OSC|10
Ohio Safety Congress & Expo

Aerosol sampling – How particle size-selective criteria impacts your exposure monitoring program

312

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Tuesday, March 30, 2010 9:30 to 10 :30 a.m.

Objectives

- Aerosol Monitoring
  - Understand rationale for size selective criteria
  - Learn to choose the right sampler for the aerosol being monitored.
  - Identify good practices for using the samplers.

In The Past

Total Dust

- Method for most aerosol sampling was "total dust".
- A 2 or 3 piece polystyrene cassette housing a 37-mm membrane filter backed by a cellulosic support pad.

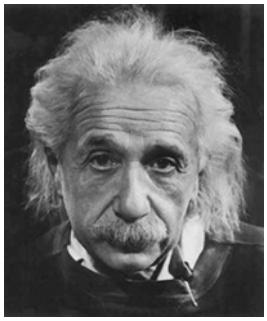
Total Dust

- Air sampled into the 4mm orifice of the closed face cassette and through the filter.
- Aerosol is collected on the filter face.
- Collected samples capped and returned to the laboratory

Total Dust

- Limitations
  - No defined cut point
  - No sampling method is 100% efficient ("total")
  - Ineffective (underestimate) larger 30 – 100 micron particles
  - Particles adhere to cassette walls
  - Sample loss

Knowledge Expands



Began Questioning

- Sample losses – particulate adhering to cassette walls
- Interpretation of results without defined cut point
- Underestimation of larger particles
- Leads us to ……

Particle Size Selective Criteria

- Recognizes the potential hazard of aerosols depends on:
  - Mass concentration
  - Particle size
    - Effects the deposition site
    - Relationship between occupational disease and material being deposited in specific regions of the respiratory tract

Particle Size Selectivity - History

- 1980's – early 1990's
- Committees
  - International Organization for Standards (ISO) (1983)
  - American Conference of Governmental Industrial Hygienists (ACGIH) (1982)
  - Comit European de Normalisation (CEN) (1987)
- Developed internationally accepted definitions of sampling criteria

Particle Size Selectivity - History

- German Commission
  - MAKs replaced total with respirable and inhalable
- UK Health and Safety Executive
  - Already changed all OELs from total to respirable

Particle Size Selective Criteria

- ACGIH
  - History with respirable fraction for crystalline silica
  - 1993 revised Appendix and adopted 3 mass fractions
  - Currently re-examining substances to identify
    - Size selective fraction associated with health effect
    - Mass concentration within the fraction for TLV

Particle Size Selective Criteria

- Particle Size Selective TLVs
  - Inhalable Particulate Matter
    - Hazardous when deposited anywhere in respiratory tract

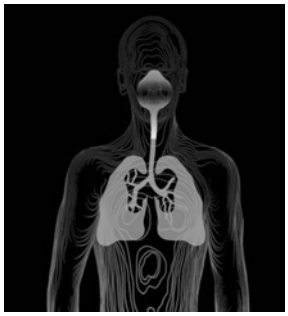
Particle Size Selective Criteria

- Particle Size Selective TLVs
  - Thoracic Particulate Matter
    - Hazardous when deposited anywhere within lung airways and the gas-exchange region
    - Particles that pass the larynx and penetrate conducting airways

Particle Size Selective Criteria

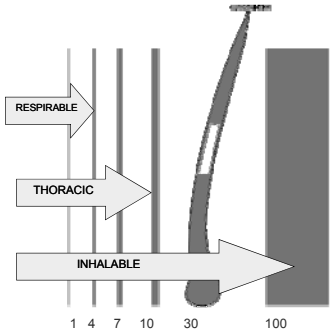
- Particle Size Selective TLVs
  - Respirable Particulate Matter
    - Hazardous when deposited in the gas exchange region
    - Deepest part of the lung (alveoli)

Particle Size Selective Criteria



- Inhalable
- Thoracic
- Respirable

Particle Size Selective Criteria

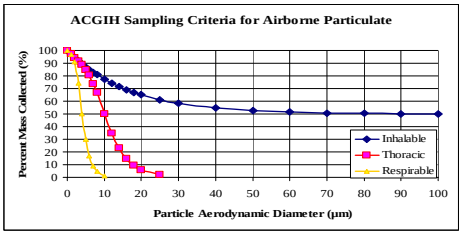


•Respirable
•4 micron

•Thoracic
•10 micron

•Inhalable
•100 micron

Particle Size Selective Criteria



Particle Size Selective Criteria

- Two other terms
  - Tracheobronchial
    - Particles that pass beyond the larynx but do not reach alveoli
    - Tracheobronchial = thoracic - respirable
  - Extrathoracic
    - Fraction of inhaled particles that do not penetrate beyond the larynx
    - Extrathoracic = inhalable - thoracic

Respirable Fraction Sampling

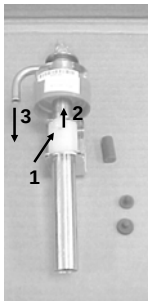
- Cyclones
  - Traditional samplers for respirable particulate matter
  - Named for the rotation of air within the chamber
  - Function on the same principle as a centrifuge
  - Use rapid air circulation to separate particles by aerodynamic diameter
    - Small particles whirled up onto filter
    - Large particles fall into grit pot

Respirable Fraction Sampling

- Variety available

Respirable Fraction Sampling

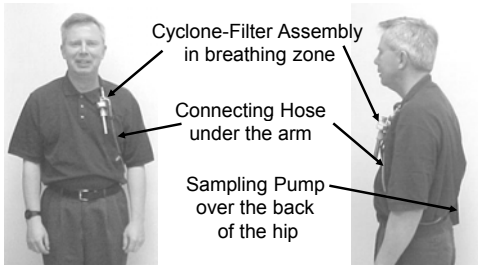
- MSA Cyclone



1. Air enters the opening between the vortex finder and the cyclone.
2. Air travels through the cyclone; up through the vortex finder; up through the coupler; and through the filter cassette.
3. Air exits the cyclone-filter assembly through the side arm to the pump.

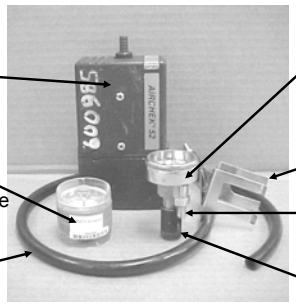
Respirable Fraction Sampling

- MSA Cyclone



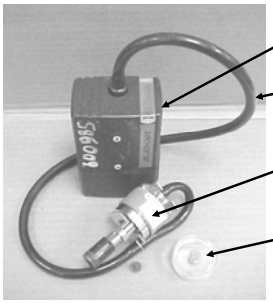
Respirable Fraction Sampling

► BGI Cyclone



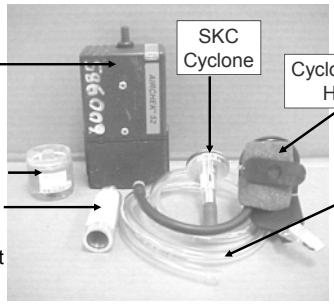
Respirable Fraction Sampling

► BGI Cyclone



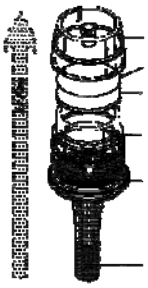
Respirable Fraction Sampling

► SKC Cyclone



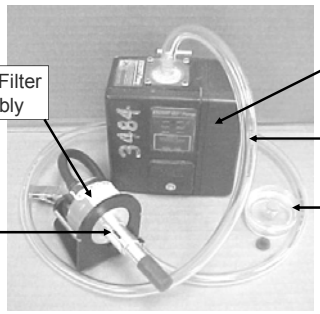
Respirable Fraction Sampling

► SKC Cyclone



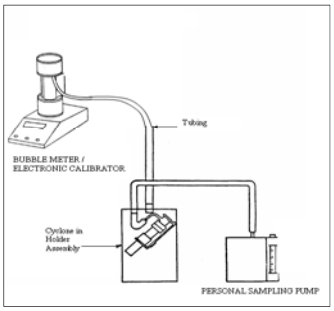
Respirable Fraction Sampling

► SKC Cyclone



Respirable Fraction Sampling

► Calibration Jar



Respirable Fraction Sampling

► Piston Style Calibrator

- Attach cyclone to calibrator pressure point
- Pump to suction port

Respirable Fraction Sampling

► Tips

- Prepare cyclone/filter assembly
  - Have plastic bags available
  - Do not invert
  - Make sure filter is inserted correctly

Respirable Fraction Sampling

► Tips

- Calibrate pump with sampler in line
  - Run pump for 15 minutes
  - Calibrate with cassette/filter assembly not used for sample collection
  - Make sure specified flow rate is used
    - MSA 1.7 lpm
    - SKC AI 2.5 lpm
    - BGI 2.2 lpm

Respirable Fraction Sampling

► Tips

- Collect sample at specified flow rate
  - Sample duration sufficient for target LOQ
  - Inlet faces forward
- Remove cyclone/filter assembly at end of period
  - Do not invert assembly
  - Recap cassettes immediately

Respirable Fraction Sampling

► Tips

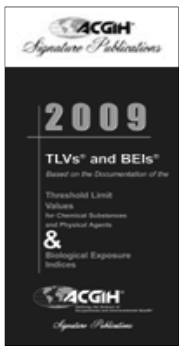
- Recalibrate pump
  - Flow variation < 5%
- Clean cyclone before reuse
  - Mild soapy water or IPA
  - Air or blow dry
  - Wipe exterior with dust-free tissue or IPA wipe
  - Do not use strong solvents

TLVs – Inhalable Fraction

► Currently 70+

► 8 more on 2009 NIC list

► Total particulate (PNOS) - guideline



Inhalable Fraction Sampling

► IOM Sampler

- Developed at the Institute of Occupational Medicine, Edinburgh, Scotland.
- Mimics particulate intake of human respiration.
- Sampling head with a 15mm orifice housing a 25mm filter within a contained stainless steel or conductive plastic cassette.
- Sampled cassettes removed from the sampler body, capped, and submitted to the laboratory in a transport clip.
- Initially used for gravimetric analysis and later expanded to compound specific sampling.

Inhalable Fraction Sampling

► IOM Sampler

IOM Advantages

► Filter and cassette weighed together

► Dislodged particulate retained in cassette

► No wall losses due to static electricity

► Performance independent of wind speed for particles up to 75 micron aerodynamic diameter

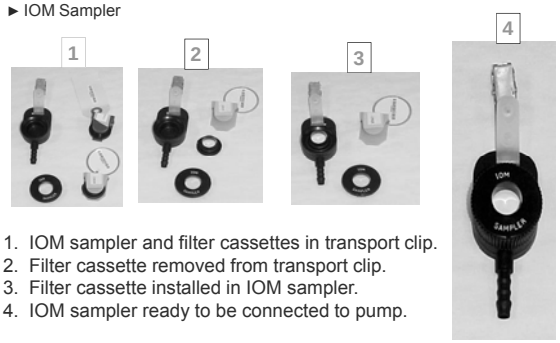
Inhalable Fraction Sampling

► IOM sampler

Filter cassettes in transport clips separate from IOM sampler. Remove filter cassette from transport clip and install in IOM sampler.

Inhalable Fraction Sampling

► IOM Sampler

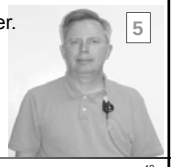


1. IOM sampler and filter cassettes in transport clip.
2. Filter cassette removed from transport clip.
3. Filter cassette installed in IOM sampler.
4. IOM sampler ready to be connected to pump.

Inhalable Fraction Sampling

► IOM Sampler

1. IOM sampler and flow rate calibration adapter.
2. Sampler and adapter assembled.
3. IOM sampling train connected to rotometer. Flow rate 2 LPM.
4. IOM sampling train connected to burette.
5. IOM sampler on worker.



Inhalable Fraction Sampling

► Tips
- SKC sole source
- Plastic model light weight (< 2 oz)
- Foam insert allow for size selectivity
- Stainless steel model
  - Ultimate moisture stability
  - Allows autoclaving at higher temperatures

Inhalable Fraction Sampling

► Tips
- Wear gloves when handling cassettes
- Use tweezers when working with filters

Inhalable Fraction Sampling

► Tips
- Calibrate
  - Insert IOM with filter cassette into adapter
    - Push IOM through hinged bracket
    - Place inlet against foam ring
    - Clamp IOM in place with clamping screw until foam ring compresses 1 mm
    - Screw hose barb into threaded hole on adapter
    - Connect hose barb to calibrator outlet
    - Connect IOM outlet to sampling pump
    - Disconnect representative IOM and save for post-cal

Inhalable Fraction Sampling

► Tips
- Post sampling
  - Remove cassette
  - Place cover on cassette immediately
  - Wipe external surface with lint-free cloth or brush
  - Place cassette with cover into transport clip
  - Wear gloves
- Transporting
- Blanks

Inhalable Fraction Sampling

► Tips
- Transporting
  - Place cassette in transport clip in plastic bag
  - Package in padded container

Button Sampler

Button Sampler

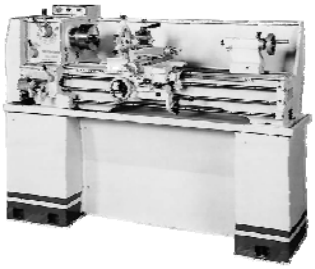
- ► Inlet screen
- ► Closed face inlet keeps out large particles
- ► Higher flow rate (4 lpm) improves sensitivity
- ► Multidirectional sampling capabilities
- ► Minimized wind sensitivity
- ► Calibration adapter or calibration chamber required
- ► Use filter pore size 1 micron or greater
- ► Filter transport cases required

Inhalable Fraction Sampling

- ► Don't Be Surprised By Results
  - Studies report the mass ratio of aerosols collected for IOM samplers / "Total Dust" > 1.
  - Ratio by which "Total Dust" samplers under sample IOM samplers typically range from 2 to 4.
  - Ratio of IOM / "Total Dust" appears to be particle size dependant and greater for larger particles.

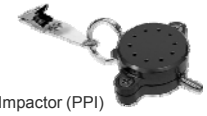
TLV - Thoracic Fraction

- ► Sulfuric Acid
- ► NIOSH Method 5524 – metalworking fluids



Thoracic Fraction Sampling

- ► Personal Environmental Monitor (PEM)



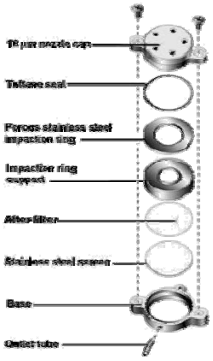
- ► Parallel Particle Impactor (PPI)

Thoracic Fraction Sampling

- ► PEM
  - PM_{10}
    - Single stage impactor removes particles above 50% cut point
    - Cut point = 10 microns
    - Large particles collected on greased ring
    - Small particles collected on 37 mm after-filter

Thoracic Fraction Sampling

- ► PEM



Thoracic Fraction Sampling

- Tips
  - Assemble PEM/PPI
  - Wear gloves
    - Use tweezers to place filter on filter support screen
    - Set impaction ring assembly on filter
    - Screw nozzle cap in place
    - Ready to calibrate
      - Use flow calibration cap adapter
      - 2 lpm (maybe)

Thoracic Fraction Sampling

- PEM/PPI Tips
  - Post-calibrate
  - Wear gloves
  - Remove filter with tweezers
  - Do not turn filters upside down
  - Place in sealed container (like SKC Filter-Keeper)

IEQ

- EPA has methods for pollutants in indoor air
- Particulate defined as PM_{10} or $PM_{2.5}$
- Method IP 10A specifies size selective impaction
- Method referenced by US Green Building Council for PM_{10}
- PEM or PPI can be used
- Cascade Impactor an option
- Real-time monitors
  - PDR
  - DustTrak

IEQ

- PM_{10} – 150 ug/m^3 as 24 hr average
- $PM_{2.5}$ – 15 ug/m^3 as annual average
- $PM_{2.5}$ – 35 ug/m^3 as 24 hr average

Real Time Monitors

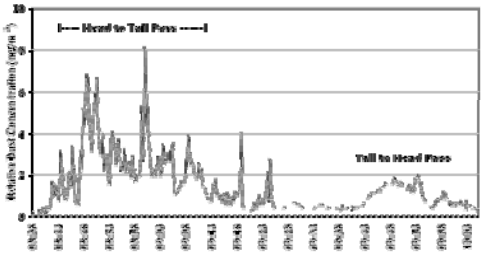
- TSI DustTrak
- Personal DataRAM (pDR)
- Both
  - Use light scattering as measurement technology
  - Correlate instantaneous readings with time and store in internal memory
  - Generate real-time graphic displays

Real Time Monitors

Real Time Monitors

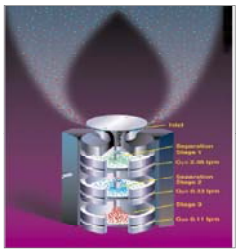
Real Time Monitors

pDR provides time record of dust levels



RespiCon

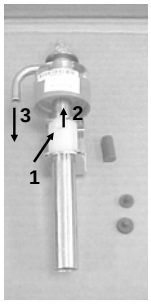
RespiCon



RespiCon

- Flow rate 3.1 lpm
- Multi-stage impactor
- Optional inlet module gives 2.5 micron cut point
- Three collection filters
  - Inhalable = sum of three
  - Thoracic = sum of first two

Wrap-up



THANK YOU!

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