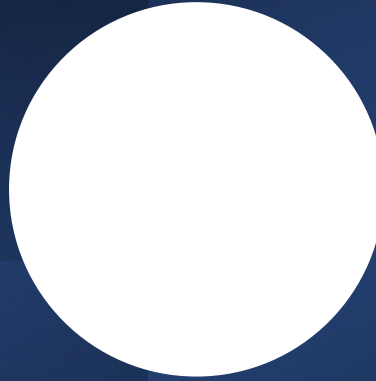


WHEN AND HOW TO SAMPLE

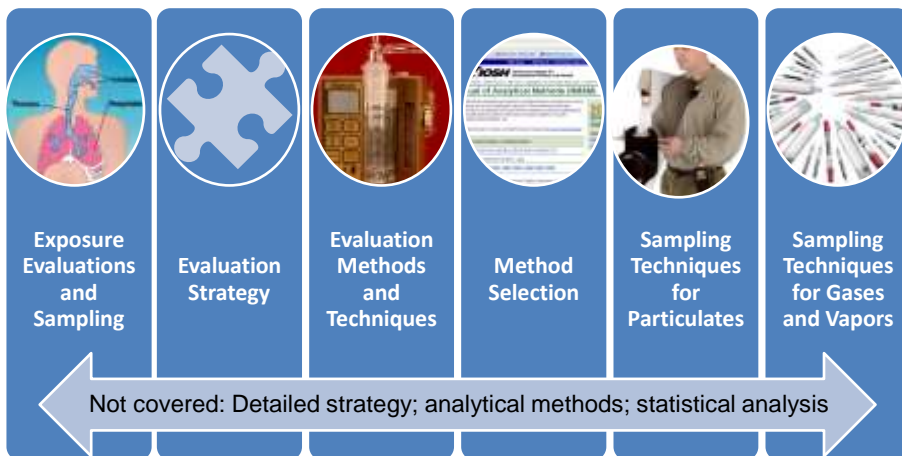
**Industrial Hygiene
Monitoring**

Vic D'Amato, CIH, CSP



WHY?

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

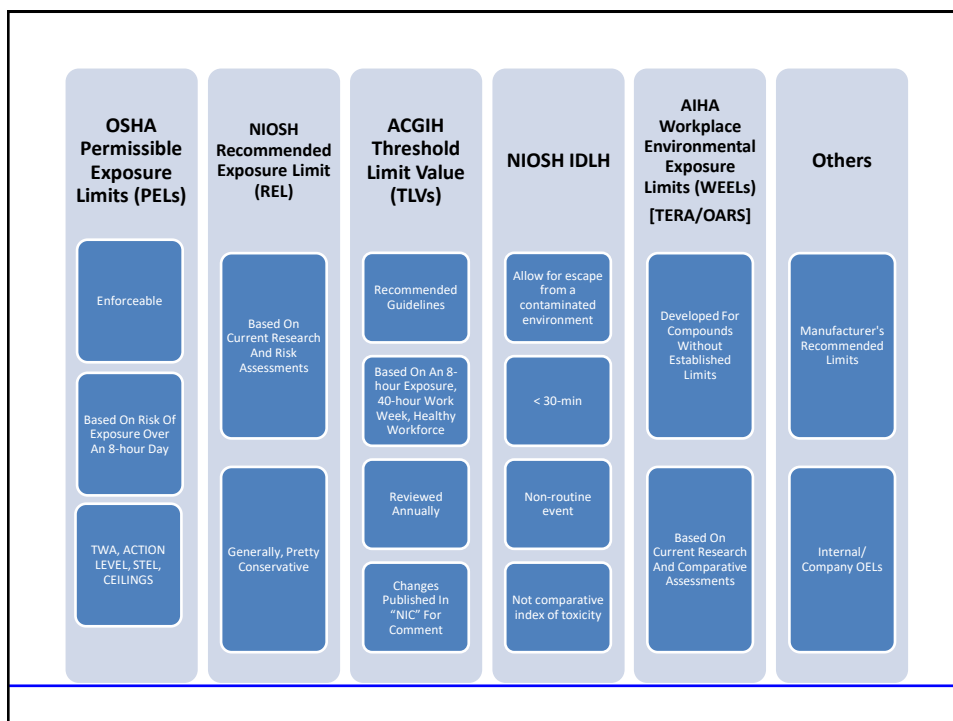
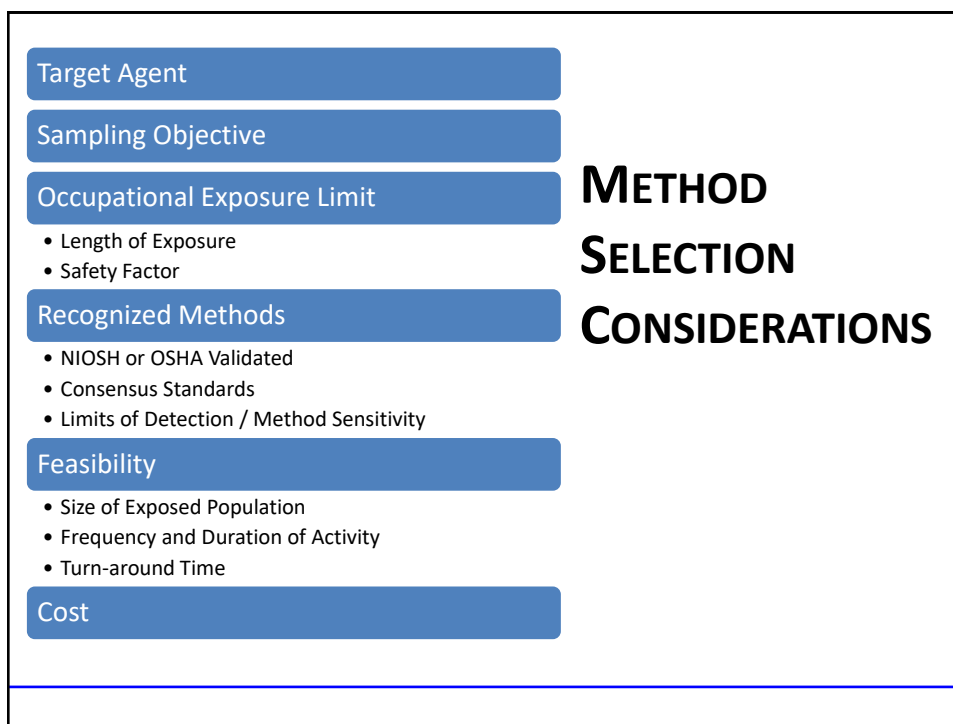


Exposure Assessment *Strategy*

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

Sampling *Methodology*

- HOW to sample



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)

The screenshot shows the NIOSH Manual of Analytical Methods (NMAM) website. The browser window has a single tab titled "http://www.cdc.gov/niosh/nmam/". The address bar shows the URL. The browser's menu bar includes File, Edit, View, Favorites, Tools, and Help. The toolbar shows several icons, including a search icon and a mail icon. The browser's status bar shows the address bar and the text "Edmond VanderBosche ...".

The website header features the CDC logo on the left and the NIOSH logo on the right, with the text "National Institute for Occupational Safety and Health" below it. The header also includes a search bar and a navigation menu with links to "CDC Home", "CDC Search", and "CDC Health Topics A-Z".

The main content area is titled "NIOSH Manual of Analytical Methods (NMAM)". Below the title, there is a paragraph describing the NMAM as a collection of methods for sampling and analysis of contaminants in workplace air, and in the blood and urine of workers who are occupationally exposed. The text states that these methods have been developed or adapted by NIOSH or its partners and have been evaluated according to established experimental protocols and performance criteria. It also mentions that the NMAM includes chapters on quality assurance, sampling, portable instrumentation, etc.

Below the paragraph, there is a link to "Individual analytical methods are in Adobe Acrobat format and require the [free Acrobat Reader](#)." Below this link, there is a section titled "Links to NMAM Methods by Chemical Name or Method Number:". This section contains three search fields: "Chemical:" with a dropdown menu showing "A", "B", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", "M", "N", "O", "P", "Q", "R", "S", "T", "U", "V", "W", "X", "Y", "Z"; "Chemical CAS Number:" with a dropdown menu showing "0", "1", "2", "3", "4", "5", "6", "7", "8", "9", "ALL"; and "NIOSH Method:" with a dropdown menu showing "0 - 2000", "2001 - 4000", "4001 - 5000", "5001 - 6000", "6001 - 8000", "8001 - 9999".

Below the search fields, there is a section titled "Chapters". The text states that the NMAM chapters contain useful information on methods, Quality Assurance, method evaluation, biological monitoring, aerosols, and serial measurement considerations.

On the right side of the page, there is a sidebar with the title "NMAM" and the subtitle "NIOSH Manual of Analytical Methods". Below the title, there are links to "NMAM Index", "What's New?", and "Order NMAM".

ACETIC ACID / CAS# 64-19-7

NOTE: All prices include media and flow pump loan, unless otherwise noted, and excluding passive sampling badges. See [Media Fee Schedule](#).
 NEW: Group pricing available for compatible metals and VOCs. [Click Here for more information.](#)

Acetic acid	Acetic acid	Acetic Acid
FEE PER SAMPLE: \$74.00	FEE PER SAMPLE: \$74.00	FEE PER SAMPLE: \$74.00
COMPATIBLE ANALYTES:	COMPATIBLE ANALYTES:	COMPATIBLE ANALYTES:
METHOD: PASSIVE SAMPLING	METHOD: PASSIVE SAMPLING	METHOD: In-house: IC-SOP-20; IC- SOP-20
ANALYTICAL TECHNIQUE: IC	ANALYTICAL TECHNIQUE: IC	Manufacturer recommends returning sample to the laboratory within 14 days of the sampling event.
COLLECTION MEDIUM: Charcoal	COLLECTION MEDIUM: Washed Silica Gel	ANALYTICAL TECHNIQUE: IC
ORDER NUMBER: 224-01	ORDER NUMBER: 0980 53	COLLECTION MEDIUM: PM
VOL./TIME/AREA/MASS: 40 L	VOL./TIME/AREA/MASS: 1-24 L	ORDER NUMBER: N543
SAMPLING RATE: 0.2 LPM	SAMPLING RATE: 0.05-0.2 LPM	VOL./TIME/AREA/MASS: 15 min. - 6 hrs.
LOD: 10 ug	LOD: 10 ug	SAMPLING RATE: --
		LOD: 30 ug
SELECT THIS METHOD	SELECT THIS METHOD	SELECT THIS METHOD

ANALYTICAL SENSITIVITY AND SAMPLING

- OEL = 50 ug/m³
- QL = 10 µg/ sample
- $V_{\min} = (10 \mu g / 50 \text{ ug/m}^3) \times 1000 \text{ L/m}^3$
- V min = 200 L

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

$$V_{\min} = (10 \mu g / 5 \mu g/m^3) \times 1000 \text{ L/m}^3$$

$$V_{\min} = 2,000 \text{ L}$$

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

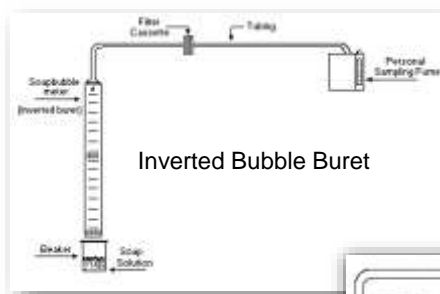


Random Sources of Sampling Error

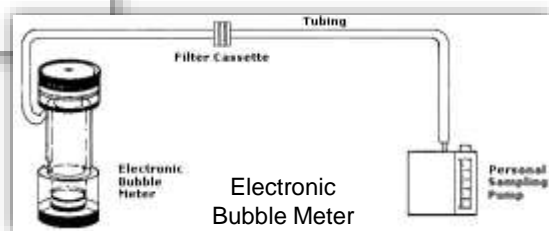
- Within and b/n day variations in:
 - exposure concentrations
 - operation of sampling equipment
 - lab analysis (b/n days)
 - b/n analysts in conducting analysis

Sampling - Calibration

Primary vs Secondary Calibration Standards



Precision Rotometer



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



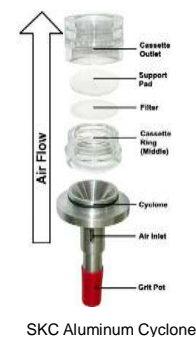
DIRECT MONITORING OF PARTICULATES

- 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



Cascade Impactor



IOM Sampler



Image source: SKC, Inc.

SAMPLING PARTICULATES

- Filtration
- Impingement
- Impaction
- Centrifugation
- Elutriation



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

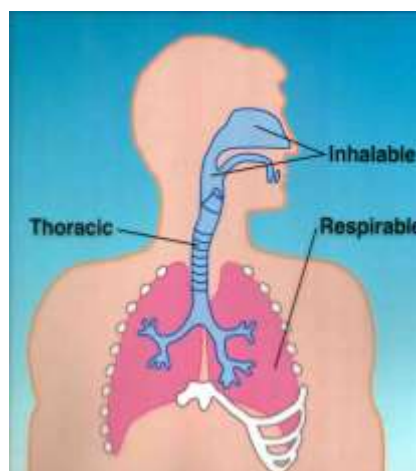
- Glass impingers contain absorbing solution
- Air driven into or pulled through solution
- Glass frit generates bubbles, ↑ surface area of air in contact with solution
- Also used to collect hot stack emissions in air pollution sampling



ACGIH'S PARTICLE-SIZE SELECTIVE TLVs

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

- **Inhalable** - 100 μ m A.E.D.
- **Thoracic** - 10 μ m A.E.D.
- **Respirable** - 4 μ m 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?