Overview of Workshop

David Weissman M.D.

Manager,

Exposure Assessment Cross-Sector Program

304-285-5749

Overview of Workshop

- Purpose: to gather diverse stakeholder input on research needs in the area of direct reading methods for assessing occupational exposures.
- Day 1
  - General Session: state-of-the-art presentations addressing issues in direct reading exposure assessment methods that are relevant to a broad range of employment sectors and occupational hazards, including regulatory framework, validation, and approach to collecting and using data.
  - Concurrent Breakout Sessions: organized by hazard, including: gases / vapors; aerosols; ergonomics / vibration; noise; radiation; and surface sampling / biomonitoring.
- Day 2
  - Summary Session: Reports from each breakout session on the specific research needs for each type of occupational hazard.

Rapporteur Report

Hazard Session: Aerosols

Monitor: Martin Harper
National Institute for Occupational Safety & Health

Co-Monitor: Pam Susi
CPWR

Rapporteur: Mark Methner
National Institute for Occupational Safety & Health

Top Five Research Priorities

1. Basic research into how instruments respond to aerosol characteristics
2. Invention/Continued development (esp. agent specific)
3. Develop consensus accuracy and validation standards
4. Develop standards for performance and use
5. Education and guidance on sector specific applications for existing products

Rapporteur Report

Hazard Session: Ergonomics and Vibration

Monitor: Brian Lowe
National Institute for Occupational Safety & Health

Co-Monitor: Rob Radwin
University of Wisconsin

Rapporteur: Vern Anderson
National Institute for Occupational Safety & Health

Participants

Valerie Beck
Rebecca Bell
Frank Buczek
Linda Byrnes
Steven Chervak
Patrick Dempsey
Sunwook Kim
Brian Lowe
Raymond McGorry
Dinkar Mokadam
Gail Murphy
Vern Putz Anderson
Robert Radwin
Scott Robbins
Brian Roethlisberger
Thomas Waters
Daniel Welcome
Mike Wurm
Daniel Youhas

Importance of DRM for MSDs in Sectors

- National Academy of Sciences NRC/IOM 2001 Panel on Musculoskeletal Disorders in the Workplace

  RESEARCH AGENDA - METHODOLOGICAL RESEARCH

  1. Develop improved tools for exposure (dose) assessment.

  “Develop practical and consistent methods for objectively measuring physical stress (force, motion, vibration, and temperature) in the workplace and for quantifying occupational exposure (magnitude, repetition, and duration) with sufficient precision and accuracy.”

- All 8 industry sectors have identified MSDs in their strategic goals (#1 or #2)
  - May be sector-specific environmental constraints

Working Definition

"These instruments provide objective *field-based* measurement of exposures *(force, motion, vibration and temperature)* that provide a method that indicates whether or not the exposures pose an occupational health or safety risk and if the *interventions* employed are actually providing the proper level of protection."

Unique Challenges of MSDs for DRM

- Exposure is the worker’s mechanical interaction with workplace and tools (i.e. forces and motions)
- Hazard lies in the physical demands of the work
- Exposure measurement is indirect (chemical/physical agent model is not directly applicable)

Exposure Assessment for MSDs

- Job titles
- Checklists
- Observational-Based Analysis
- Biomechanical Modelling
- Instrumentation-Based Methods (limited)
  - Electrogoniometer (joint position)
  - Electromyography (muscle electrical activity)
  - Accelerometry
  - Force sensors
  - Video Exposure Monitoring

Top Research Priorities

1) Assess specific needs of customers for DRM (research-based vs. practitioner vs. worker)
2) Develop technologies to measure exposure dose
3) Investigate pathophysiological processes associated with exposures
4) Establish valid exposure assessment criteria (exposure limits)
5) Translate research into practical instruments for DRM

Attributes of Exposure Assessment

	Researcher	Practitioner	Worker
Reasonable cost	low priority	high priority	
Accurate	high priority	medium priority	
Unobtrusiveness	low priority	medium priority	
Real time			
Force and posture			
Repetition (frequency) magnitude			
Reliable			

Top Research Priorities

- **Assess researcher v. practitioner v. worker needs for DREAM in ergonomics**
  - On-site measurement (field)
  - Direct reading
  - Field measurement v. lab measurement
- **Need for technology to measure exposure (dose)**
  - Kinetics (force), kinematics (motion), vibration and cold
  - Repetition (frequency), magnitude, and duration
- **Understand pathophysiological processes associated with exposures**
  - Physiological responses to exposure (bio-monitoring)
  - Health monitoring instruments
- **Need for exposure assessment criteria**
  - Dose-response relationship
  - Inform decision making to prevent MSDs
  - Evaluate intervention effectiveness
  - Display and dissemination of information
- **Instruments for measurement and exposure assessment**
  - Measurement characteristics
    - Accurate
    - Reliable
    - Objective measurement and assessment procedure
    - Relationship to physical work
  - Usability of instruments
    - Manufacturability
    - Ruggedized
    - Worker and management acceptance
    - Reasonable cost
    - Training analyst and user
    - Speed of assessment
    - Real time
    - Unobtrusive

Rapporteur Report

Hazard Session: Gases and Vapors

Monitor: Jay Snyder
National Institute for Occupational Safety & Health

Co-Monitor: Dr. Ted Zellers
University of Michigan

Rapporteur: Jason Ham
National Institute for Occupational Safety & Health

Invited Speakers

Dr. Dean R. Lillquist, (**Director, OSHA Salt Lake Technical Center**) - History of OSHA's use of direct reading instruments, the Agency's current applications, and possible future directions.

Mr. Mark Spence, (**Manager, North American Health and Safety Regulatory Affairs, Dow Chemical**) – Experiences and needs for direct reading methods and instrumentation from a broad chemical producer's perspective.

Mr. Mark Spence, (**International Isocyanate Institute**) -Current direct readings instrumentation and anticipated future challenges and needs for the polyurethanes industry.

Dr. Rebecca Blackmon, (**Technical Support Working Group**) - Instrumentation for gas and vapor detection currently under development.

Dr. Ted Zellers, (**Professor of Environmental Health Science, U of Michigan**) – Development of the micro gas chromatograph.

Mr. Jay Snyder, (**Sensor Project Officer, NIOSH**) - Application of MEMs sensors

Top Five Research Priorities

1. GC miniaturization – worth pursuing
2. Worker ability to measure own exposures
    a. Simple, cheap, high-throughput; inaccurate “ok”. More data!!
3. Refinement of existing technologies (improved sensitivity, selectivity)
    a. e.g., toxic gases, H_2S, CO (existing products not great).
4. Make devices multi-functional
    a. Chemicals, temperature, gps, heart rate, etc.
5. Development of self-calibrated systems (no need for gas transport)
6. DRI for HCHO, HF, chloramines (poultry), nicotine, R-N=C=O, needed
    a. Small-volume need, won’t be commercially successful
7. NIOSH-OSHA collaboration on transitioning new DRIs to compliance-acceptable status
8. Development of DRIs for unknown chemical components in mixtures
9. Worker empowerment (behavior modification, feedback to worker)

Direct Reading Instruments

(Usage & Implementation)

- What do you see as the most important impediments to more widespread use of DRIs?

- Where are they needed most?:
  1. Personal Monitoring for Compliance
  2. Personal Monitoring for Exposure Assessment
  3. Emergency Response
  4. Warnings for Life-Threatening Exposures

Rapporteur Report

Hazard Session: Noise

Monitor: Chuck Kardous
National Institute for Occupational Safety & Health

Co-Monitor: Rob Brauch
Larson-Davis, AIHA

Rapporteur: Terri Pearce
National Institute for Occupational Safety & Health

Noise Exposure Assessments

- Noise exposure instruments (Noise dosimeters and Sound Level Meters) are already direct-reading
- Standards (ANSI, ISO, IEC) exist for all instruments
- Regulations guidelines are well-established
- Several DRI/DRM issues still need development

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Noise Instruments

Mixed or Combined Exposures

- Exposure to continuous, intermittent, and impact/impulse noise
- Exposure to chemicals or other hazards that can (additively or synergistically) cause hearing loss
- Issues related to different scenarios in which workers are exposed to mixed noise
- Non-auditory effects of noise exposure

Impulse/Impact Noise

- Impulsive noise more damaging than continuous noise
- No instrument capable of characterizing exposure or hazard on the market
- Direct-reading methods are not universally accepted
- Damage risk criteria based on incomplete data
- Rethink the damage risk concept

Worker Empowerment

- Will the worker modify behavior if they have access to direct, real-time, noise exposure readings?
- How to deal with occupational vs. non-occupational environments (musicians, soldiers, etc..)
- Inexpensive "dose" indicators are currently available

Testing, Evaluation, Certification

- Sound instruments must comply with current ANSI and IEC standards
- No entity to test and certify noise instruments today
- NIOSH was involved in the testing and certification of noise dosimeters in the 70's
- Suggestion that NIOSH might want to consider testing and certification

Top Five Research Priorities

1. Re-examine the basis for current damage risk criteria
2. Determine the relationship between DRM metrics and achieving behavioral modification
3. New sensor technology (better microphones, acoustic manikins)
4. Metrics to quantify performance and economic impact of not having solid hearing conservation program
5. Develop a repository of exposure and risk data

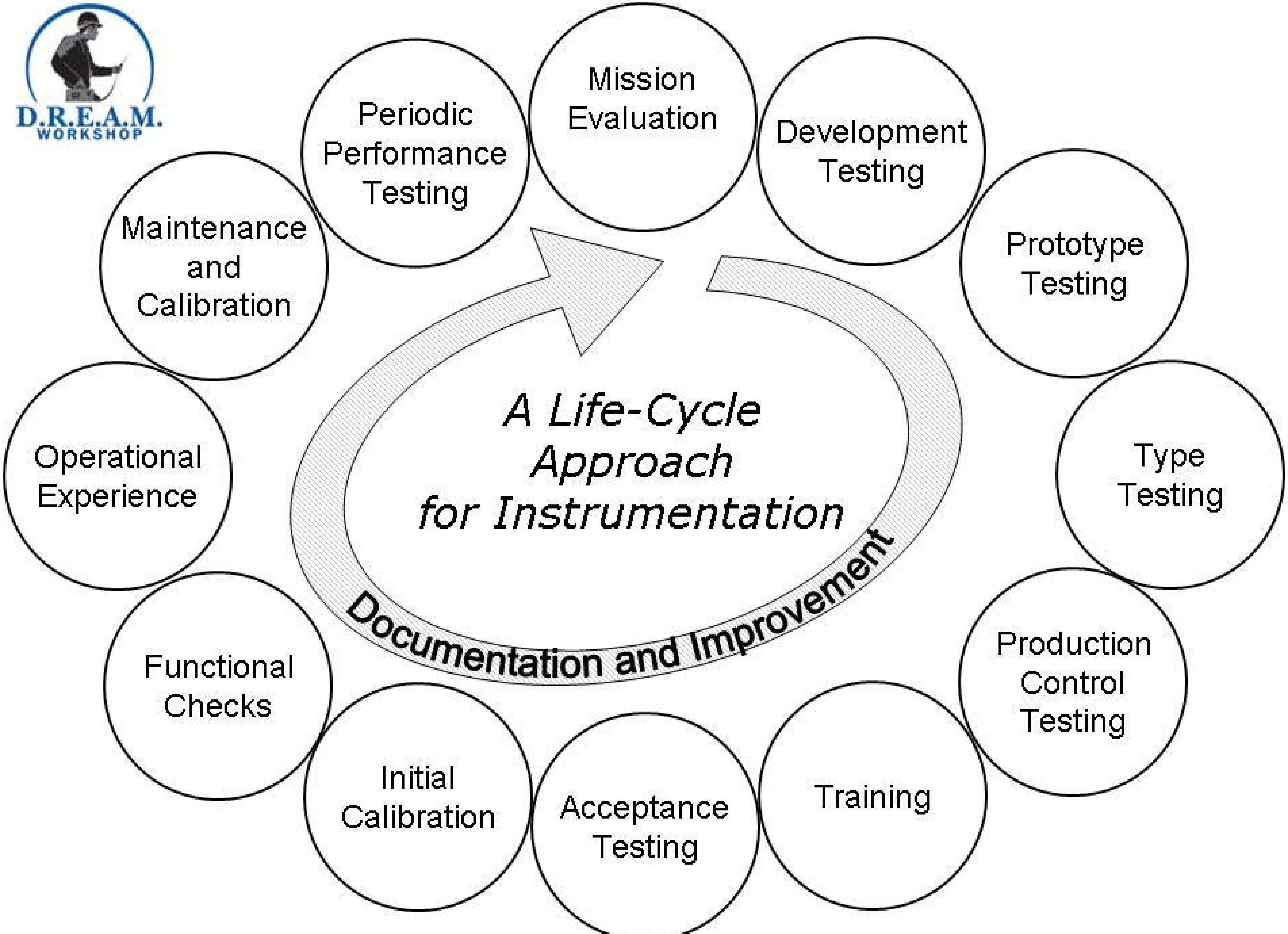
Rapporteur Report

Hazard Session: Radiation

Monitor: Mark Hoover (and Jeri Anderson)
National Institute for Occupational Safety & Health

Co-Monitor: Cynthia Jones
U.S. Nuclear Regulatory Commission

Rapporteur: Pamela Drake
National Institute for Occupational Safety & Health


D.R.E.A.M.
WORKSHOP
Mission Evaluation
Development Testing
Prototype Testing
Type Testing
Production Control Testing
Training
Acceptance Testing
Initial Calibration
Functional Checks
Operational Experience
Maintenance and Calibration
Periodic Performance Testing
A Life-Cycle Approach for Instrumentation
Documentation and Improvement

Status of current DRM for radiation detection/exposure assessment

- Extensive knowledge of radiation physics and measurement (including anomalies)
- Can measure at levels lower than hazardous
- Current success with miniaturization
- Photons = mature (rate, total, spectral)
- Alpha, beta, neutrons = need work

Status of current DRM for radiation detection/exposure assessment

- Extensive knowledge of radiation physics and measurement (including anomalies)
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- Current success with miniaturization
- Photons = mature (rate, total, spectral)
- Alpha, beta, neutrons = need work

Status of current DRM for radiation detection/exposure assessment

- Serves as a model for other threat agents
- Graduated Radiation/Nuclear Detector Evaluation and Reporting Program
- Responder Knowledge Base (Web-based reference)

Research Needs

- Develop bio methods that are direct reading, efficient, and available
  - Biodosimetry
  - Bioassay
- Reduce size and increase speed of neutron detectors for all energies
- 3rd party independent testing of instruments
- *Develop methods and standards for immediate first-responder detection of airborne particulates (CBRN)*

Data management challenges

- IEEE 1451 series -- harmonization of data acquisition and transmission
- ANSI 42.42 -- data format (for all sensors)
- ANSI 42.36 -- RADnet standard for data transmission
- Voice, video, data, positioning (GIS, GPS)

Possible NIOSH Roles

1. Evaluate and report on operational experiences with various instruments in various industries
   - Cover routine and emergency operations
   - Include national and international input
   - Transfer emerging technologies to the US
2. Expand role on the Interagency Board (IAB) for Equipment Standardization and Interoperability (CBRN)

Possible NIOSH Roles

3. Expand role in development of national and international standards
4. Identify gaps in safety practices nationwide
   - Develop training materials and guidance to bridge the gaps
   - Identify opportunities for DRM solutions
5. Collaborate with stakeholders to develop and implement new and improved methods
   - National laboratories, federal agencies, users, manufacturers

Rapporteur Report

Session 6: Surface Sampling/Biomonitoring

Monitor: John Snawder
National Institute for Occupational Safety & Health

Co-Monitor: Matthew Magnuson
Environmental Protection Agency

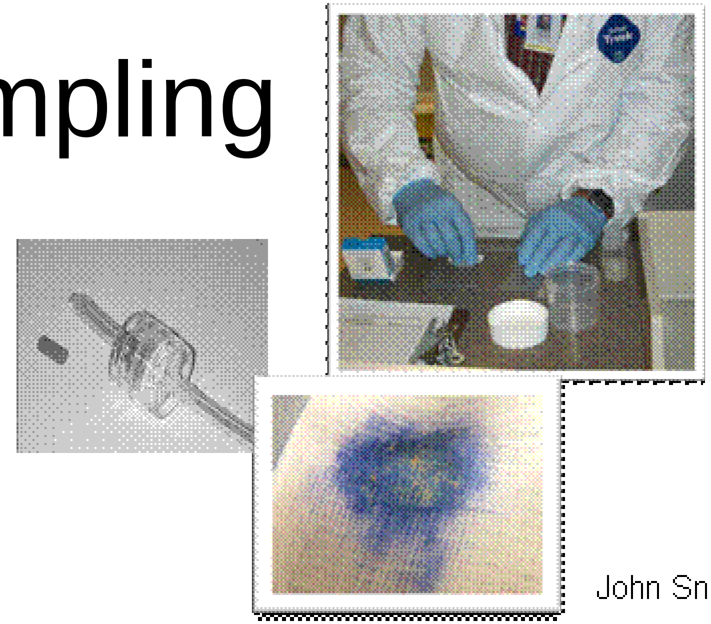
Rapporteur: Deborah Sammons
National Institute for Occupational Safety & Health

Speakers

- Michael Philips
  - Menssanna Research, Inc.
- Charles Timchalk
  - Pacific Northwest National Laboratory
- Jayne Morrow
  - National Institute of Standards and Technology
- Wassana Yantasee
  - Pacific Northwest National Laboratory
- Kevin Ashley
  - National Institute for Occupational Safety and Health

Surface Sampling

- Surface Sampling
  - Types
    - Wipes
    - Swabs
    - Tape
    - Vacuum
    - Dermal
    - Bulk
  - Considerations
    - Characteristics of sample
    - Type of surface
    - Transfer of sample
    - Extraction/recovery of sample
    - Matrix of sample



John Snawder

Kevin Ashley

Biomonitoring

- Biomonitoring
  - Blood
  - Urine
  - Saliva
  - Sperm
  - Tissue
  - Bronchial lavage
  - Exhaled breath

- Assess worker exposure
- Evaluate effectiveness of engineering controls or other exposure reduction/ preventive measures

Chicken or the Egg?

- Surface Sampling
  - Source of contaminant
- Biomonitoring
  - Measured analyte or marker in biological fluid

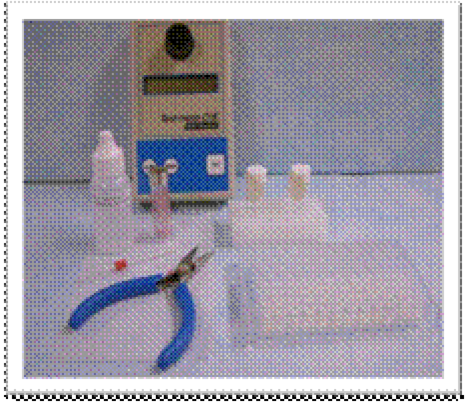
Where have we been?
Where are we going?

- Laboratory Based Analysis
  - Complicated
  - Requires extensive training
  - Expensive
  - Time consuming requiring sending samples out

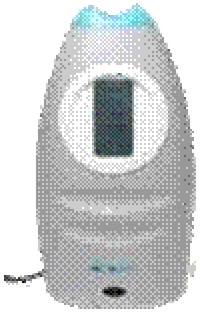
- Field Portable
  - Convenient for worker (Spirometry)
  - Miniaturized (ELISA- portable spectrophotometers), but not necessarily real time

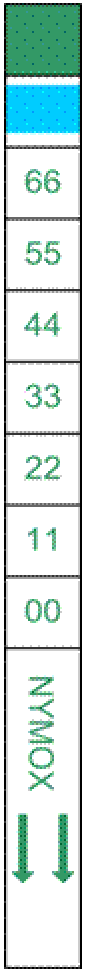
- Direct Reading Instruments
  - Real time
  - No or minimal sample preparation
  - Cost effective
  - User friendly but require training

NIOSH Efforts



- Application of Commercial/ Clinical Point of Care Instruments in the Field
-
  - TobacAlert- cotinine
  - Testmate AchE- Acetylcholinesterase
  - Avox
  - LeadCare- blood lead
  - Niox- Nitric oxide





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NIOSH Efforts Development and Commercialization of Kits

- Lead Wipes for surface sampling, NMAM 9105
- Licensed to SKC inc as “Full Disclosure”

Kevin Ashley

NIOSH Efforts

- Methamphetamine surface wipe methods, NMAM Draft 9106,9109,9111 by MassSpec with isotopic dilution.

- 2 Direct Reading Methods, Colorimetric and Immunochemical. Licensed to SKC as “MethAlert” “MethChek”

NIOSH Efforts Development of Lateral Flow Cassettes

- Anti Protective antigen of *B anthracis* in serum, plasma and whole blood

- Antineoplastic drugs on surfaces
  - Paclitaxol
  - 5-Fluorouracil (5FU)

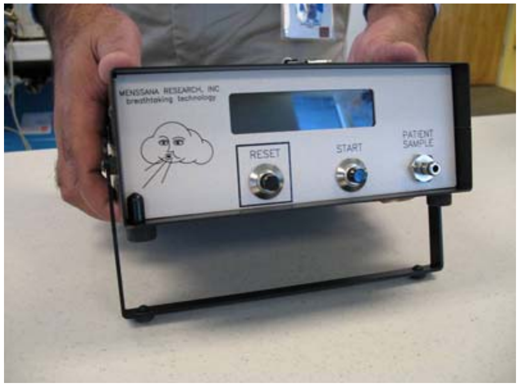
Uses of Direct Reading Methods

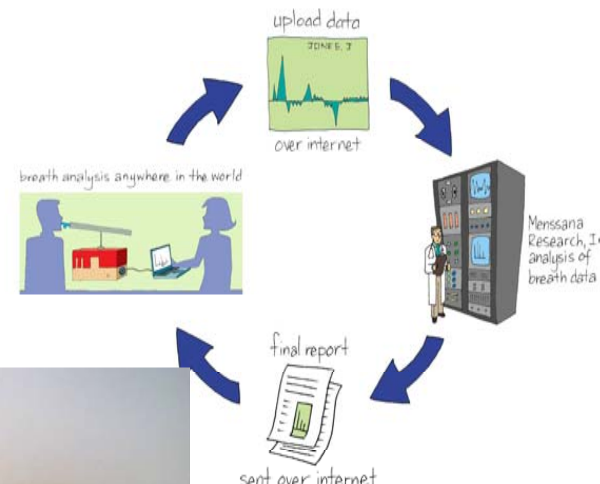
- Lead hand wipes
- Identification of Exposure/Exposure Assessment
- Evaluation of Cleanup or Controls
- Worker Empowerment

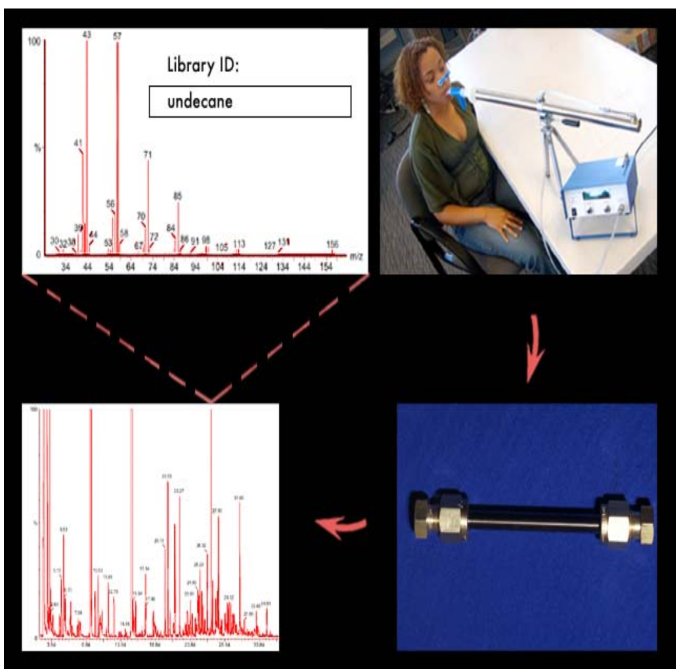
Advantages/Challenges

- Advantages
  - Low cost
  - Rapid
  - High throughput
  - Sensitive
- Challenges
  - Sampling strategies, reference materials, reference values
  - What do the results mean
  - Field versus lab validation
  - Breath analysis- Regulation nightmare to market products

Future Applications- VOCs in Exhaled Breath





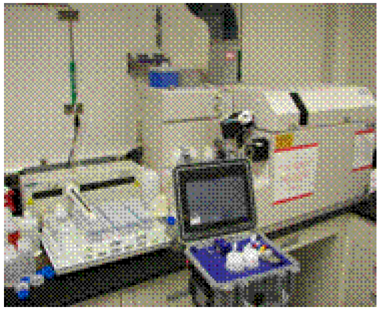


Michael Philips

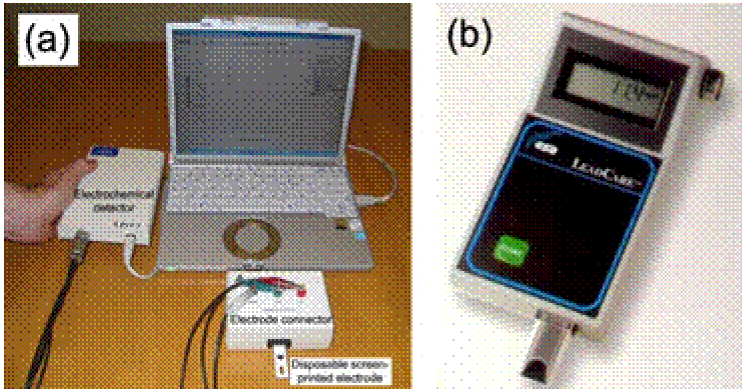
Future Applications- Electrochemical Sensors for Chemical Mixtures

- Sequential/injection immunoassay for quantitation of trichloropyridinol (metabolite of chlorpyrifos)-ppt
- Carbon nanotube-sensor for quantitation of cholinesterase activity
- Nano-particle immunosensor for phosphorylated AChE

Future Applications- New Generation Sensors for Pb, Cd, and Hg



- Functional silica (SAMMS) Sensors
  - Self assembled monolayers on mesoporous supports



- Magnetic nanoparticle sensors

Yantasee, Wassana

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WORKSHOP

Top Five Research Needs

1. Standardization of instruments and defined performance specifications.
2. Address accreditation issue. DRM/DRI need to be accepted after validation and accreditation, they to be defensible in court. Need a workshop on accreditation and training.
3. Training
4. Know what qualifies as an acceptable DRM or screening method. Need action levels.
5. New biomarkers and sensors. Perhaps partner with something like NIEHS gene environment interaction program. Other medical diagnostic tests used as DRMs. Need means to look at exhaled breath.

Research Agenda

Stakeholder input to identify top problems

http://www.cdc.gov/niosh/nora

Updates on the progress of NORA

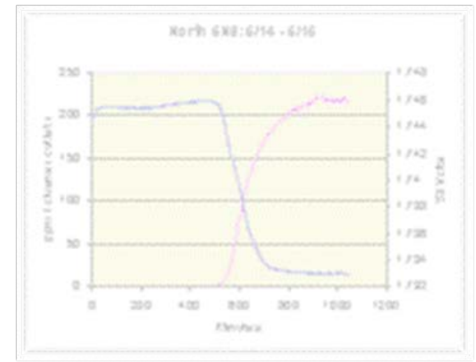
http://www.cdc.gov/niosh/enews/

National Personal Protective Technology Laboratory

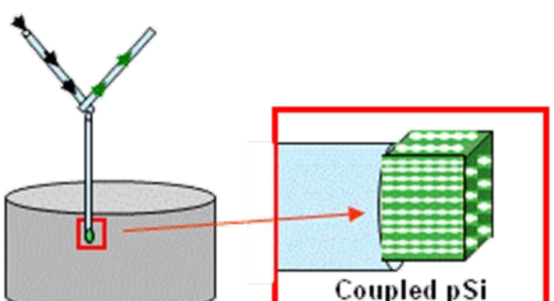
Sensor Development for ESLI

&

Application to Chemical Detection

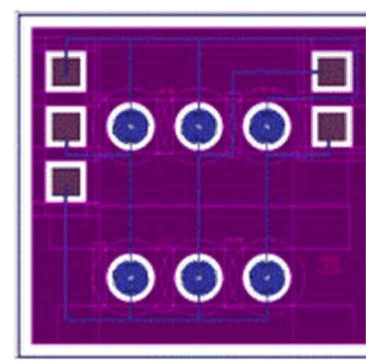


Jay Snyder- NIOSH



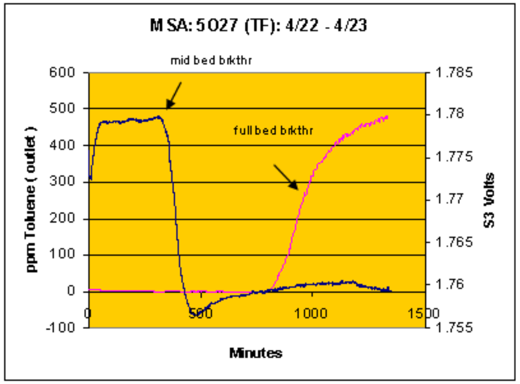
412-386-6775

JSnyder@cdc.gov

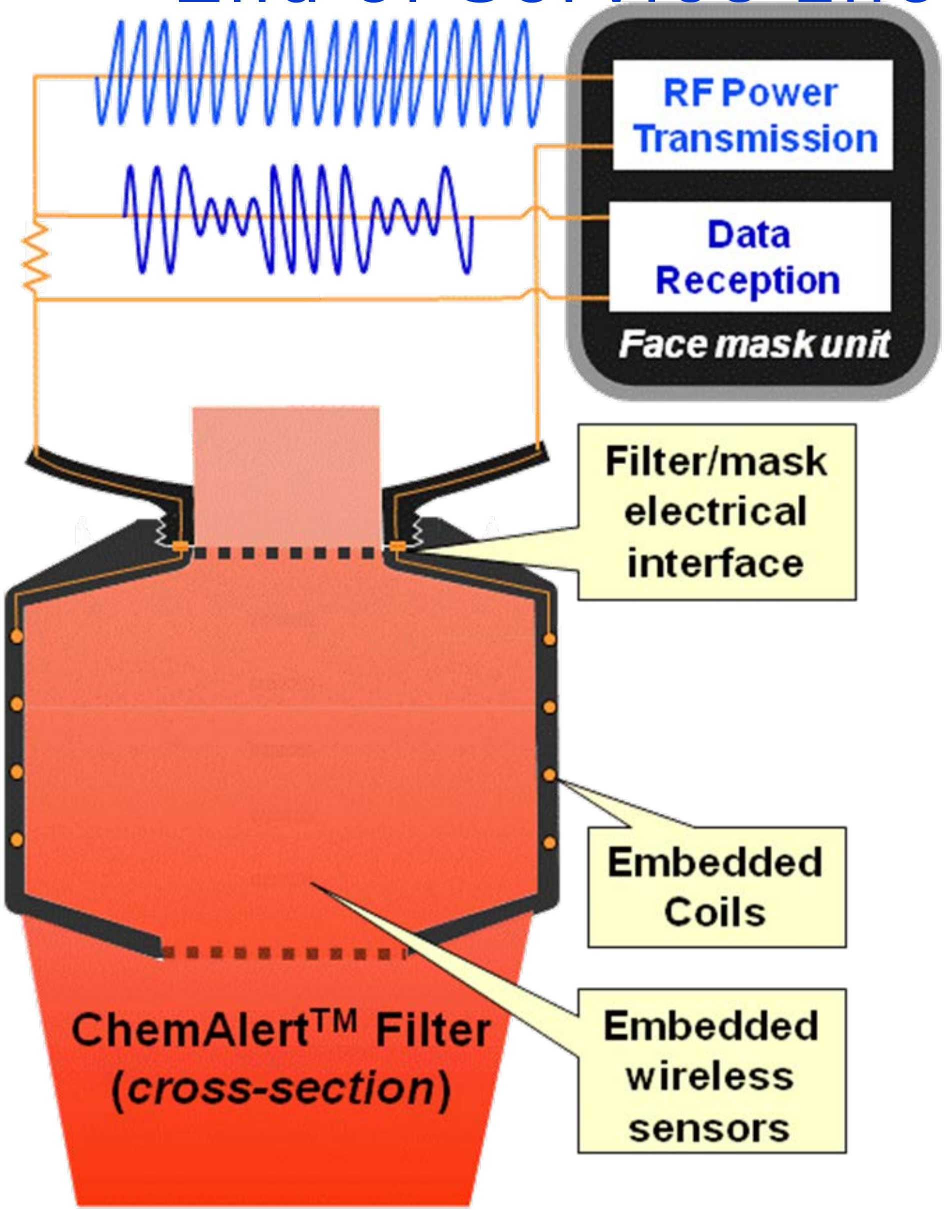


Presentation Outline

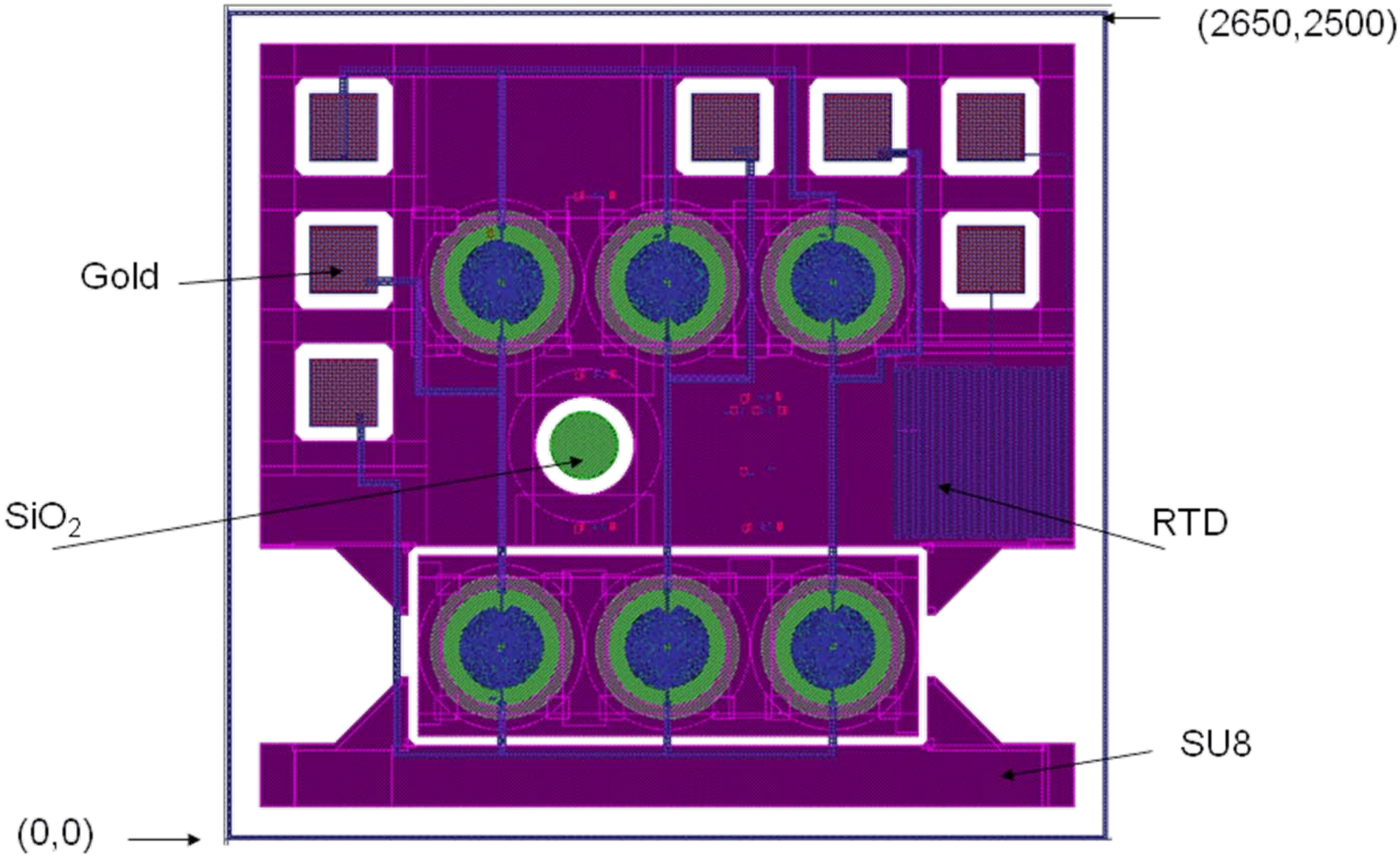
- **Current and Future Electronic System Work**
- **Current and Future Optical System Work**



End-of-Service Life Detection System



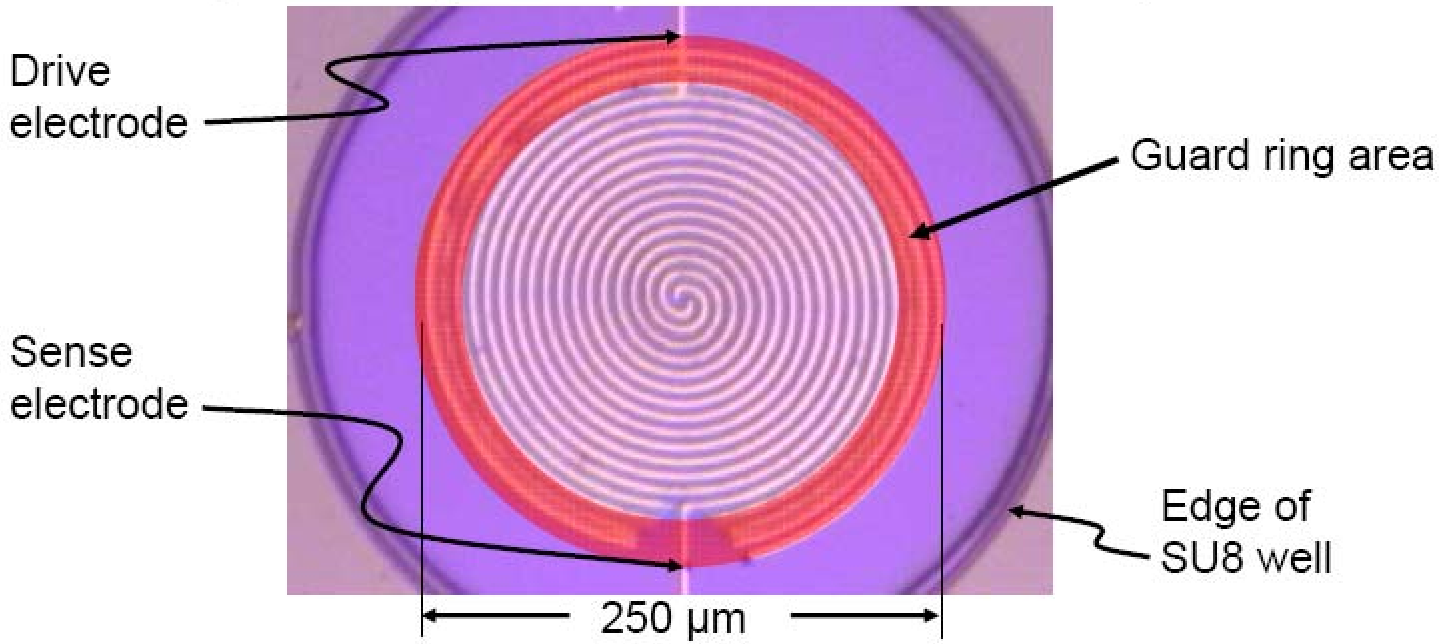
Generation V – Embedded T sensor.



GenV – May 29, 2007, rev July 12, 2007

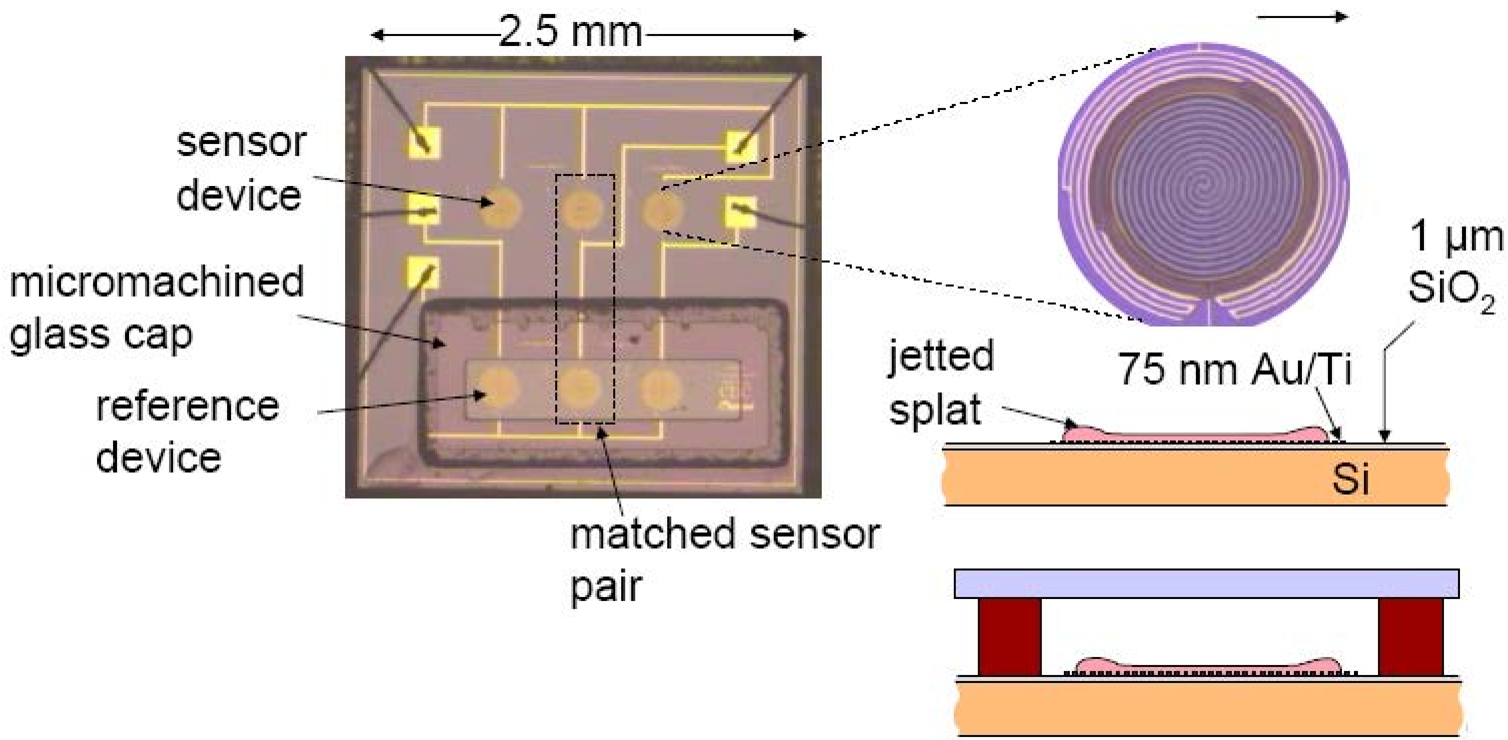
Electrode Design

- **Spiral interdigitated gold electrodes**
  - Symmetric coverage of jetted splat
  - 3 µm-wide traces, 4 µm spacing, 75 nm thick
- **Sized to accommodate 30 to 60 µm diameter nozzles**
- **Outer guard ring to achieve better uniformity**



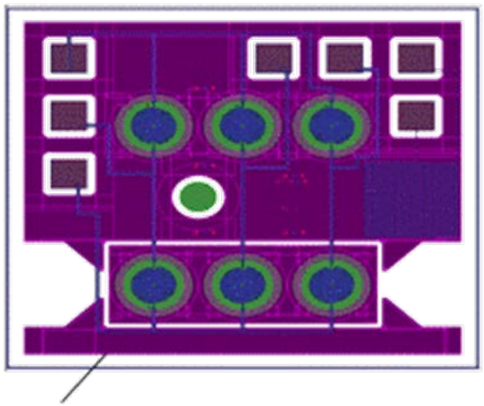
Sensor Circuit Chip

- **3 chemiresistive sensor circuits**
- **Reference devices capped with glass/SU8 epoxy cap**
- **Sealed with low outgassing arathane**

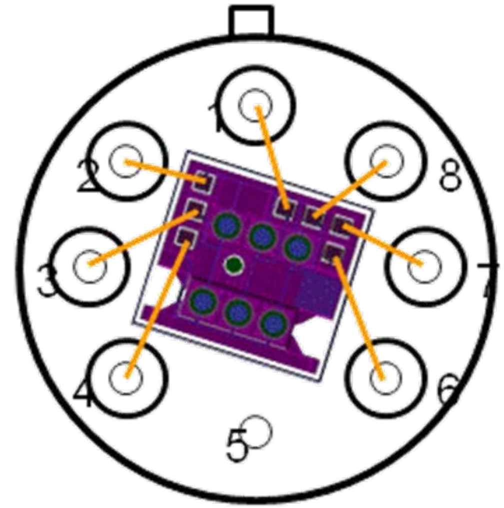


Sensor Assembly

Si chip

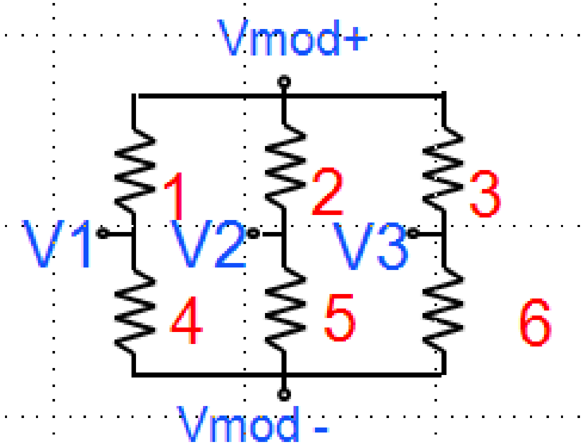


Cover glass



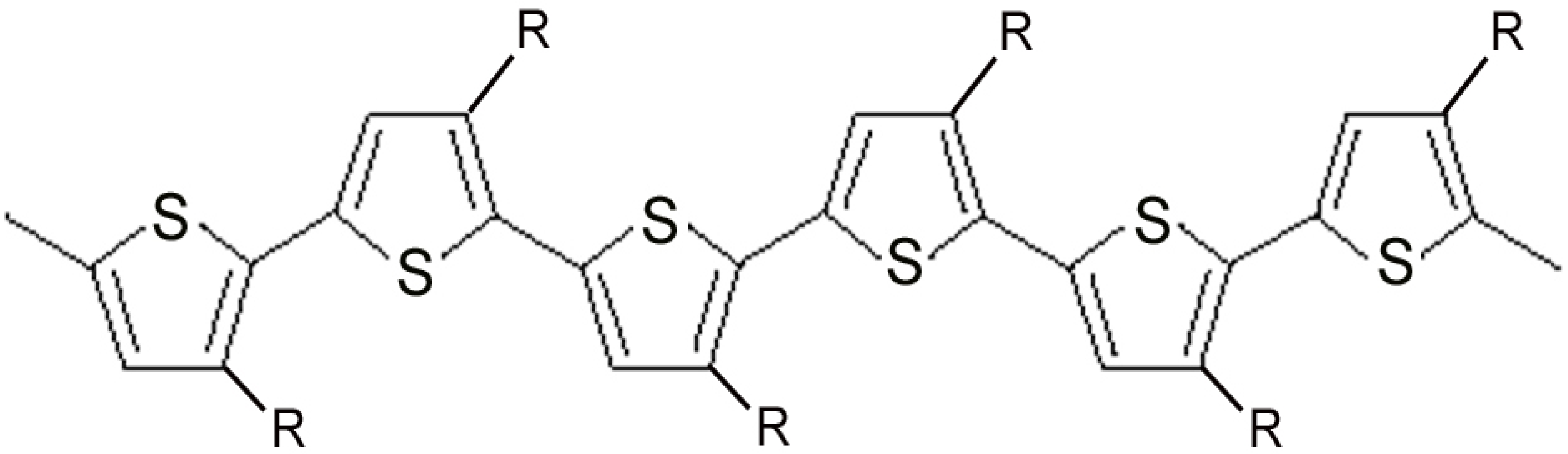
Sensor

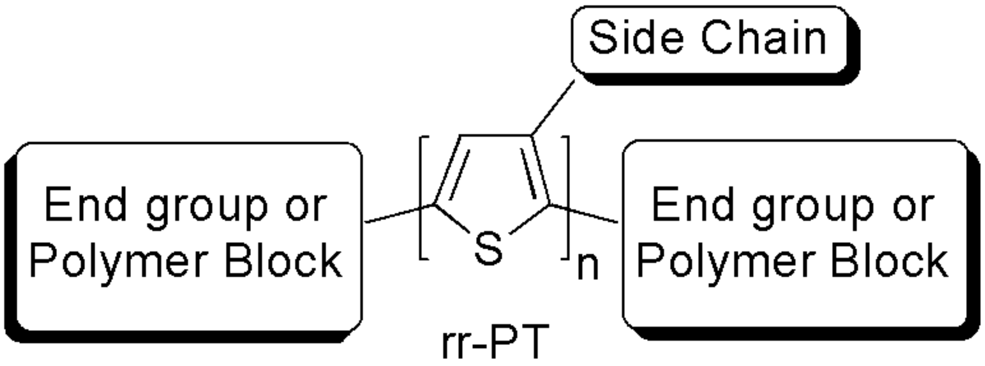
Equivalent circuit



TO-5

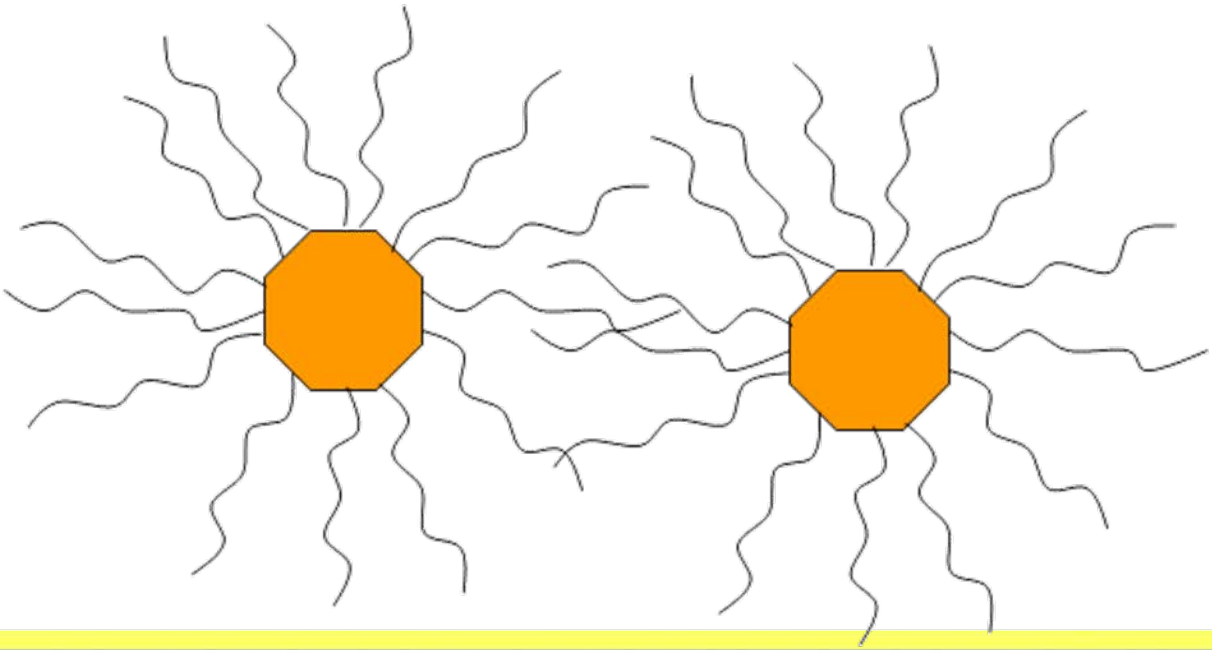
Regioregular poly(alkylthiophene)





What are Au-Monolayer Protected Clusters?

- **Composite material consisting of a cluster of gold atoms surrounded by a single layer of an organic molecule (thiol) bound to the metal through a sulfur atom:**

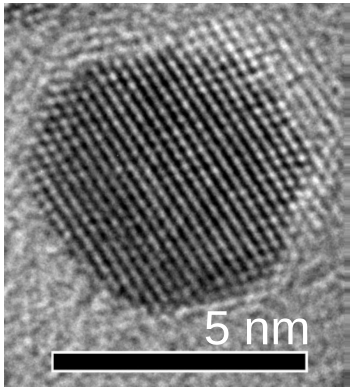


Nanoparticle Terminology

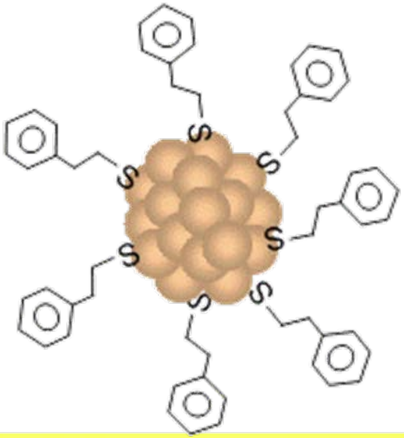
Nanoparticle:

• Solids in a size range of 1-100 nm in diameter (a general term).

• New phenomena not seen in atoms/molecules or bulk will emerge at this scale (**The exact size at which this happens depends both on the system and the property being considered*).



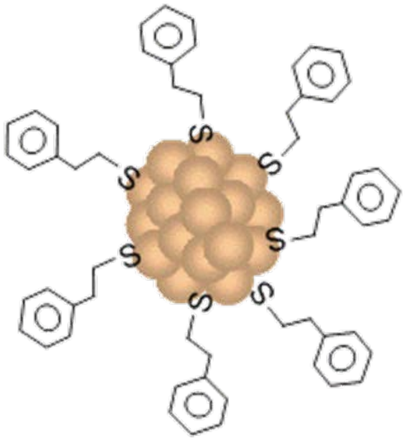
Nanocrystal: single crystalline nanoparticles (typically > 2nm to exhibit crystallinity (i.e. translational symmetry).



Nanocluster or cluster: individual molecular units that have **well-defined** structure (e.g. Au_{11} and Au_{25}), but are too small to be true crystals, with sizes ranging from subnanometer to ~2 nm).

They are closely akin to molecules in terms of transport and other properties.

Gold Nanoclusters for VOC sensing



A New Type of Ultrasmall Gold Nanoparticles:

- These particles have well-defined composition and structure (e.g. Au_n, n=the # of gold atoms);
- Too small to be true crystals (size ranging from subnanometer to 2 nm);
- New physiochemical properties that could benefit VOC sensing.

<u>Synthetic Challenges:</u>

1. How to achieve the ultrasmall size (< 2nm)?

— Ultrasmall size effects electron quantum confinement (semiconducting gold nanoparticles)

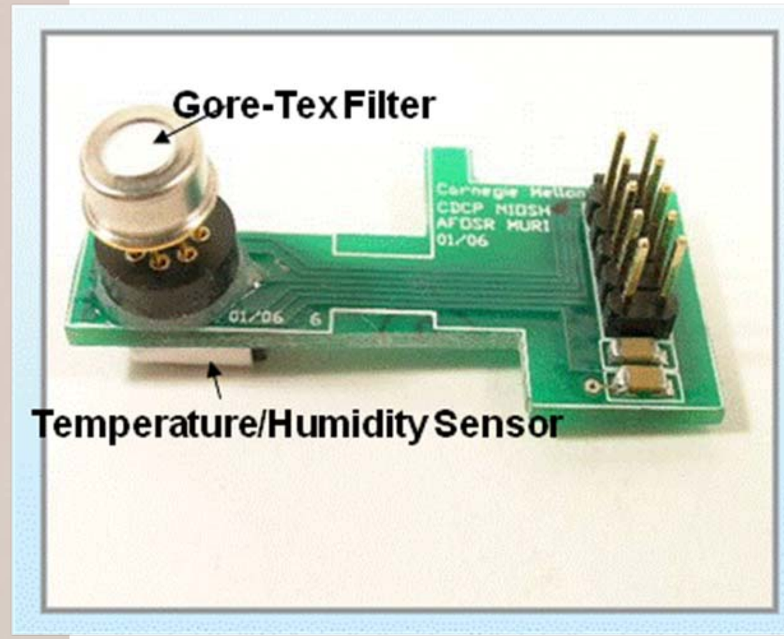
2. How to achieve atomic monodispersity?

— Controlling the # of atoms in a particle via kinetic control (atomically monodisperse: the ultimate)

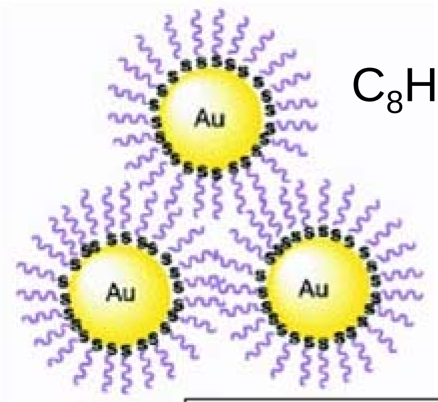
MPC Properties

- **Easy to handle**
  - Air stable.
  - Soluble in organic solvents*.
  - Can be coated on substrates by ink-jetting, dipping, spinning and spraying.
- **Can be modified**
  - Size and shape.
  - Functional end groups of organic monolayer.
  - *Solubility determined by the nature of the monolayer.
- **Reusable**

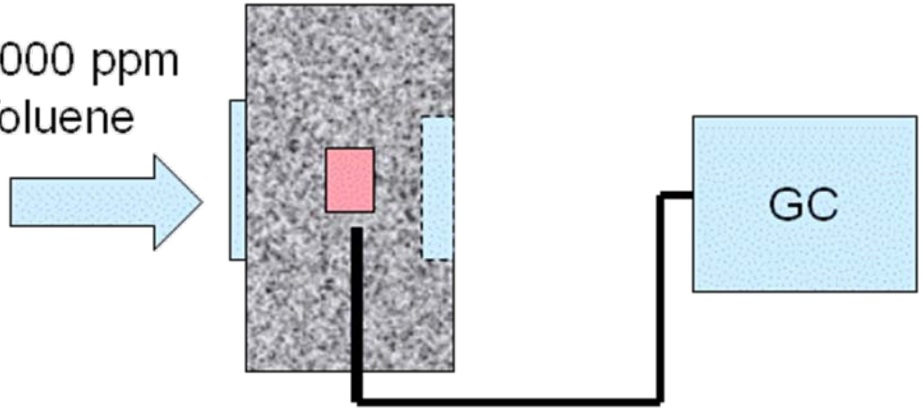
Complete TO-5 Package

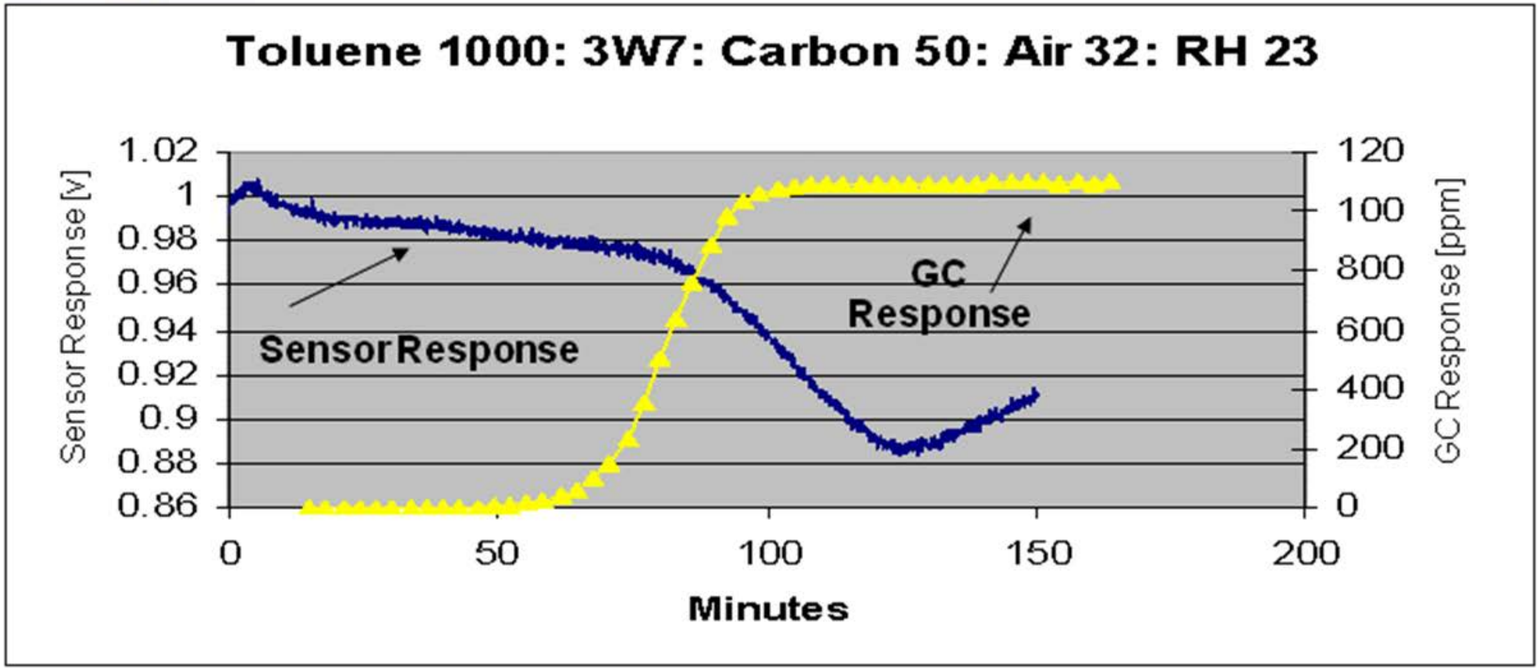


Performance of a MPC

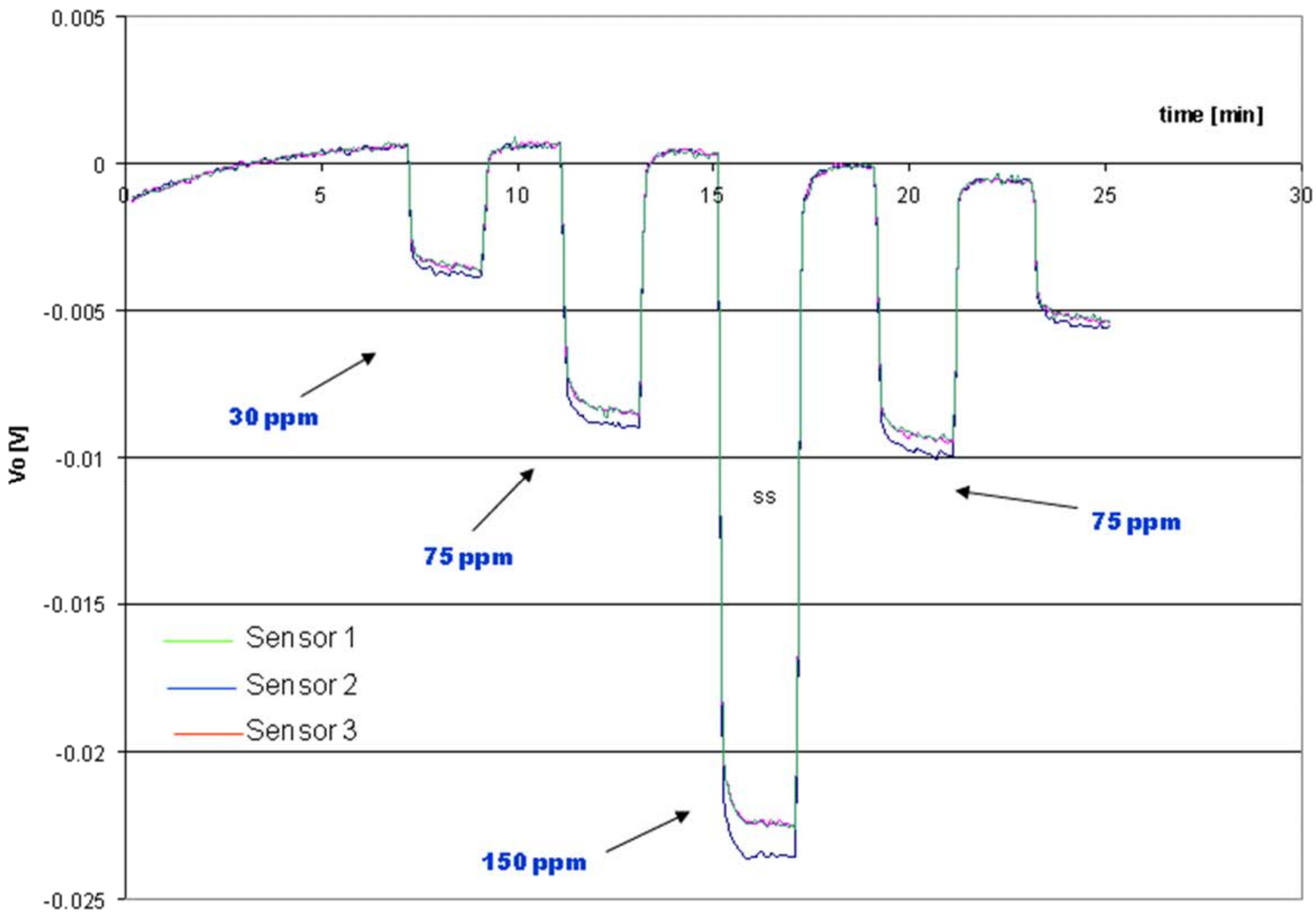


$C_8H_{17}SH$ (C8)



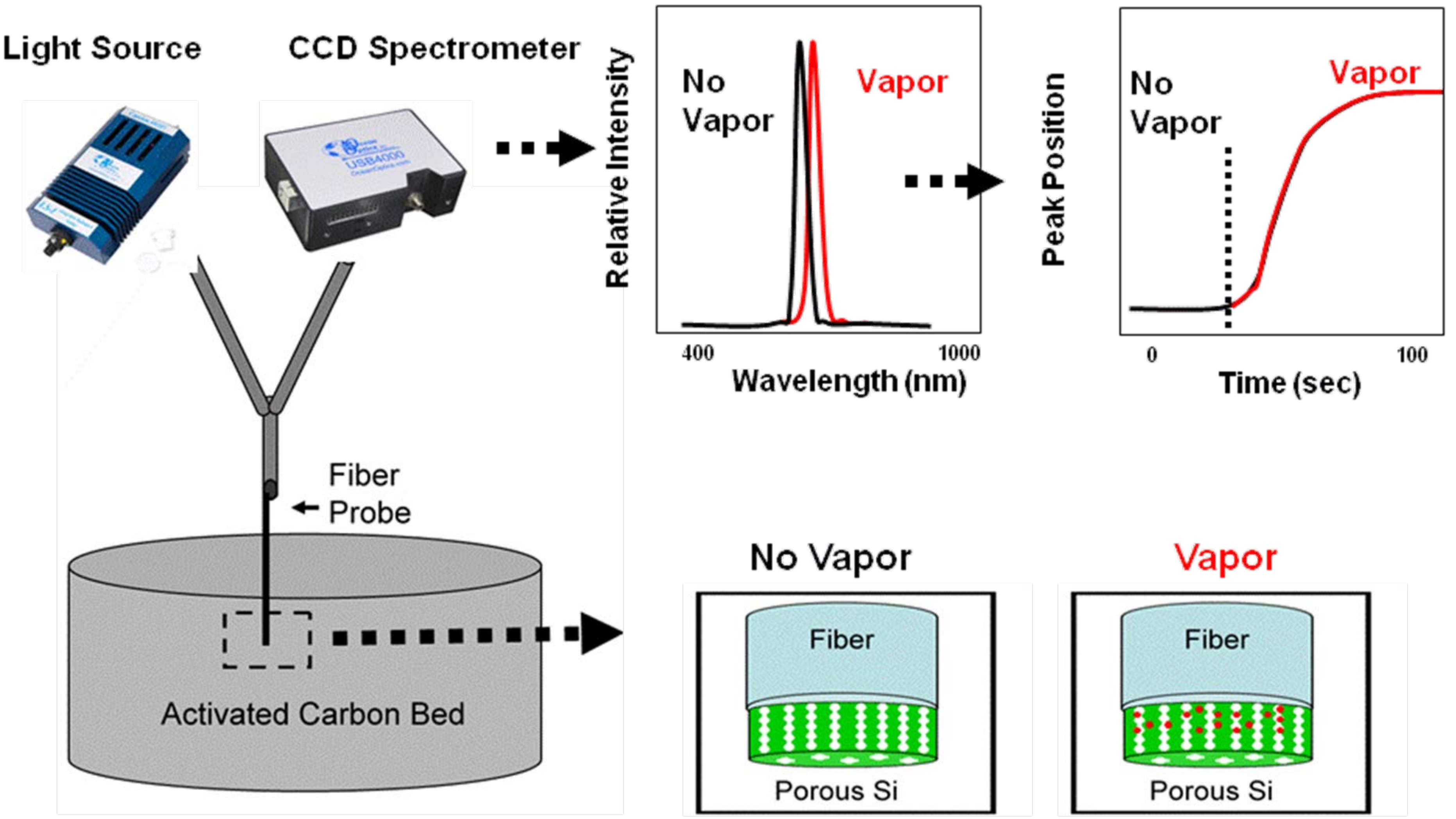


MPC Sensor Response to Toluene in Air

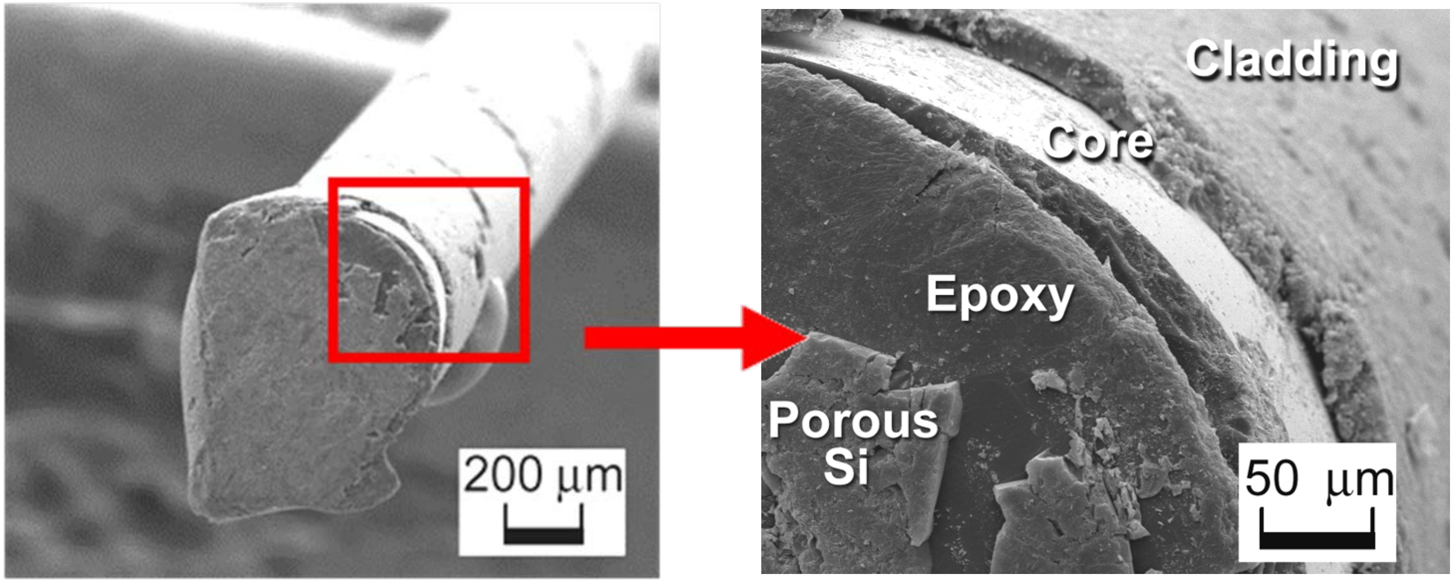


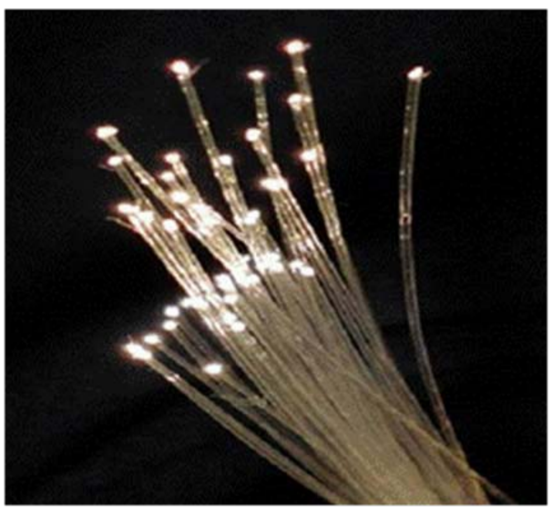
3F7NRL-C8 Sensor

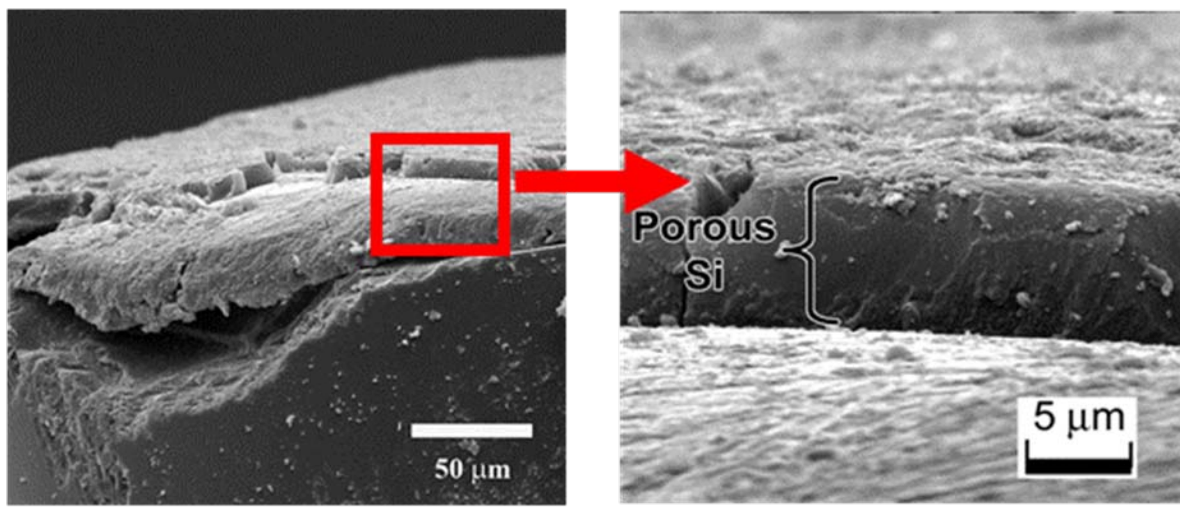
Optical Fiber Sensing Scheme



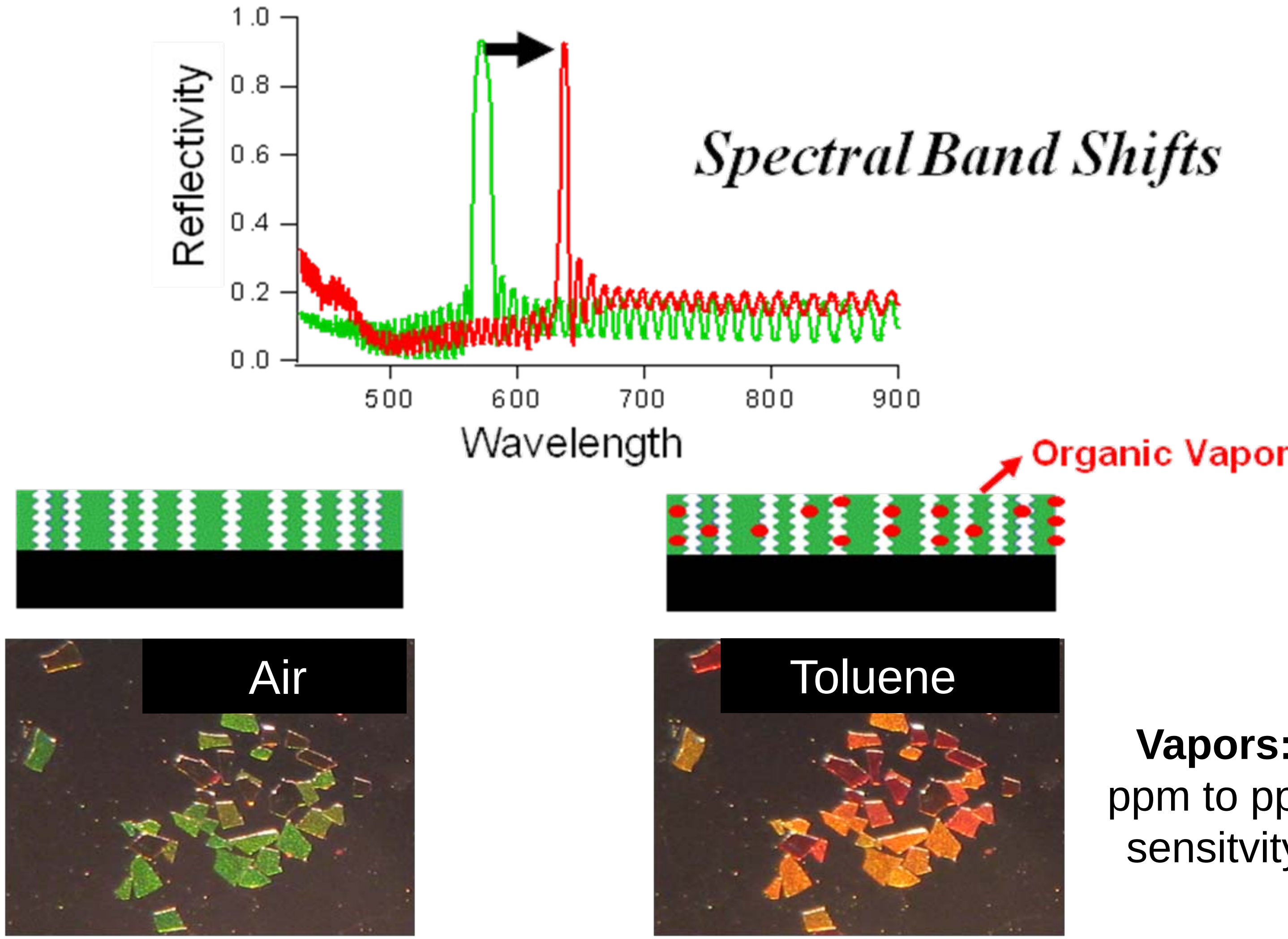
Attachment to Optical Fiber







General Sensing Scheme



Vapors:
ppm to ppb
sensitvity

Conclusions

- **NIOSH and its partners have made great progress toward ESLI for organic vapor respirator cartridges.**
- **Prototype electronic sensor systems have been inserted into commercially available cartridges.**
- **Optical based ESLI systems have completed proof of concept testing.**

Summary

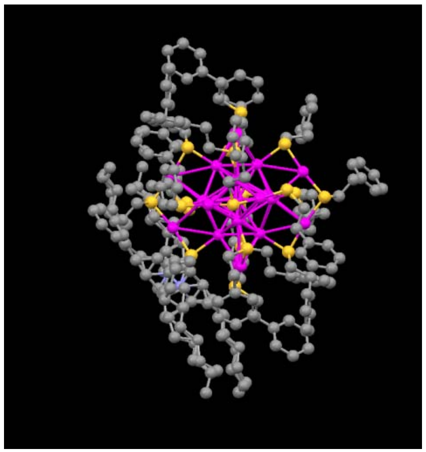
- Many ESLI design parameters still need to be optimization and continued development is underway.
- Application to commercial chemical detection is possible.

Disclaimer

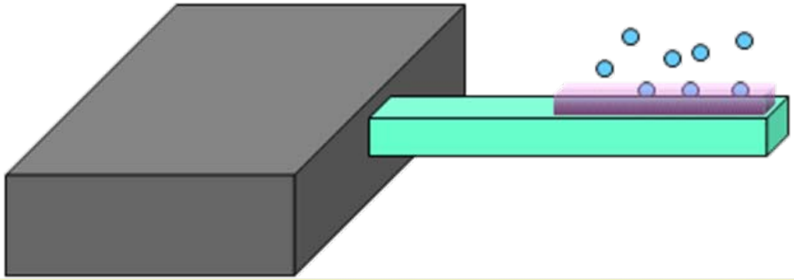
Visit Us at: http://www.cdc.gov/niosh/npptl/

Disclaimer:

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.



Thank you



2008 NIOSH Direct-Reading Exposure Assessment Methods (DREAM) Workshop

November 13-14, 2008 @ Hilton Crystal City, Washington D.C.

Session 6

Surface Sampling/ Biomonitoring

Current NIOSH Efforts

Lead Wipes for surface sampling, NMAM 9105

Licensed to SKC inc as "Full Disclosure"

Current NIOSH Efforts

- Methamphetamine surface wipe methods, NMAM Draft 9106,9109,9111 by MassSpec with isotopic dilution.

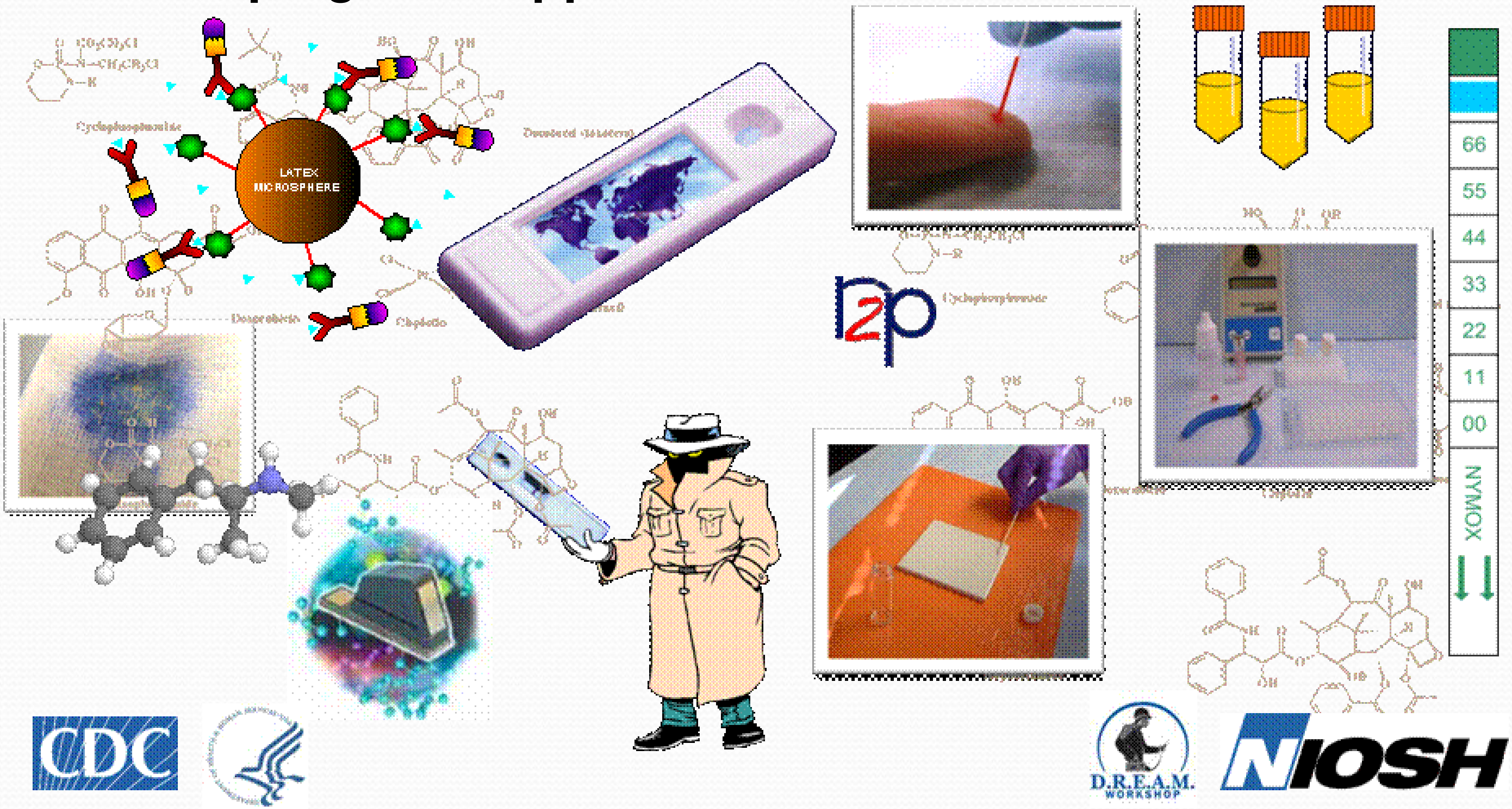
- 2 Direct Reading Methods, Colorimetric and Immunochemical. Licensed to SKC as “MethAlert” “MethChek”

Current NIOSH Efforts

Antineoplastic drugs on surface wipes Immunochemical detection

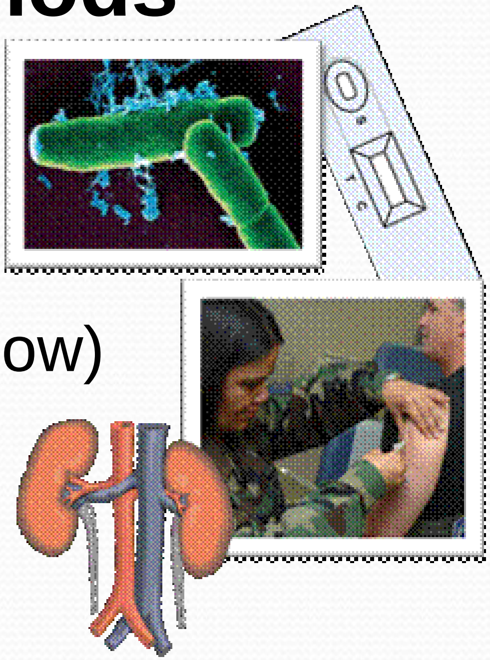
Current NIOSH Efforts

Developing New Applications for Common Platforms



Current NIOSH Efforts

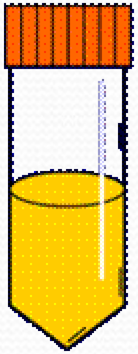
Development of new methods



- Anthrax vaccine status (lateral flow)
- β2-microglobulin in urine (lateral/vertical flow)
- Toxicity/Allergy (lateral/vertical flow)
- Cooperation with other federal /university/industry partners to evaluate new technologies

Current NIOSH Efforts

Application of commercial/clinical methods



- Smoking status (lateral/vertical flow)
- CO monitors (exhaled breath /carboxyhemoglobin)
- Modification of test kits (pesticides)
- Point of Care (POC) diagnostics

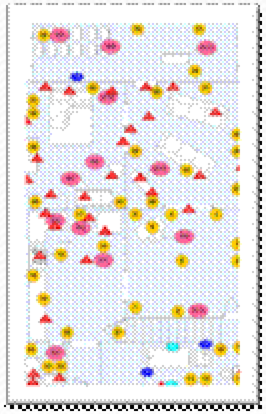
CDC

D.R.E.A.M. WORKSHOP

NIOSH

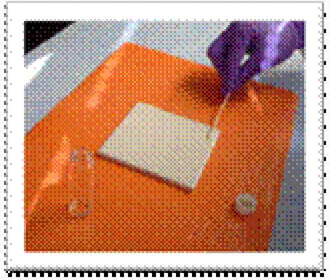
NIOSH DRM/DRI Uses

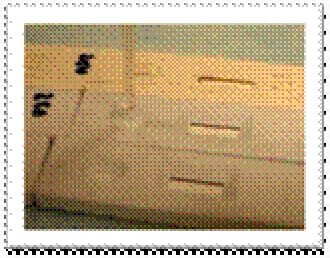
- Health Hazard Evaluations
  - Environmental Sampling, Biological Monitoring
- Exposure Assessment Studies
  - Environmental Sampling, Biological Monitoring
- Evaluation of Work Practices and Controls
  - Environmental Sampling, Biological monitoring



Challenges

- Limited REL/PEL for surface contaminants
- Limited Biological Reference Values (BRV)
- When is a qualitative measure good enough?
- What do quantitative numbers mean?
- How 'Direct' is direct reading? 1, 2, 3 steps

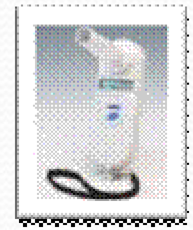


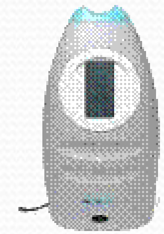



Workshop Aims

- What is the role for NIOSH in addressing DRI/DRM issues?
- Should NIOSH take the lead on a special DRI/DRM initiative?
- Identification of stakeholders/users: level of involvement.

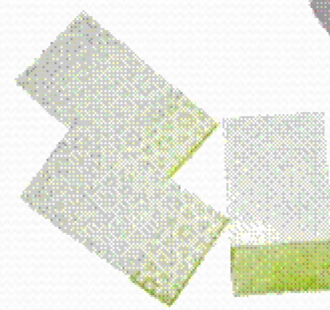
Workshop Aims





- Types of DRI/DRM

- Current applications for DRI/DRM



- Obstacles to use of DRI/DRM
- Future applications/New Technologies

- Advantages/Disadvantages of particular instrumentation/methods

Workshop Aims

- Guidelines development: common criteria needed for multiple agencies.
- Specific NIOSH **N**ational **O**ccupational **R**esearch **A**genda (NORA) sector needs
- http://www.cdc.gov/niosh/nora

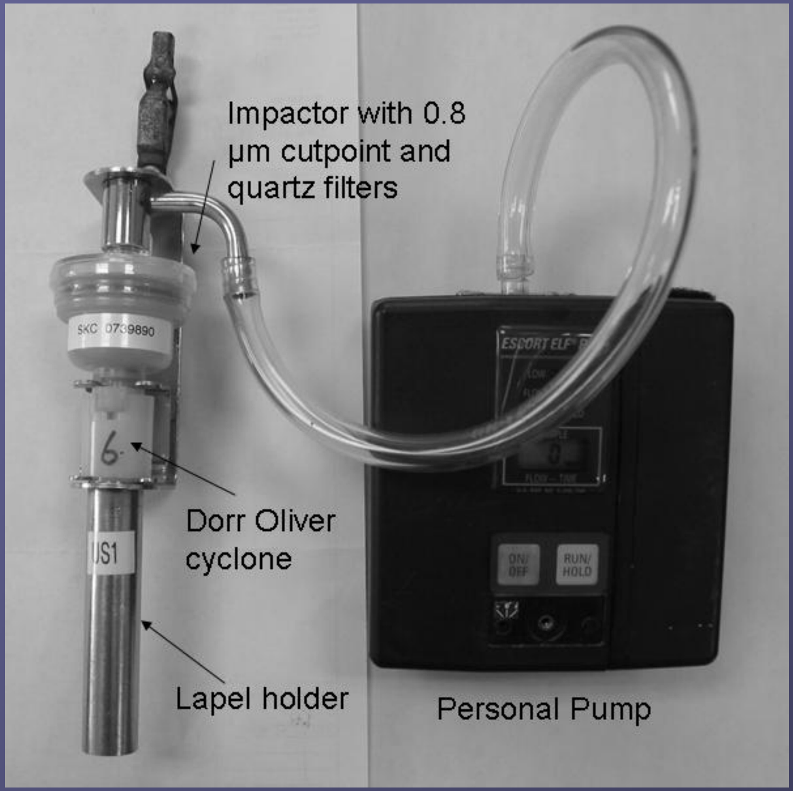
Reducing exposures to diesel particulate matter (DPM) using direct-reading instruments

Jim Noll
Center of Disease Control
National Institute for Occupational Safety and Health
Pittsburgh Research Laboratory

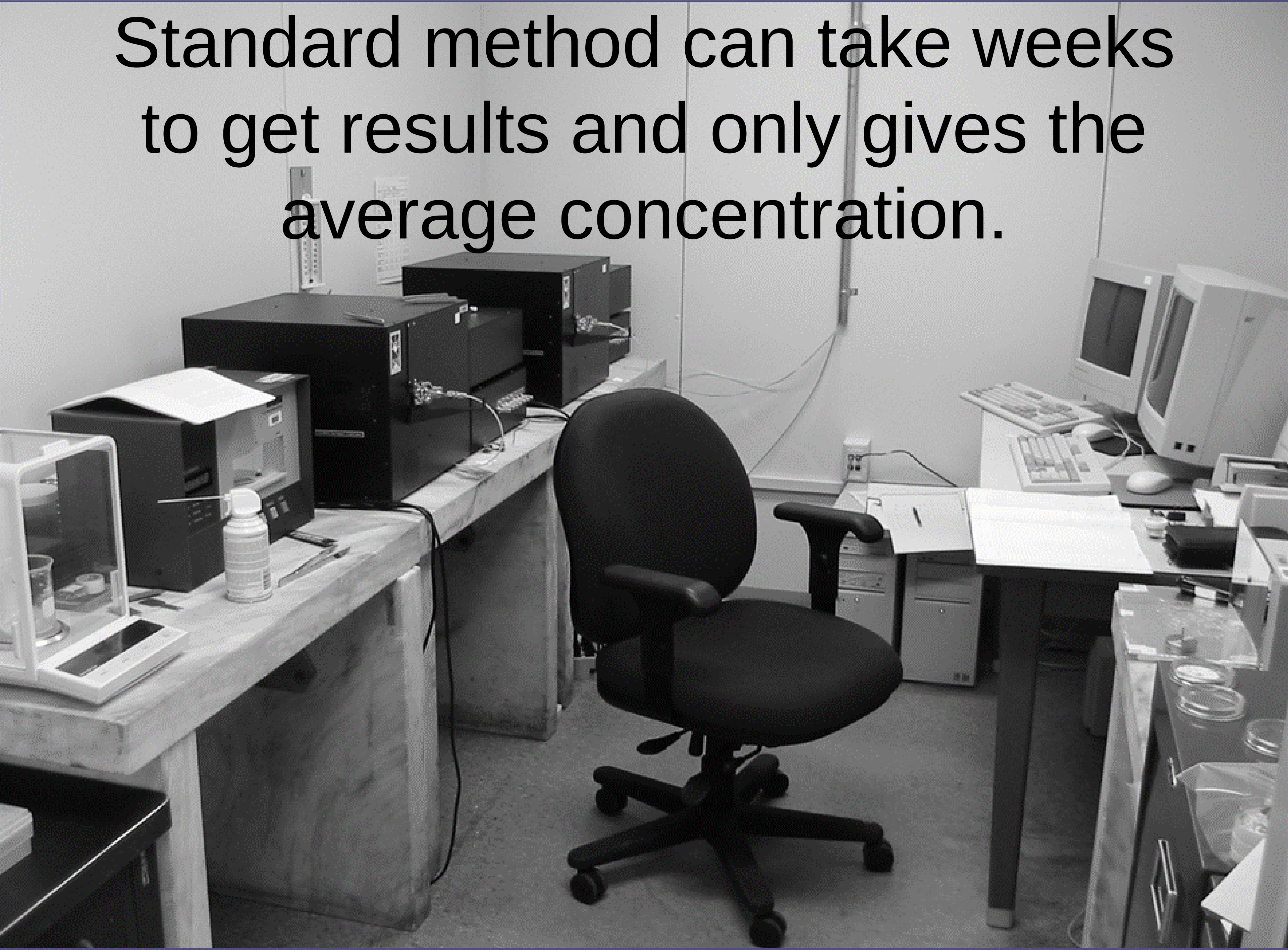
DPM is considered a potential health hazard

Workplace exposures can be significantly higher than environmental concentrations

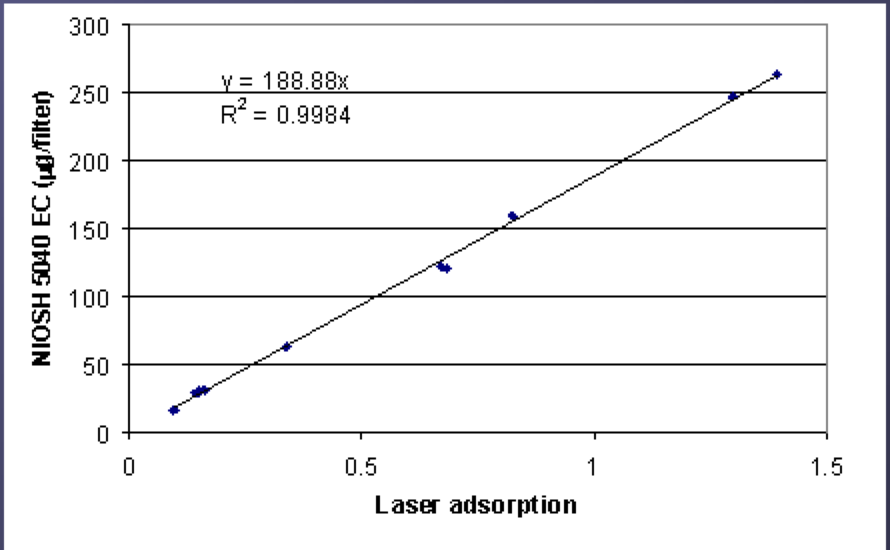
In the standard method, DPM is collected on quartz filters and analyzed for elemental and total carbon using NIOSH method 5040



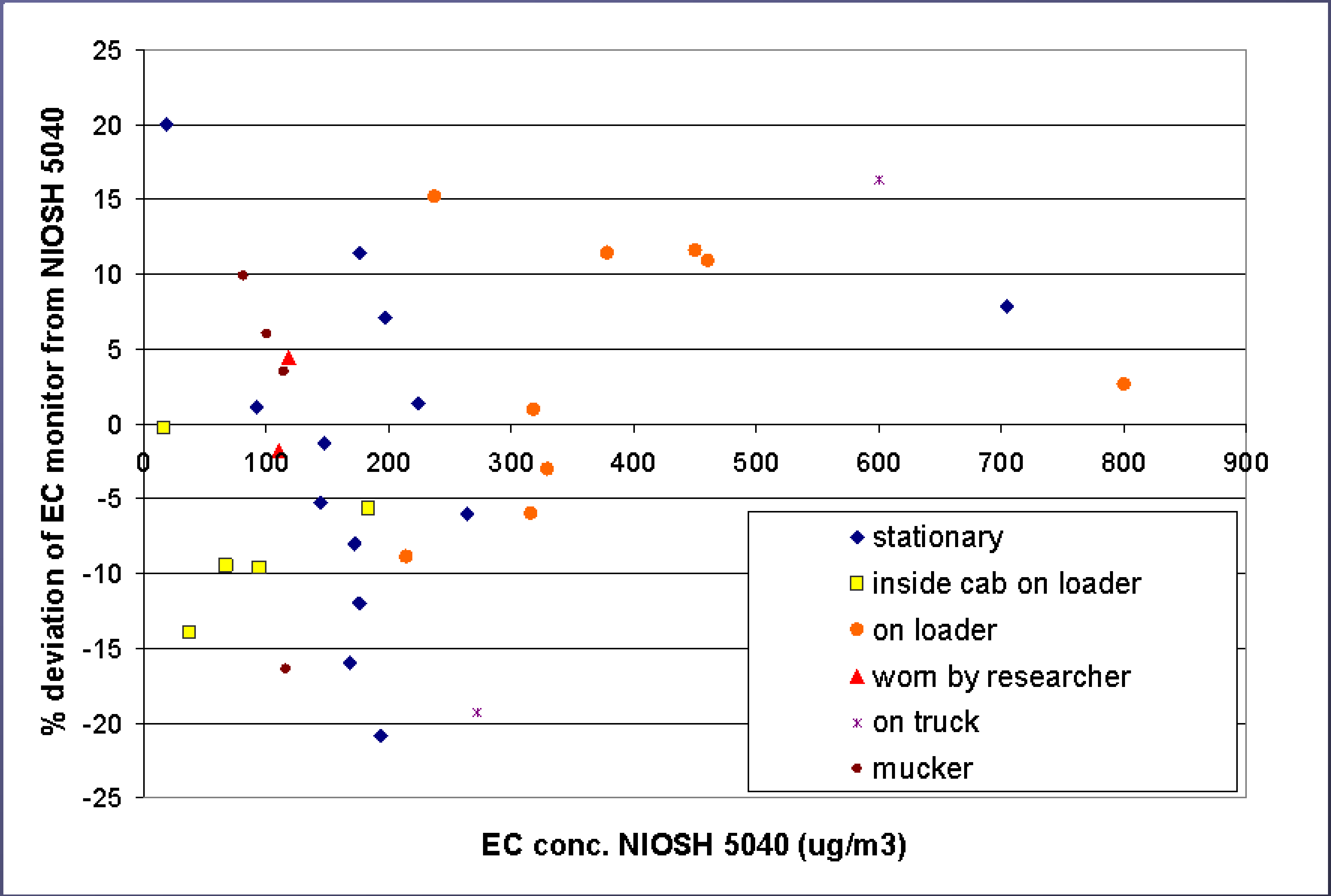
Standard method can take weeks to get results and only gives the average concentration.



NIOSH has developed a near real time monitor that measures the darkness of the filter.



EC monitor measured accurately in field



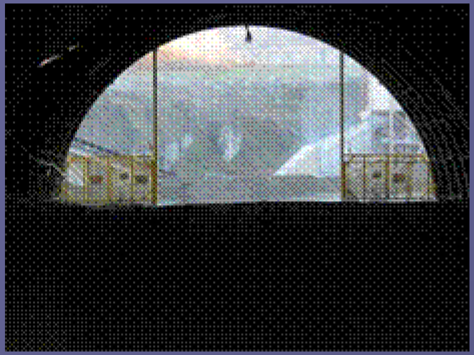
Great tool for reducing DPM exposures

EC monitor can help evaluate control technologies

Ventilation

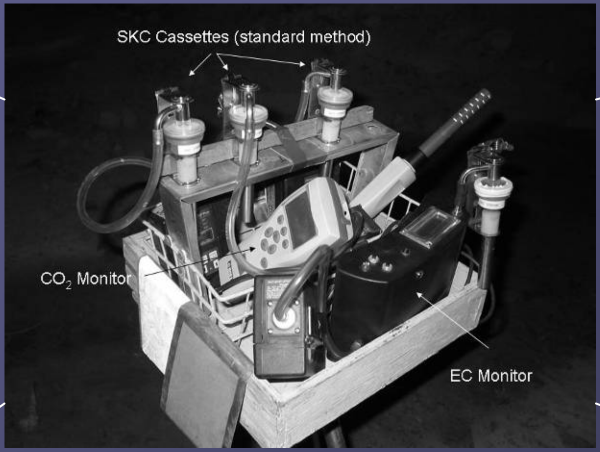
Enclosed Cabs

Area samples were taken in several underground stone mines



intake

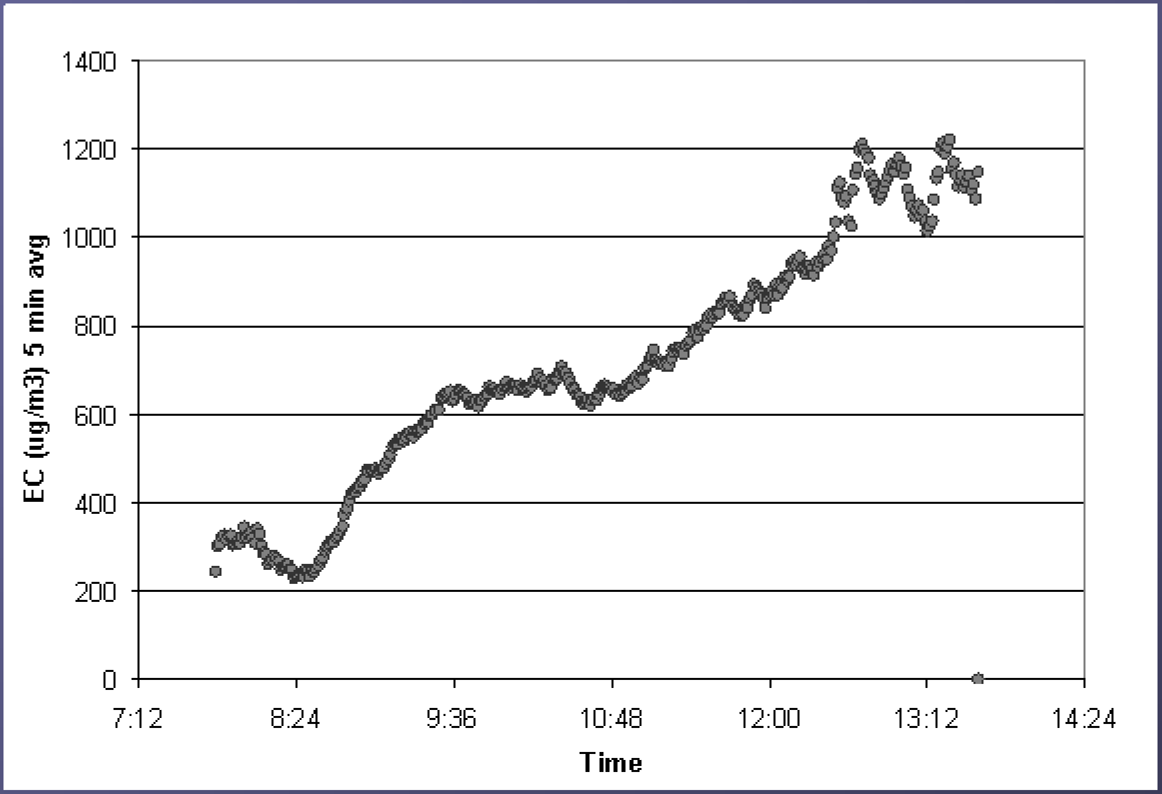
Working area or face



return

crusher

EC monitor not only showed the average concentration but also that DPM was building up and not being flushed out by fresh air.

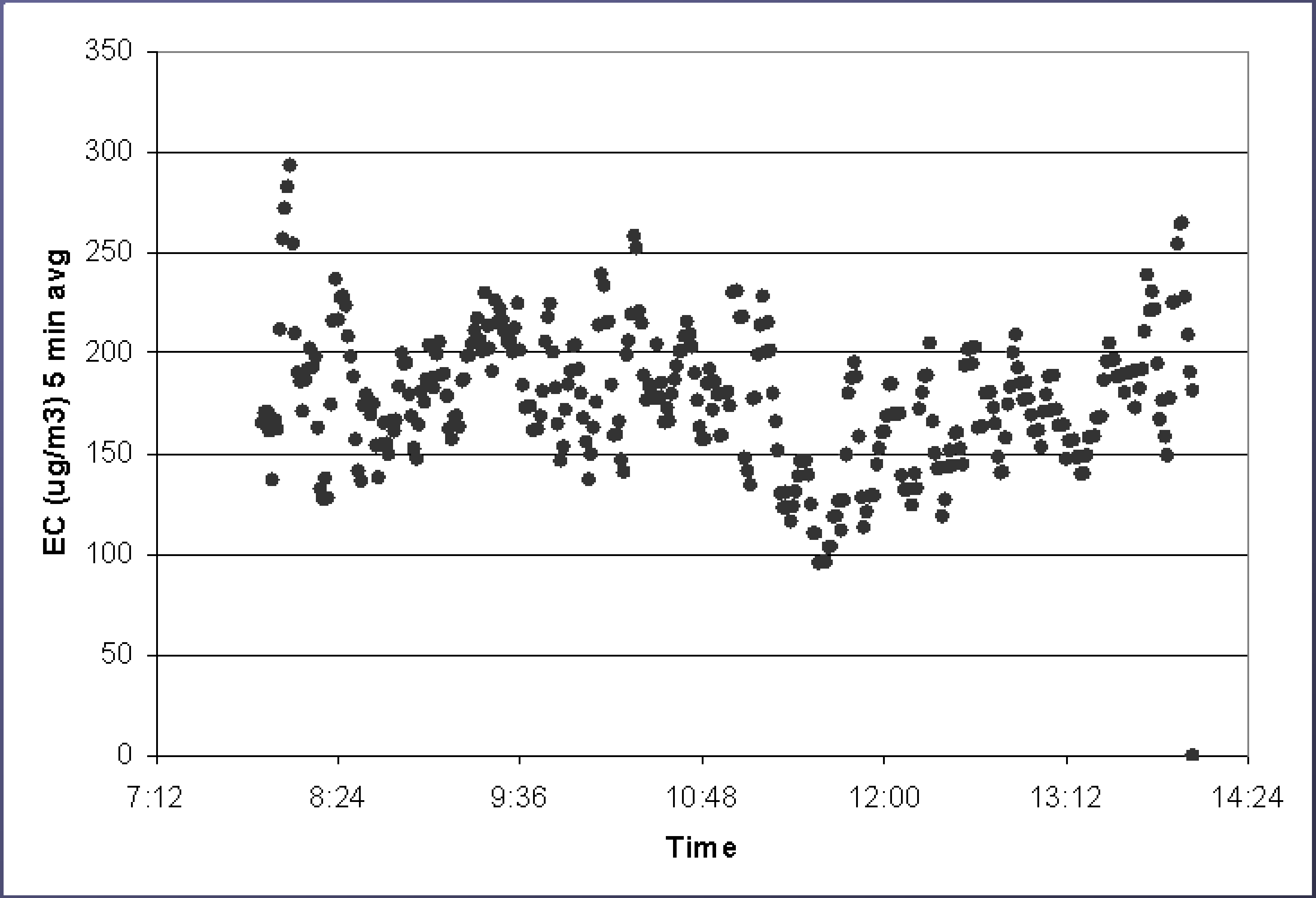


Average Concentration

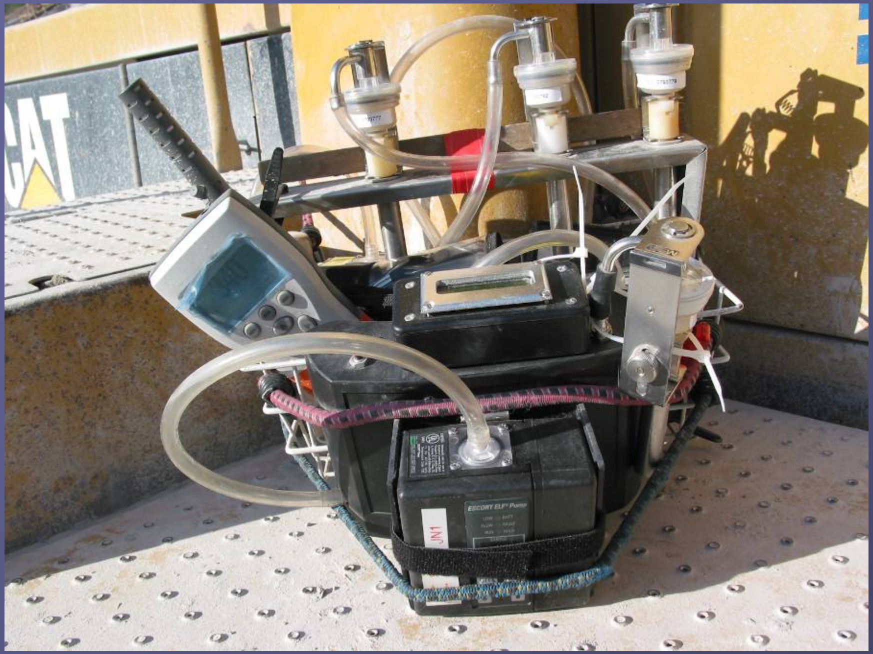
NIOSH 5040: 653 μg/m^3 EC

EC monitor: 704 μg/m^3 EC

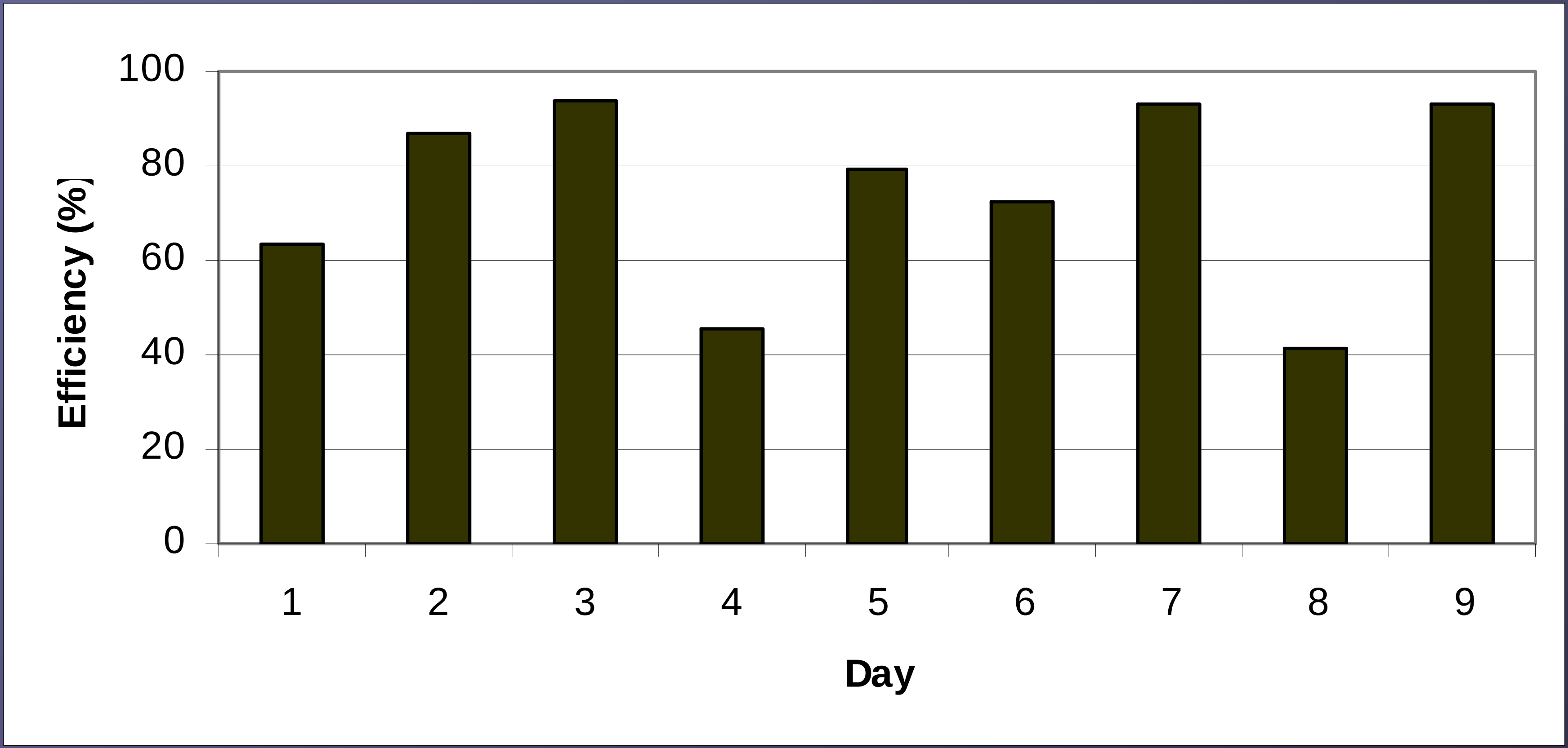
The ventilation was flushing the DPM out at the crusher.



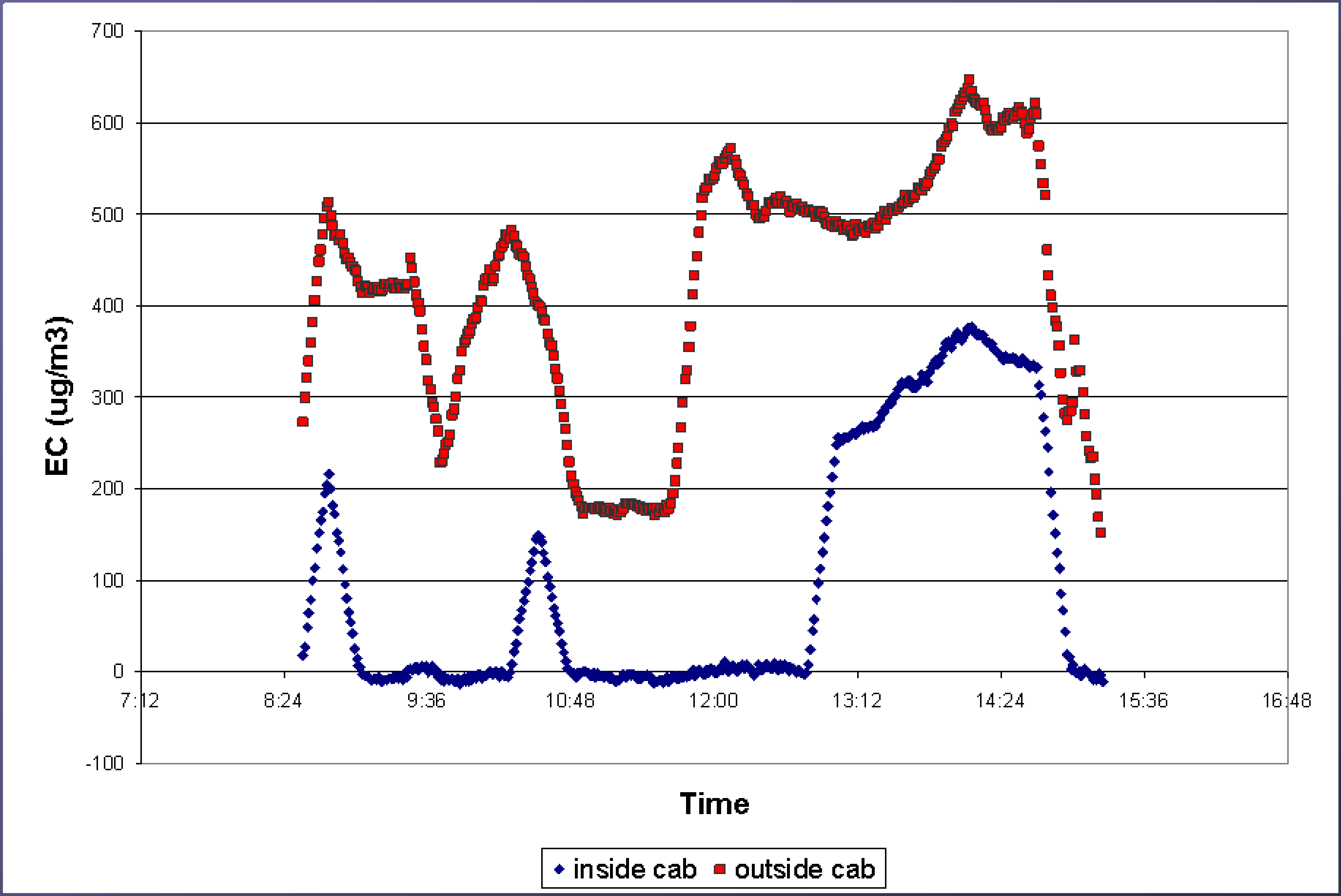
Measured EC inside and outside of cab



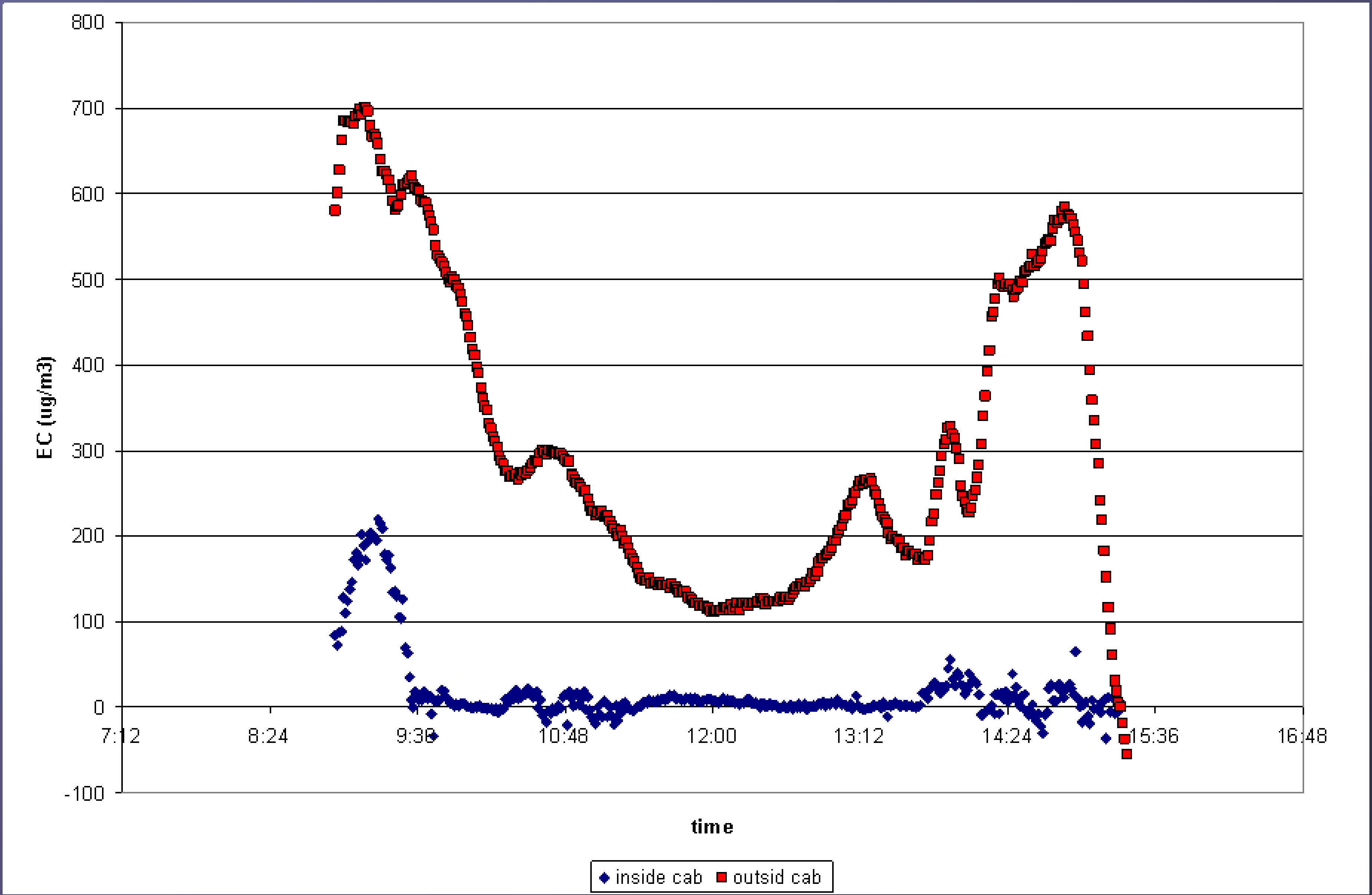
Using 5040 data, cab efficiencies ranged from 40-93%



Day 6:
73% efficiency



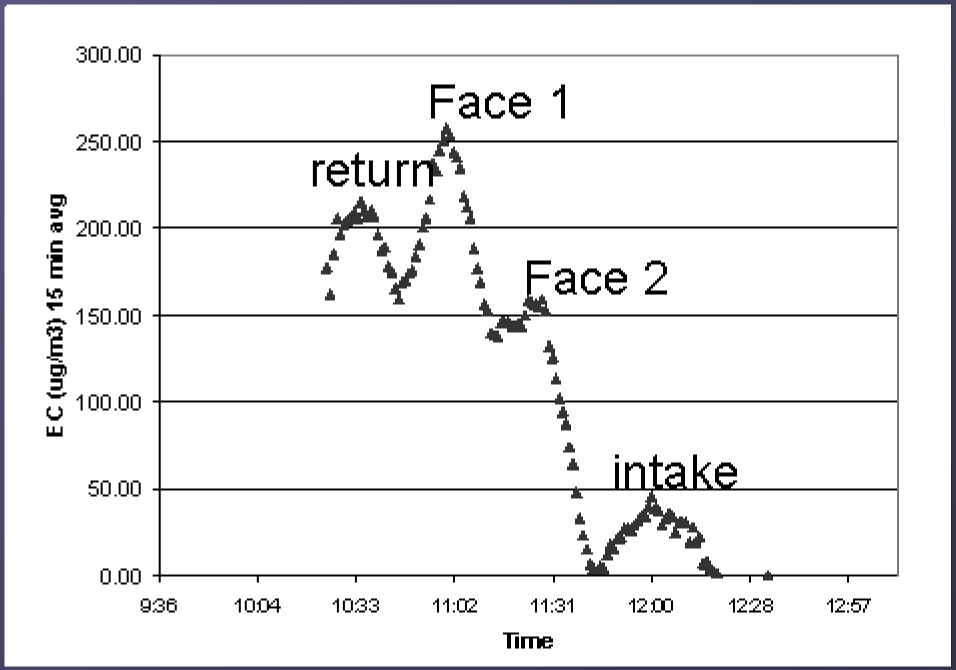
Day 9:
93% efficiency



The cab was probably over 90 % efficient in removing diesel particulate

Determine control technology failures

A worker can control own exposure

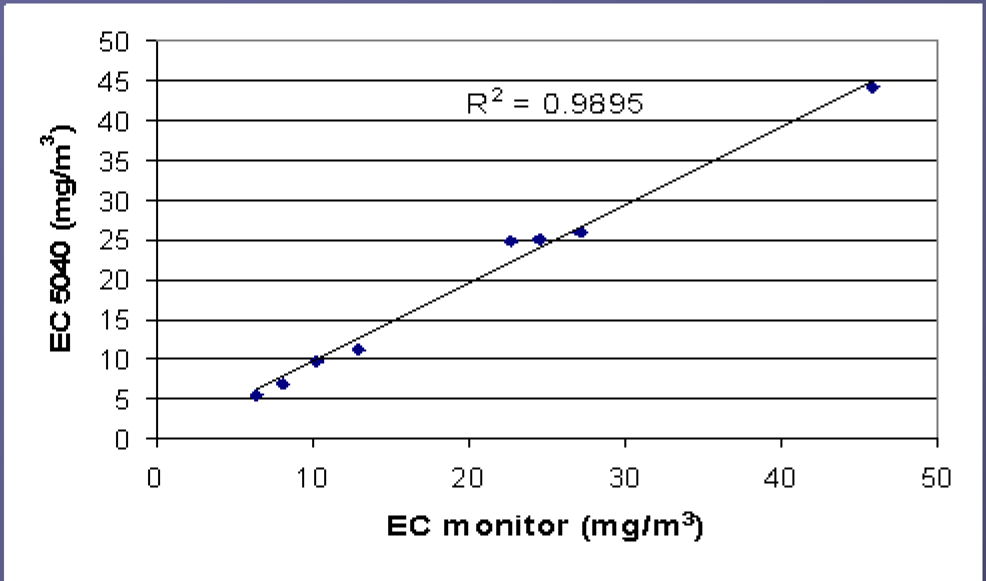


Control location of workers

- Example
  - Blasters in a stone mine that cannot work in enclosed cab
    - set location to blast in low DPM concentrations

Control the number of vehicles in an area

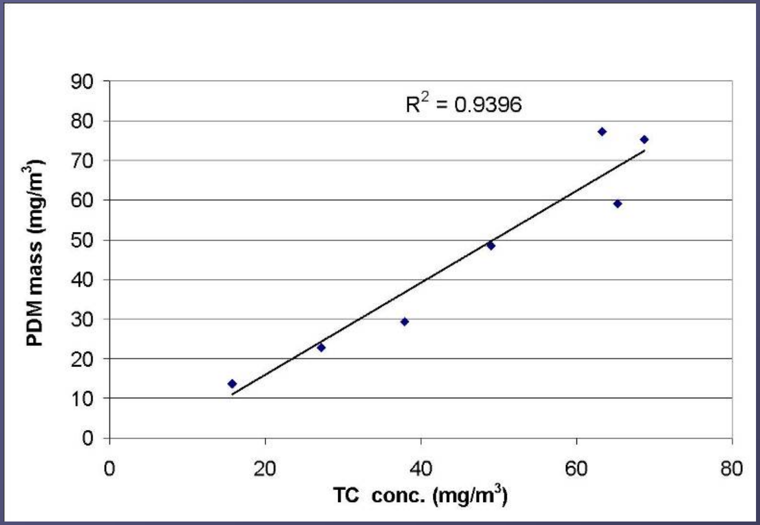
Tailpipe Evaluation



Determining DPF failure

Maintenance

NIOSH is also investigating other direct reading devices for diesel

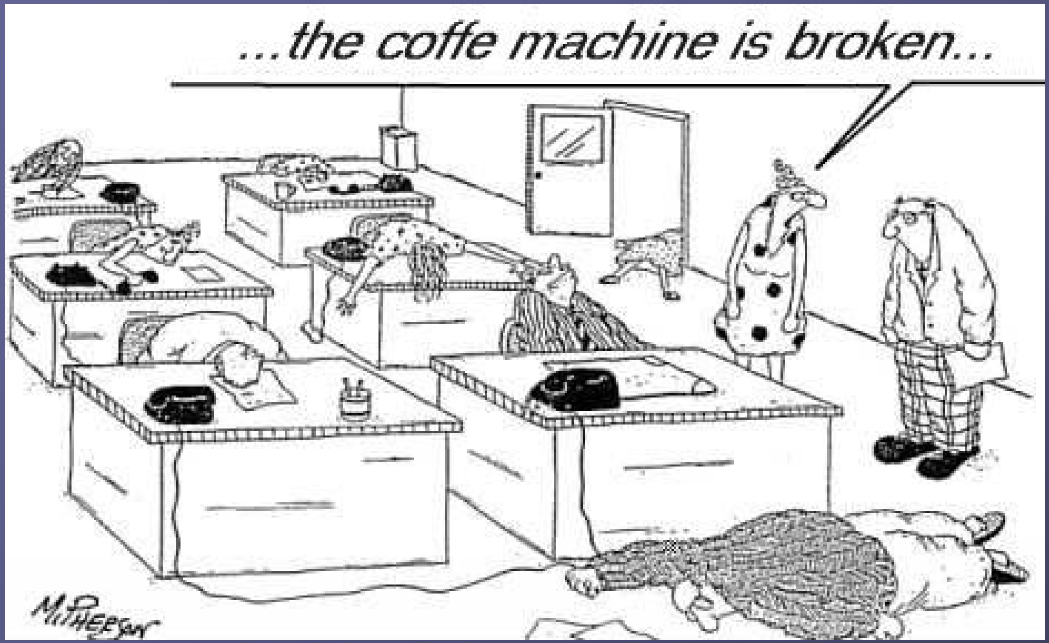


e.g. PDM was used as

Tailpipe monitor

Engineering tool for coal mines

Questions


...the coffe machine is broken...


Snapshots at jasonlove.com
GROCERIES
POST
OFFICE
GASOLINE

Surface sampling & analysis:
Examples from NIOSH work

Kevin Ashley, Ph.D.
CDC/NIOSH
Cincinnati, Ohio

National Institute for Occupational Safety and Health
NIOSH

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The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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Examples for Pb, Be & Metals

1. Handwipe disclosing method for the presence of lead (qualitative)

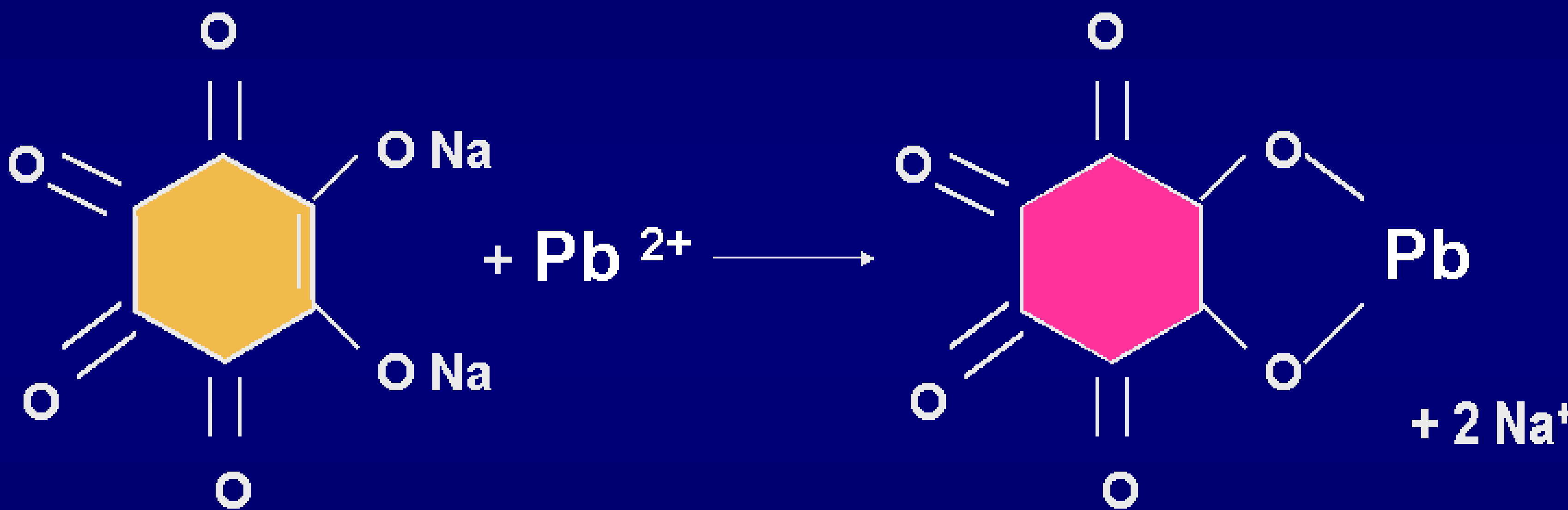
2. Determination of trace beryllium in wipe samples (quantitative)

3. Microvacuum sampling (performance data)

HANDWIPE DISCLOSING METHOD FOR THE PRESENCE OF LEAD*

*[*US Pat. 6,248,593*]

Sodium Rhodizonate – Lead Colorimetric Reaction



Sodium rhodizonate
(yellow / orange, pH < 7)

Lead – rhodizonate adduct
(pink /red)

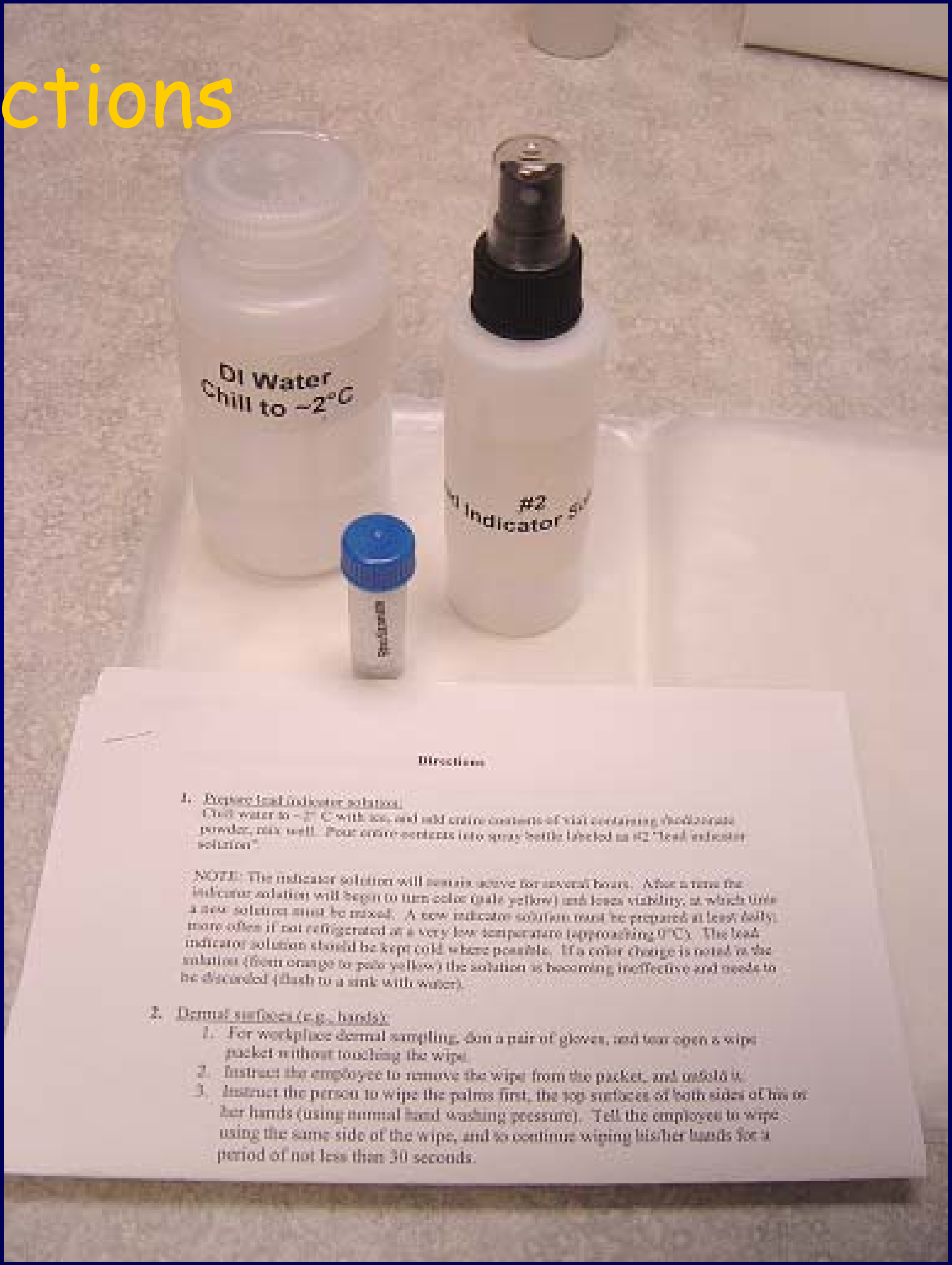
HANDWIPE DISCLOSING METHOD FOR THE PRESENCE OF LEAD

<u>The kit includes</u>:

1 instruction sheet
1 pre-weighed vial
of rhodizonate powder
12 handwipes
(10 samples and 2 blanks)
10 pairs of gloves
2 pre-labeled spray bottles
1 bottle of 105 mL DI water
12 50-mL sample collection tubes
10 sheets of pre-cut wax paper

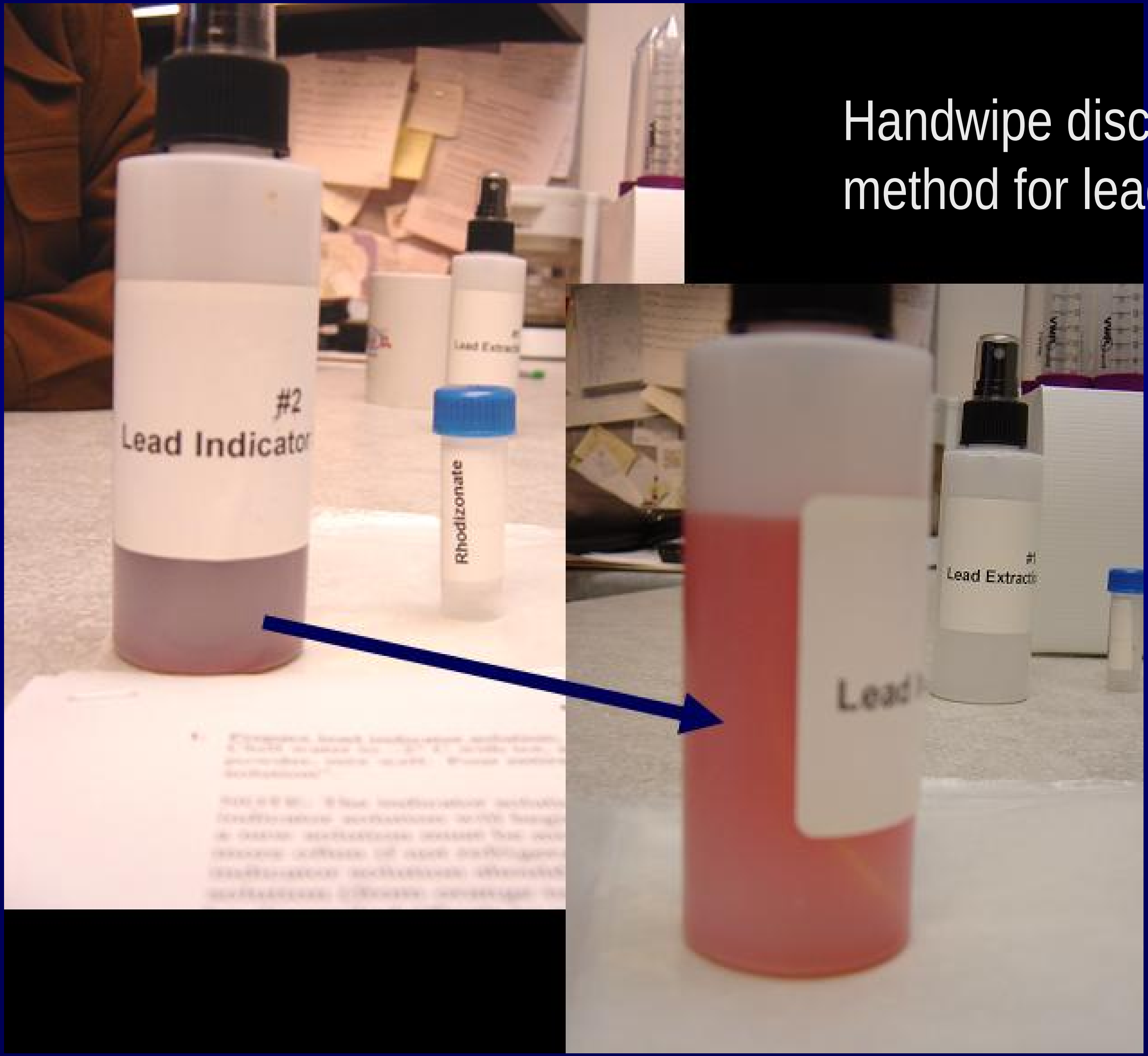
1. Read the Instructions

Handwipe disclosing method for lead – Commercial product: “Full Disclosure”



2. Prepare the Pb indicator solution

Handwipe disclosing method for lead, cont'd.

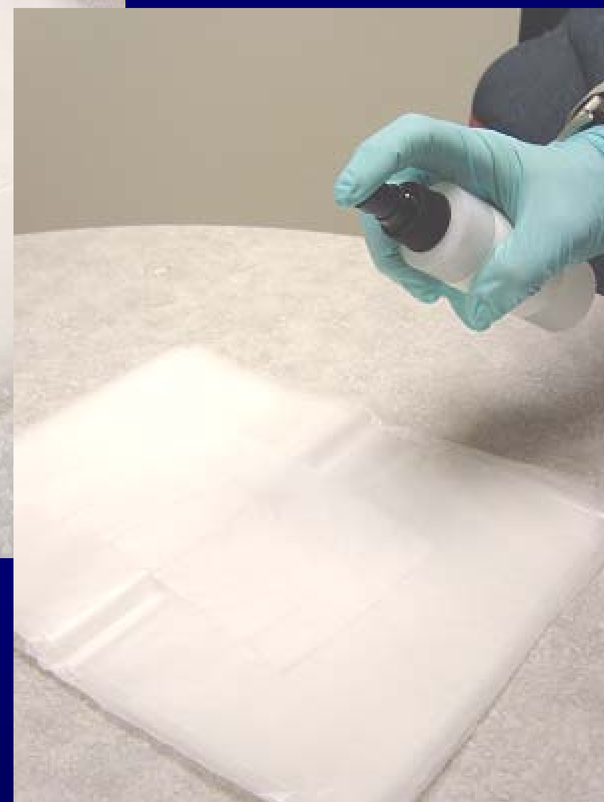


(NIOSH Method 9105)

3. Wipe hands for 30 seconds

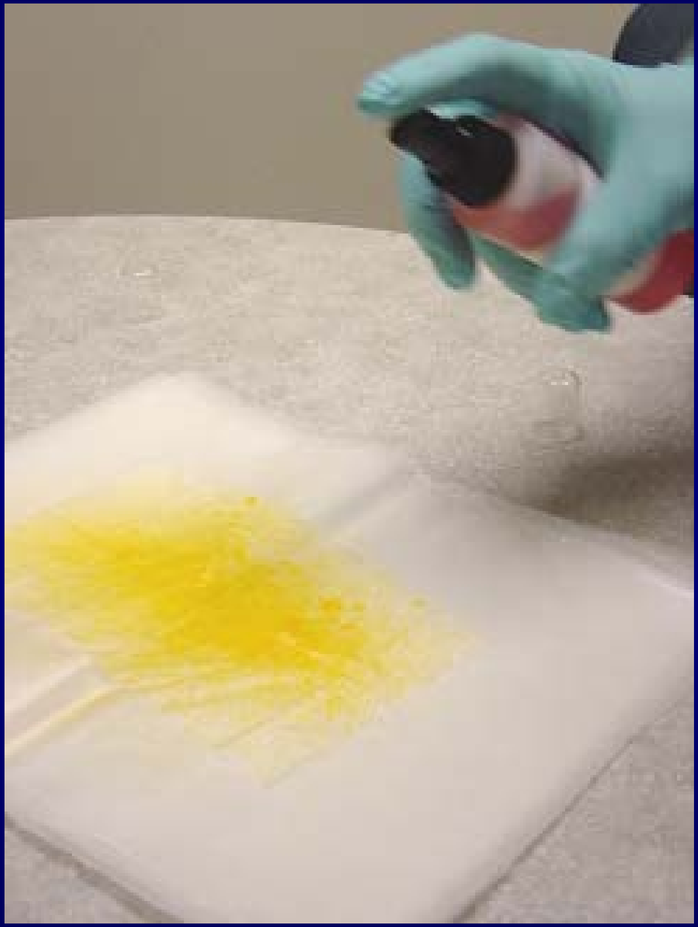
(use ASTM E1792 wipes)

Handwipe disclosing method for lead, cont'd.



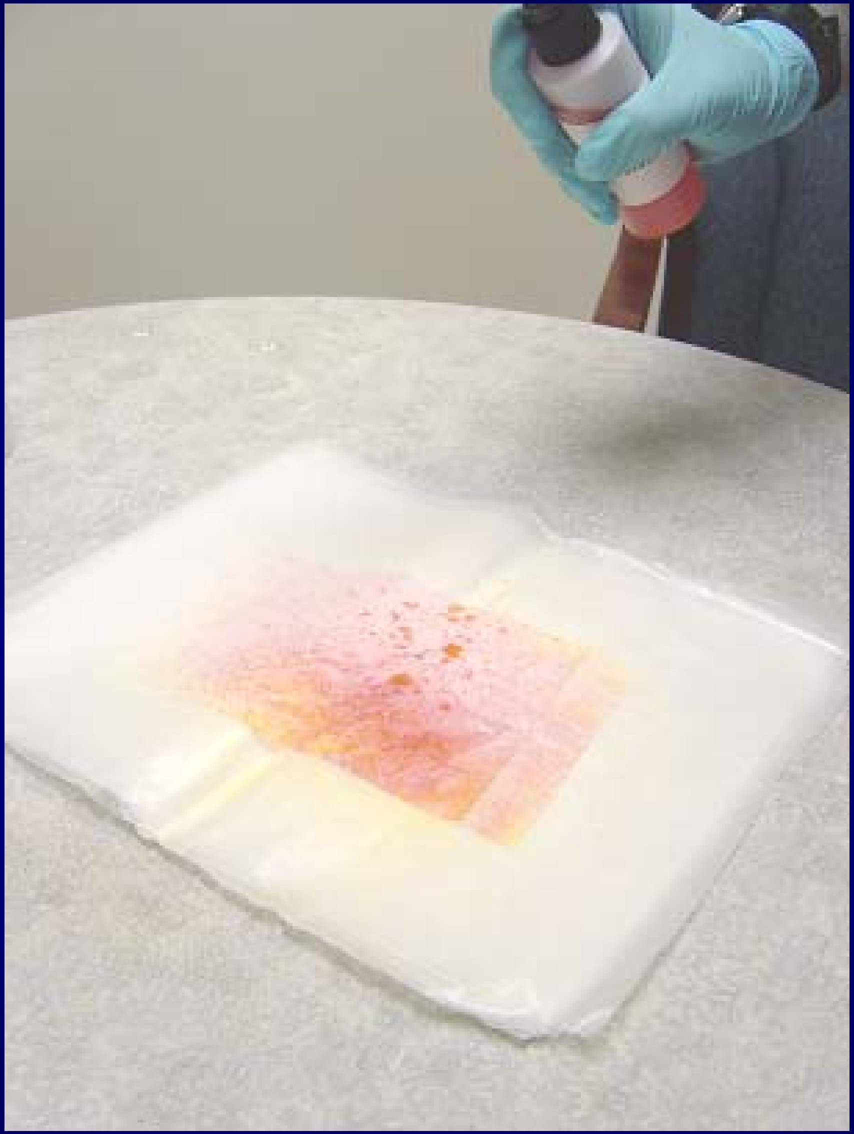
4. Spray 3 pumps of extraction solution (soln. #1) onto center of wipe

Handwipe disclosing method for lead, cont'd.



5. Spray 2-3 pumps of the disclosing solution (bottle #2) onto the center of the wipe

Handwipe disclosing method for lead, cont'd.

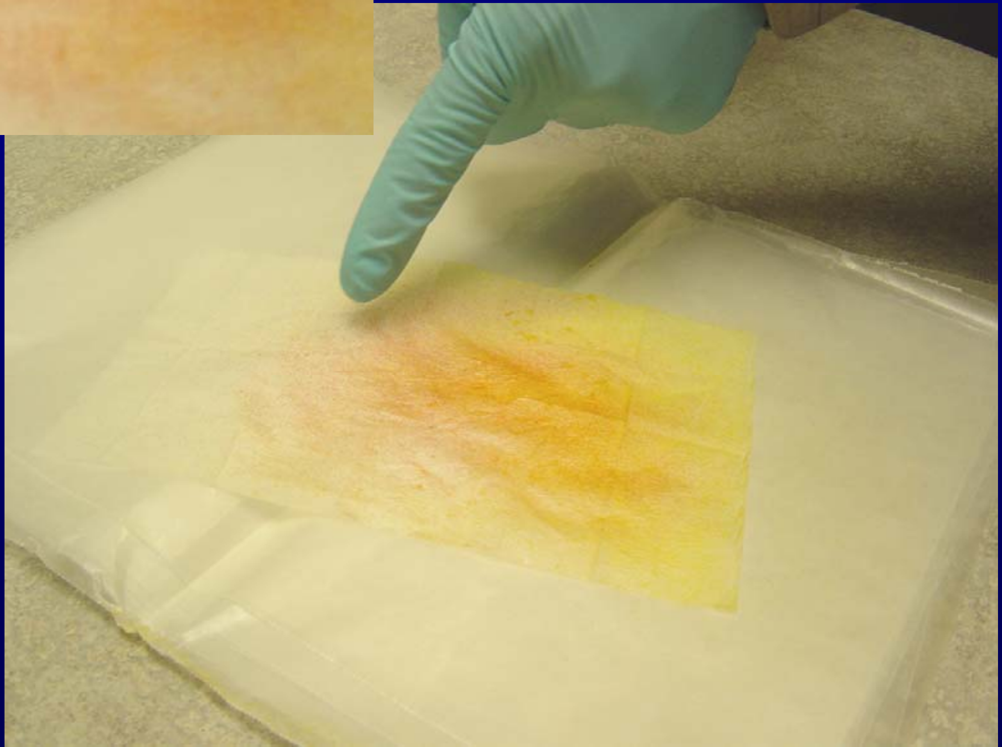


6. The presence of Pb is disclosed if the sample turns a pink to red color

Negative control

Positive Sample

Handwipe disclosing method for lead, cont'd.



The method is sensitive and specific for lead

Handwipe disclosing method for lead, cont'd.

Can be also be used to disclose the presence of lead on hard surfaces, e.g., Floors & WindowSills (pre-clearance), Shoes (take-home Pb), Car Interiors…

Wet wipe sampling of lead dust – Performance data (ASTM D6966)

Collection efficiency of Pb in dust from smooth surfaces (RTI, 1990s):

75-80% (1^{st} wiping); to >90% (3^{rd} wiping)

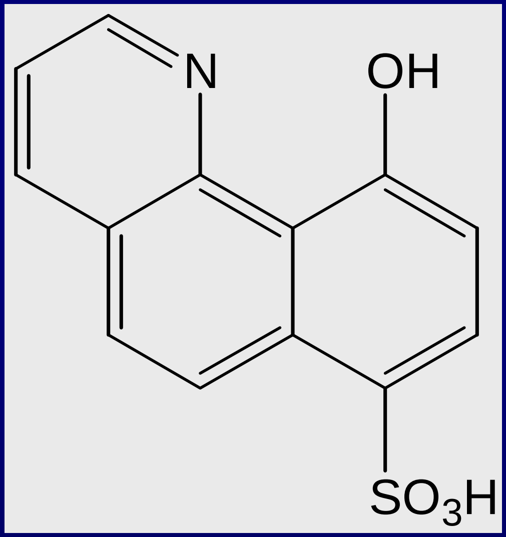
Collection efficiency of PbO dust from hands (NIOSH, 2000s):

55-60% (1 wipe, 30 sec per pair of hands);

to nearly 80% (3 wipes)

Trace beryllium measurement: New extraction – fluorescence method
[ASTM D7202 / NIOSH 9110]

1. Sample collection using standard methods
2. Extraction of beryllium with dilute ammonium bifluoride, $(NH_4)HF_2$
3. Ultra-trace fluorescence measurement of beryllium with high quantum yield fluorophore (LOD <0.001 μg Be/sample)



Hydroxybenzoquinoline sulfonic acid (HBQS)

Trace beryllium measurement by extraction/ fluorescence method* – Performance data

Sample / media (n=no. of samples)	***Extraction method***	***Mean % recovery***	***RSD (%)***
Be (n=3)	mechanical	96	3.1
Be/Whatman (n=3)	mechanical	95	4.2
BeO (n=6)	mechanical	86	6.8
BeO (n=3)	heat (85 °C)	95	9.8
BeO/Whatman (n=15)	mechanical	82	5.6
BeO/Whatman (n=6)	heat (85 °C)	96	6.2

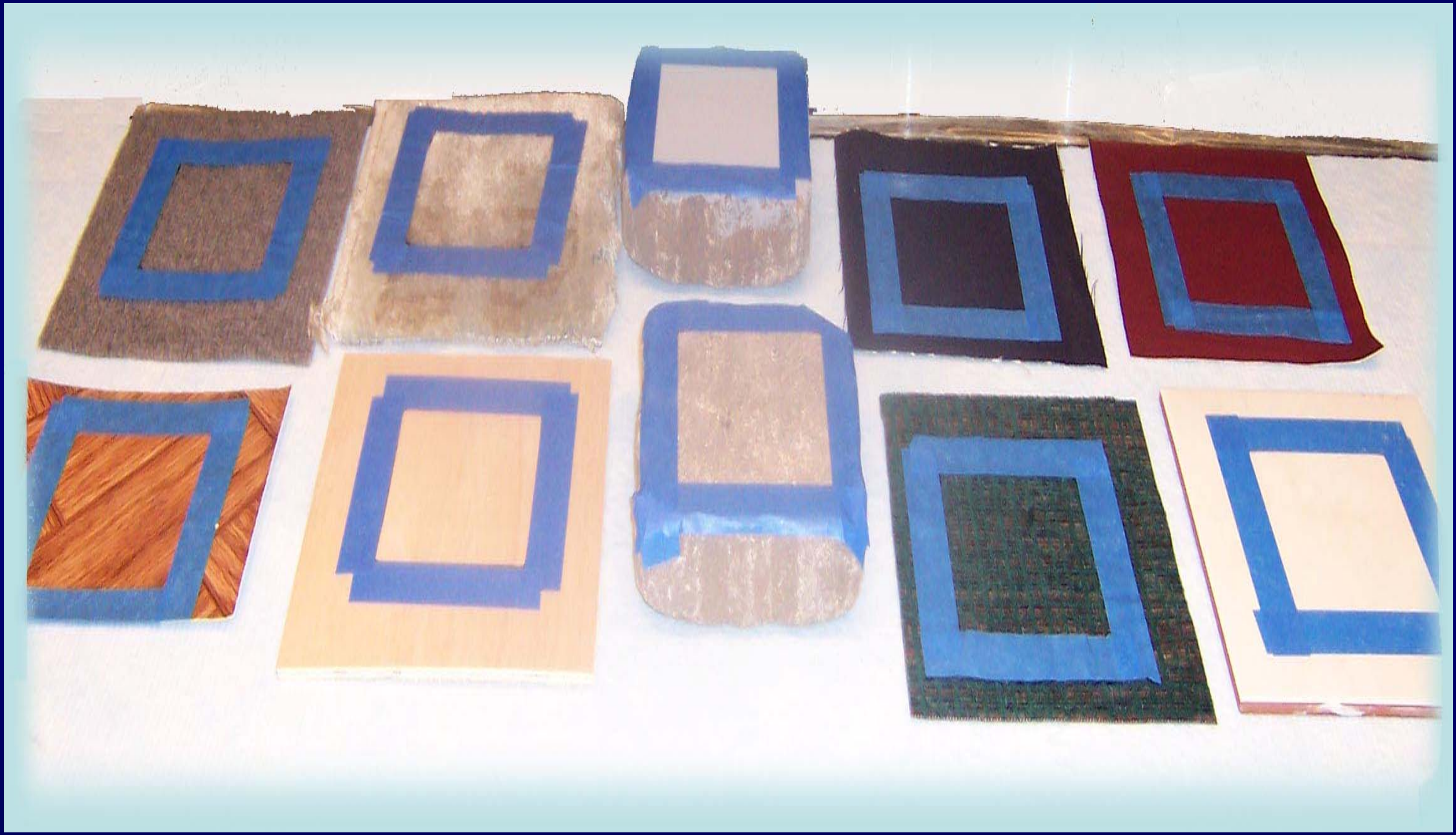
*[*Agrawal et al., JEM, 2006; Ashley et al., ACA, 2007*]

Dry wipe sampling of beryllium – Performance data* (ASTM D7296)

Sampling Media	% Recovery (RSD, %)
Wet PVA wipe	86 (7)
Dry PVA wipe	16 (54)
Wet cellulose filter	106 (9)
Dry cellulose filter	43 (25)
Wet smear tab	64 (13)
Dry smear tab	14 (22)

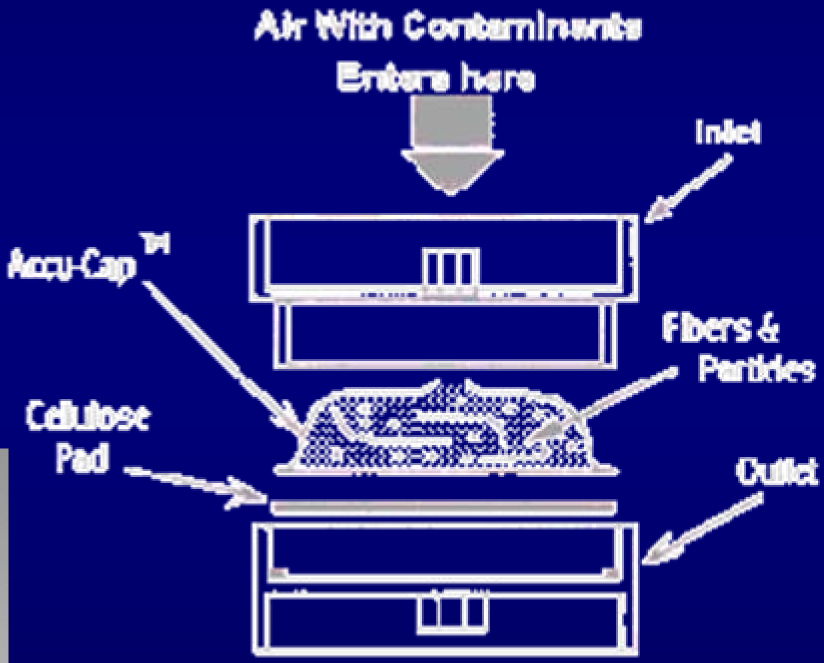
*[*Dufay & Archuleta, JEM, 2006*]

Micro-vacuum sampling: Performance evaluation* (ASTM D7144) – Substrates



*[*K. Ashley et al., JOEH, 2007*]

PVC inserts (Accu-cap^{TM}) for gravimetric analysis



Micro-vacuum sampling – Performance data (soft / rough surfaces)

Substrate material	% Recovery (95% CL's), SRM 1579	% Recovery (95% CL's), SRM 1648	% Recovery (95% CL's), SRM 2583
Industrial carpet	22 (10)	32 (14)	27 (8)
Plush carpet	36 (30)	34 (24)	41 (16)
Car seat material	31 (18)	49 (12)	49 (12)
Denim	45 (17)	37 (13)	55 (21)
Concrete block	64 (210)	69 (37)	87 (72)
Concrete block, painted	33 (14)	45 (21)	43 (26)

Micro-vacuum sampling – Performance data (hard / smooth surfaces)

Substrate material	% Recovery (95% CL's), SRM 1579	% Recovery (95% CL's), SRM 1648	% Recovery (95% CL's), SRM 2583
Glass	59 (11)	43 (10)	50 (14)
Tile	51 (27)	42 (35)	50 (18)
Steel	51 (10)	39 (9)	38 (21)
Linoleum	41 (21)	28 (10)	30 (15)
Vinyl	38 (18)	33 (13)	38 (18)
Wood	34 (19)	33 (10)	49 (23)

Micro-vacuum sampling – Cassette plus collection nozzles (soft / rough surfaces)

Substrate material	**Approx. % collected, SRM 1579**	**Approx. % collected, SRM 1648**	**Approx. % collected, SRM 2583**
Industrial carpet	35	57	50
Plush carpet	59	73	69
Car seat material	55	78	77
Denim	71	81	85
Concrete block	105	113	130
Concrete block, painted	55	72	59

Micro-vacuum sampling – Cassette plus collection nozzles (hard / smooth surfaces)

Substrate material	Approx. % collected, SRM 1579	Approx. % collected, SRM 1648	Approx. % collected, SRM 2583
Glass	87	88	76
Tile	77	88	85
Steel	72	83	71
Linoleum	71	70	56
Vinyl	64	74	65
Wood	55	76	75

Summary - Surface Sampling of Metals

Use standardized protocols and appropriate media to estimate surface contamination of:

Beryllium	*Lead*	*Chromium*
Arsenic	*Cobalt*	*Manganese*
Cadmium	*Silver*	*Molybdenum*
Aluminum	*Zinc*	*Uranium*
Mercury	*Tin*	*Nickel*

Acknowledgments

Lead handwipe method:
Eric Esswein, CDC/NIOSH

Beryllium fluorescence method:
Anoop Agrawal et al., Berylliant, Inc.
Mark McCleskey et al., Los Alamos Nat'l Lab

Microvacuum sampling method:
Greg Applegate & Tami Wise, CDC/NIOSH

Standardized Surface Sampling Methods for Metals

Kevin Ashley, Ph.D.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Cincinnati, Ohio (USA)

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Overview

Background

- Reasons for surface sampling
- Comparison to action levels or background

Surface sampling techniques

- Wipe, dermal, vacuum, etc.
- Attributes & limitations
- Available research & data gaps

Discussion & summary

- Performance data available (presented later)
- Examples of standardized methods
- Recommendations / improvements

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Introduction

Why Surface Sampling? Examples:

- Evidence of skin sensitization by exposure to beryllium particles
- Ingestion of lead from surface particles on hands
- Take-home exposures to metals in dust
  - Prevent exposure to metals on surfaces through exposure monitoring

Surface Action Levels for Pb, Be

Few metals have surface action levels established by regulatory agencies.

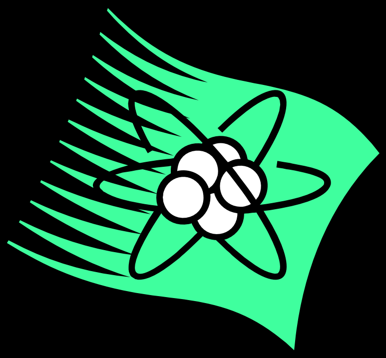
Lead and Beryllium are two elements having surface dust loading limits in the US.

Pb: EPA; Be: DOE

Beryllium surface compliance levels (DOE: 10 CFR 850)

Equipment release:

0.2 μg Be/100 cm^2



Housekeeping:

3.0 μg Be/100 cm^2

(But no information on sampling methodology)

"*Analysis by AIHA-accredited lab or equivalent*"

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Surface action levels for lead
[40 CFR 745 (EPA 403 Rule), 2001]

Definition of dust-lead hazard (§745.6)

- floors (bare or carpeted): 40 µg/ft^2
- window sills (interior): 250 µg/ft^2

Clearance levels (§745.227)

- floors (bare or carpeted): 40 µg/ft^2
- window sills (interior): 250 µg/ft^2
- window troughs: 400 µg/ft^2

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EPA 403 Rule Pb Samples:

Samples of settled dust for risk assessment or clearance shall be collected:

- from horizontal surfaces underneath friction surfaces
- from floors (bare & carpeted)
- from interior window sills
- from window troughs (clearance only)
- *using wipes that meet ASTM E1792*

Definition of Wipe Sample (40 CFR Part 745, §745.63):

Wipe Sample means a sample collected by wiping a representative surface of known area, as determined by ASTM E1728 [sample collection standard practice], or equivalent method, with an acceptable wipe material as defined in ASTM E1792 [Pb wipe specification].

EPA 403 Pb samples, cont'd.

All samples shall be analyzed by a laboratory recognized under the National Lead Laboratory Accreditation Program (NLLAP).

[40 CFR 745.227(f)(2)]

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Surface sampling of metals

Consider:

- Wipe samples (wet, usually)
- Vacuum samples (various techniques)
- Swab sampling (rare for metals)
- Tape samples
- Rinsates

Surface sampling of metals, cont'd

- Hard / smooth / nonporous surfaces
- Soft / rough / porous substrates
- Fragile substrates
- Oily / grossly contaminated surfaces
- Dermal sampling
- Bulk sampling

Surface Sampling Techniques

- *Wipe sampling*

  Wet: consider wetting agent

  Dry: consider sampling medium

- *Vacuum sampling*

  Alternative to wipe sampling

  Consider substrate to be sampled

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Dermal & Bulk Sampling

- *Dermal sampling*

  Wipe, patch, tape & rinse methods

- *Bulk sampling*

  Use if there is gross dust buildup

  Soils / sediments

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National Technology Transfer and Advancement Act of 1995 (NTTAA)

Public Law 104-113 (enacted 1996); directs federal agencies to:

(A) Use voluntary consensus standards in lieu of in-house procedures

(B) Participate in the development of relevant voluntary consensus standards

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Advantages of the consensus standards development process

- Brings together people with a diversity of backgrounds, expertise, and knowledge
- Provides a balanced representation of interests at the standards-writing table (users, producers, general interest)
- Quality is enhanced by strict balloting and due process procedures, and requirements for method precision and bias / uncertainty statements
- Working group format promotes open discussion

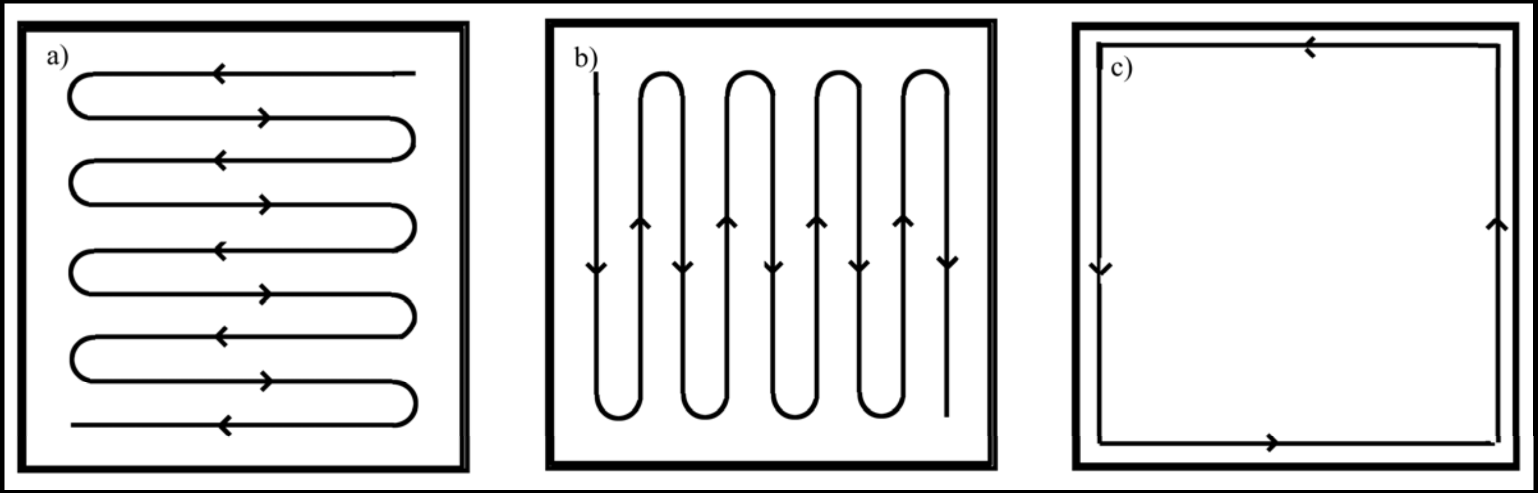
ASTM International wipe sampling standard for metals

ASTM D6966,
Standard Practice for Collection of Settled Dust using Wipe Sampling Methods for Subsequent Determination of Metals

(Note: Established by voluntary consensus)

ASTM D6966 Requirements

- Individually packaged wipes; non-interfering materials; minimal metals background
- >75% collection efficiency (RTI, 1990s)
- Sampling scheme (100-cm^2 minimum sampling area):



ASTM E1792
Wipe Specifications

- Minimal background lead
- Ruggedness testing
- Uniform moisture content
- Individually packaged
- Dimensions & thickness
- Pb collection efficiency/ recoverability tests

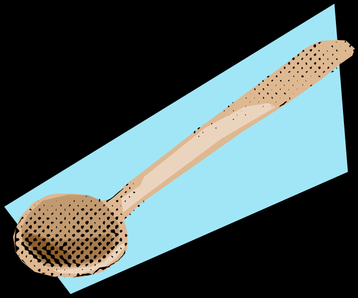
•Dry sampling methods

Vacuum cleaner method (carpets)
- ASTM D5438

Micro-vacuum sampling (rough / fragile / inaccessible surfaces)
- ASTM D7144

Dry wipe sampling (special cases)
- ASTM D7296

Bulk sampling
- ASTM & EPA methods



Vacuum sampling: Consensus standards

ASTM D7144

ASTM D5438

Dry wipe sampling

- ASTM D7296, Standard Practice for Collection of Settled Dust Samples using Dry Wipe Sampling Methods for Subsequent Determination of Beryllium and Compounds
- Use *only* if wet wipe sampling or vacuum sampling inappropriate
  [Also may be applicable to sampling radioactive elements]

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Dermal sampling methods

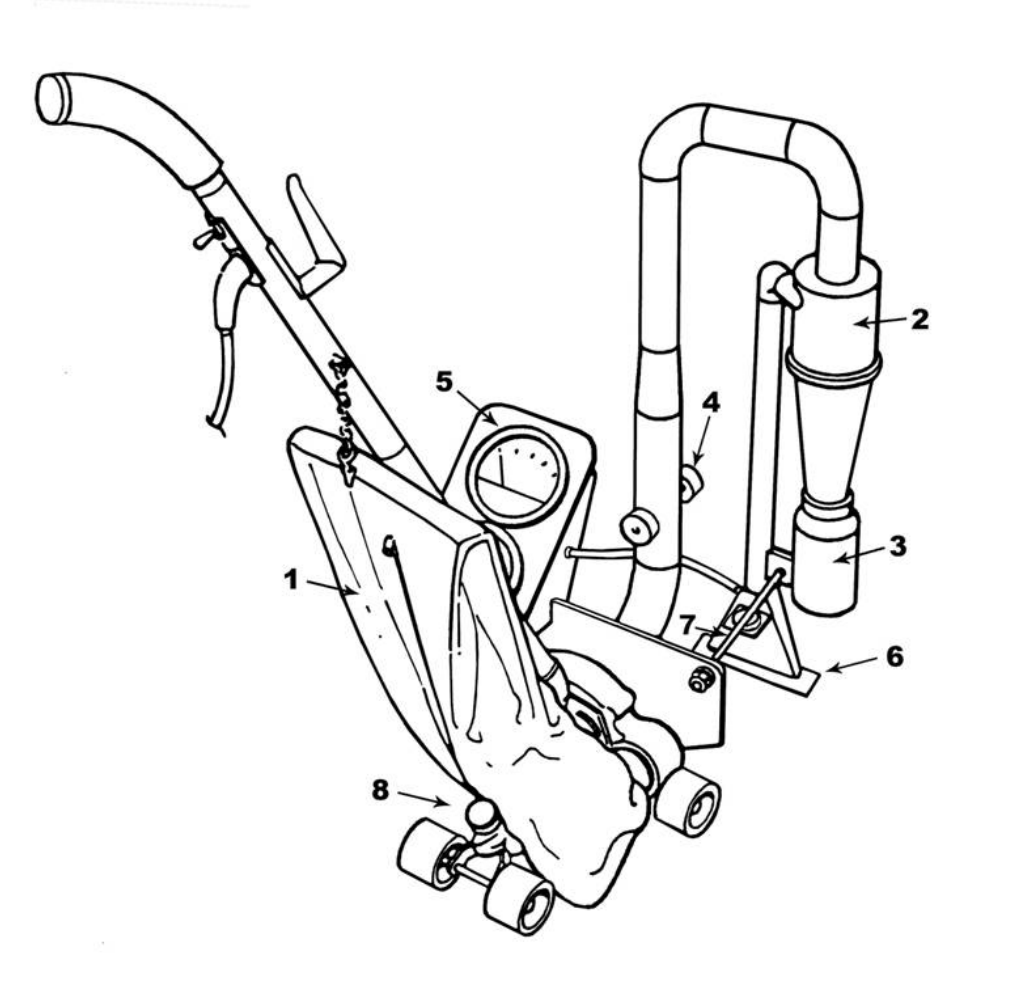
1. **Wet wipe**
2. **Patch sampling**
3. **Tape sampling**
4. **Skin rinsates**

(Photo by Dr. A. L. Sussell)

Surface sampling stds for metals (gov't & consensus)

Method	**Media / device**	**Surfaces**
OSHA ID-125G & ID-206	Wet or dry filter or wipe	Smooth / Hard; Dermal
NIOSH 9100, 9102	Wet wipe	Smooth; Dermal
ASTM D6966	Wet wipe	Smooth / Hard
ASTM E1216	Adhesive tape	Smooth
OSHA & NIOSH (several)	Patch or Rinse	Dermal samples
ASTM D5438	Vacuum cleaner	Carpets
ASTM D7144	Micro-vacuum	Rough or fragile
ASTM D7296	Dry wipe	Oily or fragile

ASTM D5438 – High-volume vacuum sampler (HVS3)



Dust sample collected in catch bottle (part #3)

(Figure courtesy of Dr. R. G. Lewis)

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ASTM D7144 Micro-vacuum sampler evaluation (Ashley et al., JOEH 2007)

Main sampler components:

- **Collection nozzle**
- **Cassette (& filter)**

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Dermal sampling: Need for voluntary consensus standards

- Recent review articles demonstrate lack of harmonization & consequent difficulty in data comparisons between different dermal exposure studies.
- New working groups in ISO TC 146 / SC 2 and ASTM International D22.04 will develop standardized procedures for dermal sampling.

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Bulk sampling methods

- Many published ASTM standard procedures: Scooping, coring; penetrometers, augers, etc. (www.astm.org)

  See, e.g.:

  (a) J.H. Morgan, Ed., *Sampling Environmental Media;* ASTM STP 1282 (1996)

  (b) EPA/OSW, *RCRA Waste Sampling Draft Technical Guidance* [EPA 530-D-02-002] (2002)

- Sample surface vs. subsurface: Distinguish anthropogenic vs. natural sources of elements.

Surface sampling of nonmetals

Recognize that other surface sampling methods for non-metals have been published by gov't and consensus standards groups; Examples:

- Drugs / pharmaceuticals
- Pesticides
- Biological agents

Summary

Focus here has been on available governmental and *voluntary consensus standards* for sampling of metals on surfaces, esp. wipe & vacuum collection methods.

- Performance data support some of the consensus standards (to be presented later).
- Bulk sampling methods are available (ASTM International; EPA) & well standardized.
- Identified need for standardization of dermal sampling methods (ISO, ASTM).

Acknowledgments

ASTM International Subcommittee D22.04 on Workplace Air Quality

ASTM International Subcommittee E06.23 on Mitigation of Lead Hazards

Beryllium Health and Safety Committee, Sampling and Analysis Subcommittee

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The development of a personal dust monitor for coal mines

Direct Reading Exposure Assessment Methods Workshop

Washington, DC
November 13, 2008

Outline

- Spoke on the worker aspects this am
- This talk focuses of the thought process of how to compare direct reading personal aerosol monitors with TWA
- Approaches to assess personal aerosol direct reading monitors
  - Laboratory
  - Field

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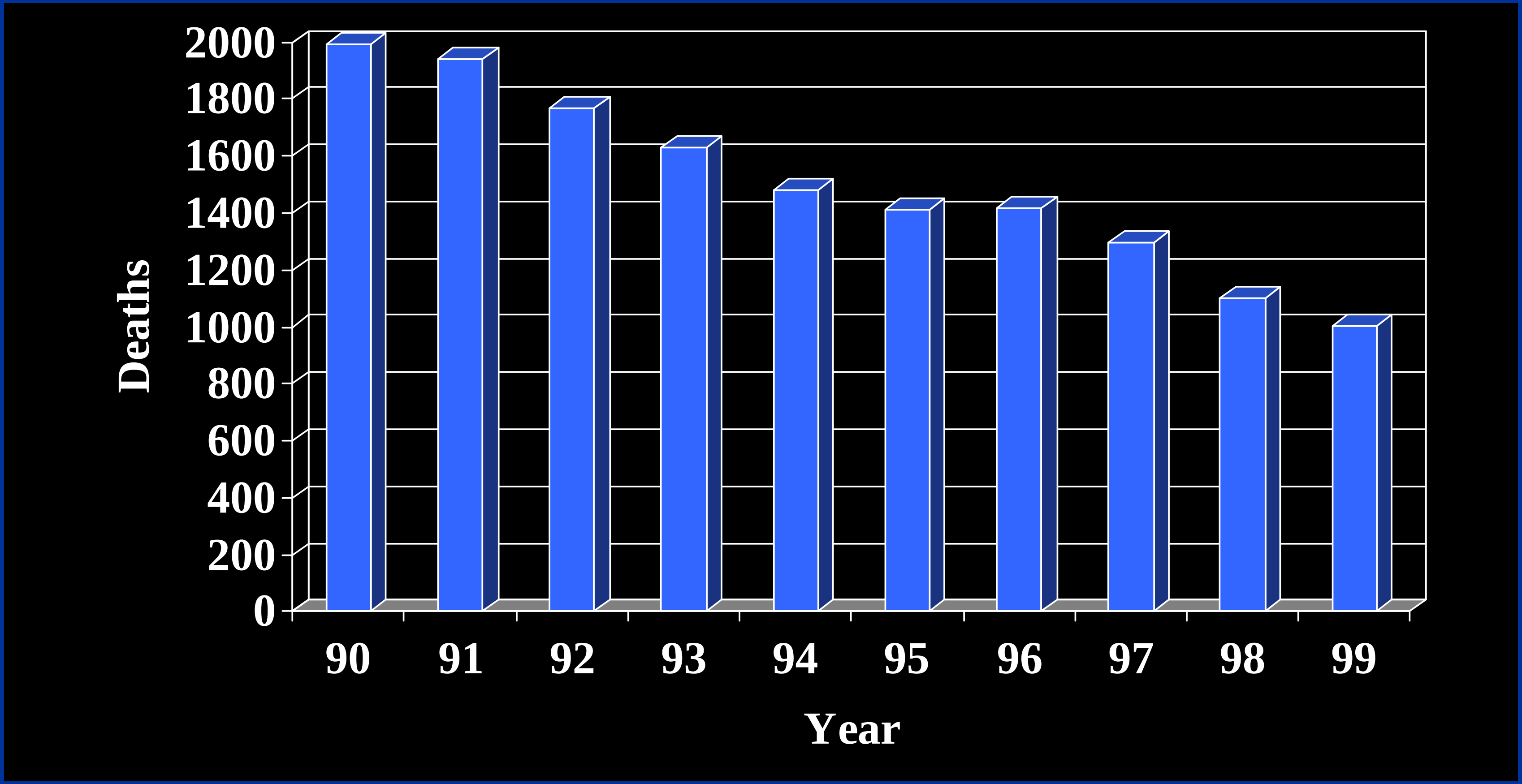
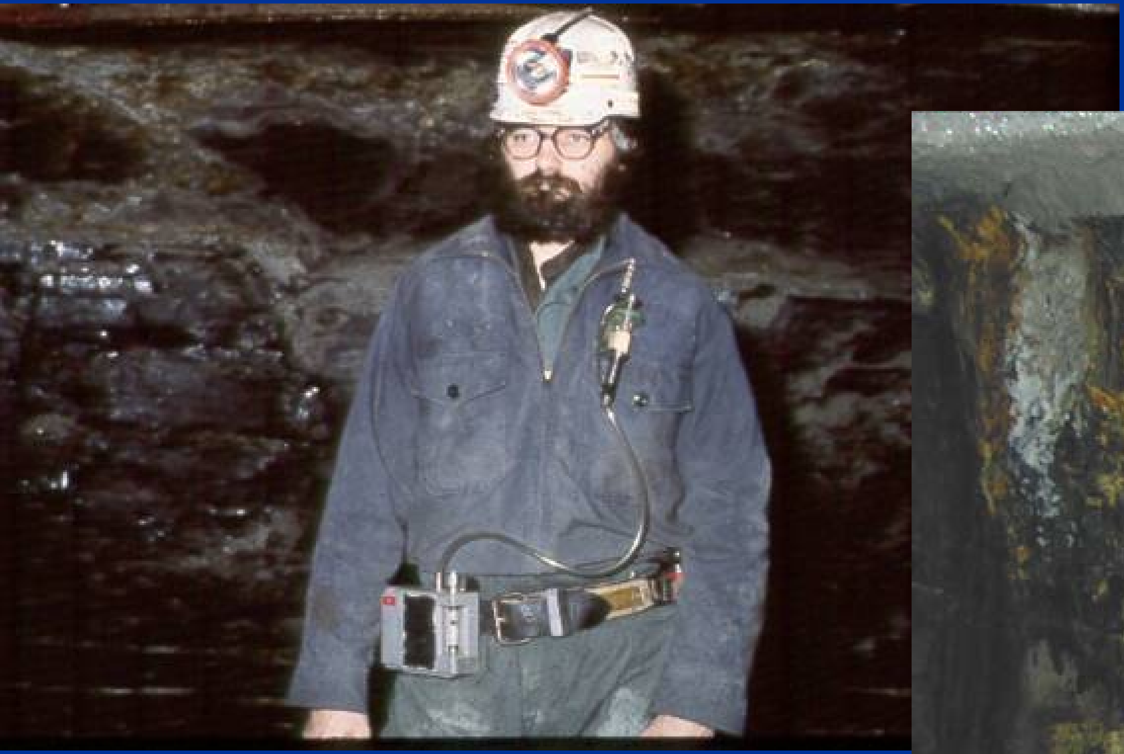
Number of Deaths Attributed to Coal Workers' Pneumoconiosis



U. S. Coal Mine Dust Sampling



Little has changed in the last 30 years.

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Direct Reading Exposure Assessment Needs

- Under recommendation of Secretary of Labor and the 1995 Federal Advisory Committee on the Elimination of Pneumoconiosis among Coal Mine Workers, NIOSH mandated to improve personal dust monitoring instruments to provide timely data output to miners
- U. S. miners interested in better technology for coal mine dust sampling for the past 20 - 30 years
- In consultation with labor, industry, and government, NIOSH contracted with R&P for the development of new mass based monitoring technology for mining

Direct reading dust monitors have been needed for a long time

1975

1978

1984

1990's

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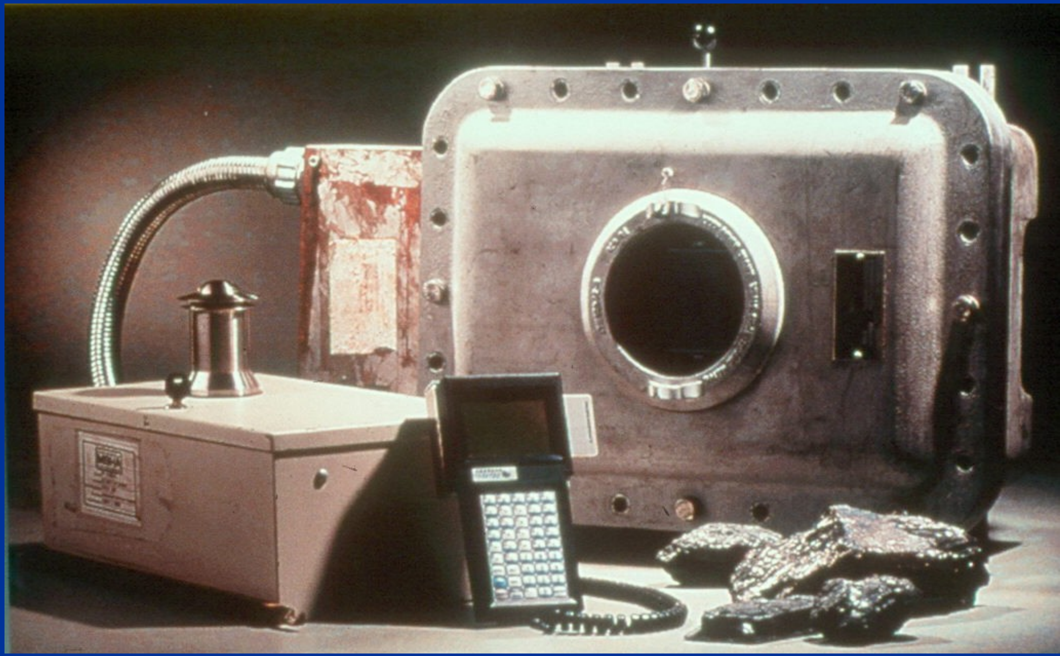
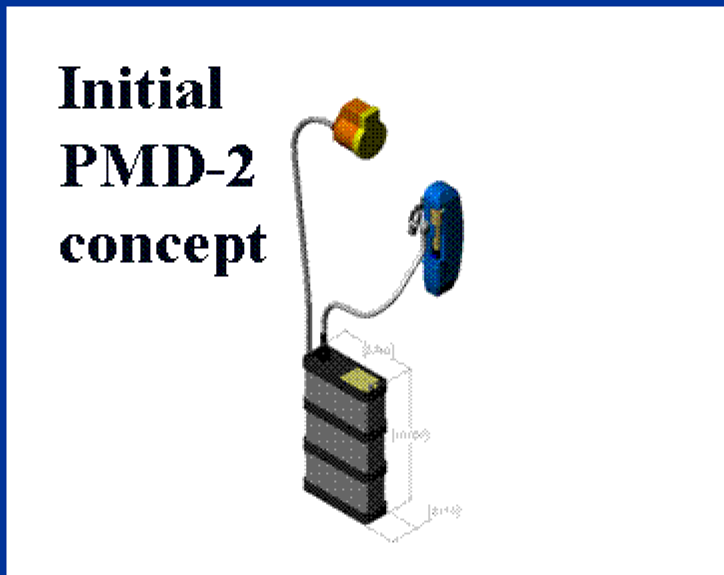
Decision by MSHA and BOM in mid-1990's to develop a mass based sensor

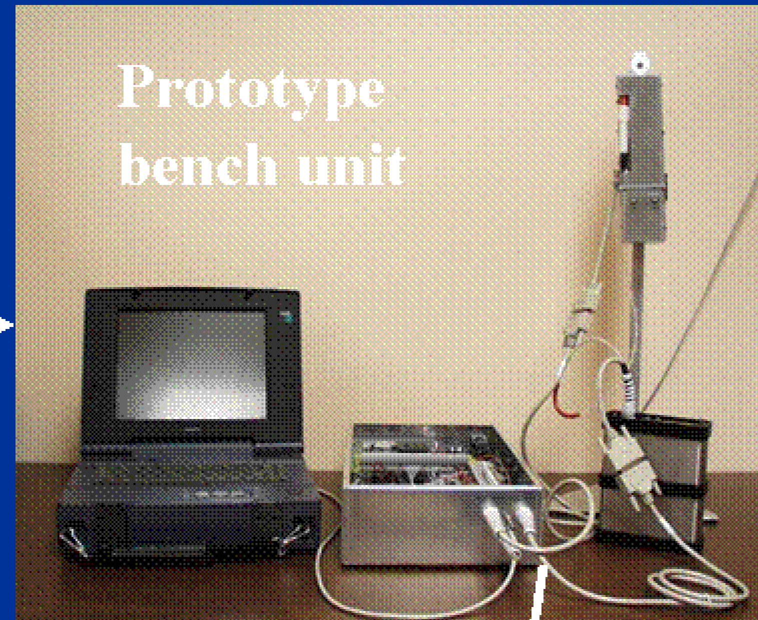
- Initial approach used existing fixed site environmental monitor
- Mount on mining machine much like a methane monitor
- 4 cu ft box weighing 160 lbs.
- Relied on area measurements, no data on personal exposure and not reliable

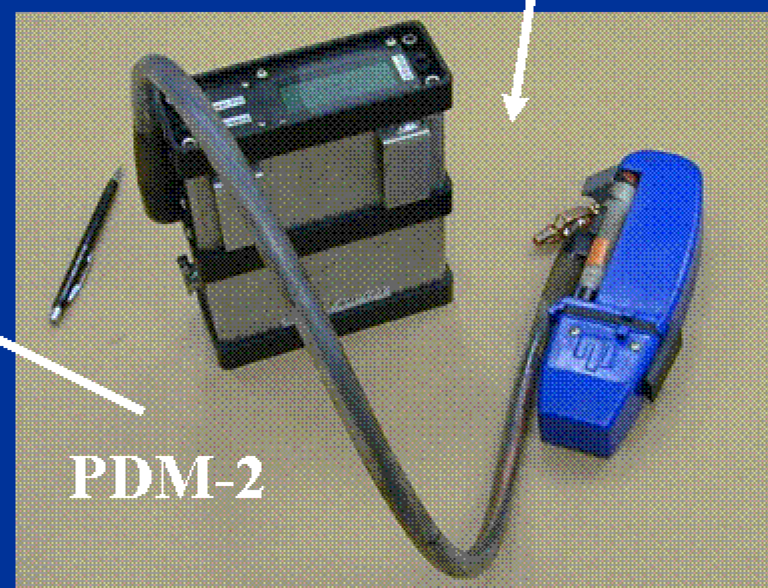


Enabling technology

Evolution of PDM Technology





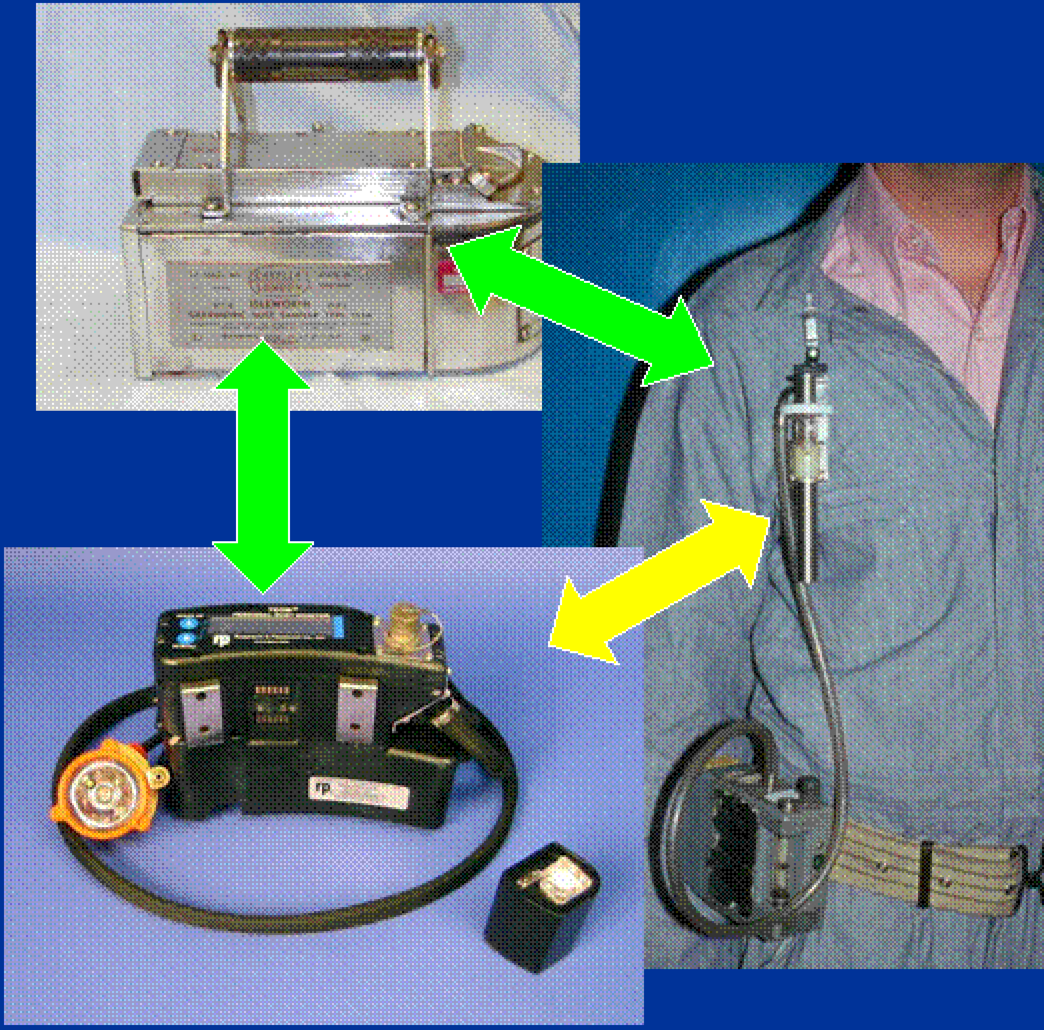


PDM Design Goals

- Equivalent to or better than the current sampler
- Provide accurate EOS reading for:
  - Mass
  - Cyclone bias – kept low
- Include cyclone with low bias relative to the MRE and ISO respirable dust convention
- Compliance with MSHA intrinsic safety requirements for both sampler and cap lamp

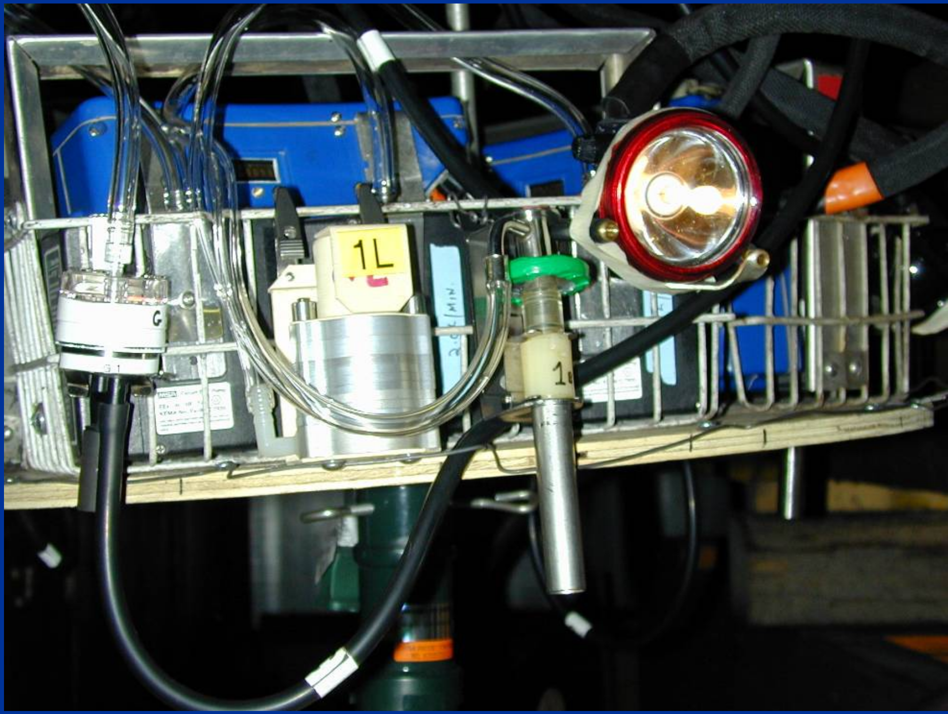
Equivalency testing

- U. S. law uses MRE equivalency
- Compare PDM directly to MRE
- Use caution when comparing between samplers -- compounds error
- Reference samplers obsolete
- Used personal impactors as reference.



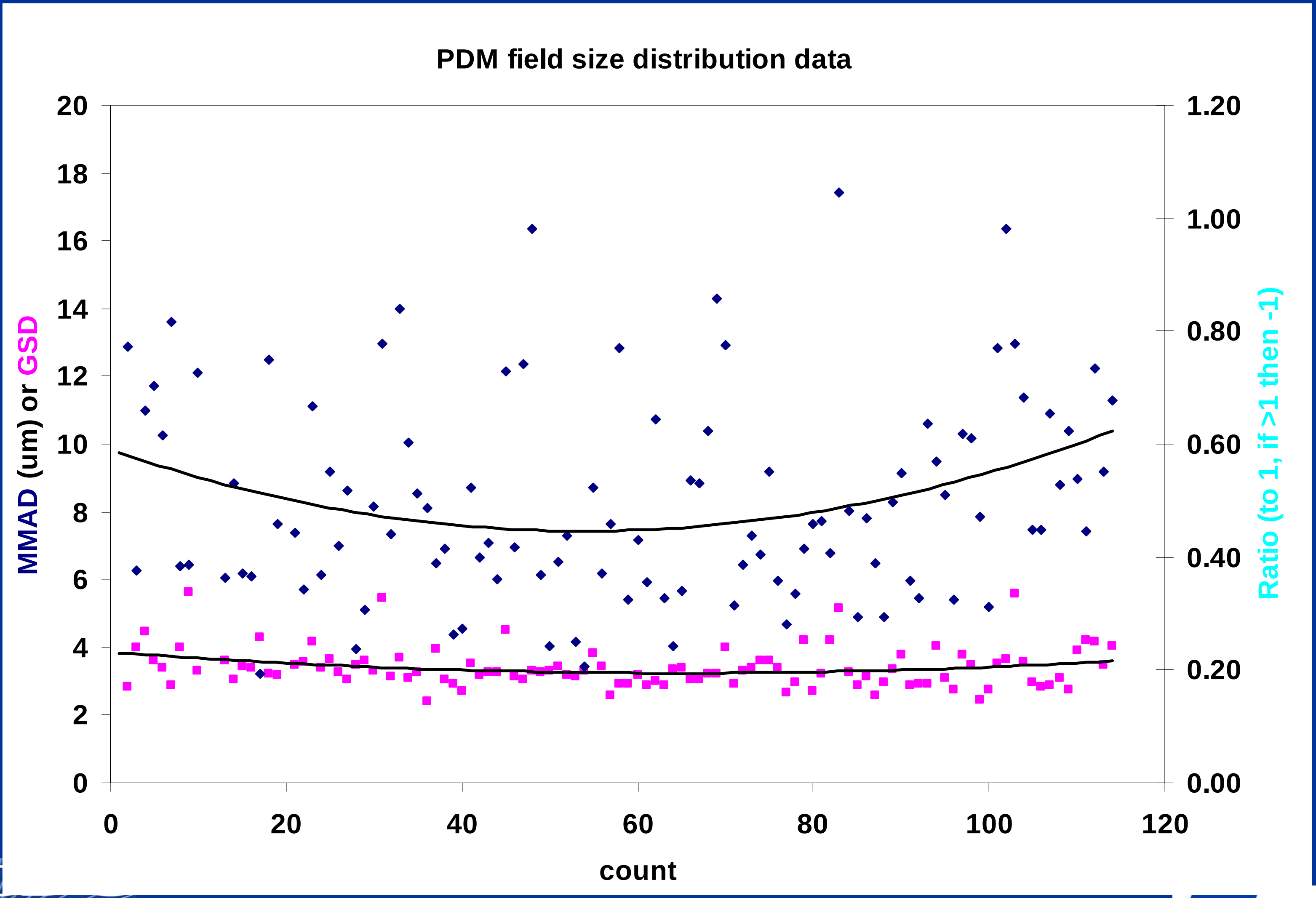
Is the mass measurement correct

- Use the best weighing procedures – QC
- Minimize variables
  - Inlet loss
  - Transport loss
  - Identical size fractionation
- Direct comparison best



NIOSH RI 9663

Why can't we directly compare instruments in the lab?



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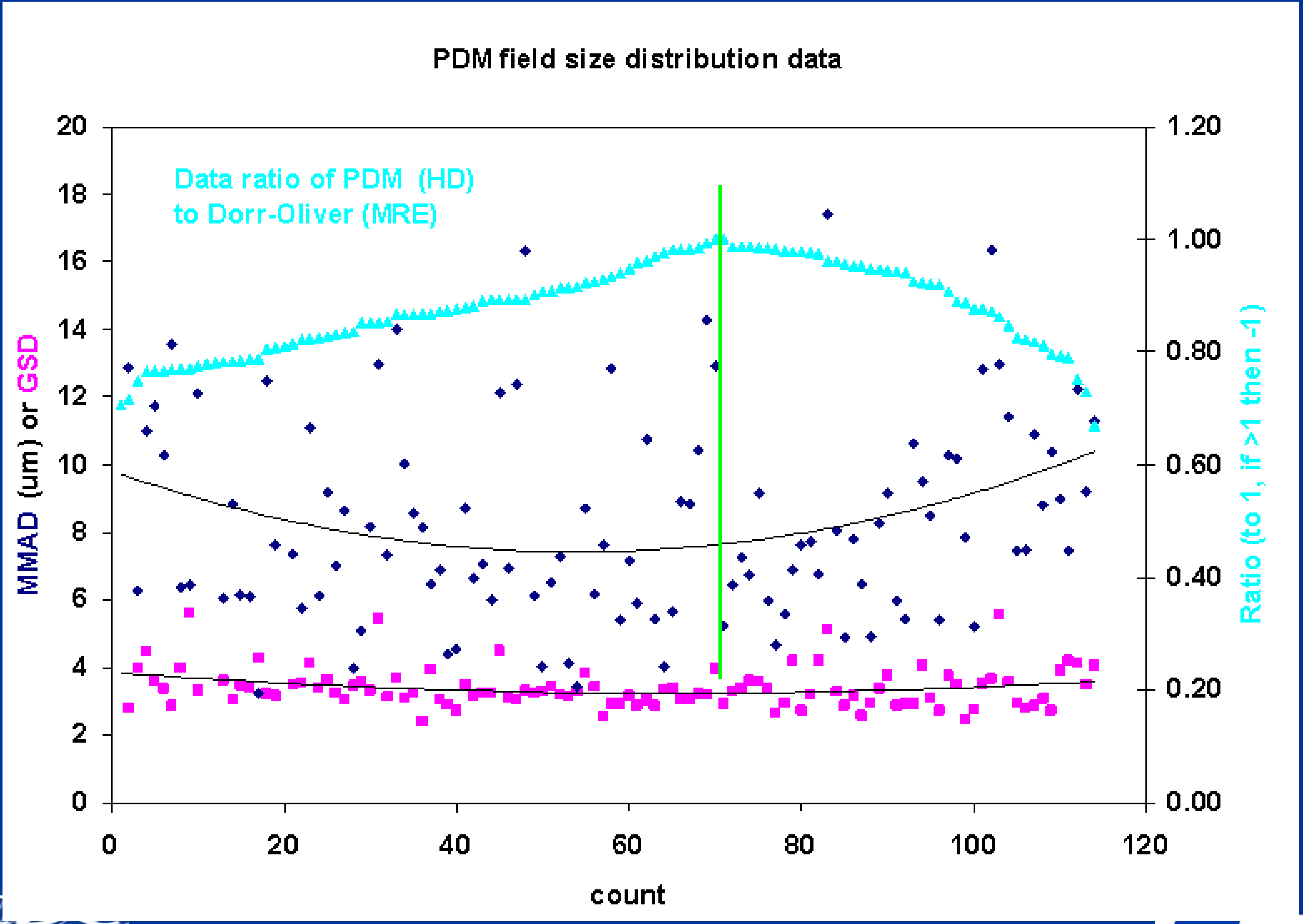
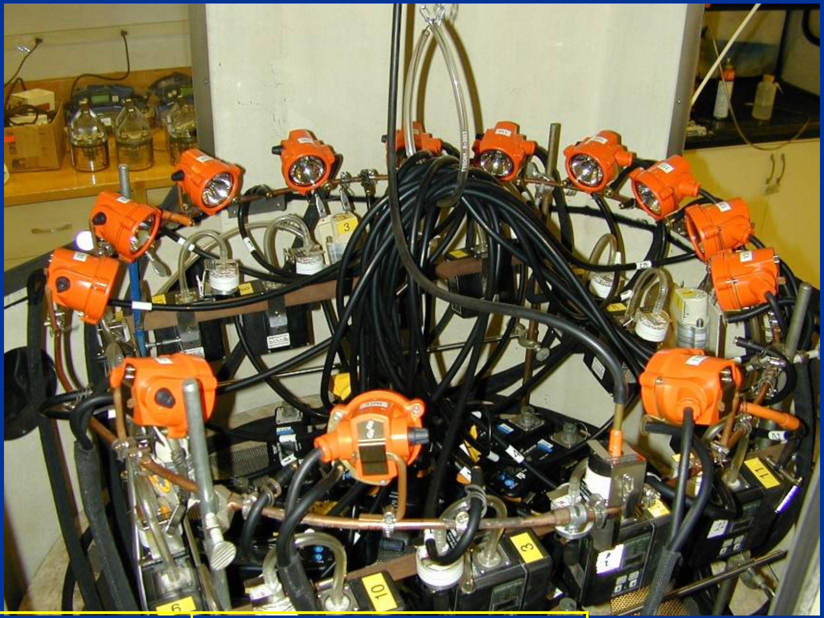


Break problem into testable hypothesis

- Direct mass to mass comparison – Does mass comparison meet recognized criterion?
- Direct determination of size selective bias. Is bias less than or equal to existing method?
- If both hypothesis are true, then direct field comparison of two methods over a wide range of aerosol size and type should be true.
- Confirm laboratory results with representative field sample

Results of Accuracy Criteria Testing for Mass Measurement

- Side by side triplicate reference versus PDM with identical inlets
- Variables
  - 3 coal types/ 3 size distributions
  - 50% RH, 22° C
- RI 9663 http://www.cdc.gov/niosh/mining/pubs/pubreference/outputid114.htm



Coal type	Unit serial number	Bias	RSD x/r	accuracy	Confidence Limits Upper 95%
Overall	101	-0.04	0.06	12.50	15.10
	102	-0.08	0.06	15.80	17.70
	104	-0.05	0.05	11.30	12.90
	105	-0.12	0.06	20.00	21.90

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Cyclone comparison testing

- Compare results of impactor defined respirable mass fraction to triplicate cyclone collected mass fraction
- Calculate ratio and test for significance by coal/size type and overall.

(MRE) Dorr Oliver /ISO	1.25
Higgins Dewell/ISO	1.15
(MRE)Dorr Oliver/ MRE	1.11
Higgins Dewell/ MRE	1.02

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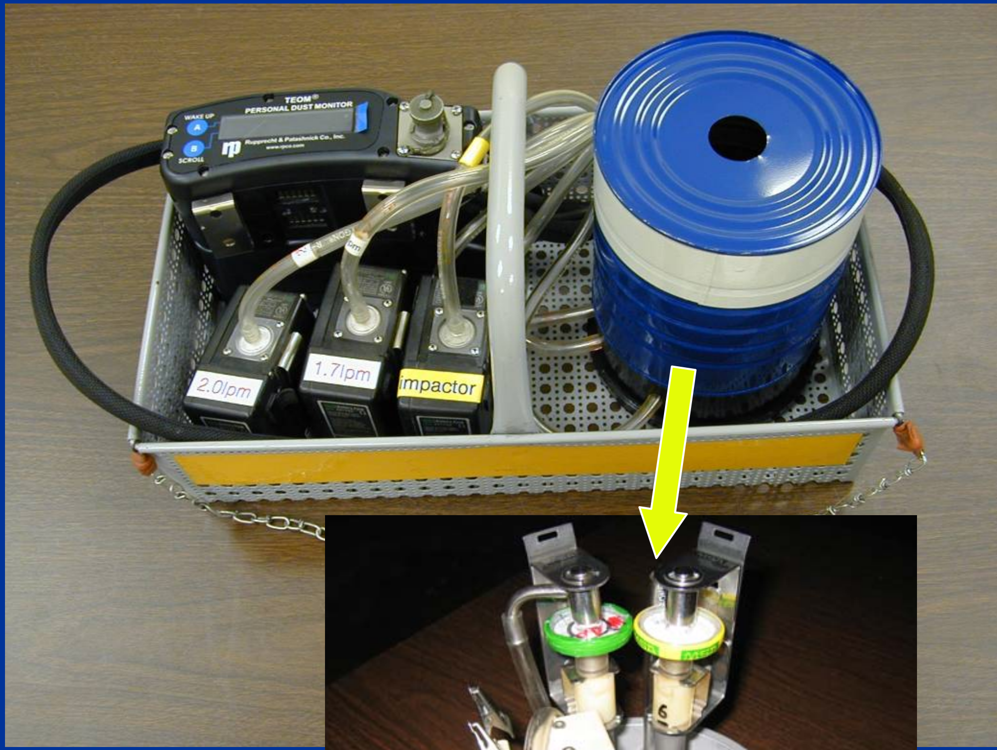
Laboratory Conclusions

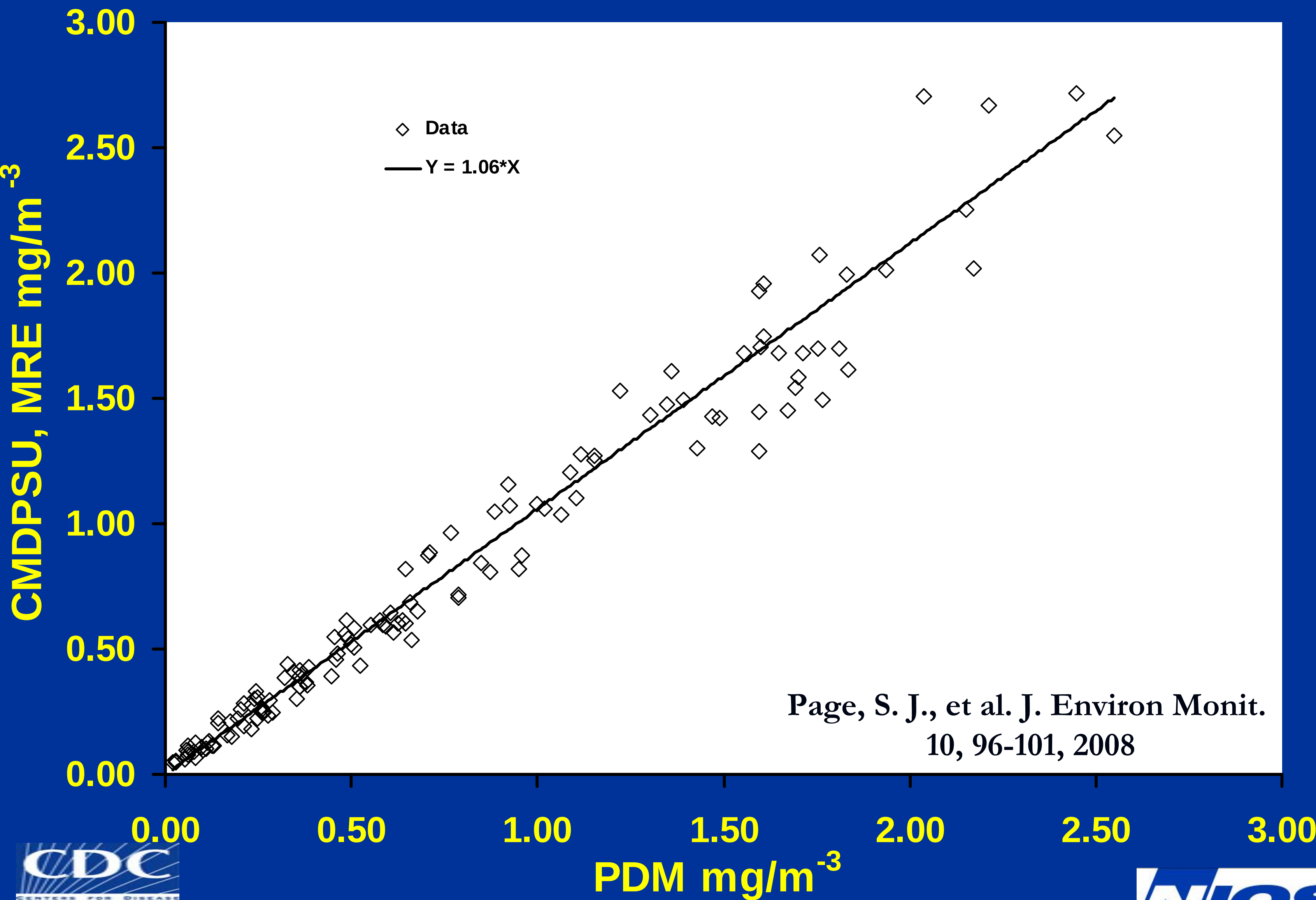
- Mass measurement by PDM meets NIOSH accuracy criteria – for an individual observation, the method gives a result that is within +/- 25% with a probability of 0.95
- And, the individual result falls within an upper or lower confidence limit of 95%
- The bias of the HD cyclone is less than the DO cyclone
- Therefore, PDM is equal to or better than existing method.

Field testing apparatus

- Chamber type sampler to minimize spatial variability
- Purpose to compare instruments
- Used central dust inlet to
  - PDM
  - Personal sampler 2 lpm
  - Personal sampler 1.7 lpm
  - Marple impactor



Field Equivalence to reference method



Conclusions

- Direct lab comparison of instruments depends on reference aerosol
- For development purposes, break problem into testable hypothesis
  - Mass
  - Size selective bias
- If end use dictates -- field test to confirm

Acknowledgements

- Joint Health and Safety Committee of the Bituminous Coal Operators and United Mine Workers,
- National Mining Association
- MSHA
- Individual mine managements
- The miners
- Thermo Fisher Scientific and formerly Rupprecht and Patashnick
- Pittsburgh Research Laboratory staff

Contact information– 412-386-6689

jvolkwein@cdc.gov

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Direct Reading Monitors and What They Mean to the Worker

Direct Reading Exposure Assessment Methods Workshop

Washington, DC

November 13, 2008

DISCLAIMER: The findings and conclusion in this presentation have not been formally disseminated by the Centers for Disease Control and Prevention and shold not be construed to represent any agency determination policy.

Overview

- Workshop is to think about how the emerging DRM technologies might improve worker health
- Present topics for discussion and thought in breakout sessions from the perspective of impact on the worker

Distinguish different needs direct reading monitors

Immediate

- Short term threats to life
  - Explosive gases
  - Toxic materials.
  - Suffocation hazards
- Need obvious for current threat
- Mature stage of development

Indirect

- Long term threats to health
  - Cancer
  - Silicosis
  - Coal workers pneumoconiosis
  - Noise
- Need seems less obvious

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Why are direct or short term measurements relevant to long term health issues?

- Historically periodic hazard assessment of work place is generally adequate.
  - Measure levels
  - Identify sources
  - Develop engineering controls for sources
  - Periodic monitor levels.
- Periodic assessment approach becomes less effective when
  - Workplaces continually move
    - Mining
    - Construction
    - Agriculture
  - Contaminant changes spatially or temporally

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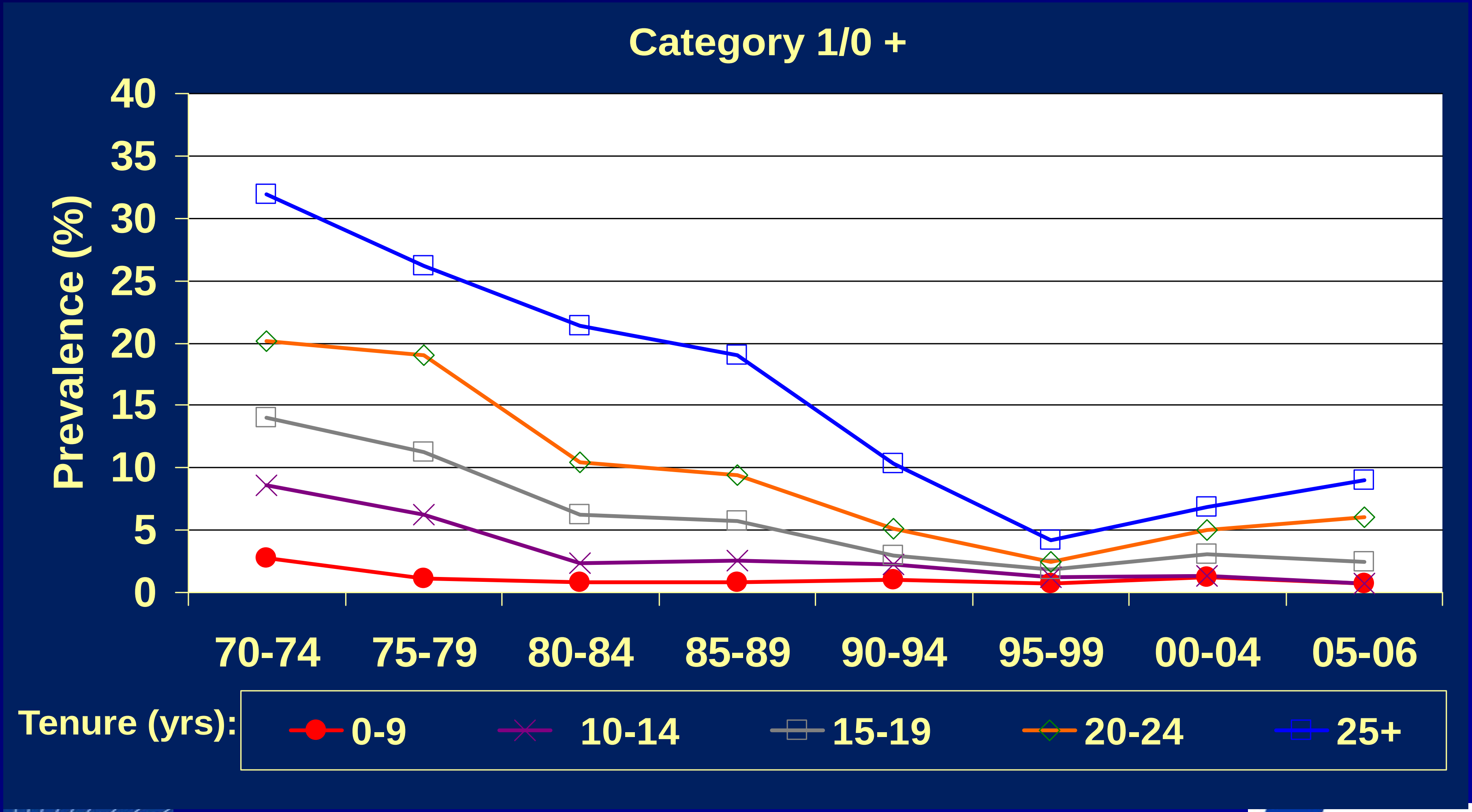
Mining as an example -- Current practice in mining is periodic

- Mines submit a ventilation control plan that lists what engineering controls are to be in place
- Mines measure dust levels every 2 months for 5 consecutive shifts.
- Inspectors monitor compliance with engineering aspects of the plan on a more frequent basis

Results of this strategy

Trends in coal workers' pneumoconiosis prevalence by tenure among examinees employed at underground coal mines, U.S. National Coal Workers' X-Ray Surveillance Program, 1970-2006



In response -

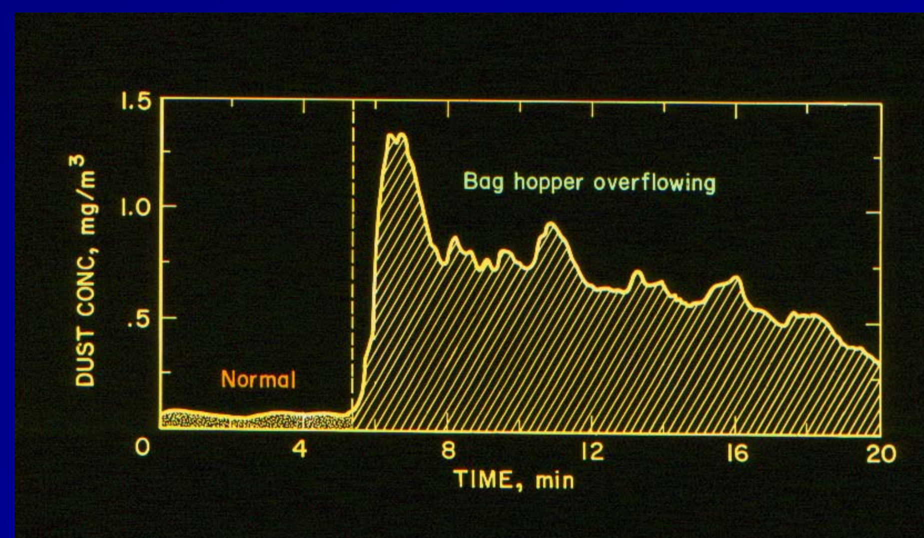
- Sec. Labor commissioned panel in 1996
  - Labor
  - Industry
  - Government
  - Academia
- Panel made recommendations
- Recommendations relevant to DRM's
  - Continuous and accurate monitors should be used
  - More frequent sampling
  - Structured training related to dust control issues
  - Increase miners participation in dust sampling program
  - Explore innovative ways to enhance compliance
  - Improve confidence in mine dust sampling program

DRM Issues for discussion

1. Continuous monitoring
2. Frequency of sampling
3. Worker participation and training
4. Verify exposures
5. Innovative approaches

1. Continuous Monitoring

- IH professionals already use available DRMs
  - Identify sources
  - Decide where to sample
  - Where to direct resources
- Requires skill to use and interpret
- Are available DRMs easy to use?
  - Accurate
  - Unambiguous results



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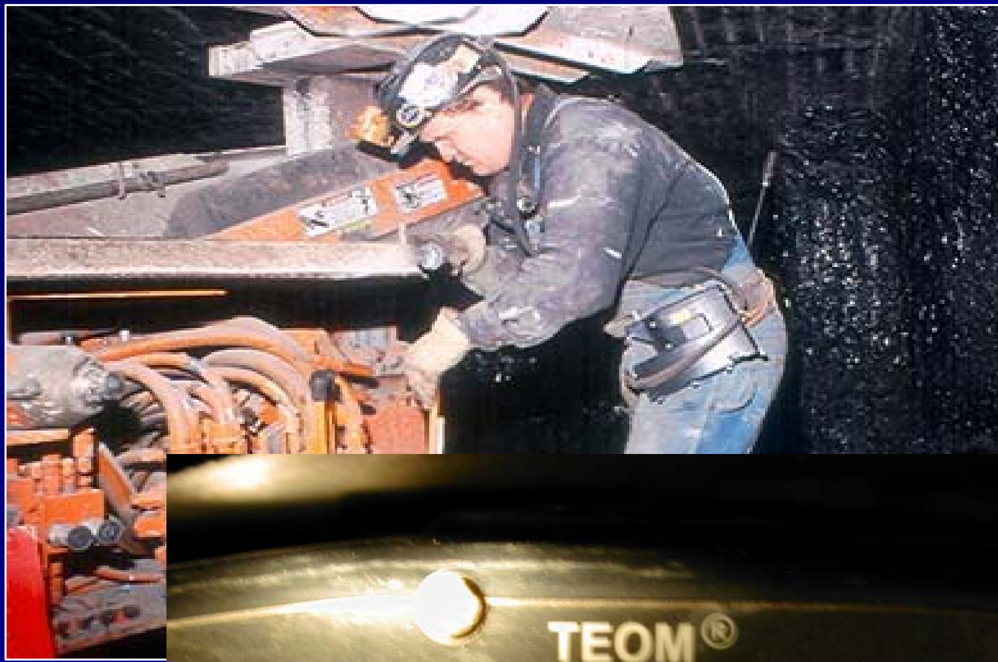
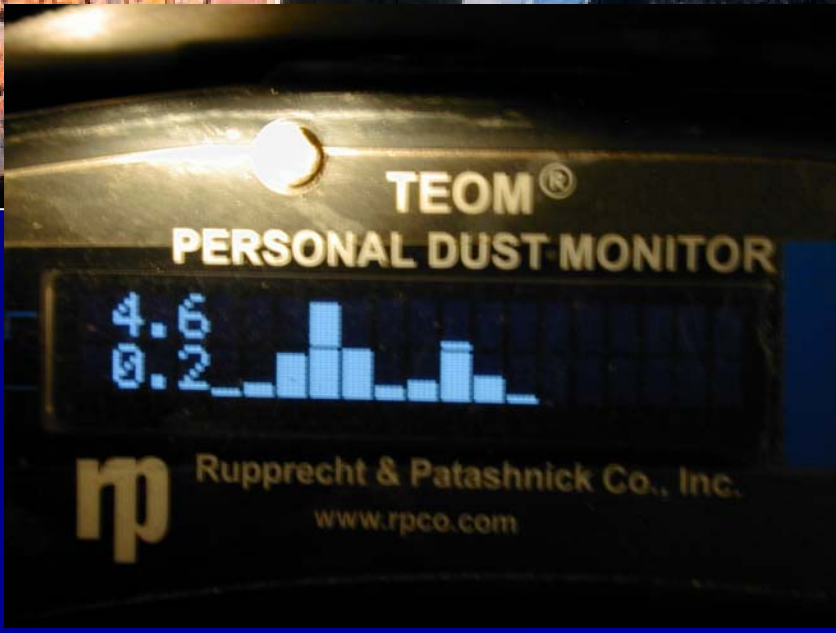
Worker need -- continuous monitoring

- Prime objective – make sampling invisible to user
    - Do not get in the way
    - Keep light weight and streamline
    - Integrate into work environment
- Provide simple interface
    - To use
    - To understand
- Accuracy may depend on use
    - Less accurate for warnings
    - Greater accuracy for compliance
- Intuitive – No “interpretation” of the meaning of the data





2. Frequency of sampling

Depends on hazard

- Lower frequency sampling
  - Low historical levels
  - Low toxicity
  - Adequate engineering controls
- Higher frequency sampling
  - High toxic hazard
  - Exposures are at the limits of engineering controls
  - High variability of hazard – mobile work places
  - Compliance history
- Cost

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Workers perspective -- frequency of sampling

- Priorities
  - No interference with work
  - Protect my job
  - Protect health
- Do not over do it –
- Enable worker and management to manage risk

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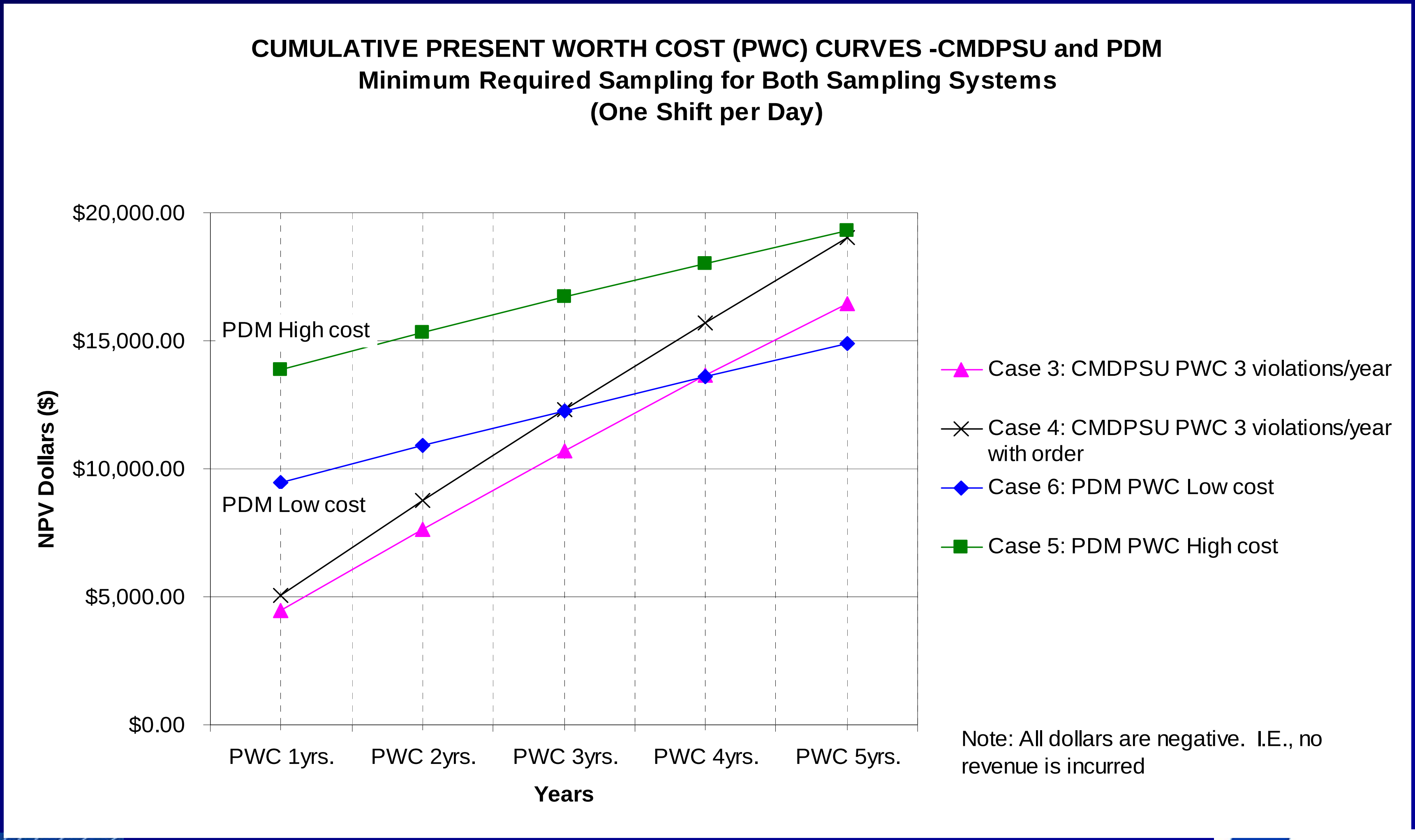
DRM Cost Analysis

- Conduct a ROSHI analysis
- DRM versus reference methods
  - Purchase price
  - Operating cost
    - Labor
    - Material
  - Citation cost avoidance - time
  - Sampling schemes
    - Continuous
    - Intermittent
  - Operating life

Example of PDM Cost Analysis –

Engineering analysis from company perspective



Economic Analysis

- Future economic evaluation of DRM's should examine societal costs and benefits
  - Cost of illness to federal & state govt. – workers comp
  - Medical costs of associated illness (COPD)
  - Insurance costs

3. Worker participation and training

- Modern workforce is better educated
- Level of participation will vary
  - Very involved
  - Could care less
- Functionality
  - Objective is not another decimal point in accuracy, but to prevent worker overexposure
  - How accurate is accurate enough
    - Understand the other errors
    - Appropriate trade off analysis to decide
- DRM as a tool to educate

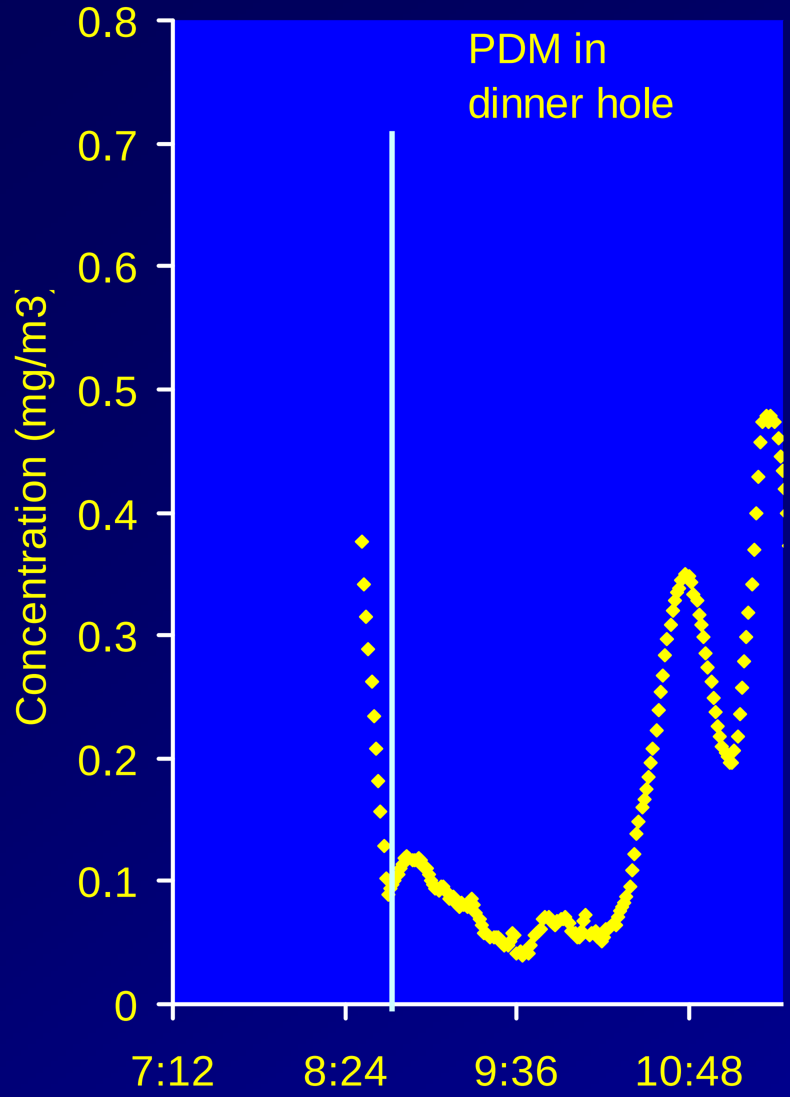
Participation through Partnership

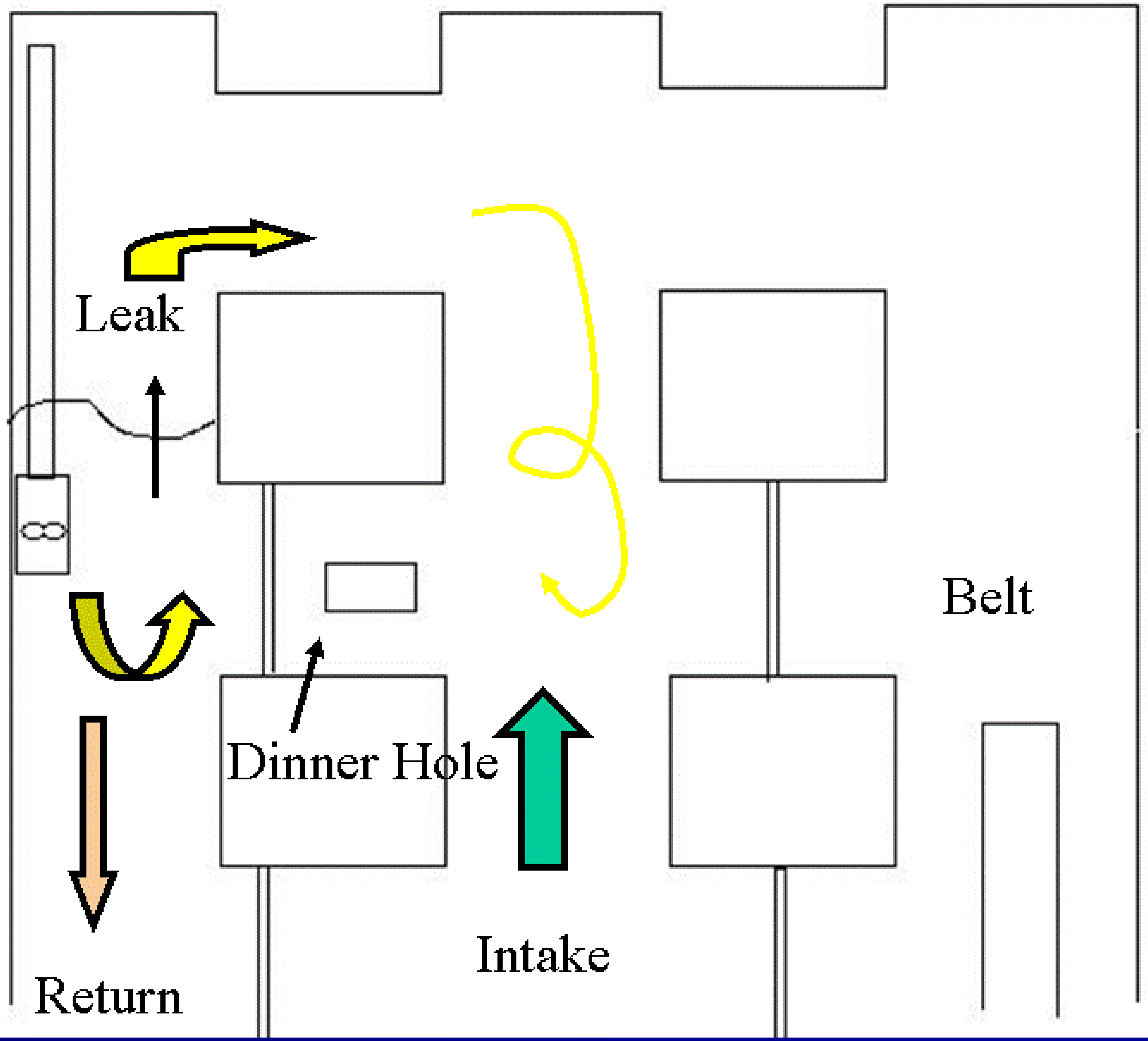
- Multiple participants strengthen development
- Workers involvement
  - Assess need
  - Development of solution
  - Consultation in design
  - Participation in testing
    - Protocol development
    - Testing
    - Feedback

Example of timely information

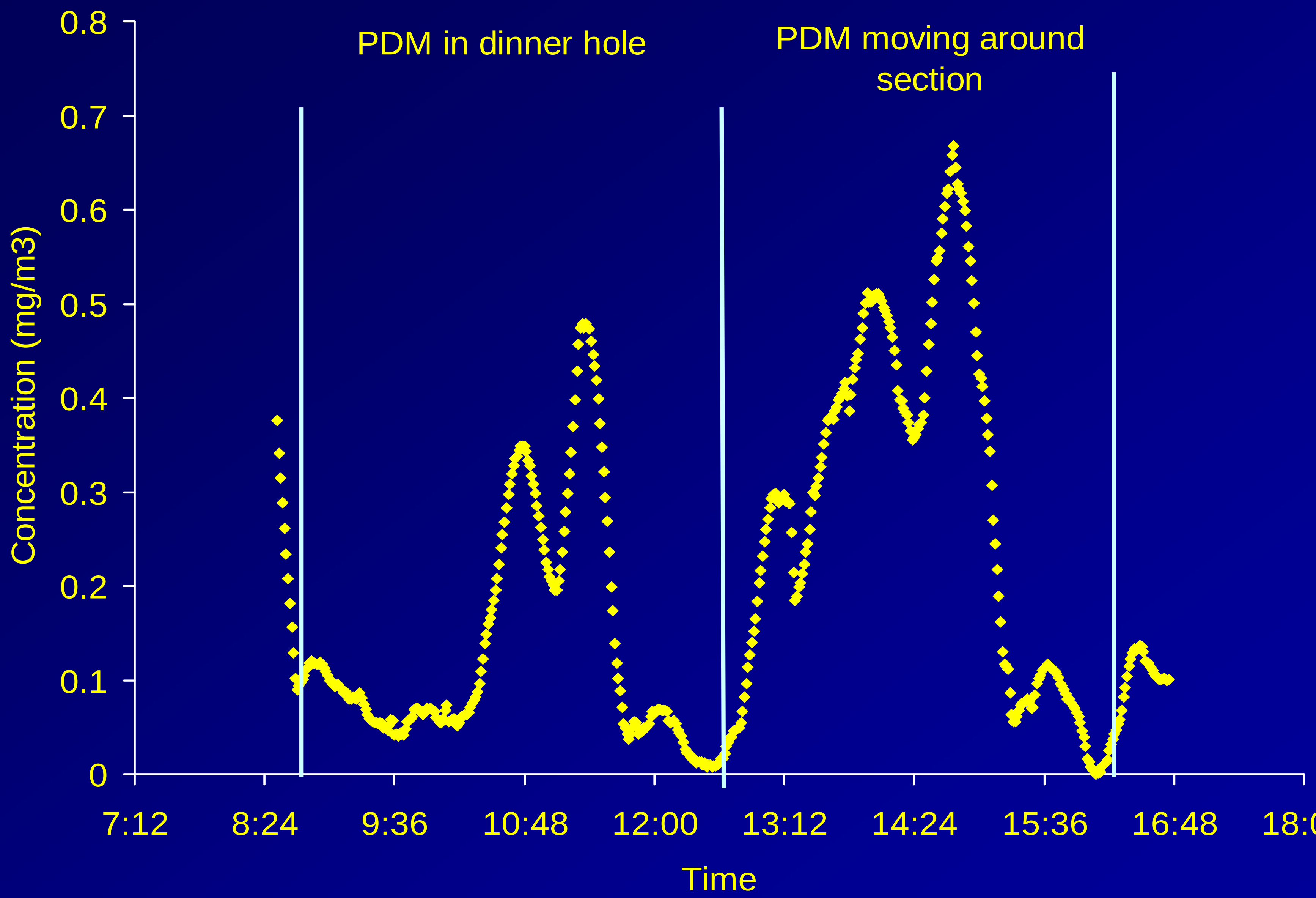
“Discovery of a Leaking Curtain”

- Benefit of immediate feedback
  - Education
  - Action – result
  - Understanding the connection between cause and effect.
  - Avoid over exposure
- PDM worn by a miner while on break in the dinner hole
- Observed an increase in the dust levels in the intake.
- Located source


PDM in
dinner hole
Concentration (mg/m3)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
7:12
8:24
9:36
10:48



Leak
Belt
Dinner Hole
Intake
Return



0.8
0.7
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0.4
0.3
0.2
0.1
0
Concentration (mg/m3)
PDM in dinner hole
PDM moving around section
7:12
8:24
9:36
10:48
12:00
13:12
14:24
15:36
16:48
18:00
Time

4. Verify exposure

- Periodic sampling – time delay
  - Allows time for conditions to change
  - Recollection of events that resulted in the exposure are forgotten
- DRM's provide timely, on-the-spot, data
  - Worker, manager, and inspector see same information at same time
  - Unambiguous arbitrator of need

5. Novel

- Psychological
  - Noise example
  - PDM example
- Empowerment
  - Employee
  - Management

Novel – Psychology Model

- Israel noise study
  - Controlled group study
  - One group saw real-time noise exposure data
  - One group did not
  - Group with information lowered exposure
- NIOSH PDM (Peters, et al. J. Int. Soc. Resp Prot. 4:2007. & NIOSH IC 9501, 2008)
  - Miners with knowledge of exposure data reduced exposure

Model of How Miners' Use Personal Dust Monitor Feedback

1. Diagnosis
2. Action Planning & Intervention
3. Evaluation
4. Institutionalization

Feedback → Behavior Change

Interview findings generally support the model

- Most miners paid attention to PDM feedback
- Most miners tried to reduce exposure
- One crew reduced their average dust exposure 60% in 4 weeks

DRM's Empower

- Worker
  - Combine job experience with timely data
  - Understand connection
  - Act to improve situation
    - Individually
    - Through management
- Management
  - Timely data allow risk to be managed
  - Demonstrate their duty to provide a healthy workplace

Challenges --
How can we improve workers health with DRM's?

Issues for discussion

1. Continuous monitoring
2. Frequency of sampling
3. Worker participation and training
4. Verify exposures
5. Innovative approaches