Evaluation of Filter Media for Alpha Continuous Air Monitoring in the Ultrafine Particle Size Range

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- **Genesis of the filter efficiency question**
  - Historical perspective and recent observation of 40% difference in radioactivity counting results between "similar" filter methods
- **Evaluation of filter differences**
  - Composition and construction
  - Pressure drop
  - Penetration efficiency
- **Opportunities to apply lessons learned**
  - Selection of appropriate filter media
  - Simple steps for quality assurance

Uranium mining – historical perspective

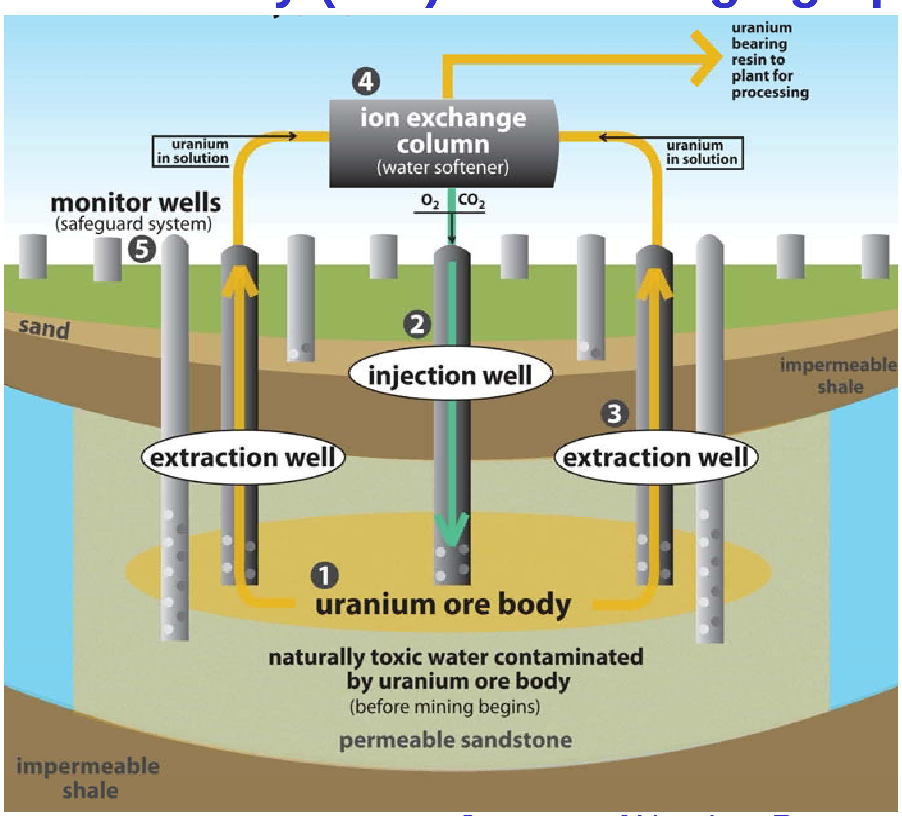
Open-pit mining

Underground mining

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

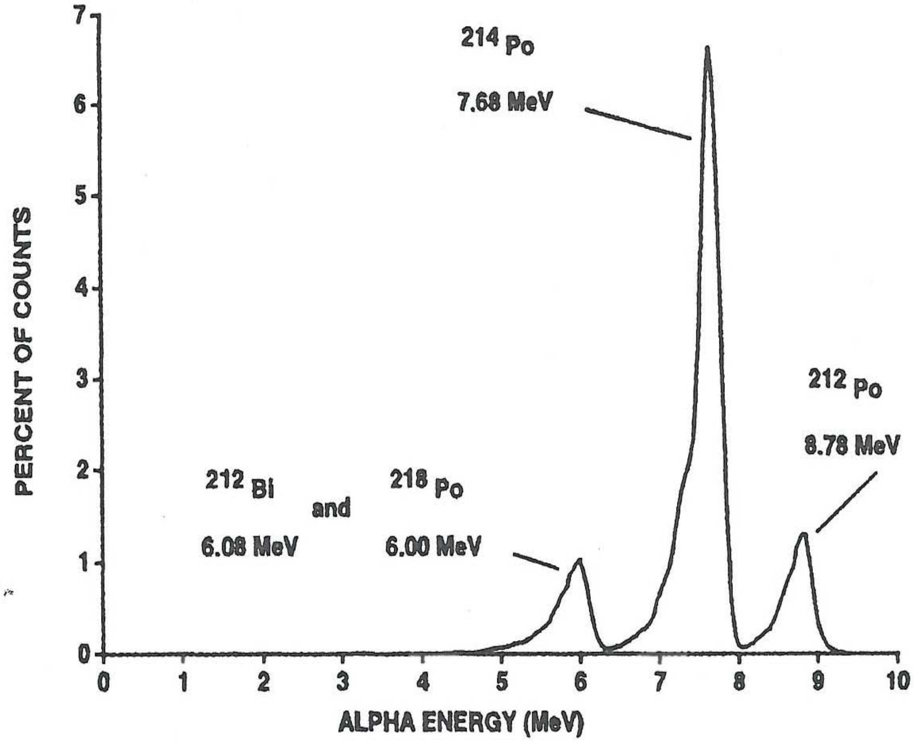
*DOJ program data as of 01/13/2009 3

In situ recovery (ISR) – an emerging option



Courtesy of Uranium Resources, Inc. 4

Alpha emissions of radon progeny



From Hoover and Newton, 1993, 2001

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 and development needs for uranium recovery

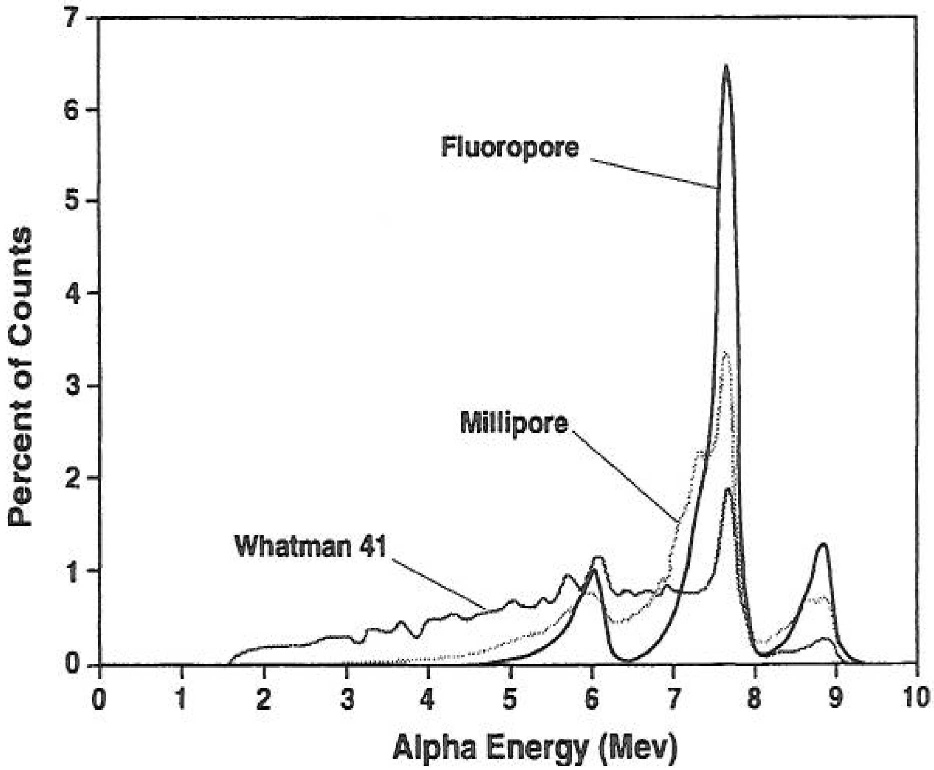
- **Improve radon/radiation area monitoring**
  - Including real-time alpha spectroscopy
- **Develop personal radon/radiation dosimeters**
- **Develop training tools to improve uranium miner health and safety**

State-of-the-art radon-progeny monitors

* SabreBZM shown with optional high-efficiency sample head

- Based on methods for monitoring airborne plutonium in the workplace
- Have significant real-time advantages over historical batch sampling methods for filtration and retrospective counting of airborne radioactivity

Influence of filter type on spectral quality



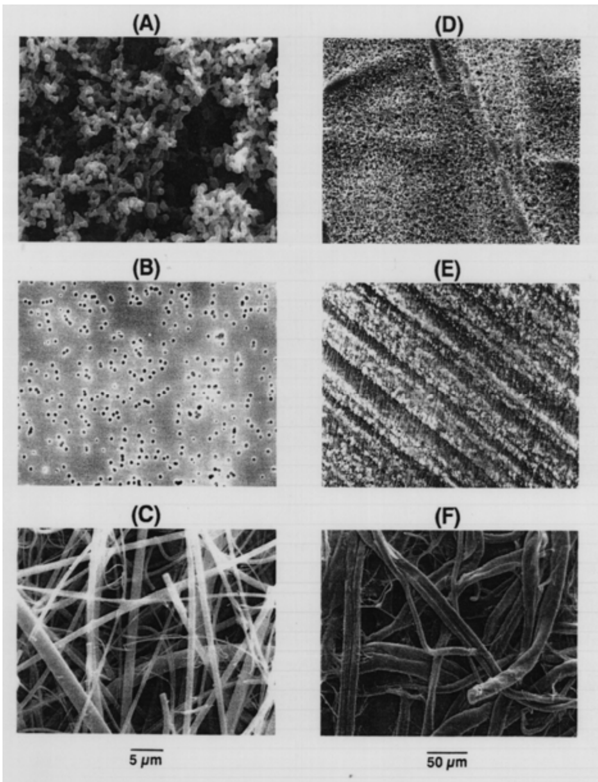
From Hoover and Newton, 1993, 2001

Characteristics of filter media

Mixed cellulose ester
- Historical filter of choice
- Moderate pressure drop
- Good alpha spectrum
- Somewhat fragile
- e.g., Millipore SMWP

Trak-etch membrane
- Microscopy option
- High pressure drop
- Good alpha spectrum
- Somewhat fragile
- e.g., Nuclepore 0.6 um

Glass fiber filter
- Gross alpha counting use
- Low pressure drop
- Very poor alpha spectrum
- Moderately rugged
- e.g., Gelman A/E glass

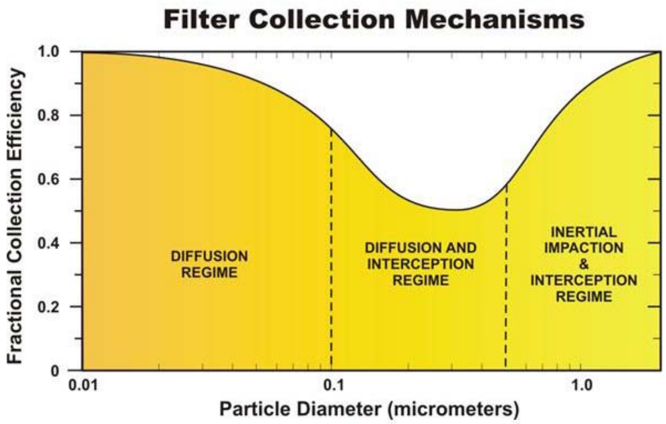


Supported MCE
- Acceptable option
- Moderate pressure drop
- Good alpha spectrum
- Rugged
- e.g., Millipore AW19

PTFE membrane
- Option of choice
- Good pressure drop
- Excellent alpha spectrum
- Rugged
- Front / back difference
- e.g., Fluoropore FLMB, Speclon 1.5, 5.0, etc.

Cotton fiber filter
- Historical workplace filter
- Low pressure drop
- Very poor alpha spectrum
- Moderately rugged
- e.g., Whatman 41

Physical basis for the Most Penetrating Particle Size (MPPS)



- Larger particles are collection by inertia
- Smaller particles are collected by diffusion
- MPPS occurs where inertial and diffusive collection are minimal

- **MPPS *decreases* with increasing face velocity**
  - Inertial collection at the old MMP size is increased
  - Residence time for diffusive collection of smaller particles is decreased

Figure from www.cdc.gov/niosh/docs/2003-136/

Experimental design

5 filter media:
Gelman A/E glass
Speclon 1.5 μm PTFE
Speclon 5.0 μm PTFE
Millipore 5.0 μm PTFE
Millipore 5.0 μm SMWP

3 filter face-velocities:
10 cm/s (3 L/min*) (personal sampling)
30 cm/s (9 L/min) (intermediate)
100 cm/s (30 L/min) (area sampling)

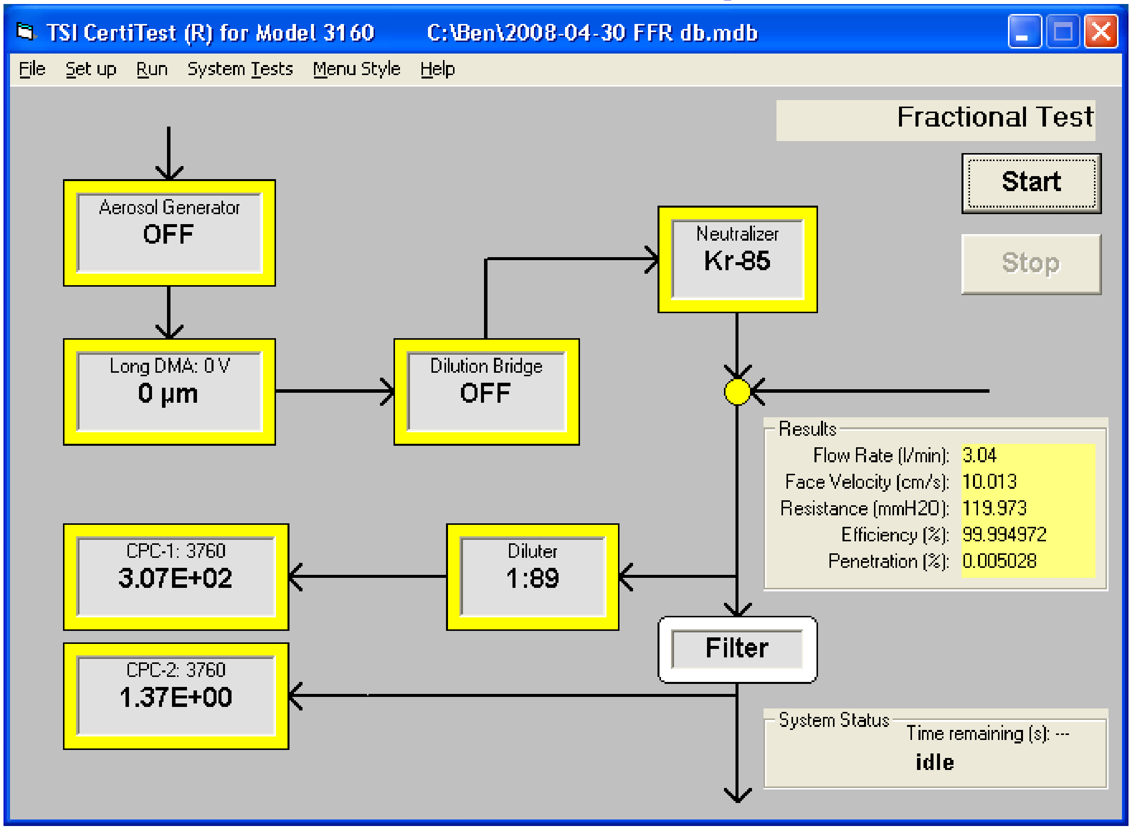
TSI Model 3160 Certitest Fractional-Efficiency Filter Tests:

- Collection efficiency for 10 monodisperse particle diameters:
20, 30, 40, 50, 60, 80, 100, 200, 300, 400 nm

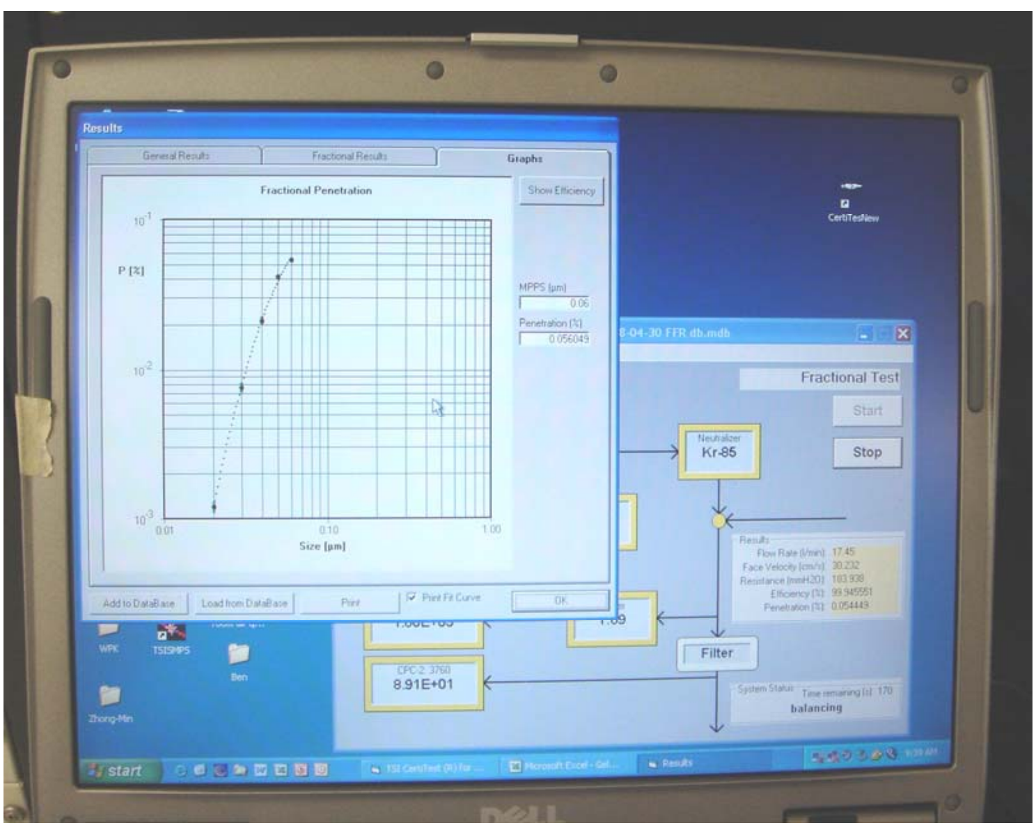
- Pressure drop as a function of face velocity

*flow rate based on 2.54 cm filter diameter

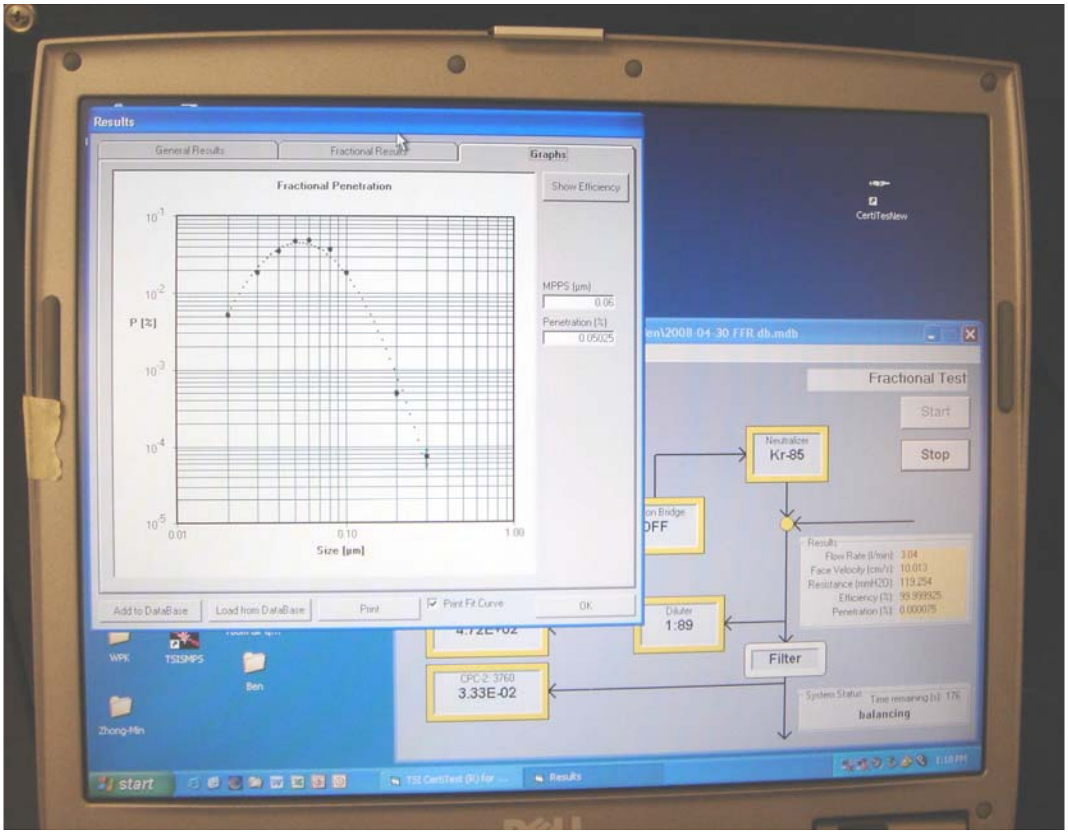
Certitest control panel



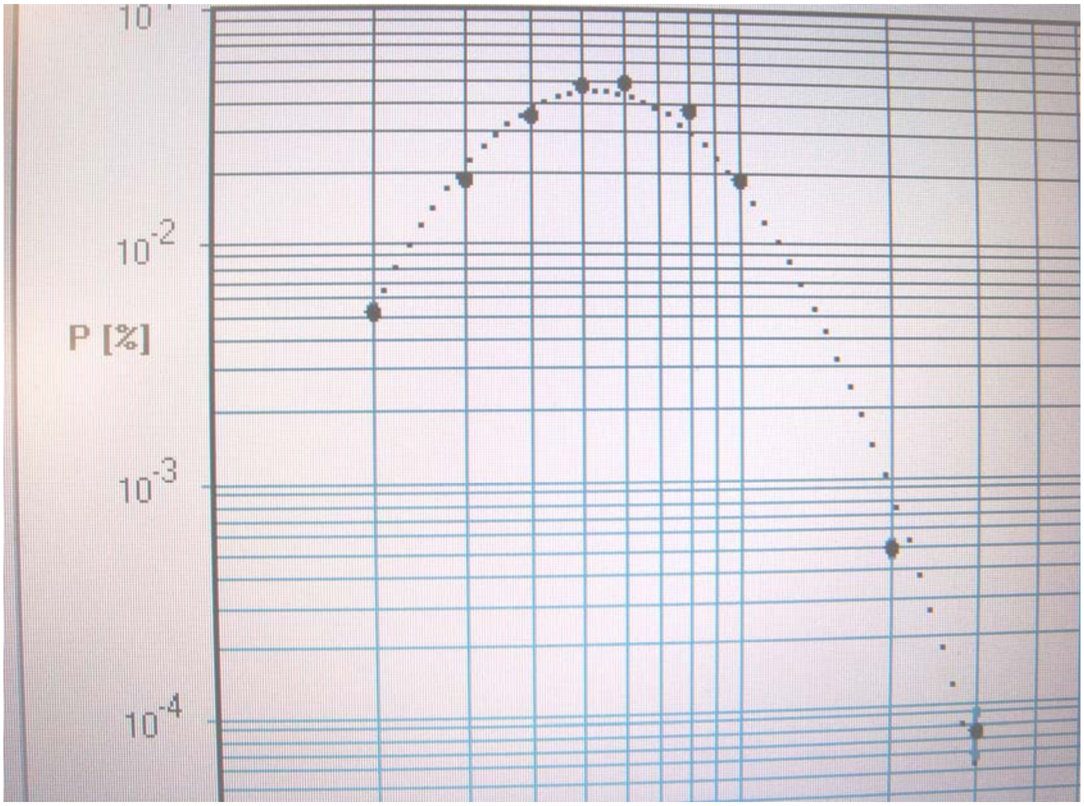
Display of a test in progress



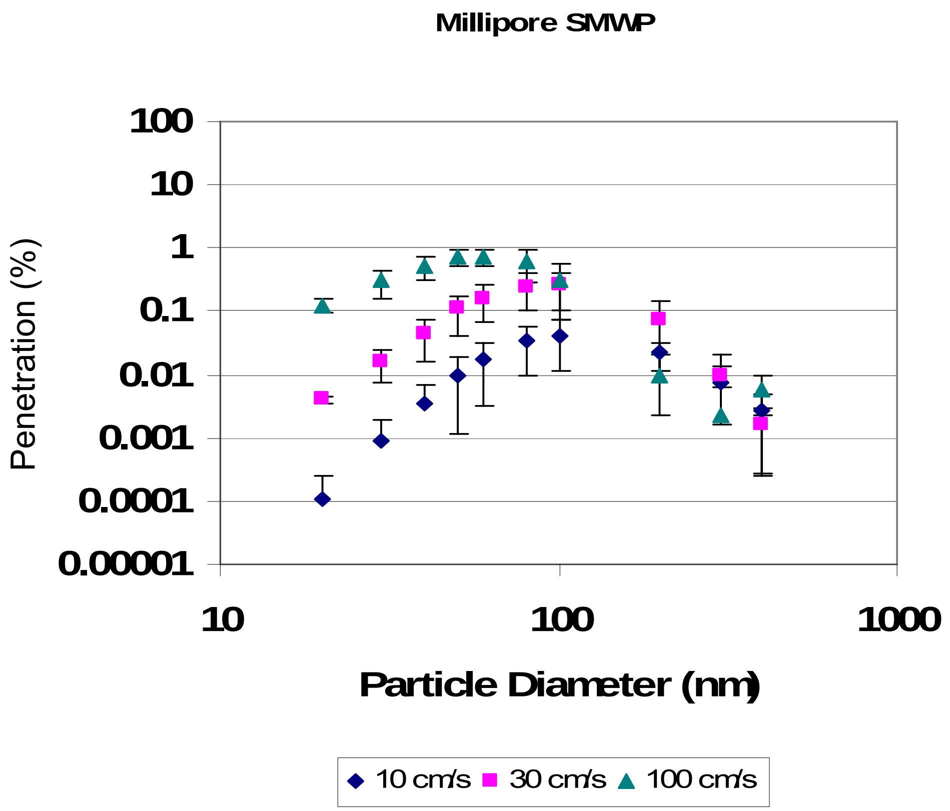
Display of a completed test



Example for a Most Penetrating Particle Size (MPPS) of approximately 50 nm

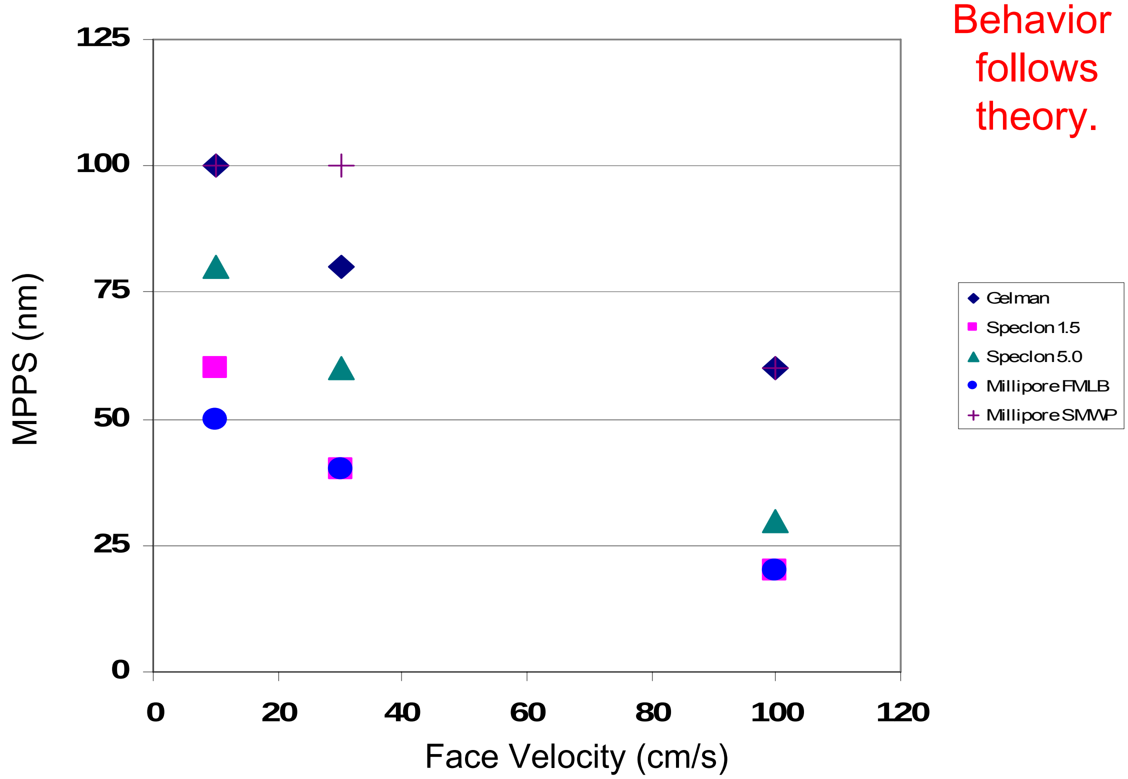


Example of penetration versus face velocity

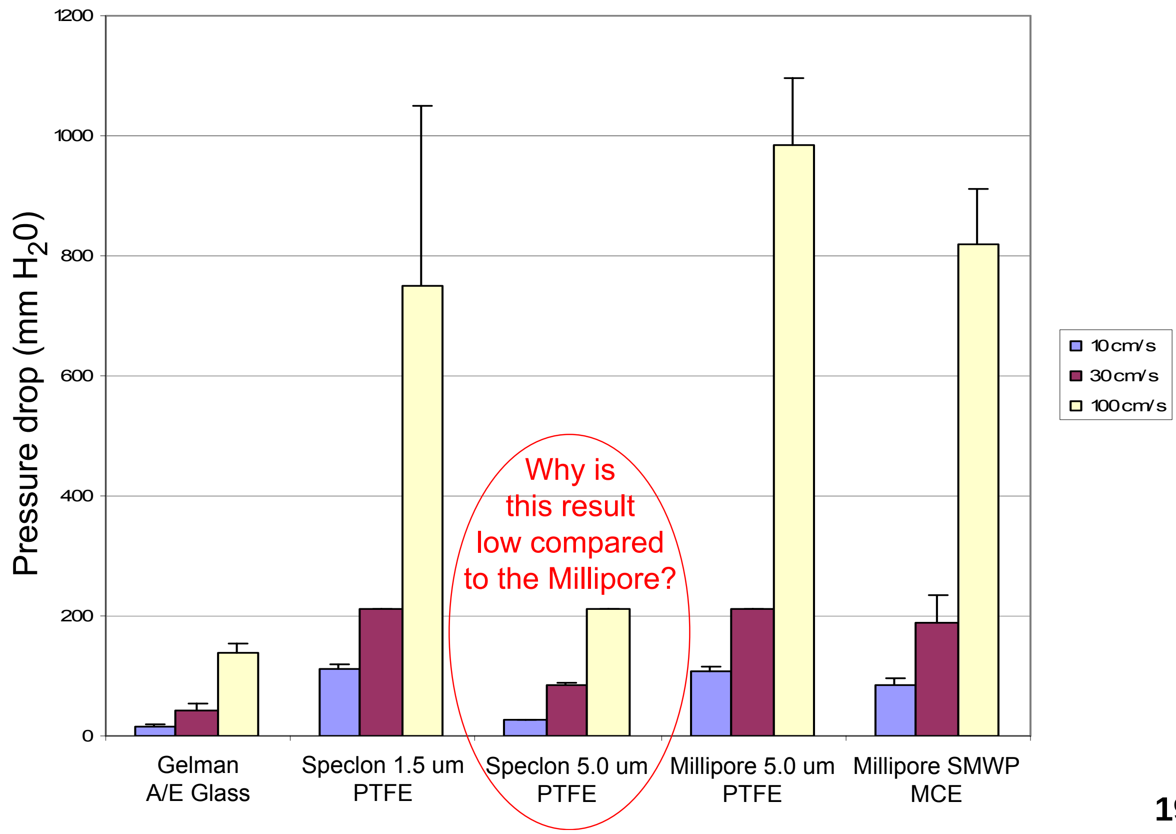


Influence of face velocity on MMPS

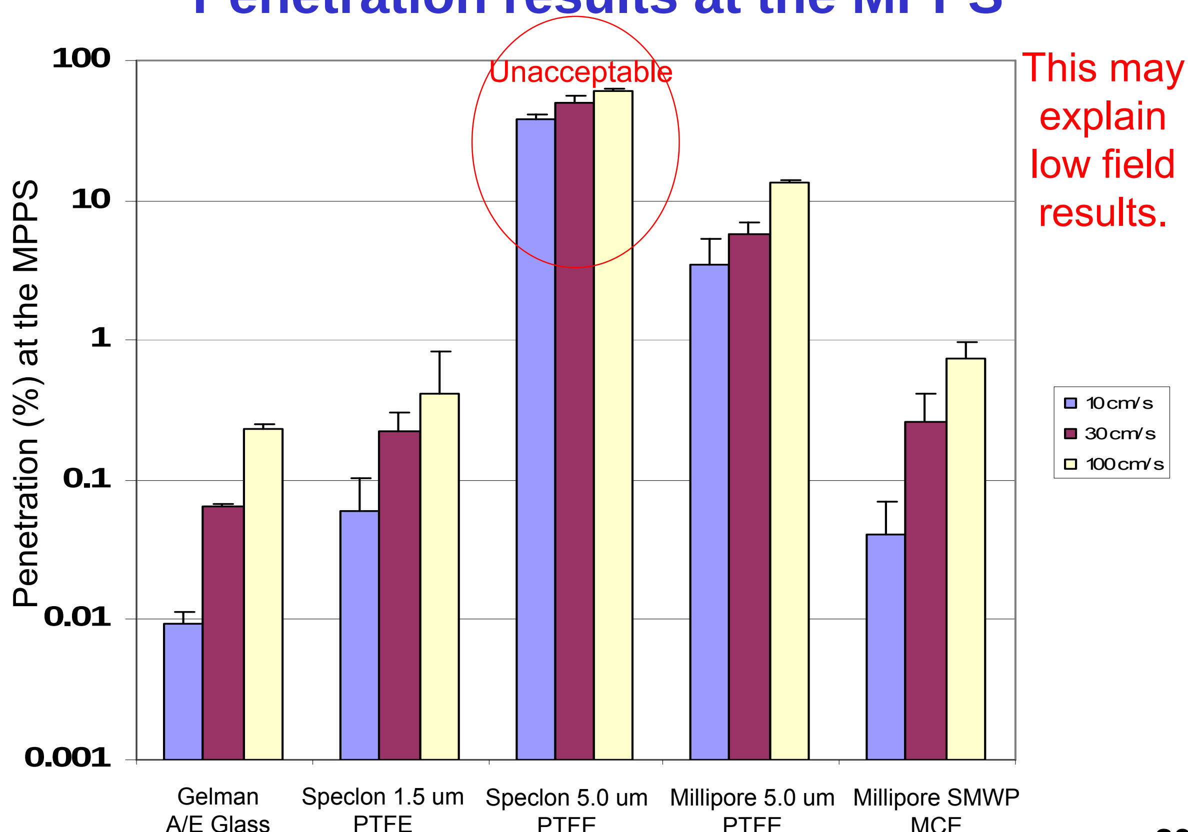
Behavior follows theory.



Pressure drop results

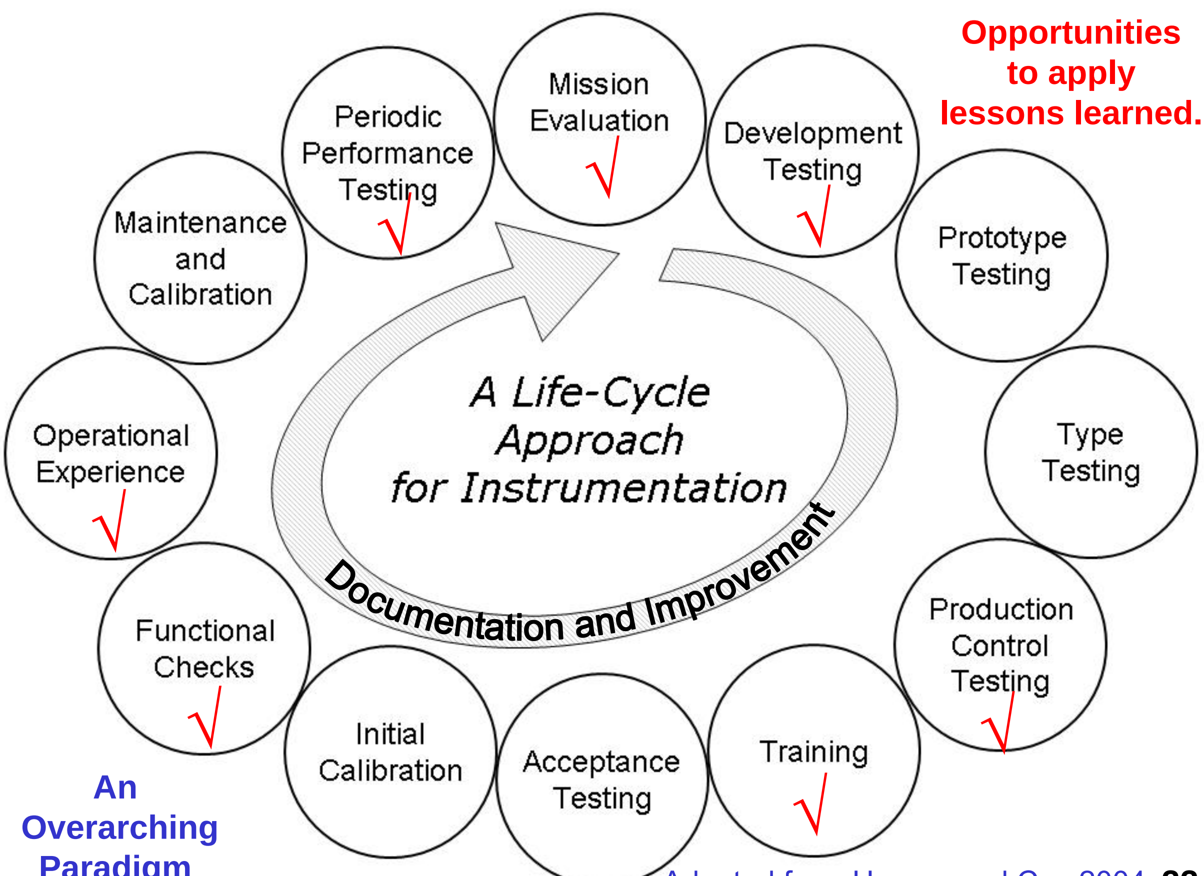


Penetration results at the MPPS



Lessons learned

- **Influences of face velocity on pressure drop and collection efficiency follow filtration principles.**
- **Low filter penetration applicable to workplace aerosols**
  (default assumption of 5 µm aerodynamic diameter)
  may not apply for environmental aerosols
  (default assumption of 1 µm aerodynamic diameter)
  or for ultrafine aerosols.
- **Higher than expected particle penetration for the Speclon 5.0 µm PTFE filter:**
  - Indicates the filter is not suitable for alpha CAM applications and
  - Is consistent with lower than expected pressure drop.
- **Routine monitoring of pressure drop provides a quality assurance check.**
- **Comparison of operational results with alternate filtration methods also provides quality assurance.**



Opportunities to apply lessons learned.

An Overarching Paradigm

Adapted from Hoover and Cox 2004

Questions ?

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