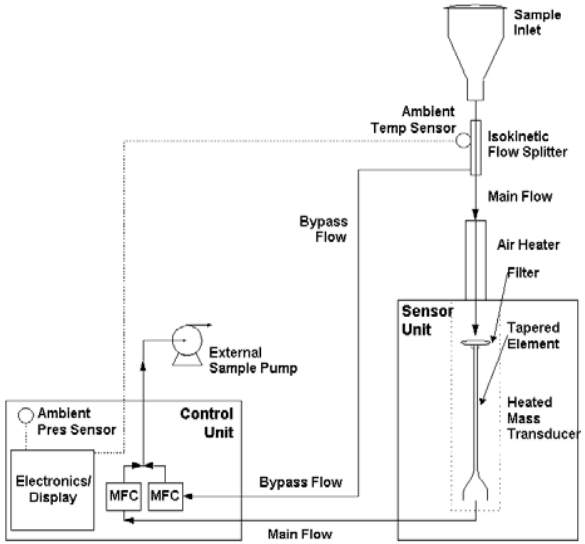

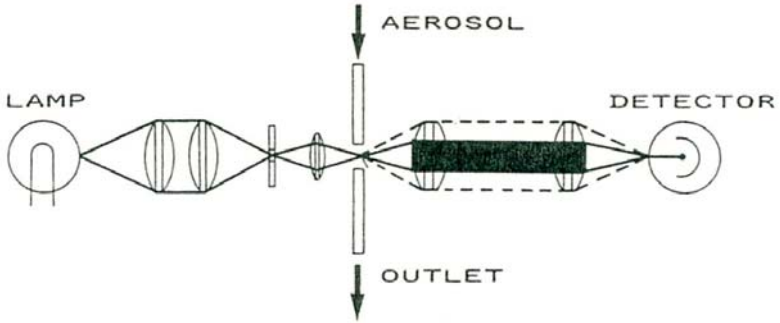

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Demonstration

Let’s go take a look…