

PMRD

Pittsburgh Mining Research Division

Sound Practices to Control Respirable Dust on Longwall Operations and Ongoing Research at NIOSH Pittsburgh

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National Institute for Occupational Safety and Health

*MSHA Coal Mine Respirable Dust Control Summit, National Health & Safety Academy, Beaver, WV
December 6, 2016*

Presentation Outline

- PMRD / DCVTSB - Mission
- Respirable Dust / Silicosis
- Dust Control Methodology
- Longwall Dust Control / Ongoing Research
 - Shearer Dust Control
 - Shield Dust
 - Stageloader Dust Control
 - Outby Sources
 - Traveling Water Curtain (Shield Sprays)
 - Foam for Shield Dust Control
 - University of Kentucky Shearer Scrubber

Dust Control, Ventilation and Toxic Substances Branch

- Mission....eliminate the adverse health effects to mine workers resulting from exposure to dust, diesel emissions and other toxic workplace contaminants.
- 27 employees
- Four main areas of research:
 - dust control technology
 - diesel research
 - ventilation
 - instrumentation development



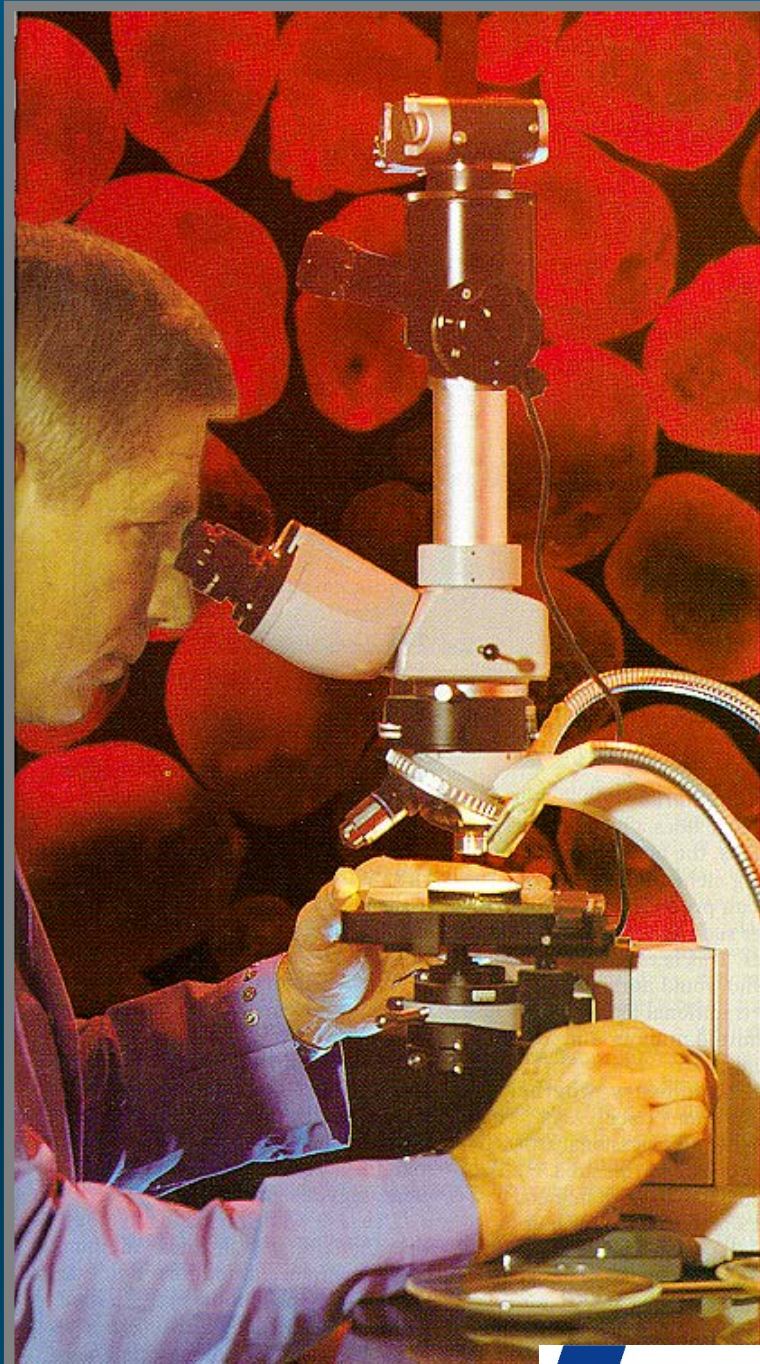
Dust Control Research Program

Work in cooperation with MSHA and industry to:

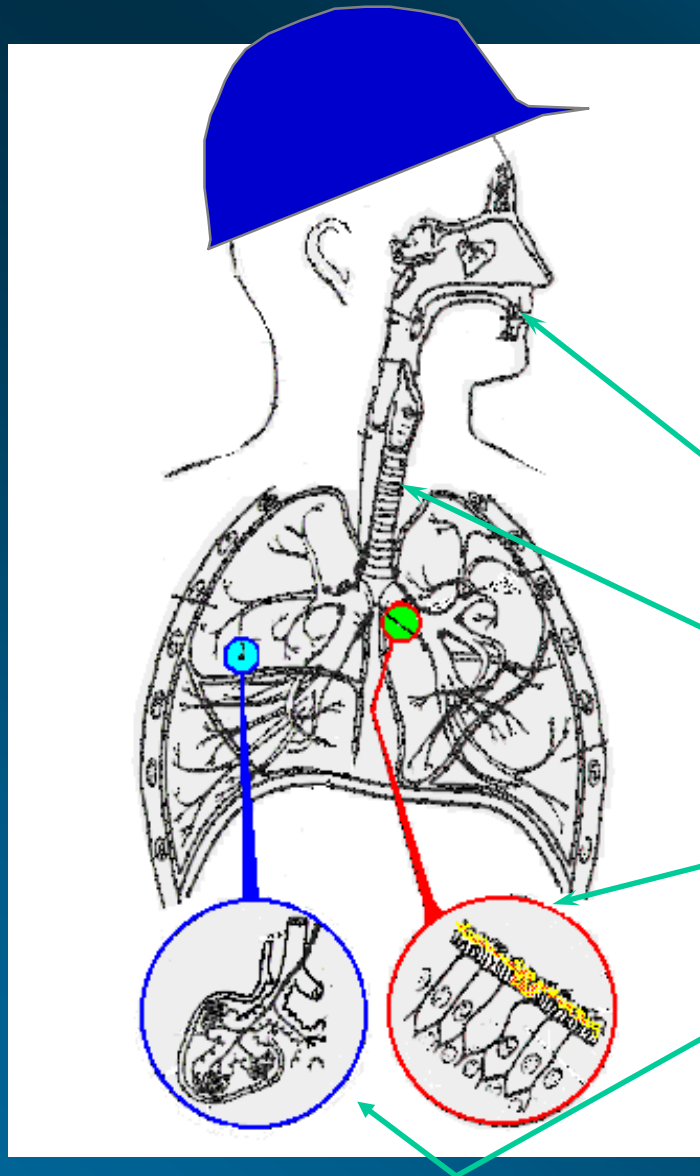
- Investigate dust sources through baseline studies and evaluate control technologies currently in use
- Modify or develop new control technologies that will benefit all stakeholders
- Transfer this technology to industry through seminars, conferences, journals, videos, NIOSH web page

Respirable Dust

- Diameter Less than 10 Micrometers (Micron)
- **What's a Micron?**
 - Pretty Darn Small
 - **1/24,000th of an inch !**
- Human Hair
 - 40-150 microns in diameter
- **The particle size that deposits in lung tissue is not visible to the naked eye.**

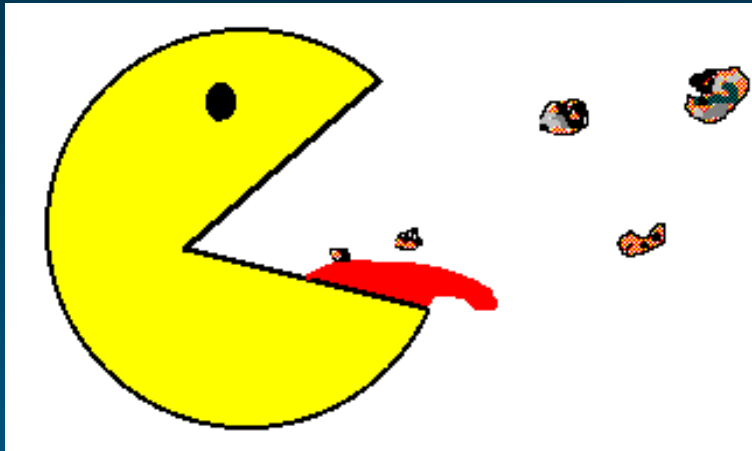


The Human Respiratory System



- **Gas Exchange**
- **Supply Oxygen**
- **Remove Carbon Dioxide**
- **Nose or Mouth**
- **Windpipe**
- **Mucous & Cilia**
- **Alveolar Region**

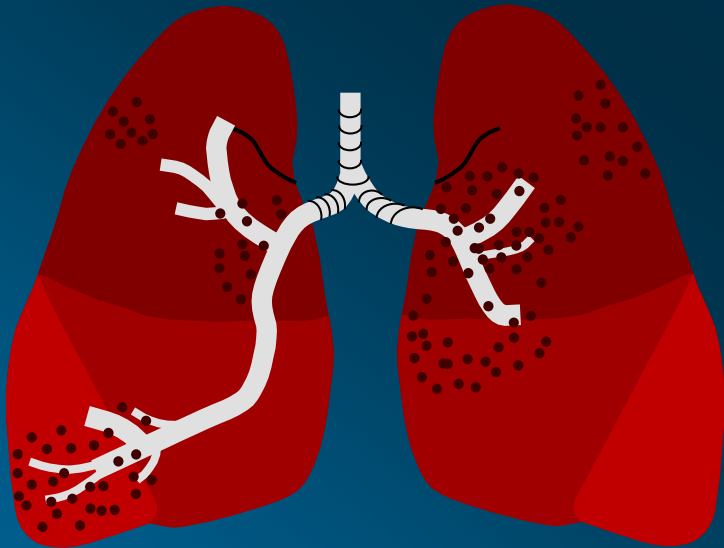
Fate of the Deposited Dust



- **Macrophage Cells**
 - Act like little PACMEN
 - Engulf dust particles
- **Some can Move**
 - Out of the alveoli
 - Into the Lymphatic System
- **Some Don't**

Pneumoconiosis

The accumulation of dust in the lungs and the tissues reactions to its presence.



- Fibrotic diseases – damage/destroy lung tissue
 - coal workers’ pneumoconiosis “CWP”
 - silicosis
- Airflow diseases “COPD” – block movement of air in and out of lungs
 - bronchitis
 - emphysema
 - mineral dust airway disease

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)

	Upwind	Shearer	Downwind
H→T	1.91	2.23	3.71
T→H	1.13	1.64	

- 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

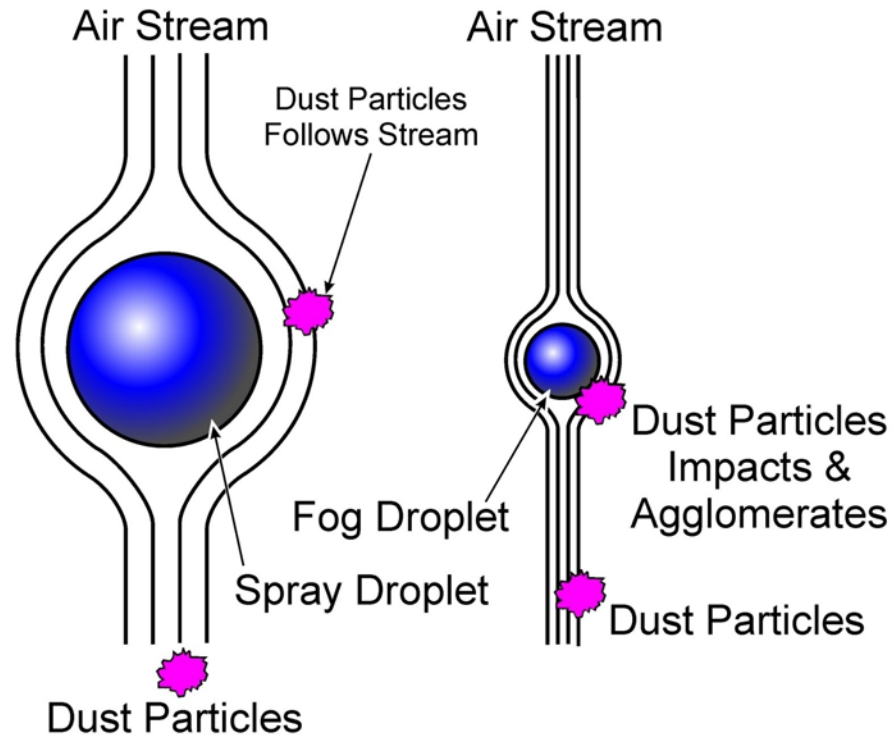
- Minimize the quantity of respirable dust generated
 - *efficient cutting (drum design, bit design, bit sharpness)*
- Prevent the respirable dust from getting airborne
 - *wet dust at generation point (nozzle type, location, operating parameters)*
 - *enclose dust source*
- Remove respirable dust from ventilating air
 - *flooded-bed scrubbers (capacity, inlet location, filters)*
 - *dry dust collectors (collector bags, monitoring)*
 - *water sprays (nozzle type, location, operating parameters)*
- Dilute remaining airborne dust
 - *ventilation quantity*
- Prevent respirable dust from reaching workers' breathing zone
 - *ventilation velocity*
 - *water sprays to move air (blocking sprays, directional sprays)*
 - *physical barriers*

Dust Control Philosophy

Droplet Size:

- **To keep dust from becoming airborne:**
Water droplet sizes above 100 microns should be used.
- **To knock down existing dust in air:**
Water droplets should be in a similar size range to the dust particles.

Water Droplet Size Should Match the Size of the Dust Particle



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 :

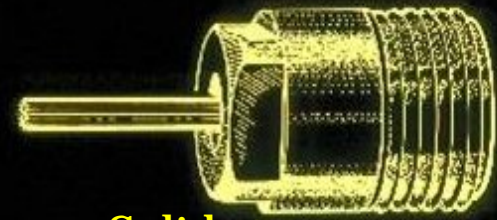
- 700 – 900 ft/min velocity shown to be effective when moisture content of dust is 5 to 8 %



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



Solid stream



Full cone

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



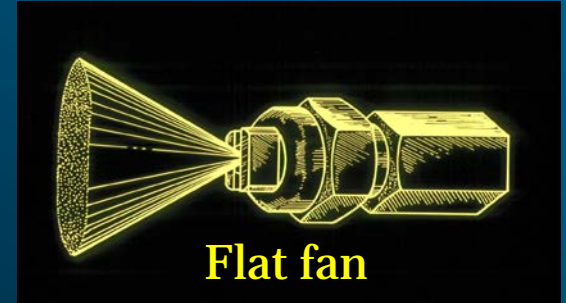
Maintenance is Critical



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

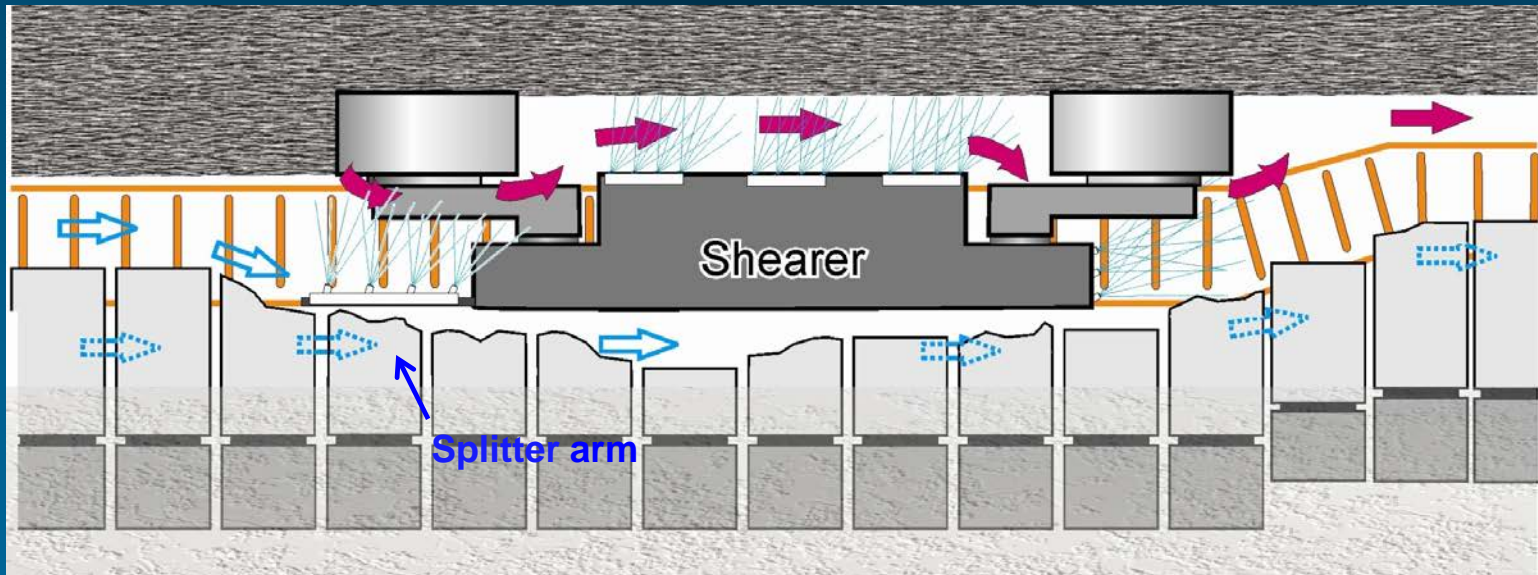
- Use caution if sprays are utilized on the headgate ranging arm
- Sprays on the end of ranging arm are oriented into the face airflow
- Can create turbulence that force dust toward the walkway



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

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

- 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

Shearer-body Sprays

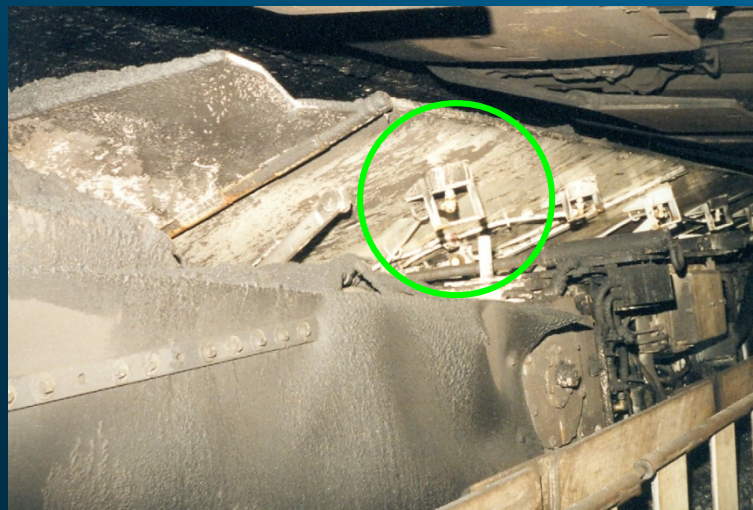
- Sprays confine dust near face and assist in moving along shearer body
- 3 or 4 manifolds evenly spaced
- along the length of the shearer
- 3 to 5 sprays per manifold
- Manifolds located on top deck of shearer or on face side of shearer body



Controlling Shearer Dust

Deflector Plates

- Observed at western mines
- Primary function is to protect operators from flying debris
- Provides 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

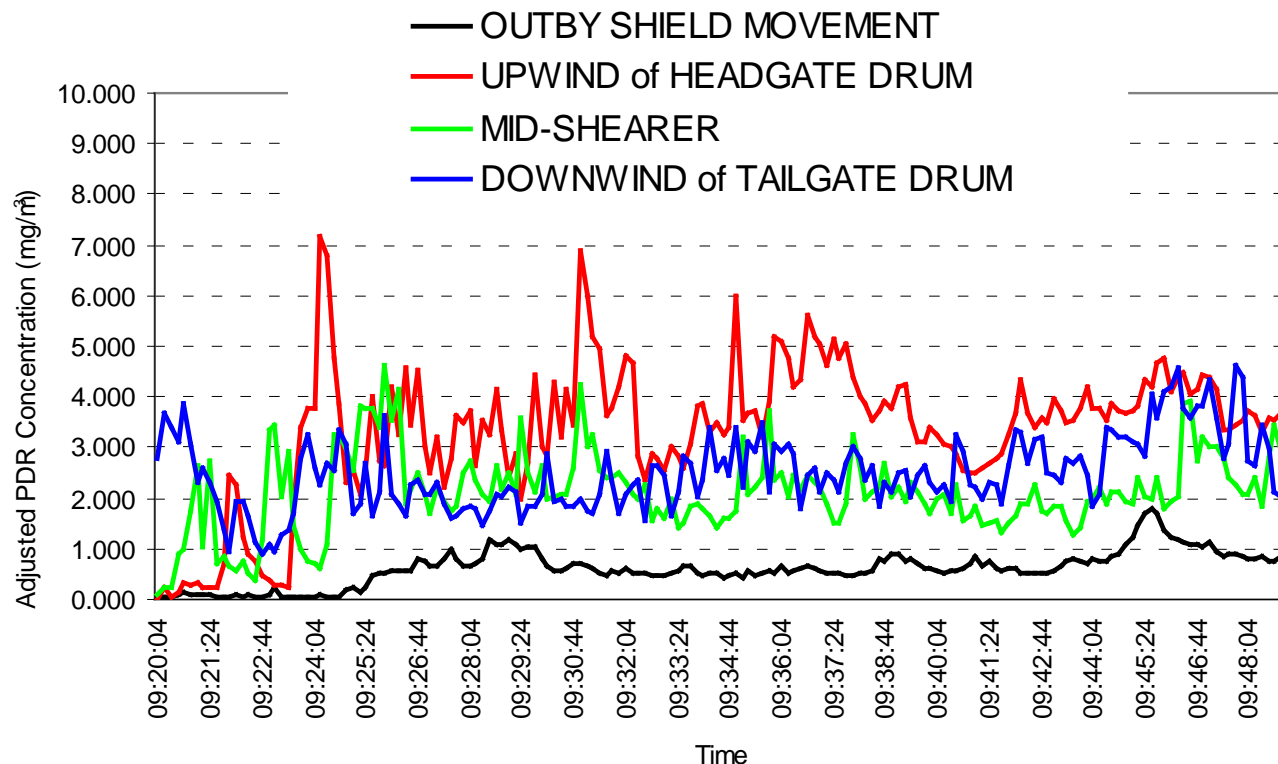
Tailgate Side Sprays

- 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



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
 - 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



Underside Canopy Sprays

- 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

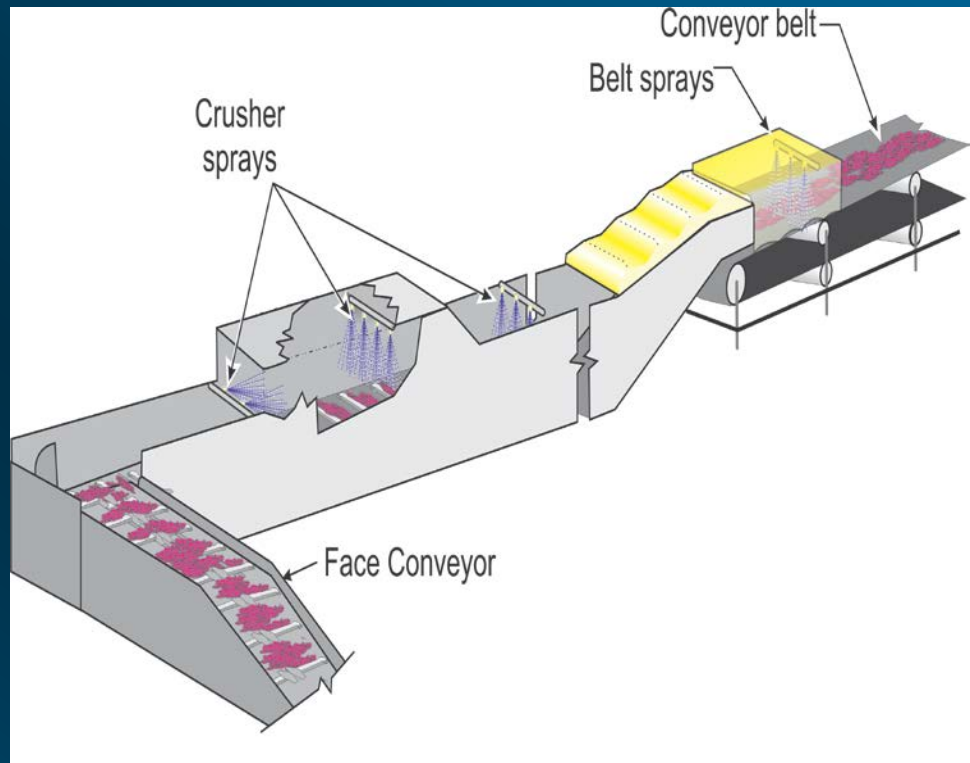
- Stageloader/crusher are fully enclosed
- No universally applied technique
- Combination of steel plates
- Conveyor belting at entrance and discharge area
- Imperative that seals and skirts be maintained
- Scrubbers



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 ≤ 60 psi
- Foam ?



Stageloader/Crusher Dust Control

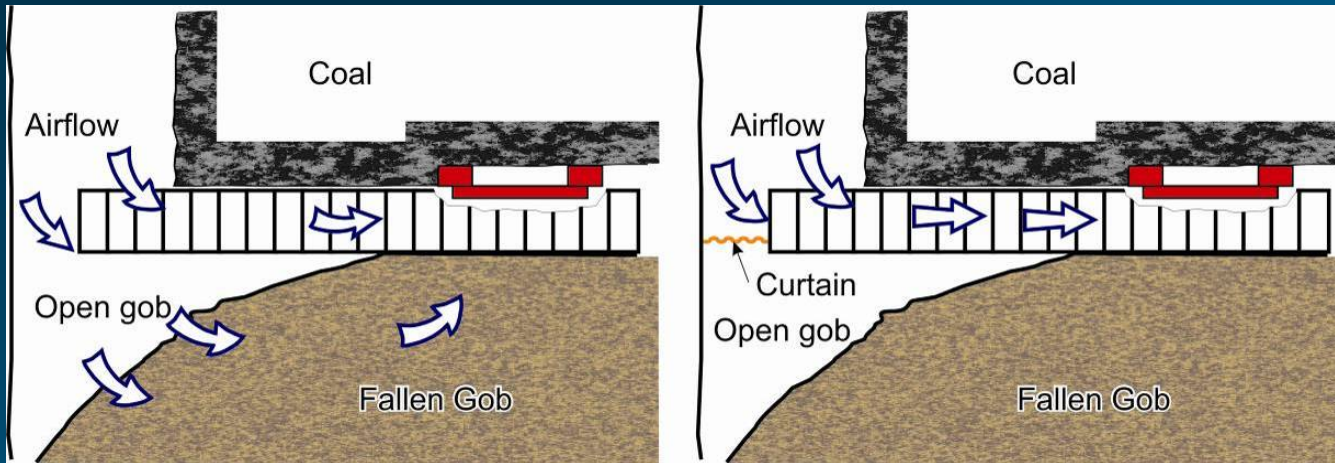
Scrubbers

- 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

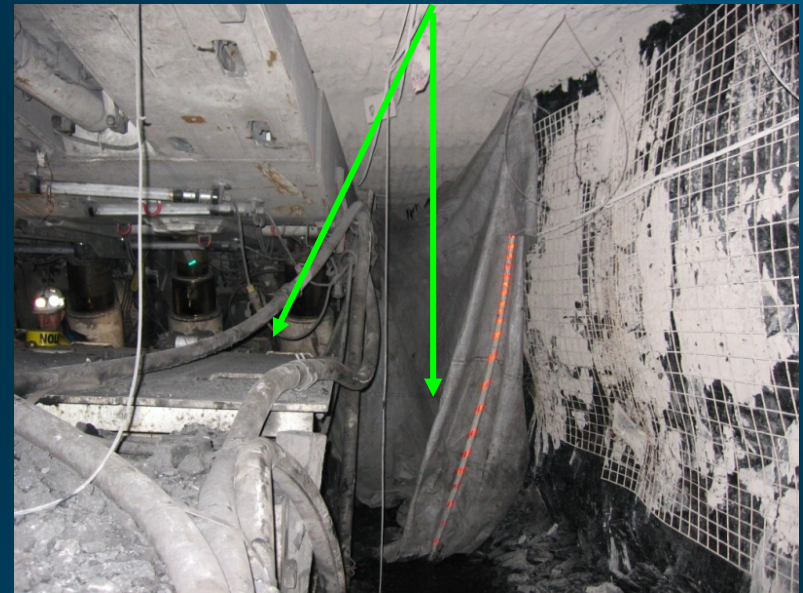


Dust Control in the Headgate Entry

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

Location of face workers



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

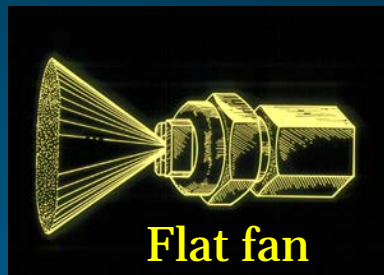
- Beneficial in maintaining proper moisture content
- Decrease surface tension
- More uniform wetting of the dust particles



Controlling Dust from the Belt Entry

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



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

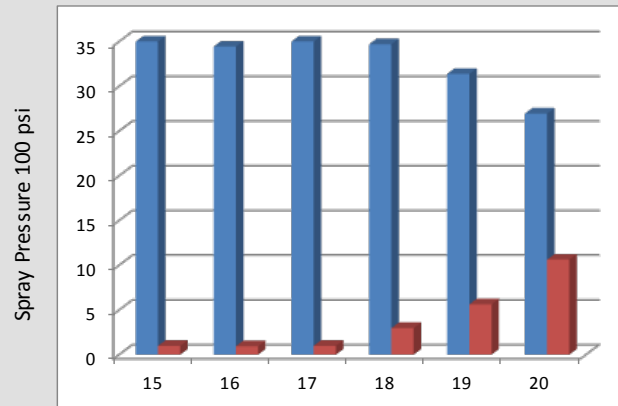
Gravimetric Dust Concentrations

2 Manifolds and 4 SS 65-15 Flat Fan Sprays

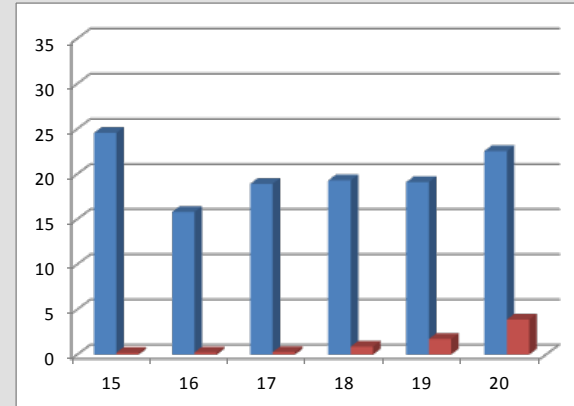
■ Sprays Off (mg/m³)

■ Sprays On (mg/m³)

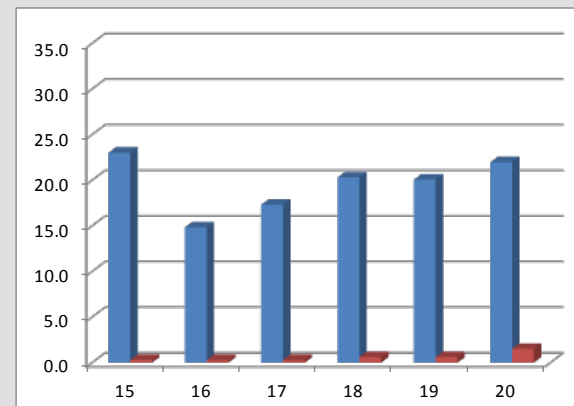
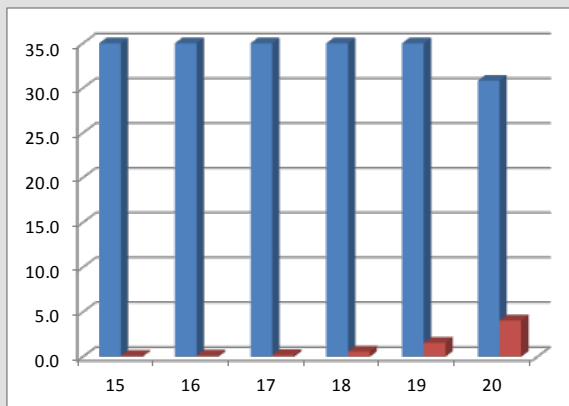
Velocity 500 fpm



Velocity 900 fpm



Spray Pressure 200 psi



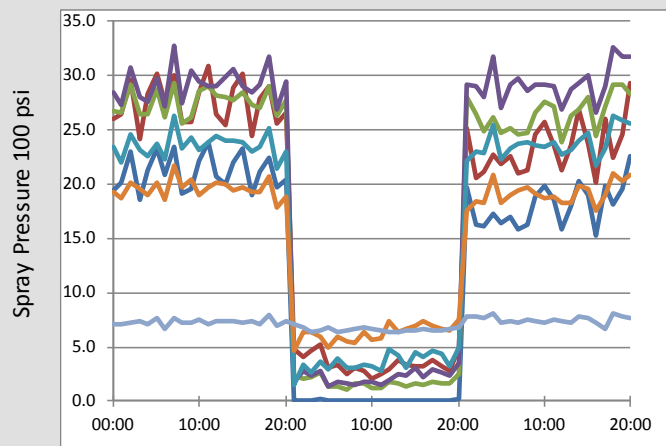
Tailgate-side Shearer Spray Manifold

Instantaneous (pDR) Dust Concentrations

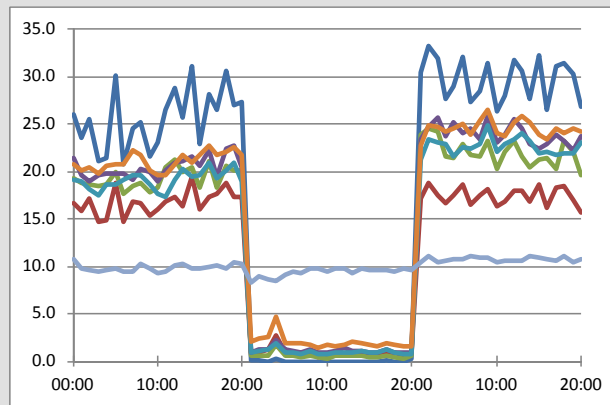
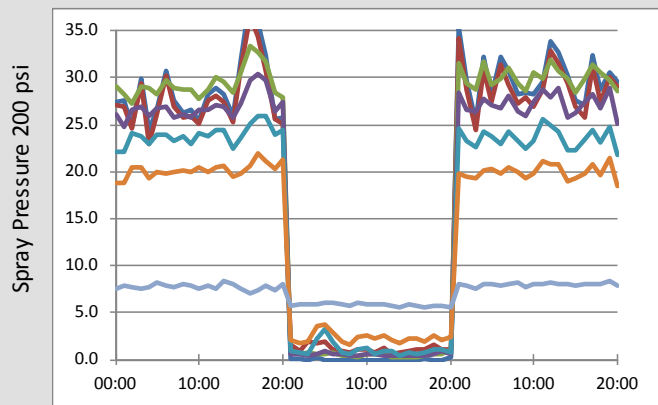
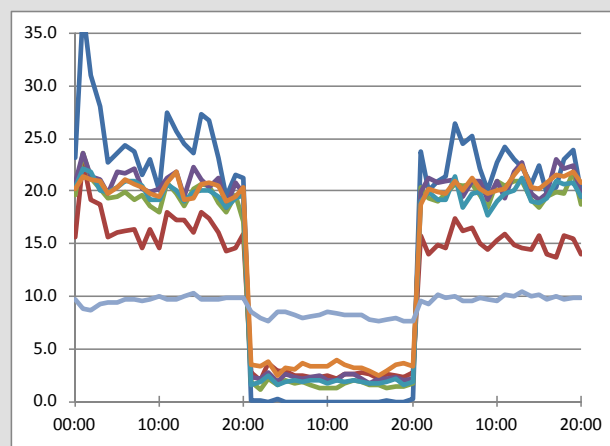
2 SS 40-20 Flat Fan Sprays

— SHIELD 15 — SHIELD 16 — SHIELD 17 — SHIELD 18 — SHIELD 19 — SHIELD 20 — RETURN

Velocity 500 fpm

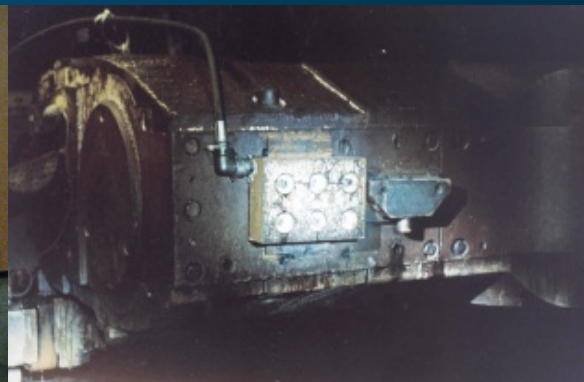
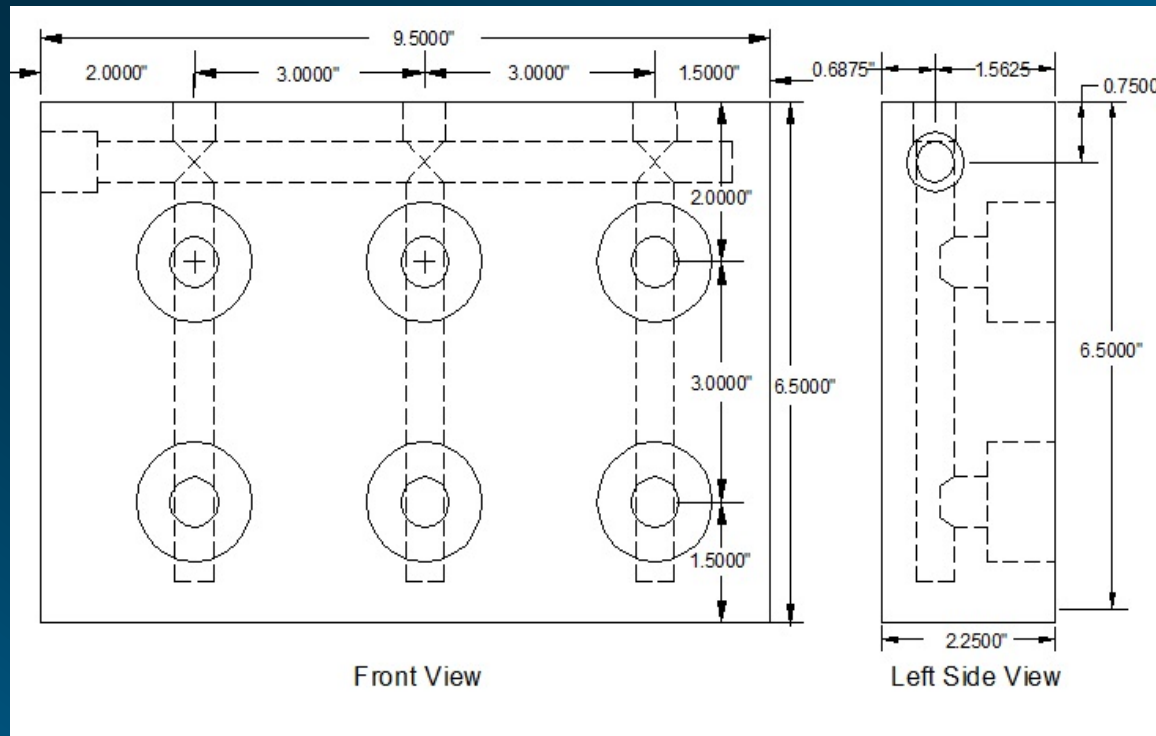


Velocity 900 fpm



Tailgate-side Shearer Spray Manifold

Underground Evaluation



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/m³ (SHEARER) ; 0.941 mg/m³ (DOWNWIND).
- Lower dust levels were observed with the tailgate spray manifold operational.
 - T->H : .067 mg/m³ OFF vs .059 mg/m³ ON
 - H->T : .142 mg/m³ OFF vs .051 mg/m³ 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.



Traveling Water Curtain / Shield Sprays (Outby Spalling)

On-going Research

- 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
 - Proper Sequencing



Traveling Water Curtain/Shield Sprays - (Outby Spalling)

Testing

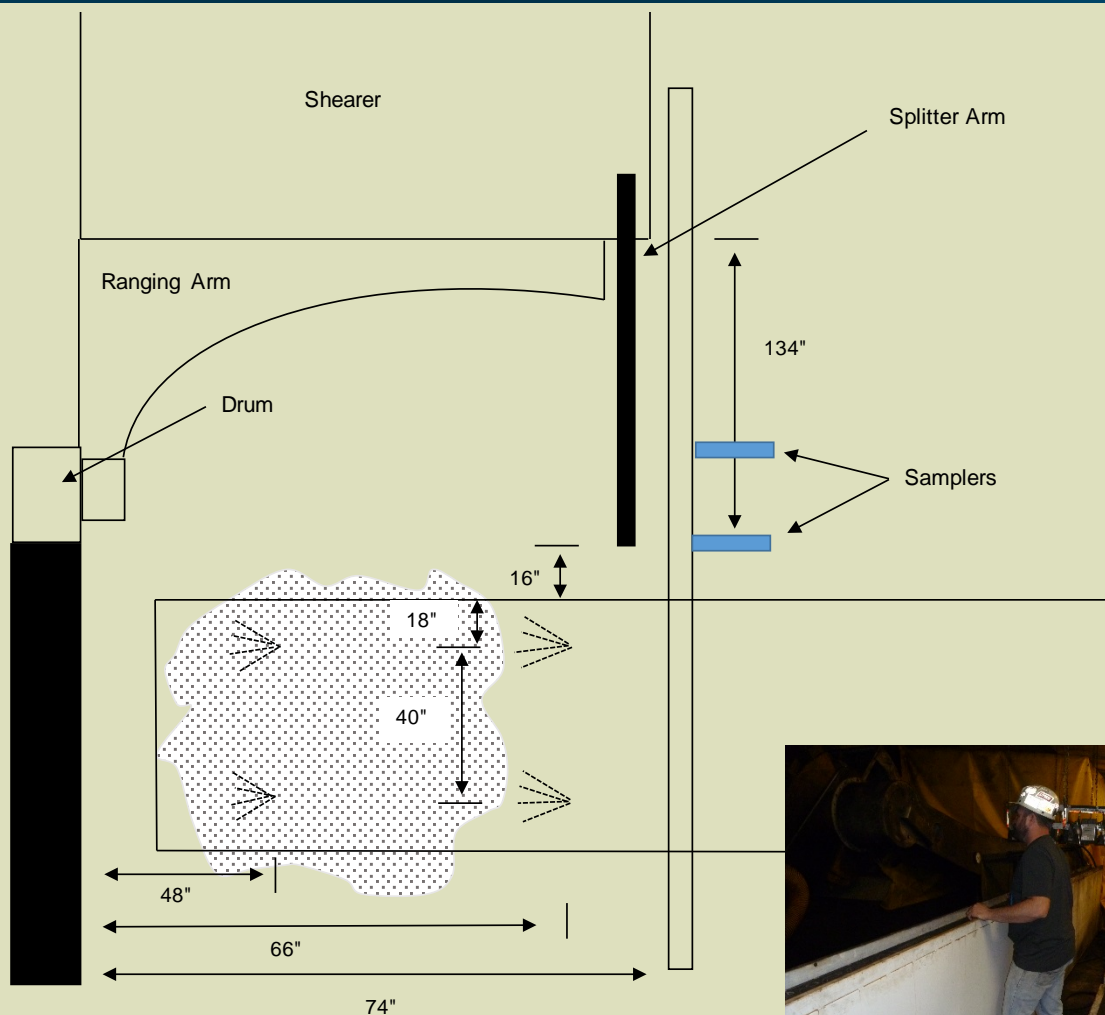


Experimental Parameters

- Face velocity – 700 fpm
- Spray types – Hollow Cone, Flat Fan (SS65-15)
- Splitter arm spray pressure – 150 psi
- Activated shield sprays – 2
- Spray angles – 60 degrees
- Underside spray pressure – 100, 150, and 200 psi
- Distance from face – 4', 4.5', 5', and 5.5'
- Distance from floor to shields – 112" and 90"

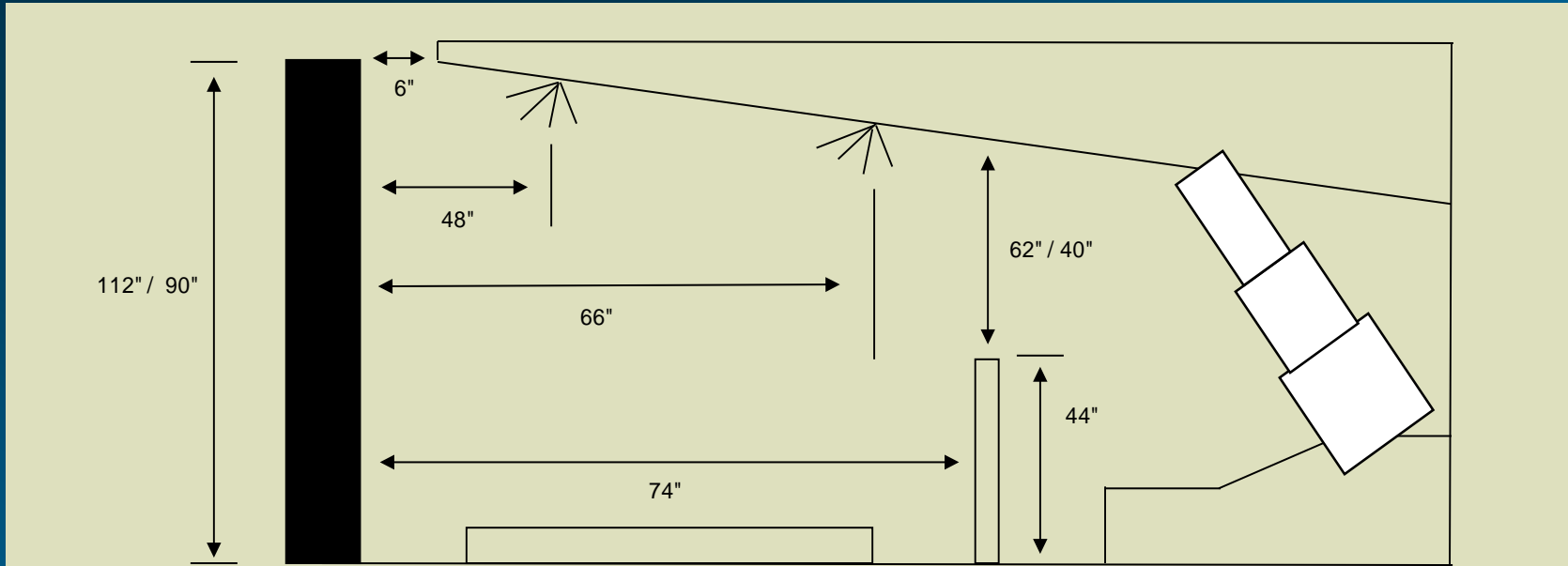
Traveling Water Curtain/Shield Sprays - (Outby Spalling)

Laboratory testing



Traveling Water Curtain/Shield Sprays - (Outby Spalling)

Laboratory testing



	PMRD	Bailey
Face to Spill Plate	74"	72.5 "
Floor to Underside of Shield Bottom	112" / 90"	77"
Spill Plate Height	44"	42"
Spill Plate to Underside of Shield Bottom	60" / 38"	27"



Traveling Water Curtain/Shield Sprays - (Outby Spalling)

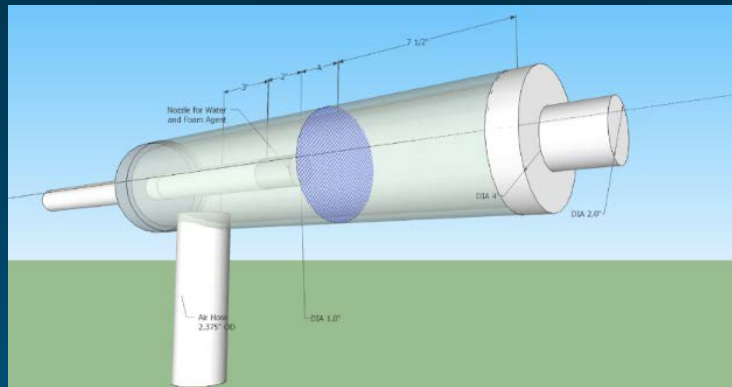
Laboratory testing



Foam for Longwall Shield Dust Control

Laboratory Testing

- Compressed air generated
 - Uses Lafferty foam generator
 - Foam expansion ratios 3 to 19
 - Drainage (44-478 ml)
- Blower air generated
 - Uses NIOSH designed foam generator
 - Foam expansion ratios 19 to 65
 - Drainage (0-15 ml)



Foam for Longwall Shield Dust Control

Video of blower generated foam roof application test

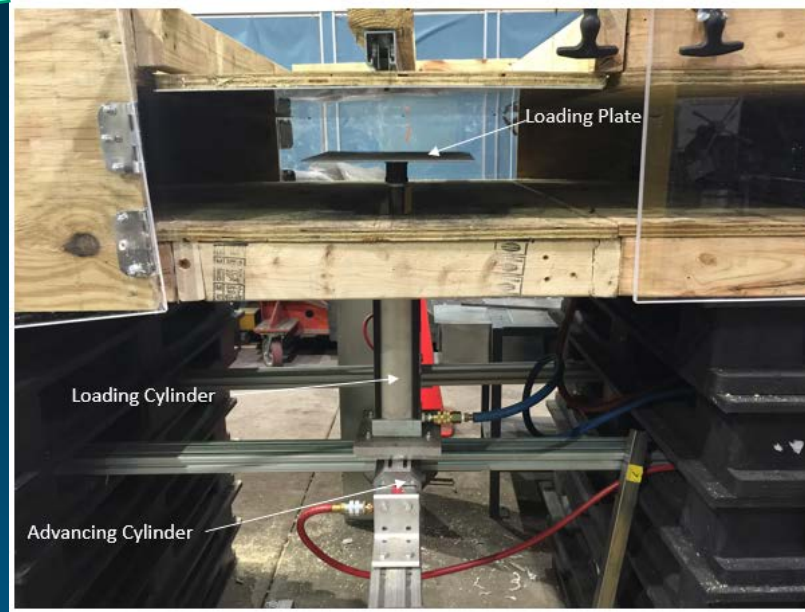


Foam for Longwall Shield Dust Control

(Dust Suppression Experiments)



- Complete fabricating test apparatus
- Develop protocol
- Conduct experiments



Foam for Longwall Shield Dust Control

(Dust Suppression Experiments)

Video of shield dust liberation being simulated in test stand



Foam for Longwall Shield Dust Control

(Dust Suppression Experiments)

Video of foam impact on shield dust liberation in test stand



Foam for Longwall Shield Dust Control

(Dust Suppression Experiments)

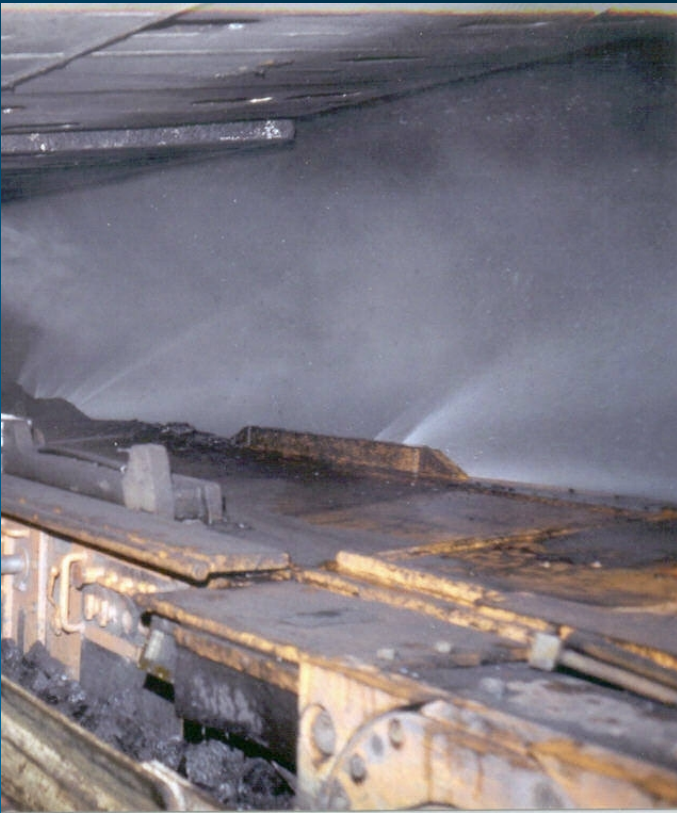


Testing of UK Shearer Scrubber



Summary

Effective Directional Spray Systems



Summary

Ineffective Directional Spray Systems



Summary

Maximum the Benefits of Available Controls



Commitment to Dust Controls

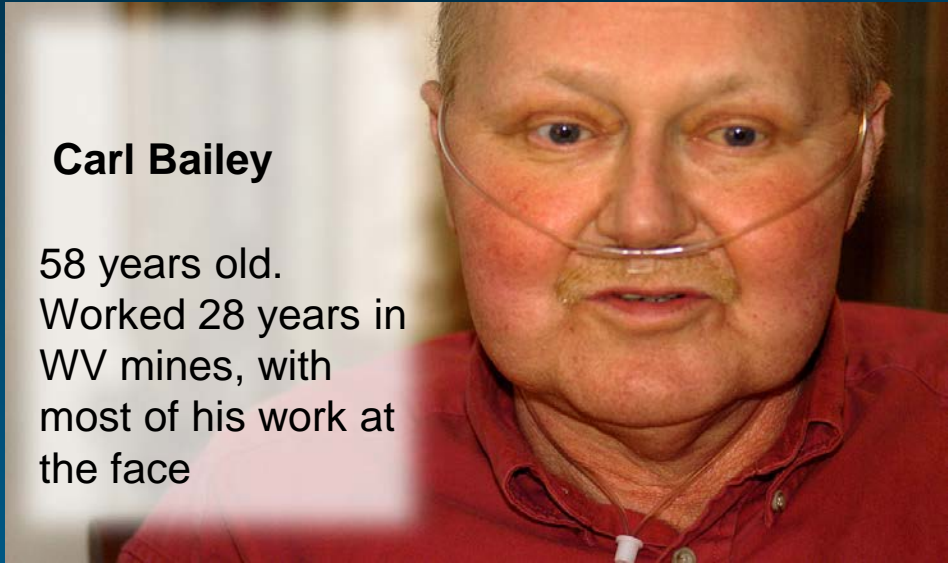
- Worker and management involvement
 - Knowledge and attitude
 - Safety => immediate / Health => long term

Maintenance is critical



Faces of Black Lung DVD

Important messages.....

A close-up portrait of Carl Bailey, a middle-aged man with a mustache, wearing a red shirt and a clear oxygen mask over his nose and mouth. The background is slightly blurred.

Carl Bailey

58 years old.
Worked 28 years in
WV mines, with
most of his work at
the face

“And always remember: What’s on your face you can wash-off, but what’s on your lungs you can’t. So be safe, and take care of yourself .”

A close-up portrait of Chester Fike, a middle-aged man with a mustache, wearing a light-colored plaid shirt and a dark cap. The background is slightly blurred.

Chester Fike

55 years old.
Worked 34 years in mines
in WV and MD and operated
a continuous miner for 27 years.

“I was always trained to avoid injuries and I should’ve paid more attention to the dust.”

Questions?

Jim Rider

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