RADIATION RESEARCH NEEDS FOR DIRECT-READING EXPOSURE ASSESSMENT METHODS: UPDATE FROM THE 2008 NIOSH WORKSHOP

AMUG
Las Vegas, Nevada
date

Morgan Cox

Contents

- Overview of the NIOSH DREAM Workshop
- Breakout Discussion Groups
- Lifecyle Approach to Instrumentation
- Current Research Needs
- Possible Path Forward

2008 NIOSH Direct-Reading Exposure Assessment Methods Workshop

D.R.E.A.M. WORKSHOP

- November 13-14, 2008
- Hilton Crystal City, Washington, DC
- Multi-disciplinary stakeholder inputs
  - State of the art
  - State of the science
  - Research needs
- 200 on-site participants
- Plenary overviews of key issues
- 6 Breakout discussions and reports
  - *Including "Radiation"*
- Workshop report under development

CDC

www.team-psa.com/dream2008

National Institute for Occupational Safety and Health NIOSH

Breakout discussion groups

- Gases and Vapors
- Aerosols
- Ergonomics / Vibration
- Noise
- ***Radiation***
- Surface Sampling / Biomonitoring

All groups included common instrumentation and exposure assessment themes

Rapporteur Report

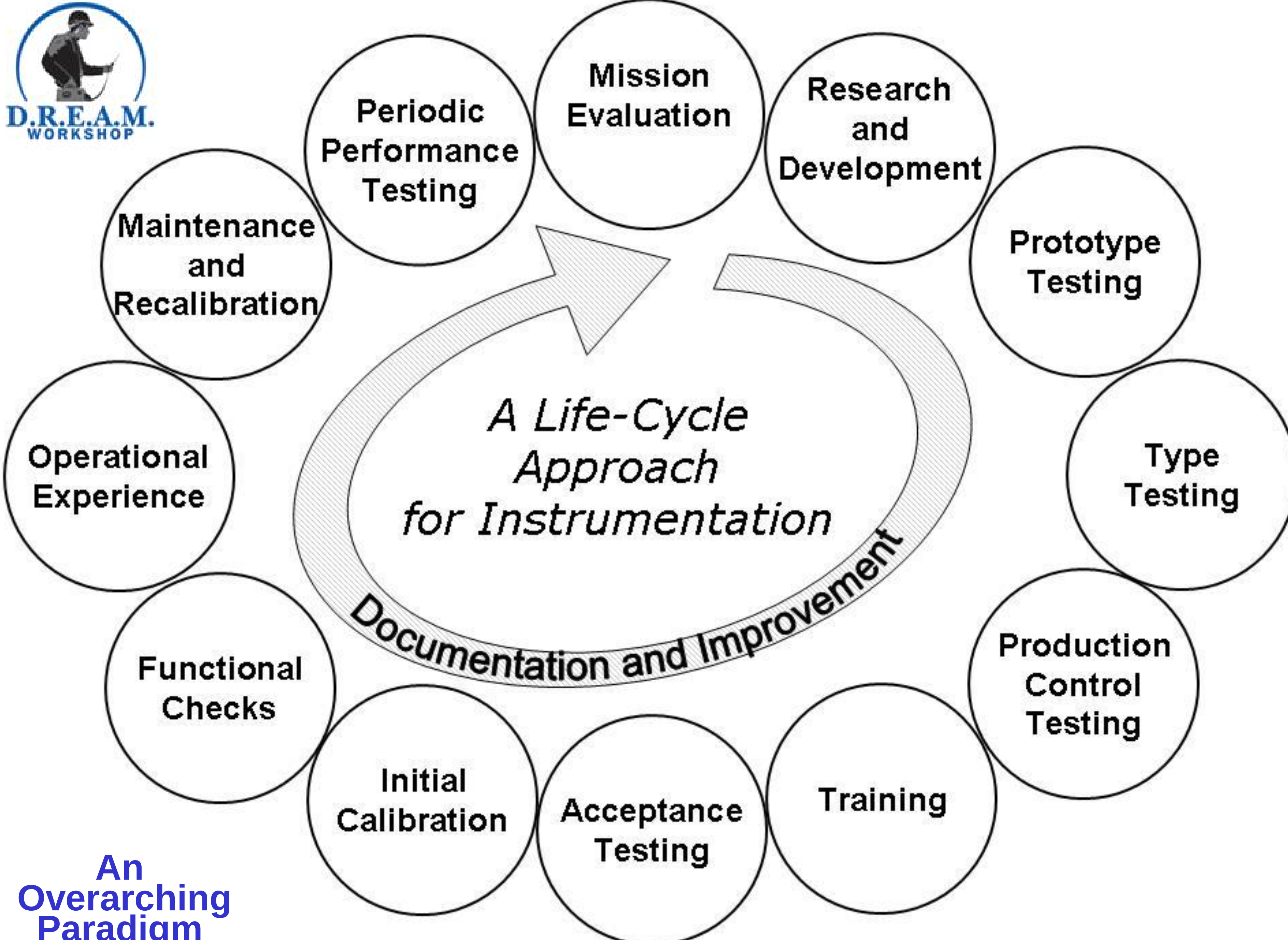
Hazard Session: Radiation

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

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

Rapporteur: Pamela Drake
National Institute for Occupational Safety and Health

An Overarching Paradigm



Adapted from Hoover and Cox 2004

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 (continued)

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

Research needs

1. *Develop methods and standards for immediate first-responder detection of airborne particulates (CBRN)*
2. Develop bioassay and biodosimetry methods that are direct reading, efficient, and available
3. Reduce size and increase speed of neutron detectors for all energies
4. 3rd party independent testing of instruments

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 (continued)

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

Example sector relationships

NORA Sector	NAICS Code	Specific Areas
Agriculture, Forestry & Fishing	115114	Fruit and vegetable irradiation
Construction	237130 237990	Nuclear power plant construction Nuclear waste disposal site construction
Healthcare & Social Assistance	621512, 621210 622110, 621910	Includes diagnostic imaging centers, hospitals, dental offices, and ambulance services
Manufacturing	325188, 325412 334517	Includes nuclear fuel manufacturing and reprocessing, source production, isotope production
Mining Oil & Gas Extraction Sub-Sector	212291 212392 213112	Uranium ores mining or beneficiating Phosphate rock mining Well-logging
Services Public Safety Sub-Sector	541380 562211 922120 922160	Industrial radiography Radioactive waste disposal facilities Police protection Fire protection
Transportation, Warehousing, and Utilities	484230 221113	Radioactive waste hauling, long-distance Nuclear power generation
Wholesale & Retail Trade	424210	Radioactive pharmaceutical isotopes merchant wholesalers

Courtesy of Jeri Anderson

End of DREAM summary

Other RDE issues and opportunities

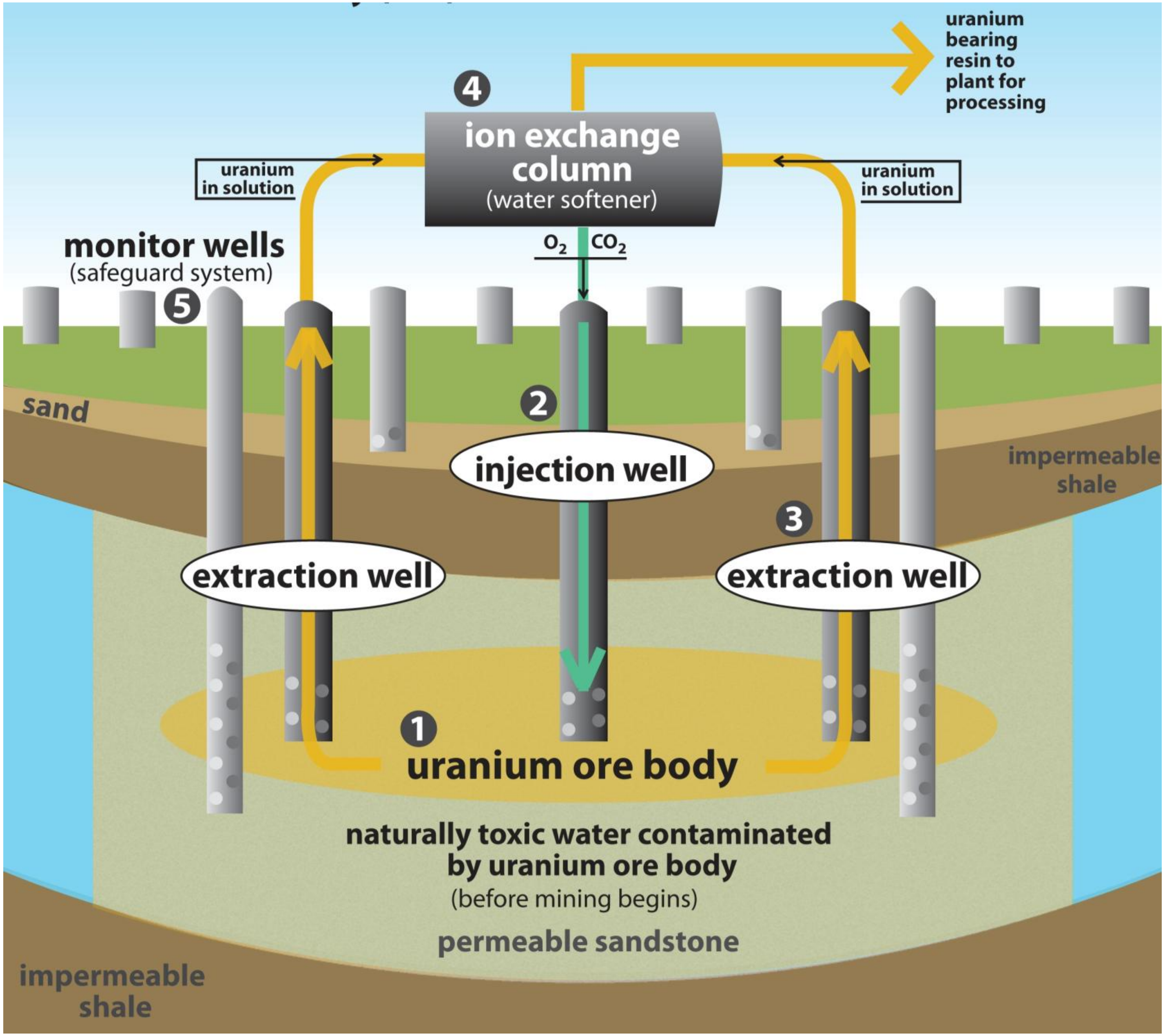
- Uranium mining and in situ recovery
- Exposure assessment strategies
  - Possible application of insights from the OCAS experience to new and emerging areas
    - Example: Questions for nanotechnology
  - Paradigm for universal air sampling objectives
  - Graded approach for comprehensive characterization

Uranium mining – past

The Radiation Exposure Compensation Program has paid $643,000,000* in compensation to date to uranium miners / millers / ore transporters

*DOJ program data as of 01/13/2009

The in situ recovery (ISR) process



Courtesy of Uranium Resources, Inc.

Opportunity to build on the existing NIOSH criteria document

A Recommended Standard for Occupational Exposure to Radon Progeny in Underground Mines

October 1987

DHHS (NIOSH) Publication No. 88-101

Recommended an annual exposure limit of 1 WLM (lower than the 1971 U.S. limit of 4 WLM)

www/cdc.gov/niosh/88-101.html

Some specific research needs for uranium recovery

- Evaluate current uranium mining regulations, procedures, and guidelines
  - Including revision of ANSI N13.8
    - Radiation Protection in Uranium Mines

- Identify/develop innovative radon-reducing and radon-decay-product-reducing controls

- Evaluate potential for a national registry

Some specific needs for uranium recovery (continued)

- Improve radon/radiation area monitoring
  - Including real-time alpha spectroscopy
- Develop personal radon/radiation dosimeters
- Develop training tools to improve uranium miner health and safety

Example state-of-the-art radon-progeny monitors

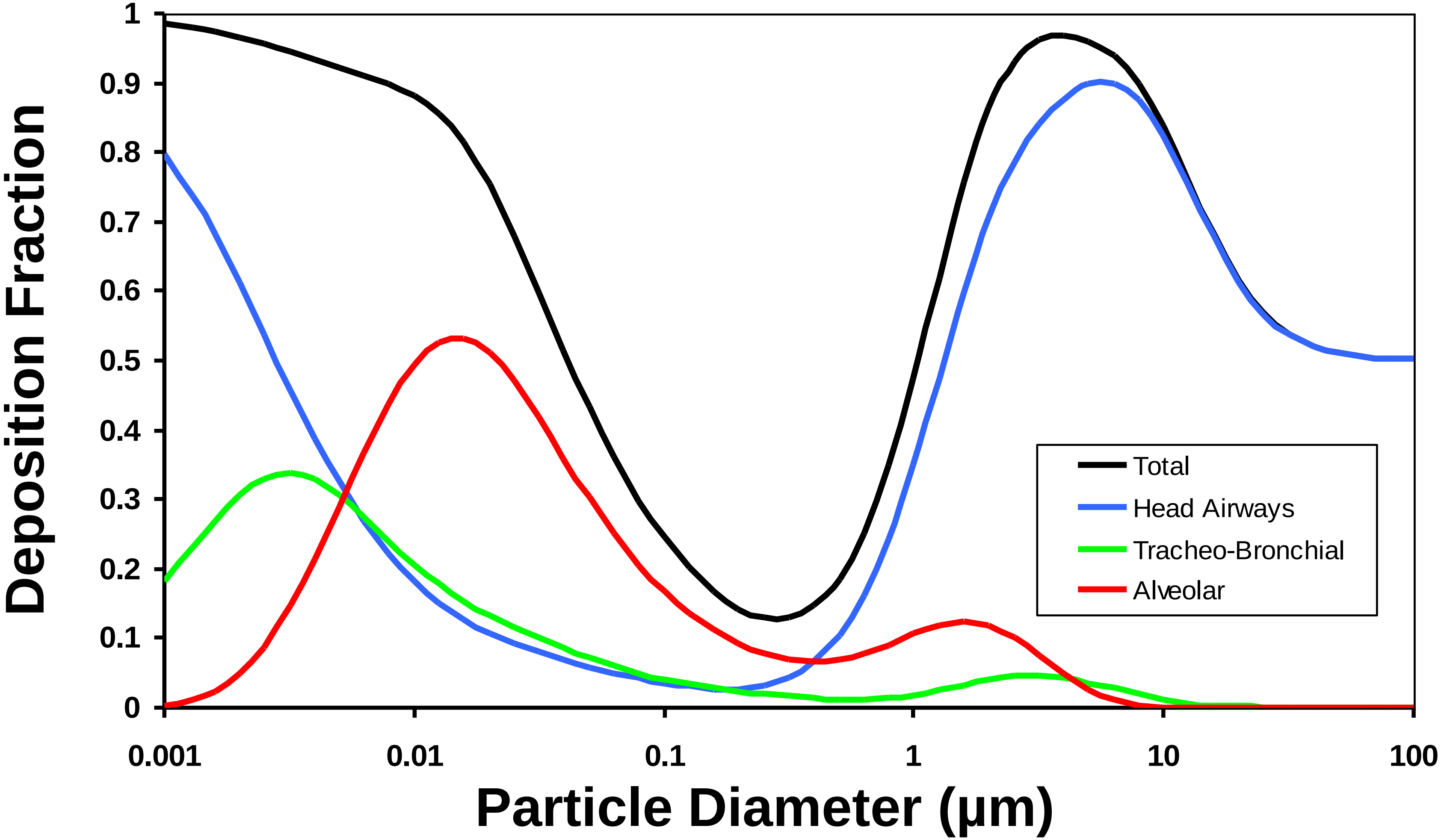
* SabreBZM shown with optional high-efficiency sample head

Courtesy of David Baltz of Bladewerx

Unusual contention of a potential sampling deficiency

- Contention that higher-than-expected radon progeny concentrations are detected downstream of filters (Robert Holub and colleagues)
- Raised as an exposure monitoring and control issue for radon decay products
- Attributed to hypothetical “quantum mechanical” or “water vapor” transport mechanisms
- Possible anomaly from accumulation of radon gas in the downstream liquid impinger used in the investigation of the possible deficiency
- May be a continuing issue for resolution

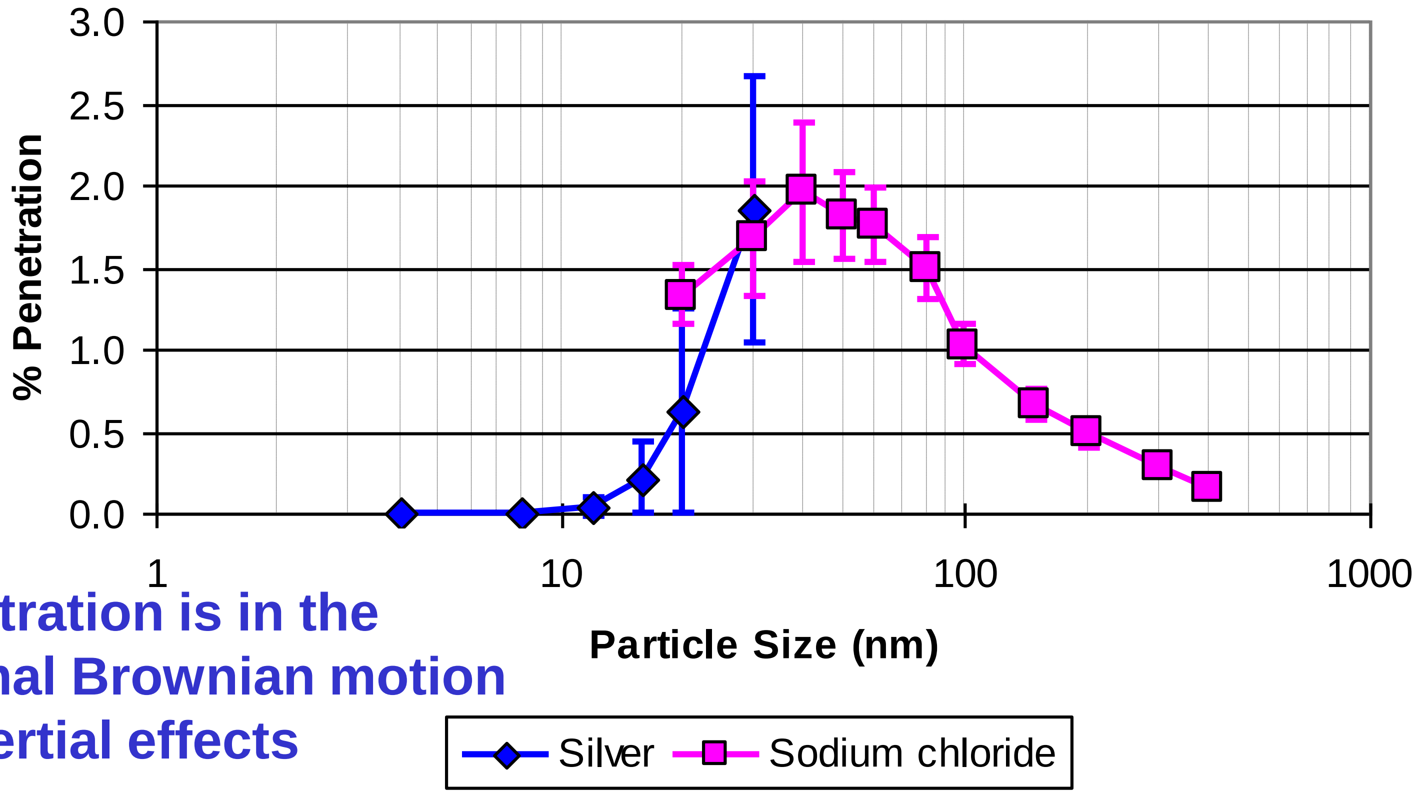
Particle size-dependent deposition in the human respiratory tract



Shares common physical principles with filtration efficiency and shows quantitative collection of smallest particles

Particle penetration through personal protective equipment: N95 respirators

- Use of respiratory protection for nanomaterials - professional judgment and hazard assessment



Maximum penetration is in the region of minimal Brownian motion and minimal inertial effects

A mechanism is not evident for penetration of nanometer or smaller-diameter metal particles or atoms

n = 5; error bars represent standard deviations
Flow rate 85 L/min; NIOSH Approved N95 (NPPTL)

Additional filtration issue example

EFFECT OF IONIZING RADIATION ON FILTRATION EFFICIENCY OF MATERIALS USED IN RESPIRATORY PROTECTION ON THE EXAMPLE OF RADON, Krzysztof Makowski, Central Institute for Labour Protection, Poland.

The most common hazards associated with radiation include the hazards due to the occurrence of radioactive aerosols the main component of which are radon degradation products with short half-life. The acceptable doses of ionizing radiation that can be absorbed by various living organisms including humans have been established. There are however no definite requirements concerning RPE in this respect. There is also no described testing methodology which could be applied for assessment of such protective devices. The primary aim of the research presented in this paper was to develop the methodology of tests and criteria of assessment making it possible to assess appropriately the protective parameters of the filtering elements used for respiratory protection against aerosols containing radioactive isotopes. In the course of the study it was established that *the value of radioactive aerosol penetration through filtering materials exceeds the results obtained for standard NaCl aerosol. The presence of radioactive aerosols in air was demonstrated to cause a decrease of filtration efficacy in materials whose filtration mechanism is based on electrostatic interactions.* The above indicates that the filter-based protective equipment currently used at worksites with radiation hazards present does not guarantee maintenance of the protective parameters crucial for the user safety. The methods currently applied for assessment of RPE have proven to be insufficient for the assessment and selection of appropriate filtering respirators for protection against radiation hazards.

http://www.isrp.com/dublin/abstracts/makowski_a25.htm

Potential application of insights from the OCAS experience for improving aerosol sampling and characterization strategies

- Are there insights for new and emerging areas such as nanotechnology?
- What makes sense for universal objectives?
- What makes sense for selecting necessary and sufficient methods for aerosol characterization?

Questions for nanotechnology are reminiscent of early questions for radiation.

What we know:

- Some potential hazard
- Some exposure occurs
- Some risk may exist
- Nanoparticles can be measured
- Nanoparticles can be controlled
- Filters and respirators should protect
- There are no specific exposure limits
- There is no recommended guidance for medical surveillance

What we don't know:

- Nature and extent of hazard
- Nature and extent of exposure
- Nature and extent of risk
- What measures to use
- Limitations of controls
- Limitations of protection
- What limits are appropriate
- Content of medical surveillance

Paradigm for Air Sampling Objectives

BASIC AEROSOL CHARACTERIZATION
Understanding relevant physicochemical and biological properties of the aerosols of interest

WORKER HEALTH PROTECTION
Ensuring that worker exposures are within allowed limits and As Low As Reasonably Achievable (ALARA)

ENVIRONMENTAL MONITORING
Ensuring that environmental releases of aerosols are within allowed limits and ALARA for environmental and public health concerns

PROCESS QUALITY ASSURANCE AND CONTROL
Ensuring that processes and process controls are operating properly

EMERGENCY PREPAREDNESS AND RESPONSE
Providing a basis for appropriate actions when things go wrong

DEMONSTRATION OF COMPLIANCE
Documenting that administrative and regulatory requirements are met

RESEARCH
Advancing a comprehensive understanding of the behavior, measurement, and control of aerosols

Adapted from Hoover and Newton 1993, 2001, 2009

Graded Approach to Aerosol Characterization

Level 1	Level 2	Level 3
Initial Screening and Detection	**Comprehensive Characterization and Assessment**	**Routine Monitoring and Control**
• Process knowledge • Gross activity counting • Optical particle counting • Condensation particle counting • Microscopy	• Elemental composition • Chemical composition • Particle size - Physical - Aerodynamic - Thermodynamic - Electrical mobility • Morphology • Surface area • Biological solubility • Etc.	• A necessary and sufficient subset of Level 2 methods

Next steps?

Hoover 2009 (draft)

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Questions ?

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