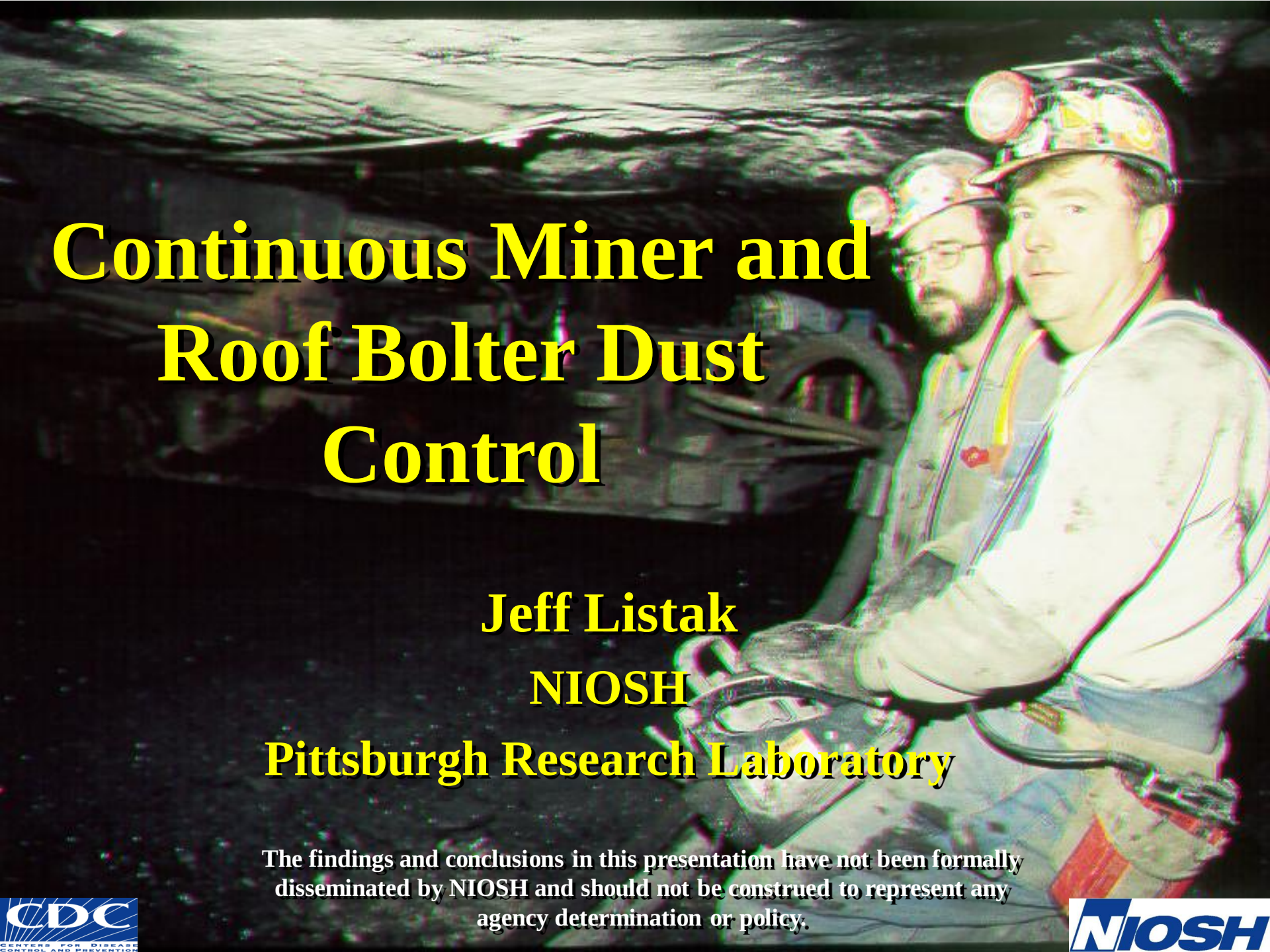

Continuous Miner and Roof Bolter Dust Control

Jeff Listak

NIOSH

Pittsburgh Research Laboratory

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

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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)

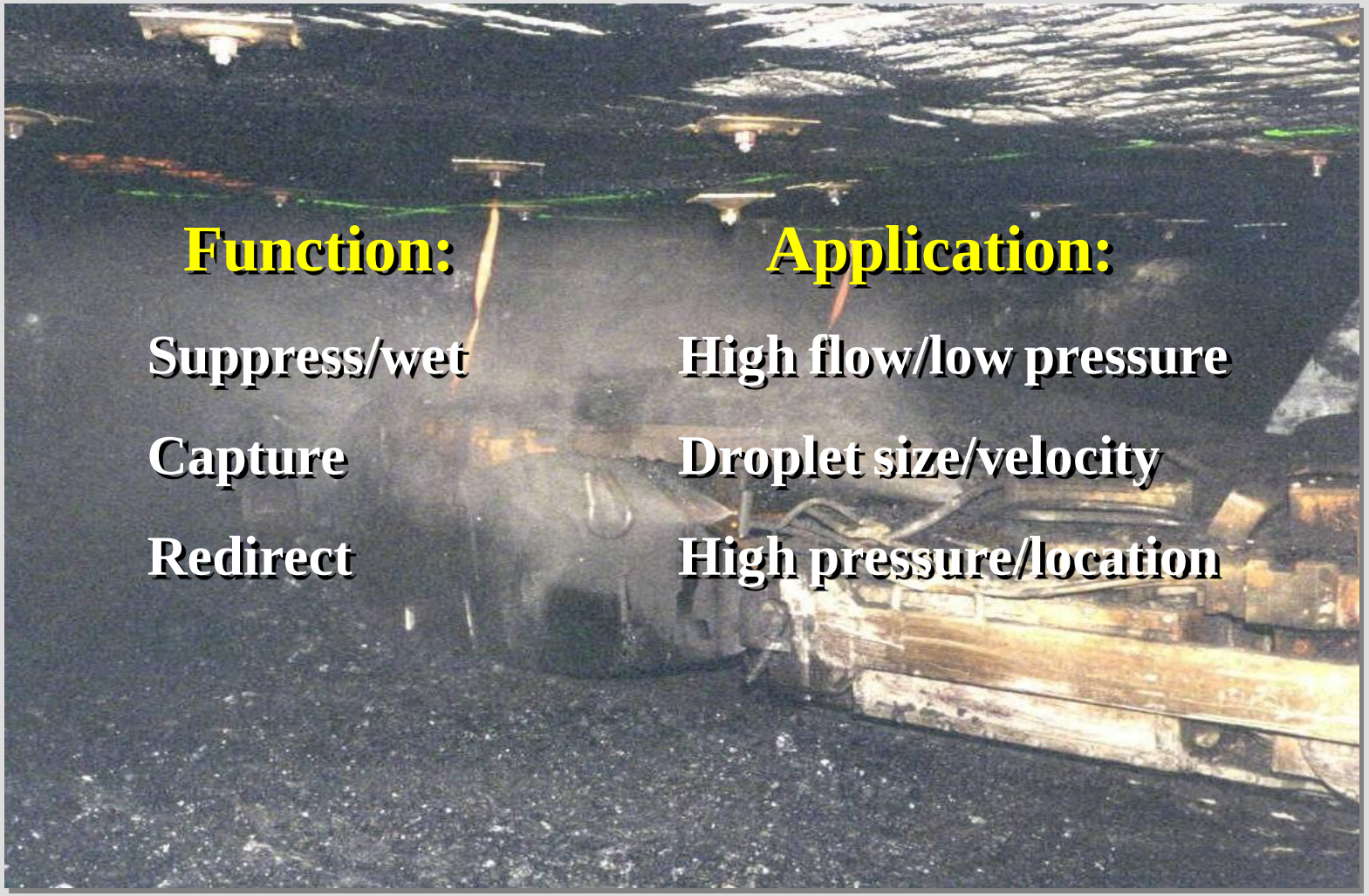
Limiting Dust Exposure

- Air
  - Dilutes
  - Transports
- Water
  - Suppresses
  - Redirects
  - Captures

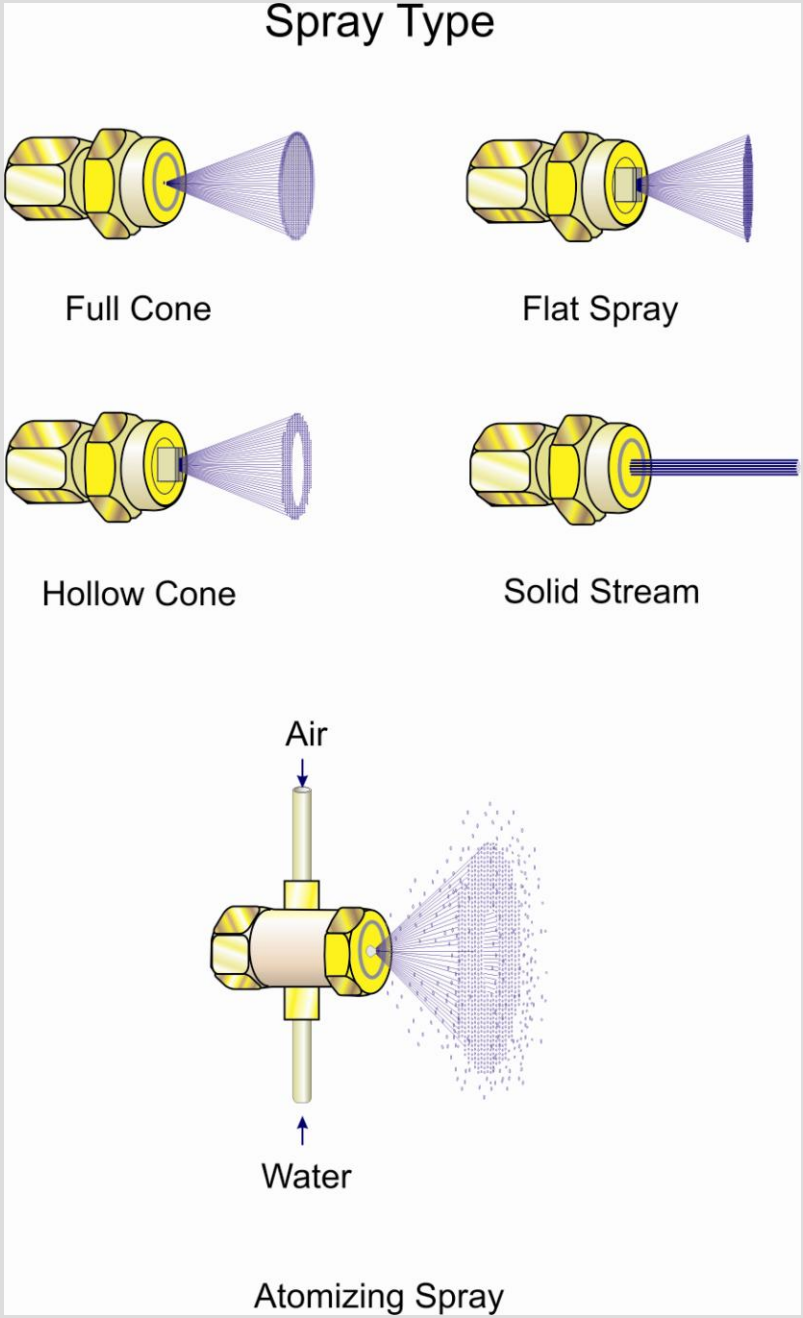
Impact of Water on Dust

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

Water Sprays on Continuous Miners



Spray Types


Spray Type
Full Cone
Flat Spray
Hollow Cone
Solid Stream
Air
Water
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

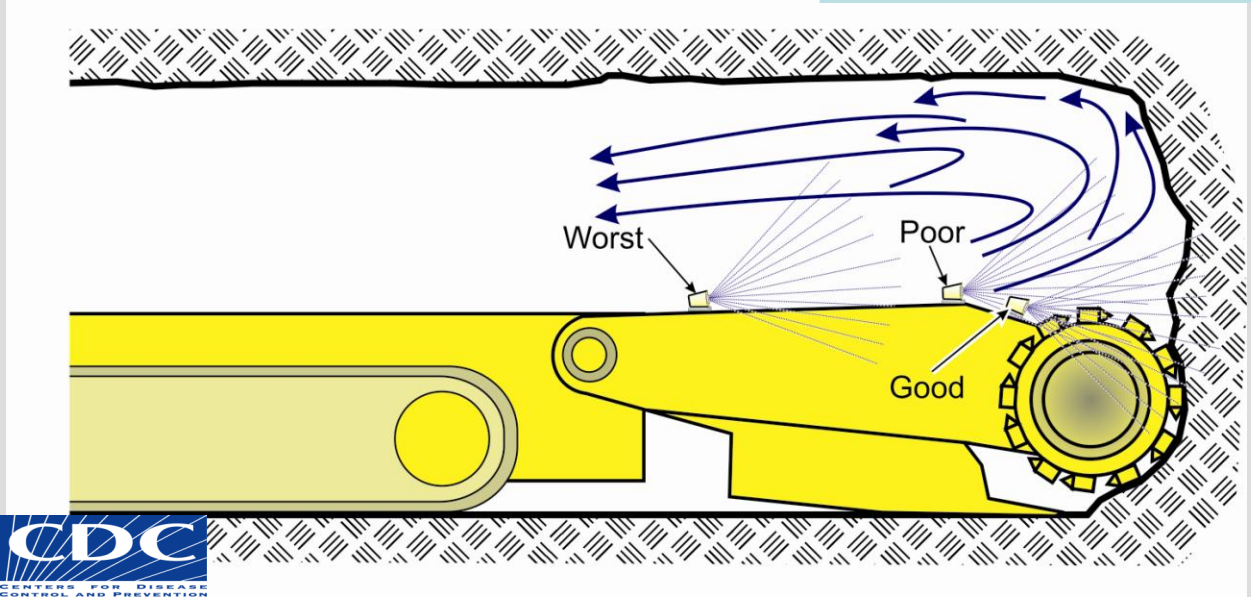
Spray Nozzles
Flat Fan

- 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

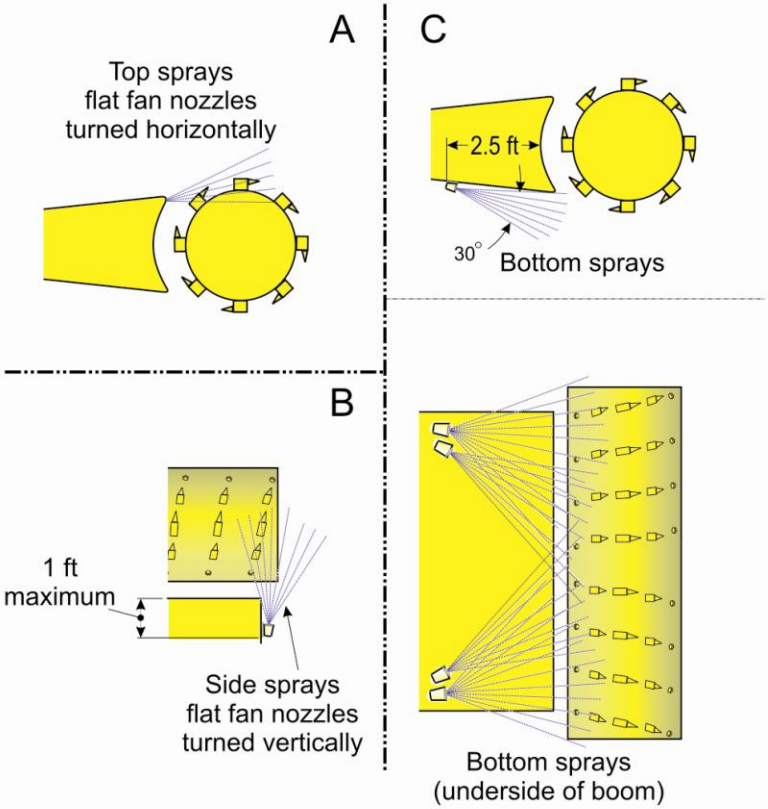


Wetting/Suppression

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

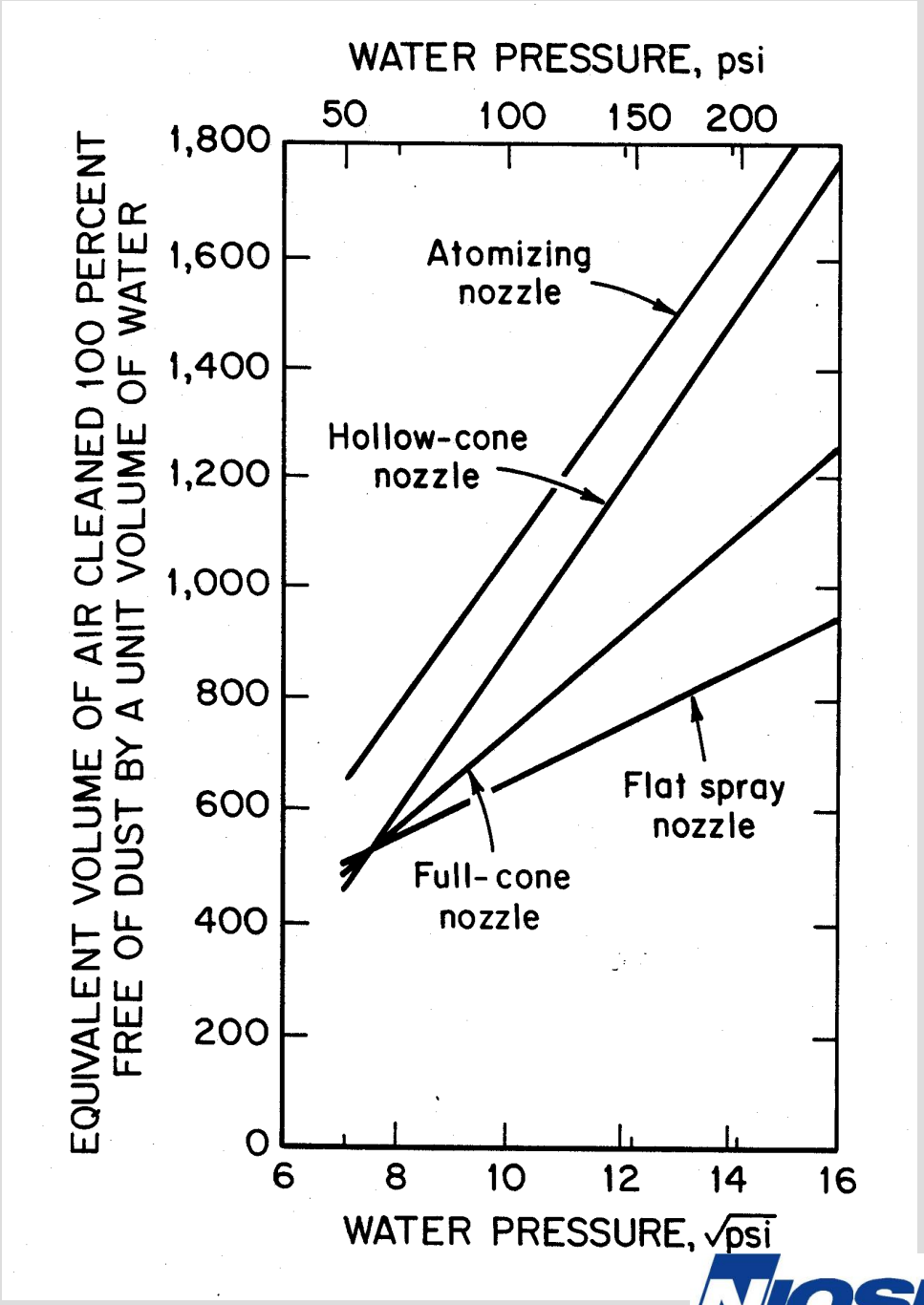
- Flow rate most important

Spray Locations

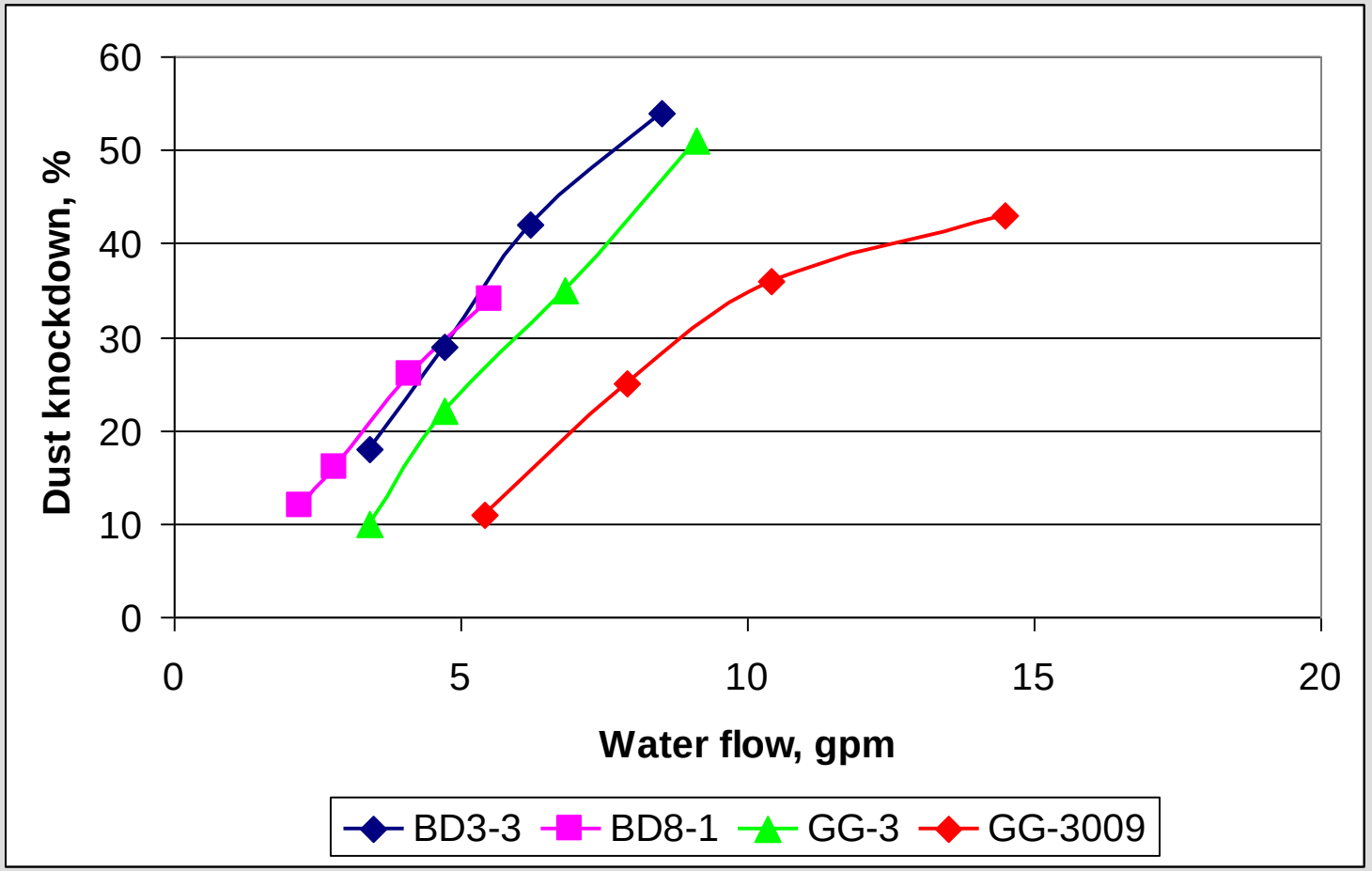


Spray Capture Effectiveness on Airborne Dust

- Smaller Droplet Sizes
- High Velocity Droplets



Airborne Dust Capture

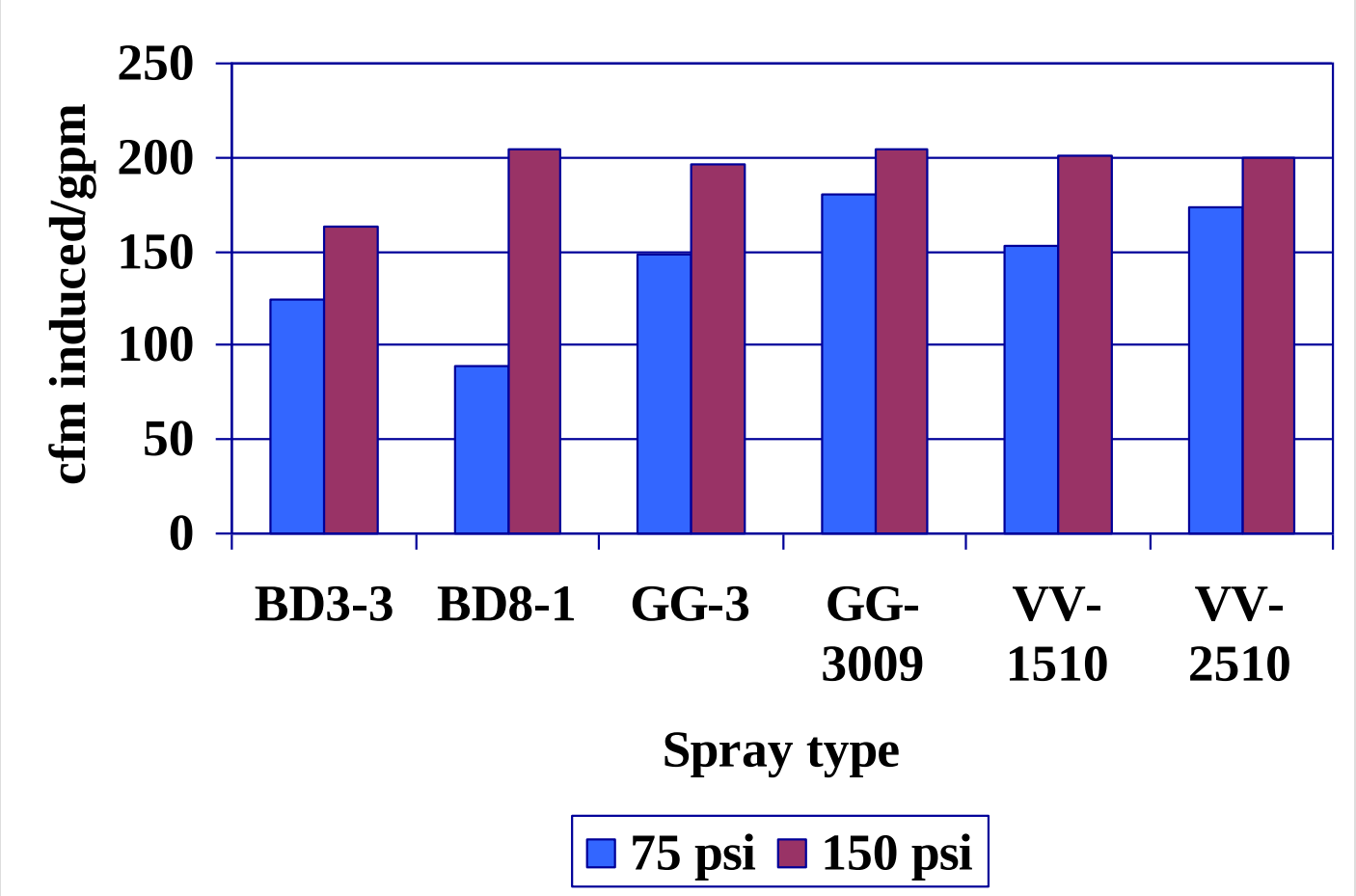


Redirecting/Moving Air

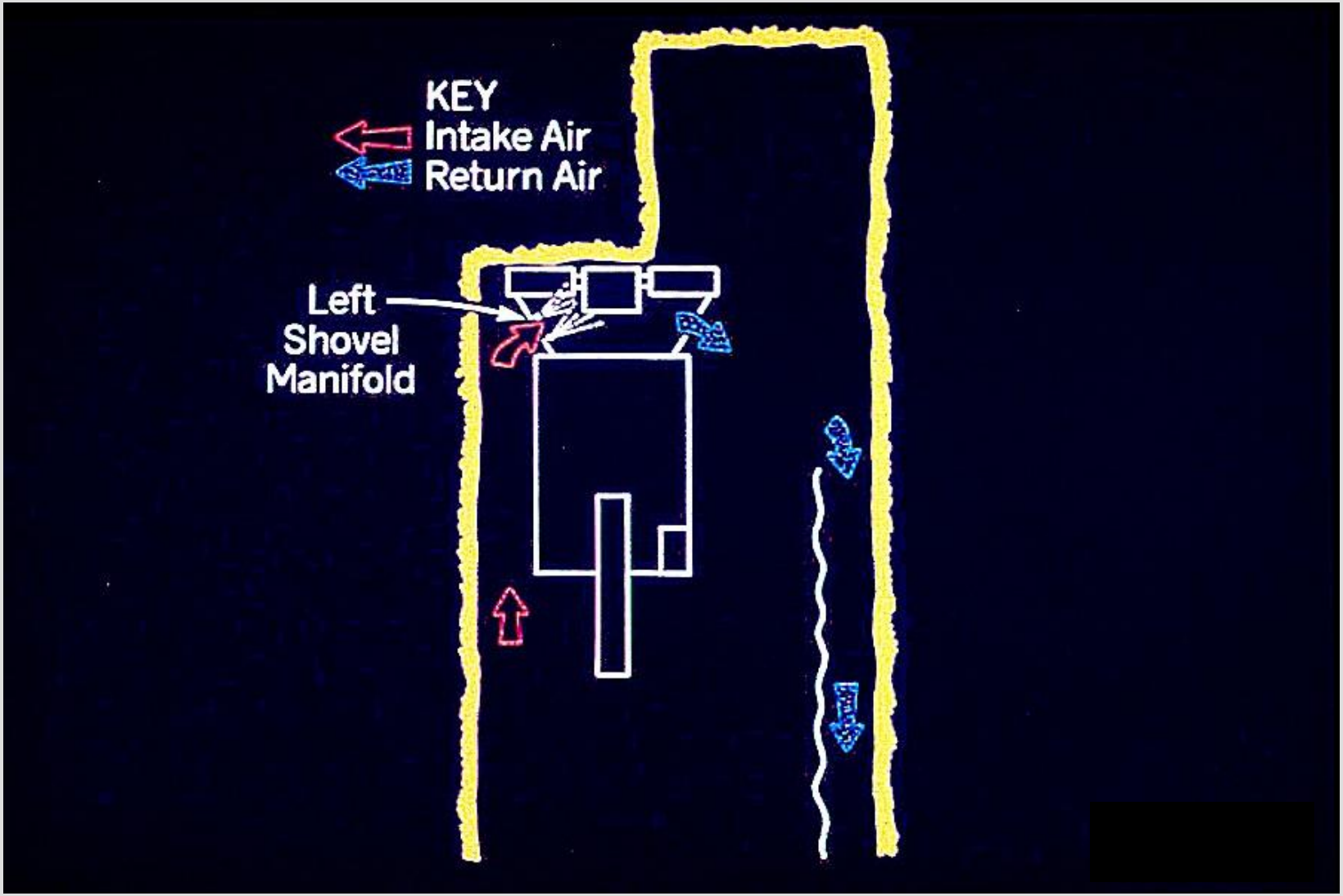
- Shovel sprays
- Spray-fan system
  - methane control
  - reduced effectiveness on dust control
- Blocking Sprays

- Pressure/location important

Air Moving Effectiveness

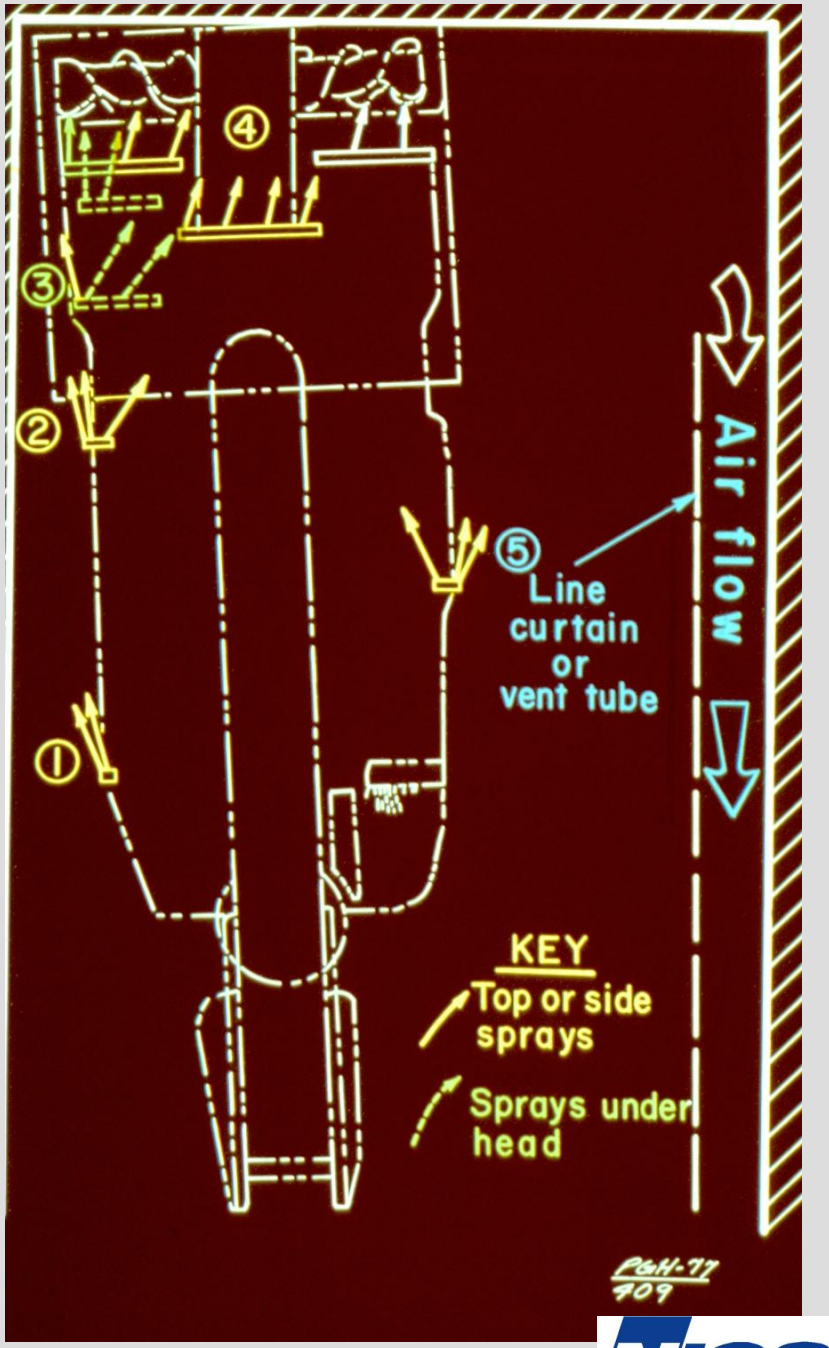


Shovel Sprays
(without scrubber)



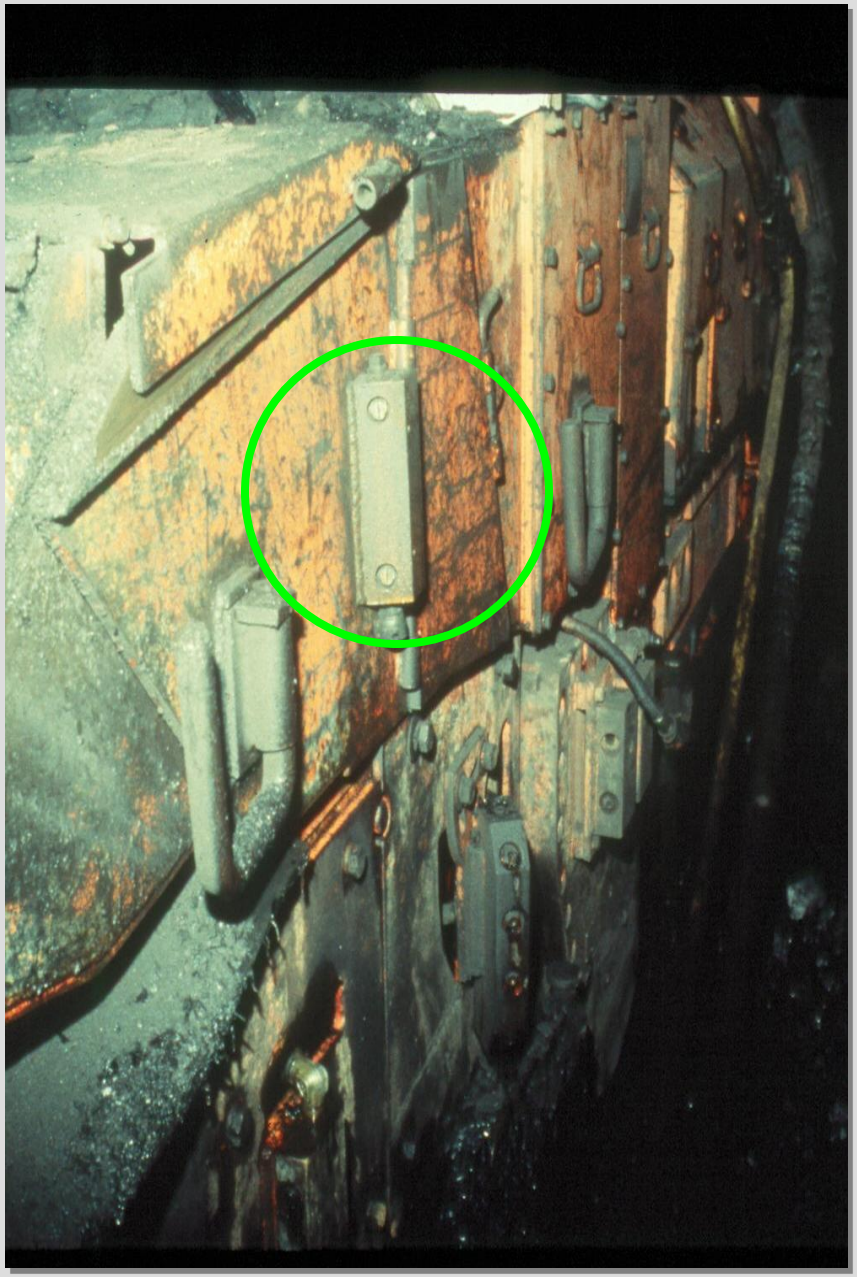
Spray Fan System

- **Primarily for Methane Control**
- **Reduced Dust Control Effectiveness**



Blocking Sprays

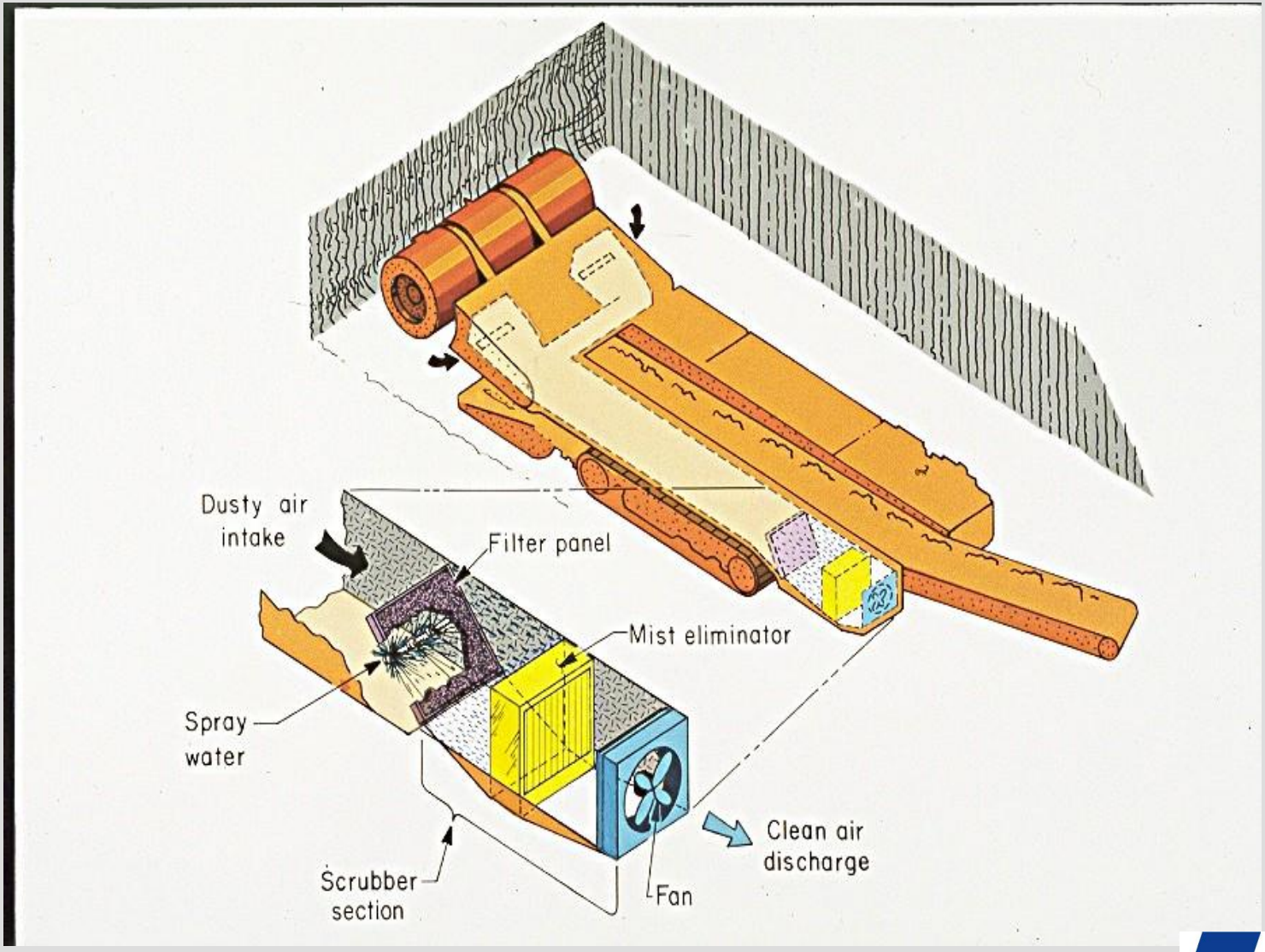
- Primarily used with scrubbers
- Contains dust beneath boom
- Lower dust levels at operator and around machine



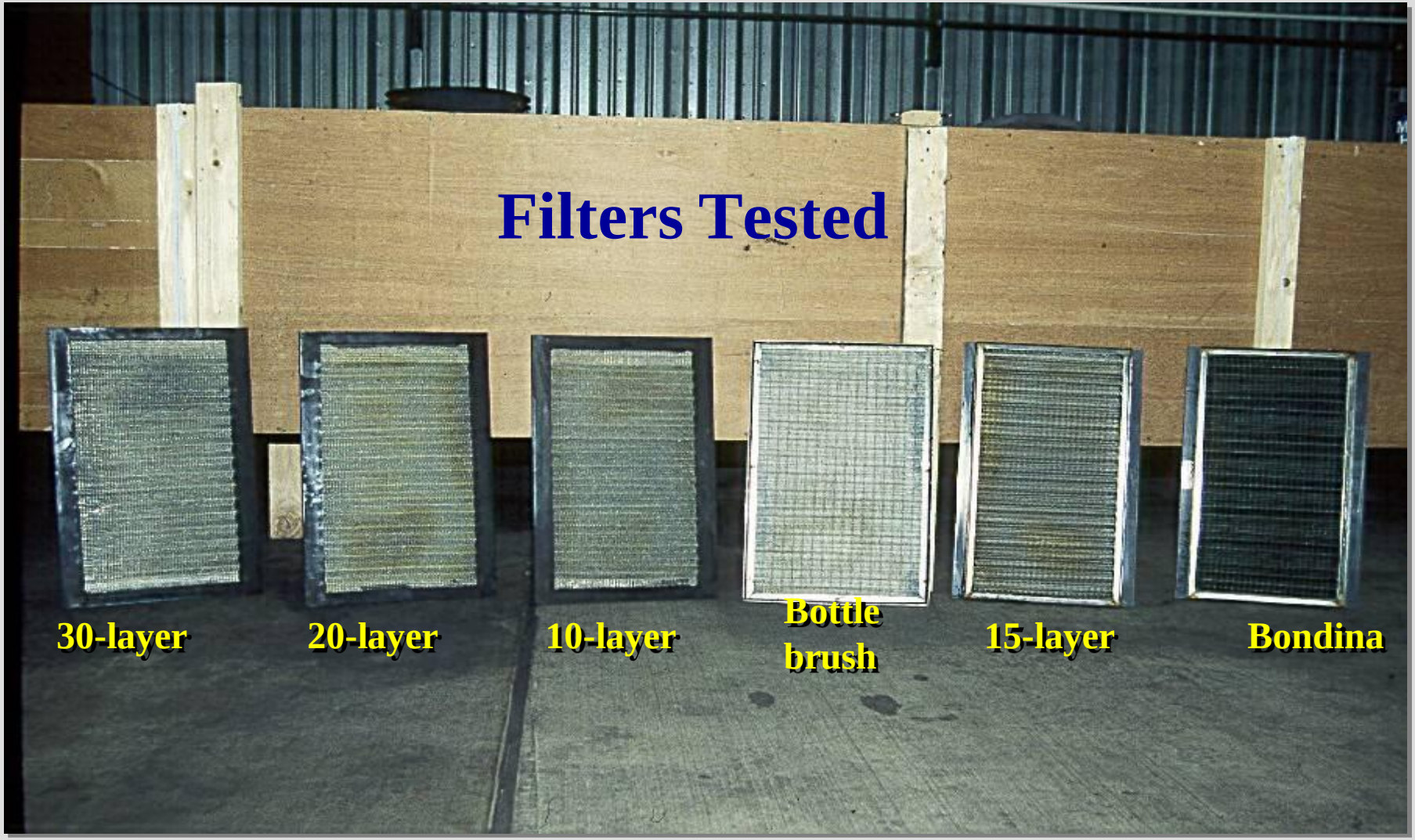
Spray Water Filtration

Reduces Plugging

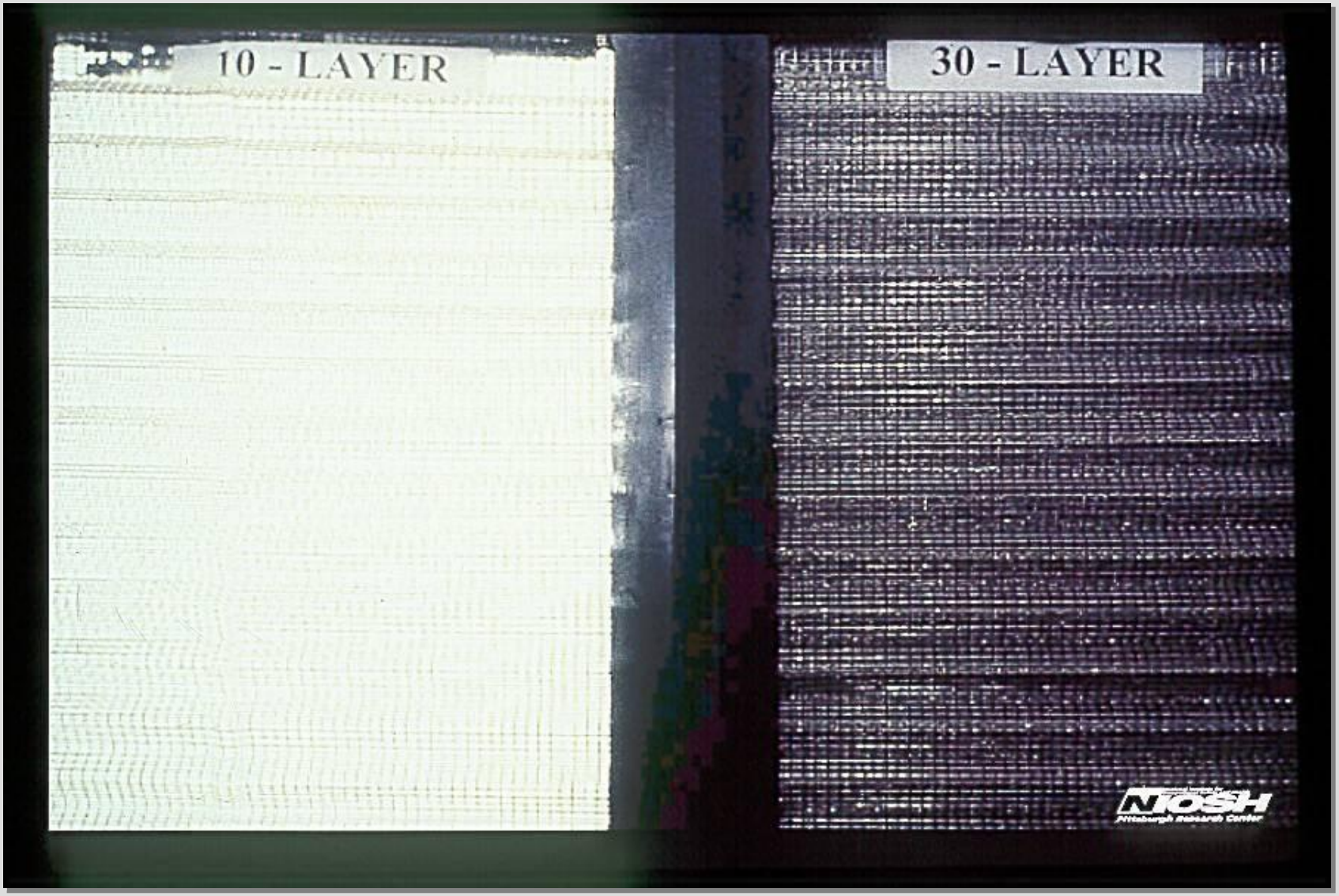
Flooded-bed Scrubbers Capture and Remove Airborne Dust



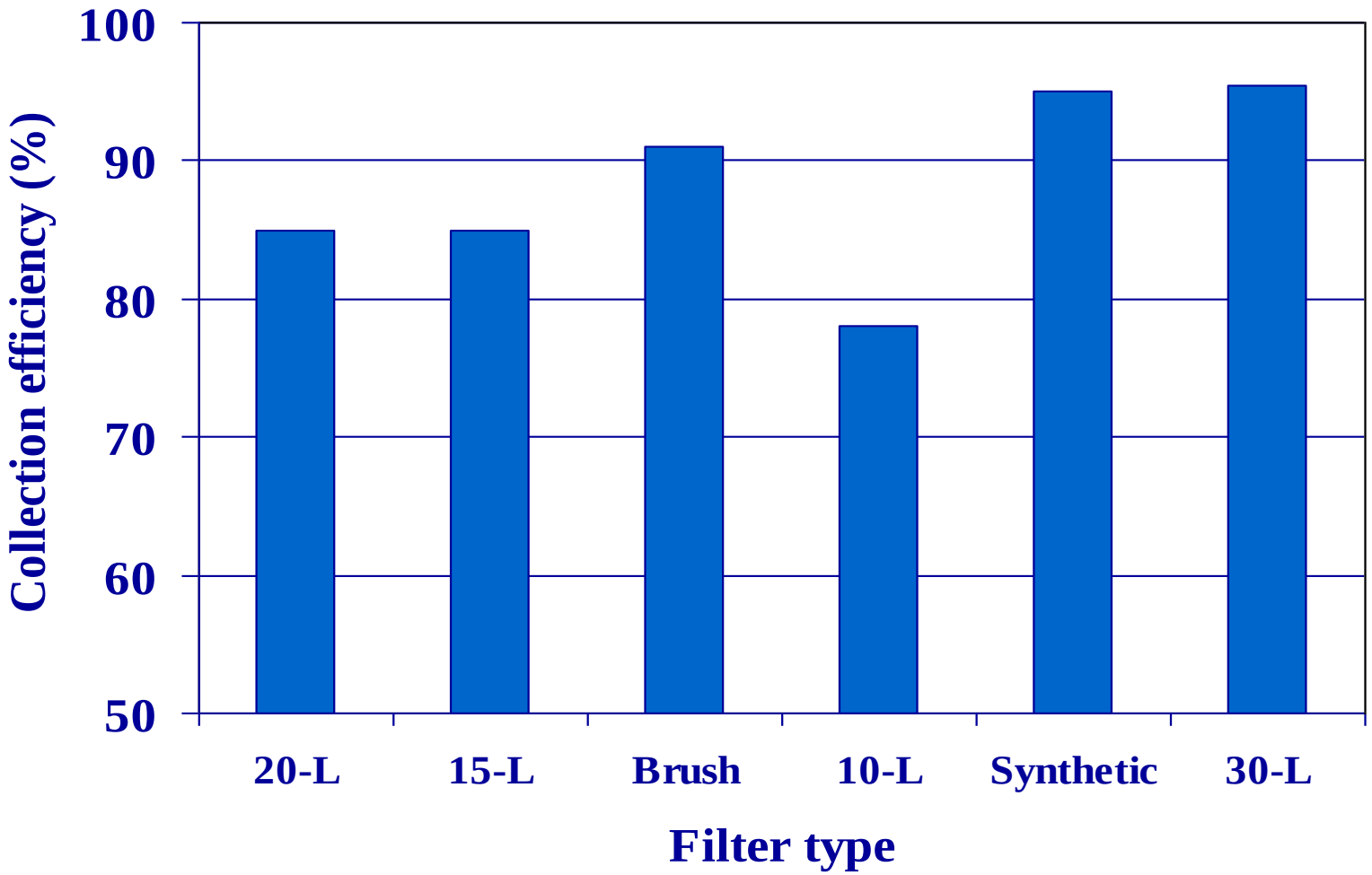
Scrubber Filter Study



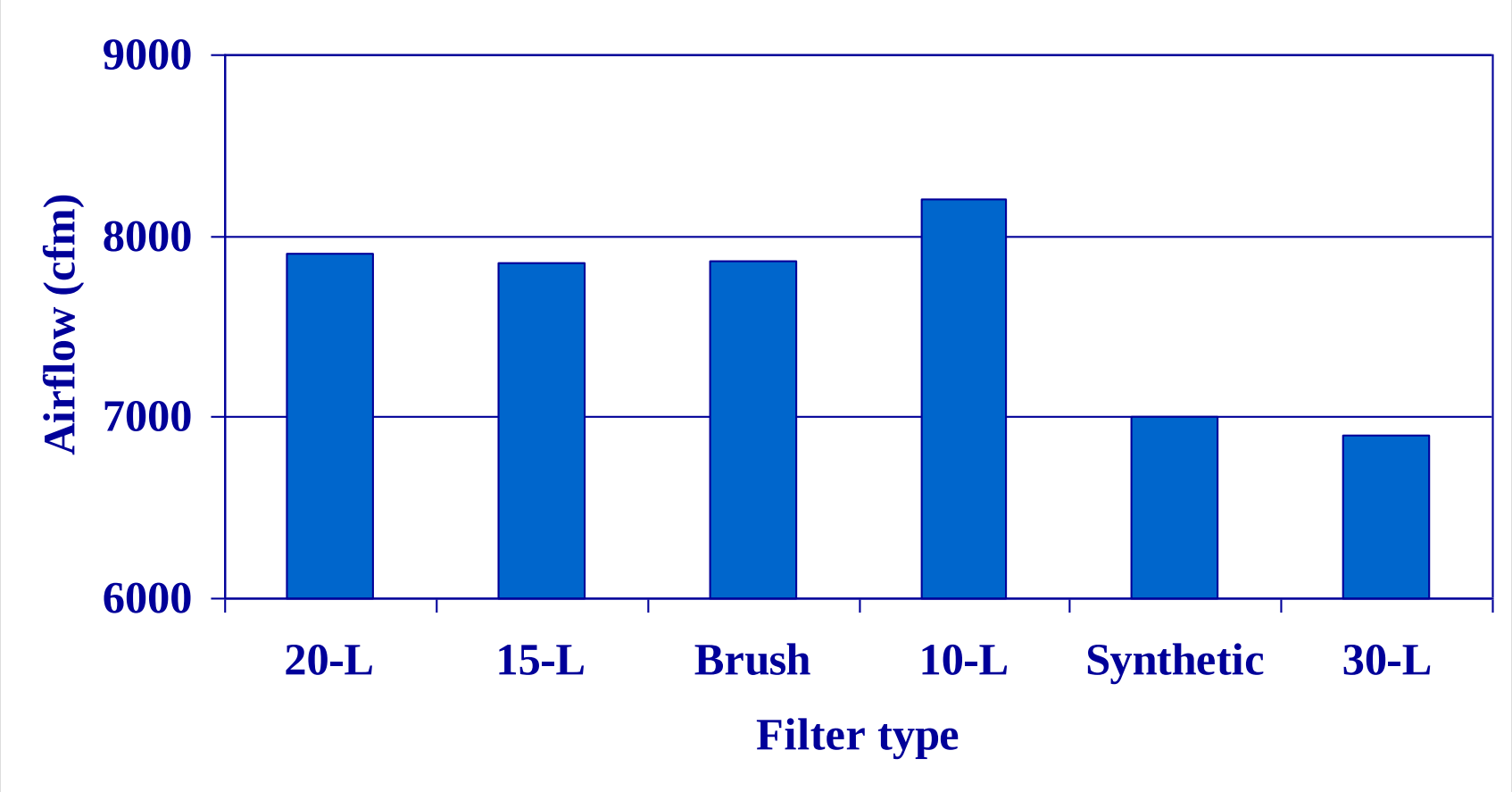
10 vs 30 Layer Filters



Respirable Quartz Collection Efficiencies



Air Quantity Measured With Each Filter Panel



Scrubber Efficiency

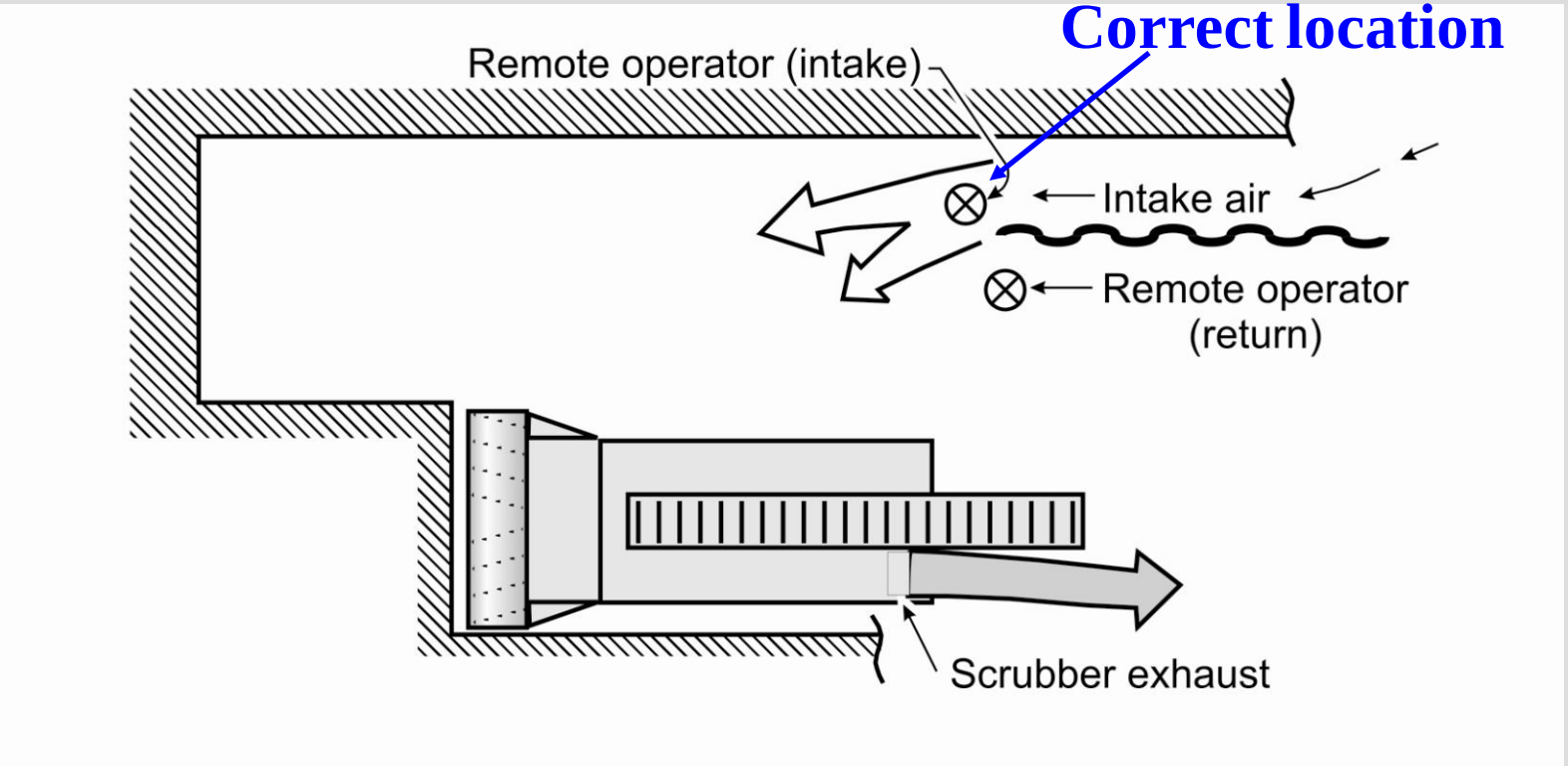
- Scrubbers can lose 1/3 of airflow after one cut
- Check air velocity with pitot tube
- Most common loss of efficiency due to filter panel clogging.

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**

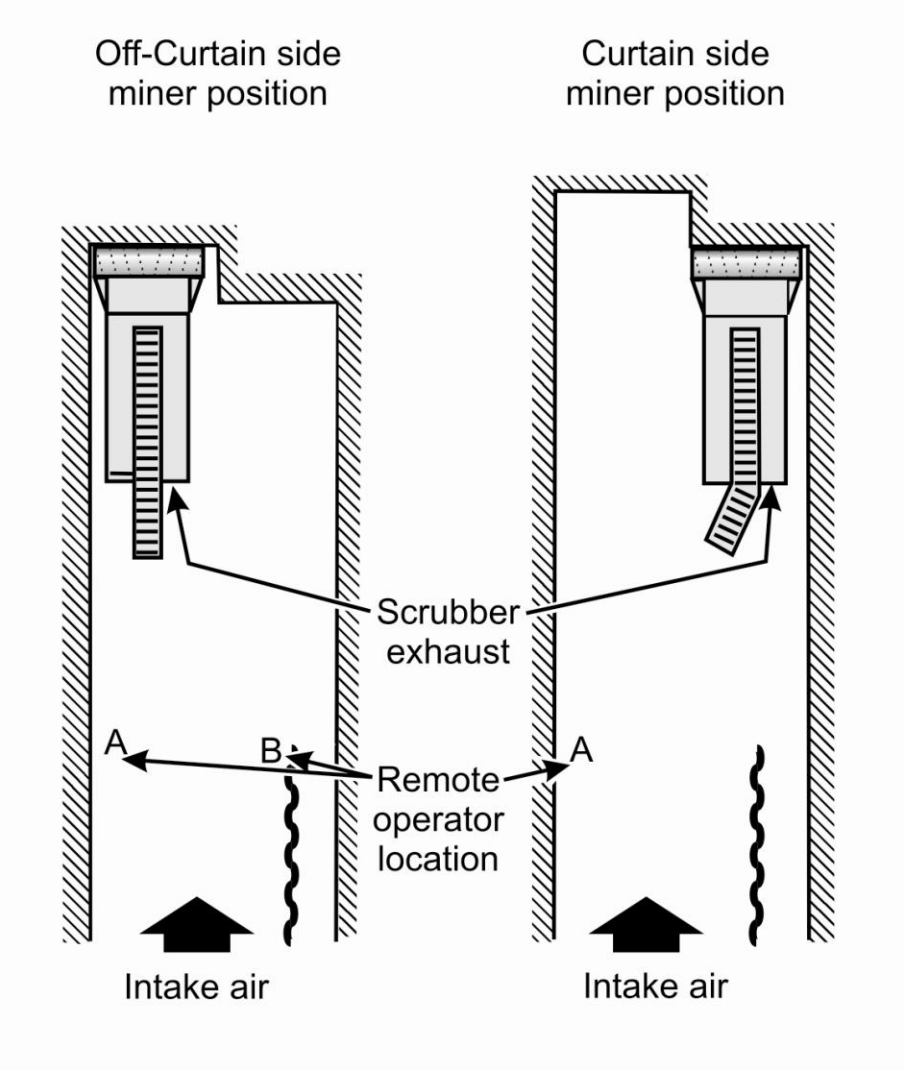
Blowing Ventilation

Recommendations

- Airflow at end of curtain, 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**

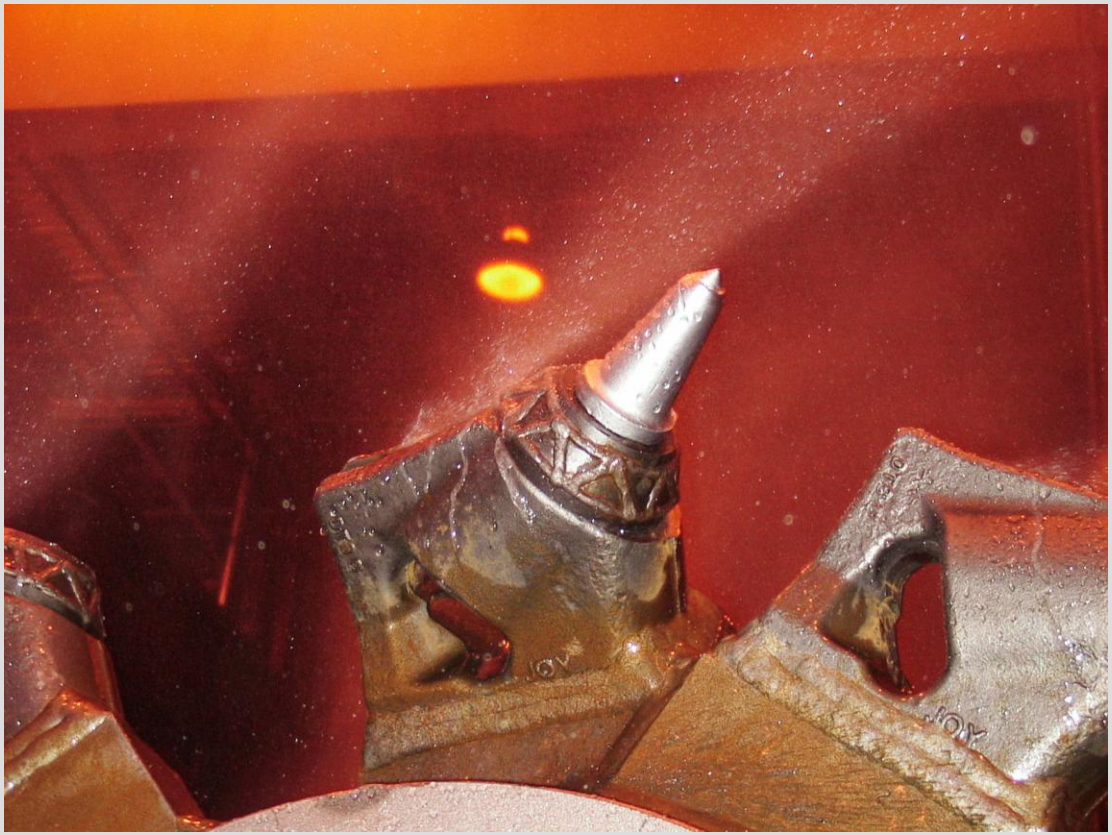
Exhausting Ventilation
Recommendations

- 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

Continuous Miner Dust Control

Wet Head Cutter

Locates water sprays directly behind cutting bits on the cutter head at point of attack



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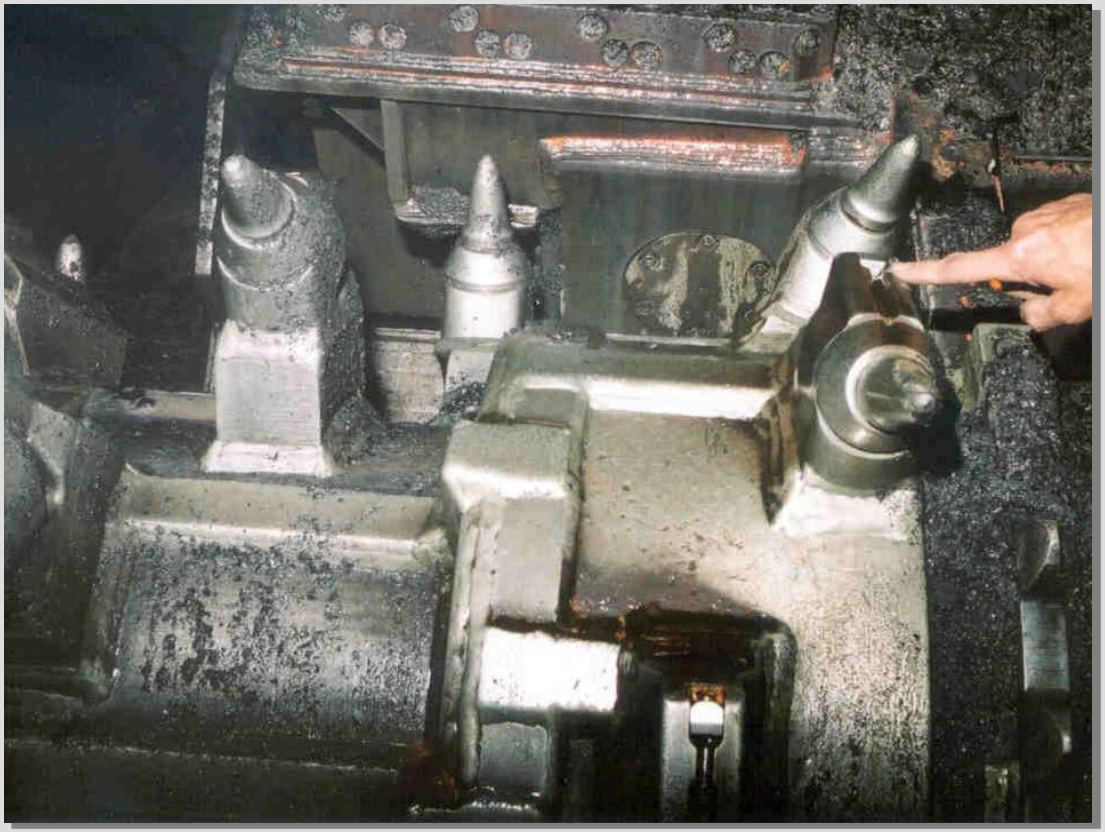
Potential Wethead Benefits

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

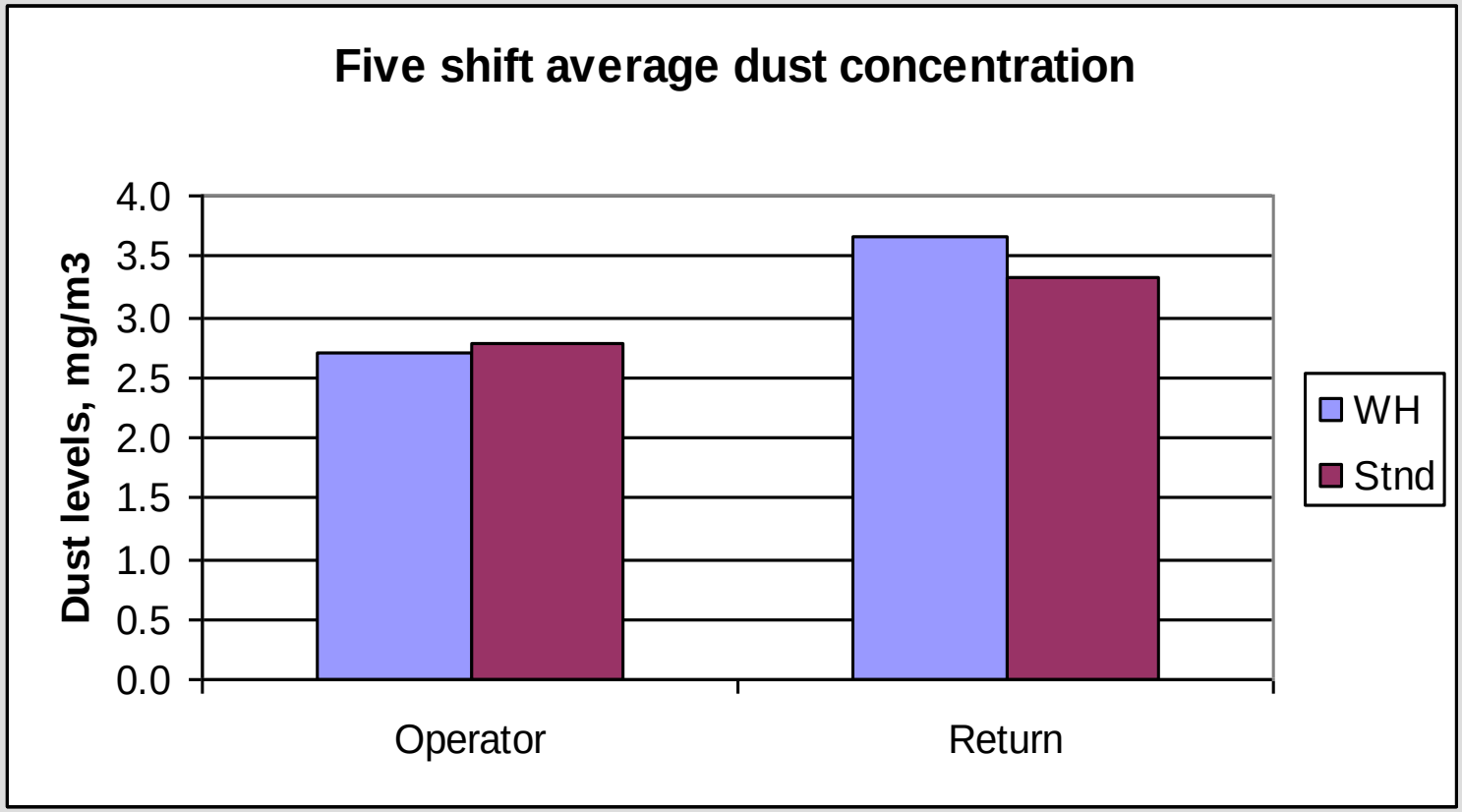
West Virginia Operation

- 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

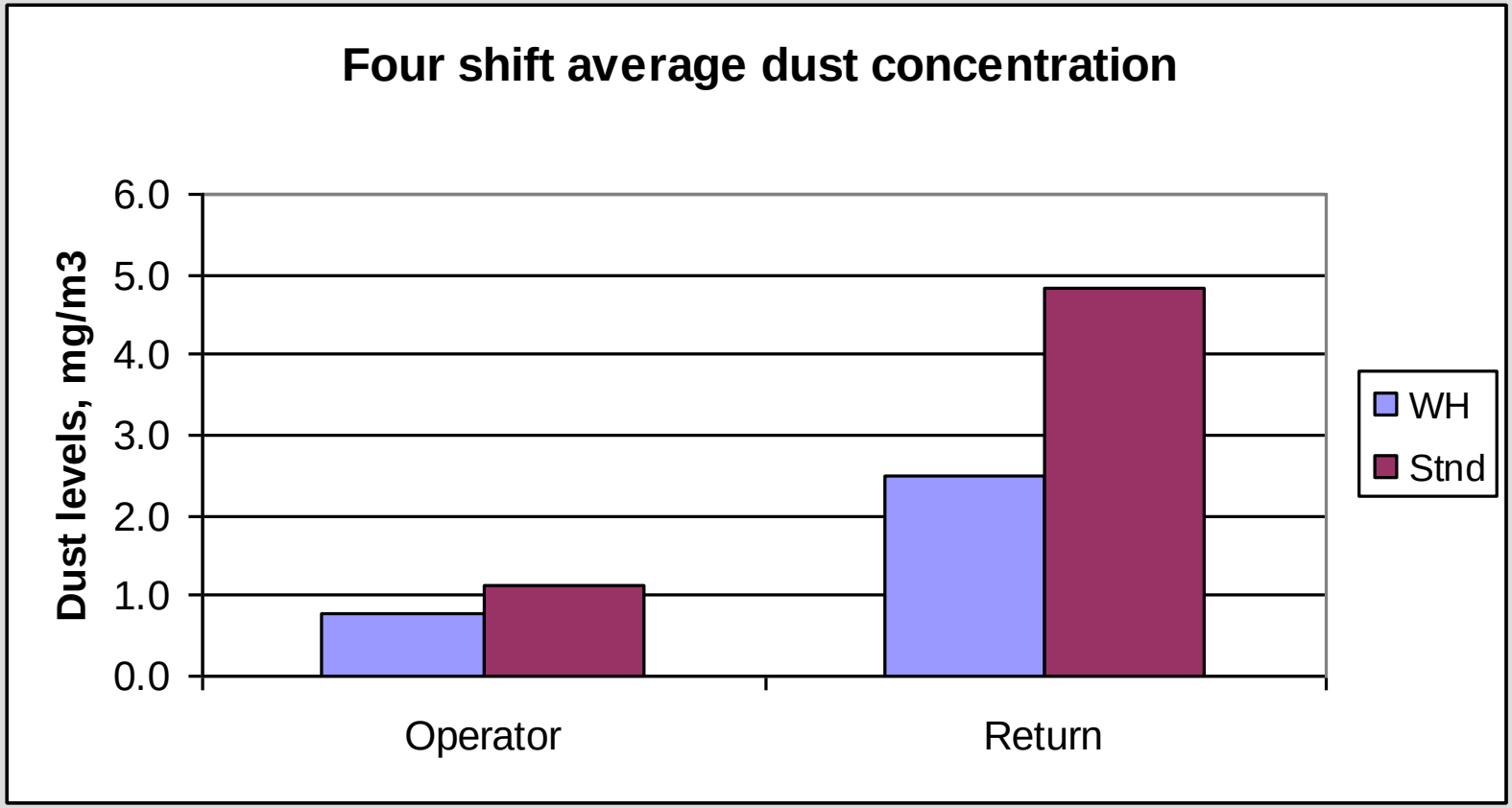
Wet Head vs Standard Sprays



Illinois Operation

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

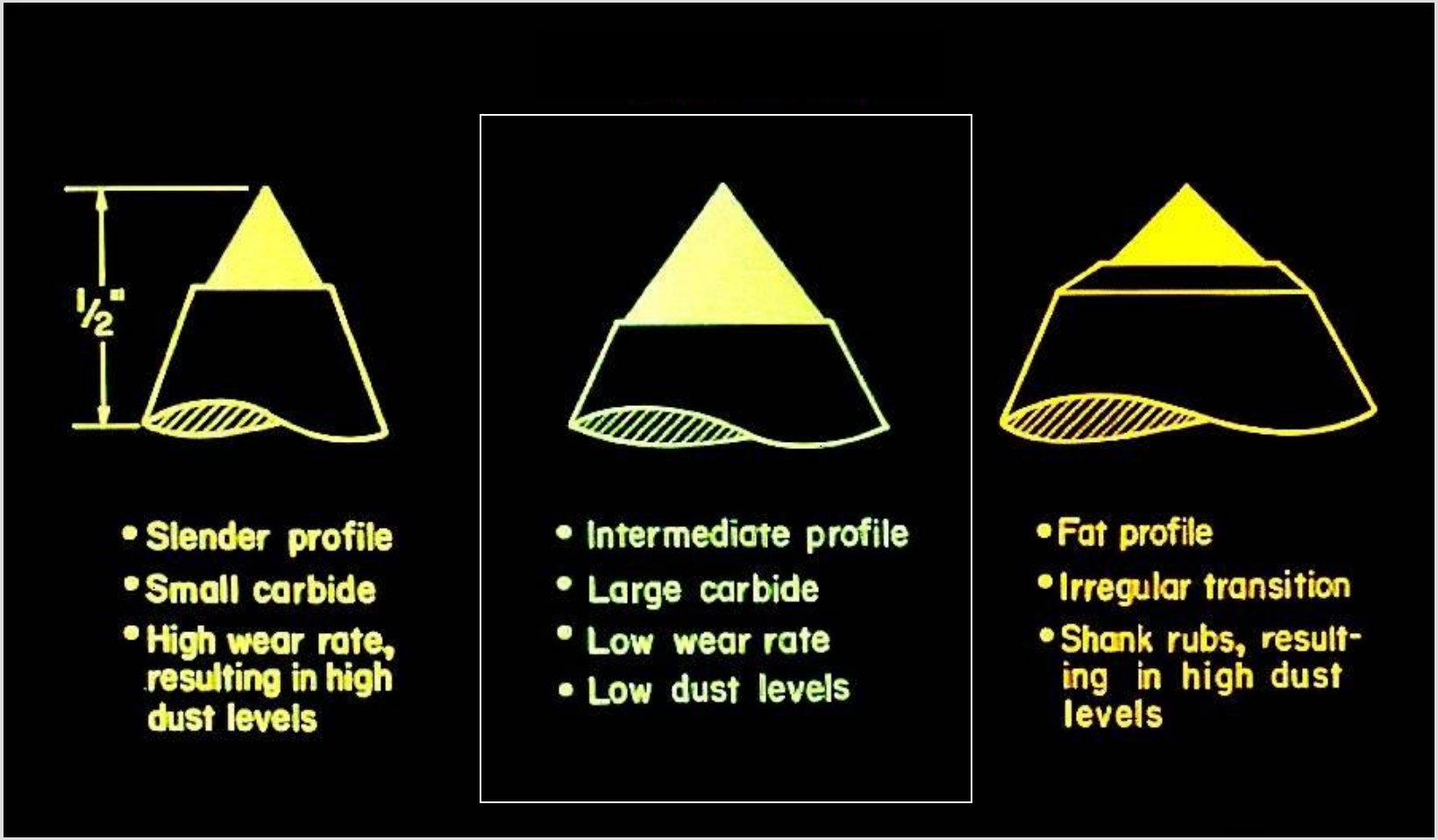
Wet Head vs Standard Sprays



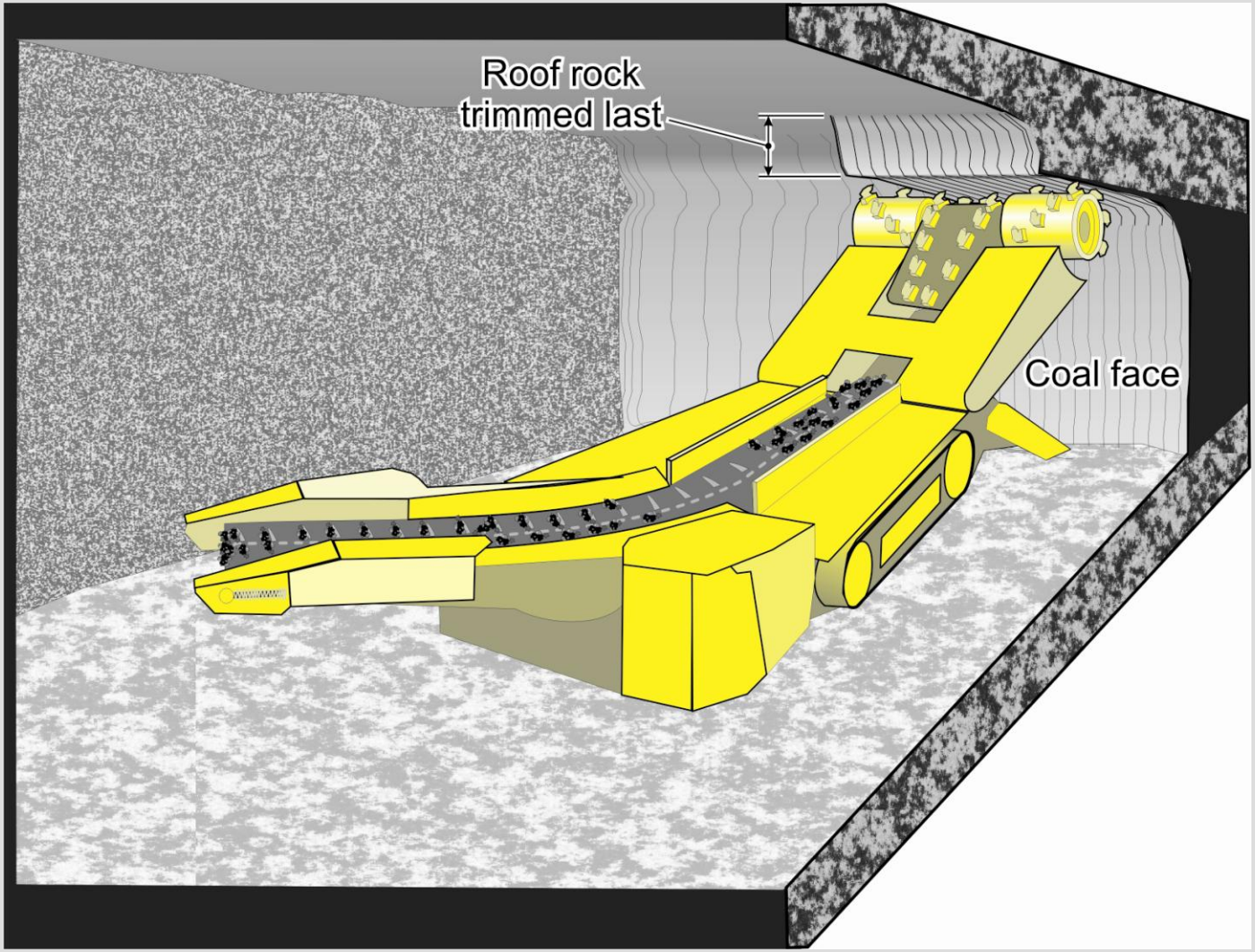
Other Considerations

- **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

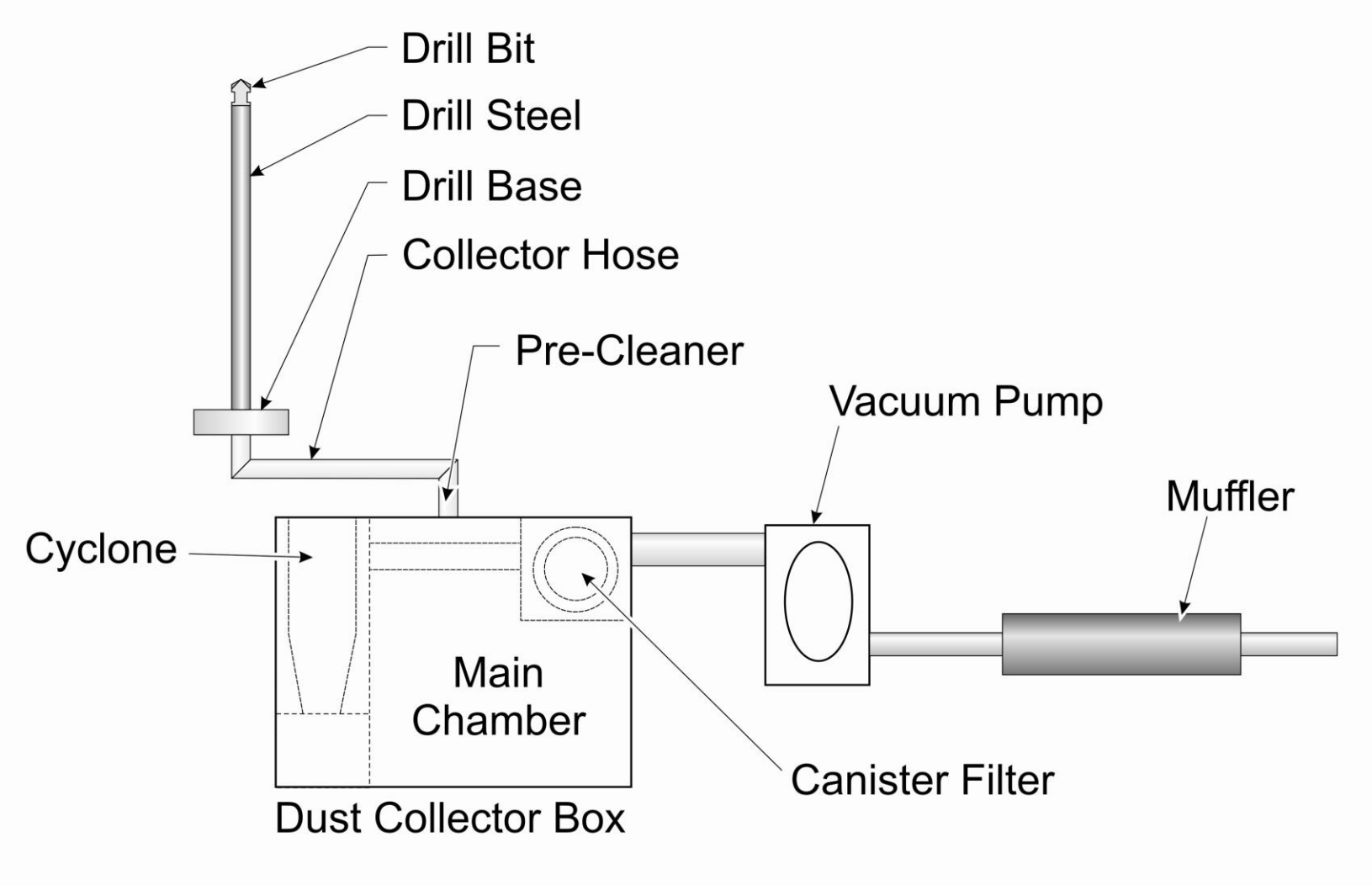


Roof Bolter Dust Control

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

Dust Collector Components



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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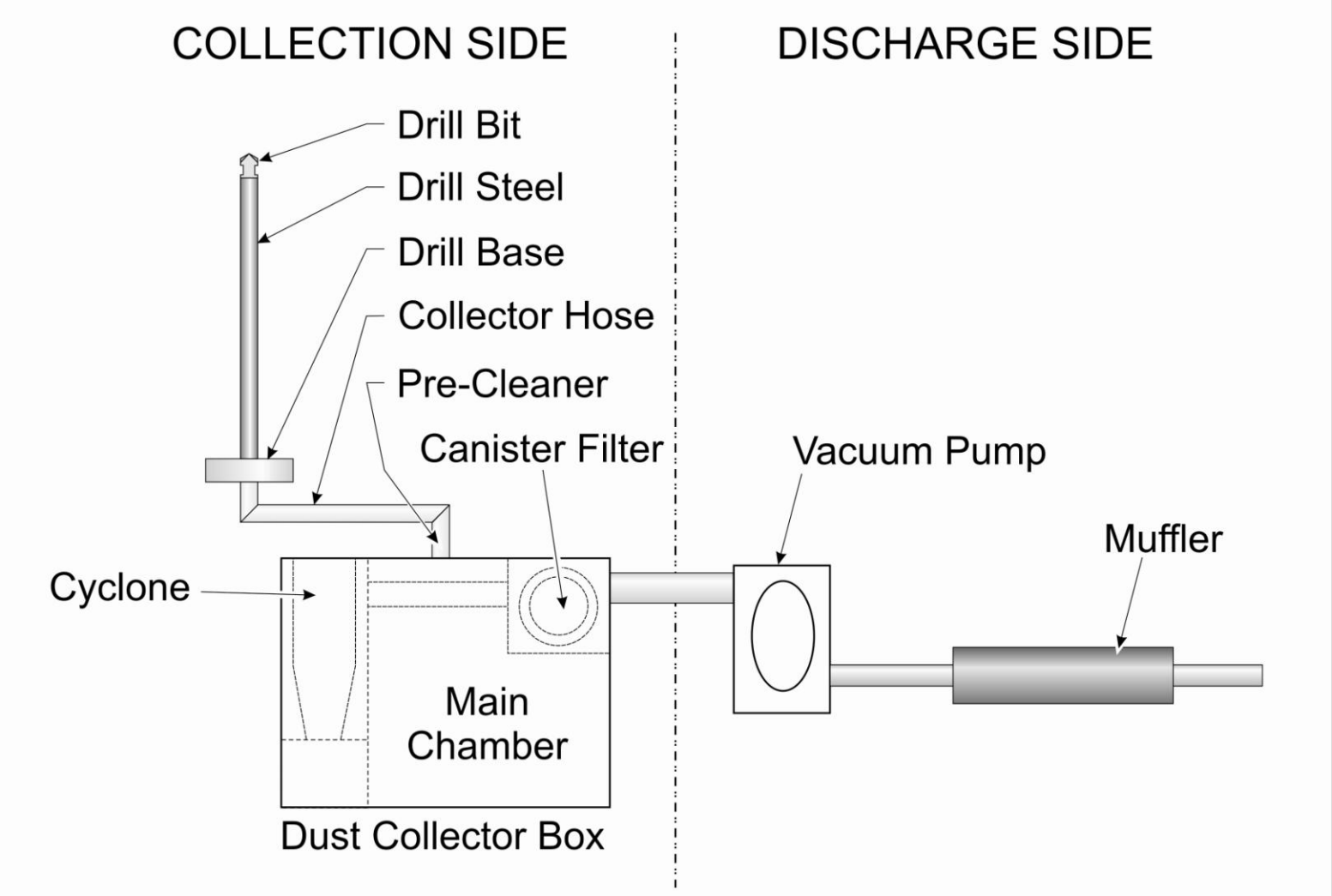
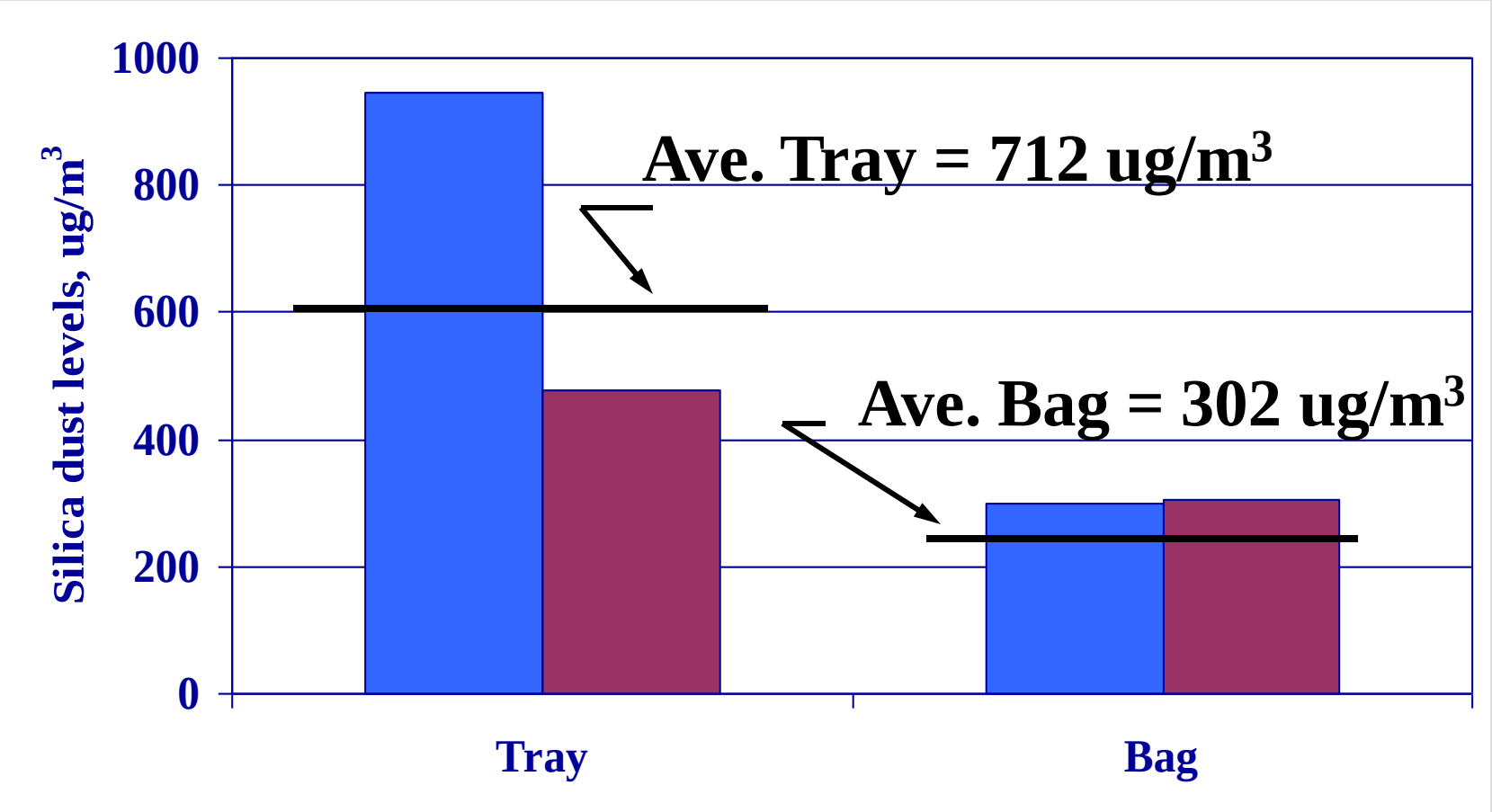
Dust Collector Components



Reusable Brattice Bag Controls Dust During Box Cleaning

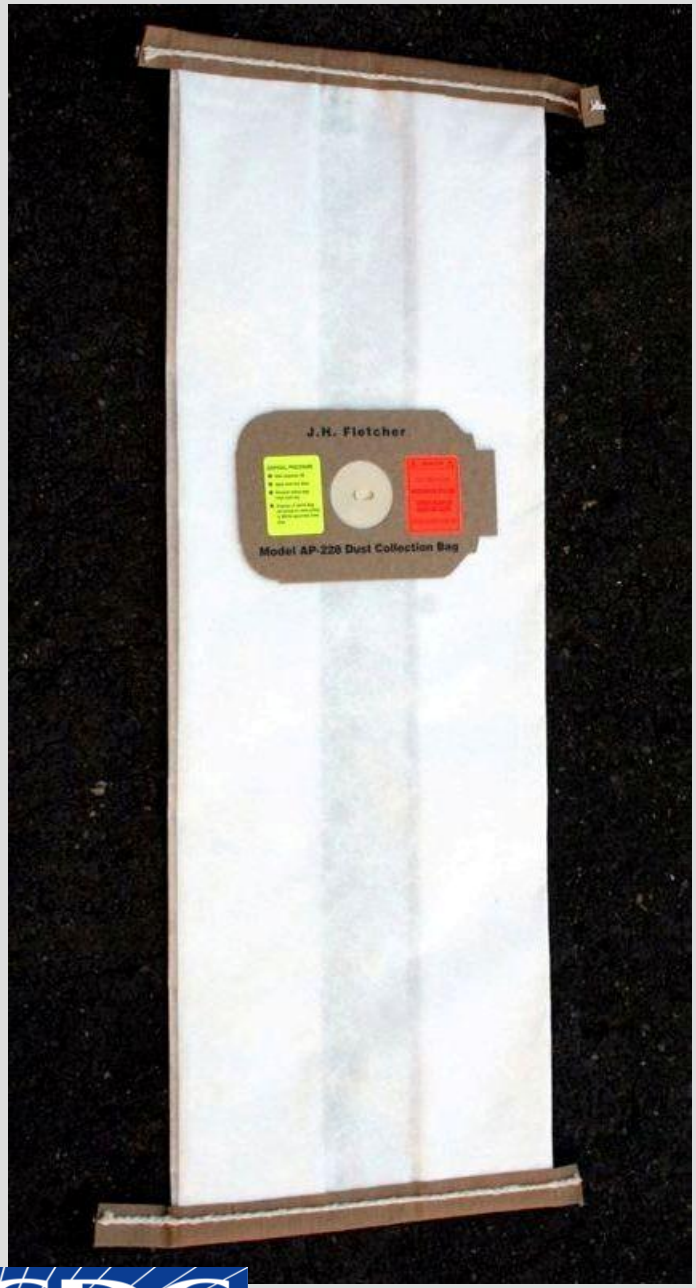
- Bag fills with dust during bolting
- Dump bag against rib
- Controls silica exposure

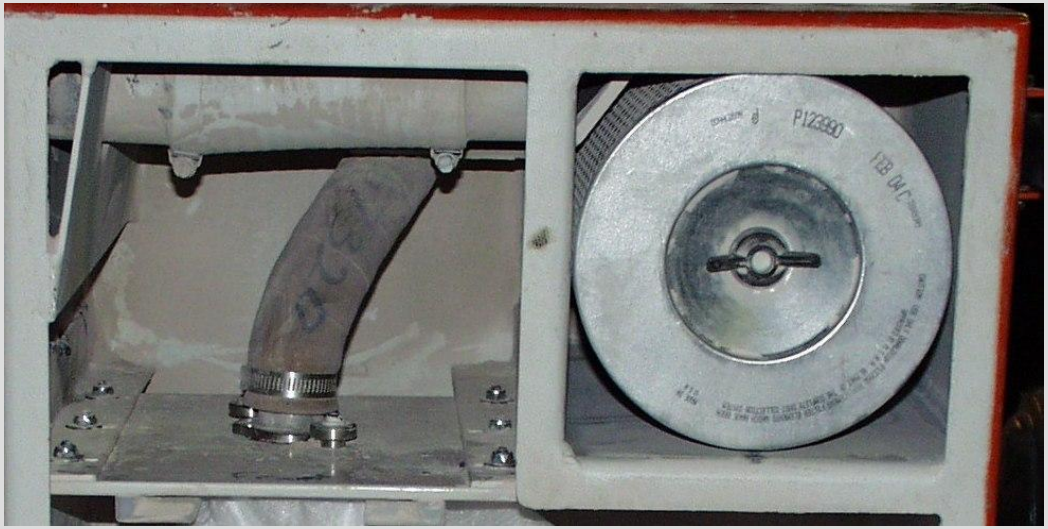
Silica Dust Levels When Cleaning Dust Box

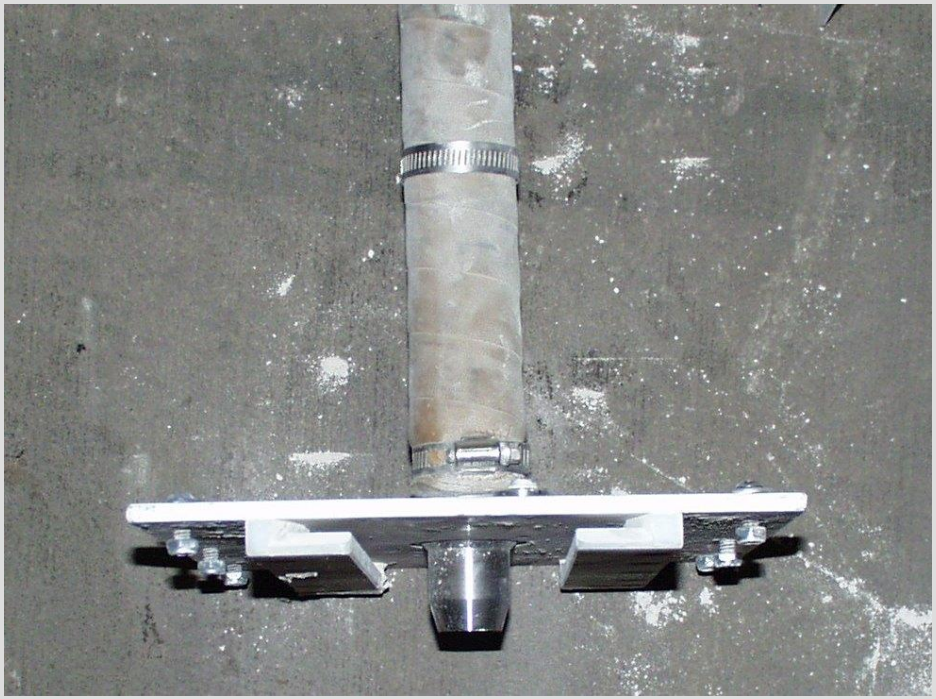


Disposable Collector Bag

- 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

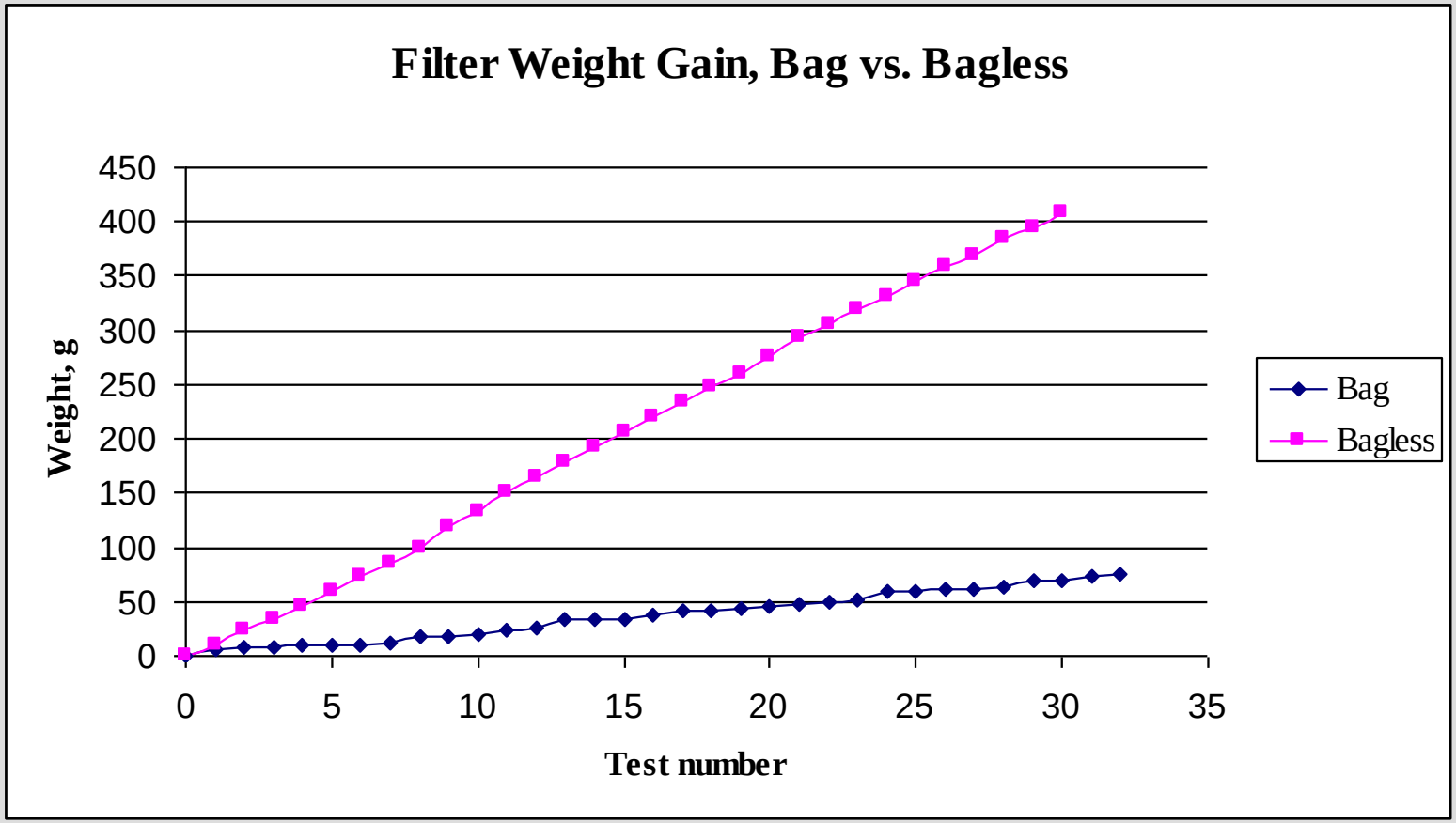
After

Collector Box Tests With Bag

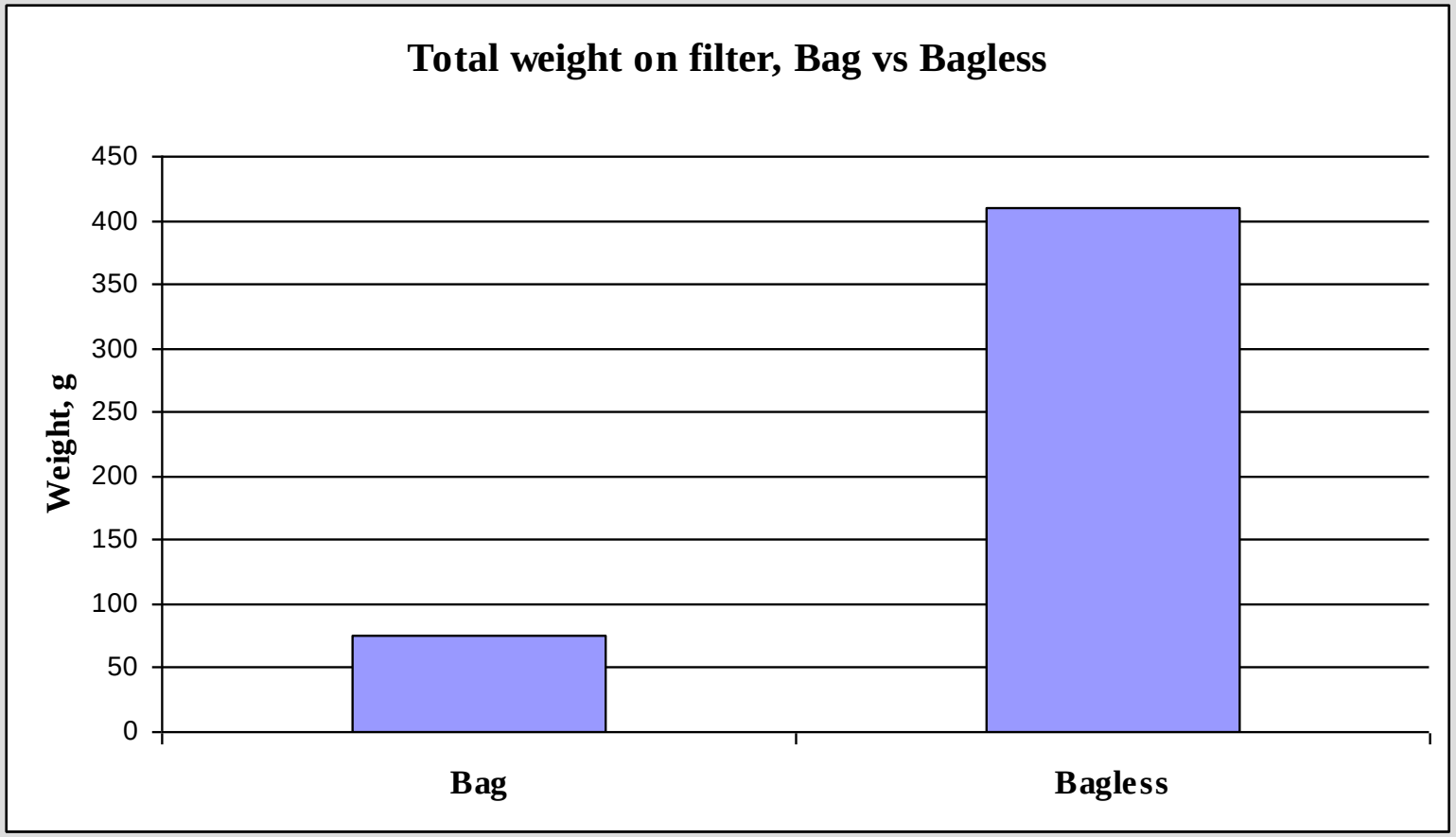
Before

After

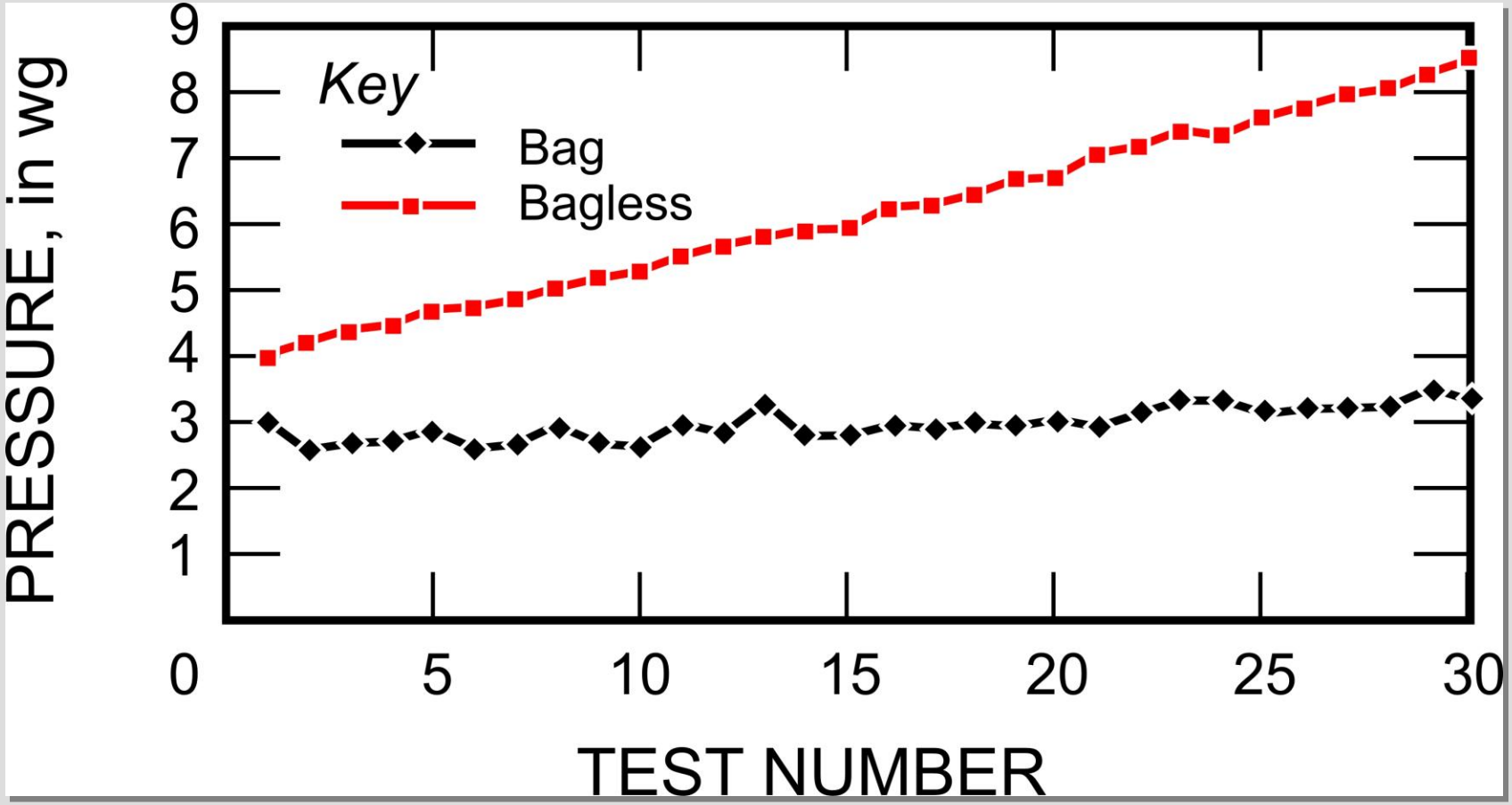
Filter Weight Gain per Test



Total Filter Loading



Pressure Drop Across Filter



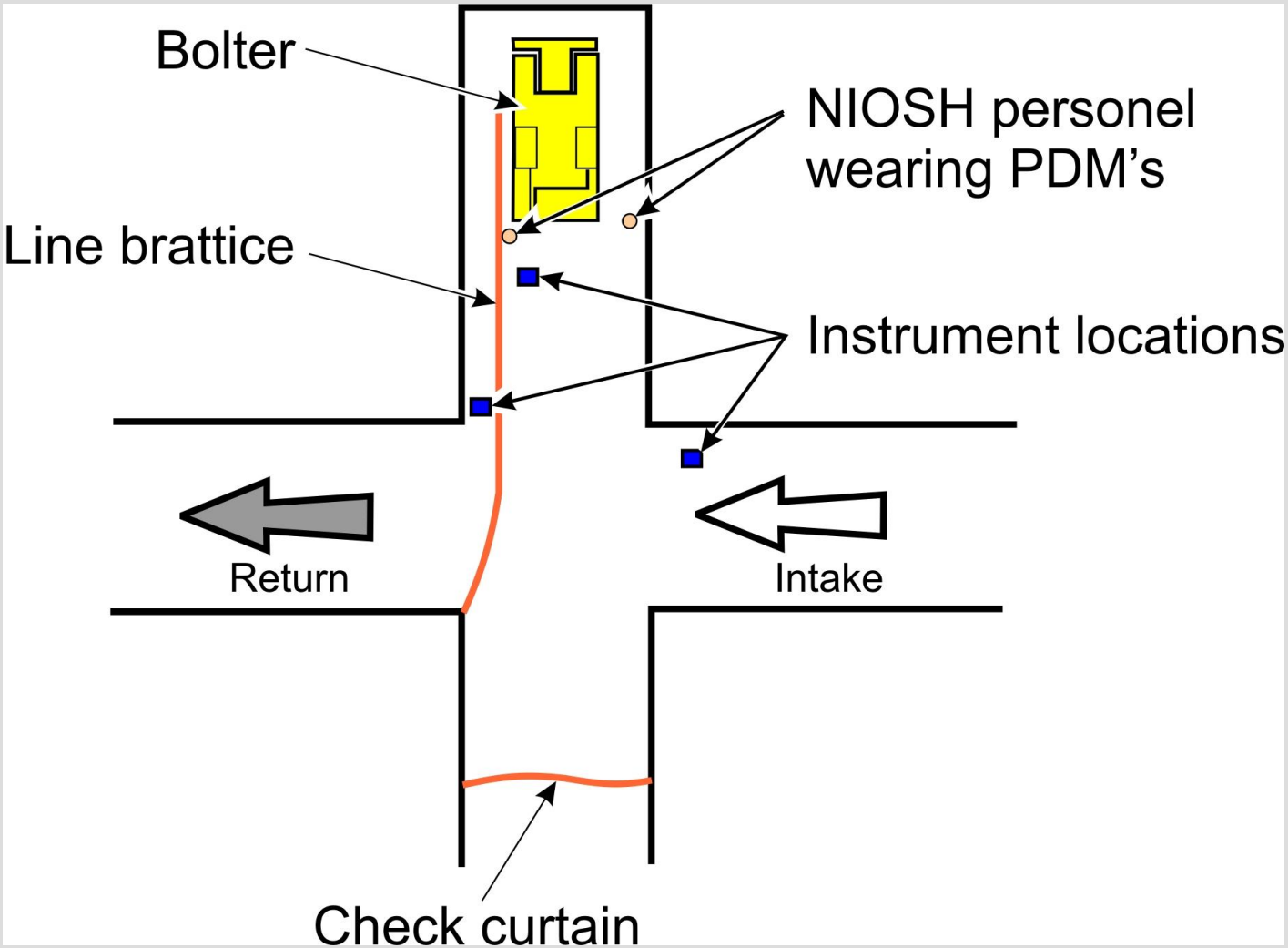
Lab Results Summary

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

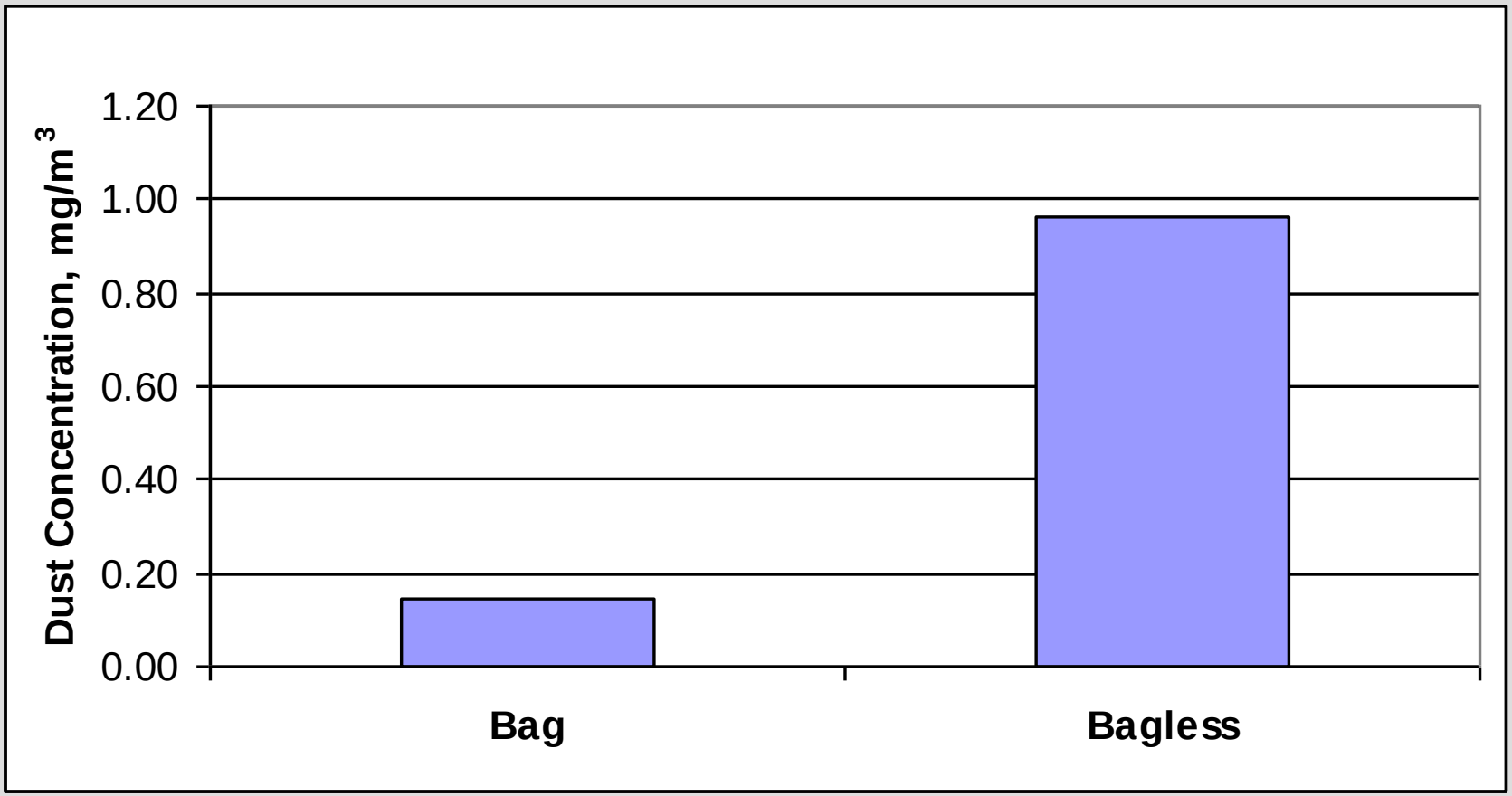
Bolter Bag Field Study

- 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



Field Results

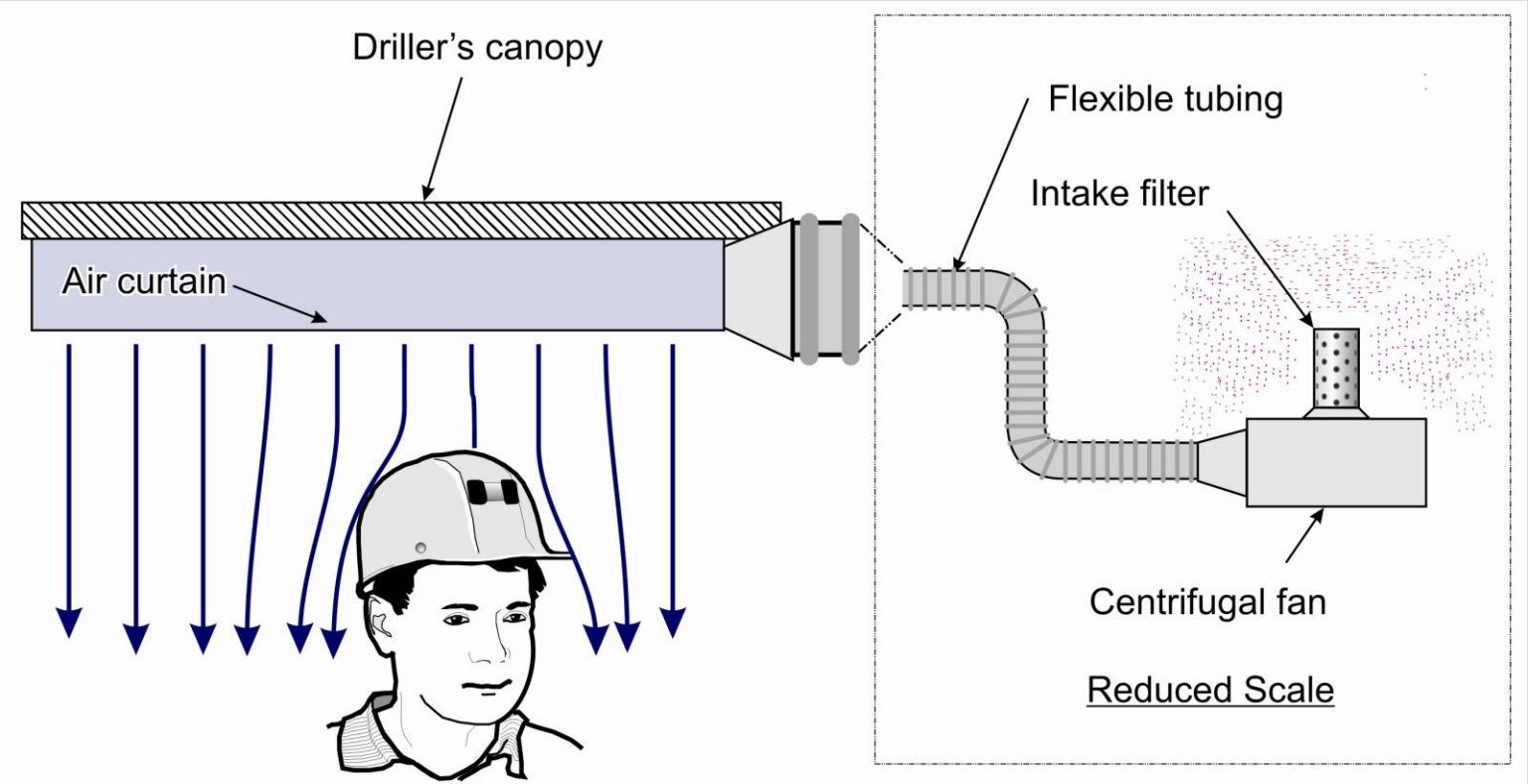
- Gravimetric samplers: respirable dust improved from 0.96 mg/m^3 to 0.14 mg/m^3 when the bag is in use.
- Personal samples from the PDMs: left side (exhaust side) of the bolter experienced over 2 times the amount of respirable dust than the right side.
- Collector box cleaning time reduced from 4 minutes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

Overall Benefits of Collector Bags

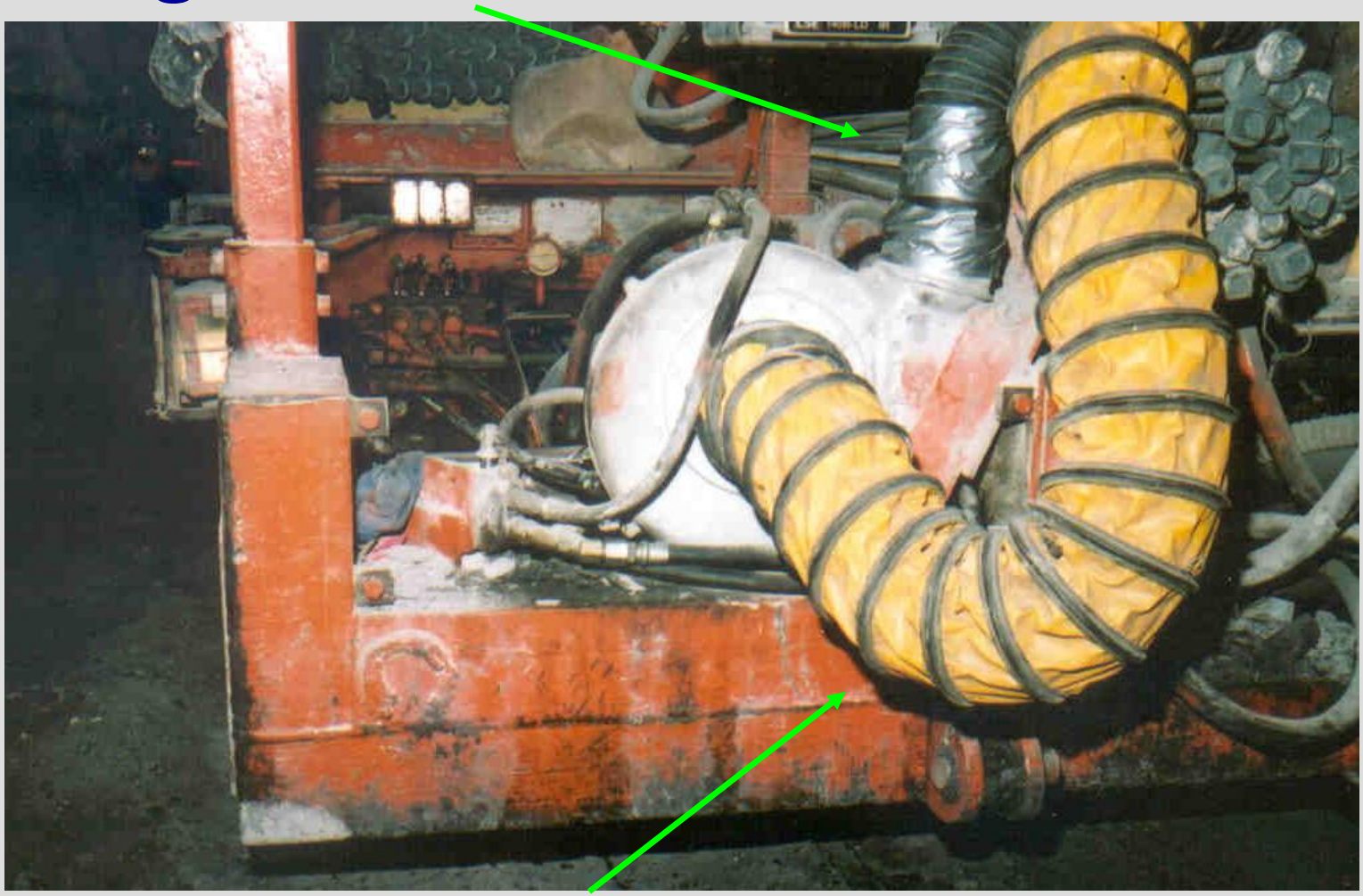
- Keeps dust contained during removal from box
- Keeps dust out of entry traffic preventing further entrainment
- Prolongs filter usage – reduces R/R frequency
- Reduces dust on outby collector components
- Reduces dust emissions from collector exhaust

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

"Dust Hog" bit (left) vs mist drilling bit (right)

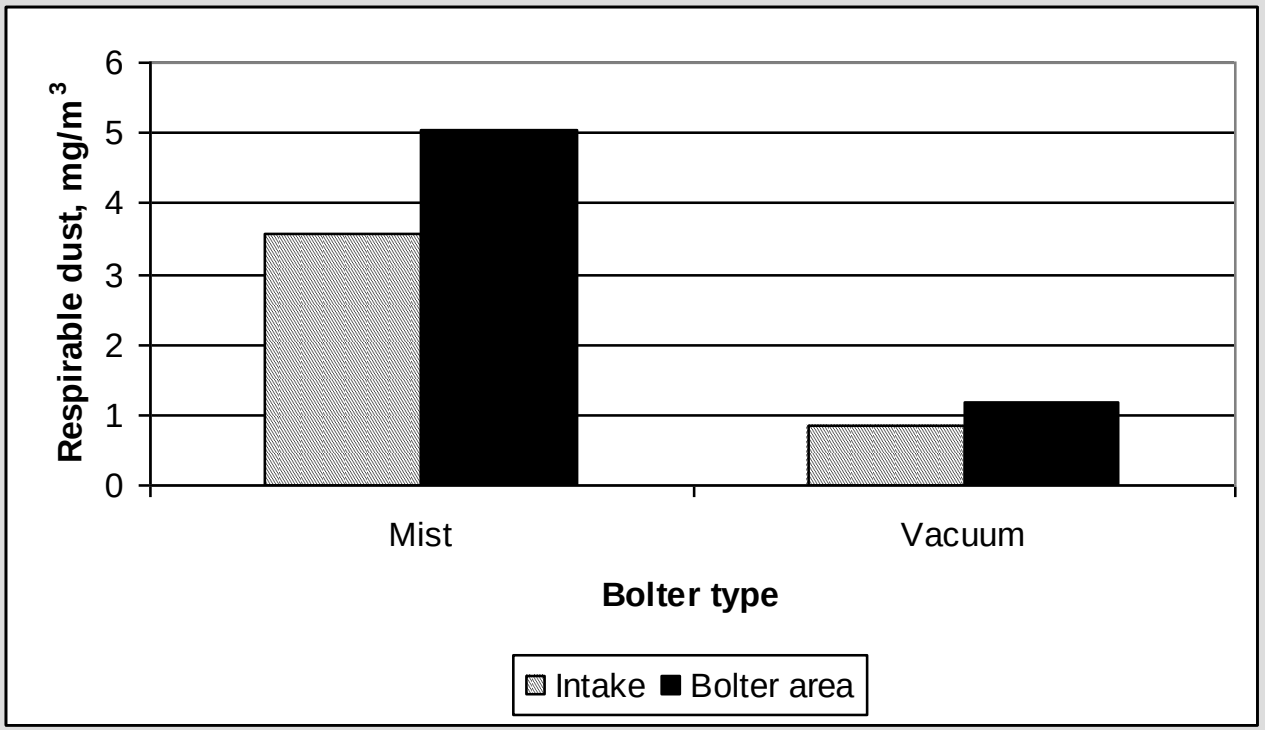
Mist Drilling

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

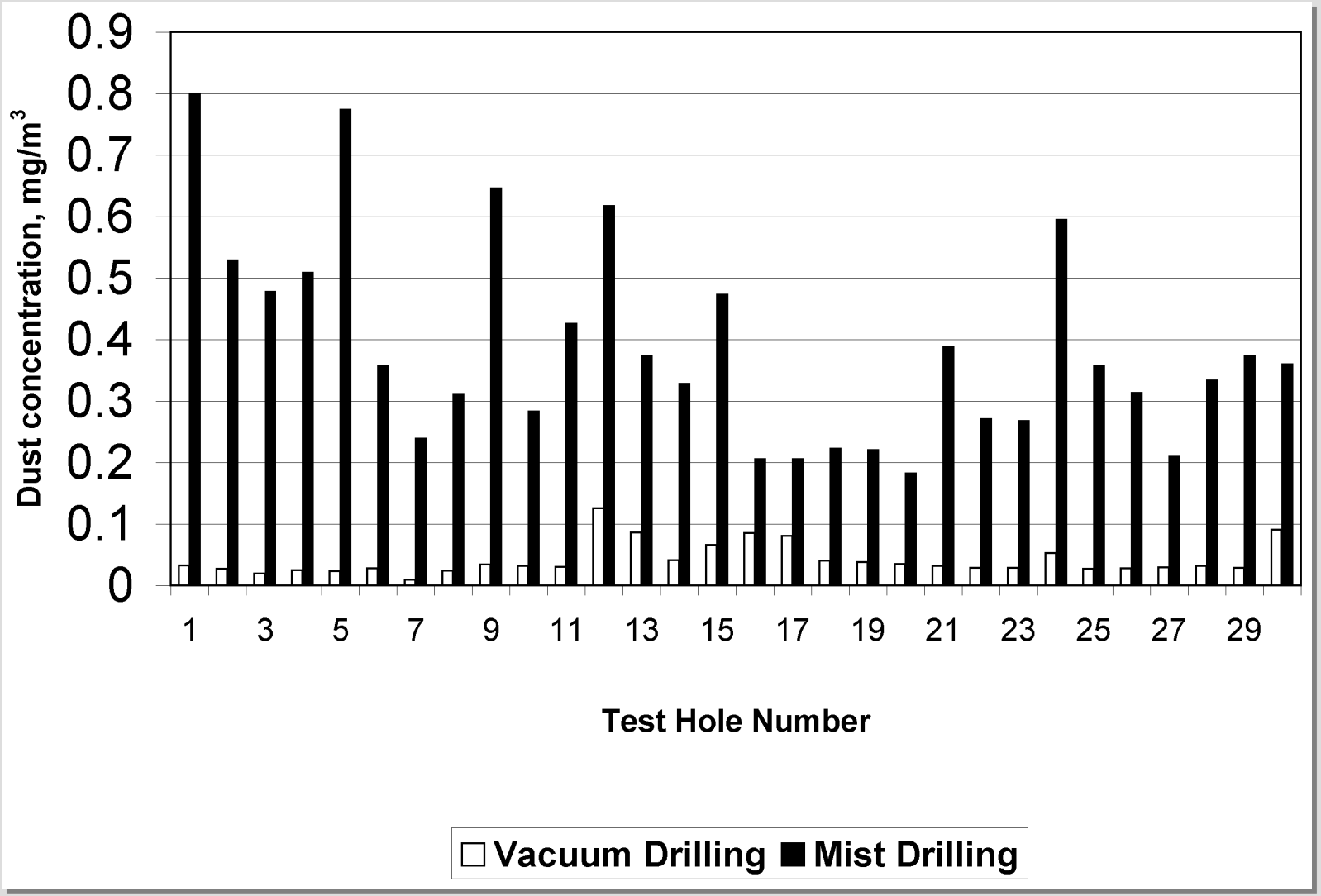
Mist Drilling Mine Study

- **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

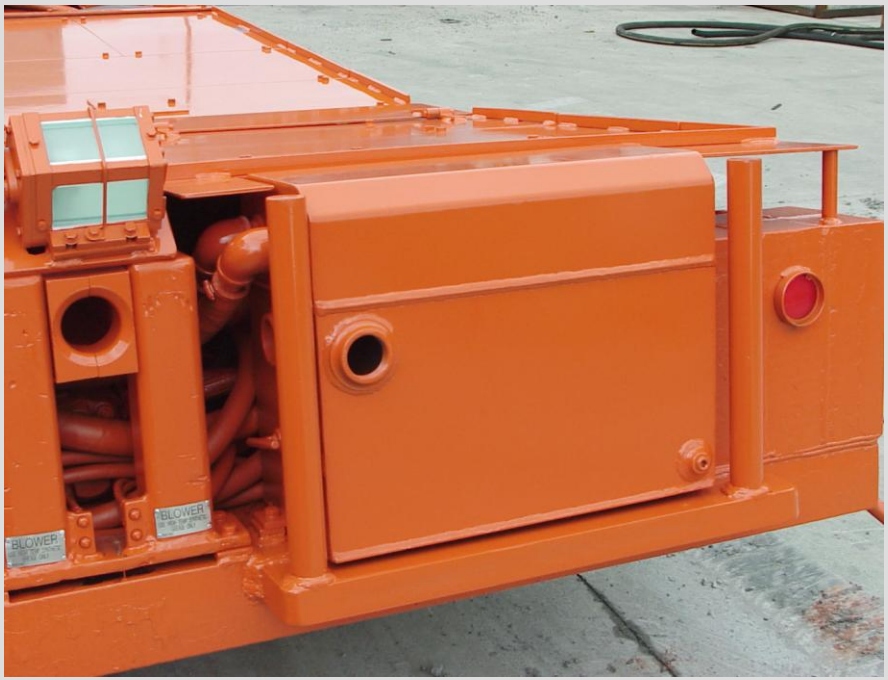
Laboratory Mist Drilling Results



Ongoing Roof Bolter Studies

Pre-cleaner dust

Exhaust conditioner (water 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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