Continuous Miner and Roof Bolter Dust Control

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MSHA Valid Inspector Samples
2003 to 2007

- 7.4% CM Operators samples (13,236) exceeded the 2 mg/m$^3$ dust standard
- 19.5% CM Operator samples (4869) exceeded the reduced silica dust standard
- 3.5% Roof Bolter samples (15,796) exceeded the 2 mg/m$^3$ dust standard
- 10% Roof Bolter samples (6,612) exceeded the reduced silica dust standard
Objective

To describe and illustrate proven methods and engineering controls to minimize respirable dust concentrations on continuous mining operations (CM and bolter operators)
Outline

1. Continuous Miner Dust Control
   • Water Sprays
   • Scrubbers
   • Air (Ventilation)
   • Wet Head Cutter

2. Roof Bolter Dust Control
   • Dust Box Maintenance
   • Cleaning
   • Dust Collector Bags
   • Canopy Air Curtain
   • Pre-cleaner Dust/Exhaust Conditioner (Water Box)
Limiting Dust Exposure

- Air
  - Dilutes
  - Transports

- Water
  - Suppresses
  - Redirects
  - Captures
Impact of Water on Dust

- Suppression – prevent generation
- Capture – remove from air (water or mechanical means)
- Redirection – directed away from worker
Water Sprays on Continuous Miners

**Function:**
- Suppress/wet
- Capture
- Redirect

**Application:**
- High flow/low pressure
- Droplet size/velocity
- High pressure/location
Spray Types

- Full Cone
- Flat Spray
- Hollow Cone
- Solid Stream
- Atomizing Spray
Spray Nozzles

Hollow Cone

- Conical shape, outer ring of circular spray
- Most widely used
- Small to medium droplets of water
- Larger orifice/less likely to clog
- Effective for dust mixing (knockdown) and redirecting
- Usually provided from manufacturer
Spray Nozzles
Full Cone

- Conical shape with solid circular pattern
- Medium to large droplets of water
- Provide uniform wetting
- Wide range of pressure and flows
- Effective for scrubber filters and belt transfer points
Spray Nozzles

Flat Fan

- Produce narrow ‘wall’ of spray at various angles
- Wide range of flow and spray angles
- Horizontal, high flow and low pressure as boom sprays suppress dust
- Vertically mounted on either side of miner directed toward face contains dust for scrubber capture
Spray Nozzles
Solid Stream

• Straight solid stream of water at high volume
• To be used close to the source
• Provide uniformity of wetting
• Effective for dust suppression bit cooling
Sprays close to cutting head
Wetting/Suppression

- Flat-fan sprays on top of boom
- Deluge sprays under boom
- Throat sprays
- Surfactants (wetting agents)

- Flow rate most important
Spray Locations

A

Top sprays
flat fan nozzles
turned horizontally

B

Side sprays
flat fan nozzles
turned vertically

1 ft
maximum

C

2.5 ft
Bottom sprays

30°

Bottom sprays
(underside of boom)
Spray Capture Effectiveness on Airborne Dust

- Smaller Droplet Sizes
- High Velocity Droplets
Airborne Dust Capture

![Graph showing dust knockdown (%) vs. water flow (gpm) for different materials: BD3-3, BD8-1, GG-3, GG-3009. The graph illustrates the efficiency of dust capture at various water flow rates.]
Redirecting/Moving Air

• Shovel sprays
• Spray-fan system
  • methane control
  • reduced effectiveness on dust control
• Blocking Sprays
  • Pressure/location important
Air Moving Effectiveness

![Graph showing the effectiveness of different spray types at 75 psi and 150 psi.]
Shovel Sprays
(without scrubber)
Spray Fan System

- Primarily for Methane Control
- Reduced Dust Control Effectiveness
Blocking Sprays

• Primarily used with scrubbers
• Contains dust beneath boom
• Lower dust levels at operator and around machine
Spray Water Filtration

Reduces Plugging
Flooded-bed Scrubbers
Capture and Remove Airborne Dust
Scrubber Filter Study

Filters Tested

- 30-layer
- 20-layer
- 10-layer
- Bottle brush
- 15-layer
- Bondina
10 vs 30 Layer Filters
Respirable Quartz Collection Efficiencies

<table>
<thead>
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<th>Filter type</th>
<th>Collection efficiency (%)</th>
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<td>20-L</td>
<td>80</td>
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<tr>
<td>15-L</td>
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<td>Brush</td>
<td>85</td>
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<td>10-L</td>
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<tr>
<td>Synthetic</td>
<td>95</td>
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<tr>
<td>30-L</td>
<td>90</td>
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The graph shows the collection efficiencies for different filter types.
Air Quantity Measured With Each Filter Panel

<table>
<thead>
<tr>
<th>Filter type</th>
<th>Airflow (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-L</td>
<td>7800</td>
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<tr>
<td>15-L</td>
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<td>Brush</td>
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<tr>
<td>Synthetic</td>
<td>7000</td>
</tr>
<tr>
<td>30-L</td>
<td>7000</td>
</tr>
</tbody>
</table>
Scrubber Efficiency

- Scrubbers can lose 1/3 of airflow after one cut
- Check air velocity with pitot tube
- Most common loss of efficiency due to filter panel clogging.
Clean and Maintain Scrubber Filter and Demister

- Filter spray(s) should completely wet the panel (full cone sprays)
- Clean filter panel and ductwork with water twice each shift
- Replace filter each shift, back flush and allow to dry, then shake out remaining dust
Clean the Demister and Sump Weekly at a Minimum
Air Blowing Ventilation

Correct location

Remote operator (intake)

Intake air

Remote operator (return)

Scrubber exhaust
Blowing Ventilation

**Advantages**
- Greater penetration to face > 800 fpm
- Effectively sweeps dust and methane from the face
- Easier to maintain than exhaust

**Disadvantages**
- Restricts operator movement
- Shuttle car operators must work in return air
- Incorrect air balance may cause recirculation or overpowering
Blowing Ventilation

Recommendations

• Airflow at end of curtain, 1000 cfm > scrubber airflow
• Measure airflow into place with scrubber off
• Shuttle car operator is on curtain side of entry
• Scrubber discharge is on off curtain side
Air
Exhausting Ventilation

Diagram showing two ventilation systems:
- Off-Curtain side miner position
  - Scrubber exhaust
  - Remote operator location
- Curtain side miner position
  - Scrubber exhaust
  - Remote operator location

Intake air

CDC
NIOSH
Exhausting Ventilation

• Advantages
  • Operator has greater range of movement
  • Shuttle car operator remains in fresh air
  • Minimal effects on scrubber inlet efficiency

• Disadvantages
  • Curtain is difficult to maintain
  • Less effective sweep of dust and methane from the face than blowing
Exhausting Ventilation
Recommendations

• Operator/helpers remain on intake side of entry
• Line curtain secured firmly to roof and floor
• Mean entry air velocity – 60 fpm minimum
• Curtain setback beyond scrubber discharge
• Shuttle car operator located on off curtain side of entry
Continuous Miner Dust Control
Wet Head Cutter
Locates water sprays directly behind cutting bits on the cutter head at point of attack
Potential Wethead Benefits

- Reduce frictional ignitions – bit cooling
- Increase bit life
- Reduce respirable dust – increased wetting
- Less water consumption
West Virginia Operation

- 1 machine (wethead vs regular)
- 73 small orifice solid stream sprays at 95 psi
- 27 external sprays at 150-185 psi
- 48-52 gpm
Boom Sprays Plugged for Wethead Machine
Wet Head vs Standard Sprays

Five shift average dust concentration

Dust levels, mg/m³

Operator
Return

WH
Stnd
Illinois Operation

- 2 machines (wethead & regular)
- 63 small orifice solid stream sprays at 90 psi
- 26 external sprays at 150 psi
- 38-42 gpm
Wet Head vs Standard Sprays

Four shift average dust concentration

Dust levels, mg/m3

Operator

Return

WH
Stnd

Dust levels, mg/m3

0.0
1.0
2.0
3.0
4.0
5.0
6.0
Other Considerations

- Bit Design
- Cutting Roof Rock
Bit Designs

- Slender profile
- Small carbide
- High wear rate, resulting in high dust levels

- Intermediate profile
- Large carbide
- Low wear rate
- Low dust levels

- Fat profile
- Irregular transition
- Shank rubs, resulting in high dust levels
Improved Cutting Methods
Roof Bolter Dust Control
Operator Over Exposures

- Poor maintenance of vacuum dust collector
- Improper cleaning of collector compartment
- Removing and replacing canister filter
- Contamination of the downstream collector components
Dust Collector Components

- Drill Bit
- Drill Steel
- Drill Base
- Collector Hose
- Pre-Cleaner
- Vacuum Pump
- Muffler
- Cyclone
- Main Chamber
- Dust Collector Box
- Canister Filter
Maintenance

- Eliminate leaks in vacuum system
- Check door gasket integrity
- Hoses and clamps
- Door latches intact
- Door not bent, seating tight
Improper Cleaning of Dust Box

- Insufficient air
- Downwind of ventilation
- Too close to source
- Clothes contamination
Filter Removal and Replacement

Cleaning the Filter?
Discharge Contamination
Dust Collector Components

COLLECTION SIDE
- Drill Bit
- Drill Steel
- Drill Base
- Collector Hose
- Pre-Cleaner
- Canister Filter

DISCHARGE SIDE
- Vacuum Pump
- Muffler

Cyclone
- Main Chamber
- Dust Collector Box
Reusable Brattice Bag Controls Dust During Box Cleaning

- Bag fills with dust during bolting
- Dump bag against rib
- Controls silica exposure
Silica Dust Levels When Cleaning Dust Box

Ave. Tray = 712 ug/m$^3$

Ave. Bag = 302 ug/m$^3$
Disposable Collector Bag

• Manufactured by Wildwood Industries
• Distributed by JH Fletcher for bolters
• Can be retrofitted to most Fletcher dust collectors
• Recommended to be used with pre-cleaner
Bolter Bag Lab Study

- Simulated roof bolter drilling dust collector
- 60 tests (30 with bag installed and 30 without bag)
- 50 lbs of ground limestone per minute for each test
- Sampling: RAM1, APS, Canister filter loading, Pressure drop across filter
Collector Box Tests

Before

After
Collector Box Tests With Bag

Before

After
Filter Weight Gain per Test

Filter Weight Gain, Bag vs. Bagless

Test number

Weight, g

Bag

Bagless

CDC

NIOSH
Total Filter Loading

![Graph showing weight on filter, Bag vs Bagless](image)
Pressure Drop Across Filter

![Graph showing pressure drop across filter for Bag and Bagless configurations over test number]
Lab Results Summary

• Avg of 99.6% of feed dust contained in collector bag
• Dust concentration: 2 times higher when bag not installed
• Total dust particle count of fine dust (< 2 microns) 3 times greater without bag in place
• Canister filter loading greatly reduced with bag in place
• Pressure drop across filter: 3.0 to 3.3 with bag in place, 4.0 to 8.4 without bag
Bolter Bag Field Study

- Dual boom Fletcher bolter
- Upwind of miner
- Exhausting ventilation
- Bag vs bagless
- Area samplers – gravimetric and pDR’s
- Personal samplers - PDM
Instrument Locations

Bolter

Line brattice

NIOSH personnel wearing PDM’s

Instrument locations

Return

Intake

Check curtain
Gravimetric Sample Results
Collector Emissions

Dust Concentration, mg/m³

Bag     0.20
Bagless 1.00

Bag
Bagless
Field Results

- Gravimetric samplers: respirable dust improved from 0.96 mg/m\(^3\) to 0.14 mg/m\(^3\) when the bag is in use.
- Personal samples from the PDMs: left side (exhaust side) of the bolter experienced over 2 times the amount of respirable dust than the right side.
- Collector box cleaning time reduced from 4 minutes to 30 seconds.
Overall Benefits of Collector Bags

- Keeps dust contained during removal from box
- Keeps dust out of entry traffic preventing further entrainment
- Prolongs filter usage – reduces R/R frequency
- Reduces dust on outby collector components
- Reduces dust emissions from collector exhaust
Canopy Air Curtain

Limits exposures downwind of continuous miner
Tubing to air curtain

Tubing to filter
Nylon tie-downs

Tubing from fan
Operator Under Air Curtain
Findings From Field Evaluation

- Reduced dust under air curtain
- Must keep operator under air curtain
- Must increase air curtain size (improves protection)
Air Curtain Development

Original prototype

Current design
Mist Drilling

- Transmits a combination of water and compressed air through the drill steel
- Drill bit injects water/air mixture directly on cutting surface
- Utilizes an on-board air compressor and on-board water reservoir or supply hose
Mist Drilling

Onboard water tanks holds 110 gallons

Onboard air compressor supplies 20 cfm
Mist Drilling Mine Study

- Two roof bolting machines: one with conventional vacuum system and one with mist system
- Machines did not operate simultaneously
- Mist bolting machine worked downwind of the continuous miner
- Sampled three shifts of operation
Mist Drilling Mine Study

• Dust levels were elevated around mist drilling machine (even after accounting for increased intake dust levels)

• Mist system relies on proper balancing of air/water mixture
Mist Drilling Laboratory Testing
Laboratory Mist Drilling Results

Dust concentration, mg/m³

Test Hole Number

Vacuum Drilling
Mist Drilling
Ongoing Roof Bolter Studies

Exhaust conditioner (water box)

Pre-cleaner dust
Controlling Worker Exposure

• Minimize Quantity of Dust Generated
• Apply Controls Close to Source
• Utilize a Multitude of Controls
• Worker Involvement
• Maintenance is Critical
Questions?

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