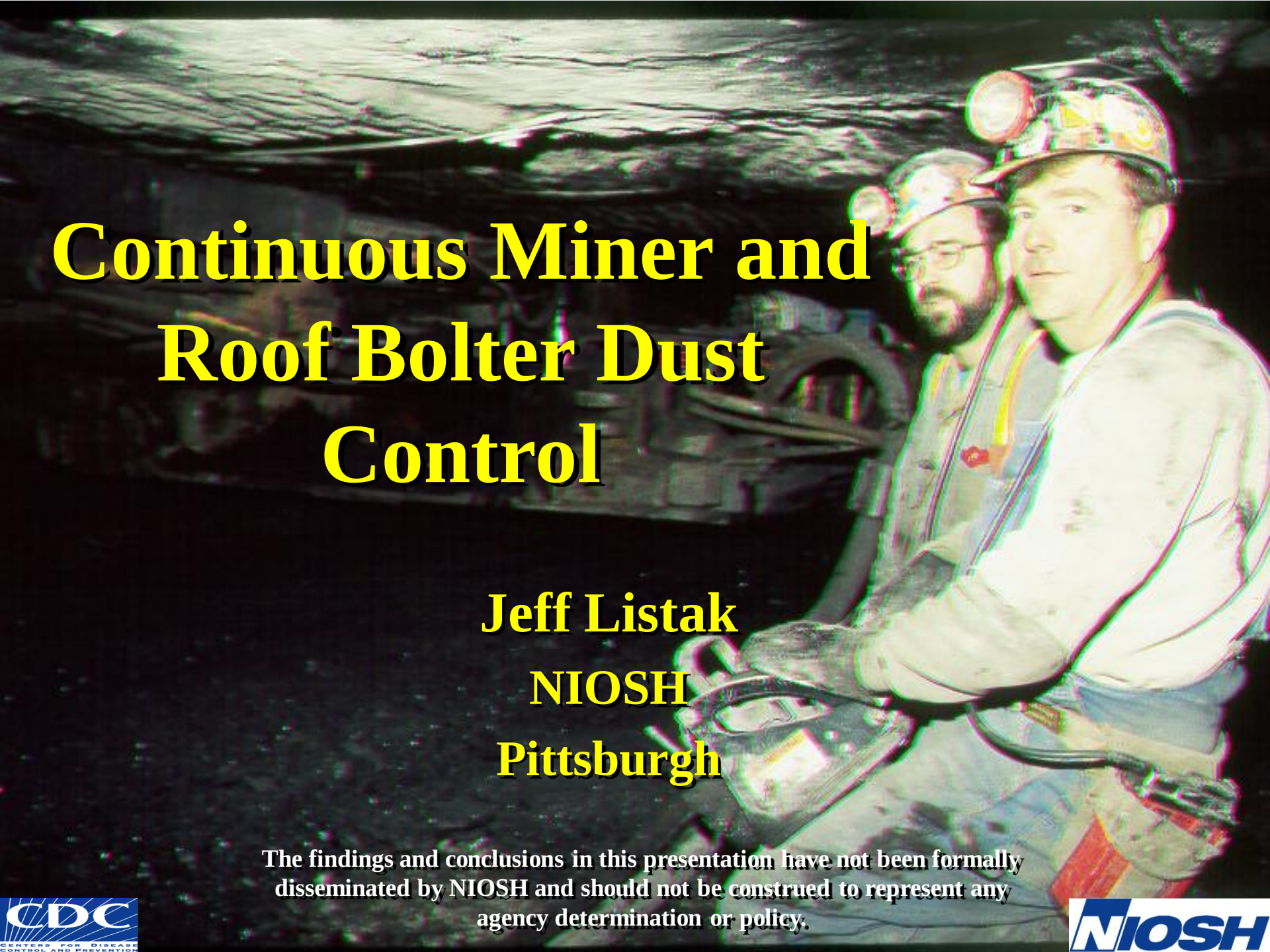

Continuous Miner and Roof Bolter Dust Control

Jeff Listak

NIOSH

Pittsburgh

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

CDC Centers for Disease Control and Prevention

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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

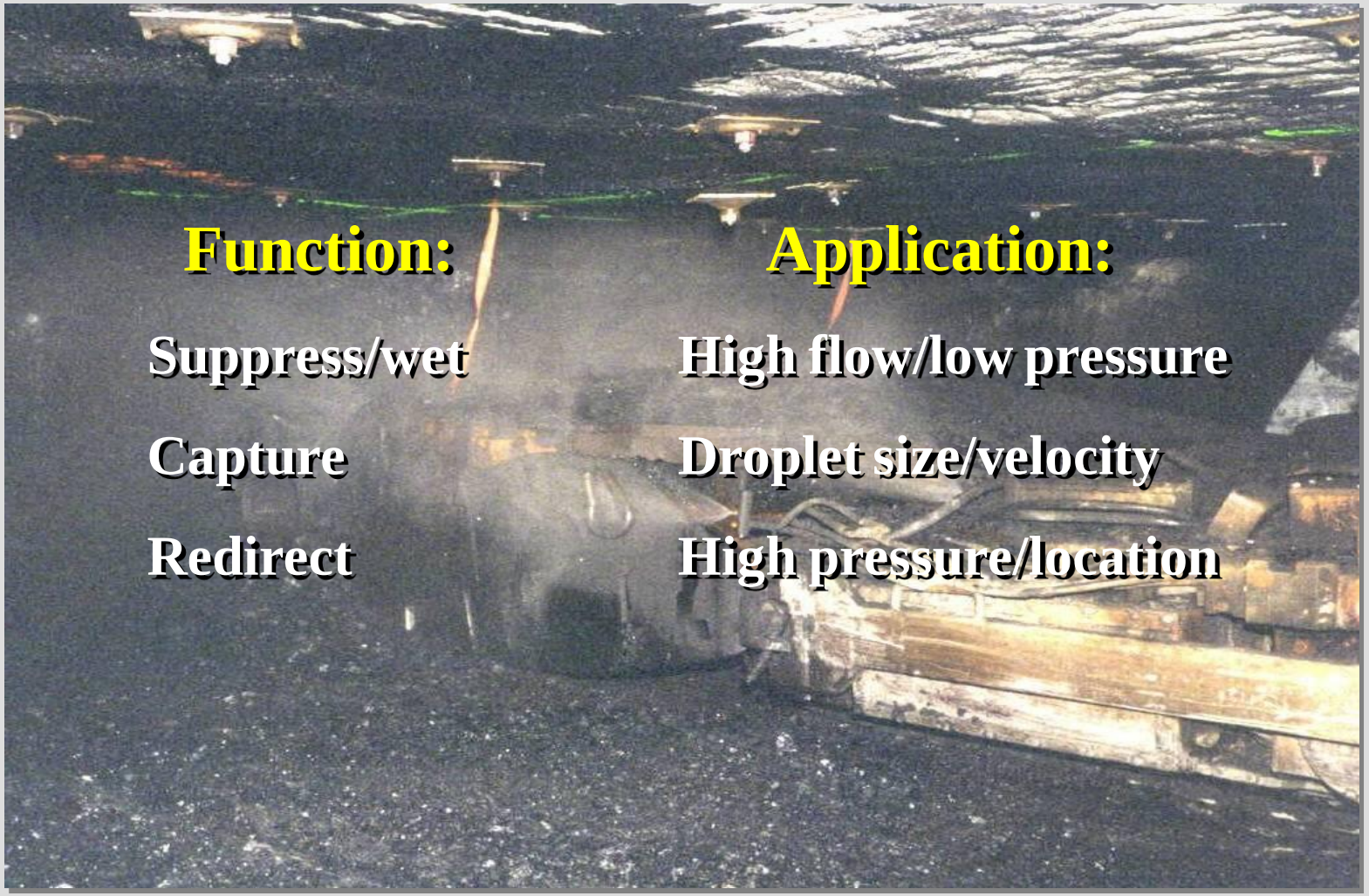
- **Water (sprays)**
  - **Suppresses**
  - **Redirects**
  - **Captures (sprays and scrubbers)**

- **Air (ventilation)**
  - **Dilutes**
  - **Transports**

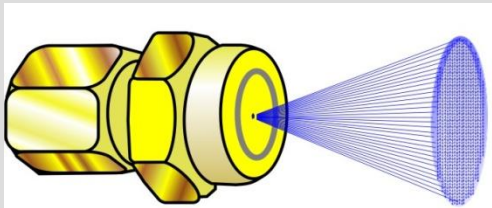
Impact of Water on Dust

- **Suppression – prevent generation**
- **Capture – remove from air (water or mechanical means)**
- **Redirection – directed away from worker**

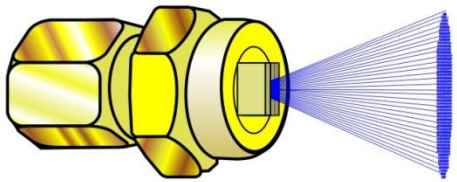
Water Sprays on Continuous Miners



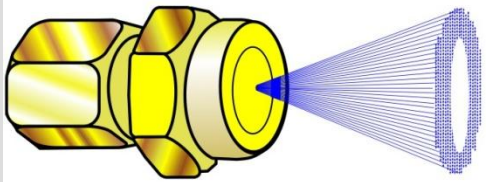
Spray Types



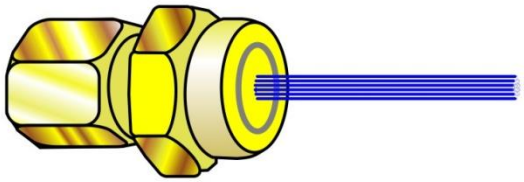
Full Cone



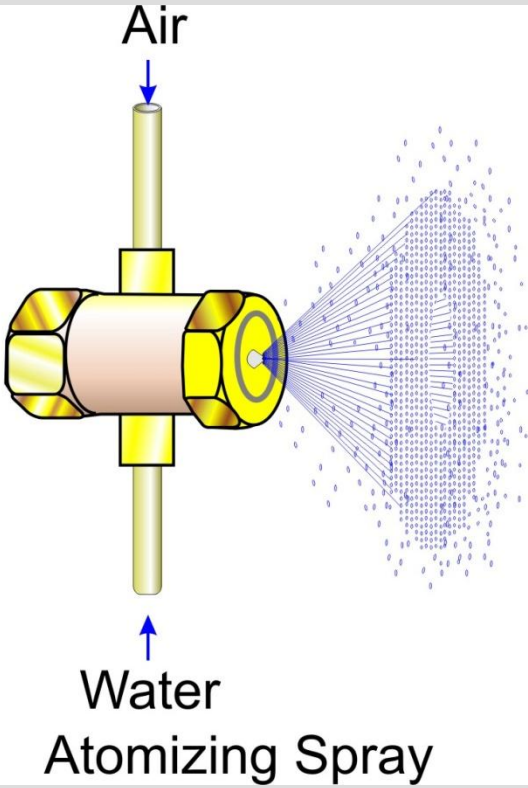
Flat Spray



Hollow Cone

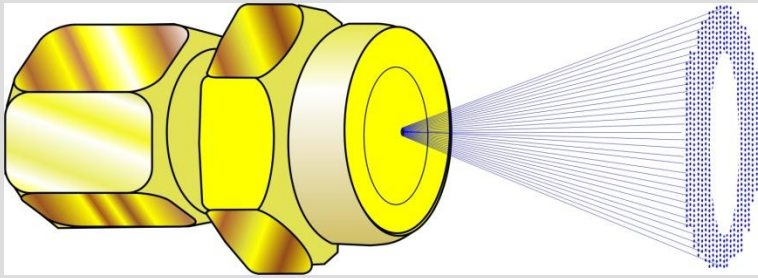


Solid Stream



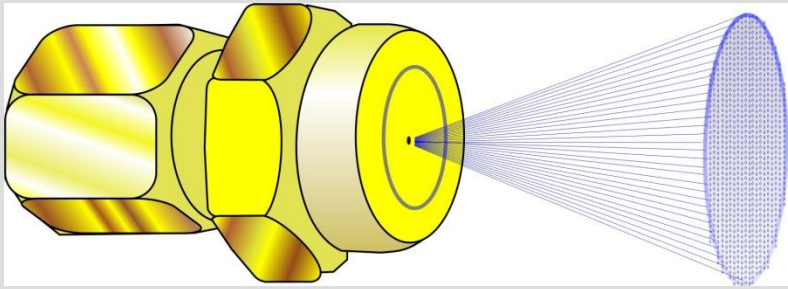
Spray Nozzles

Hollow Cone



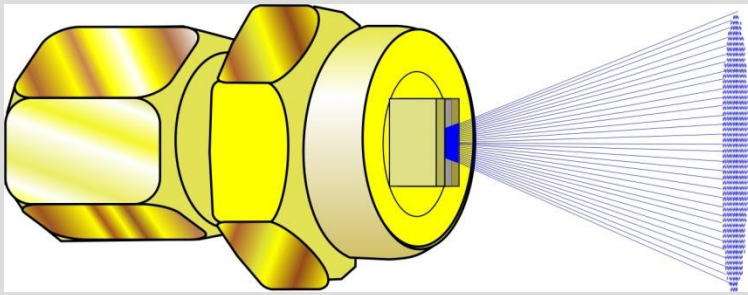
- Conical shape, outer ring of circular spray
- Most widely used
- Small to medium droplets of water
- Larger orifice/less likely to clog
- Effective for dust mixing (knockdown) and redirecting
- Usually provided from manufacturer

Spray Nozzles
Full Cone



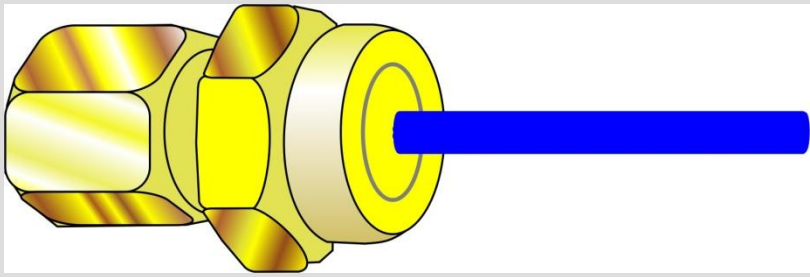
- Conical shape with solid circular pattern
- Medium to large droplets of water
- Provide uniform wetting
- Wide range of pressure and flows
- Effective for scrubber filters and belt transfer points

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



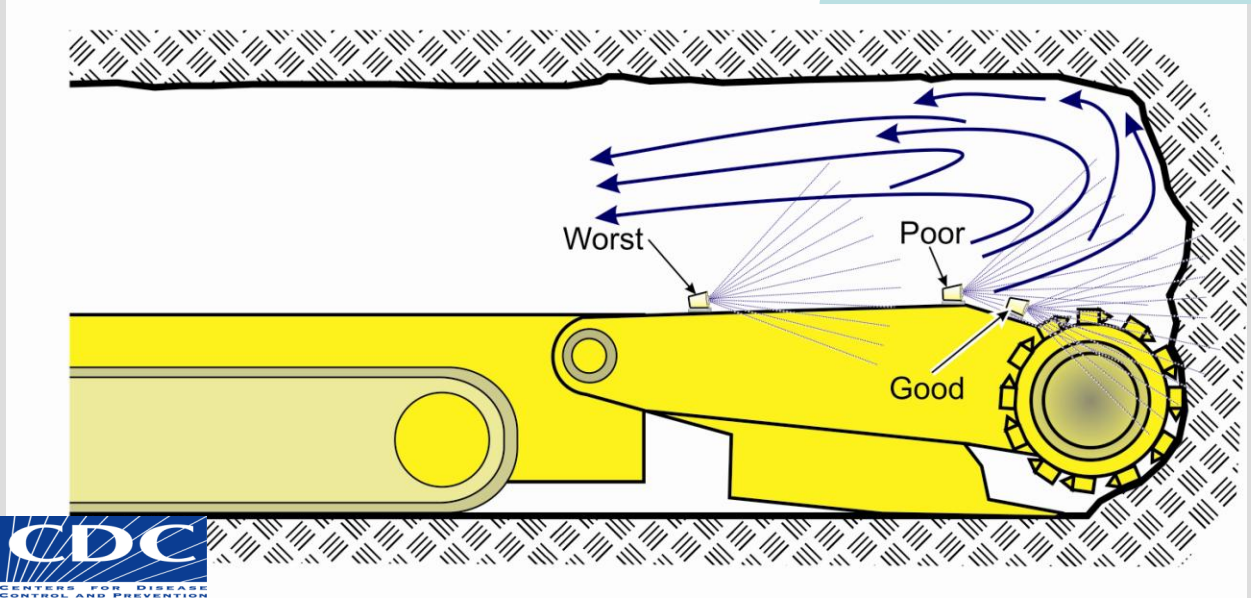
- Straight solid stream of water at high volume
- To be used close to the source
- Provide uniformity of wetting
- Effective for dust suppression bit cooling

Wetting/Suppression

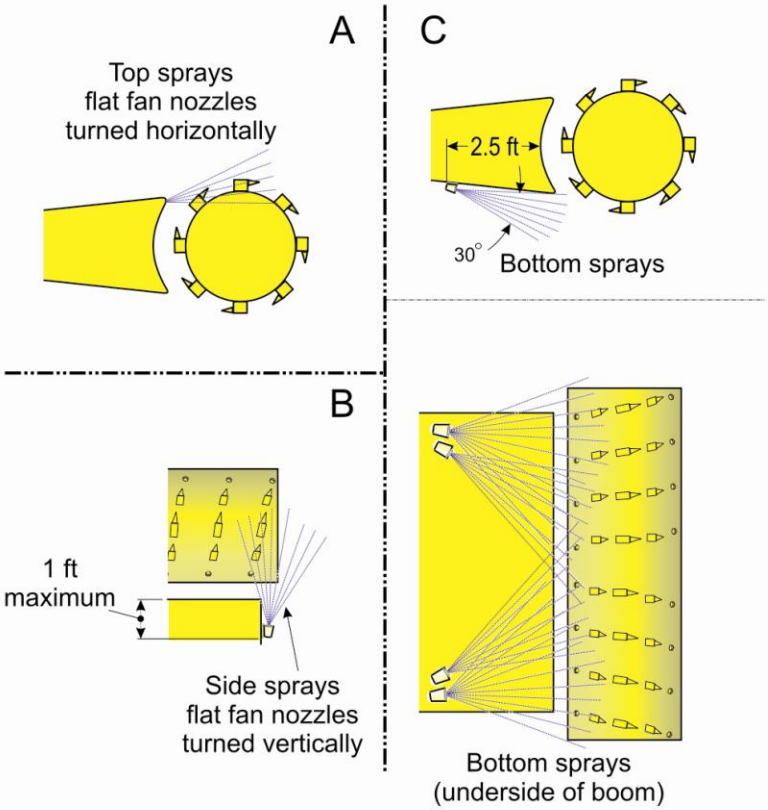
- Flat-fan/Hollow cone sprays on top of boom
- Deluge sprays under boom (flat or hollow cone)
- Throat sprays
- Surfactants (wetting agents)

- Flow rate most important

Sprays close to cutting head

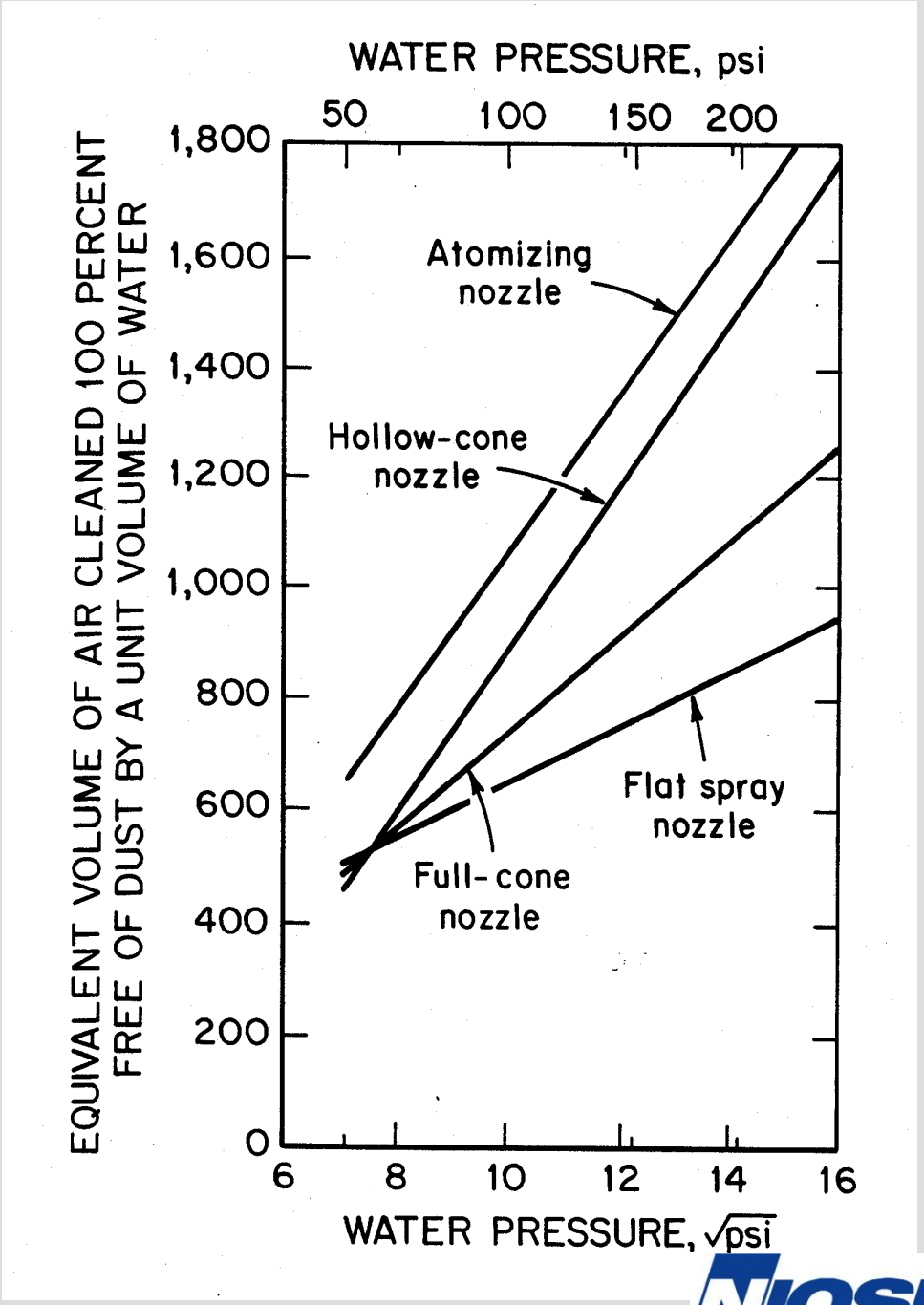


Spray Locations

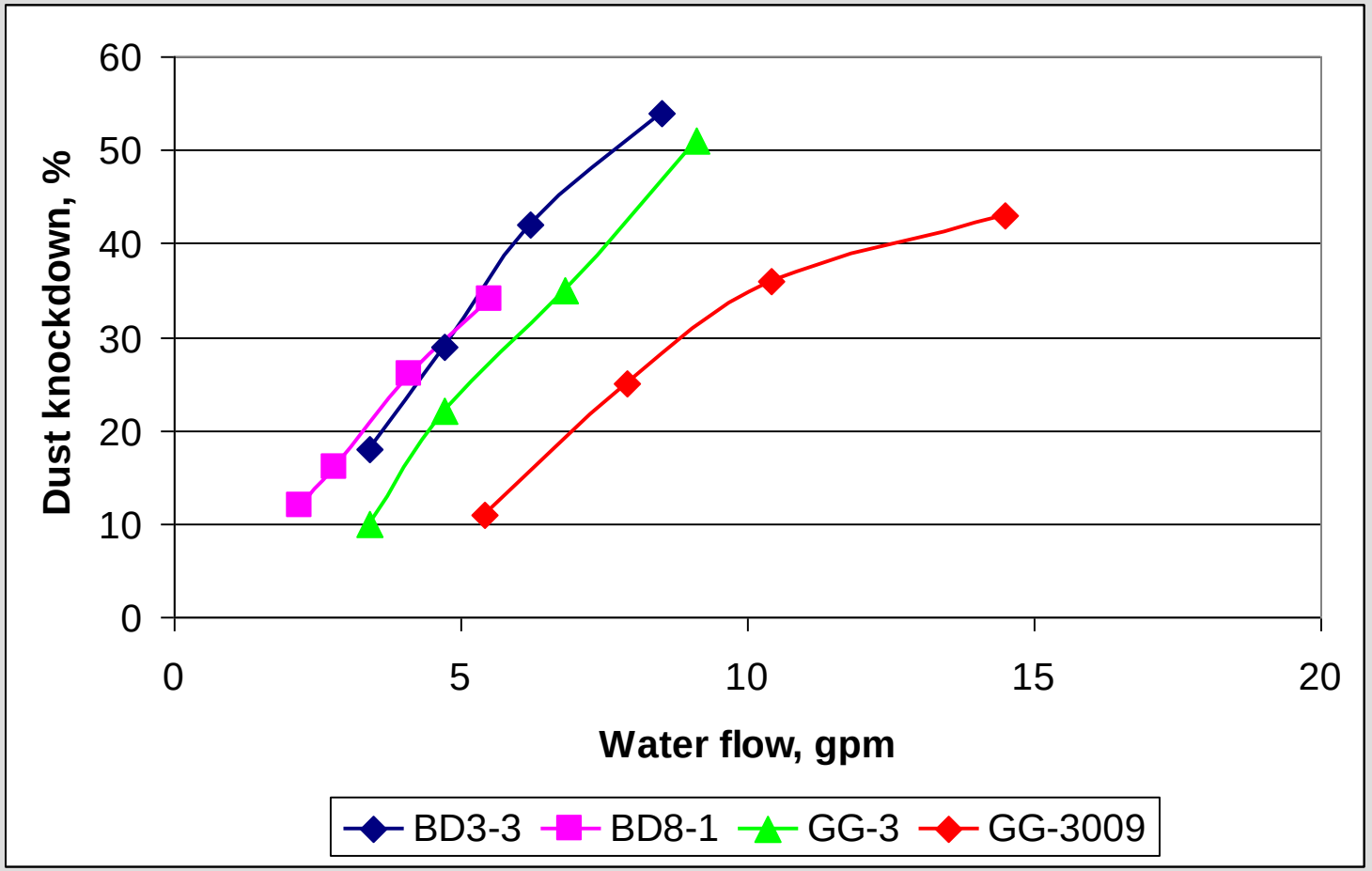


Spray Capture Effectiveness on Airborne Dust

- Smaller Droplet Sizes
- High Velocity Droplets



Airborne Dust Capture

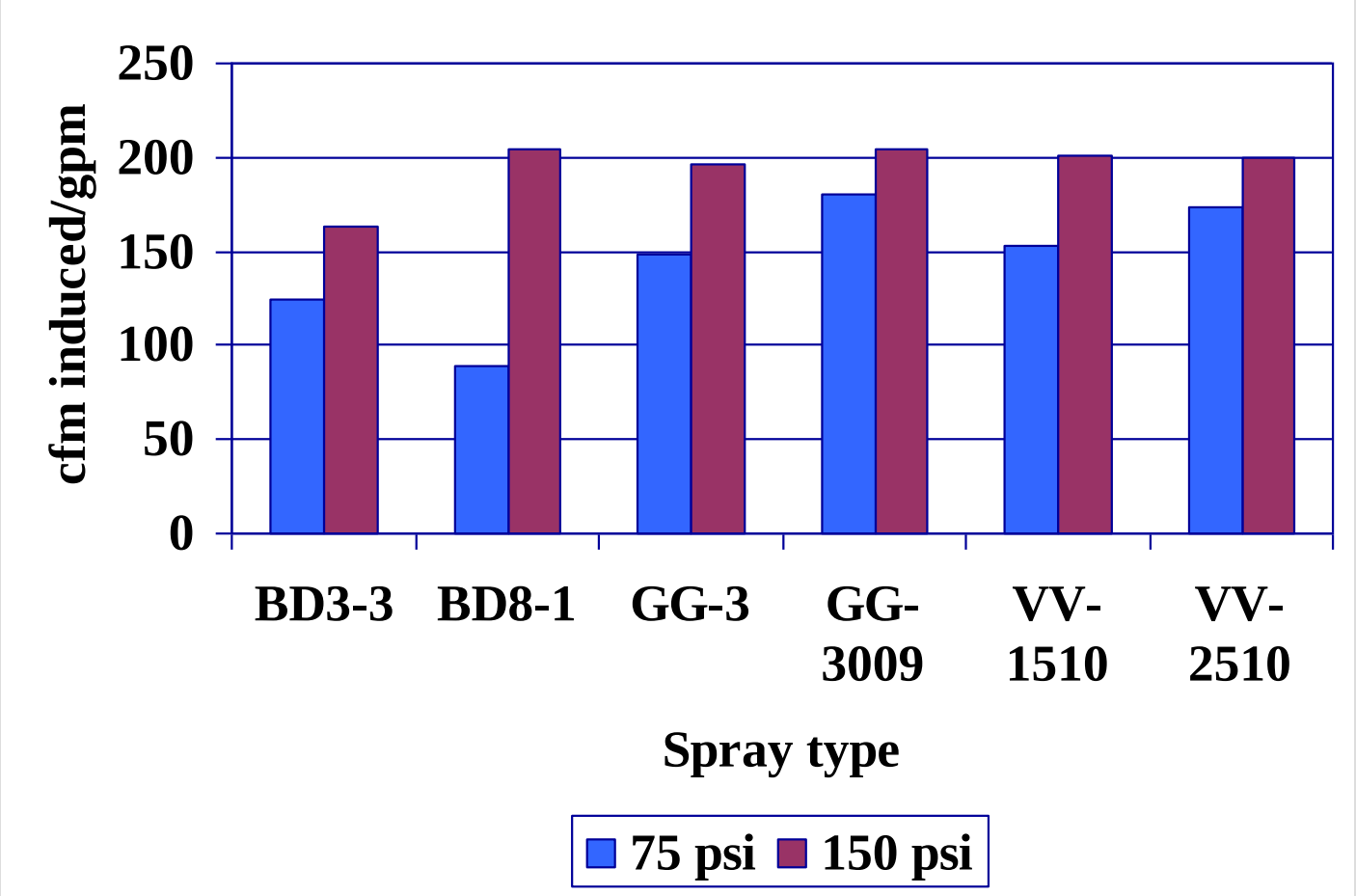


Redirecting/Moving Air

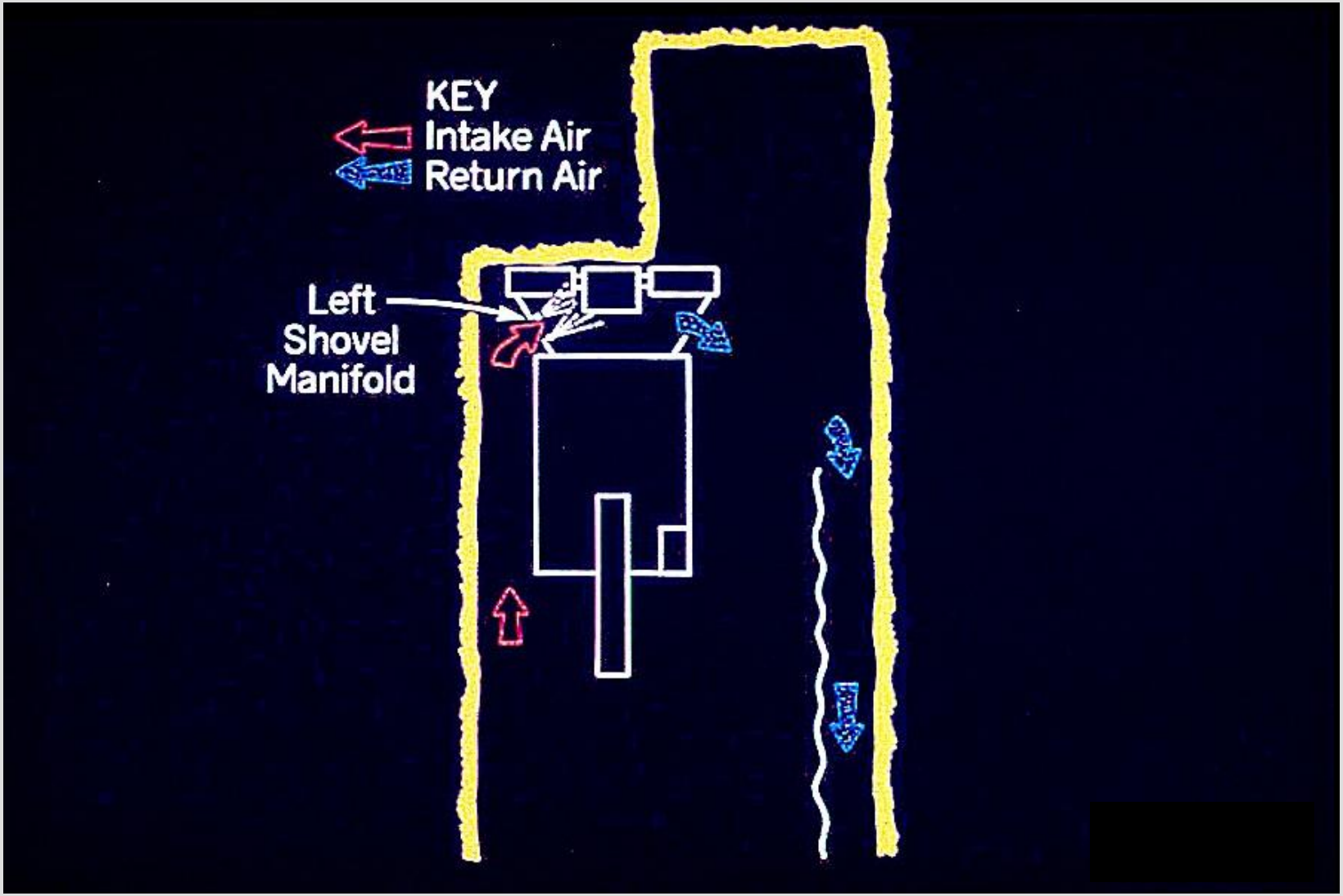
- Shovel sprays (hollow cone)
- Spray-fan system (hollow cone)
  - methane control
  - reduced effectiveness on dust control
- Blocking Sprays (flat)

- Pressure/location important

Air Moving Effectiveness

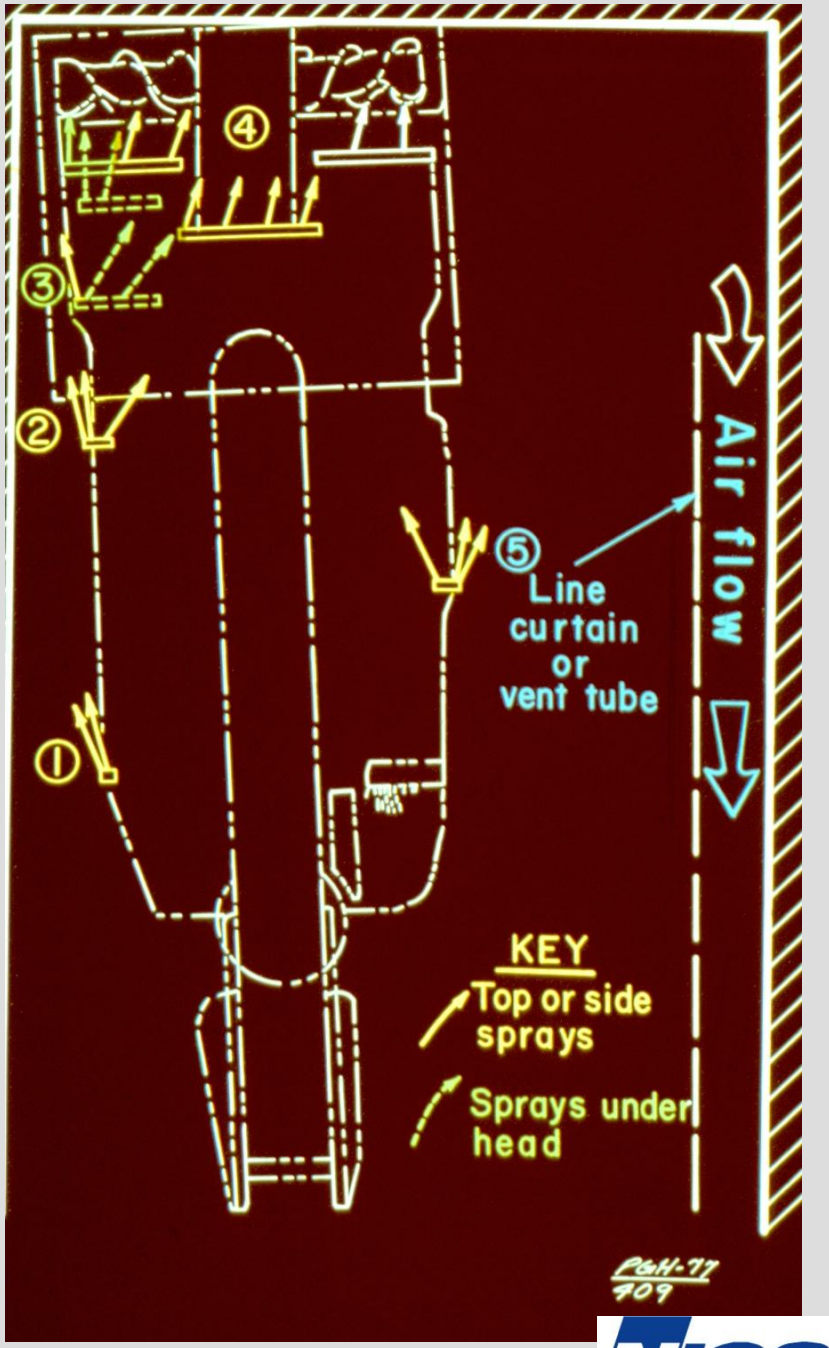


Shovel Sprays
(without scrubber)



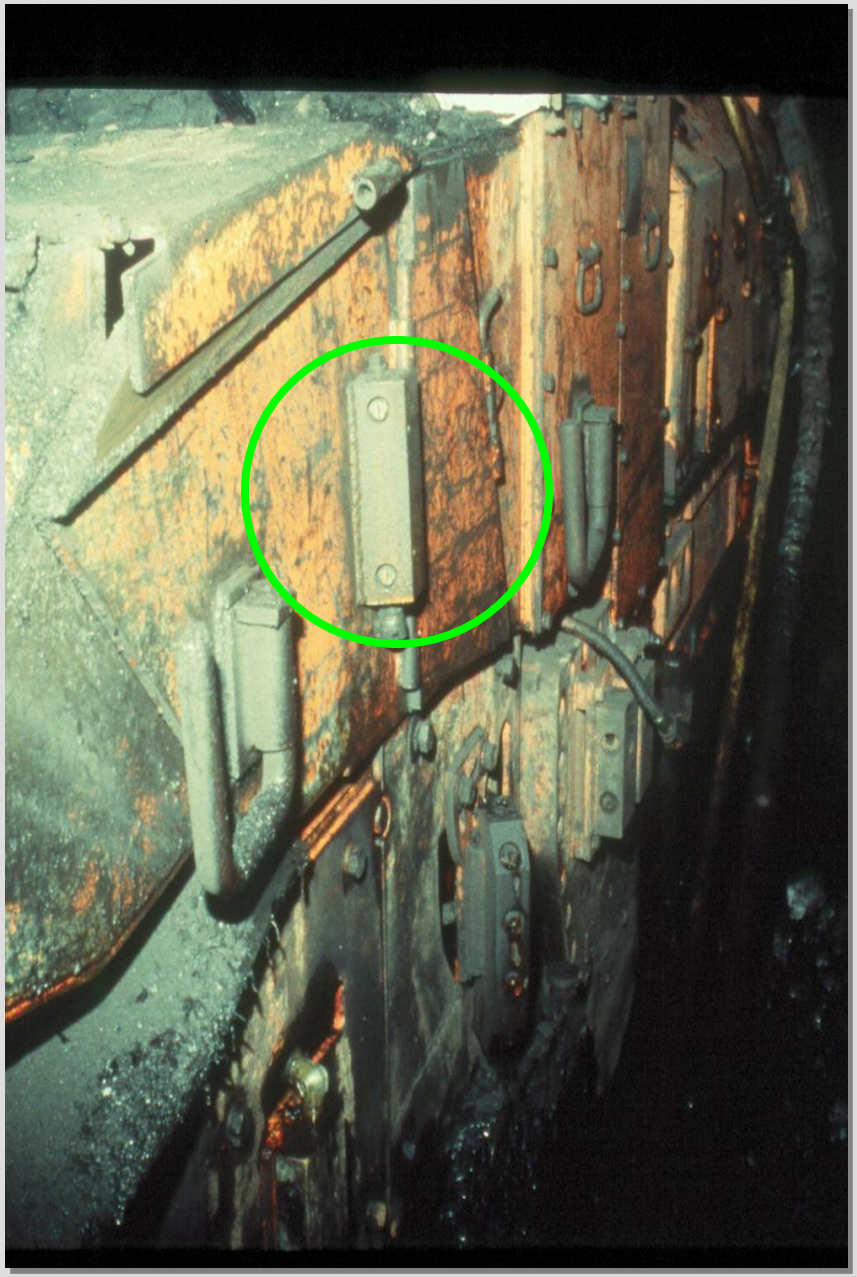
Spray Fan System

- Exhausting Ventilation
- 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

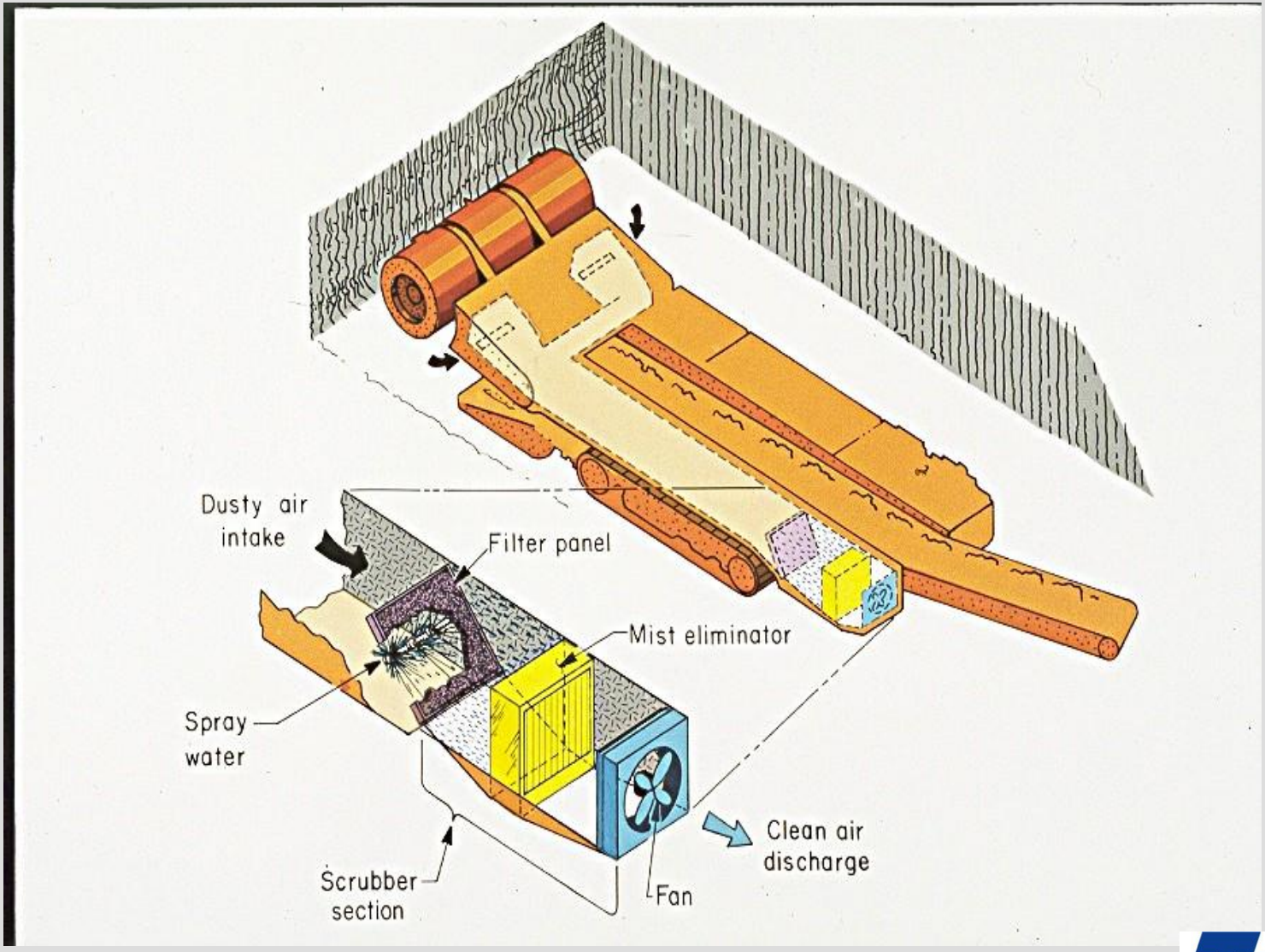
Spray Nozzle Flow Comparisons

Hahn vs Spraying Systems Nozzles

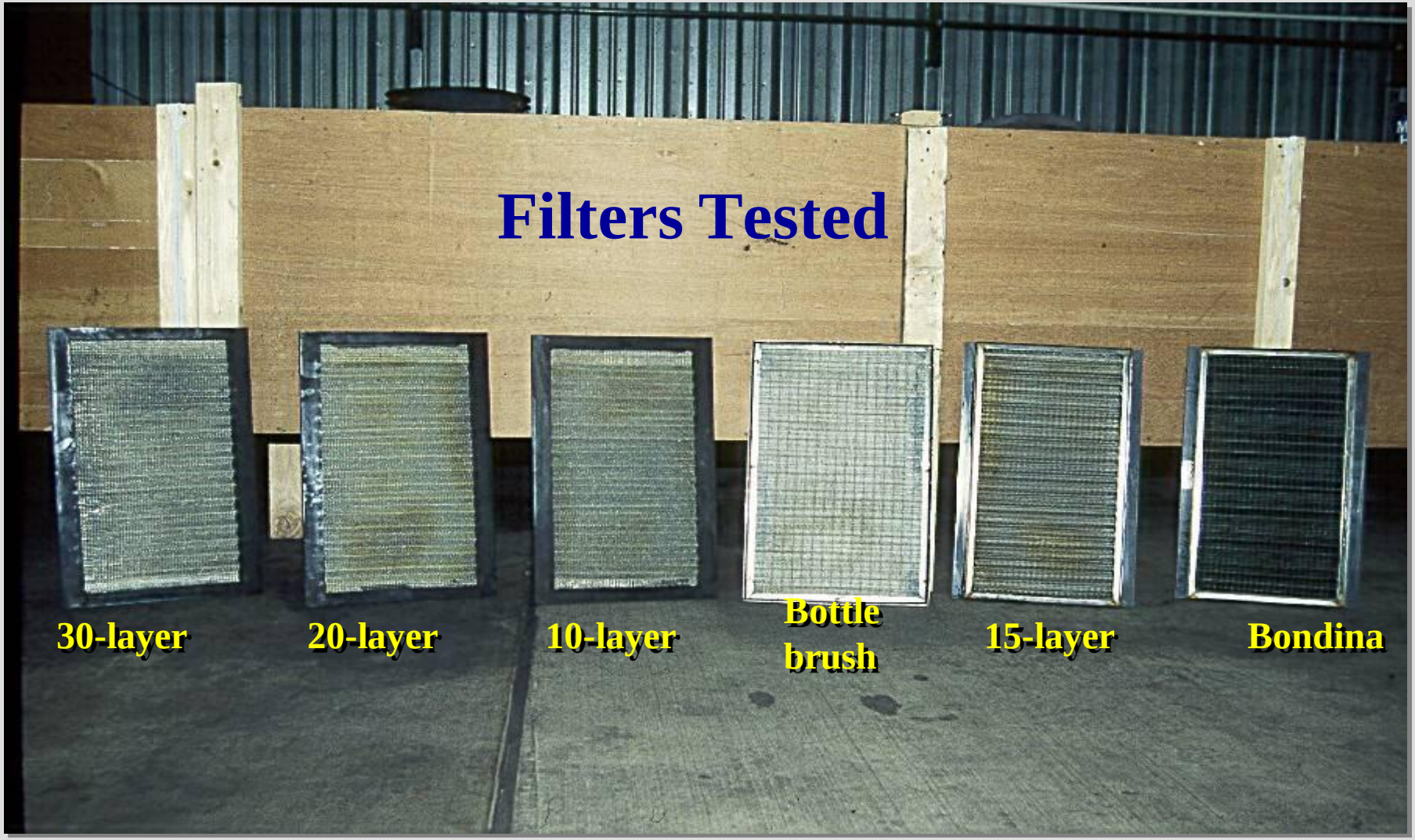
- **Hahn 3-3 equivalent to BD-3**

- **Hahn 3-5, 24% less than BD-5**

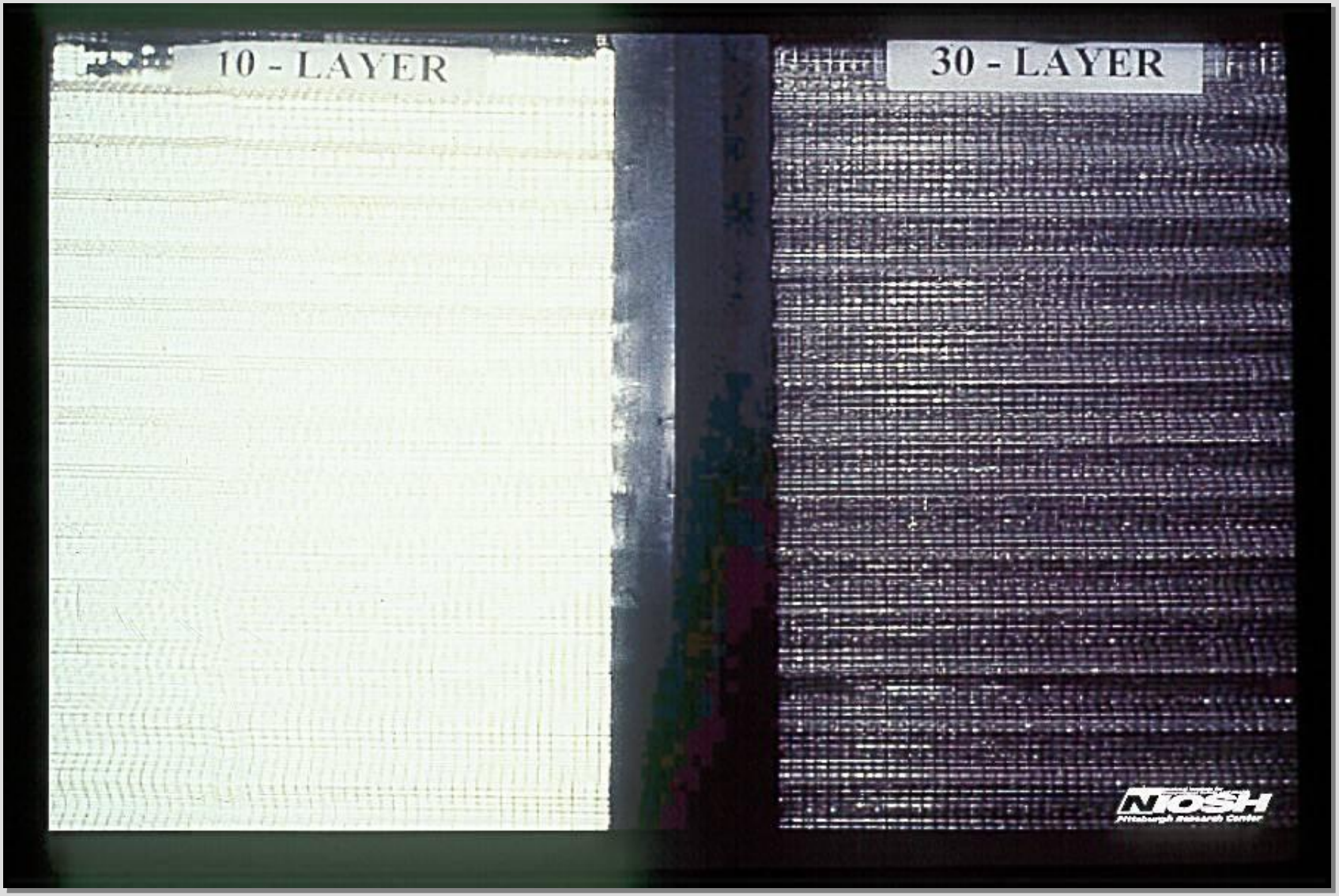
Flooded-bed Scrubbers Capture and Remove Airborne Dust



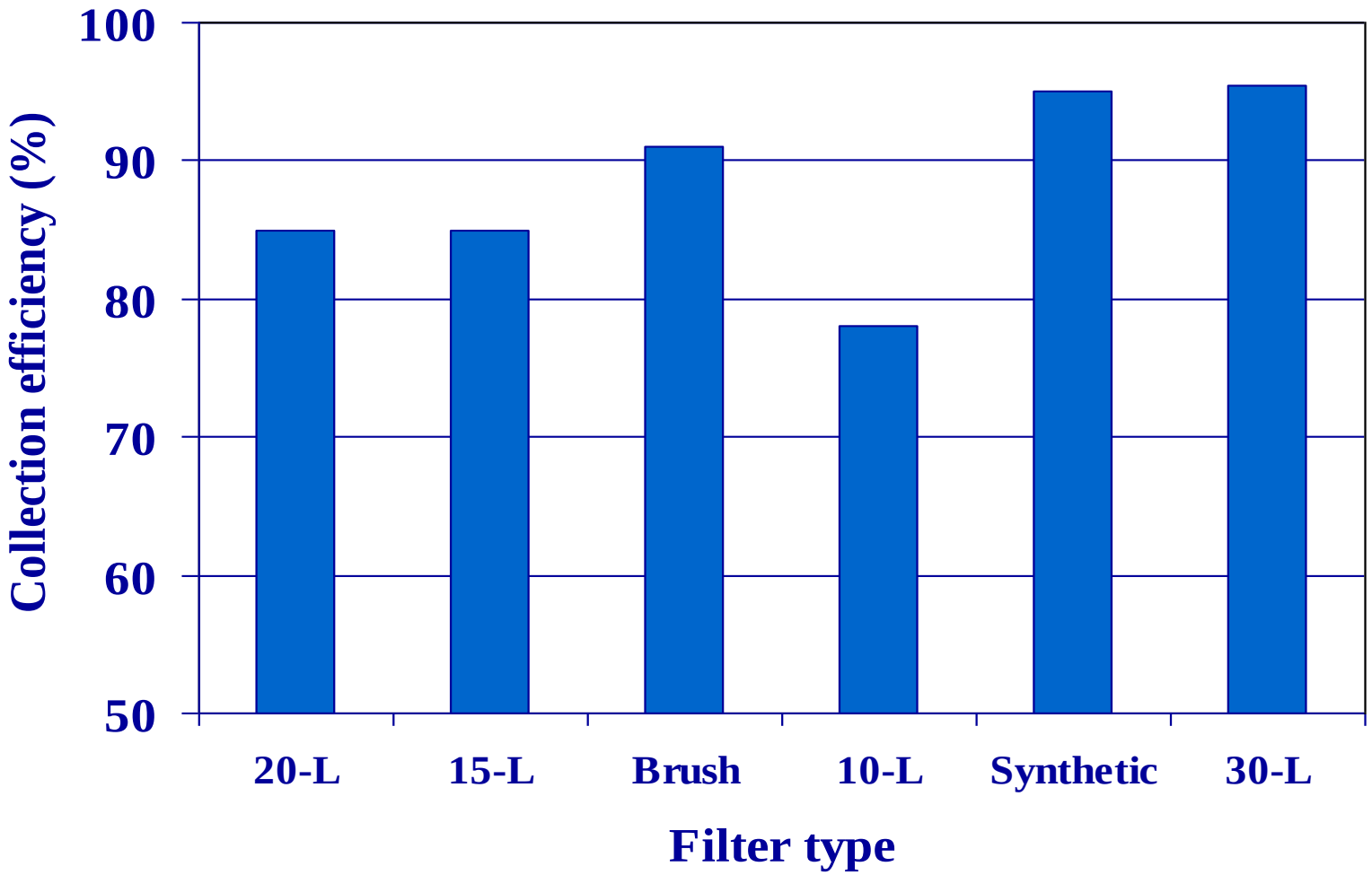
Scrubber Filter Study



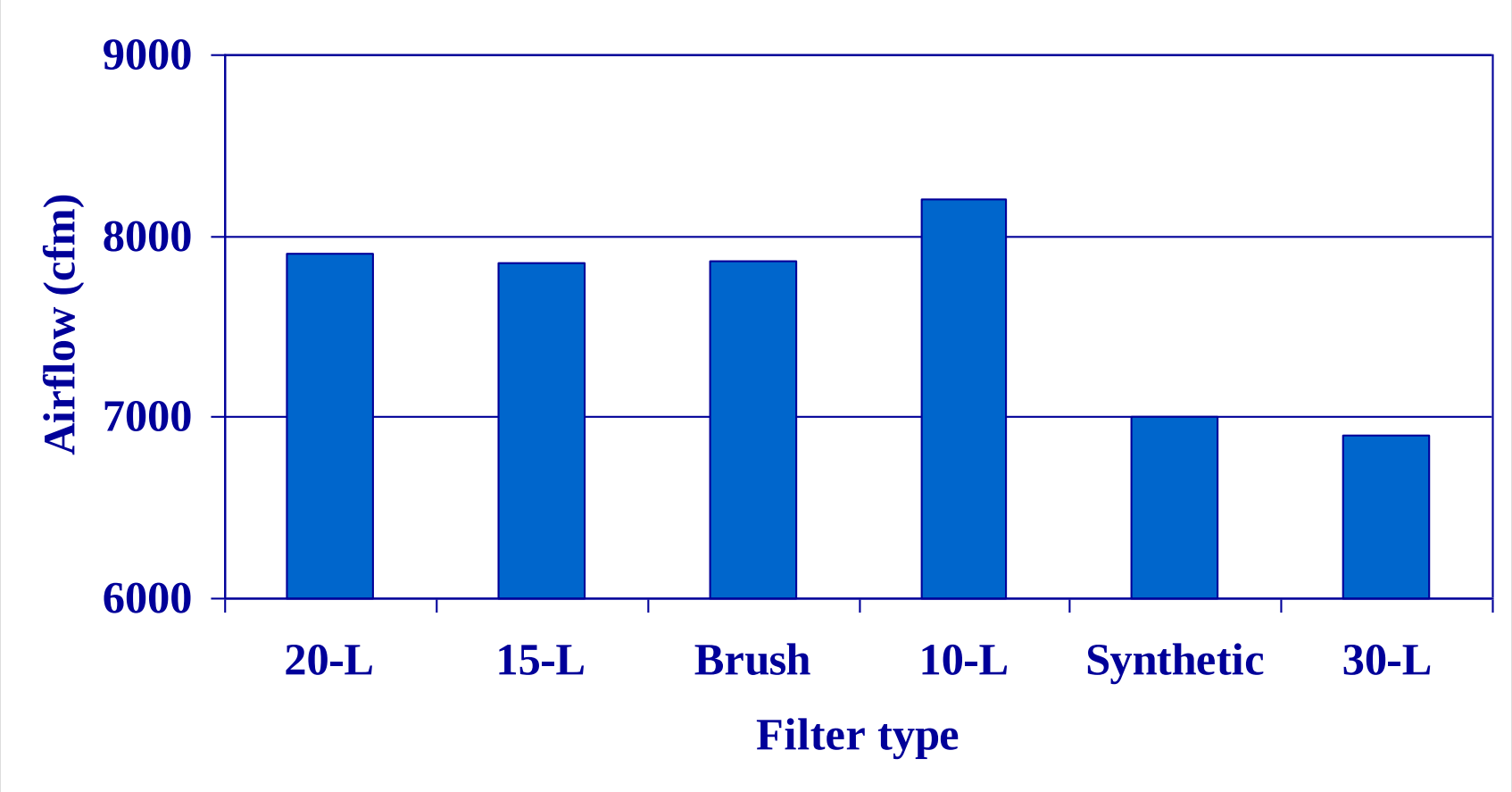
10 vs 30 Layer Filters



Respirable Quartz Collection Efficiencies



Air Quantity Measured With Each Filter Panel



Scrubber Efficiency

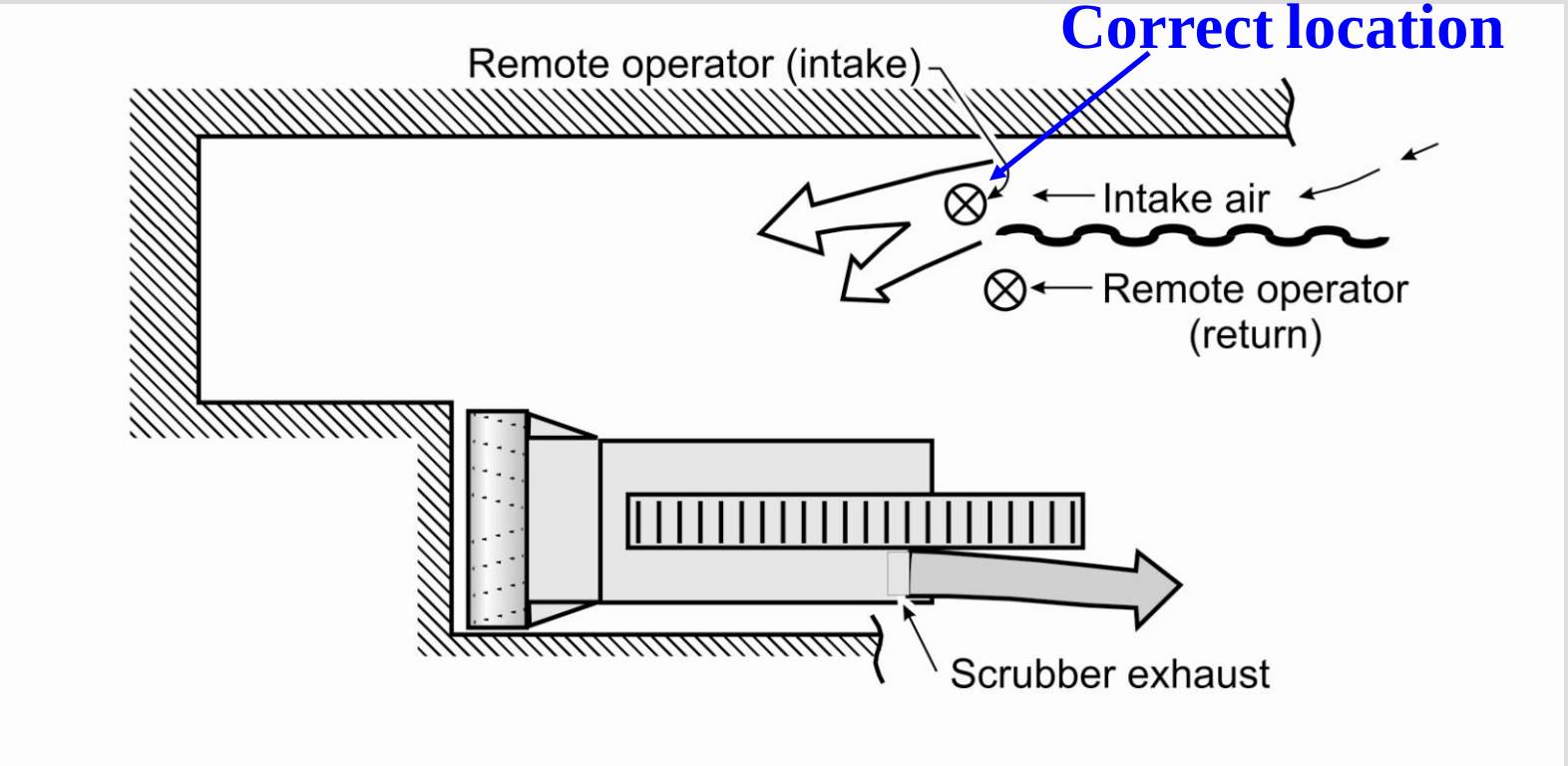
- Scrubbers can lose 1/3 of airflow after one cut
- Check air velocity with pitot tube
- Most common loss of efficiency due to filter panel clogging.

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



Blowing Ventilation

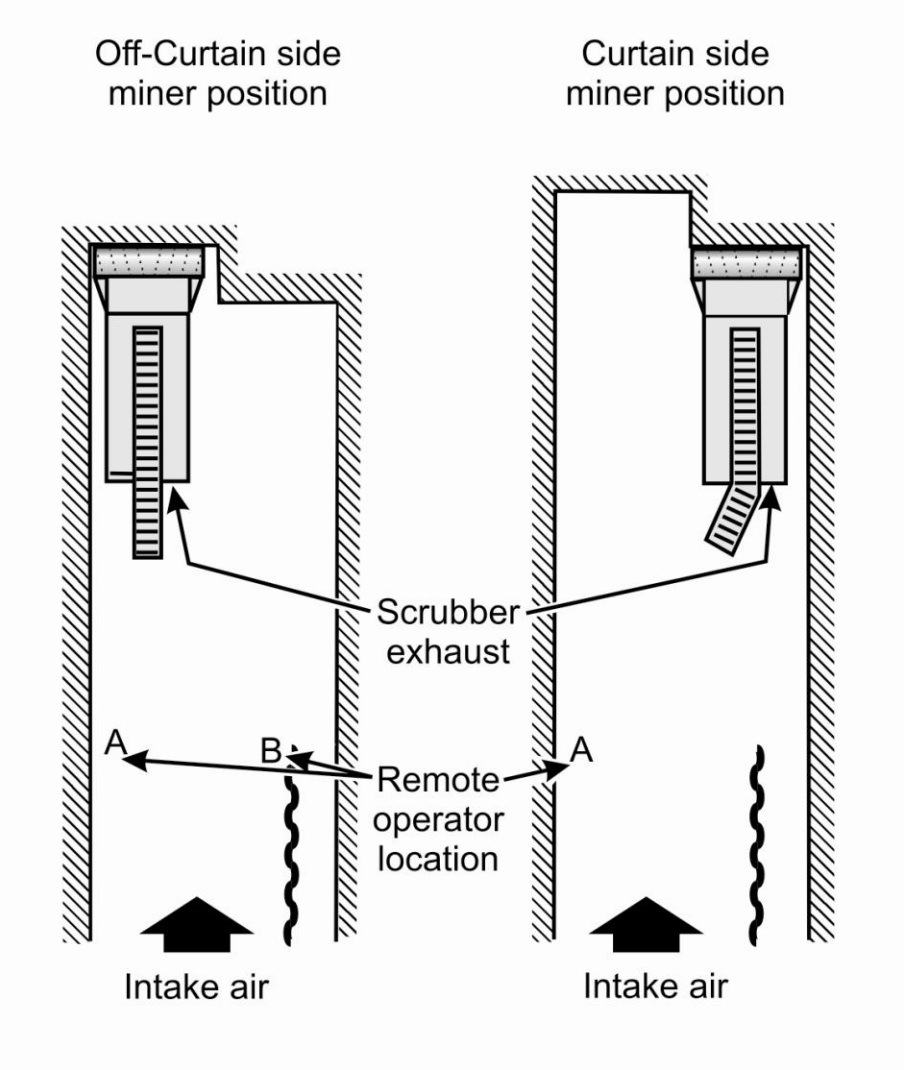
- **Advantages**
  - **Greater penetration to face > 800 fpm**
  - **Effectively sweeps dust and methane from the face**
  - **Easier to maintain than exhaust**
- **Disadvantages**
  - **Restricts operator movement**
  - **Shuttle car operators must work in return air**
  - **Incorrect air balance may cause recirculation or overpowering**

Blowing Ventilation

Recommendations

- Airflow at end of curtain should match or be no more than 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



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**

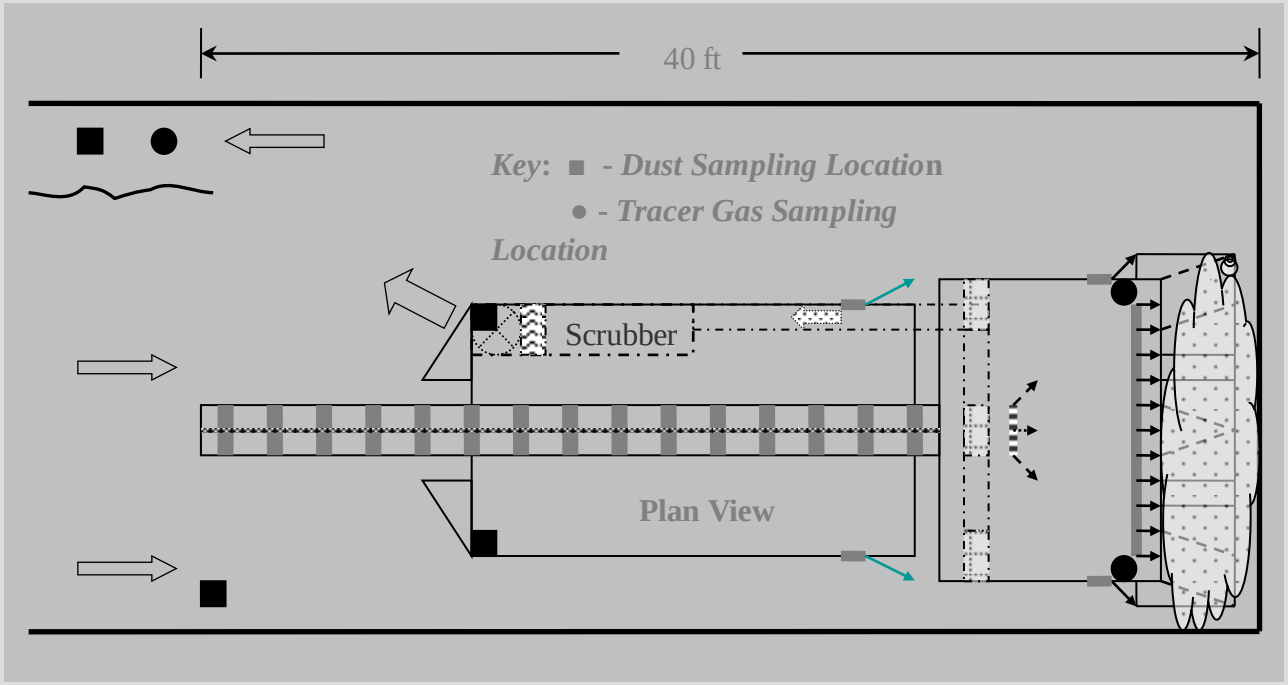
Exhausting Ventilation
Recommendations

- 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
- Exhaust curtain airflow should exceed scrubber airflow.

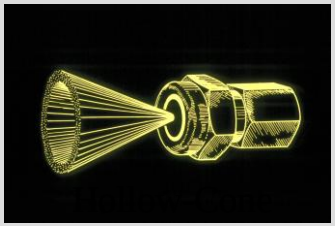
Spray system optimization

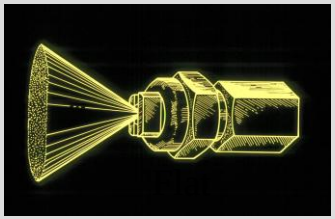
Continuous Miner Gallery Testing

Exhaust Ventilation with Flooded-Bed Scrubber



2 Spray Types





Test Factors: Spray pressure (80psi – 160 psi)
Blocking Sprays (Off – On)
Scrubber Flow (Max. – Reduced 20%)

Spray system optimization
Results – Optimal Dust & Gas Results

- **Position – Off curtain location**
- **Spray Type – Hollow Cone**
- **Spray Pressure – 80 psi**
- **Blocking Sprays – Yes**
- **Scrubber airflow – Maximum**

Continuous Miner Dust Control
Wethead Cutter Drum

Locates water sprays directly behind each bit on the cutter head at point of attack

Courtesy of Joy Mining Machinery

- 62 to 73 sprays on head
- 25-30 gpm at 100psi
- Solid or hollow cone sprays

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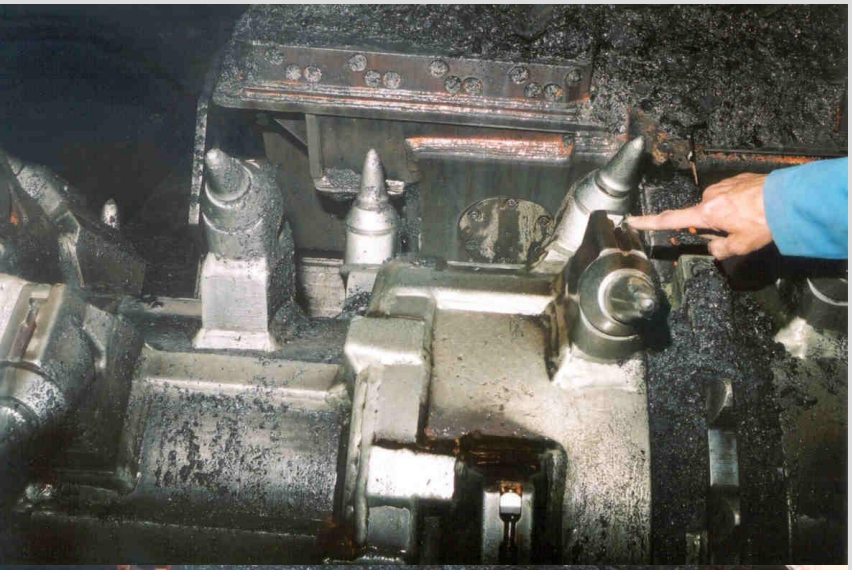
Wethead vs Standard Sprays



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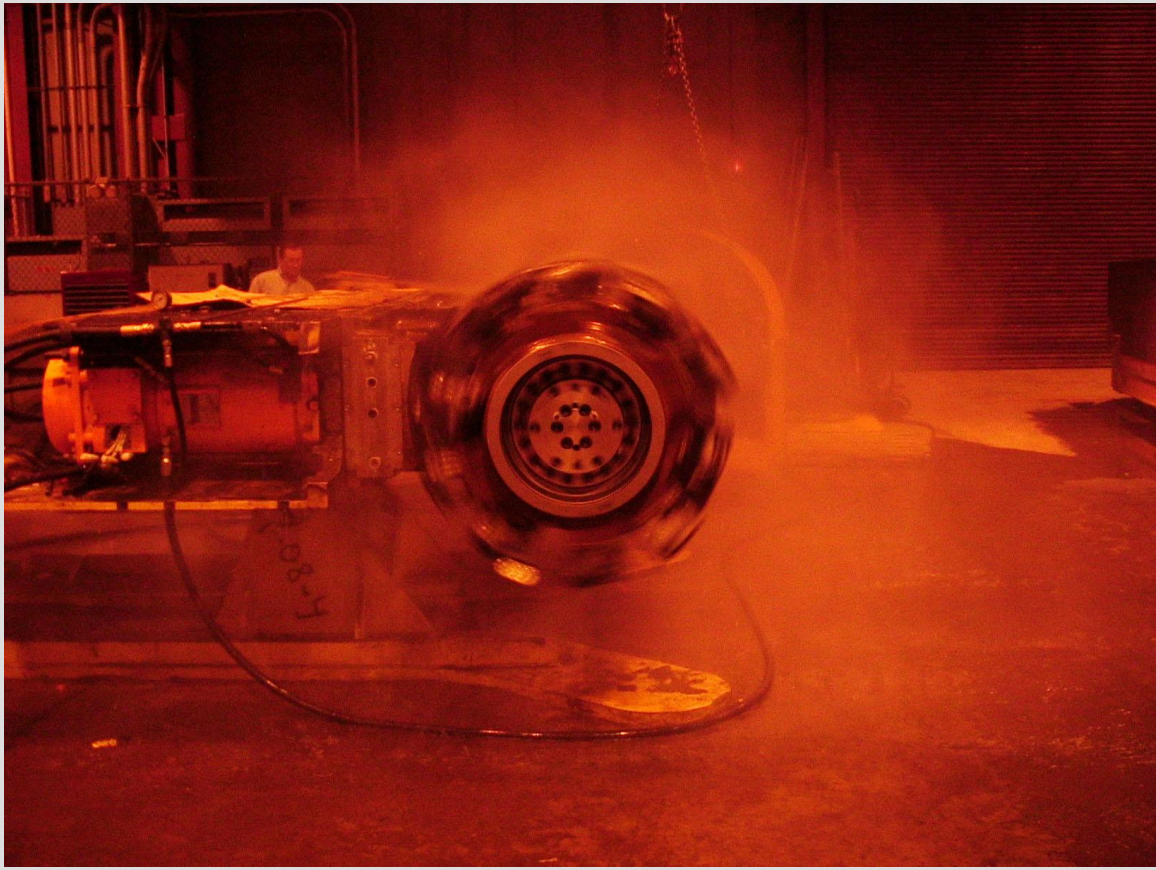
Background

- Bureau of Mines
- South Africa
- MSHA
- SIU
- NIOSH



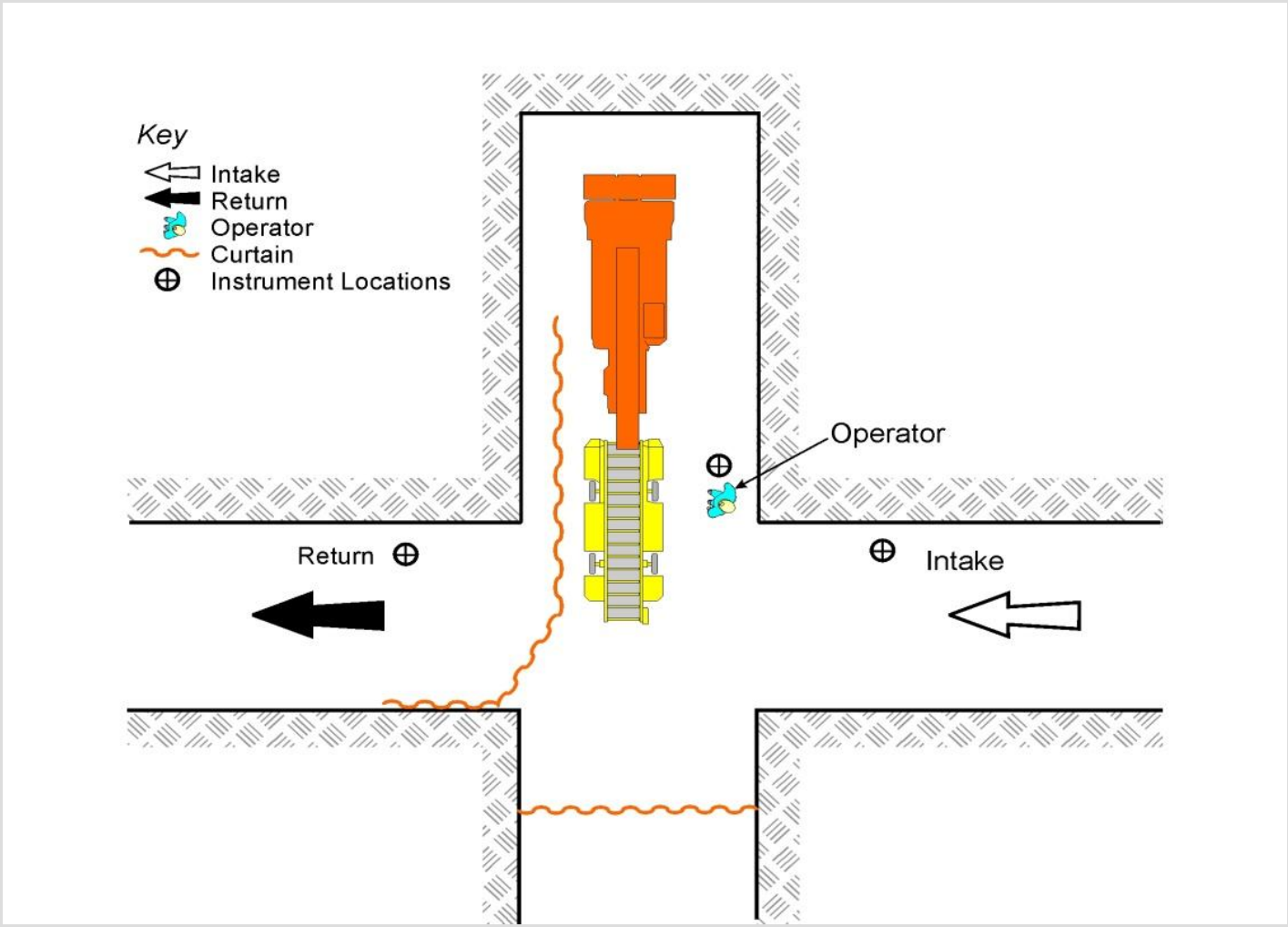
Wethead Benefits

- Bit cooling - reduce frictional ignitions
- Increase bit life
- No increase in water consumption
- Potential to reduce respirable dust

Research Methods

- Five mine study compares wethead CM to standard spray CM
- Kentucky, Illinois, Virginia, West Virginia

Sampling Methods



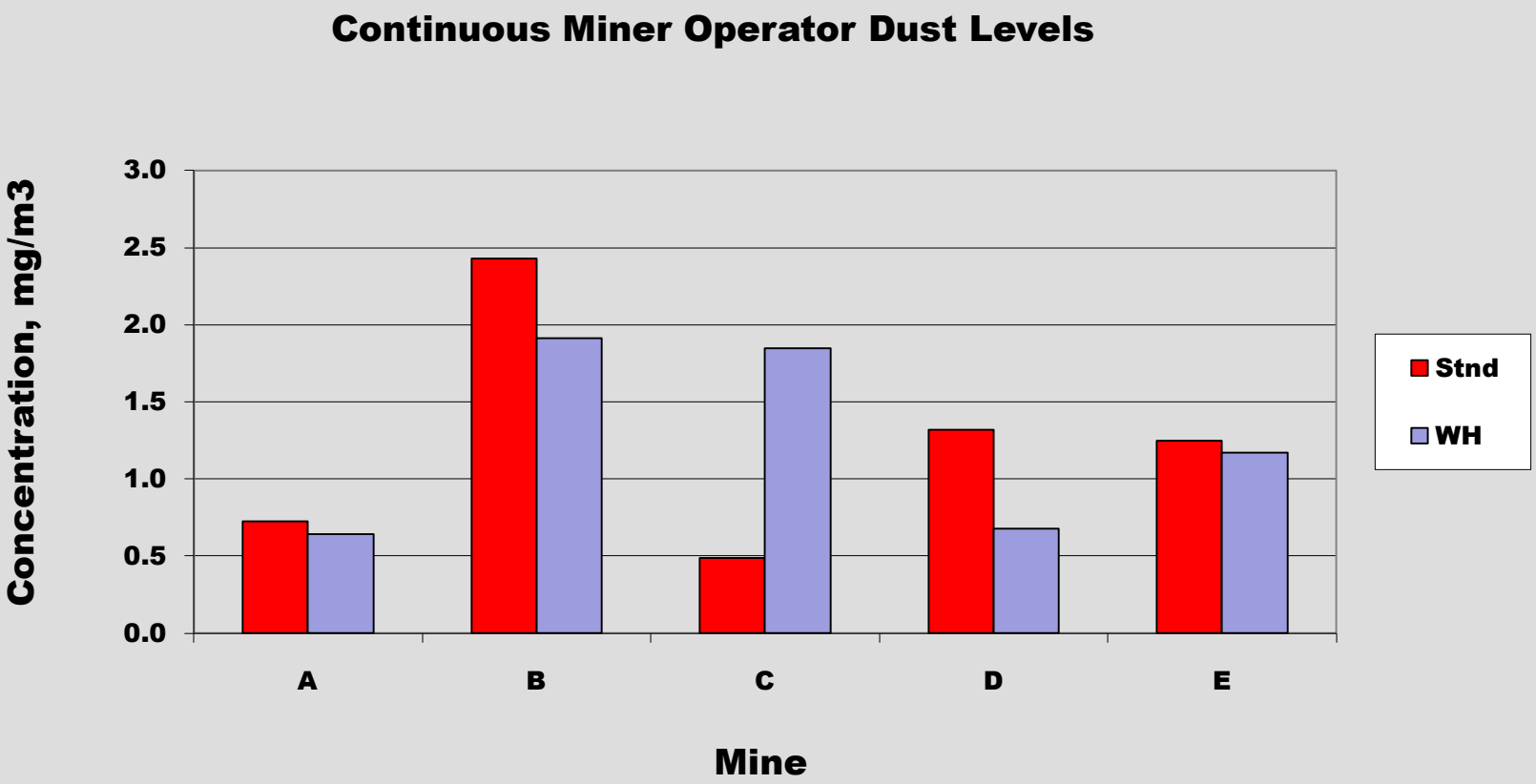
Data Analysis

- Normalized for production
- Compare operator exposure
- Compare return concentrations
- Return quartz concentrations

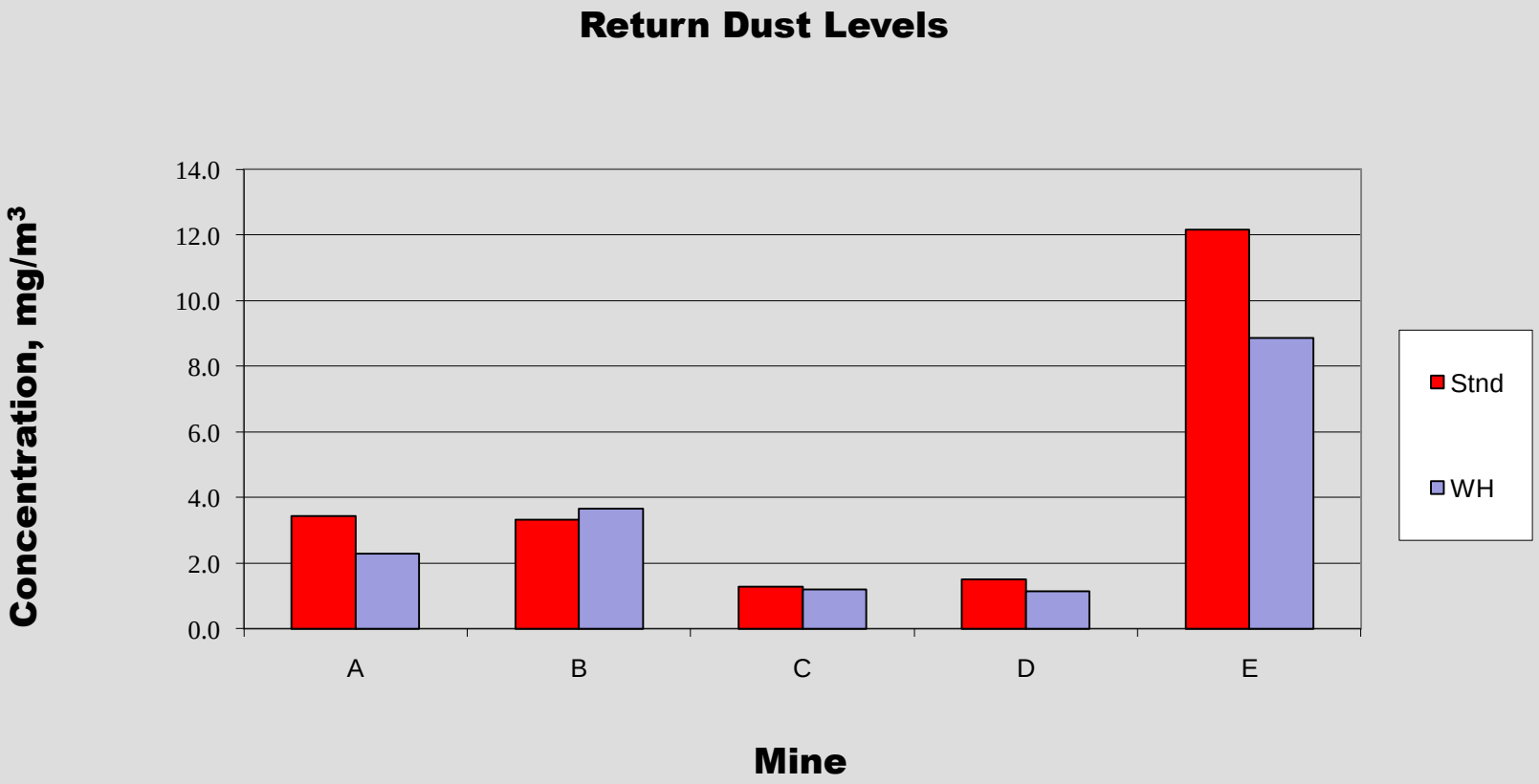
Section Parameters

	Mine A	Mine B	Mine C	Mine D	Mine E
Ventilation	Blowing	Exhausting	Blowing	Blowing	Exhausting
Section	Super sect.	Single	Super sect.	Single	Single
Scrubber	Yes	Yes	Yes	Yes	No

All Mines - CM Operator



All Mines - Return



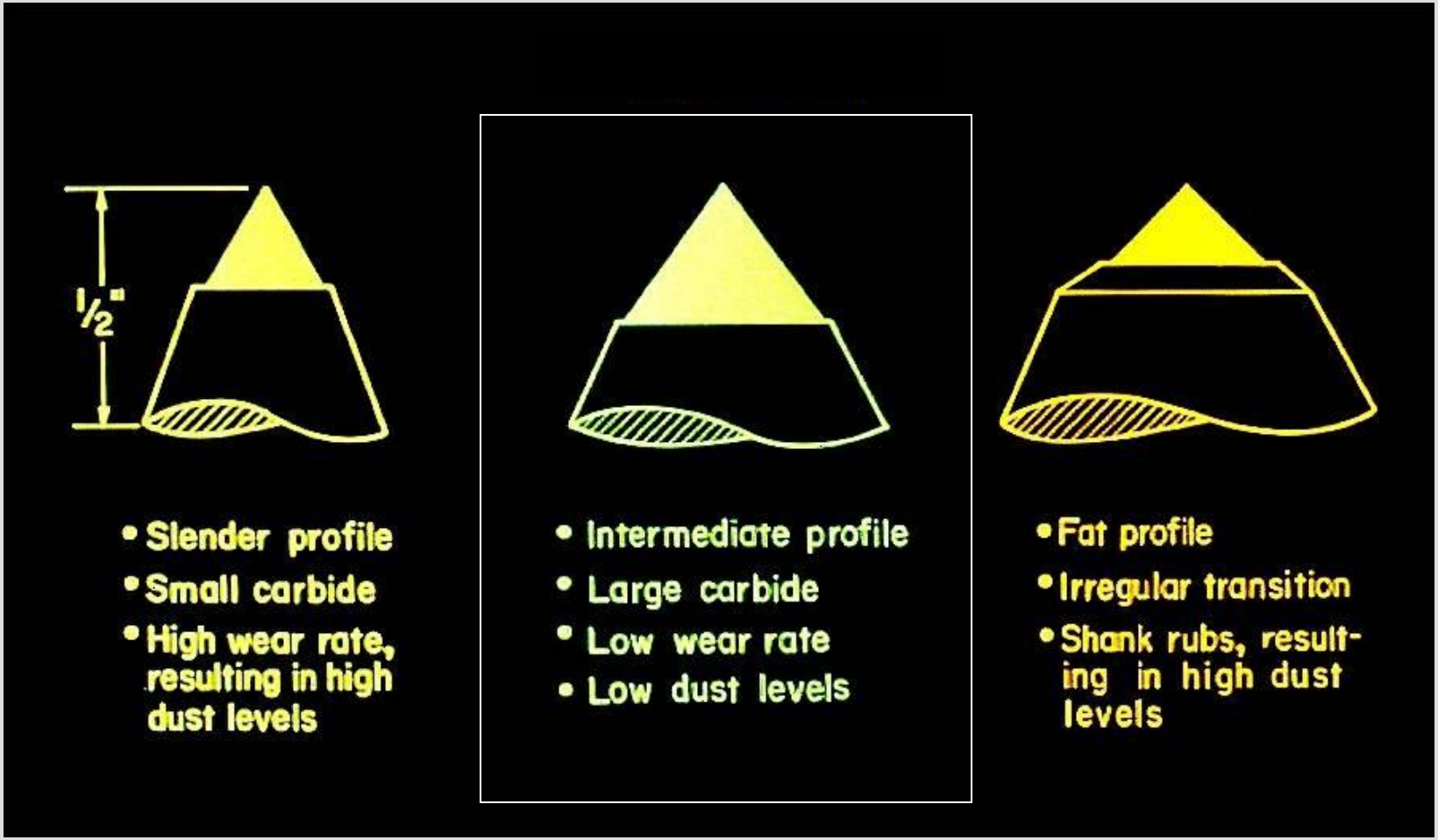
Summary

- **Dust reduction in return with exhausting ventilation without scrubber**
- **Moderate to small reductions at the CM operator**
- **Quartz dust reduction variable**
- **Increased visibility**
- **Operator acceptance**

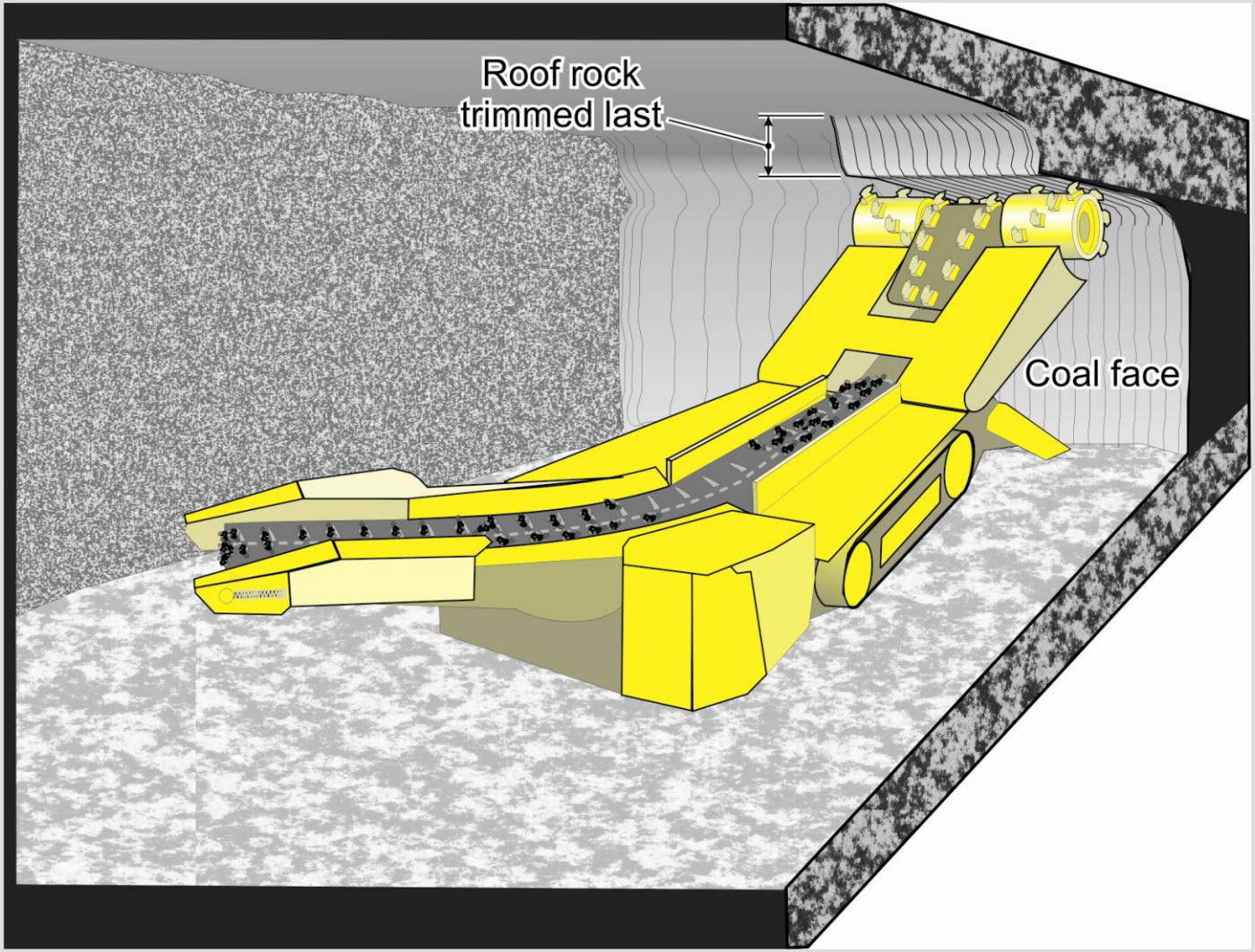
Other Considerations

- **Bit Design**
- **Cutting Roof Rock**

Bit Designs


1/2"
• 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

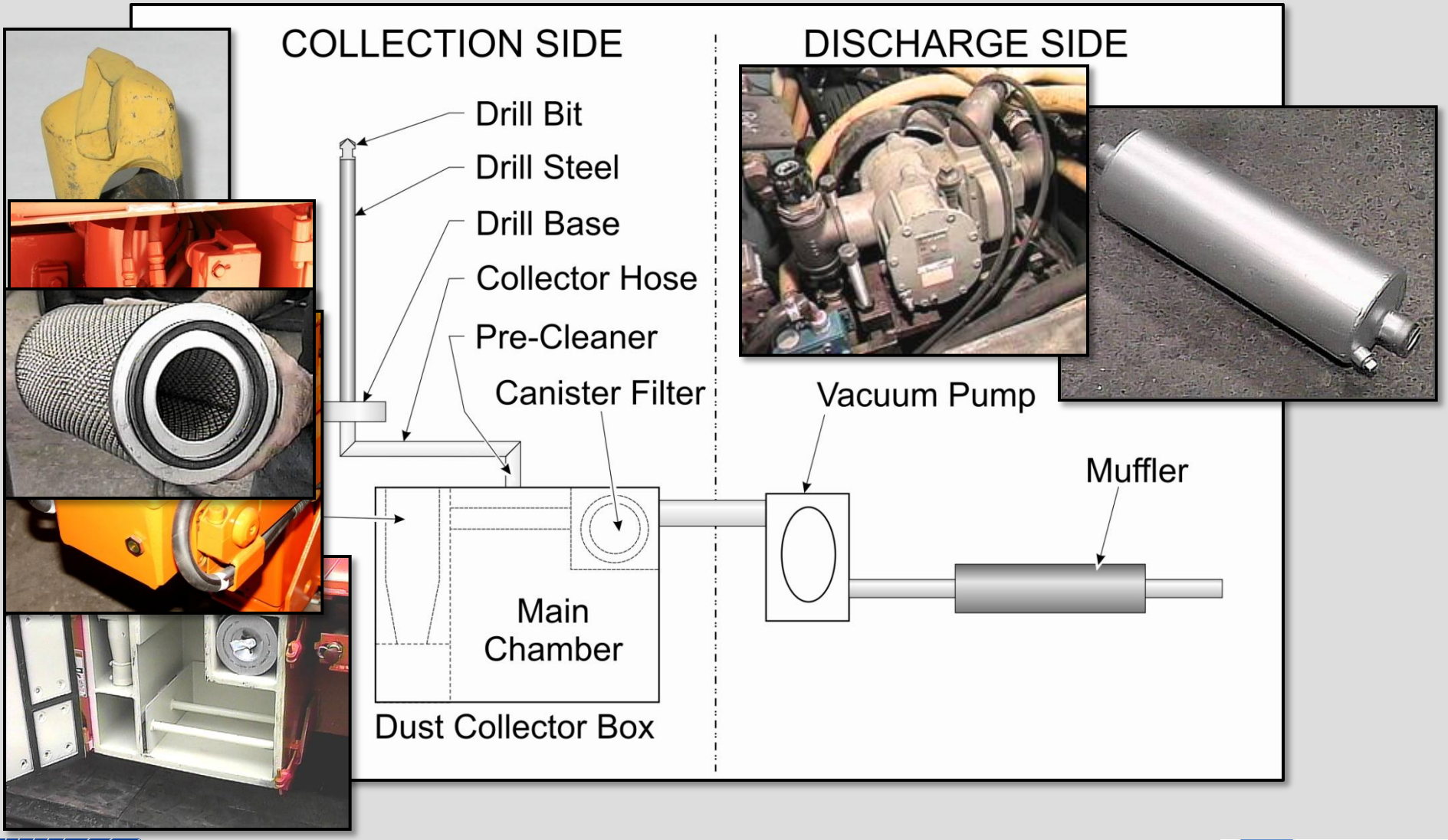


Roof Bolter Dust Control

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

Roof Bolter Dust Collector



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?

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Discharge Contamination

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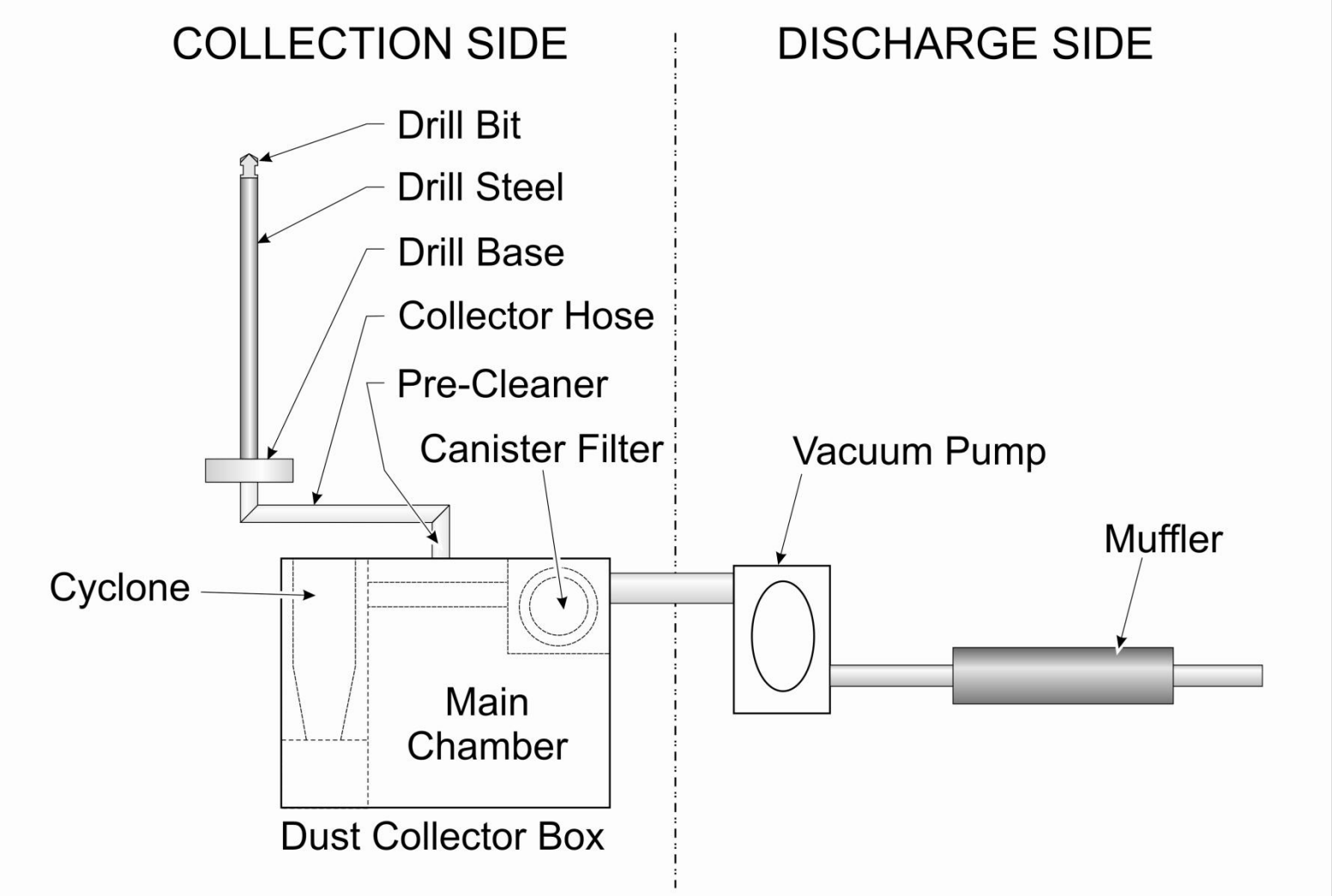
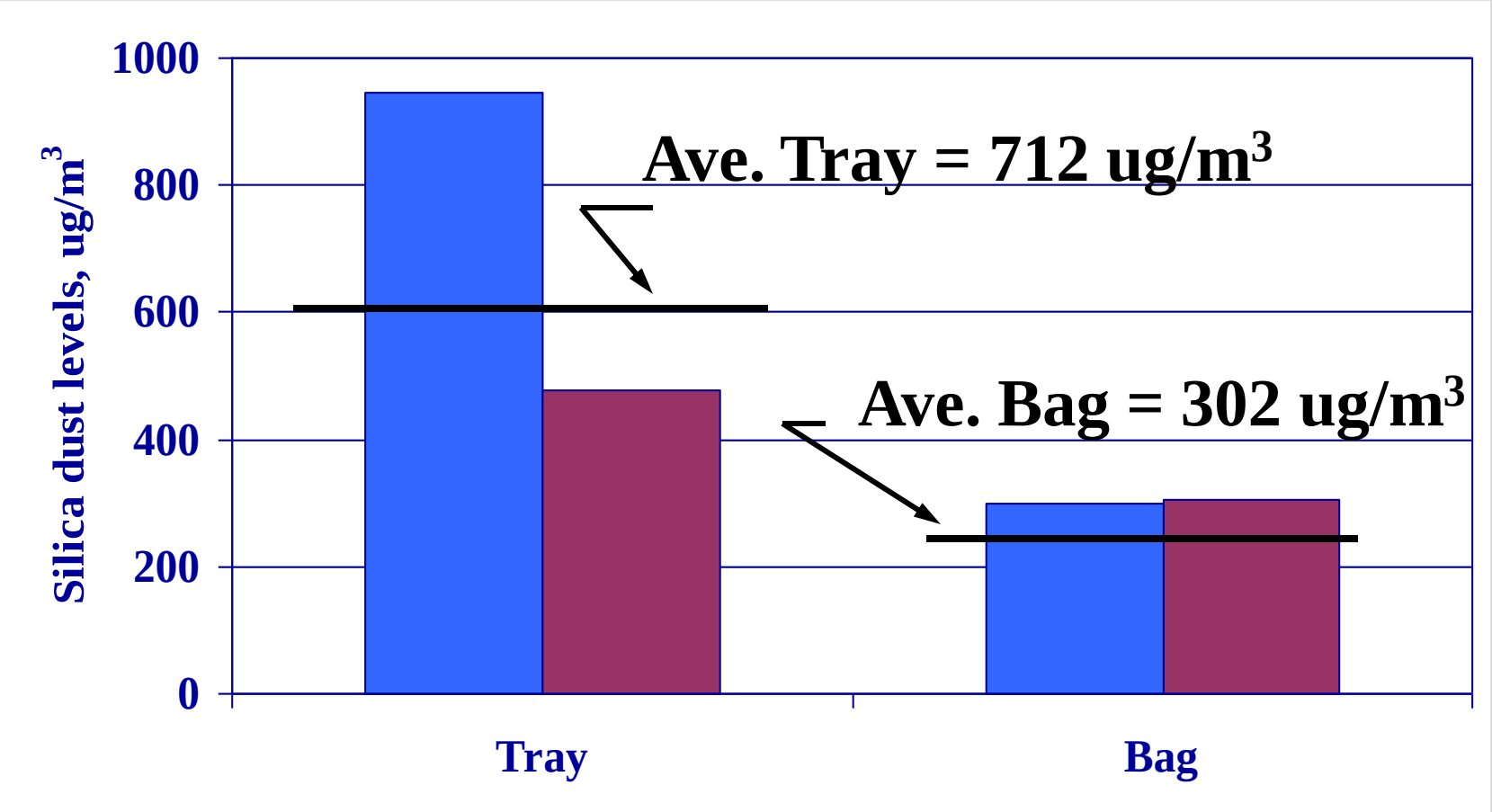
Dust Collector Components



Reusable Brattice Bag Controls Dust During Box Cleaning

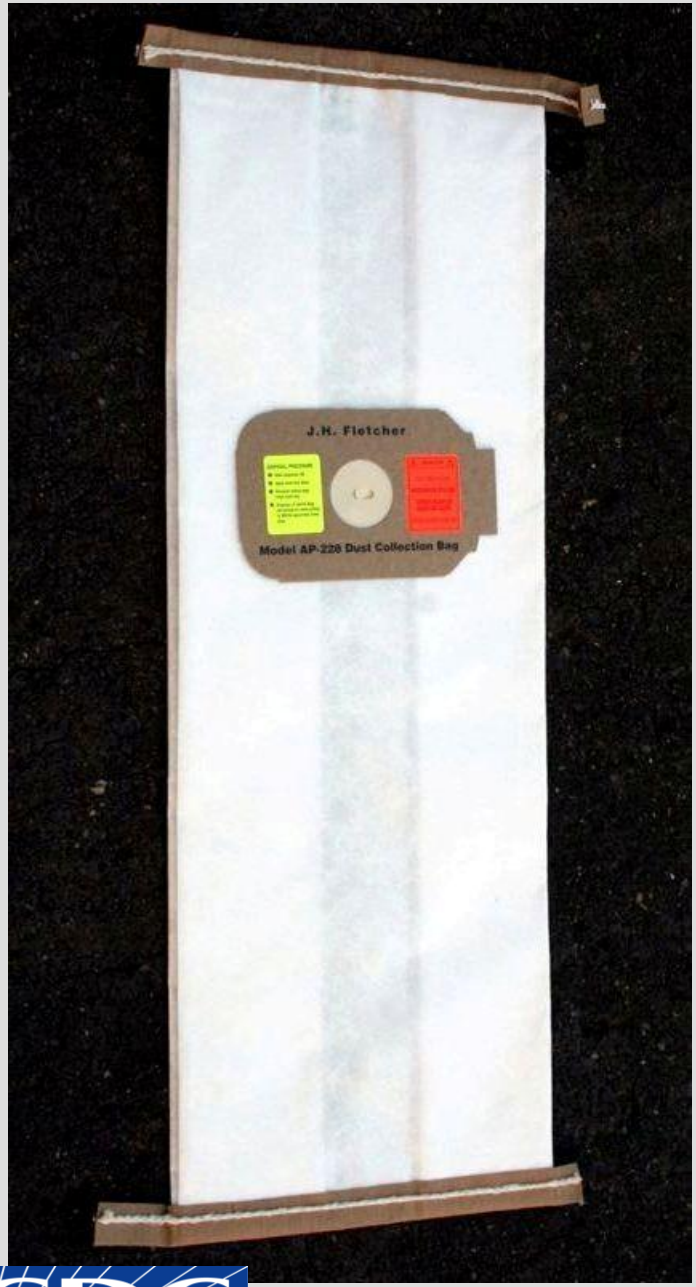
- Bag fills with dust during bolting
- Dump bag against rib
- Controls silica exposure

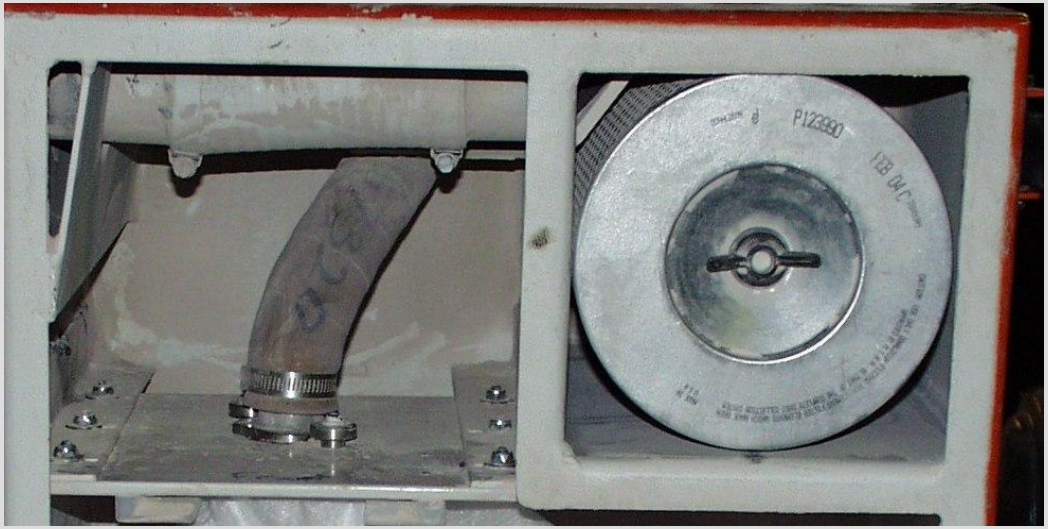
Silica Dust Levels When Cleaning Dust Box

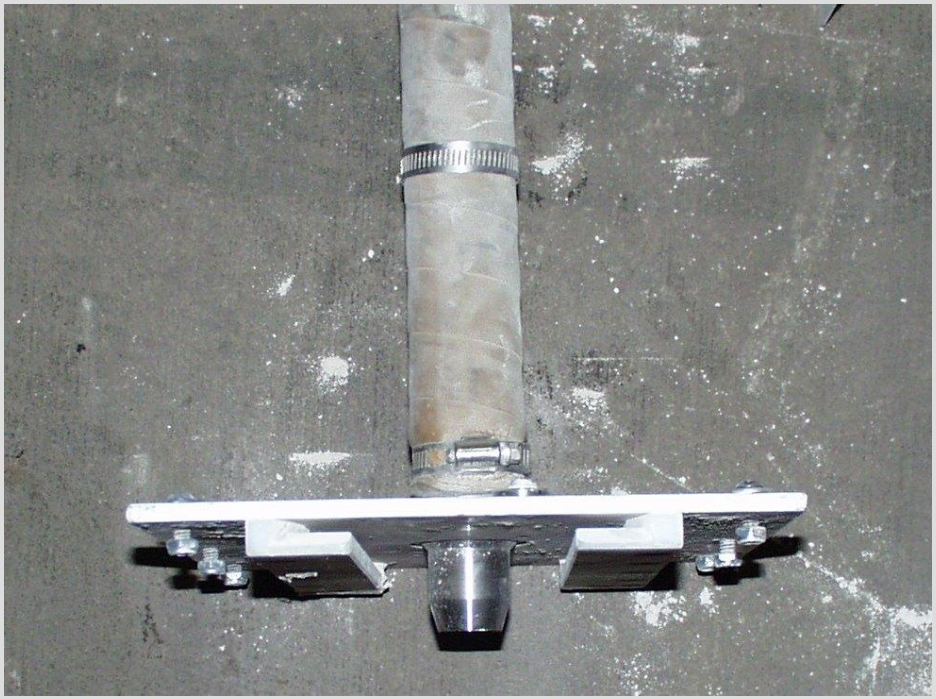


Disposable Collector Bag

- 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







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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

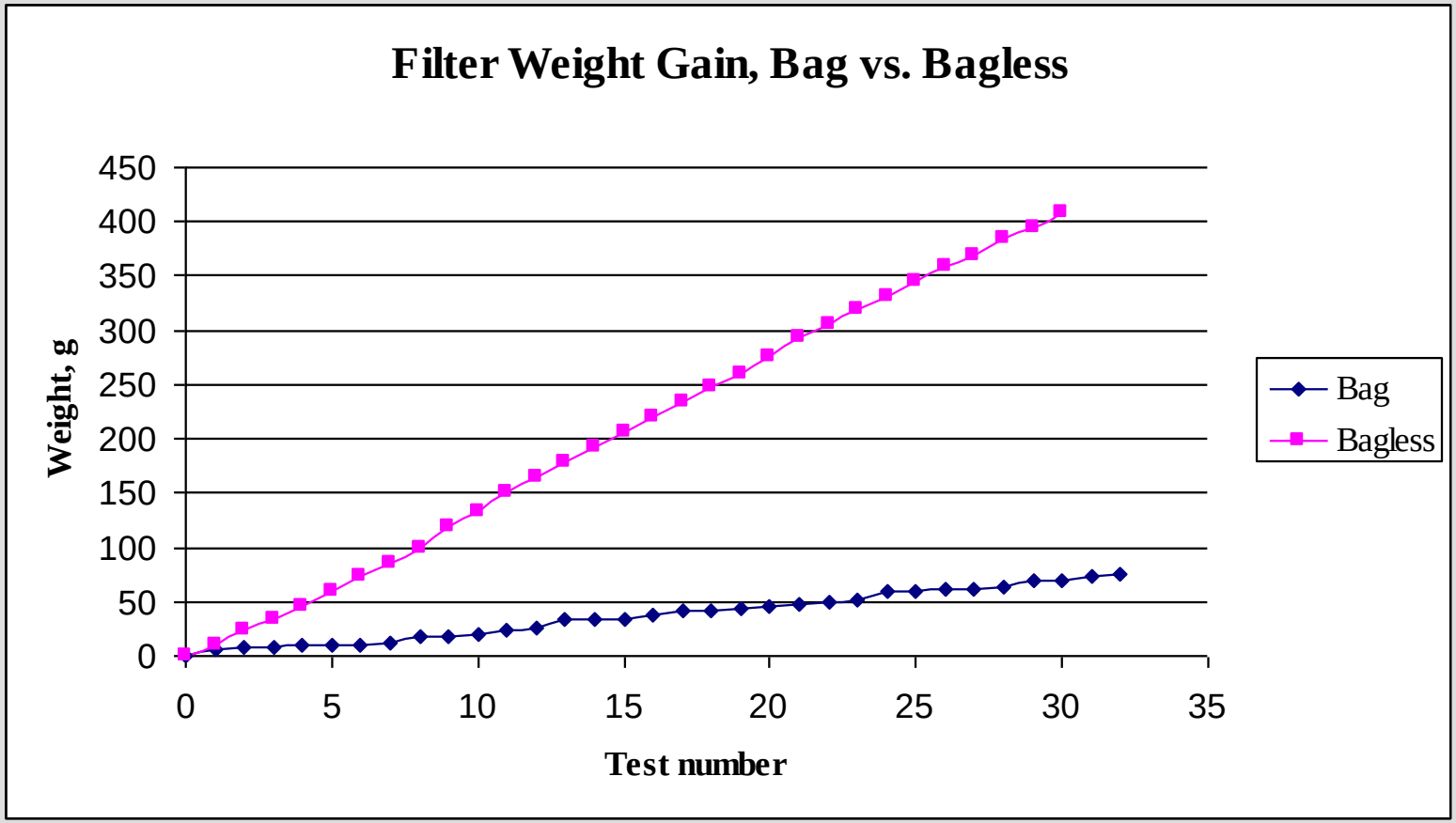
After

Collector Box Tests With Bag

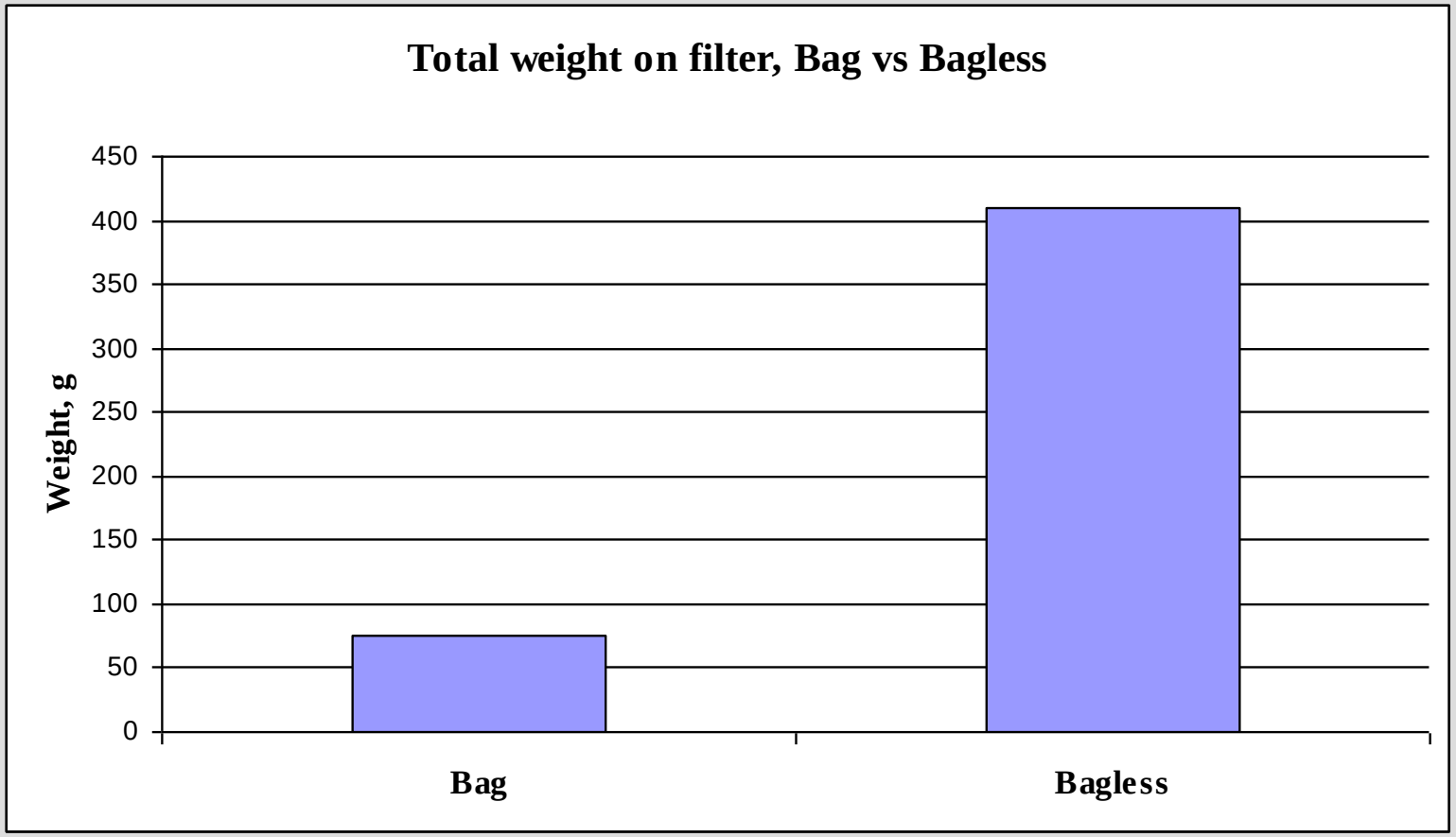
Before

After

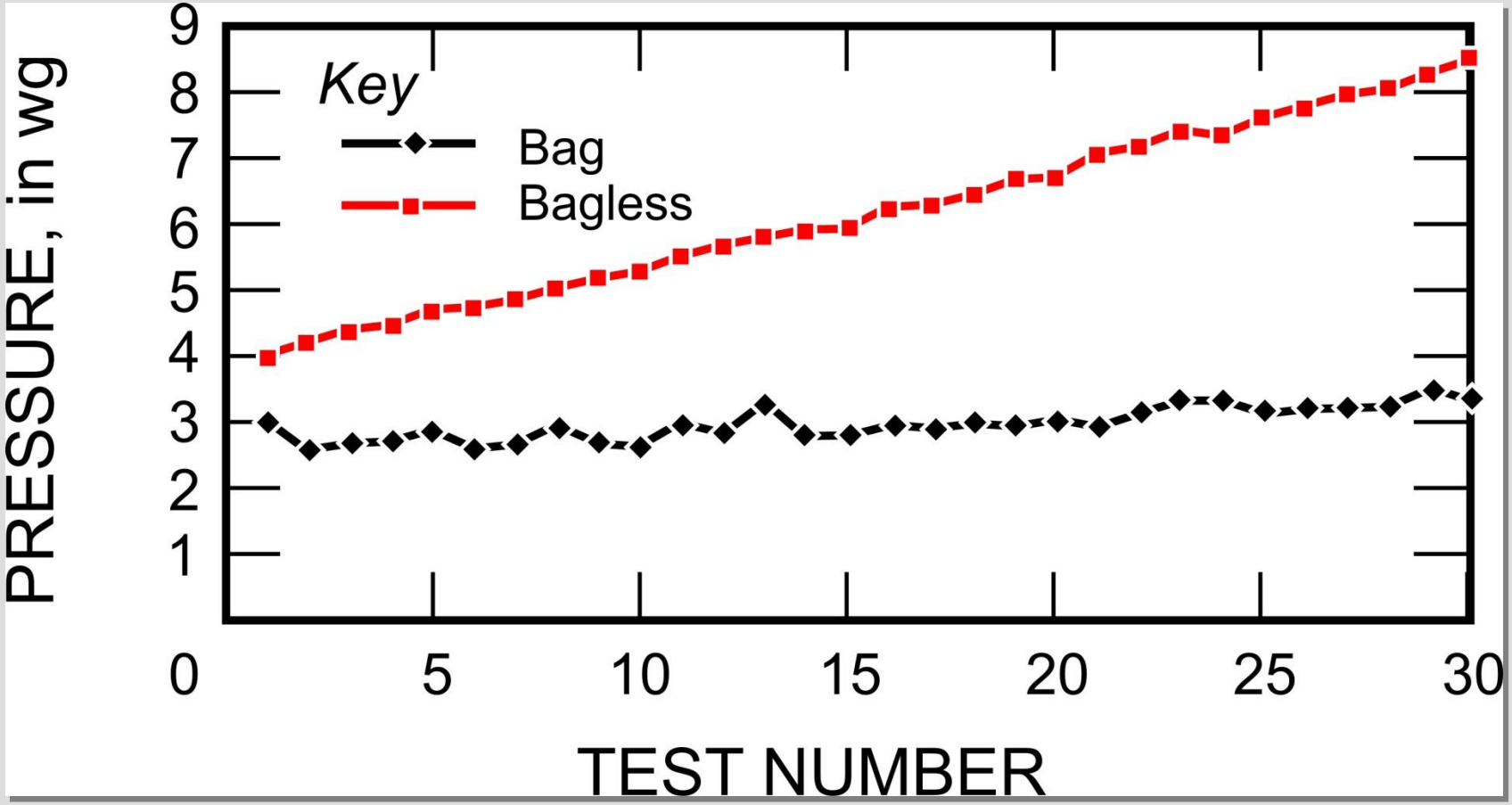
Filter Weight Gain per Test



Total Filter Loading



Pressure Drop Across Filter



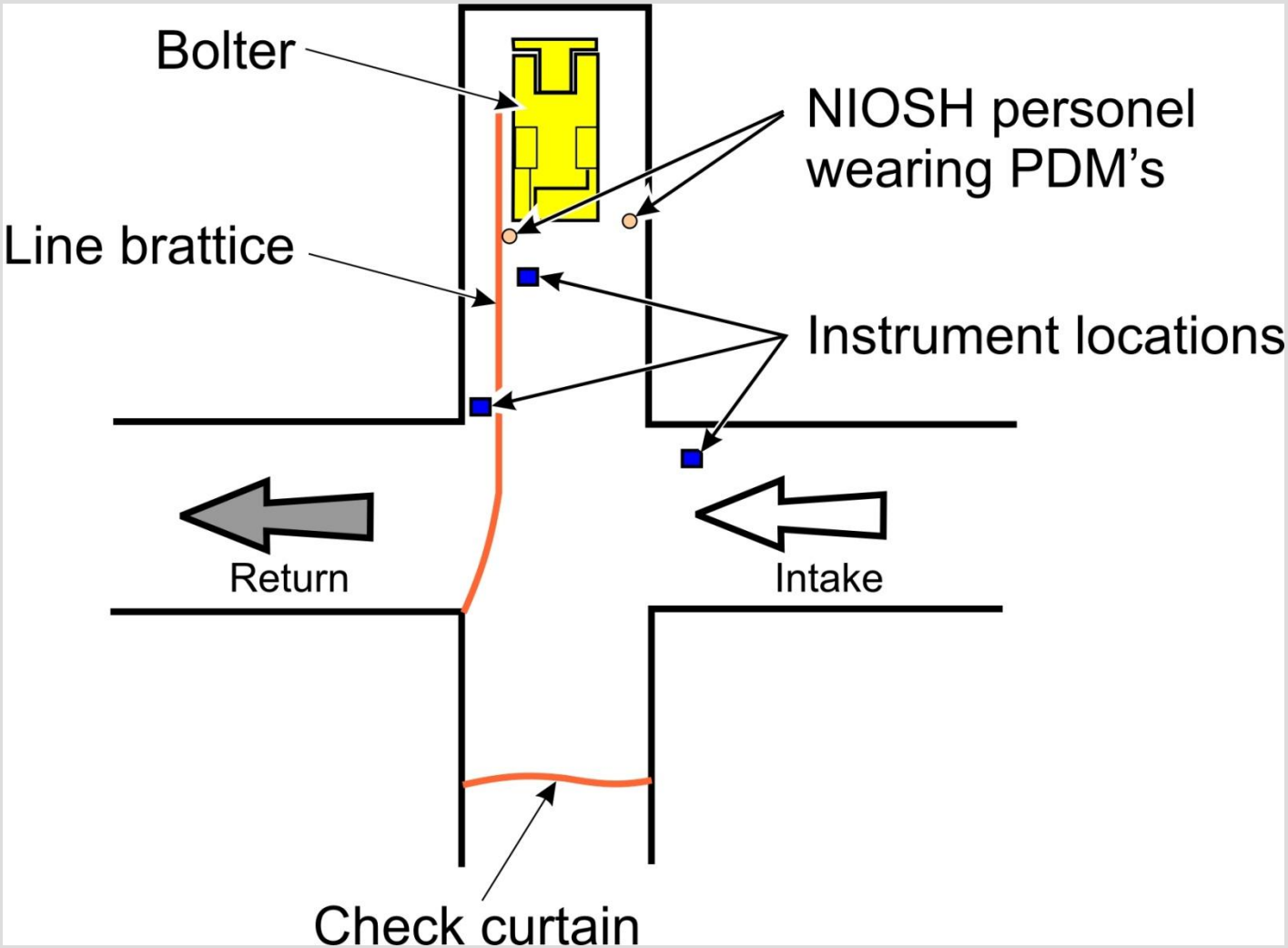
Lab Results Summary

- Avg of 99.6% of feed dust contained in collector bag
- Dust concentration in exhaust: 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

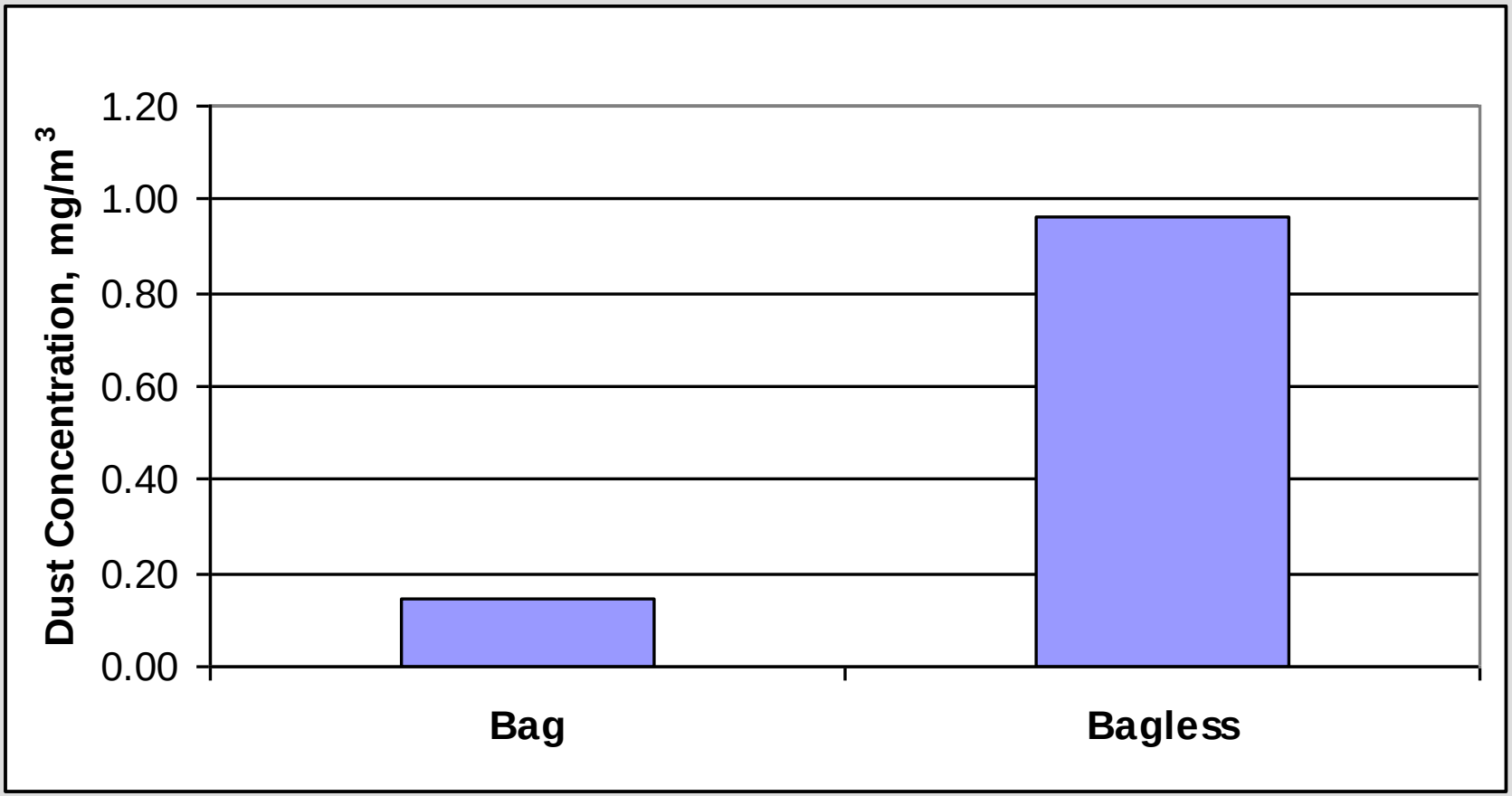
Bolter Bag Field Study

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

Instrument Locations



Gravimetric Sample Results
Collector Emissions



CDC Centers for Disease Control and Prevention

NIOSH

Field Results

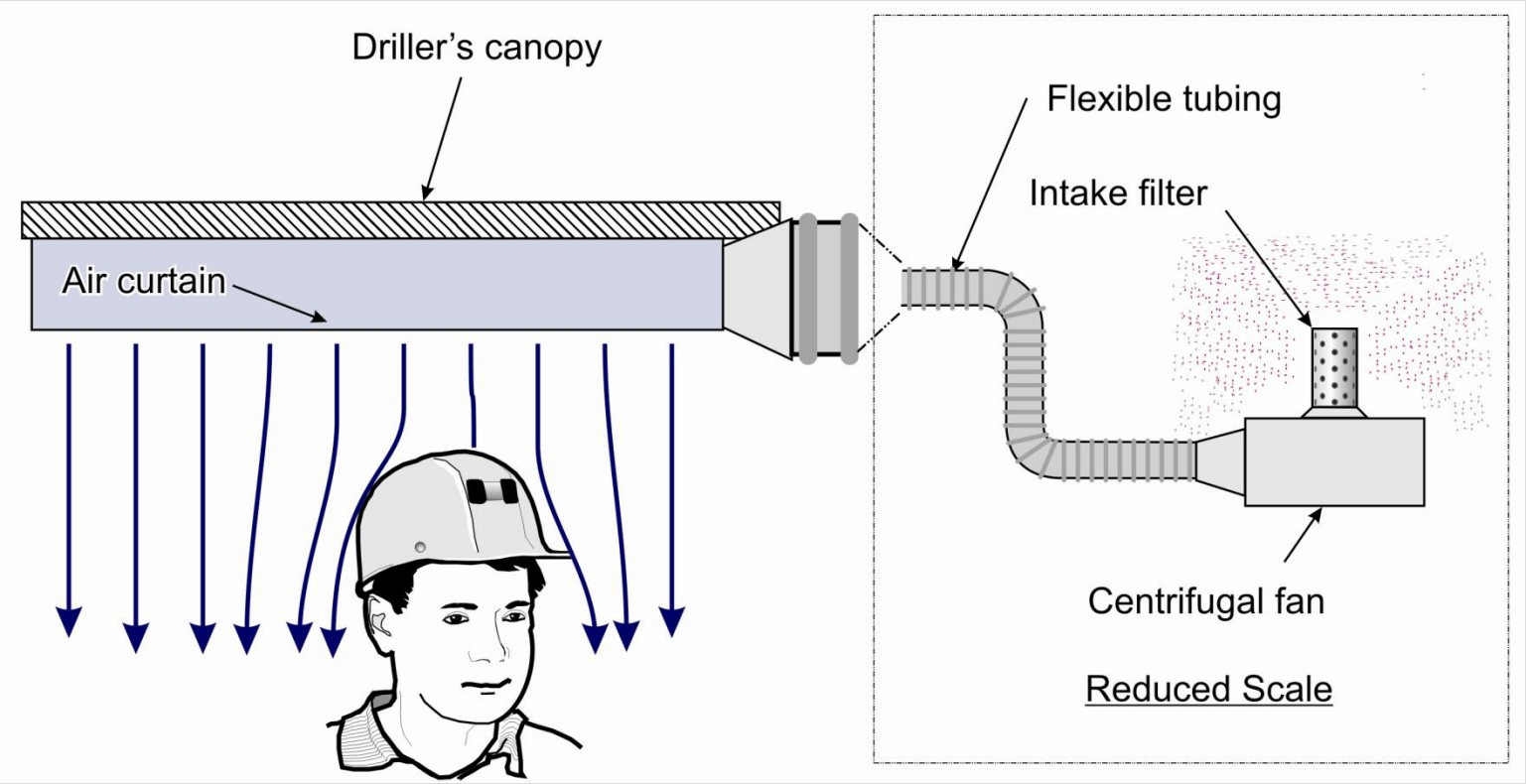
- Gravimetric samplers: respirable dust improved from 0.96 mg/m^3 to 0.14 mg/m^3 when the bag is in use.
- Personal samples from the PDMs: left side (exhaust side) of the bolter experienced over 2 times the amount of respirable dust than the right side.
- Collector box cleaning time reduced from 4 minutes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

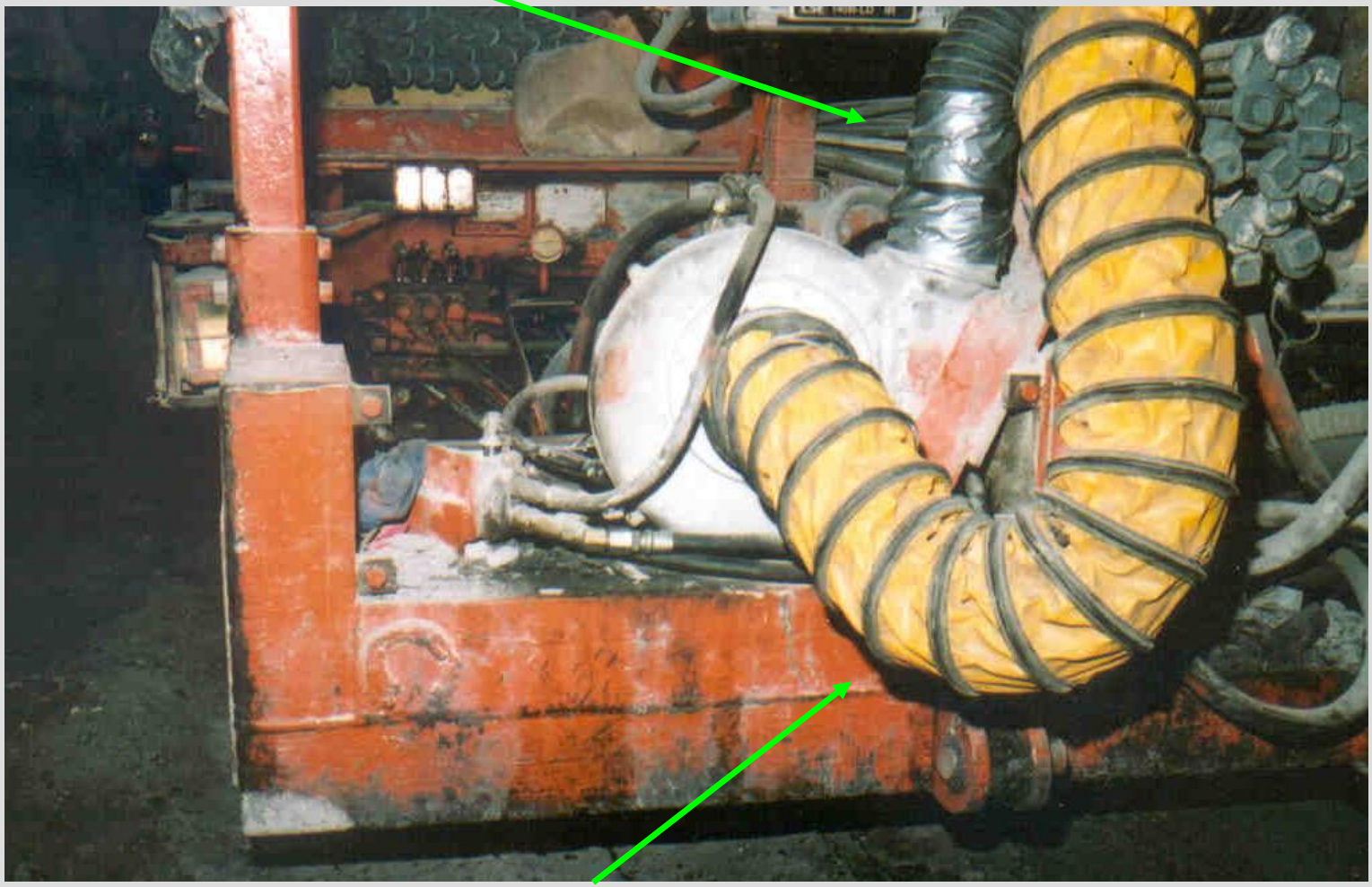


Air Curtain Development

Original prototype

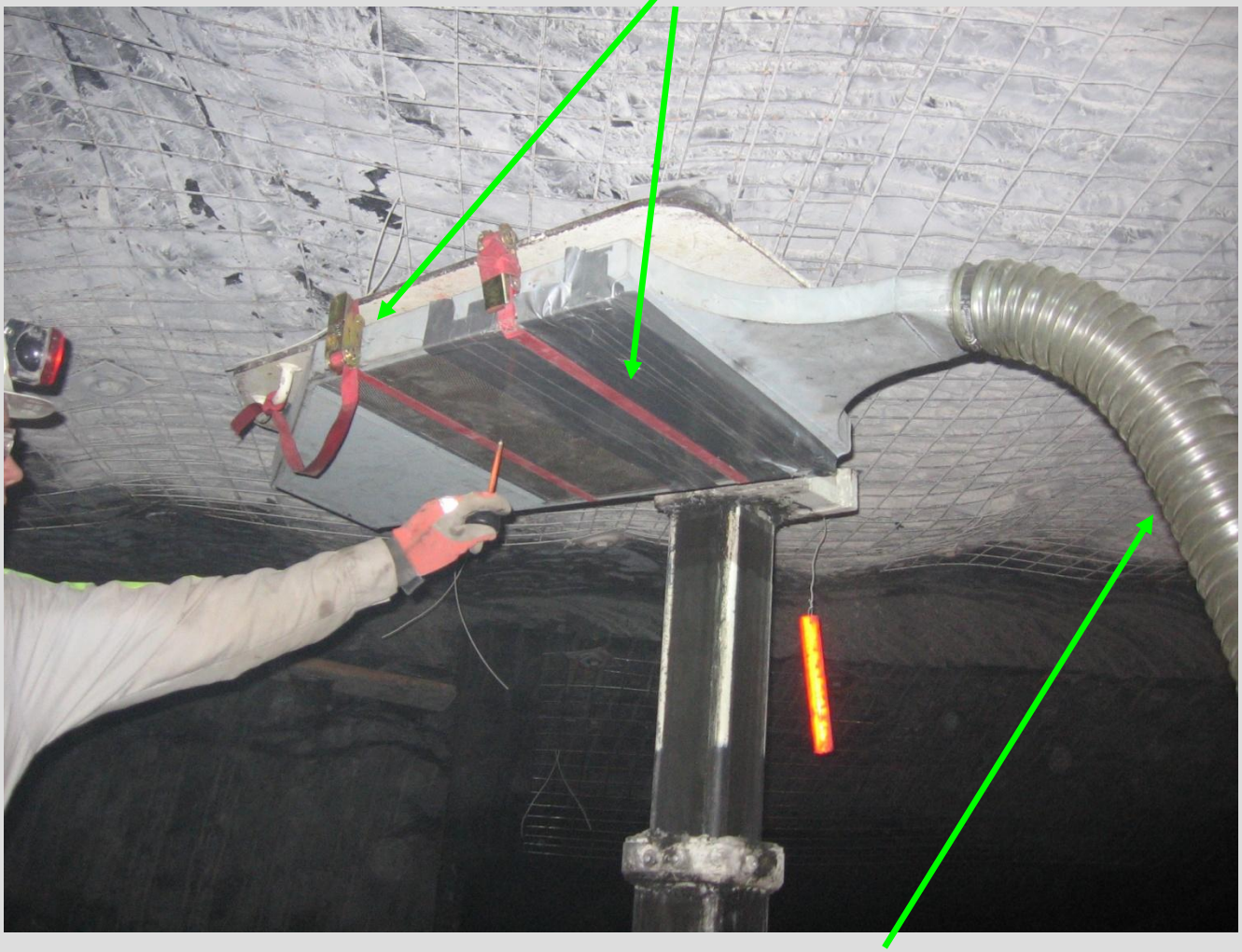
Current design

Tubing to air curtain



Tubing to filter

Nylon tie-downs



Tubing from fan

Operator Under Air Curtain

Canopy Air Curtain Test Methods

- Lab test of varying Canopy Air Curtain designs to provide maximum protection for bolter operators
  - Sample beneath CAC and 1 Ft upwind (60fpm)
- Field test Canopy Air Curtain to determine dust reduction during normal bolting operations
  - Sample both bolter operators, CAC on off curtain side canopy
  - Time study on CAC operator

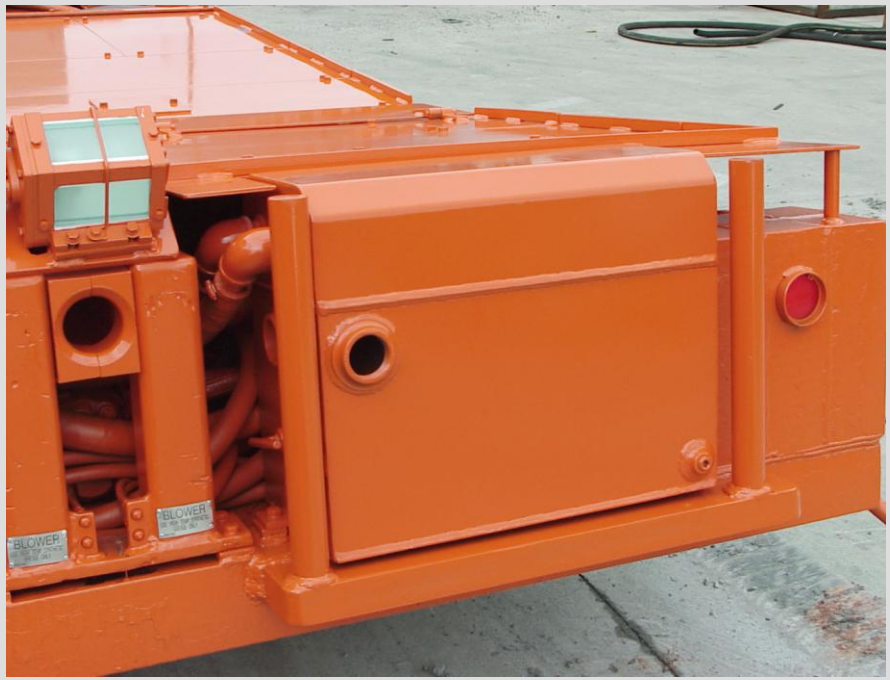
Canopy Air Curtain
Results

- **Lab study show 95% reduction under canopy at 60 fpm mean entry air velocity.**
  - **Sampling 100% of time under CAC**
- **Field study of 3 bolter places shows reductions of 53, 35, and 89%**
  - **CAC operator under canopy only about 50% of the sampling time**

Ongoing Roof Bolter Studies

Pre-cleaner dust

Exhaust conditioner (water box)



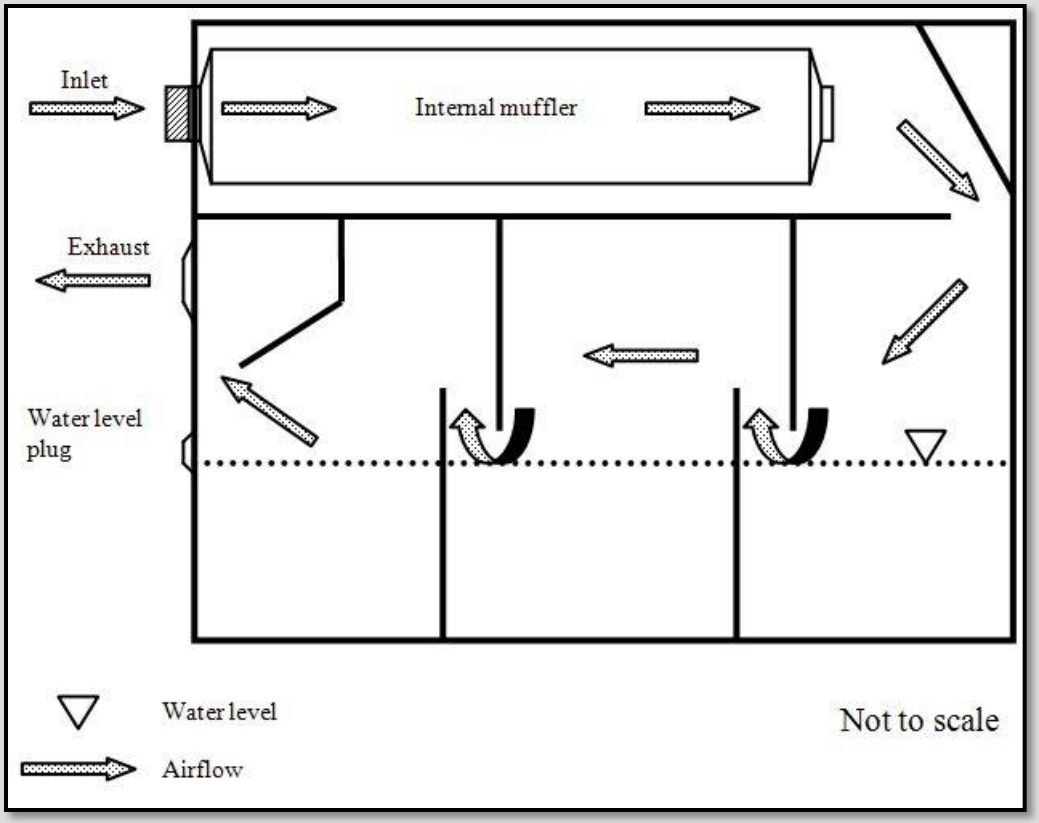
Pre-cleaner Dust Evaluation

- Forty-six bulk samples of roof bolter collector dust were collected by NIOSH and MSHA inspectors from UG coal mines in Districts 4, 5, 6, and 7.
- Bulk dust samples were analyzed for quartz content and particle size distribution.
- Airborne respirable dust measurements were made in three sections of two mines by NIOSH to identify any respirable dust contribution from precleaner dust dump events.

Pre-cleaner dust assessment
Results

- 18% of the precleaner dust is respirable size (< 10 µm).
- 38% of the collector box dust is respirable size.
- Quartz content of precleaner dust is not significantly different from that of collector box dust (27.3% vs. 26.2%).
- Based on a preliminary study, precleaner dust dump events did not result in measurable increases of airborne respirable dust.
- Precleaner dump dust is a potential hazard due to the amount of respirable size and quartz content. Miners should be trained to avoid disturbing dust piles.

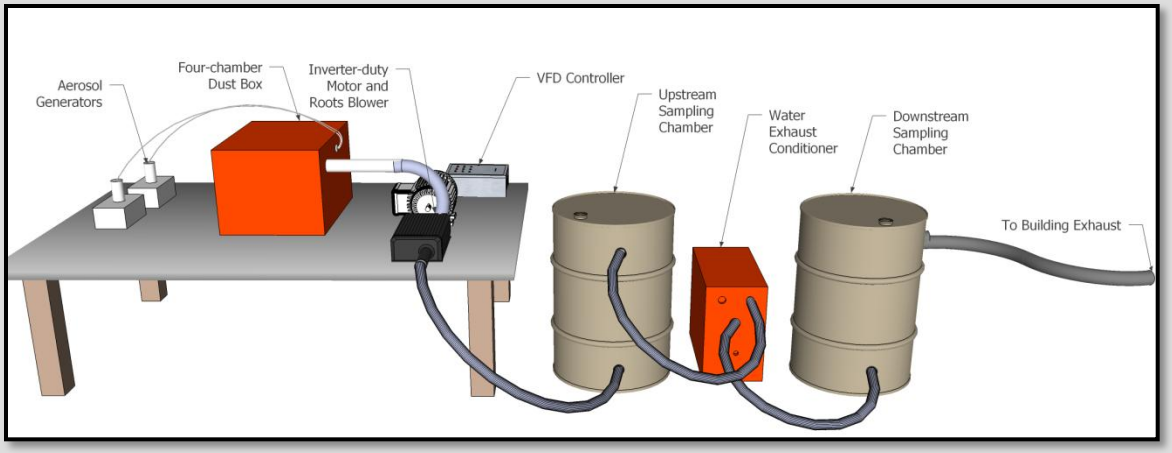
Water Exhaust Conditioner



Exhaust conditioner

Laboratory Test Methods

- Add water box to existing dust collector simulator in lab
- Test two dust types: limestone and coal
- Sample upstream and downstream of device



Exhaust conditioner
Results

- **Exhaust conditioner improves respirable dust collection efficiency by 41%**
- **Minimal potential for benefits/impact on operator exposure when dust collector box is properly maintained**
- **Not a substitute for poorly maintained collector box**

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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