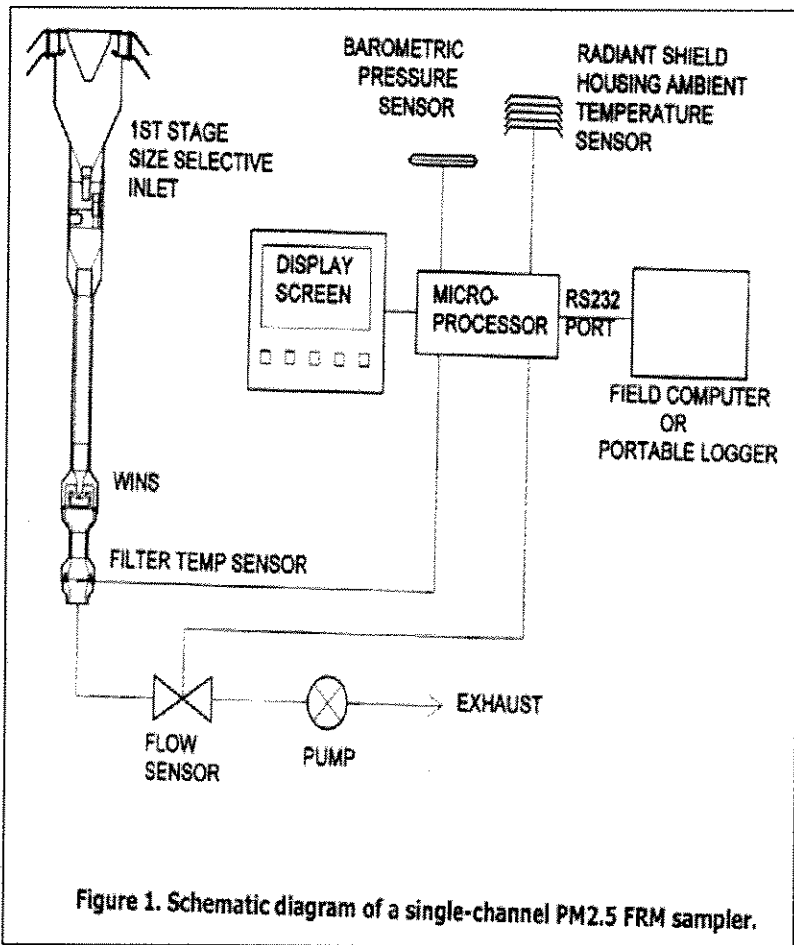
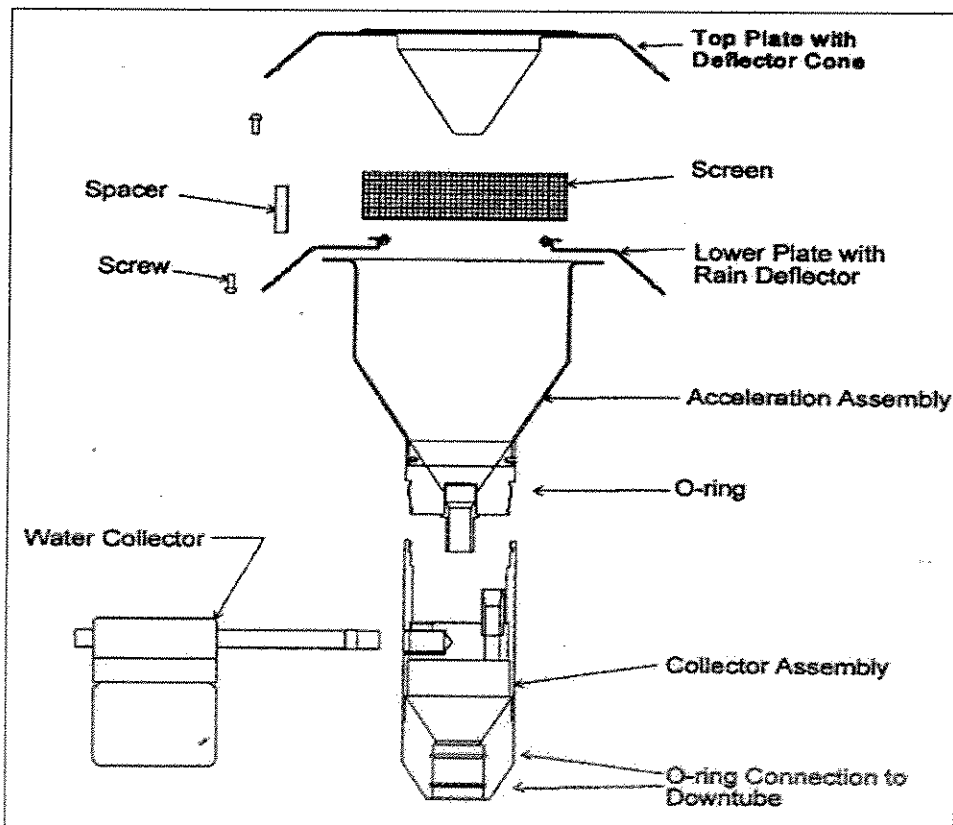


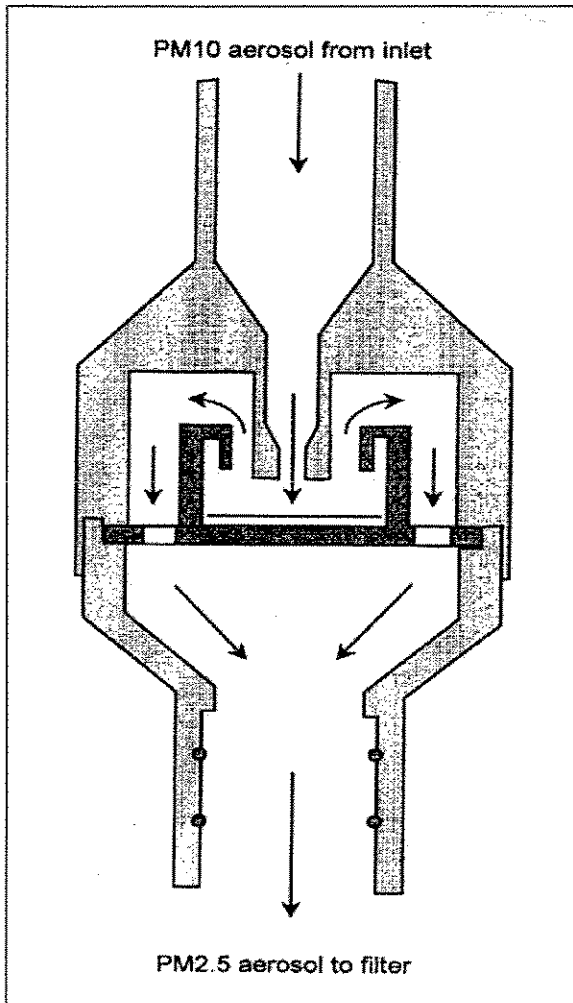
Example Problem 1 Measurement of PM2.5 Particle Mass Concentration in atmospheric air with the Federal Reference Method



The US Federal Reference Method which the EPA and other govt air pollution control agencies use to measure PM2.5 mass concentration in the atmospheric air has a 1st stage size selective inlet to remove particle larger than 10 μ m, then a 2nd impaction (or cyclone) stage to remove particles greater than 2.5 μ m in aerodynamic diameter (diameter of a unit density sphere which behaves the same in air as the real particle), and then the particles of 2.5 μ m and less continue to a filter which collects the PM2.5 particles. A PM2.5 system is shown to the left.



Shown to the left is a schematic of the size selective inlet for a PM2.5 sampler. The screen is to remove larger objects such as insects, leaves, etc. Particles larger than 10 μ m are removed in an impaction section. The PM10 aerosol (particles of 10 μ m and smaller) continue in the air flow towards the WINS impaction stage.



Shown to the left is the WINS impaction stage which uses an air jet to inertially impact the particles larger than $2.5 \mu\text{m}$ aerodynamic diameter and these impacted particles are collected in this section (on an oil covered collection plate in this WINS stage), the $\text{PM}_{2.5}$ aerosol particles continue in the air flow to be collected on the downstream filter.

WINS (Well Impaction Niney Six) was the EPA design originally specified for the Federal Reference Method for measuring $\text{PM}_{2.5}$ in ambient air.

The EPA allows other instrumentation to be used for $\text{PM}_{2.5}$ sampling if it is shown by measurements to provide identical $\text{PM}_{2.5}$ concentrations as the WINS method. The Sharp Cut Cyclone was developed by BGI ("Bob Gussman Inc") and has been shown to have the advantage of not needing oil to keep the particles from being re-entrained.

$$\text{microgram} := \frac{\text{gm}}{10^6}$$

$$\text{grain} := \frac{\text{lb}}{7000}$$

Given:

A $\text{PM}_{2.5}$ sampler is operated for 24 hrs at an air flow rate of 16.7 liter/min. The 47 mm filter is weighed before and after the air sampling and the particle weight was found to be 327 micrograms.

Find:

The $\text{PM}_{2.5}$ mass concentration in units of micrograms/cubic meter and grains/cubic ft (stock gas particle concentrations are reported in grains/ ft^3 units)

A. Calculation of volume of air sampled

$$\text{VolumeAirSampled} := (24 \cdot \text{hr}) \cdot \left(60 \cdot \frac{\text{min}}{\text{hr}}\right) \cdot \left(16.7 \cdot \frac{\text{liter}}{\text{min}}\right)$$

$$\text{VolumeAirSampled} = 24.048 \text{ m}^3$$

B. Calculation of $\text{PM}_{2.5}$ Particle Mass Concentration

$$\text{VolumeAirSampled} = 849.247 \text{ ft}^3$$

$$\text{PM}_{25} := \frac{(327 \cdot \text{microgram})}{24.048 \cdot \text{m}^3}$$

$$\text{PM}_{25} = 13.598 \frac{\text{microgram}}{\text{m}^3}$$

$$\text{PM}_{25} = 5.942 \times 10^{-6} \frac{\text{grain}}{\text{ft}^3}$$

Note that the particle mass concentration in stack exhaust gases can be on the order of 0.001 grains/ ft^3 and hence the lower atmospheric $\text{PM}_{2.5}$ concentrations are caused by dilution with atmospheric air which is much cleaner than the stack exhaust gases.