Silica dust controls for surface mines

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Outline

Drilling
Cabs
Hauling
Crusher dump point
EVADE/HelmetCAM
NIOSH Respiratory Health Division

- 2010-2011
- 2328 surface miners screened
  - 2.0% (≈ 47) pneumoconiosis
    - 12 miners radiographic changes consistent with PMF
    - 9 of the 12 reported no underground experience
    - Common occupation among the 9

Drilling or Blasting Occupations
Dust Emissions From Blasthole Drills

- 52% - Drill deck
  - 28% shroud
  - 24% table bushing
- 38% - Collector dumping
- 10% - Other mining equipment sources
Typical Dust Concentrations Encountered

- Drill Deck (Shroud & Table Bushing)
  - Peak conc. can reach 98 mg/m³

- Dust Collector
  - Peak conc. can reach 68 mg/m³
Drilling Dust Control

• Wet Drilling
  – Use of water combined with air to flush drill cuttings
  – Prevents dust generation during drilling

• Dry Drilling
  – No water used in bailing air
  – Use of a dust collector to prevent dust generation
Wet Drilling

- **Best Drilling Dust Control**
- Does not require large amounts of water
- Wet drilling eliminates up to 97% respirable dust
- Rotary bit degradation
Wet Drilling

Potential problems:
- Bit Degradation (hydrogen embrittlement)
- Cold climates (water freezing)
Water Separator Sub Increases Roller Bit Life

Bit life increased 4.5 times with use of separator sub
9000 ft with sub
2000 ft without sub
Small Diameter Water Separator Sub Study

Wet vs Dry Drilling

Concentration, mg/m³

Wet

Dry
Dry Drilling

- Use of dust collector
- Can be up to 99% efficient
  - Properly maintained
  - Operated correctly
Dust Collector System of Blasthole Drill
Dry Drilling Dust Control Solutions

- Proper maintenance of dust collector system
- Maintain high collector airflow to bailing airflow ratios
  - 3:1 or more; collector airflow 3 x bailing airflow
- Prevent/reduce drill deck shroud leakage
Drill Shroud Leakage

Maintain tight shroud enclosure with the ground
(Unlike this example)
Shroud Height Effects

![Graph showing the effect of shroud height on control efficiency. The graph compares two models, BE45R and BE60R, with control efficiency (%) on the y-axis and shroud height (in.) on the x-axis. The graph indicates that control efficiency decreases as shroud height increases.]
Shroud Height & Airflow Effects

![Bar Chart Showing Shroud Height & Airflow Effects]

- **Y-axis**: ARD mg/m³
- **X-axis**: Shroud Gap Height, in.

- **2” ht.**
- **8” ht.**
- **14” ht.**

3:1 ratio
Shroud Height & Airflow Effects

![Graph showing ARD mg/m³ vs Shroud Gap Height, in. for 2", 8", and 14" heights at 2:1 and 3:1 ratios.](image-url)
Shroud Height & Airflow Effects

![Diagram showing ARD mg/m³ with height and airflow effects]

- **2" ht.**
- **8" ht.**
- **14" ht.**

Legend:
- 2:1 ratio
- 3:1 ratio
- 4:1 ratio
CFD Dust Concentrations in Pittsburgh Drill Shroud Lab Facility

Respirable dust concentration distribution - 300 cfm with 2:1 CTB ratio case (legend from 2 to 40 mg/m³)
CFD Dust Concentrations in Pittsburgh Drill Shroud Lab Facility

A cross section of the 2 inch gap showing the respirable dust concentration distribution 300 cfm with the 2:1 collector-to-bailing airflow ratio (legend from 2 to 40 mg/m³).
CFD Dust Concentrations in Pittsburgh Drill Shroud Lab Facility

Respirable dust concentration distribution - 300 cfm with 3:1 CTB ratio case (legend from 2 to 40 mg/m³)
CFD Dust Concentrations in Pittsburgh Drill Shroud Lab Facility

Respirable dust concentration distribution - 300 cfm with 4:1 CTB ratio case (legend from 2 to 40 mg/m³)
CFD Airflow Patterns Underneath Drill Shroud

Velocity vectors 500 cfm with 2:1 CTB ratio case (legend from 0 to 26 m/s)
Airflow Patterns Underneath Drill Shroud

Normal airflow patterns

Airflow patterns w/ shelf
Horizontal Shelf

- **Mine A**
  - 69-70% reductions area surrounding drill
    - Variation dependent upon wind direction
  - 66% reduction at shroud location

- **Mine B**
  - Low dust concentrations surrounding drill
    - For both shelf-off/shelf-on
  - 81% reduction at shroud location
Adjustable Height Shroud

Dust emissions below 0.5 mg/m³
Table Bushing Dust Control

- Replace table bushing
Collector Exhaust Port Dust Control

- Replace dust collector filters
- Stand away from drill
Dust Collector Dump Shroud

63 – 88% reduction

Easy installation, Little maintenance
Enclosed Cab Filtration Systems

• Integrated into HVAC Systems
• Protection Factors Vary
  \[ \text{PF} = \frac{C_{\text{outside}}}{C_{\text{inside}}} \]
  – Drills 2.5 to 84
  – Bulldozers 0 to 45
Protection Factor, Efficiency, & Penetration

- **Protection Factor (PF)** = $\frac{C_{\text{outside}}}{C_{\text{inside}}}$
  - $C$ = dust concentration (mg/m$^3$)
  - The bigger the number the better

- **Efficiency ($\eta$)** = $\frac{(C_{\text{outside}} - C_{\text{inside}})}{C_{\text{outside}}}$
  - Range 0 – 1
  - 0 = bad, 1 = good

- **Penetration (Pen)** = $1 - \eta$
  - Range 0 – 1
  - 1 = bad, 0 = good
Refurbish Cabs

- Ensure good cab integrity
- Positive pressurization

Ceiling mount heating and AC units
External filter and fan units
Improve cab enclosure seals
Positive Pressurization

- To prevent infiltration

\[ Wind\ Velocity = \left( 4000 \sqrt{\Delta p_{cab}} \right) 0.011364 \]
  - \( Wind\ Velocity \) = Wind speed in mph
  - \( \Delta p \) = Cab static pressure in inches w.g.
Uni-Directional Design

- Intake for recirculation air at bottom of cab
  - Prevents contaminated air flow over operator
  - Prevents short-circuit of contaminated air
Utilize High Efficiency Respirable Dust Filters

- Intake filter $\geq 95\%$ on respirable-sized dusts
- Use an efficient recirculation filter
  - Improves cab protection factor
  - Reduces stability time
Minimize Dust Sources in Cab

- Use good housekeeping practices
- Remove floor heaters
  - Floor heater use increased dust levels from 0.03 to 0.26 mg/m³
- Rubber mats better than carpeting
- Gritless sweeping compounds *non-petroleum based*
Keep Doors Closed During Equipment Operation

- 0.81 mg/m³ when briefly opened to add drill steels
- 0.09 mg/m³ with door closed
Controlling Haul Road Dust

- ≈15% of airborne dust < 10 µm
- ≈4% of airborne dust < 3.5 µm
Dust Dissipation Effect

Increase distance between vehicles
Haul Road Construction

- Properly constructed haul roads important for dust control
- Proper materials
  - Resistance to wear
  - Soundness (resists weathering)
  - Angular shaped particles
  - Gradation

  - \[ P = 100 \left( \frac{d}{D} \right)^n \]
    - \( P \)=% by weight finer than sieve
    - \( d \)=sieve opening dimensions, common sizes -2”, 1”, ¾”, ⅜”, No. 4, No. 40, and No. 200
    - \( D \)=maximum size of aggregate (inches)
    - \( n \)=empirical gradation exponent (0.33 to 0.5), generally 0.5 represents max density of material
Haul Road Construction

- Ensure proper design
  - Subgrade
    - Foundation
  - Subbase
    - Compacted angular aggregate
  - Wearing surface
    - Contains sufficient fines
- USBM IC 8758
Treatment of Unpaved Road Surface

- Water effective with reapplications
- Alternative road treatments
  - Salts, surfactants, soil cements, bitumens, films (polymers) may extend time of effectiveness
  - Application requirements
  - Selection of treatment site specific
Watering Haul Roads

- Dedicated water truck
- Maintain regular watering schedule
- Fan sprays
  - Custom built
  - Purchased from manufacturer
Other Road Dust Control Methods

- **Speed control**
  - 25mph to 10 mph, 58% control efficiency
  - 25 mph to 15 mph, 42% control efficiency

- **Traffic control**
  - 20 second intervals between trucks

- **Load covers**
  - Tarps
  - Freeboard (3”)

- **Cab maintenance**
Stockpiles and Open Areas

• Methods for dust control
  – Water
    • Forms a crust
    • Cementation/alternate wetting and drying
  – Coatings
    • $$$
    • Forms a durable crust
  – Compaction
Stockpiles and Open Areas

• Methods for dust control (cont’d)
  – Surface roughness
    • Vegetation/gravel blankets
      – Clean gravel
    • Ripping (last resort)
  – Wind barriers
Crusher Hopper Dump Points

- Enclose dump point
- Water sprays
Enclose Hopper Dump Point

- Staging curtains reduce dust escape
- Exhaust ventilation systems may be used, but must be properly designed
Water Spray Use

- Amount of water to use
  - Initially, apply water to obtain 1% moisture content
- Use automated spray system
  - Conserve water use
Prevent Dust Rollback Underneath Vehicle

- Tire stop reduces dust rollback
- Water sprays redirect dust
EVADE/HelmetCAM

- Dust source identification
  - HelmetCAM field survey
    - Coal miners
    - Metal/nonmetal miners
  - EVADE software for analysis
    - NIOSH developed

- Develop control strategies
  - Target dust sources to reduce over-exposures of miners
EVADE/HelmetCAM

- Video Cameras
  - Attach to hardhat
  - Video length limited to battery life
  - File types AVI, WMV, or MP4

Contour
Approximately $200

Go Pro
$200 - $400

V.I.O.
$300 - $400

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EVADE/HelmetCAM

- Dust monitors
  - Worn on belt
  - Provide instantaneous dust concentrations
  - Any device where data can be stored as Excel CSV file

Thermo pDR-1000  Thermo pDR-1500

TSI AM-510

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EVADE/HelmetCAM

Three Options to House Helmet-CAM

Backpack/Miner’s Safety Belts/Safety Vest
EVADE/HelmetCAM

Mobile Equipment Operators
NIOSH Testing
Miners Are Fitted with Helmet-CAM
EVADE
(Enhanced Video Analysis of Dust Exposure)
Blaster

- Stemming
Blaster

- Loading hole with ANFO
Blaster

• Bulk truck driver backing up with window open
Mechanic

- Working at rear of dozer – change oil filter
EVADe software/HelmetCAM Methodology

http://www.cdc.gov/niosh/mining/Works/coversheet1867.html
Summary

• **Wet Drilling**
  – Dust control efficiency 97%
    • Little water required
    • Water separator sub

• **Dry Drilling**
  – Dust control efficiency 99%
    • Properly maintained
    • Operated correctly
      – Minimize leakage
      – 3:1 collector to bailing airflow ratio or greater
      – Horizontal shelf, angle drill shroud, dust collector dump shroud, etc.

• **Operator Cabs**
  – Properly maintained
    • Maintain seals, filters, etc.
    • Ceiling mount HVAC systems
  – Operate correctly
    • Positive pressure
    • Housekeeping
    • Recirculation filter
Summary

• Hauling
  – Proper road construction
  – Water effectively controls road dust
  – Surfactants may be effective
  – Speed control
  – Traffic controls

• Crusher dump point
  – Enclose dump point
  – Use water sprays

• EVADE/HelmetCAM
  – Identify dust sources
  – Target dust control development
Dust Control Handbook for Industrial Minerals Mining and Mineral Processing

http://www.cdc.gov/niosh/mining/works/coversheet1765.html
Questions???

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