Sampling for particulates

EOH 466B
Evaluating the Occupational Environment
Spring 2008

Overview

- Draw known volume of air past filter. Filter is tube, paper, etc.
- Use size pre-selector according to hazard.
- Use a certified method. Otherwise research a method.

Method Discussion (NIOSH METHOD)

- NIOSH Methods readily available.
  - Use NIOSH Applet to demonstrate / discuss sample development.
- Sampling method
  - Review a NIOSH method
- Measurement section describes chemical analysis.
- Interferences and applicability

Sample Handling

- Sample handling
  - Label with unique number
  - Sample data sheet: unique numbers, time, date, duration, comments.
  - Sample seals, as required by method. Security seal.

Sample Handling

- Storage: as described, avoid elevated temperatures. Note sample stability.
- Instructions to lab
  - Analysis method desired (eg NIOSH method 1501)
  - Describe media submitted
  - Date of sampling
  - Location
  - Method
  - Volume
  - interferants
  - Sample number
  - Date shipped
  - Comments

Sample Handling

- Quality control
  - Field blanks, described in method.
  - Media blanks, usually supplied by laboratory. Unless you provide media.
  - Spiked samples. OK, but make sure you know what you are doing.
  - AIHA accredited laboratory.

Laboratory Reports

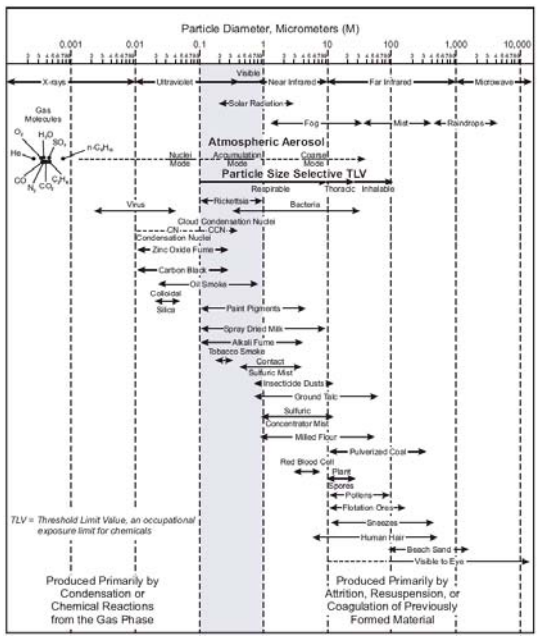
- Name of lab, analyst, reviewer.
- Analytical method used, with modifications.
- Lab sample numbers associated with customer sample numbers.
- Dates: receipt, analysis, report.
- Quantification limit.
- Potential interference.

Sample Calculations

- Sample volumes depend on quantification limit.
  - Example, aromatic hydrocarbons from NIOSH method: 0.001 to 0.01 mg per sample. The method also describes a measurement range, at minimal flow (eg toluene 548 - 2190 mg/ M^3).
  - Minimal sample volume is product of expected concentration, flow rate and minimal detection limit.

Sample Calculations

- Maximum sample volume depends on breakthrough, or overload of filter. For organic vapors, breakthrough when rear filter is >= 10 % of front filter.
- If necessary, correct sample volume to NTP.



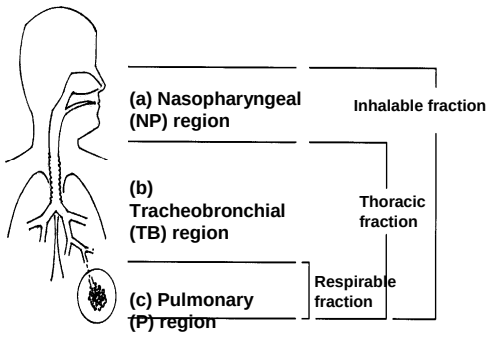
Particulates

- Particle size specific sampling is often needed. (look to web page)
  - IPM, TPM, RPM.
  - Pre-selectors allow desired particle sizes to be collected on a filter.
  - Filters intercept particles, but are themselves size-selective.
  - Historically, impingers were used.

Particulates

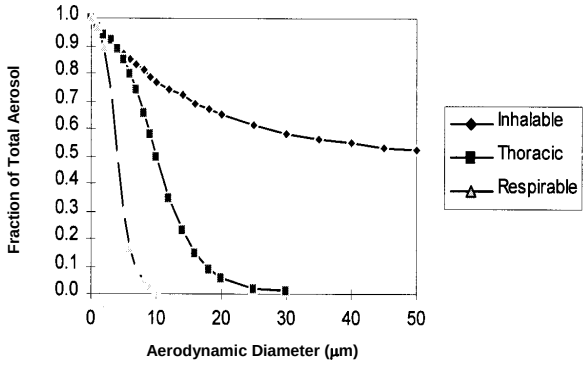
- Particle deposition can be different than IPM, TPM, RPM.
  - difference between nose and mouth breathing
  - complex relationship between anatomy, breathing rate, particle behavior in the lungs.
- NIOSH file

Regions of the Respiratory Tract



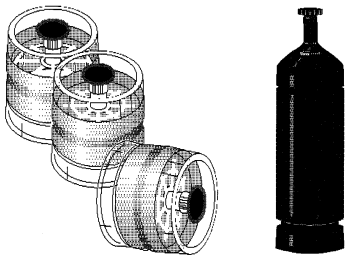
(a) the NP region conditions inhaled air to body temperature and essentially 100% relative humidity and efficiently removes larger particles; (b) the TB region conducts inhaled air quickly and evenly from the mouth and nose to the pulmonary spaces; (c) the P region performs the gas exchange function of respiration.

Collection Efficiency As a Fraction of Total Aerosol of Samplers



Collection efficiency as a fraction of total aerosol of samplers performing according to the ACGIH/ISO/CEN size selective sampling criteria.

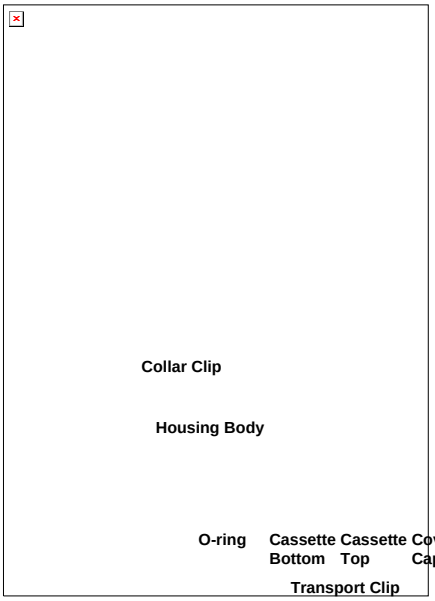
Filter Cassettes



A B

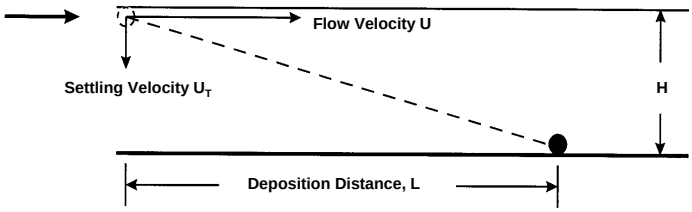
Commonly used filter holders include (a) the 37-mm three-piece styrene acrylonitrile cassette used as shown or in open-face mode with one end removed, and (b) the polypropylene 25-mm cassette with cowl, specifically for use in asbestos sampling (end cap shown is removed during sampling) (graphics courtesy SKC, Inc., Eighty Four, Pa.).

IOM Inhalable Dust Sampler

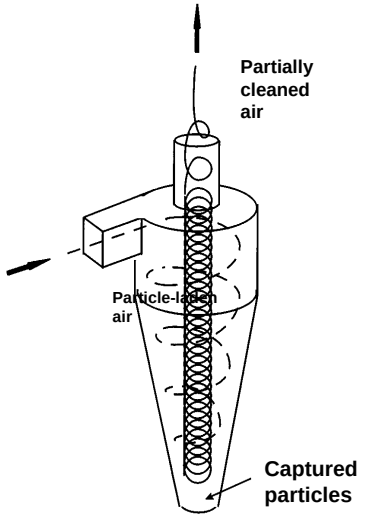


Developed by J.H. Vincent and D. Mark at the Institute of Occupational Medicine, Edinburgh, Scotland. For gravimetric analysis the interior cassette, containing the filter, is weighed before and after sampling. The sampler meets international sampling criteria for inhalable particulate matter (graphic courtesy SKC, Inc.).

Particle Deposition in an Idealized Horizontal Elutriator



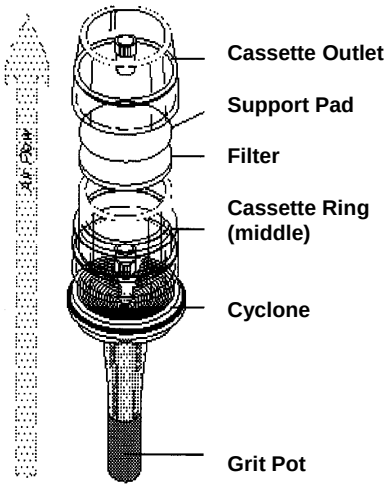
In reality, U is not constant because a parabolic flow velocity profile will exist between the top and bottom plates, and the particle will not follow a straight line trajectory; however, the approximation is adequate for instrument design.



Cyclone Separator

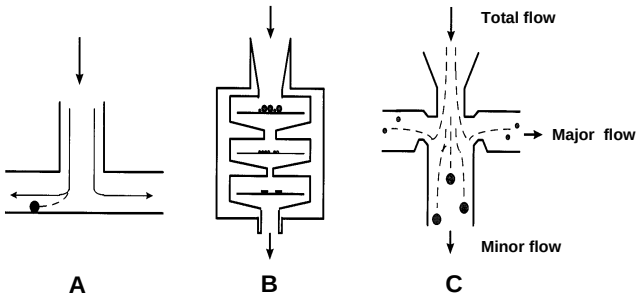
Suspended particles are captured by increasing centrifugal forces as the air spirals down the cone of the cyclone; the airflow and uncaptured particles spiral back up the central axis and exit through the top. In a personal respirable aerosol sampler the exiting air, carrying the respirable particle fraction, passes through a cassette filter, where the particles are captured for gravimetric or other analysis.

Personal Cyclone



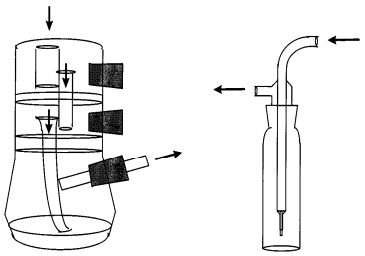
Exploded view of a personal respirable dust sampling assembly incorporating an SKC aluminum cyclone and 37-mm three-piece filter cassette. Nonrespirable particles are collected in the grit pot at the base of the cyclone, and the respirable fraction is collected on the filter for subsequent weighing or chemical analysis (graphic courtesy SKC, Inc.).

Inertial Impactors



(a) conventional jet-to-pate impactor collecting a single size fraction (say all particles over 10 µm); (b) multistage or cascade impactor in which each stage collects a different size fraction; and (c) virtual impactor or dichotomous sampler in which size fractions are separated but not removed from the airstream.

Liquid Impingers

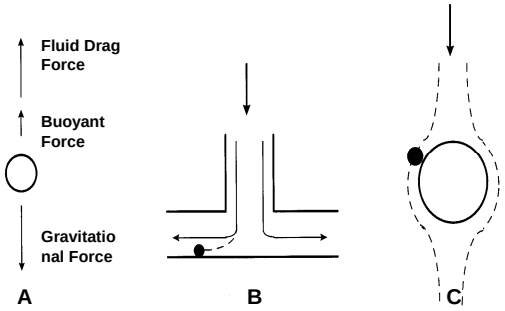


(a) multistage impinger in which a jet impinges on a wet surface, and (b) all glass impinger in which a jet impinges on a liquid surface or a submerged jet impinges on the bottom of the impinger.

Filtration Theory

- Forces that cause particles to be collected.
  - Interception
  - Sedimentation (minor)
  - Impaction
  - Diffusion
  - Electrostatic capture
- Affected by flow rate (velocity), filter media, humidity.

Aerosol Particle Collection Mechanisms



(a) sedimentation — at terminal (maximum) settling velocity, the fluid drag and buoyant forces will exactly offset the particle's weight; (b) inertial impaction — the particle's inertia carries it across airflow streamlines as the air changes direction; and (c) interception — the flow streamline passes the collecting body (such as a filter fiber) within a distance of one-half the particle's diameter.

Filtration Theory

- Calculate face velocity for a 37-mm filter at 2 Lpm. Assume all of area is available for filtration.
- Some consideration of filter theory is included in methods development.

Filtration Theory

- Summary of effects
  - 0.3 μ particles most easily penetrate filters.
  - Face velocity increases, efficiency increases.
  - Filter loading increases efficiency.
  - Filters vary in their performance.

Sampling Considerations

- Collect sufficient material for analysis: balance flow rate and mass collected. Resistance to flow may be an issue.

Sampling Considerations

- Analytical concerns. Some protocols require analysis of material on the filter, then additional analysis. Radioactivity evaluation of material on surface of filter. Content of filter, limit interference. Release from filter for analysis.

Sampling Considerations

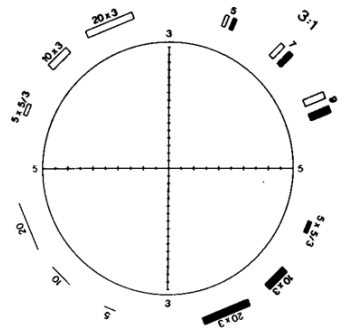
- Location of material on filter (deposition patterns). Example: asbestos analysis: count fibers in an area. Random sample of surface area.

Asbestos Analysis

- Count fibers appearing in graticle, and calculate average number per field e.g. 100 fibers in 50 fields is 2 fibers per field.

Asbestos Analysis

- For new NIOSH Method: Graticle area is 0.00785 mm^2 and filter area is 385 mm^2



Filter Types

- Cellulose fiber filters: low cost, moderate strength. Whatman 41 is common type. Poor performance for small particle size and low face velocity (less than 100 cm/sec)

Filter Types

- Glass fiber filter: more fragile than cellulose fiber. More efficient, particularly for small particle size. Stable at high T and chemical attack. Benzene, water and nitric acid extracts can be made. Quartz fiber filters becoming more popular.

Filter Types

- Membrane filters (Teflon, PVC, cellulose). Pore size from 0.025 μ to 10 μ. soluble, low ash content. Particles collected on surface of filter. Low capacity. Pressure drop.
- Asbestos: 0.8 μm mixed cellulose ester

Filter Types

- Polycarbonate pore filters (Nucleopore): U-235 make pores. Straight channels. Mechanical strength. Efficiency can be poor for large pore sizes.
- Filters are transparent
- Electron microscopy and X-ray Fluorescence

Filter Types

- Silver membrane filters: thin layer pure silver. Pore sizes 1.8 to 19 μ. benzene extractable like coal tar pitch volatiles.
- X-ray diffraction analysis for crystalline silica.

Direct Reading Instruments for Particulates.

- Optical devices
  - Light-scattering photometers: measure the light scattered by a cloud of particles in a light path. The amount of light scattered can be translated into the mass of particles collected.
  - Instrument used in lab is a forward-scattering photometer.

Direct Reading Instruments for Particulates.

- Light-attenuating photometers: measure decrease in light from aerosol in a light path. Useful in high concentrations. Most useful when conditions are reproducible, or contaminants are known.
- Used in stack sampling (air pollution control).

Direct Reading Instruments for Particulates

- Optical devices
  - Light-scattering particle counters: Direct reading instruments that measure light scattered by individual particles, and count and size at the same time. Effective for particles between 0.5 and 30 microns.
  - Condensation Nuclei counters: count very fine particles (< 0.05 micron). Very small particles are made larger by condensation of vapor.

Direct Reading Instruments for Particulates

- Resonant oscillation aerosol mass monitors: use a special crystal to measure the mass of particles deposited on a crystal. The crystal is called a piezoelectric crystal; the crystal will generate an electric current that is proportional to the mass collected on the crystal.

r2p: Personal Dust Monitor

Direct reading instruments for particulates

- Beta attenuation: a mass of material, collected on a plate, will attenuate beta radiation. Mass deposited is proportional to the attenuation.