Controlling Respirable Dust on Longwall Mining Operations

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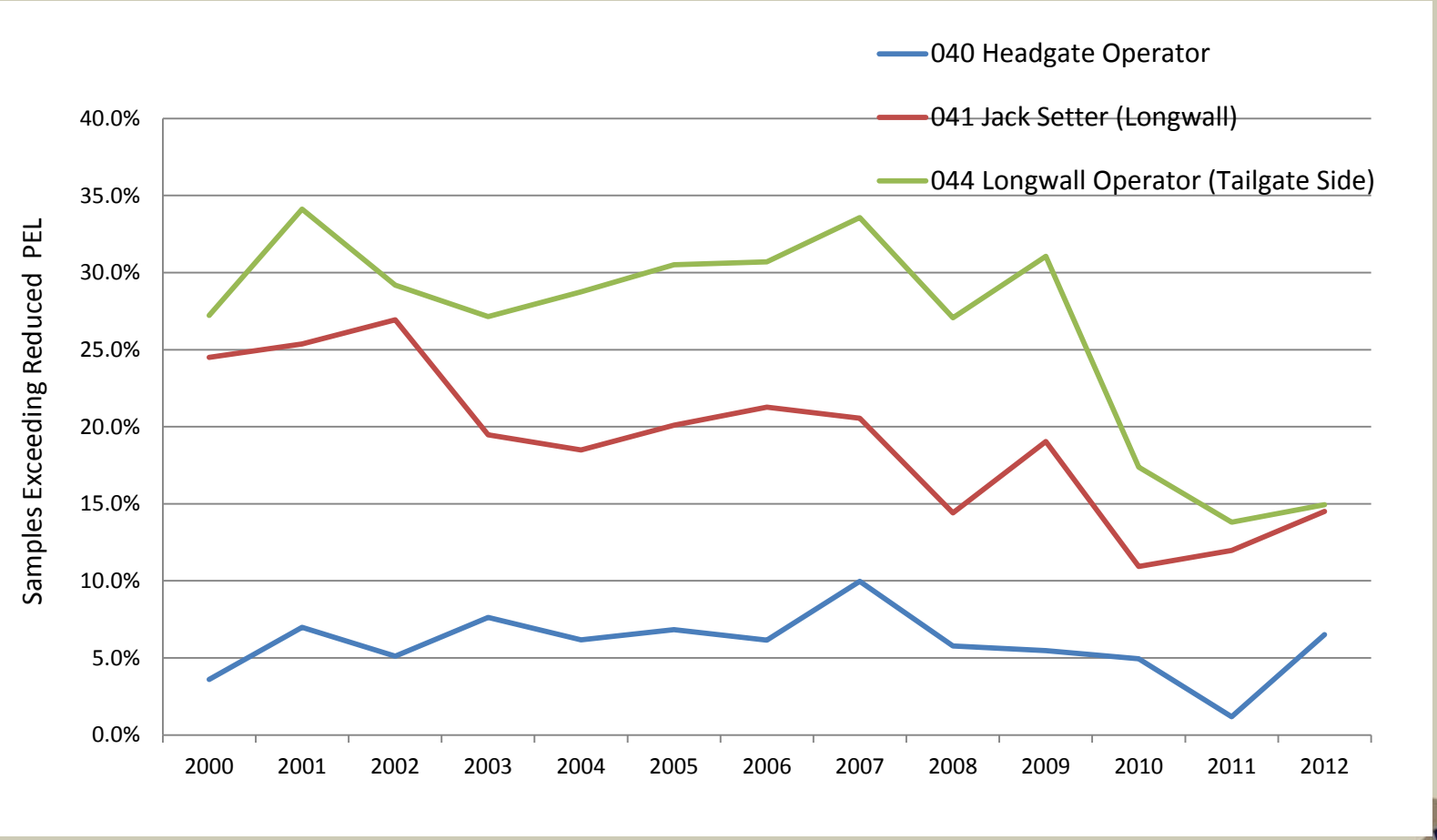
Sound Practices to Control Respirable Dust on Longwall Mining Operations

- 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/m^3 PEL, 2000 – 2012



Quantifying Longwall Dust Levels

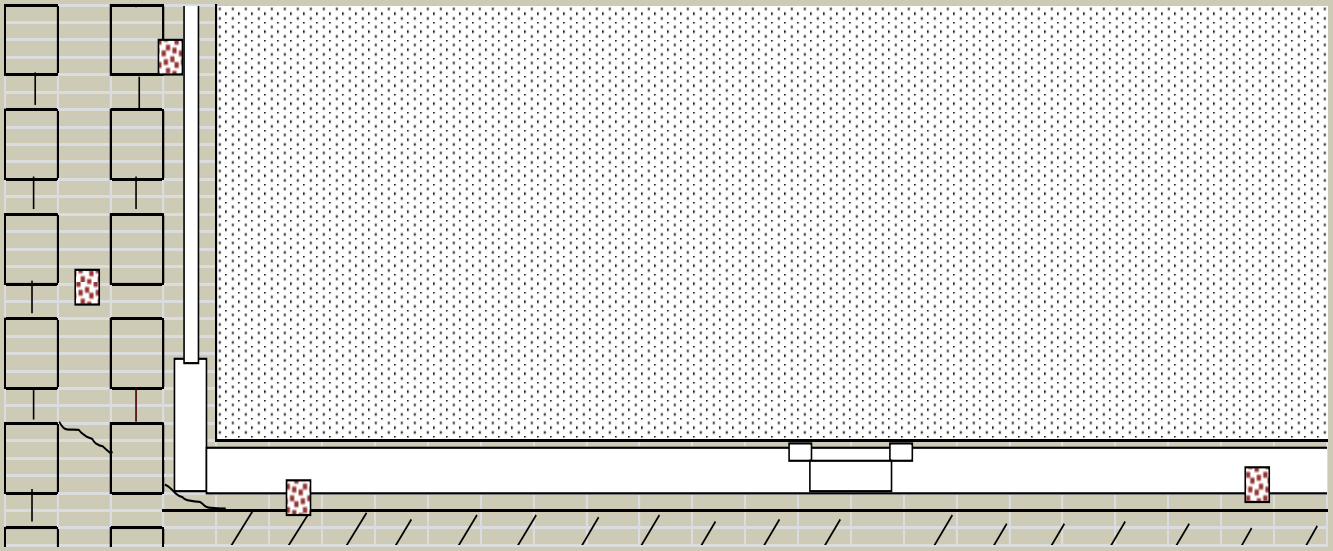
Benchmarking Surveys

- Quantifying major dust sources
- Identify controls and provide suggestions for improved dust control

Sampling to Isolate a Fixed Dust Source

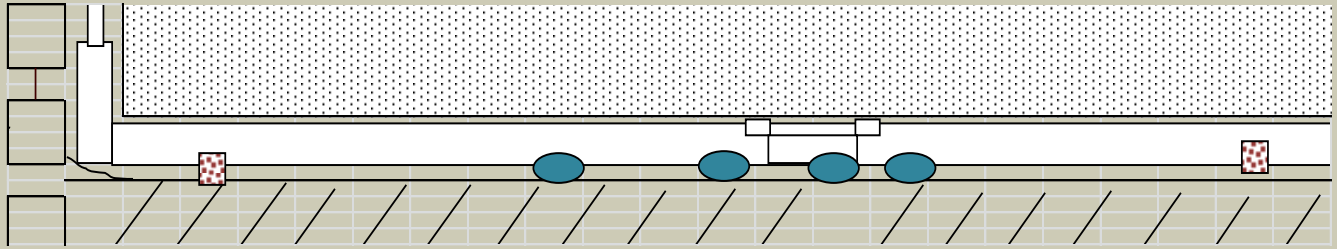
Stationary Sampling Locations

- 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)

	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*
- 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

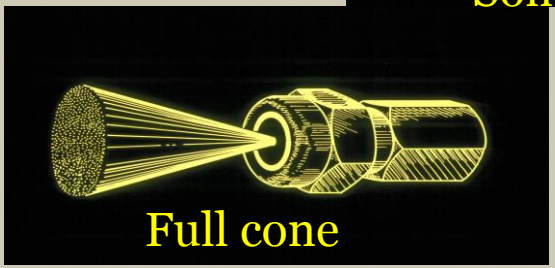
Previous studies :

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

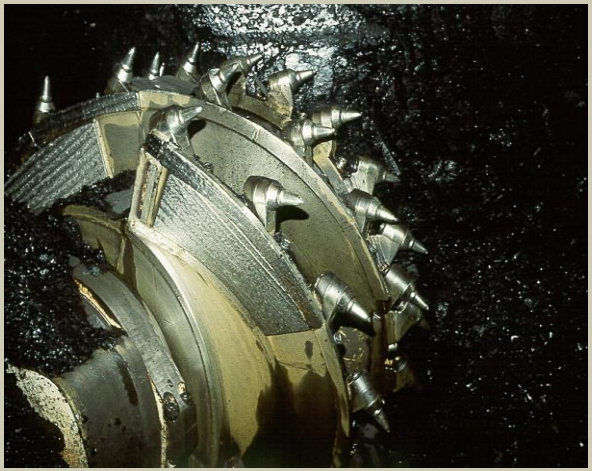
Controlling Shearer Dust

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

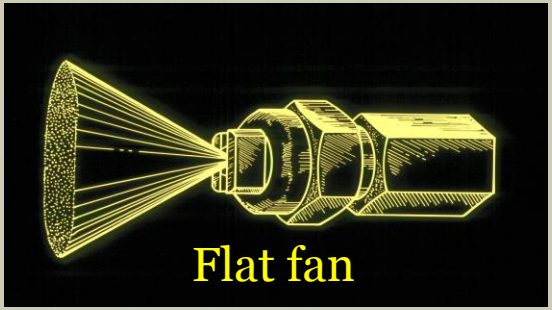
- Replacing damaged, worn or missing bits can not be over emphasized
- Dull bits result in shallow cutting and greatly increases dust generation

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

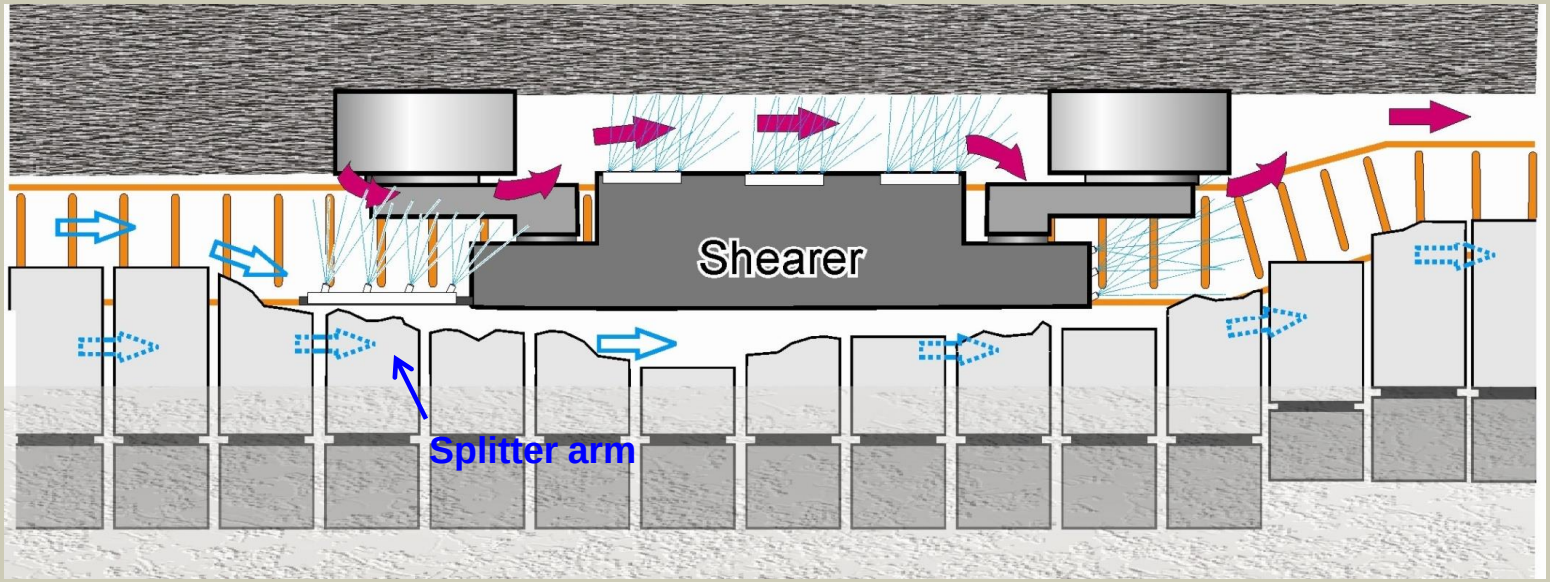
Crescent Sprays

- 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

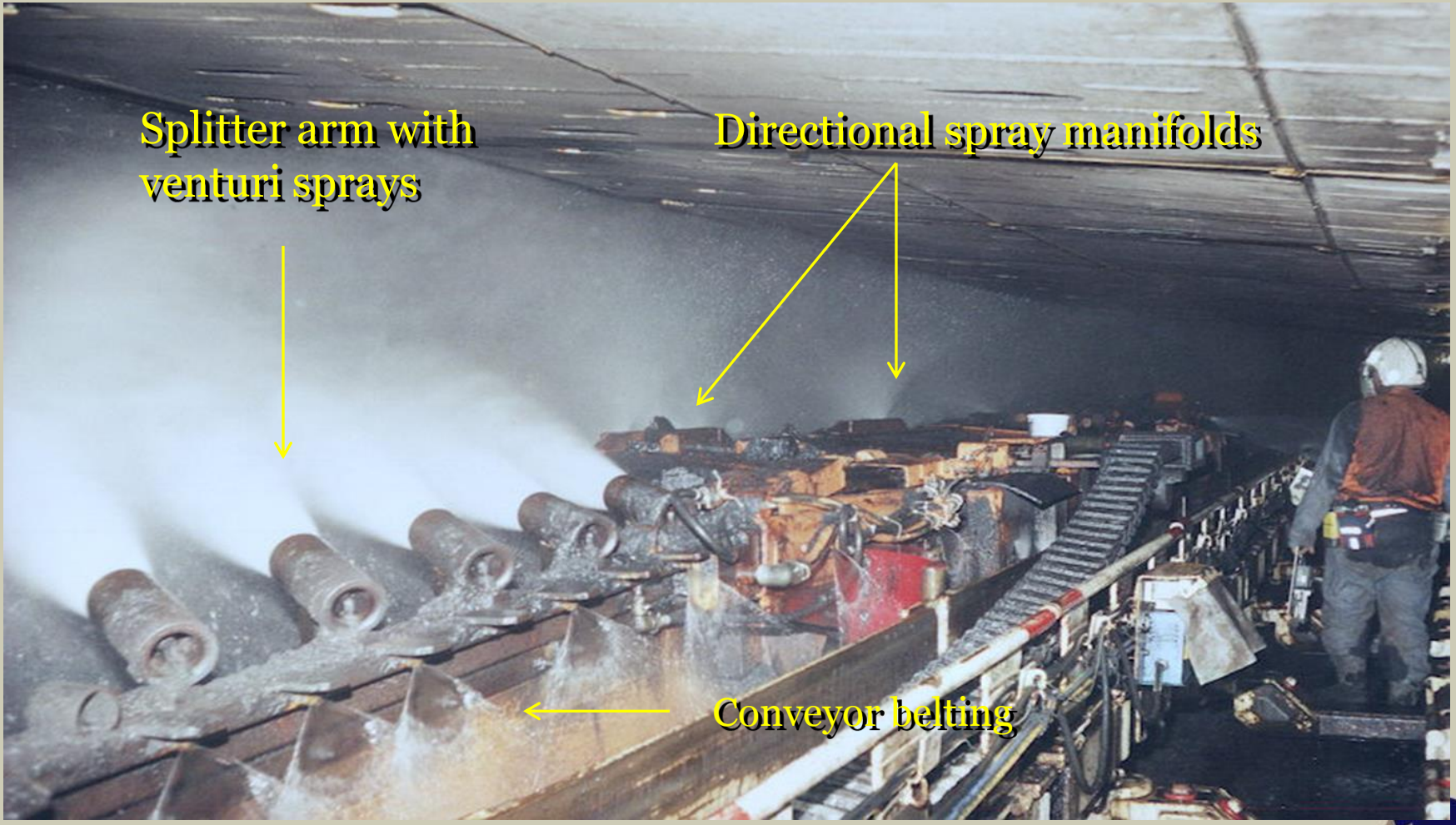
Controlling Shearer Dust

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



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

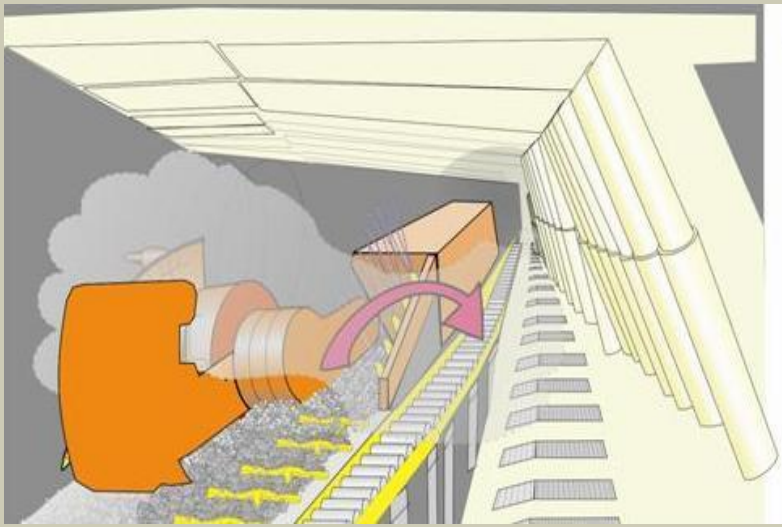
Splitter Arm Underside Sprays

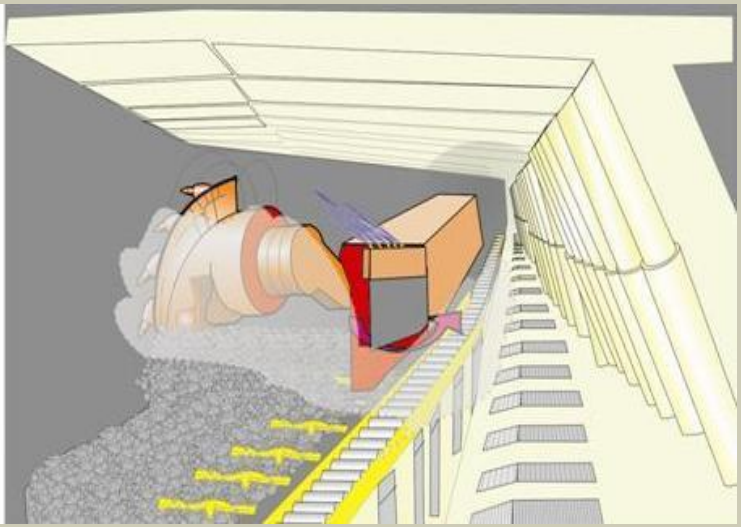
- Locate sprays on underside of the splitter arm
- Direct sprays down the face side of the belt
- Reduce dust rolling under or through the splitter arm
- Adds more water to the coal to reduce conveyor dust
- Because of turbulence in the area spray pressure is critical

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

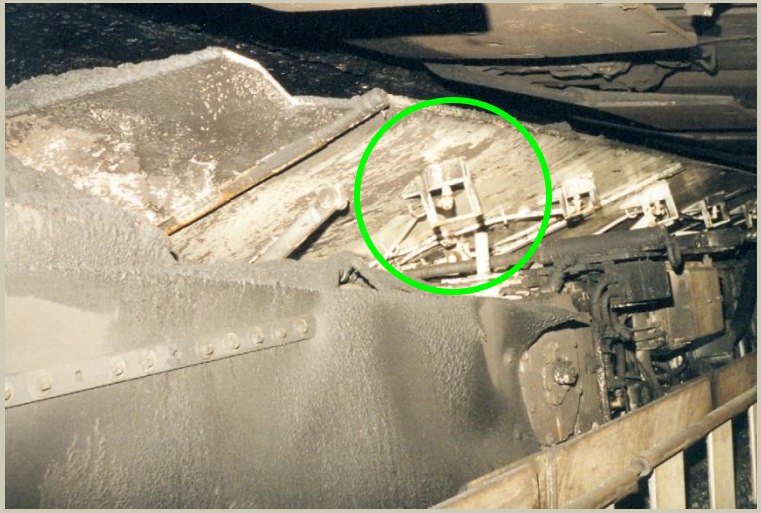
Shearer-body Sprays

- 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

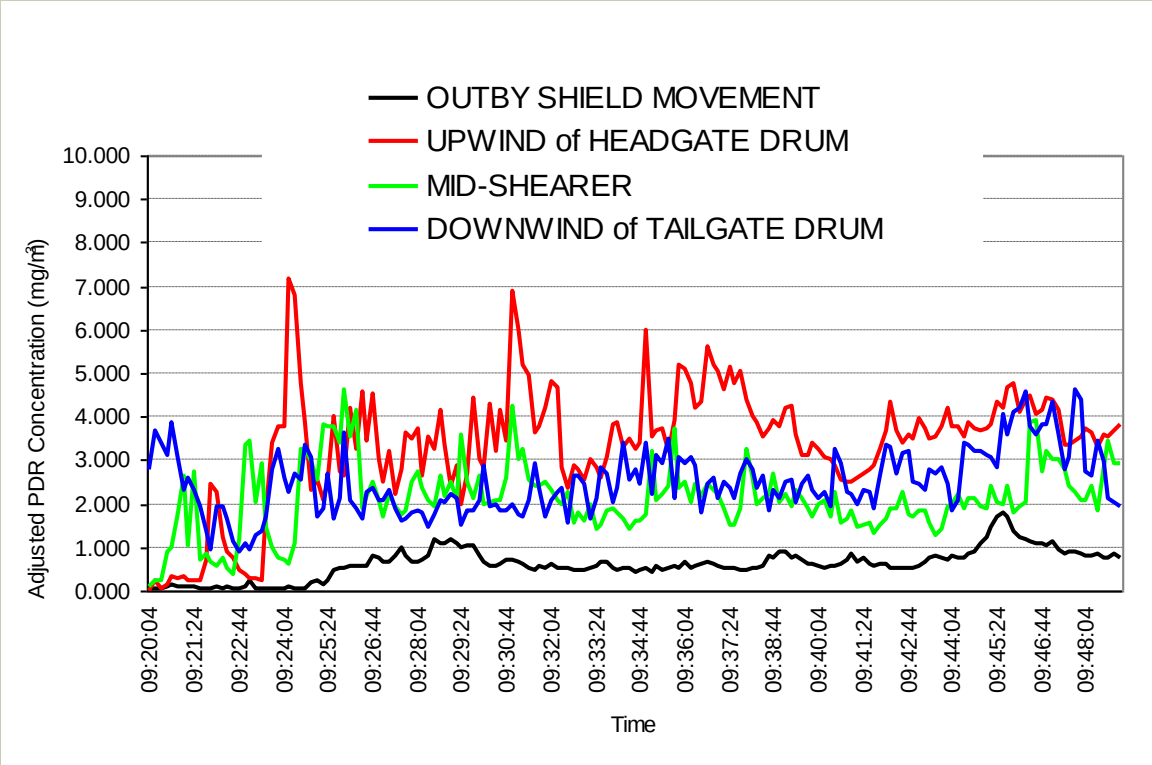
Controlling Shearer Dust

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



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

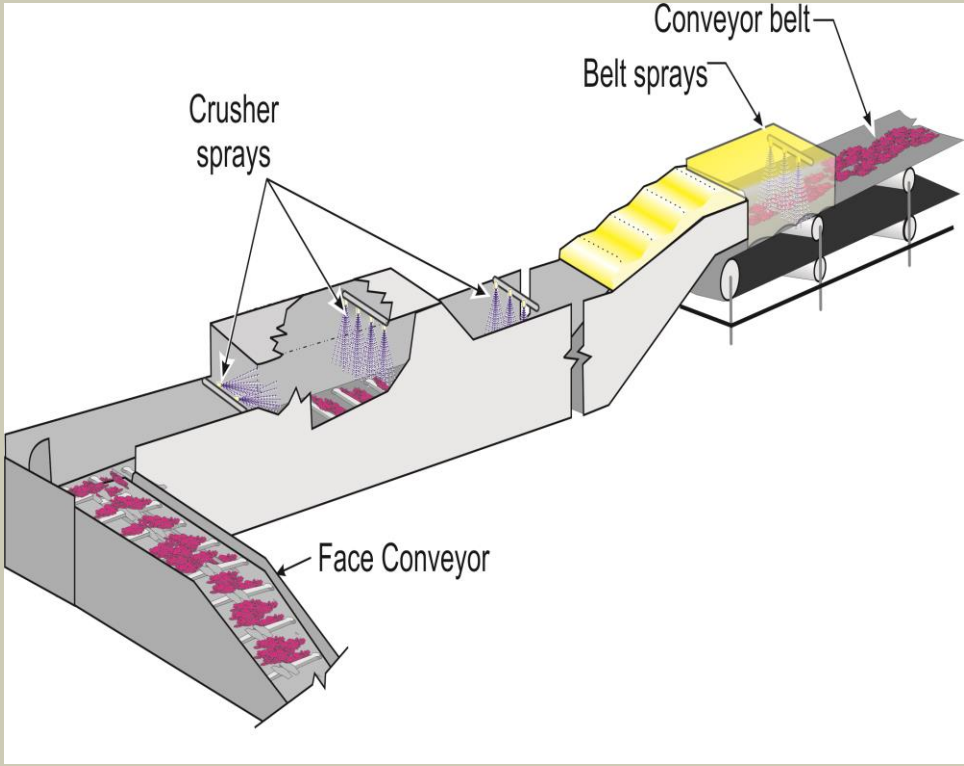
Stageloader/Crusher Dust Control

- 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 <= 60 psi



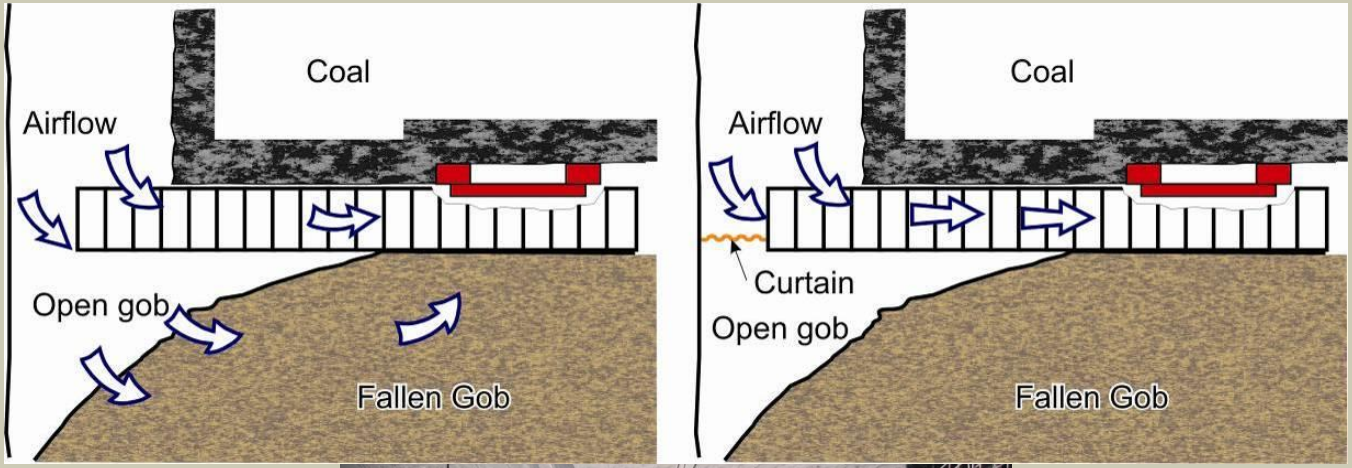
Stageloader/Crusher Dust Control

Scrubbers

- Crusher discharge
- Belt transfer area
- Capacity – 6500 – 8500 ft^3/min
- Potential to create negative pressure in the stageloader/crusher to minimize dust from leaking out

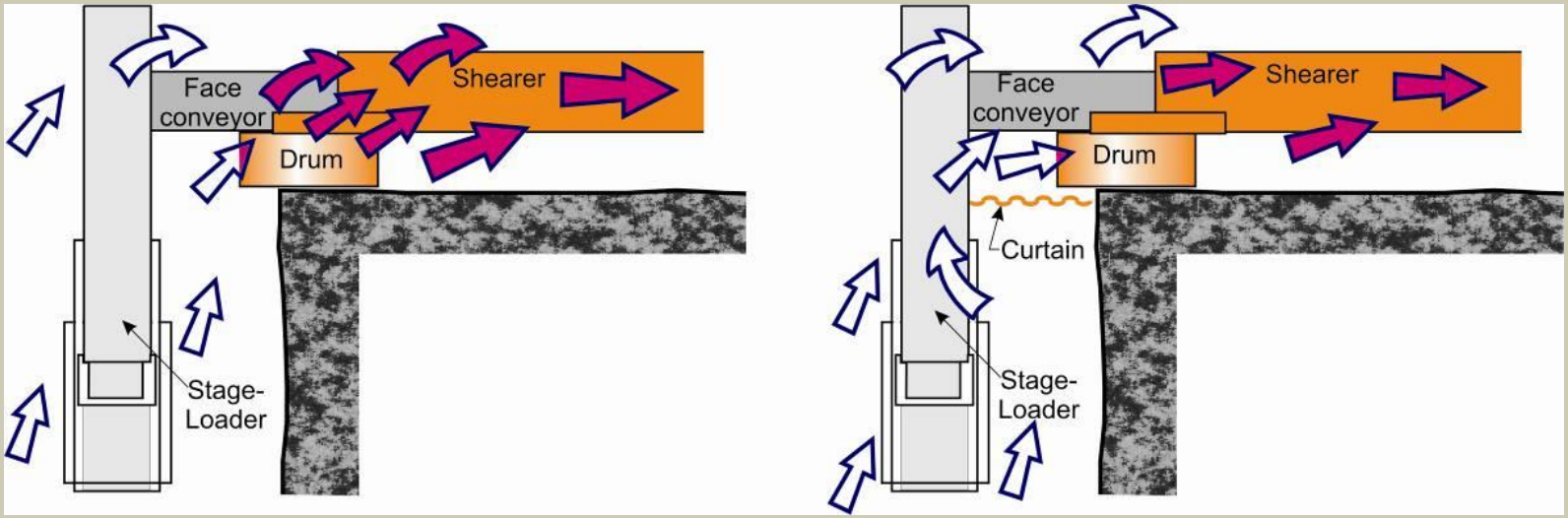
Dust Control in the Headgate Entry

- Installation and **<u>maintenance</u>** 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

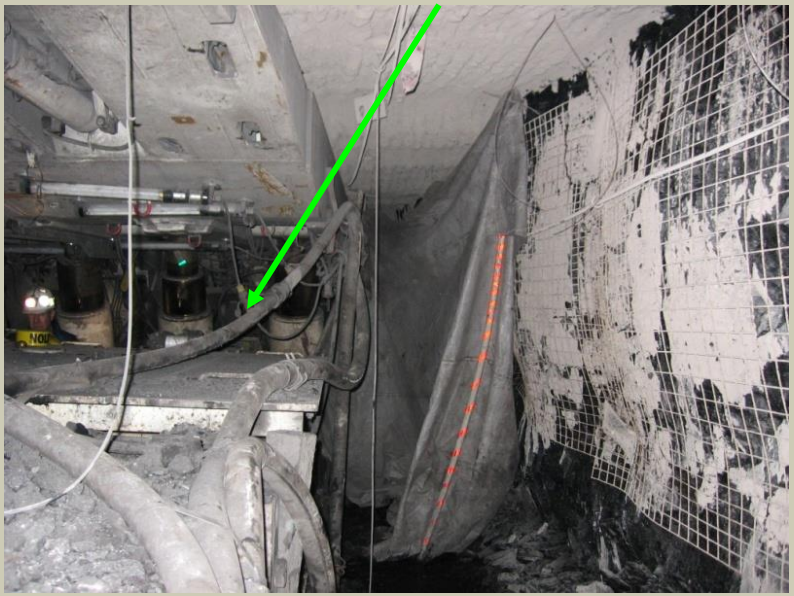


Dust Control in the Headgate Entry

- 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/m^3 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

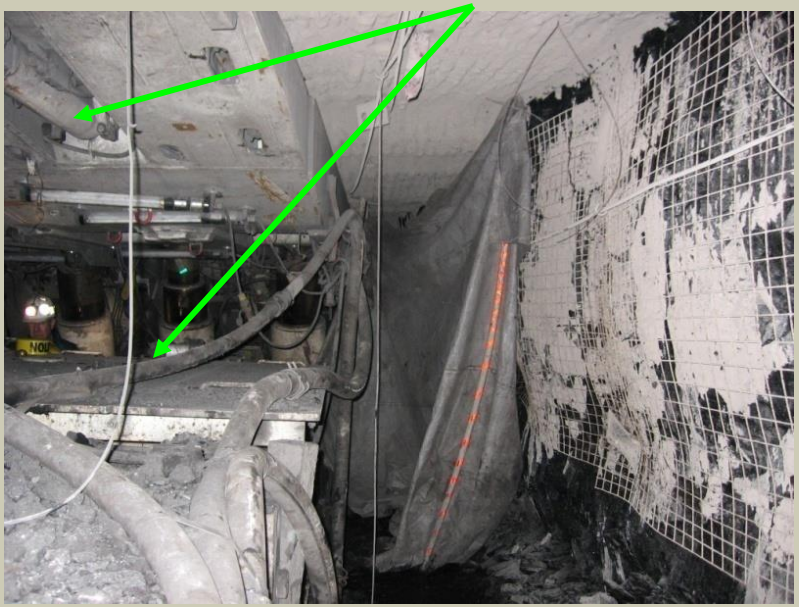


Dust Control in the Headgate Entry

- 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

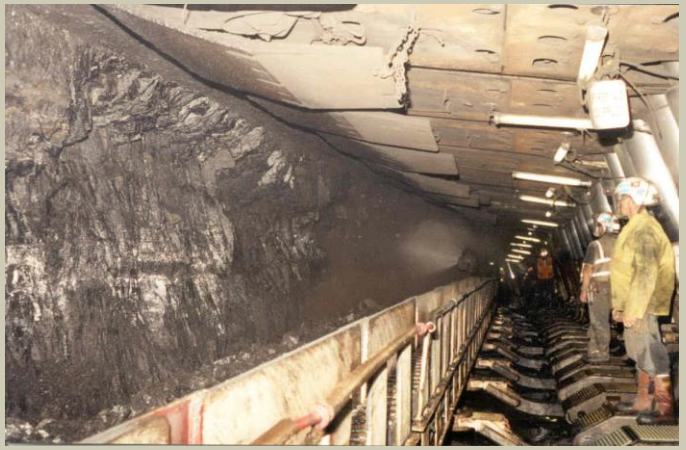


Controlling Dust on Intake Roadways

- Limit support activities during production shifts
  - Vehicle movement
  - Removal of stoppings
  - Delivering / unloading of supplies

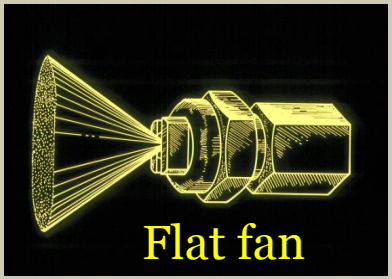
Controlling Dust on Intake Roadways

- 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

- **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

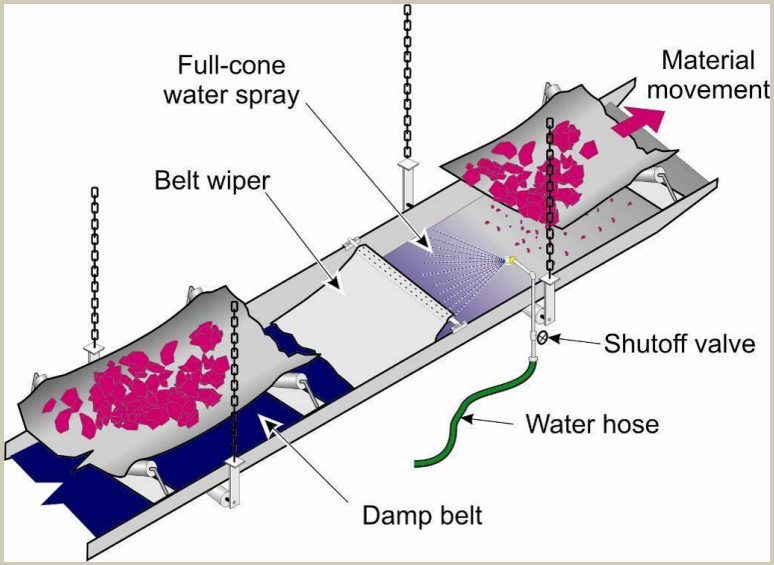


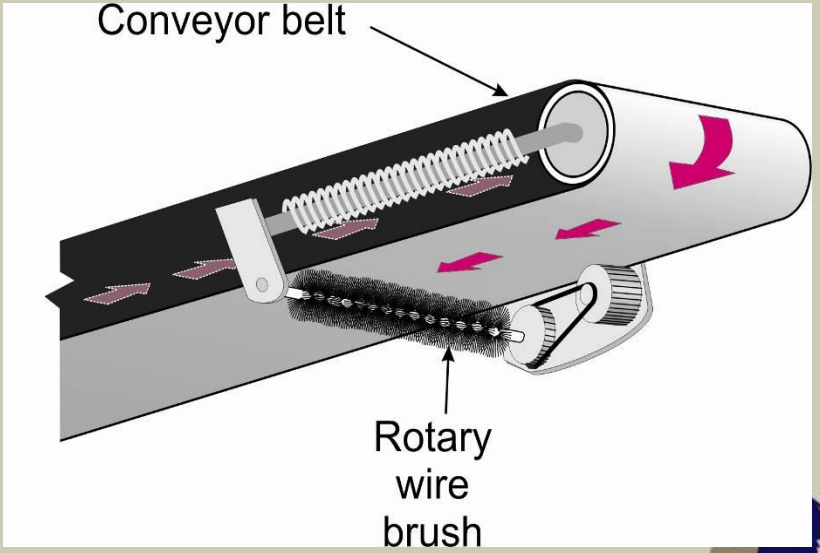
Controlling Dust from the Belt Entry

- Belt Maintenance - Missing rollers, belt slippage, and worn belts can cause belt misalignment and create spillage

Controlling Dust from the Belt Entry

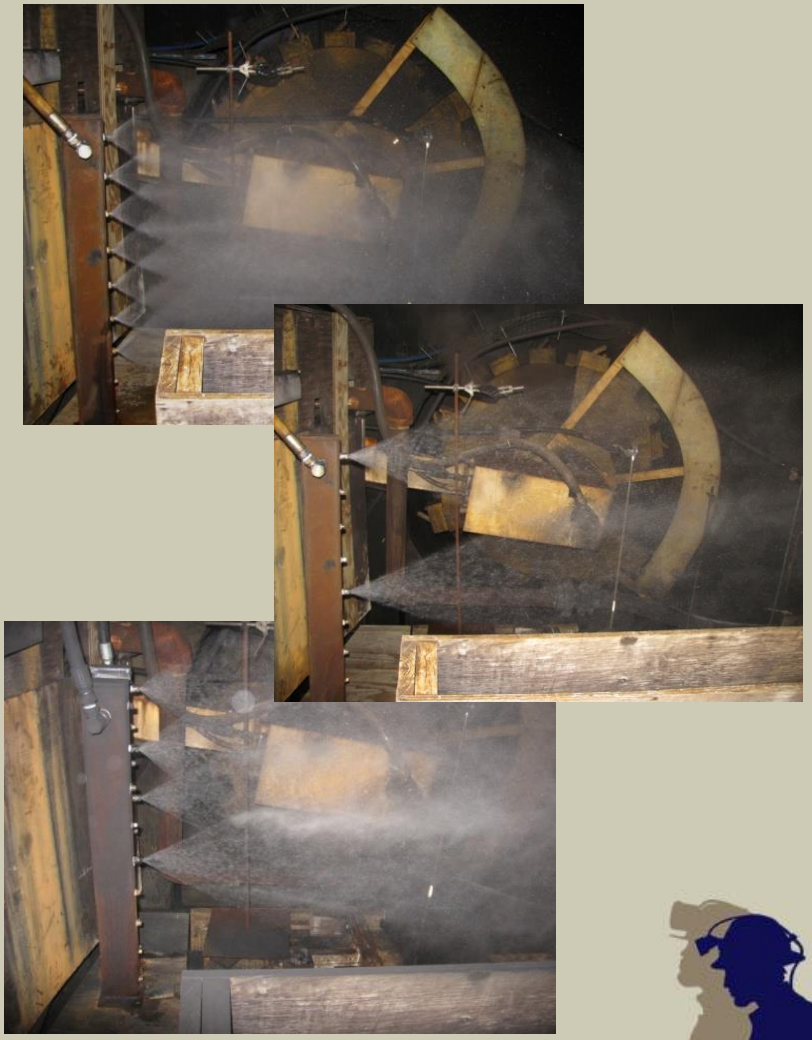
- Wetting of the Belt
  - Full cone spray on top surface of non-conveying side belt followed by material to wipe belt and remove dust fines
- Rotary Brush
  - Clean the conveying side of the belt





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



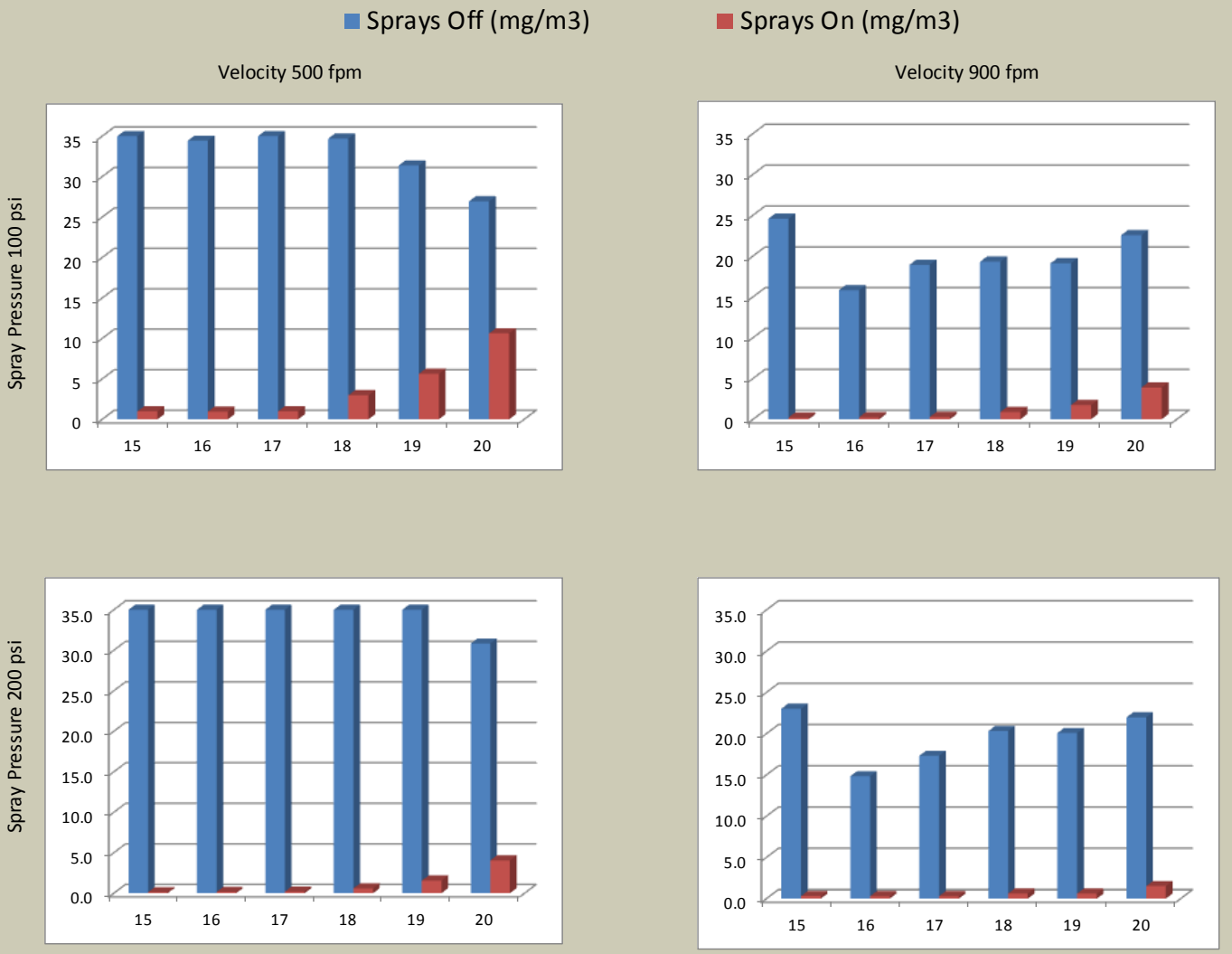
Laboratory Assessment
Tailgate-side Shearer Spray Manifold

- 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

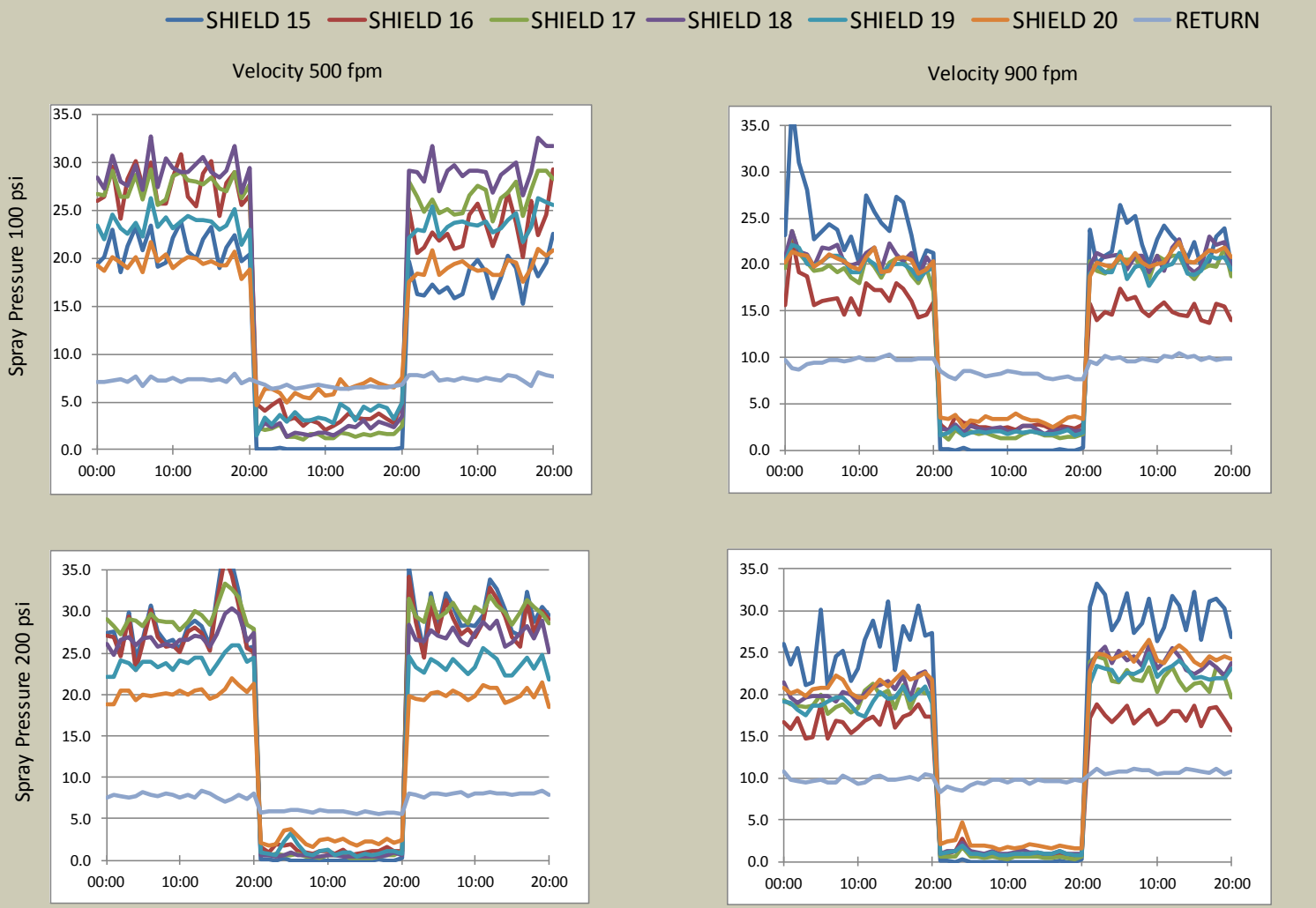
2 Manifolds and 4 SS 65-15 Flat Fan Sprays



Tailgate-side Shearer Spray Manifold

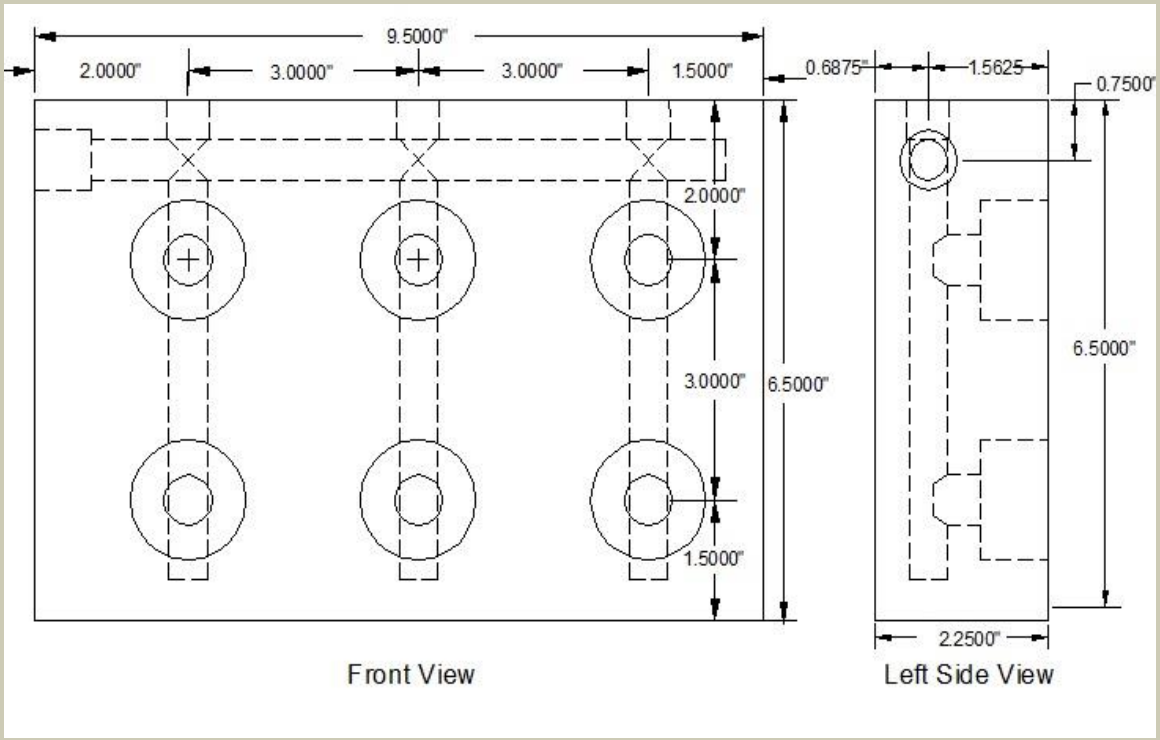
Instantaneous (pDR) Dust Concentrations

2 SS 40-20 Flat Fan Sprays



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/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->H : .067 mg/m^3 OFF vs .059 mg/m^3 ON
  - H->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

Summary

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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