Controlling Respirable Dust on Longwall Mining Operations

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Sound Practices to Control Respirable Dust on Longwall Mining Operations

- Statistics and Quantifying Dust Levels
- Dust Control Philosophy
- Dust Control Principles
- Controlling Shearer Dust
- Controlling Shield Dust
- Stageloader/Crusher Dust Control
- Dust Control in the Headgate Entry
- Controlling Dust On Intake Roadways
- Controlling Dust from the Belt Entry
- Laboratory Assessment – Tailgate Manifold
- On Going Research – Water Curtain / Shield Sprays
- Summary - Guidelines
Longwall Statistics

- 2008 – 179.2 million tons
- 2013 – 185.0 million tons
- 53 % of underground production

- Working Faces
  - 1994 – 80
  - 2008 – 46
  - 2013 – 48

- Average Shift Production
  - 1994 – 3,600 tons per shift
  - 2008 – 5,500 tons per shift
  - 2012 – 6,000 tons per shift

- Panel Widths
  - 2002 - 940 ft.
  - 2007 - 967 ft.
  - 2013 - 1,188 ft.

- Panel Lengths
  - 2002 - 10,000 ft.
  - 2007 - 10,132 ft.
  - 2013 - 11,307 ft.

- Average Cutting Height
  - 2013 - 91 inches
MSHA Inspector Samples Exceeding Reduced 1.5 mg/m³ PEL, 2000 – 2012

- 040 Headgate Operator
- 041 Jack Setter (Longwall)
- 044 Longwall Operator (Tailgate Side)
Quantifying Longwall Dust Levels

Benchmarking Surveys

- Quantifying major dust sources
- Identify controls and provide suggestions for improved dust control
Sampling to Isolate a Fixed Dust Source

Stationary Sampling Locations

- Belt Entry
- Intake
- Shield 10
- 10 Shields from Tailgate
Sampling to Isolate a Mobile Dust Source

- Outby Shield Movement (H to T)
- Upwind – 3-5 shields upwind of headgate drum
- Shearer – Between mid-shearer and tailgate drum
- Downwind - 3-5 shields downwind of tailgate drum
Quantifying Longwall Dust Levels

Notable Observations From Most Recent Benchmarking Surveys
(concentrations based on 2.0 mg/m$^3$ standard)

- **Shield 10 Dust Levels** - 0.70 mg/m$^3$
  Good indication of dust entering face from outby sources

- **Average Dust Levels (mg/m$^3$)**
  
<table>
<thead>
<tr>
<th></th>
<th>Upwind</th>
<th>Shearer</th>
<th>Downwind</th>
</tr>
</thead>
<tbody>
<tr>
<td>H→T</td>
<td>1.91</td>
<td>2.23</td>
<td>3.71</td>
</tr>
<tr>
<td>T→H</td>
<td>1.13</td>
<td>1.64</td>
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- **H→T Shield Advances**
  
  H→T Upwind dust levels increased 1.05 mg/m$^3$
  when compared to T→H Upwind dust levels
Dust Control Philosophy

- Minimize the quantity of respirable dust generated
  - efficient cutting

- Prevent the respirable dust from getting airborne
  - wet dust at generation point
  - enclose dust source

- Remove respirable dust from ventilating air
  - flooded-bed scrubbers and dry dust collectors
  - water sprays

- Dilute remaining airborne dust
  - ventilation quantity

- Prevent respirable dust from reaching workers’ breathing zone
  - ventilation velocity
  - water sprays to move air
  - physical barriers
Dust Control Principles

Ventilation Air
- Dilution (quantity)
- Transport or Move (velocity)

Impact of Water on Dust
- Suppression – prevent generation
- Capture – remove from air (water or mechanical means)
- Redirection – directed away from worker

Water Sprays
- Suppress (high flow; low pressure)
- Capture (type of spray; velocity)
- Redirect (high pressure; spray location)
Controlling Shearer Dust

Face Ventilation – *Principal method* of controlling respirable dust on longwall faces

Recent Surveys:

- 80% > 600 ft/min
- 30% > 800 ft/min, as high as 1300 ft/min

Previous studies:

- 700 – 900 ft/min velocity shown to be effective when moisture content of dust is 5 to 8%
Controlling Shearer Dust

Drum Mounted Water Sprays

- Dust suppression directly at the point of coal fracture
- Adds moisture to minimize dust liberation
- Full cone or solid stream spray pattern
- Larger orifices increase water quantity while decreasing pressure
- Observed spray pressure ranged between 100 – 160 psi
- Number of sprays per drum ranged between 35 - 62
Controlling Shearer Dust

Minimize Dust Generation

- Replacing damaged, worn or missing bits can not be over emphasized
- Dull bits result in shallow cutting and greatly increases dust generation

Maintenance is Critical
Controlling Shearer Dust

Crescent Sprays

- Located on the top and end of ranging arms
- Sprays oriented toward face
- Observed on 50% of recently survey longwalls
- Flat fan sprays
Controlling Shearer Dust

Crescent Sprays

- Use caution if sprays are utilized on the headgate ranging arm
- Sprays on the end of ranging arm are oriented into the face airflow
- Can create turbulence that force dust toward the walkway
Controlling Shearer Dust

*Directional spray system (shearer clearer spray system)*

- **Headgate Splitter Arm**
  - Headgate arm designed to split the face airflow at the shearer
  - Splitter arm sprays induce airflow movement toward face
  - Belting on splitter arm provides physical barrier to confine dust

- Shearer mounted sprays oriented downwind

- Tailgate splitter arm or spray manifold
Controlling Shearer Dust

- Splitter arm with venturi sprays
- Directional spray manifolds
- Conveyor belting
Controlling Shearer Dust

*Headgate Splitter Arm*

- Extend as far beyond the headgate drum as possible
- Sufficient number of sprays to prevent dust from migrating into walkway
- Hollow cone or venturi sprays
- Water pressure of at least 150 psi
- Maintain proper arm position
Controlling Shearer Dust

Splitter Arms

- Unique to each mine operation
- Length – 5 to 14 ft.
- 3 – 20 sprays
- 2 splitter arms utilized venturi sprays

Spray orientation
- Perpendicular
- 30 - 45 degrees toward panline
- 30 – 45 degrees up
Controlling Shearer Dust

Splitter Arms

- Built to withstand coal and rock impact from face spalls
- Splitter arm extensions oriented at a 30 - 45 degrees toward face
  - Length – 2 to 4 ft.
  - 3 – 5 sprays

Splitter Arm Belting

- Belting should be suspended the length of the splitter arm
- Provides a physical barrier
Controlling Shearer Dust

Splitter Arm Belting

- Tears and gaps in the conveyor belting greatly compromise the effectiveness of the splitter arm
Controlling Shearer Dust

Splitter Arm Gob-Side Spray Bar

- Locate sprays on the walkway side of splitter arm
- Direct sprays down the side of the belt
- High capacity low pressure flat-fan sprays evenly spaced the length of the splitter arm
Controlling Shearer Dust

Splitter Arm Underside Sprays

- Locate sprays on underside of the splitter arm
- Direct sprays down the face side of the belt
- Reduce dust rolling under or through the splitter arm
- Adds more water to the coal to reduce conveyor dust
- Because of turbulence in the area spray pressure is critical
Controlling Shearer Dust

Positioning of the Splitter Arm

- Position of the splitter arm may allow dust to migrate into the walkway
- Maintaining the splitter arm near parallel is critical to keep dust from boiling into the walkway
Controlling Shearer Dust

Shearer-body Sprays

- Sprays confine dust near face and assist in moving along shearer body
- 3 or 4 manifolds evenly spaced
- along the length of the shearer
- 3 to 5 sprays per manifold
- Manifolds located on top deck of shearer or on face side of shearer body
Controlling Shearer Dust

Deflector Plates

- Observed at western mines
- Primary function is to protect operators from flying debris
- Provide a physical barrier that can enhance the effectiveness of the directional spray system
- Equipped with water sprays
  - Evenly spaced the length of the deflector plate
Controlling Shearer Dust

Deflector Plates

- If sprays operational, spray plume is directed upward, strikes the underside of the shields creating turbulence
- Potentially allowing dust to migrate into the walkway
- Operators have to be diligent in turning off the sprays when in the down position
Controlling Shearer Dust

Tailgate Side Sprays

- Spray manifold mounted on tailgate end of shearer
- Oriented parallel to ranging arm and angled slightly toward drum
- Confines dust-laden air to face and carries it beyond the tailgate drum
Controlling Shield Dust

- Automated and usually are initiated within 3-5 shields of trailing drum
- Can be a significant source of dust exposure when shields are advanced upwind of shearer
- Concerted effort to rotate jacksetter operators outby

![Graph showing dust concentration over time](image-url)
Controlling Shield Dust

- Traditional canopy-mounted sprays
  - Discharge water on top of shields
  - Hard to maintain sprays
  - Effectiveness not quantified

- Dilution
  - Higher face air quantities can increase dilution of shield dust
  - Higher velocities have the potential to entrain more shield dust because the dust is typically dry
  - Advance shields as far upwind as possible on head-to-tail passes to allow dilution

- Depending on roof conditions consider using uni-directional cutting sequence
Controlling Shield Dust

Shield Sprays on the Underside of the Canopy

- Automatically activated by shearer to create a moving water curtain
- 1 or 2 rows of sprays per shield
- Located between the tip of the shield to an area above the spill plate
- Spray activation and de-activation sequencing was mine specific
- Proper sequencing is critical
- Observed shield sprays interacting with splitter arm sprays creating turbulence
- Dust and mist cloud rolled into walkway
Stageloader/Crusher Dust Control

- Stageloader/crusher are fully enclosed
- No universally applied technique
- Combination of steel plates
- Conveyor belting at entrance and discharge area
- Imperative that seals and skirts be maintained
- Scrubbers
Stageloader/Crusher Dust Control

Crusher and Belt Transfer Sprays

- Typical spray locations
  - Entrance
  - Above crusher hammer
  - Discharge area
  - Belt transfer area
- Spray bar spans the width
- 3-4 full cone sprays
- Water quantity over pressure
- Water pressure $\leq 60$ psi
Stageloader/Crusher Dust Control

Scrubbers

- Crusher discharge
- Belt transfer area
- Capacity – 6500 – 8500 ft³/min
- Potential to create negative pressure in the stageloader/crusher to minimize dust from leaking out
Dust Control in the Headgate Entry

- Installation and **maintenance** of a gob curtain
Dust Control in the Headgate Entry

- Installation of a wing or cut-out curtain between and panel-side rib and the stageloader
Dust Control in the Headgate Entry

- Position face personnel outby as headgate drum cuts out into headgate entry
  - Drum is exposed to the primary airstream
  - Dust levels as high as 20.0 – 30.0 mg/m³ for a short duration
  - Position face personnel near shields 1 and 2 and further outby
  - Concerted effort to move outby cutout area
Dust Control in the Headgate Entry

- Deflection barriers in headgate area
  - Belting attached to underside of shields 1-4
  - Belting attached to top of conveyor drive
  - Aids in turning air down the face
  - Protects face personnel from flying rock

Location of deflection barriers
Controlling Dust on Intake Roadways

- Limit support activities during production shifts
  - Vehicle movement
  - Removal of stoppings
  - Delivering / unloading of supplies
Controlling Dust on Intake Roadways

- **Water Application**
  - Maintain moisture content at approximately 10%
  - Operators must diligent in monitoring moisture content

- **Salts**
  - Apply calcium and magnesium chloride to increase surface moisture

- **Utilize Surfactants**
  - Beneficial in maintaining proper moisture content
  - Decrease surface tension
  - More uniform wetting of the dust particles
Controlling Dust from the Belt Entry

➢ Wetting of the Coal Product - With the substantial increase in airflow rewetting of the coal may be necessary along the belt

  - Flat or full cone sprays
  - Quantity over Pressure
  - Pressure - 50 - 60 psi
Controlling Dust from the Belt Entry

- **Belt Maintenance** - Missing rollers, belt slippage, and worn belts can cause belt misalignment and create spillage
Controlling Dust from the Belt Entry

➢ Wetting of the Belt
  • Full cone spray on top surface of non-conveying side belt followed by material to wipe belt and remove dust fines

➢ Rotary Brush
  • Clean the conveying side of the belt
Laboratory Assessment
Tailgate-side Shearer Spray Manifold

- Face Velocity - 500, 700, 900 fpm
- Spray Pressure - 100, 150, 200 psi
- Spray Manifold – 4” x 36”
  - SS BD3 Hollow Cone – 7 sprays
  - 42” from TG drum – 25 degree angle toward the face
- Spray Manifold – 4” x 36”
  - SS 40-20 Flat fan Spray – 2 sprays
  - 47” from TG drum – 15 degree angle toward the face
- Spray Manifold - 2 manifolds – 4” x 36”
  - SS 65-15 Flat fan Spray – 2 sprays
  - 32” and 37” from TG drum – parallel to face
Laboratory Assessment
Tailgate-side Shearer Spray Manifold

- All spray nozzles substantially reduced dust under all test conditions.
- Reductions in dust concentrations ranged between 60% and 95%.
- Flat fan sprays compared to the hollow cones sprays were more effective at reducing dust concentrations.
- No apparent relation between air velocity and reduced dust concentration for any of the nozzle types.
Tailgate-side Shearer Spray Manifold
Gravimetric Dust Concentrations
2 Manifolds and 4 SS 65-15 Flat Fan Sprays

- Velocity 500 fpm
- Velocity 900 fpm

Sprays Off (mg/m3) vs Sprays On (mg/m3)

Spray Pressure 100 psi

Spray Pressure 200 psi

OFFICE OF MINE SAFETY AND HEALTH RESEARCH
Tailgate-side Shearer Spray Manifold
Instantaneous (pDR) Dust Concentrations

2 SS 40-20 Flat Fan Sprays

Velocity 500 fpm

Velocity 900 fpm

Spray Pressure 100 psi

Spray Pressure 200 psi
Tailgate-side Shearer Spray Manifold

Underground Evaluation
Face velocity (approximately 1300 fpm) was the dominating dust control factor resulting in very low dust levels at the sampling locations.

Dust levels observed with gravimetric samplers: 0.856 mg/m$^3$ (SHEARER) ; 0.941 mg/m$^3$ (DOWNWIND).

Quantitative dust sampling data showed little differences in dust levels with the manifold on versus manifold off conditions. Lower dust levels were observed with the tailgate spray manifold operational.

- $T \rightarrow H : .067$ mg/m$^3$ OFF vs .059 mg/m$^3$ ON
- $H \rightarrow T : .142$ mg/m$^3$ OFF vs .051 mg/m$^3$ ON

The tailgate spray manifold appeared to have a positive influence on keeping dust the cloud confined close to face levels in the tailgate area.

Both tailgate operators liked the spray manifold and thought it helped keep dust out of the walkway in the tailgate area.

Further underground evaluations are warranted for faces that have air velocities below 1,000 fpm.
On-going Research
Traveling Water Curtain / Shield Sprays

Observed shield sprays interacting with splitter arm sprays creating turbulence

- Dust and mist cloud rolled into walkway
- Spalling upwind of headgate drum and dust rolling around splitter arm
- Seeking partners to conduct underground evaluation of underside shield sprays
  - Proper Sequencing
  - Effectiveness of shield sprays upwind of splitter arm
On-going Research
Laboratory Evaluation – Shield Sprays

- Conducting tests to evaluate dust concentrations in the walkway
  - Dust Only
  - Splitter Arm Sprays Activated
  - Splitter Arm and Shield Sprays Activated
Effective Directional Spray Systems
Summary

Ineffective Directional Spray Systems
Summary

Maximum the Benefits of Available Controls
Control Guidelines - Outby

- Minimize intake/belt dust
- Confine stageloader/crusher dust
- Quantity of water in crusher
- Gob curtain at HG and beyond
- Locate face personnel outby during HG cutout
- Shield advance/cutting sequences to minimize exposures of high risk workers
Control Guidelines - Shearer

- Optimize cutting parameters (bit maintenance)
- Maximize water quantity to drums (larger orifice nozzles)
- External sprays @ 150 psi or higher
- Caution using crescent sprays on HG drum
Control Guidelines - Shearer

- HG splitter arm
  - Extend beyond HG drum as far as possible
  - Align sprays with airflow
  - Maintain belting
  - Splitter arm parallel with HG drum

- Maintain shearer sprays
- Deflector plate as high as possible
- Utilize TG side manifold sprays
Control Guidelines - Shields

- Underside canopy shield sprays
  - Potential to be an effective method at reducing shearer dust
  - Proper sequencing of sprays
  - Proper alignment
  - Spray water pressure and volume

- Advance shields as far away from shearer as possible depending on roof conditions

- Consider uni-directional cutting sequence

- Concerted effort to rotate jacksetter operators outby
Commitment to Dust Controls

- Worker and management involvement
  - Knowledge and attitude
  - Safety => immediate / Health => long term

Maintenance is critical
Questions?

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