Sampling to Quantify Respirable Dust Generation

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Presentation topics

• Current respirable dust standards and sampling requirements

• Dust sampling instruments approved for use in underground US coal mines

• Sampling methods to quantify dust sources
Respirable dust standard for coal mining
(Federal Coal Mine Health and Safety Act of 1969)

2.0 mg/m$^3$

If silica > 5%, reduced standard = 10 / (% silica)
Gravimetric dust sampler

- Provides time-weighted-average respirable dust concentration
- Dorr-Oliver cyclone separates respirable and oversize dust
- Pump operated at 2.0 liters per minute in coal mines
Sampling with gravimetric sampler

- Filter is pre- and post-weighed to determine mass gain and is used to calculate an average dust concentration over sampling period.

- Filter processed using MSHA P7 infrared analytical technique for silica content.

- Sufficient mass must be collected to have confidence in measurement.

- NIOSH typically uses multiple gravimetric samplers and averages data.
Personal DataRAM (pDR)

- Uses light scattering as measurement technology
- Instantaneous readings correlated with time and stored in internal memory
- Relative concentrations impacted by:
  - size distribution of dust
  - composition of dust
  - water mist in air
- PRL adjusts readings with ratio obtained from adjacent gravimetric samplers
pDR field calibration

• Divide average gravimetric concentration by average pDR concentration for same sampling period

• Multiply all individual pDR readings by ratio

• Example:
  gravimetric average = 1.4 mg/m³
  pDR average = 1.1 mg/m³
  grav/pDR ratio = 1.4/1.1 = 1.27
  pDR concentrations * 1.27 = adjusted pDR concentrations
pDR provides time record of dust levels

Relative Dust Concentration (mg/m$^3$)

- Head to Tail Pass
- Tail to Head Pass

CDC
NIOSH
Personal Dust Monitor (PDM)

- Real-time measurement of respirable dust
- Combines dust sampler and cap lamp into one unit
- Sample inlet is mounted on cap lamp
- Utilizes mass-based measurement to quantify dust concentration (TEOM)
- Dust measurements are displayed on screen and stored internally for later analysis
Principle of operation

- Exchangeable filter cartridge mounted on the end of the tapered element collects particles as sample stream flows through hollow tube.

- Tapered element oscillates at its harmonic frequency -- like a tuning fork.

- Frequency changes in *direct* relation to the mass collected on the filter.

- Measurement principle does *not* respond to other particle characteristics such as size distribution or composition (heated circuit removes moisture).
**PDM status:**

- Meets NIOSH sampling accuracy requirements (NIOSH RI 9669)
- Equivalency to CMPDSU (gravimetric sampler) published in peer-review journal
- MSHA IS approval granted for use in underground coal mines
- CFR 30, Part 74 modified rule published April 6, 2010
- Thermo Scientific began delivery of commercial units in July 2009
- Two ongoing NIOSH research efforts (software and silica)
PDM analytical software

- Compile output from PDM samplers
- Provide user-selected summaries for multiple samplers (foreman, mine superintendent, etc.) or engineering evaluations
- Provide graphing capabilities
PDM filter capsule for maintaining sample integrity for quartz analysis

- Place capsule over PDM filter when TEOM unit removed from PDM
- Use capsule as filter removal tool and to secure dust
- Send to lab, remove finger tab, ash capsule
- Plan to conduct mine surveys to complete side-by-side testing with current silica analysis method
Sampling to isolate a fixed dust source

Continuous miner

Line brattice

Sampling locations

Return

Intake

Check curtain
Sampling to isolate a mobile dust source

Coal

Fallen Gob

U - Upwind location  D - Downwind location
Using real-time data to quantify mobile dust sources

- Evaluate dust levels during truck haulage cycle at an underground gold mine
- Use pDR samplers and time study data to quantify dust generation for different parts of cycle
  - loading
  - hauling full
  - dumping
  - hauling empty
- Two researchers conducting time studies
Time-weighted-average dust contributions

Dump location had highest dust contribution despite having the shortest duration… (14% time vs 34% dust)
Sampling to isolate an unconfined dust source

A – Ambient sampling location
D – Drill sampling locations

Wind direction

A

D

D

D

D

D
Thank you!

Questions??

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