WHEN AND HOW TO SAMPLE

Industrial Hygiene Monitoring

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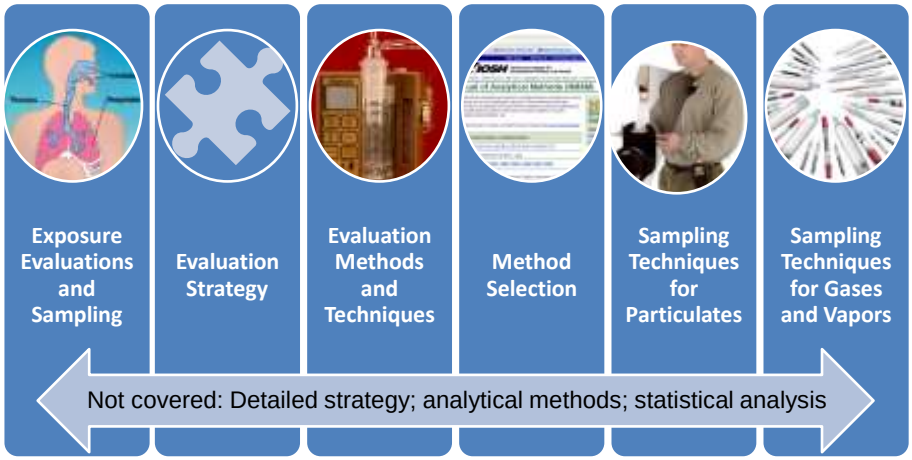
What We'll Review



Types of Exposure Evaluations

- Historical Data
- Predictive Modeling
- Direct Reading
  - Short-term / Instantaneous
  - Continuous Monitoring
- Personal Monitoring
  - Short-term
  - Length Of Activity
  - Full Shift
- Statistical Modeling
- Medical Monitoring / Surveillance

WHY SAMPLE?

- **Baseline Monitoring**
- **Compliance Monitoring**
- **Evaluate Space and Time Distributions**
- **Evaluate Effectiveness of Engineering Controls**

Sampling

Exposure Assessment *Strategy*

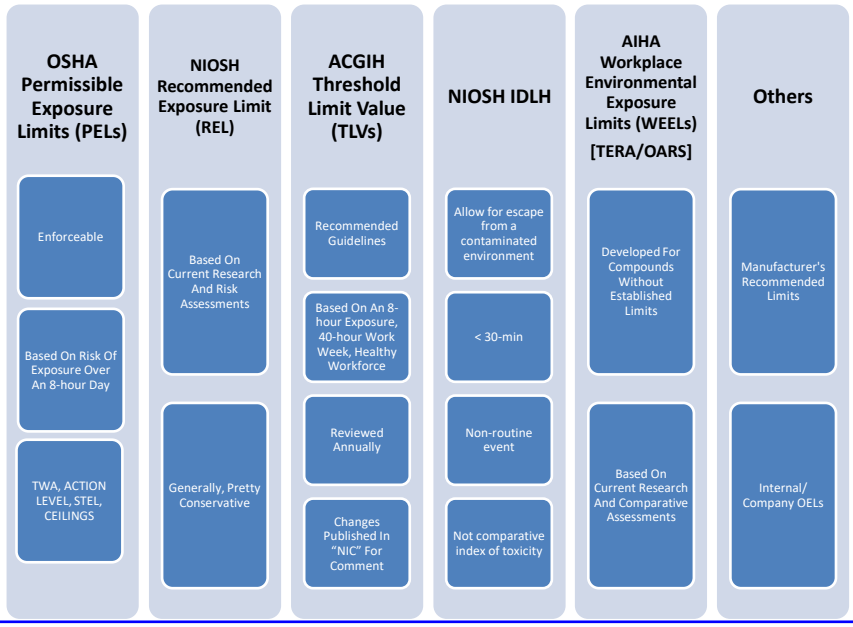
- What to sample
- Who to sample
- Where to sample
- When to sample
- How many samples

Sampling *Methodology*

- HOW to sample

Method Selection Considerations

- **Target Agent**
- **Sampling Objective**
- **Occupational Exposure Limit**
  - Length of Exposure
  - Safety Factor
- **Recognized Methods**
  - NIOSH or OSHA Validated
  - Consensus Standards
  - Limits of Detection / Method Sensitivity
- **Feasibility**
  - Size of Exposed Population
  - Frequency and Duration of Activity
  - Turn-around Time
- **Cost**



TYPES OF OELS

TIME-WEIGHTED AVERAGES (TWA)

- 8-hour Exposure Limit
- Assumes 16-hour Recovery

SHORT-TERM EXPOSURE LIMITS (STEL)

- Generally, a 15-minute Exposure

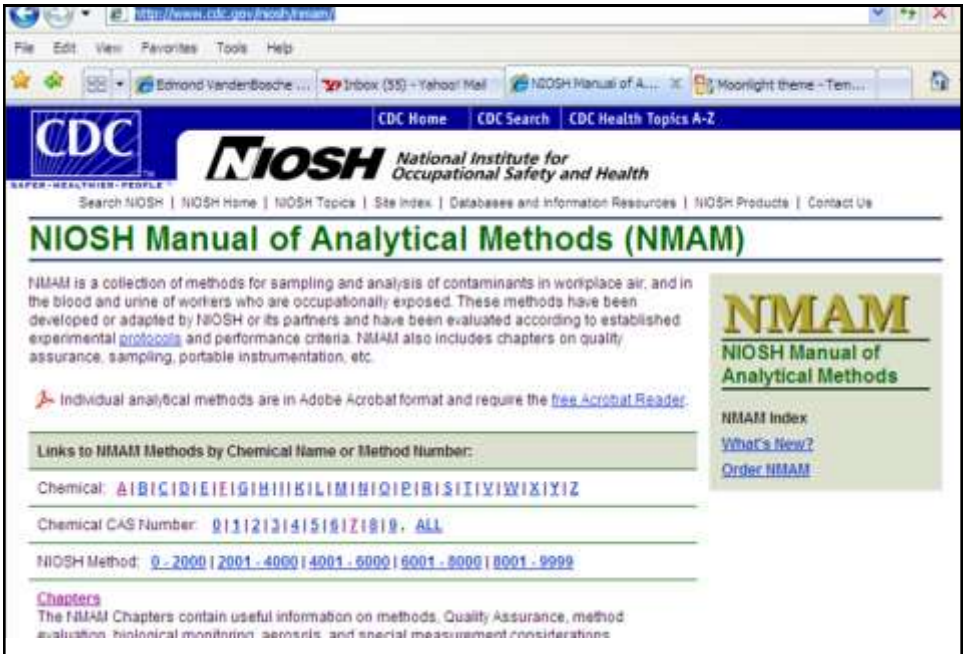
EXCURSION LIMITS

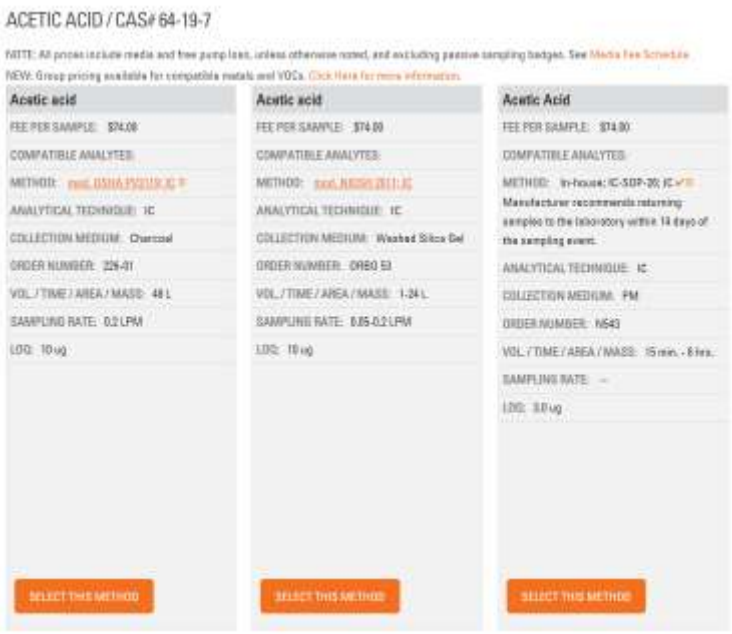
- Exposure Time Varies with Agent

CEILING

- Exposure Time Varies with Agent

IMMEDIATELY DANGEROUS TO LIFE AND HEALTH (IDLH)





ANALYTICAL SENSITIVITY AND SAMPLING

- OEL = 50 ug/m^3
- QL = 10 µg/ sample
- V_{min} = (10 µ g / 50 ug/m^3) x 1000 L/m^3
- V min = 200 L

BUT WAIT – We actually want to detect down to 10% of OEL so

V_{min} = (10 µg / **5 µg/m^3**) x 1000 L/m^3
V_{min} = 2,000 L

SAMPLING & ANALYTICAL ERRORS

Systemic Errors in Sampling

- Leaks in sampling train
- Poor instrument calibration
- Wrong sampling media
- Improper sample storage

Systemic Errors in Lab Analysis

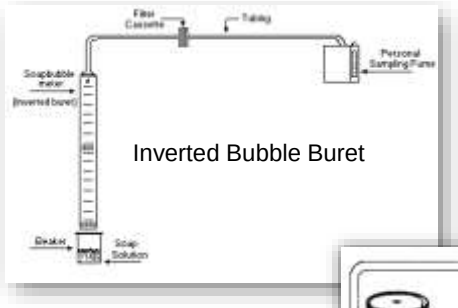
- Poor sample recovery w/solvent
- Preparation of calibration stds.
- Loss of sample
- Poor resolution of detector peaks

Random Sources of Sampling Error

- Within and b/n day variations in:
  - exposure concentrations
  - operation of sampling equipment
  - lab analysis (b/n days)
  - b/n analysts in conducting analysis

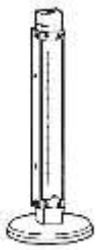
Sampling - Calibration

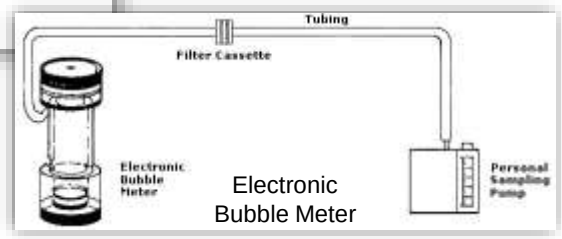
Primary vs Secondary Calibration Standards



Inverted Bubble Buret

Precision Rotometer





Electronic Bubble Meter

Properties of Direct-Reading Instruments

LIMIT OF DETECTION (L.O.D.)
Lower Limit Above the Background Level where a Reproducible Response Occurs.

SENSITIVITY
Reproducible Instrument Response to the Substance that Generates a Measurement.

"NOISE LEVEL"
The Background Level Below the L.O.D. Generated by the Instrument.

INTERFERENCES
Sensitivity to Other Substances that Affects the Reliability & Confidence in the Measured Value.

RANGE
Min. & Max. Output of the Instrument.

RESPONSE TIME
Usually Expressed as the Time Required to Reach 90-95% of Full Response (15-120 Seconds). All DRIs Take Time to Respond.

ACCURACY
How Closely the Instrument's Measurement is to the True Sample Concentration.

REPEATABILITY
Precision. How Close Repeated Measures are to Each Other. A Series of Measurements may be Precise (In Close Agreement w/ Each Other) yet Vary from the True Sample Concentration.

RELIABILITY
How Well the Sample Data can be Recovered.

Sampling Techniques For Particulates

Direct Monitoring of Particulates

- Optical
  - Light scattering vs light extinction
- Condensation
  - Vapor condensation and light scattering
- Electrical/Electromagnetic
  - Piezobalance vs β- attenuation vs ESP
- Visual

Particulate Sampling and Analysis

- Sampling - Particle Size and Exposure Criteria
  - Total Dust
  - Inhalable Dust
  - Respirable Dust
  - Particle Size Determination
- Pre-weighed or matched weight filter media
- Flow rate considerations

SKC Aluminum Cyclone

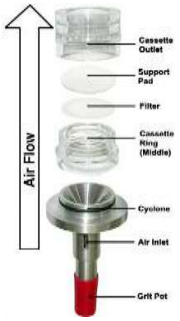
IOM Sampler

Cascade Impactor

Image source: SKC, Inc.

SAMPLING PARTICULATES

- Filtration
- Impingement
- Impaction
- Centrifugation
- Elutriation



SKC Aluminum Cyclone

PARTICULATE SAMPLING BY FILTRATION

- Cheap & simple to use for aerosol monitoring
- Applications:
  - Gravimetry (change in filter weight)
  - Chemical analysis
  - Fiber and particle counting

PARTICLE SAMPLING BY IMPINGEMENT

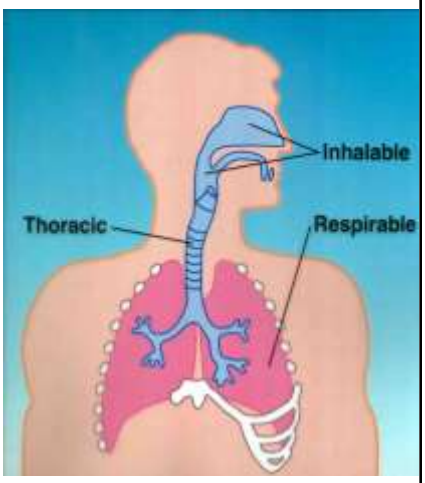
Wet method of particle and chemical sampling

- Glass impingers contain absorbing solution
- Air driven into or pulled through solution
- Glass frit generates bubbles, ↑ surface area of air in contact with solution
- Also used to collect hot stack emissions in air pollution sampling

ACGIH'S PARTICLE-SIZE SELECTIVE TLVS

Based on 3 classes of particle sizes (50th%ile):

- ***Inhalable*** - 100μm A.E.D.
- ***Thoracic*** - 10μm A.E.D.
- ***Respirable*** - 4μm A.E.D.



PARTICLE SAMPLING BY IMPACTION

Cascade Impactor (multi-stage collector)

- large particles impact plate
- smaller particles pass thru mesh or bounce off plate to next stage
- each stage has a pre-determined particle size “cut point”

PARTICLE SAMPLING BY CENTRIFUGE

Ex. Cyclone

- Typically has one defined cut point
- Large particles fall out by inertia
- Cut point efficiency depends on flow rate

SKC Aluminum Cyclone

Sampling Methods for Gases and Vapors

Direct-Reading Instruments

- Colorimetric Indicator Tubes
- Chemically Sensitive Paper Tape
- Combustible Gas Indicators (CGI)
- Broad-band or Metal Oxide Sensors
- Electrochemical Cells
- Photoionization Detectors
- Flame Ionization Detectors
- Infrared Spectrophotometers

GAS AND VAPOR SAMPLING

- Sorbent Tube
- Summa Canister
- Tedlar Bag
- Impinger
- Passive Monitor

GAS AND VAPOR SAMPLING

Short-term, “grab” sampling

- portable bags (ex. Tedlar)
- evacuated canisters

Longer-term, integrated sampling

- Use of solid adsorbents
- passive monitoring badge

SOLID ADSORBENTS

- Charcoal
  - HC, HC-Cl, Esters, Alcohols, Ketones
- Silica Gel
  - Amines, Phenols, Methanol, Inorganic Acids
- Polymers
- Chemically-treated
  - Ethylene Oxide (EtO), Inorganic Acids, Formaldehyde

BREAKTHROUGH

- Tubes typically have a front & back half
- The sample can migrate on the tube
- If concentration on back half of tube is $\geq$ 10% of the front, breakthrough may have occurred
- Loss of sample results in random error, negative bias.

PASSIVE MONITORING BADGES

- a.k.a. diffusive samplers
- operate @ low air flow (20-45 cc/min)
- integrate exposure over time
- as accurate & precise as actively pumped samples submitted for lab analysis
- Accuracy of chemical sorbent affected by T & RH (same for activated charcoal)

QUESTIONS?