Reducing Dust Generation and Optimum Suppression Techniques

Jay Colinet and Jeff Listak
Pittsburgh Research Laboratory
National Institute for Occupational Safety and Health

Controlling Respirable Coal Mine Dust in Underground Mines
National Mine Health and Safety Academy
July 25, 2007

Approach to Dust Control

- **Minimize dust liberation**
  - **Cutting**
  - **Wetting**
  - **Enclosures**
- **Direct dust clouds away from workers**
  - **Air velocity**
  - **Directional sprays**
  - **Barriers or avoidance**
- **Reduce airborne dust levels**
  - **Dilution**
  - **Capture**

Minimize Dust Generation

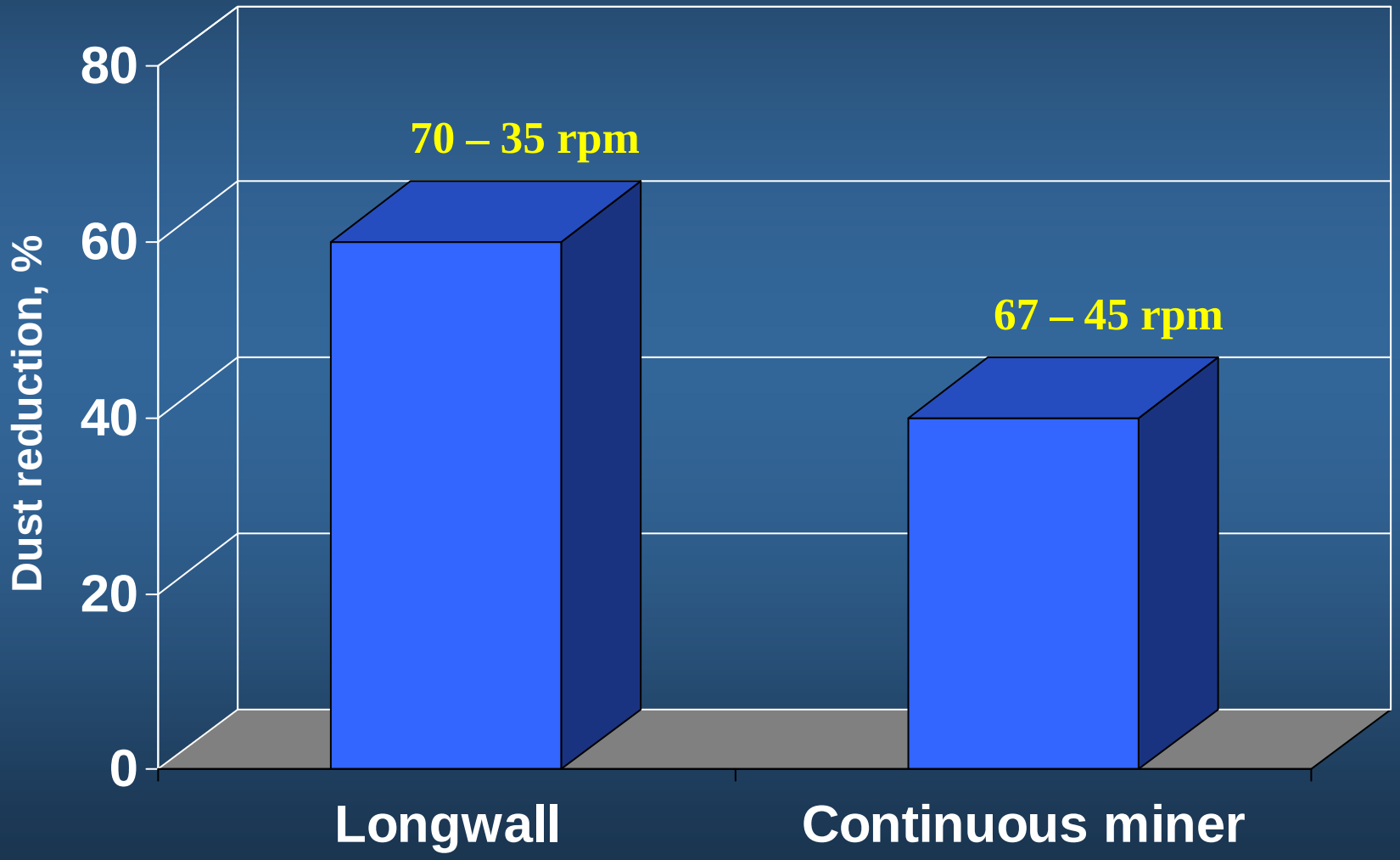
Drum Design

- water distribution
- water quantity
- bit lacing
- vanes
- rpm

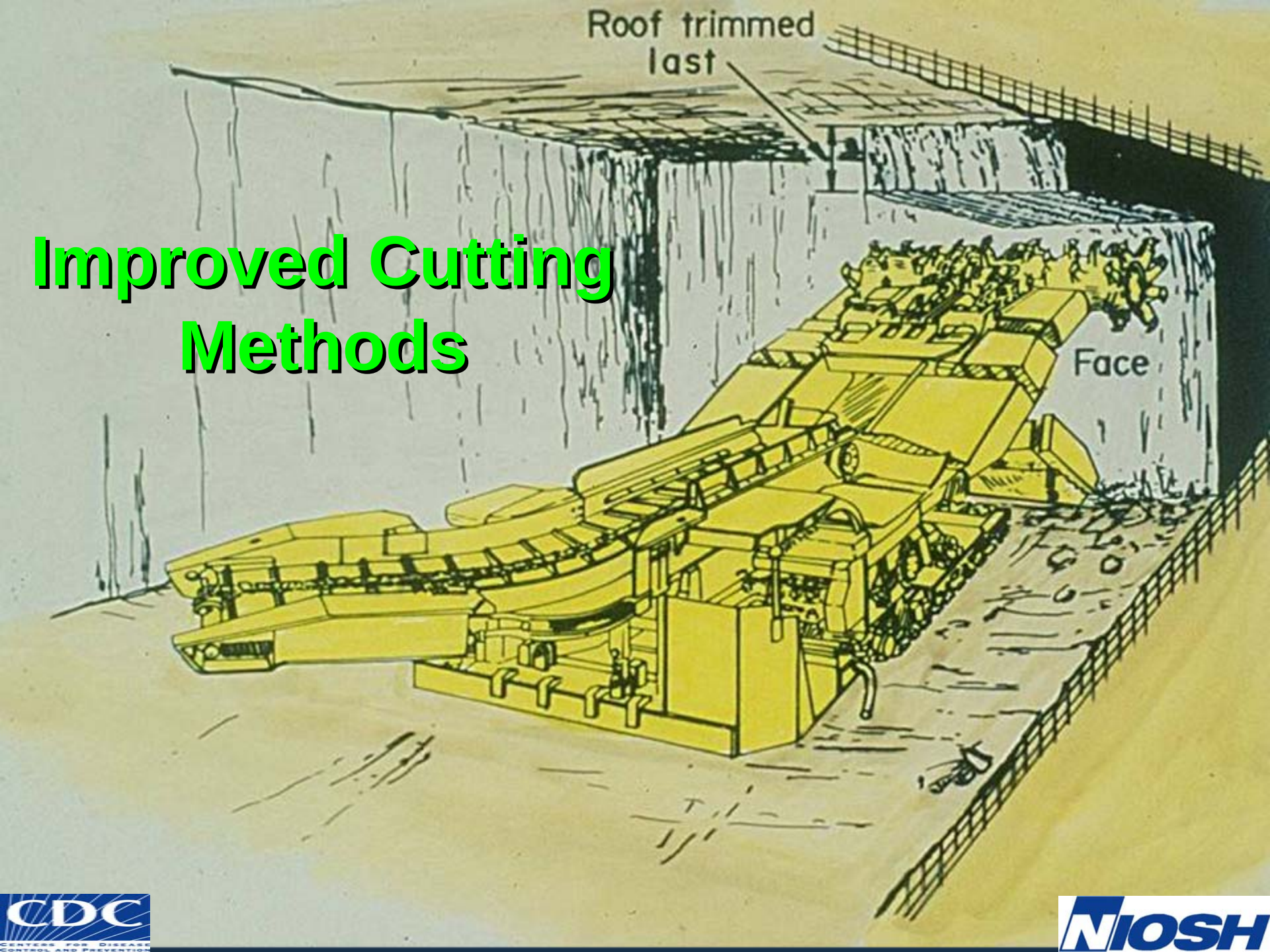
CDC CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

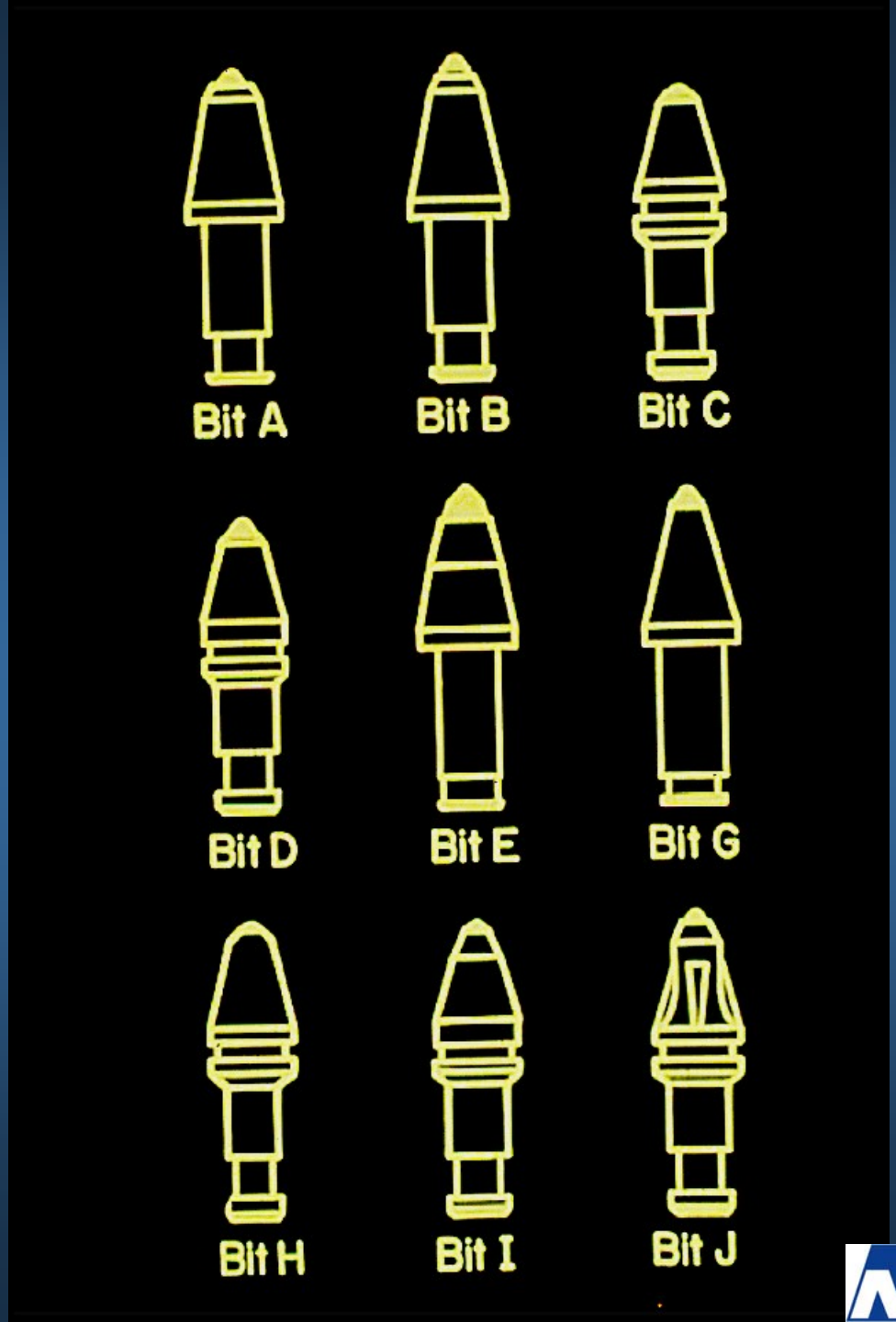
Impact of reduced cutting rpm



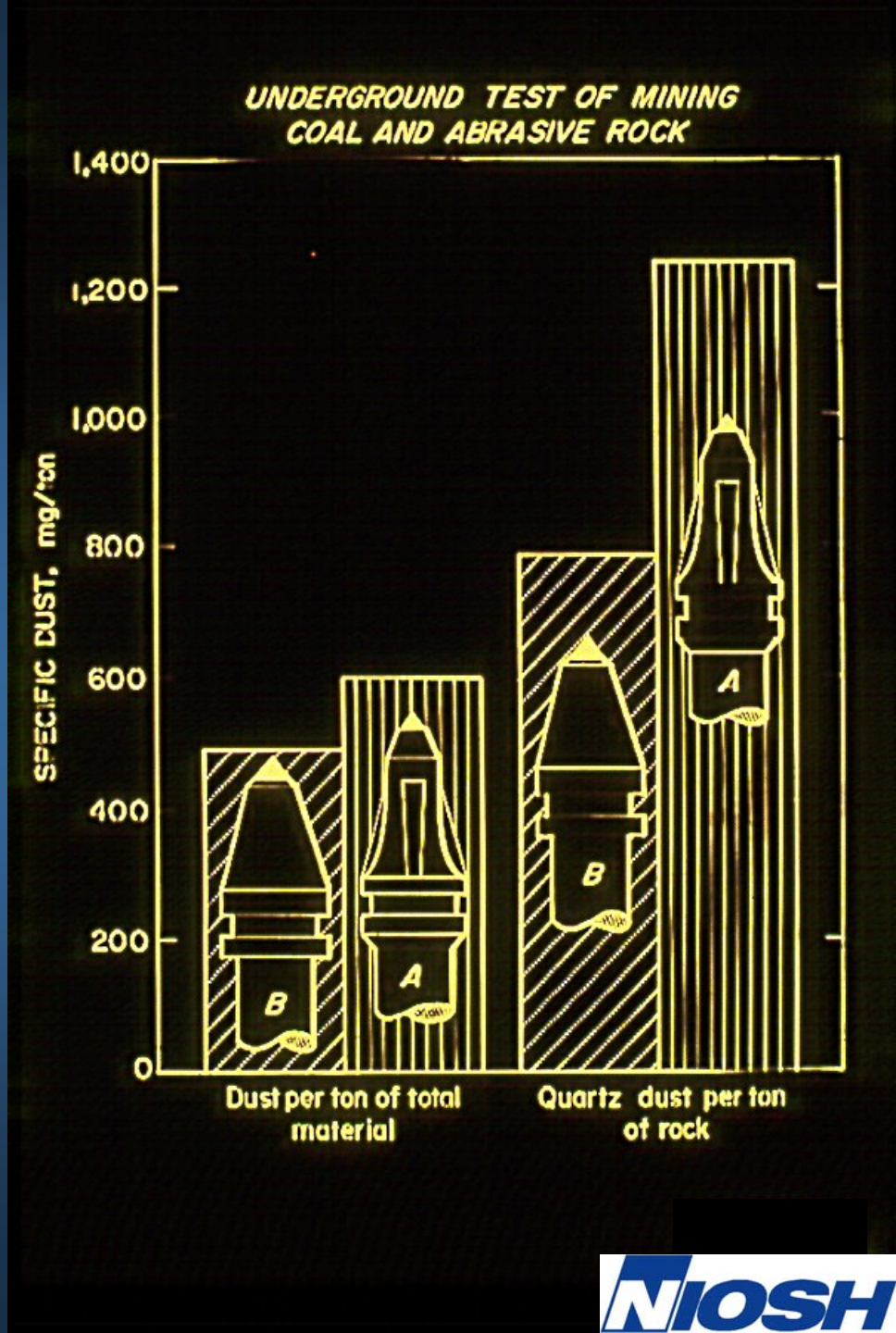
Improved Cutting Methods



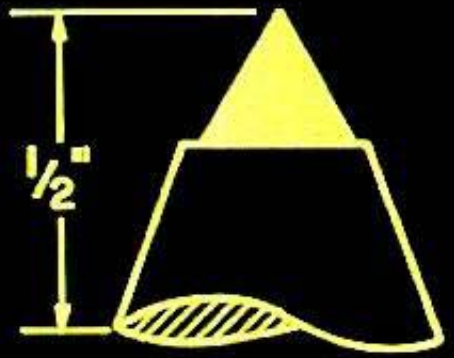
Bit Designs Tested on Continuous Miners



Differences in quartz and coal dust levels



Preferred bit design



- Slender profile
- Small carbide
- High wear rate
- High dust levels

- Intermediate profile
- Large carbide
- Low wear rate
- Low dust levels

- Fat profile
- Irregular transition
- Shank rubs
- High dust levels

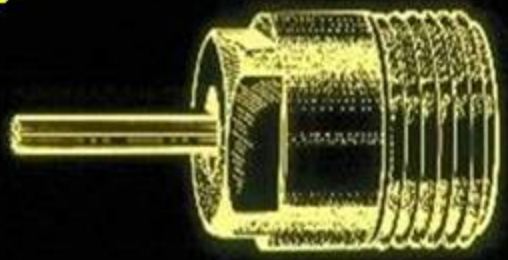
Impact of Water Sprays on Dust

- **Suppression** (volume)
- **Redirection** (pressure)
- **Capture** (type & pressure)

SPRAY TYPES

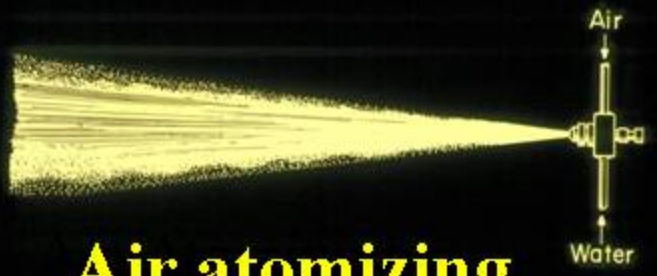
Hollow cone

Full cone



Solid stream

Flat fan



Air atomizing

Shearer water spray systems

- Drum sprays (wetting)
- External sprays (directional)

Spray Quantity More Important Than Pressure in Drum Sprays

- Operate at maximum of 100psi

- Use larger orifice nozzles to increase spray quantity to drum

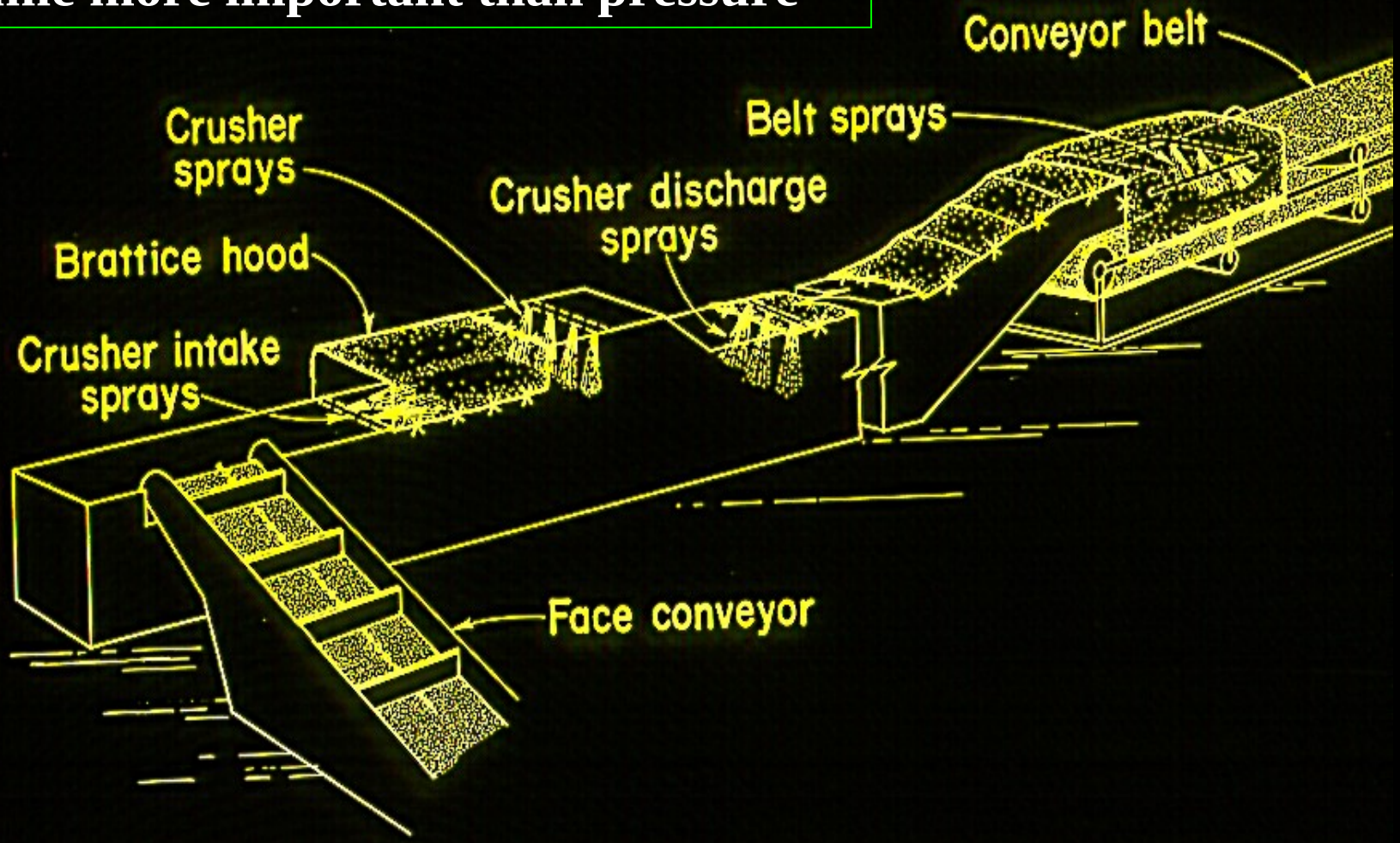
- Full-cone or solid stream spray patterns

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

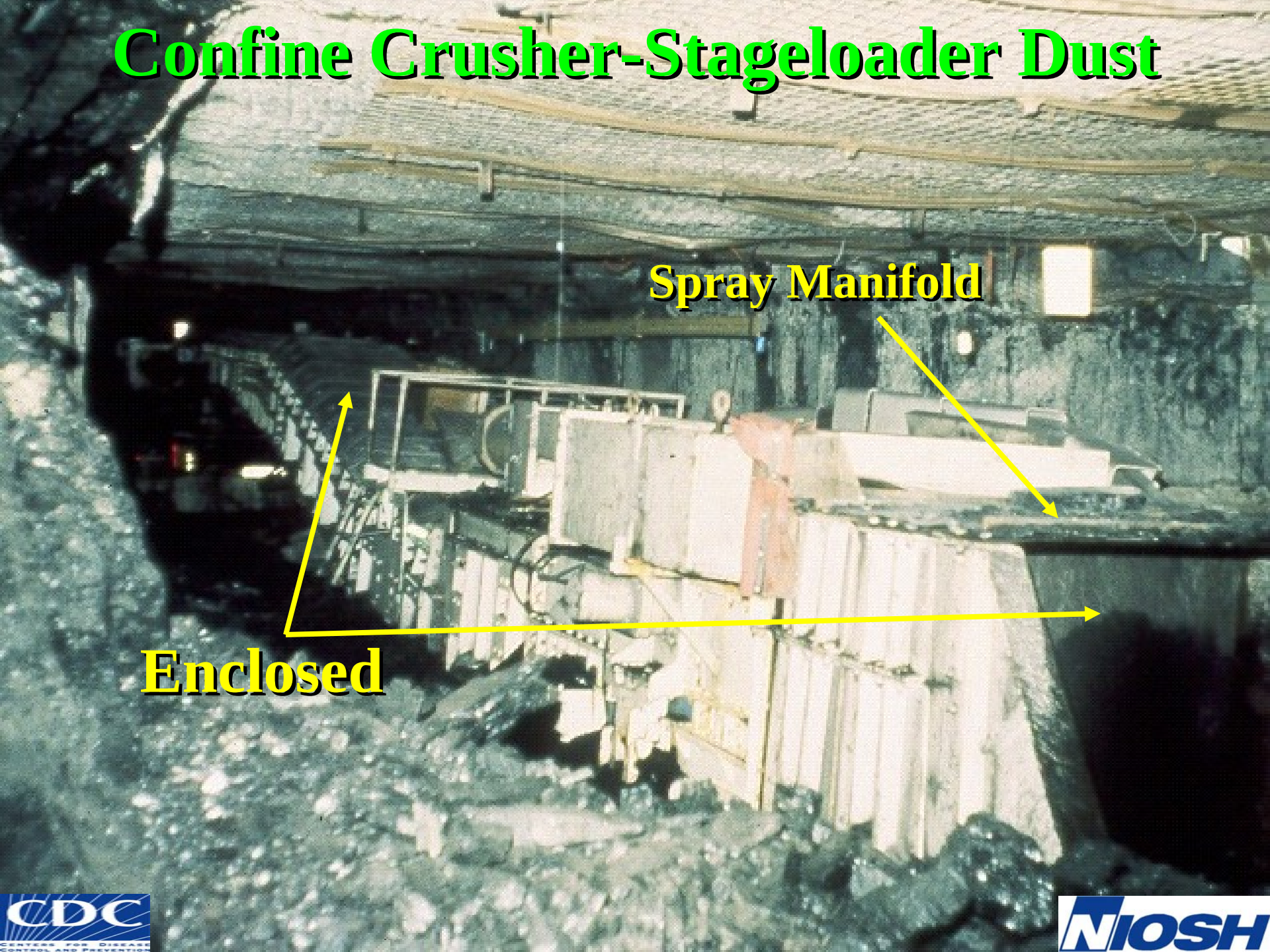
NIOSH

Stageloader-Crusher Controls:

- confine and wet with sprays
- volume more important than pressure



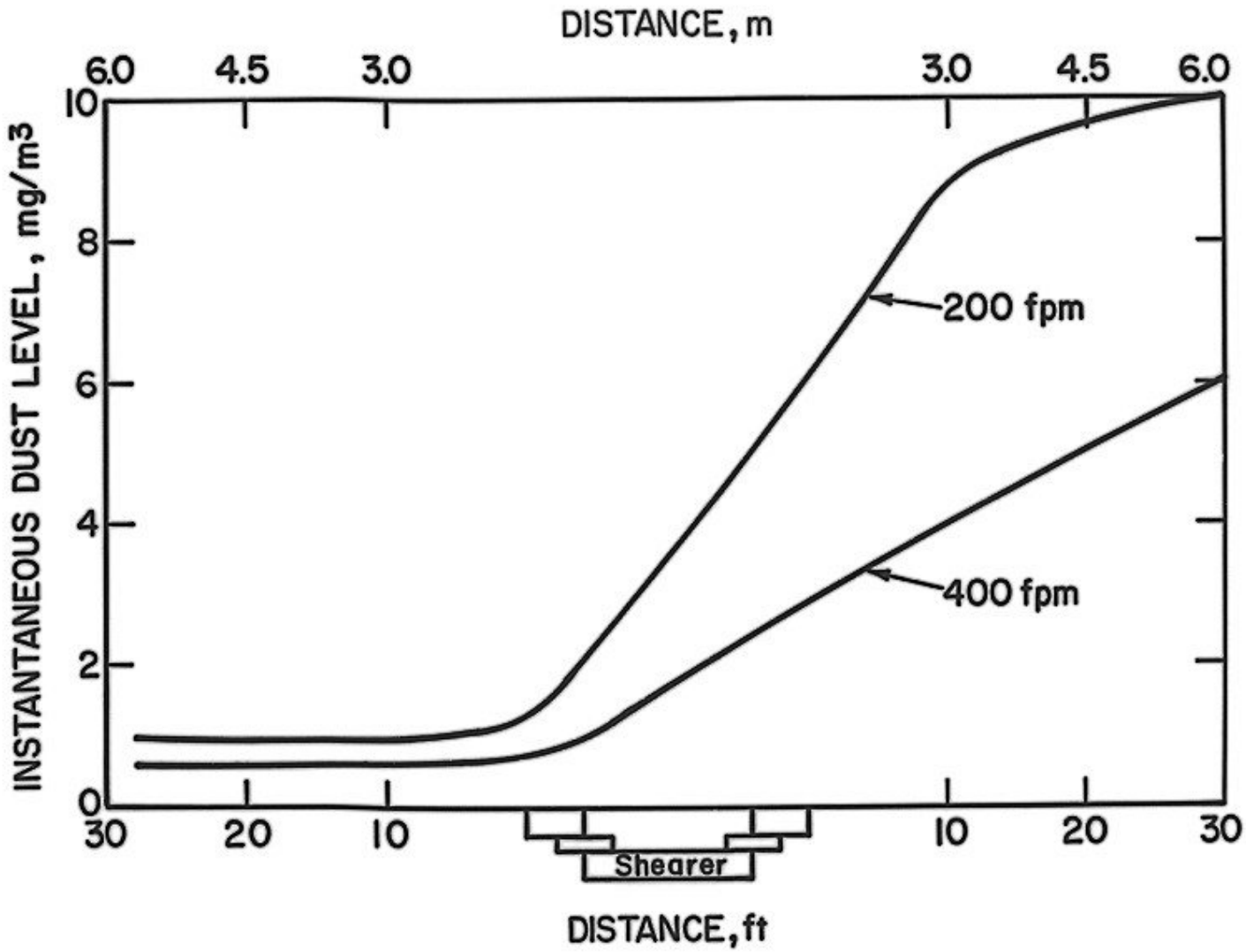
Confine Crusher-Stageloader Dust



Approach to Dust Control

- Minimize dust liberation
  - Cutting
  - Wetting
  - Enclosures
- Direct dust clouds away from workers
  - Air velocity
  - Directional sprays
  - Barriers or avoidance
- Reduce airborne dust levels
  - Dilution
  - Capture

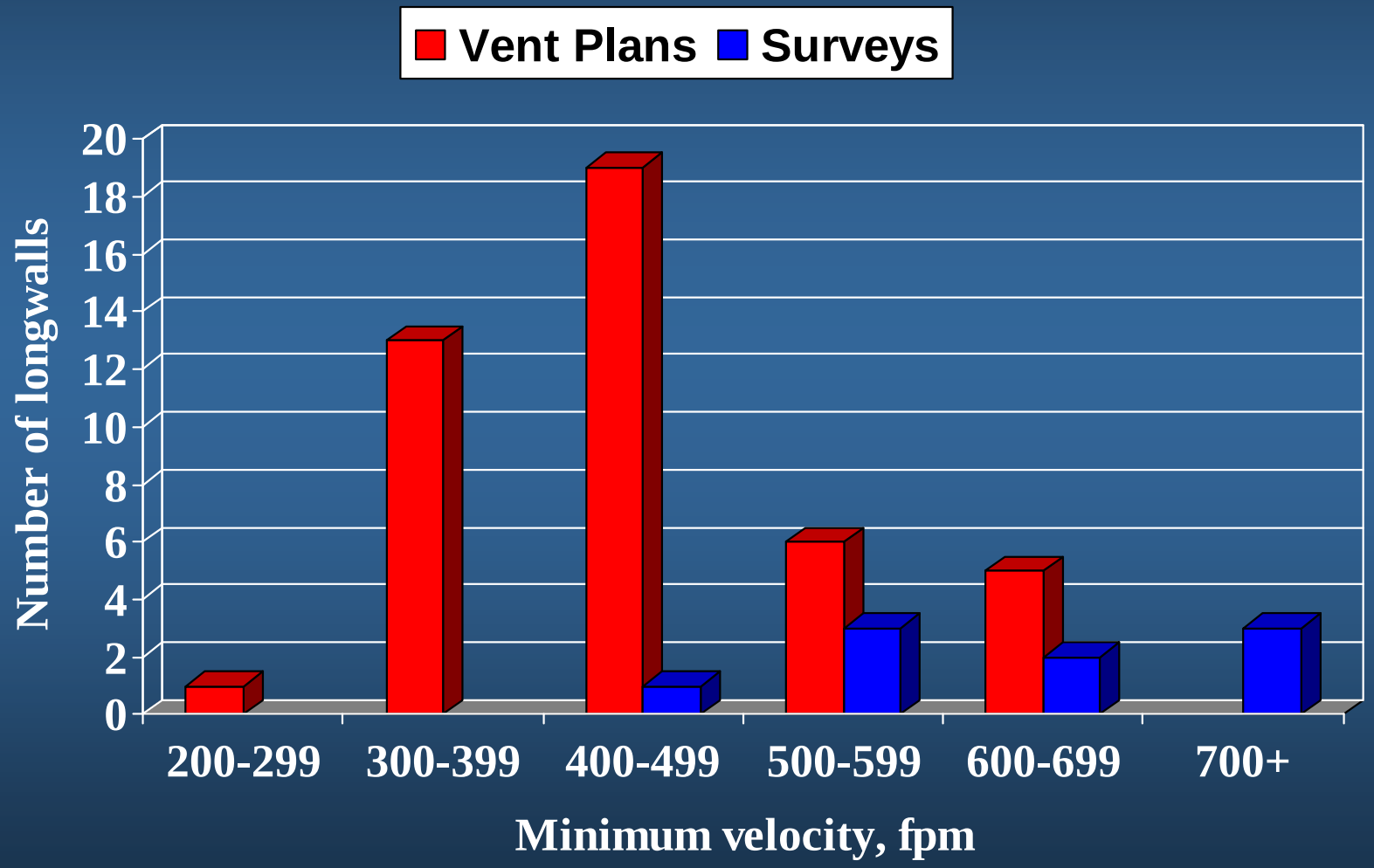
Higher Velocities Confine Dust Near Face



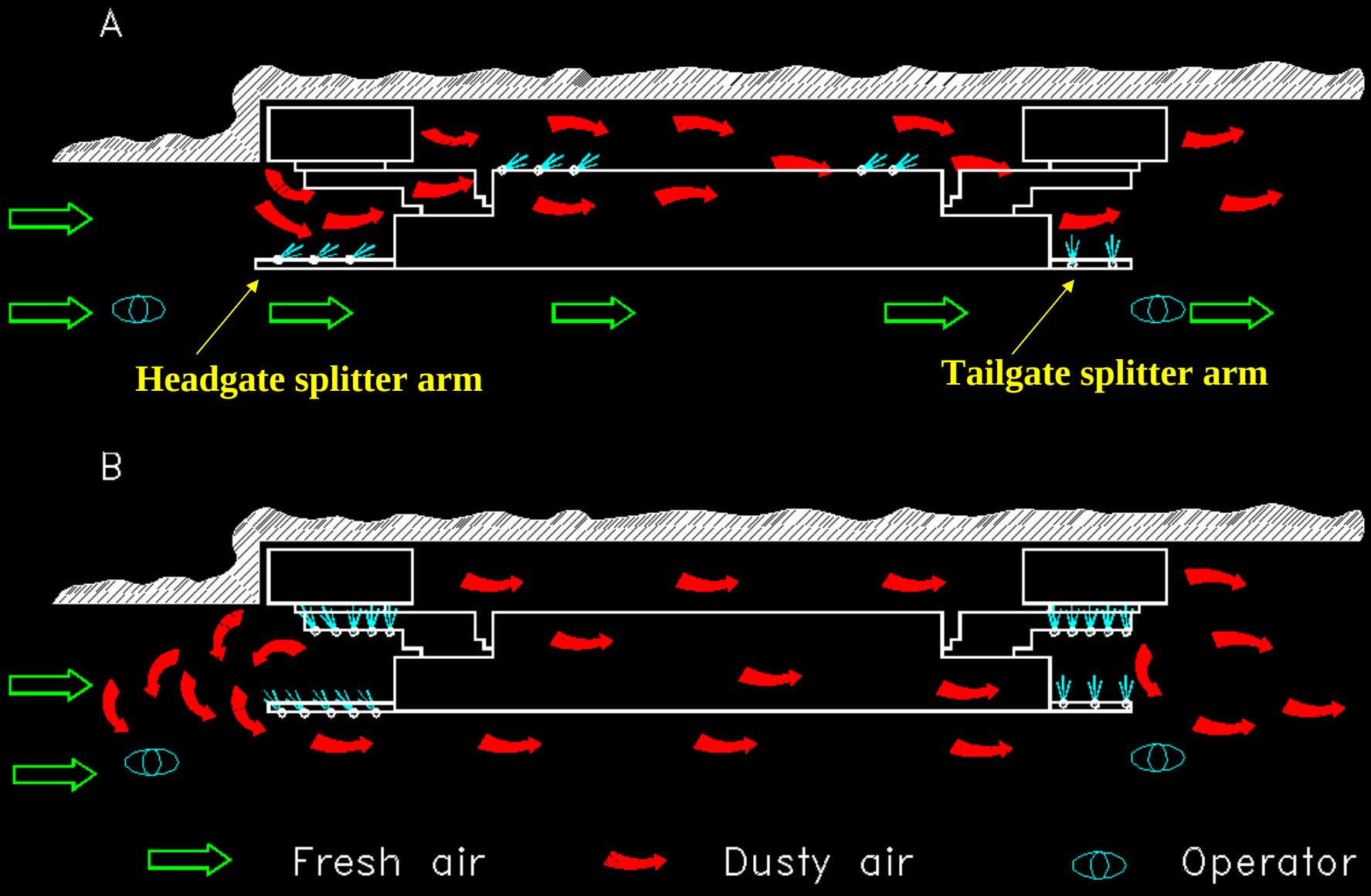
Added Benefit of Increased Airflow

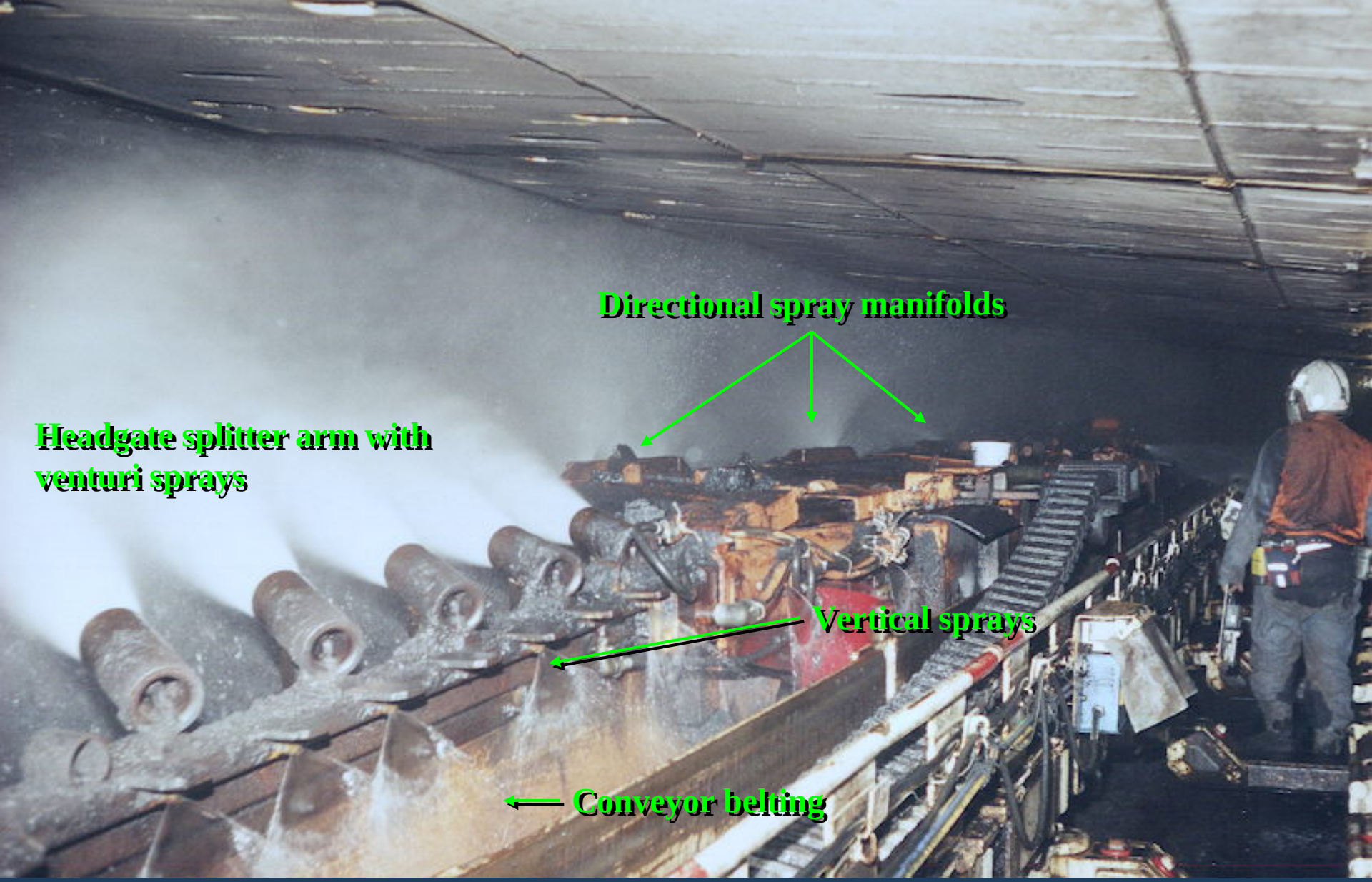
Uncontrolled or intermittent sources….

Air Velocities on Longwall Faces
(44 vent plans from 2000 – 2003, 9 NIOSH surveys)



Directional Sprays (Shearer Clearer)





Key components of a shearer clearer spray system

Design considerations for an effective shearer-clearer spray system

- Splitter arm length
- Spray angle and pressure (150 psi)
- Physical barriers - belting/plate
- Splitter arm height

Spray manifold in lieu of tailgate splitter arm

Effective directional spray systems

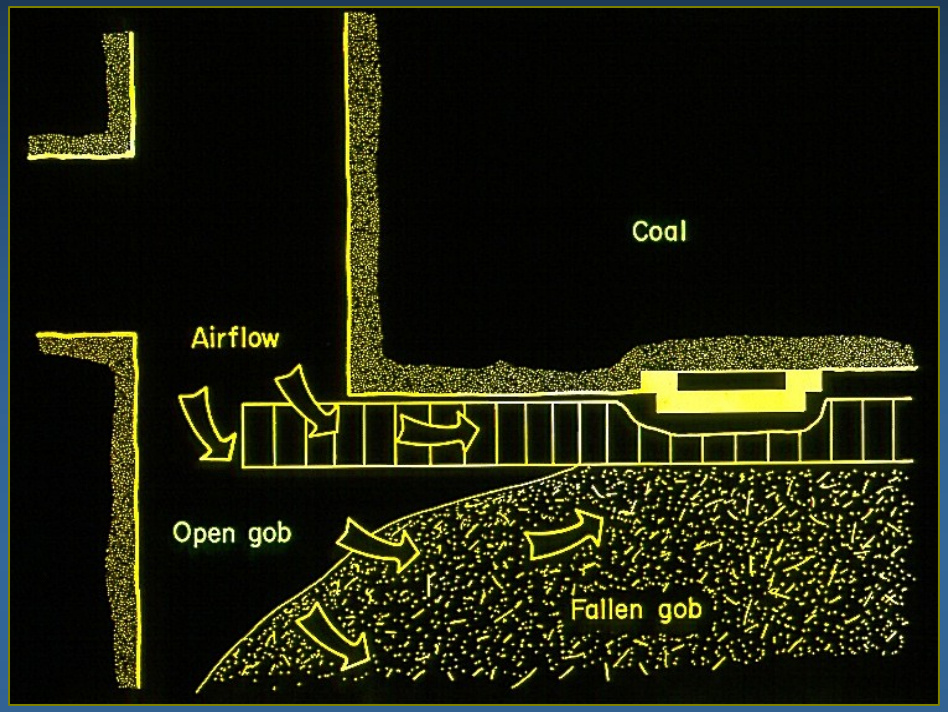
Ineffective directional spray systems

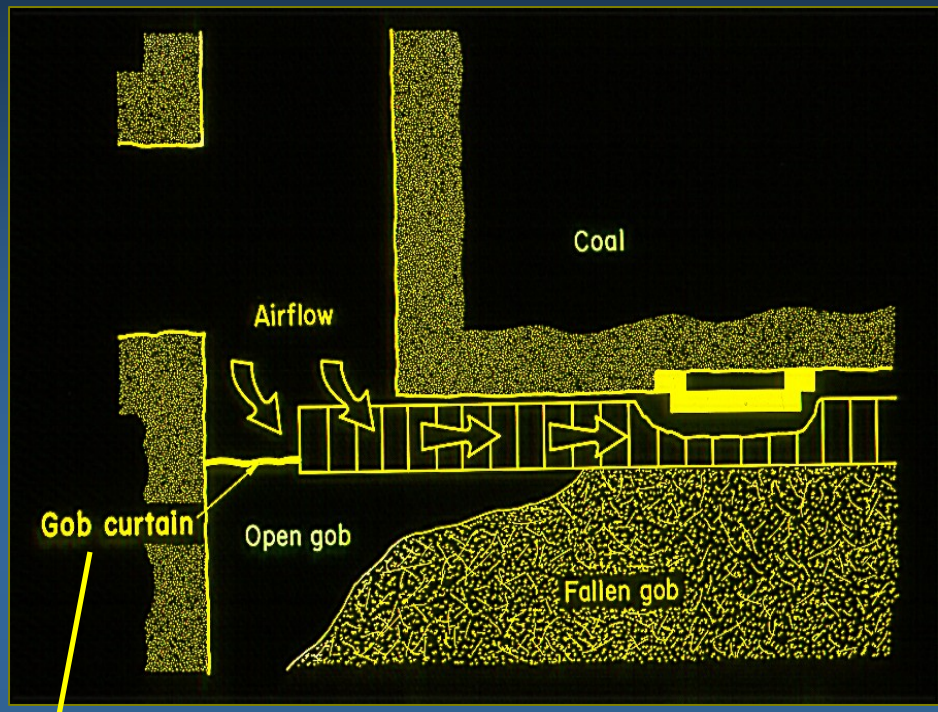
Caution: crescent sprays on headgate ranging arm

Approach to Dust Control

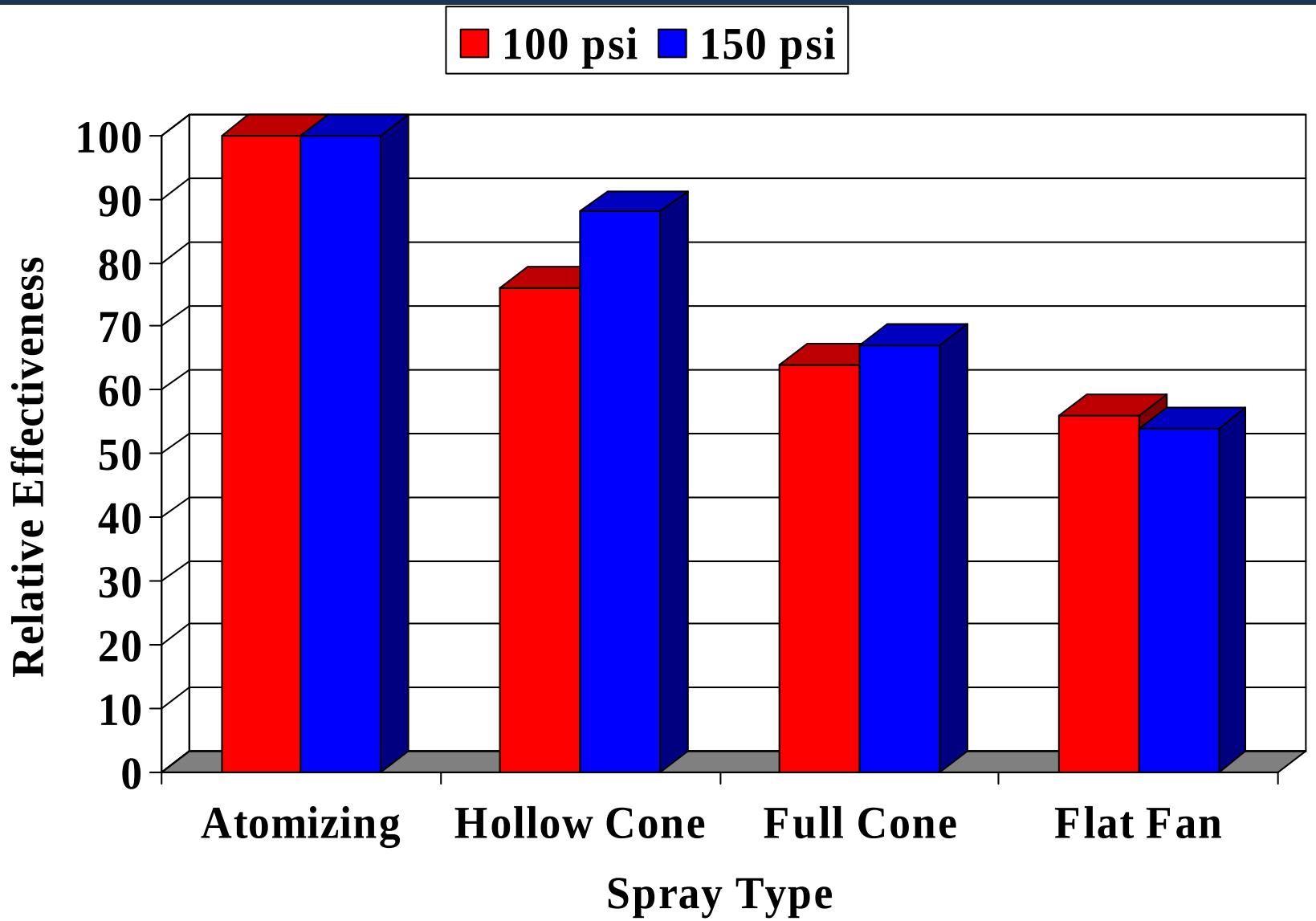
- Minimize dust liberation
  - Cutting
  - Wetting
  - Enclosures
- Direct dust clouds away from workers
  - Air velocity
  - Directional sprays
  - Barriers or avoidance
- Reduce airborne dust levels
  - Dilution
  - Capture

Maximize Air Flow to Longwall Face

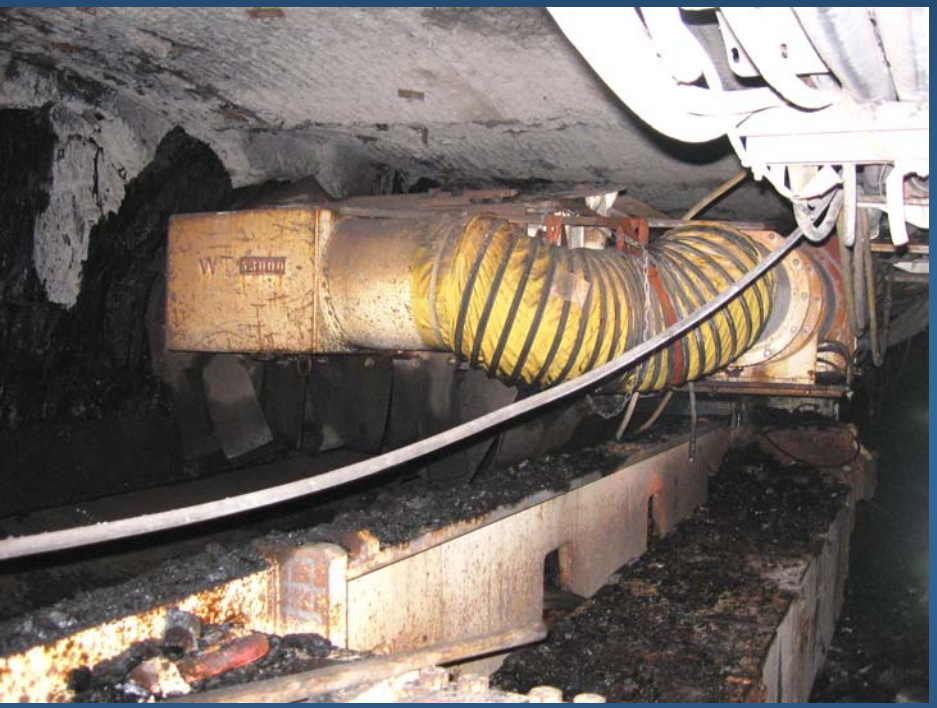




Airborne Dust Capture With Sprays



Scrubbers on stageloader/crusher



Stageloader to belt transfer

Crusher

Primary Dust Controls for Longwalls

- **Ventilating Air**
  - Dilution (quantity)
  - Removal (velocity)
- **Water Sprays**
  - Suppression (volume)
  - Redirection (pressure)
  - Capture (type)
- **Dust collectors**

Maximize benefit of available controls…

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Effective Water Management

Utilize available water to optimize dust control

Ongoing Longwall Dust Control Research

Benchmarking Surveys

- Quantify dust from major sources
- Identify controls and level of application
- Provide suggestions for improved dust control
- 9 surveys completed with 1 - 2 more desired

CDC CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

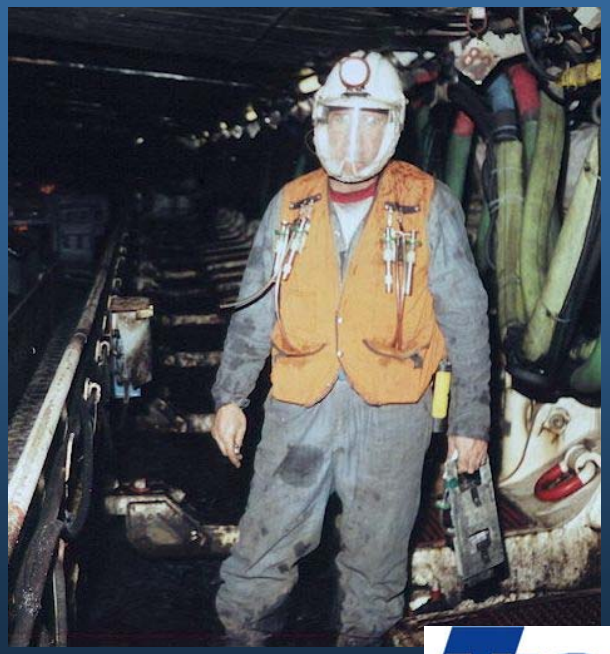
Sampling to isolate and quantify dust sources

Stationary sampling

- Intake
- Belt
- Shield 10
- Tailgate

Mobile sampling

- Outby
- Upwind
- Shearer
- Downwind

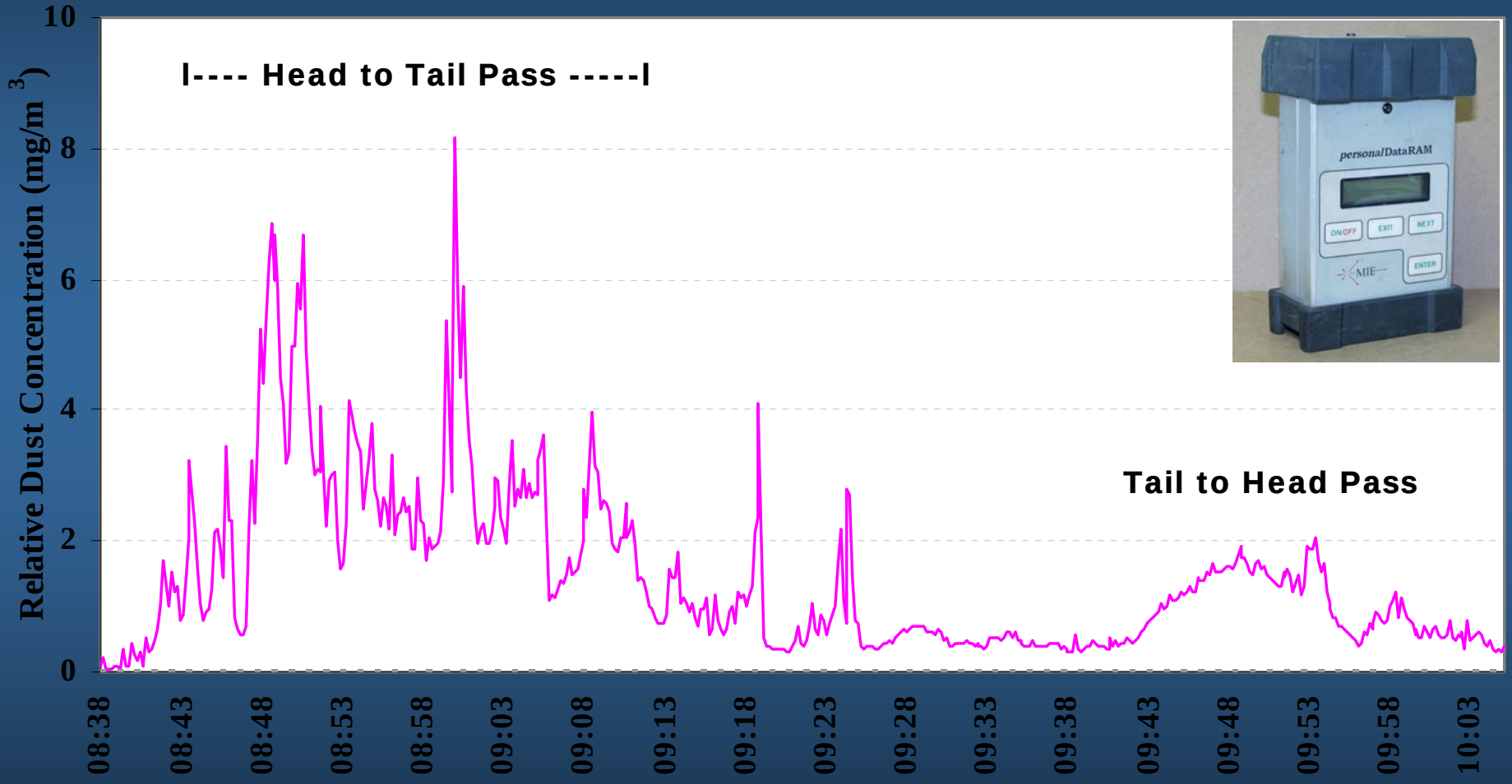


CDC CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH


Dust contribution from shield advance increasing

Impact of shield advance on shearer operator dust levels



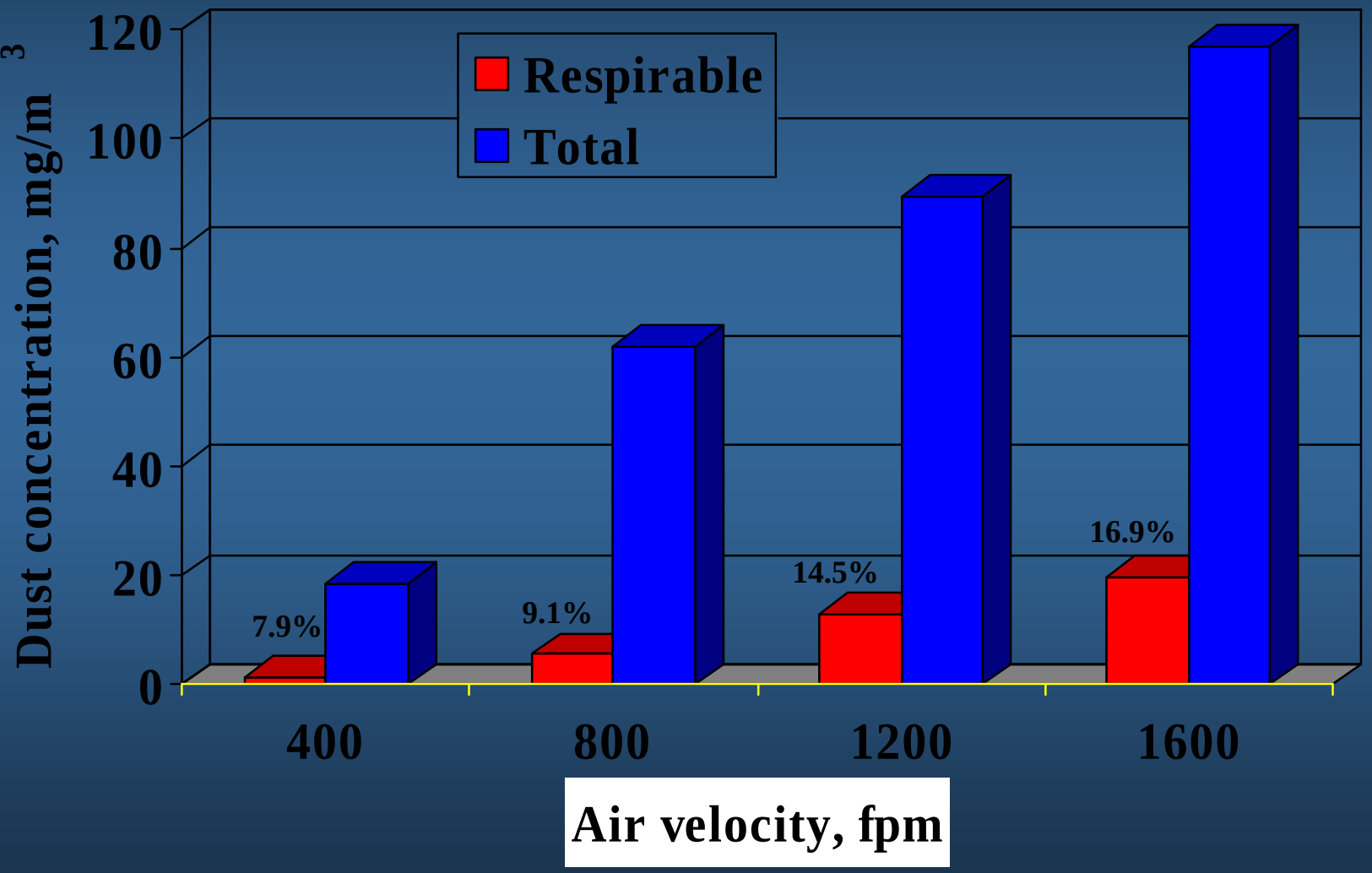
Dust Entrainment in High Velocity Airstreams

- Simulate entrainment of dust during shield advance
- Testing at air velocities from 400 to 1600 fpm

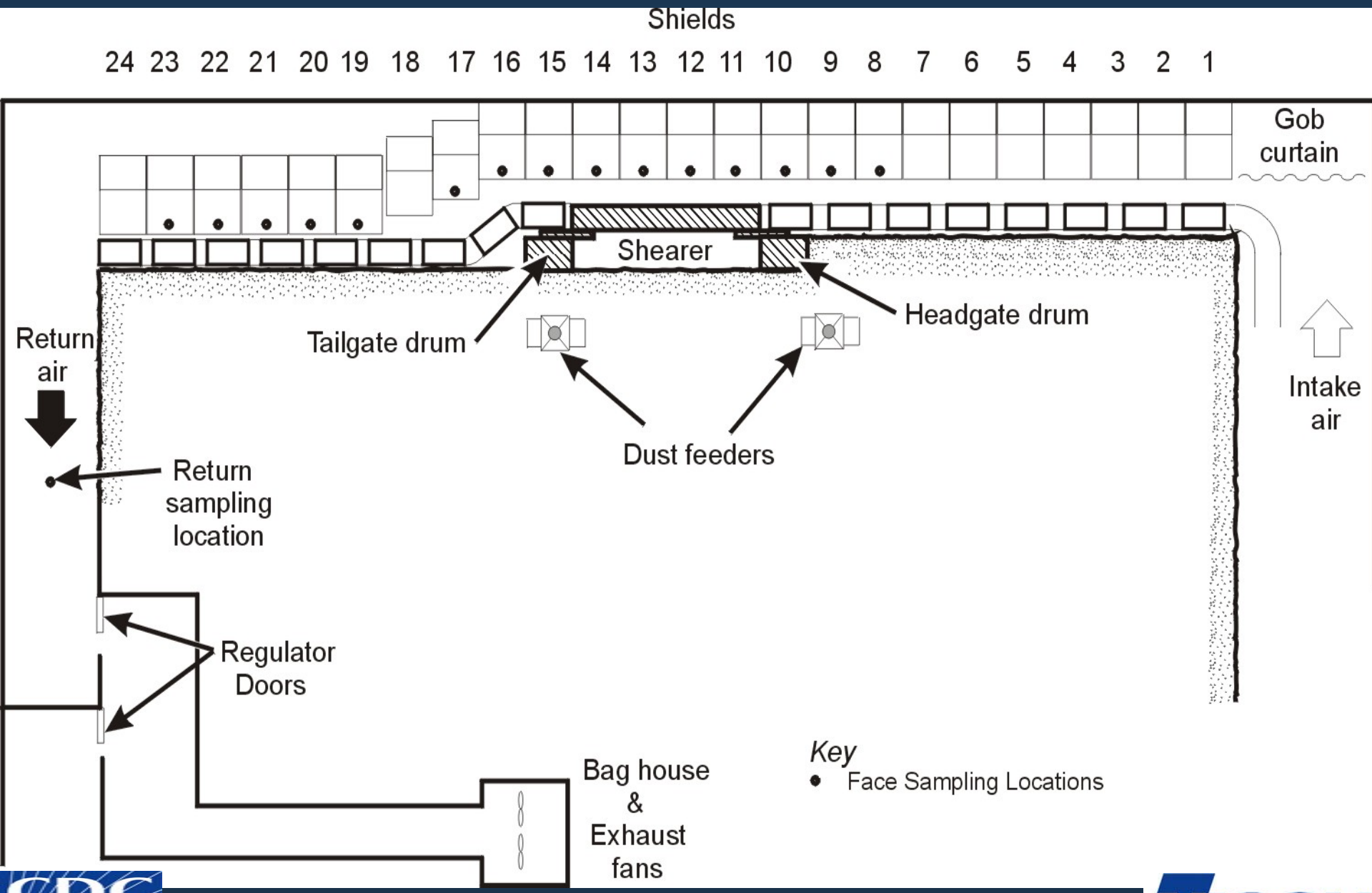
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Percent of Respirable Dust in Airborne Samples



Longwall Dust Gallery



Longwall Dust Gallery

- Examine spray applications for shield dust
- Develop improved external sprays for high coal faces

Respirable Dust Control for Continuous Mining Operations

NIOSH
Pittsburgh Research Laboratory

CDC Workplace Safety and Health

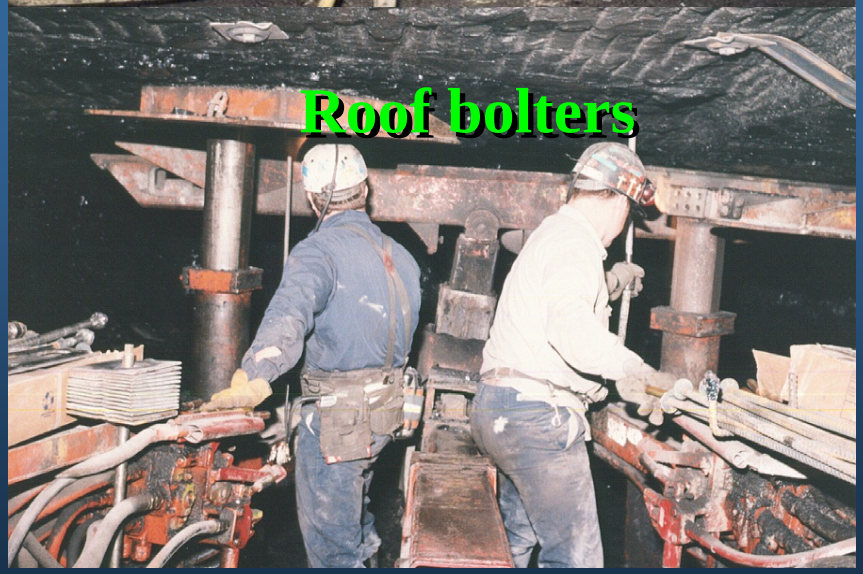
NIOSH

MSHA Data

2001 to 2004

17,000 personal samples

- 11% exceed the federal dust standard at the cm and roofbolter occupations
- 20% exceed a silica dust concentration of 100µg/m^3



Water sprays on continuous miners

Function:

Suppress/wet

Redirect

Capture

Effectiveness:

Flow rate

Pressure

Spray type

Wetting/Suppression

- flat-fan sprays on top of boom
- deluge sprays under boom
- throat sprays

- **Flow rate most important**

Sprays close to cutting head

CDC Workplace Safety and Health

NIOSH

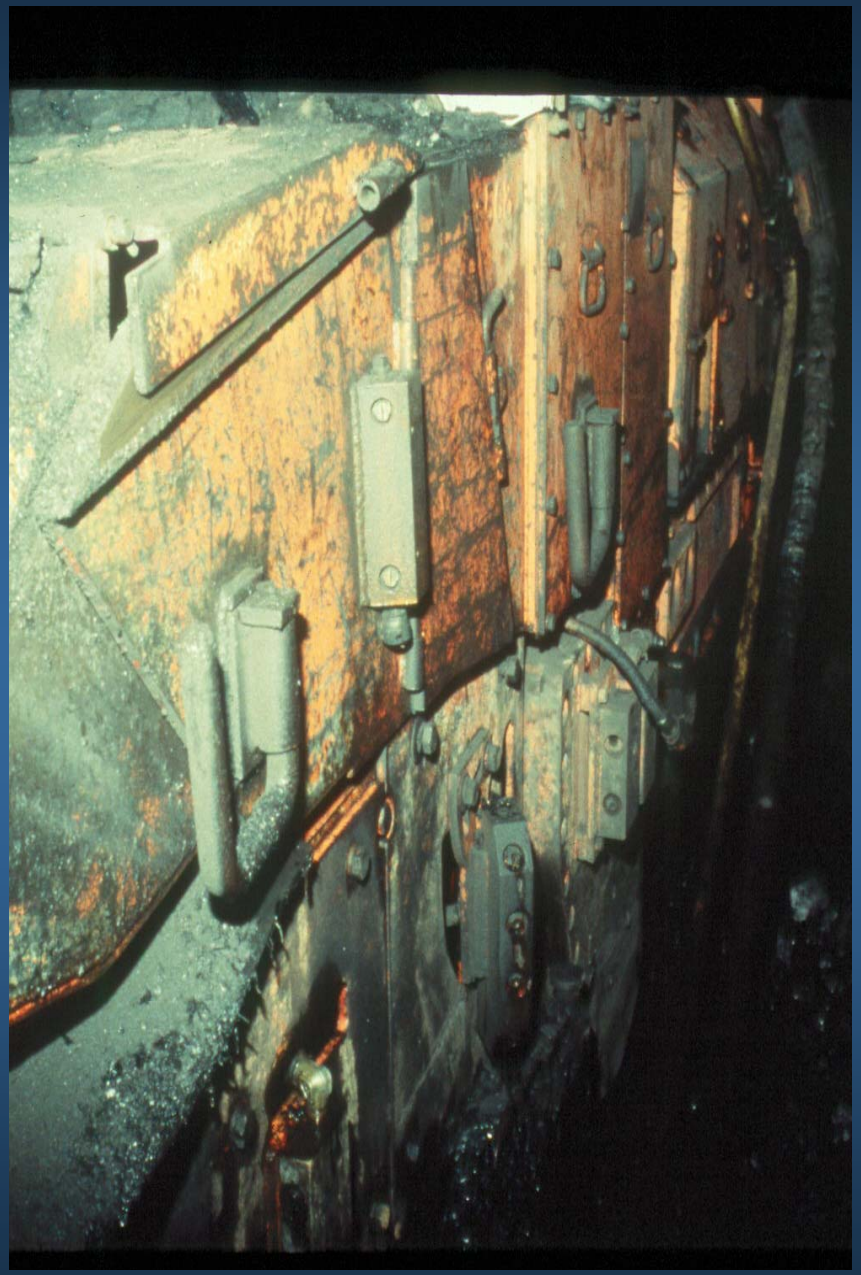
Redirecting/Moving Air

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

- Pressure/location important

Blocking Sprays

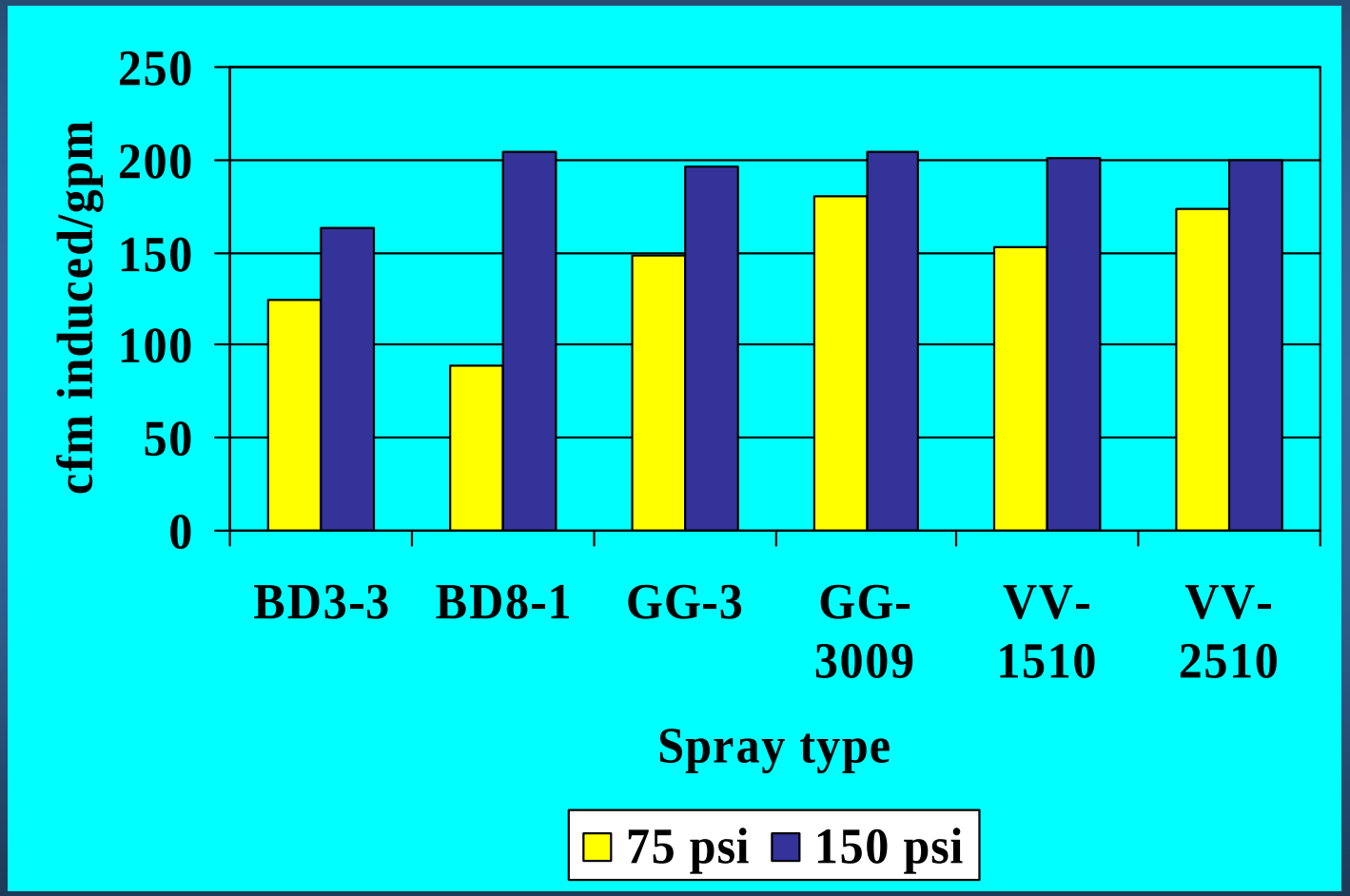
- Contains dust beneath boom
- Lower dust levels at operator and around machine



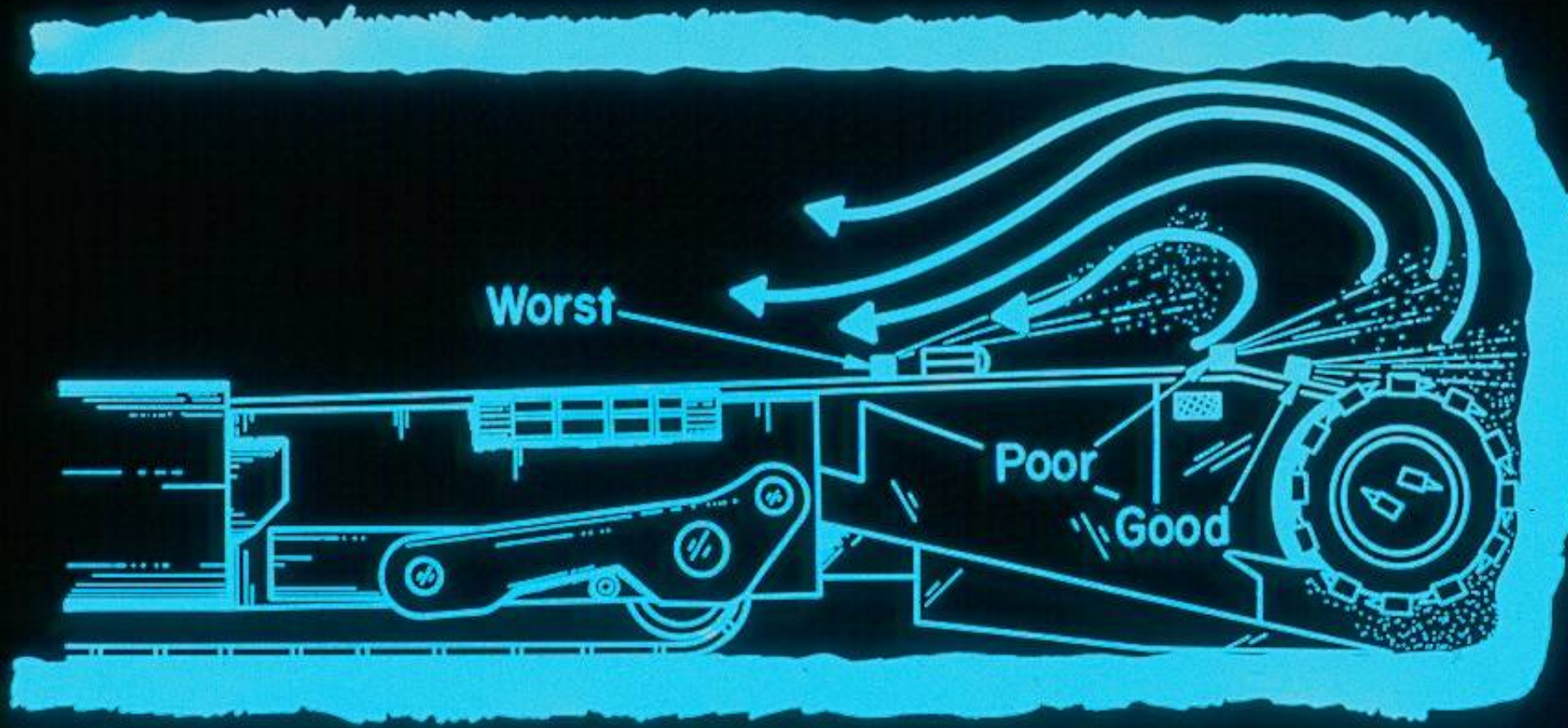
CDC Workplace Safety and Health

NIOSH

Airmoving Effectiveness

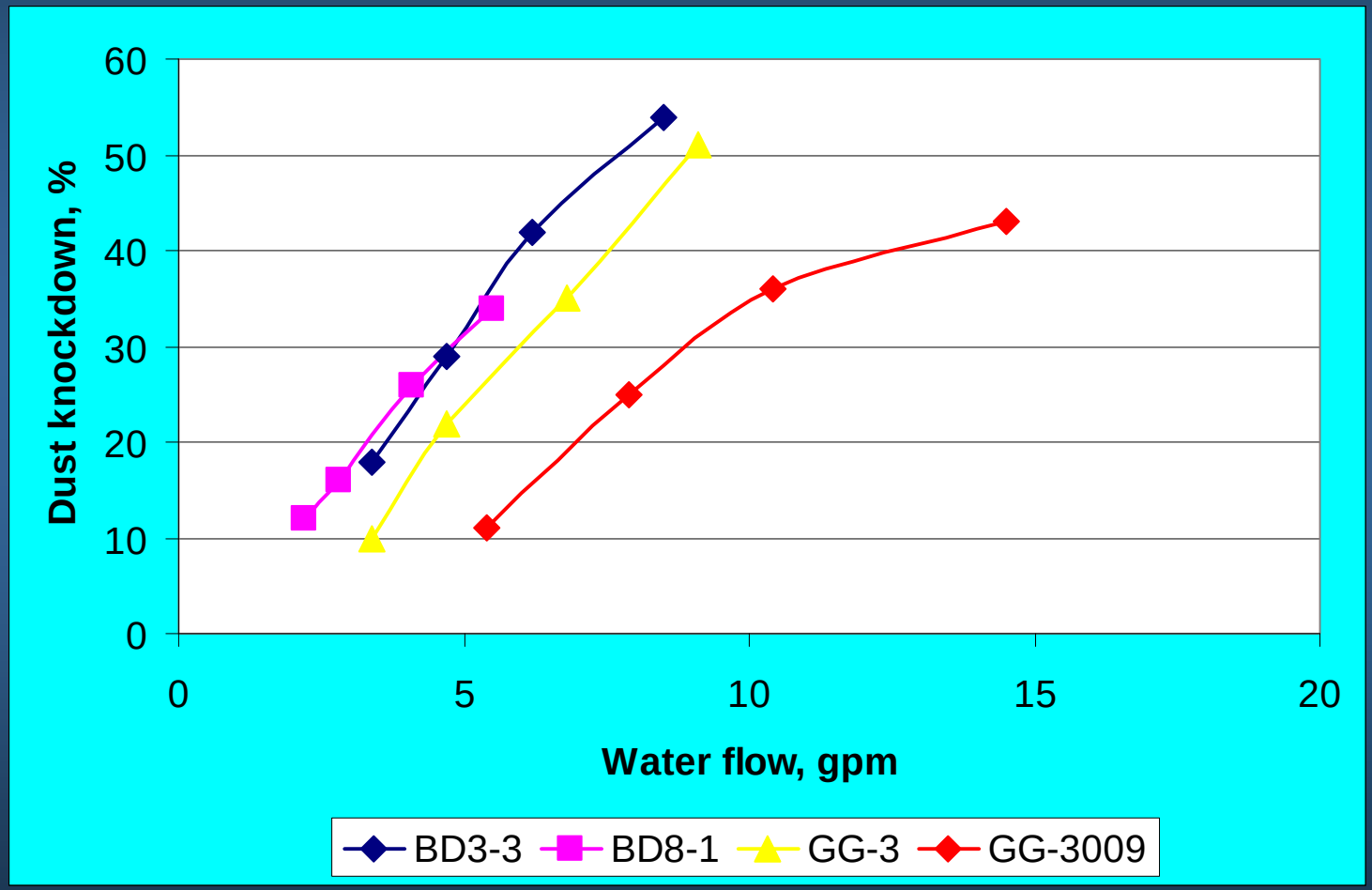


The best front spray puts water only where it is needed, and induces minimum air movement.



Airborne Dust Capture

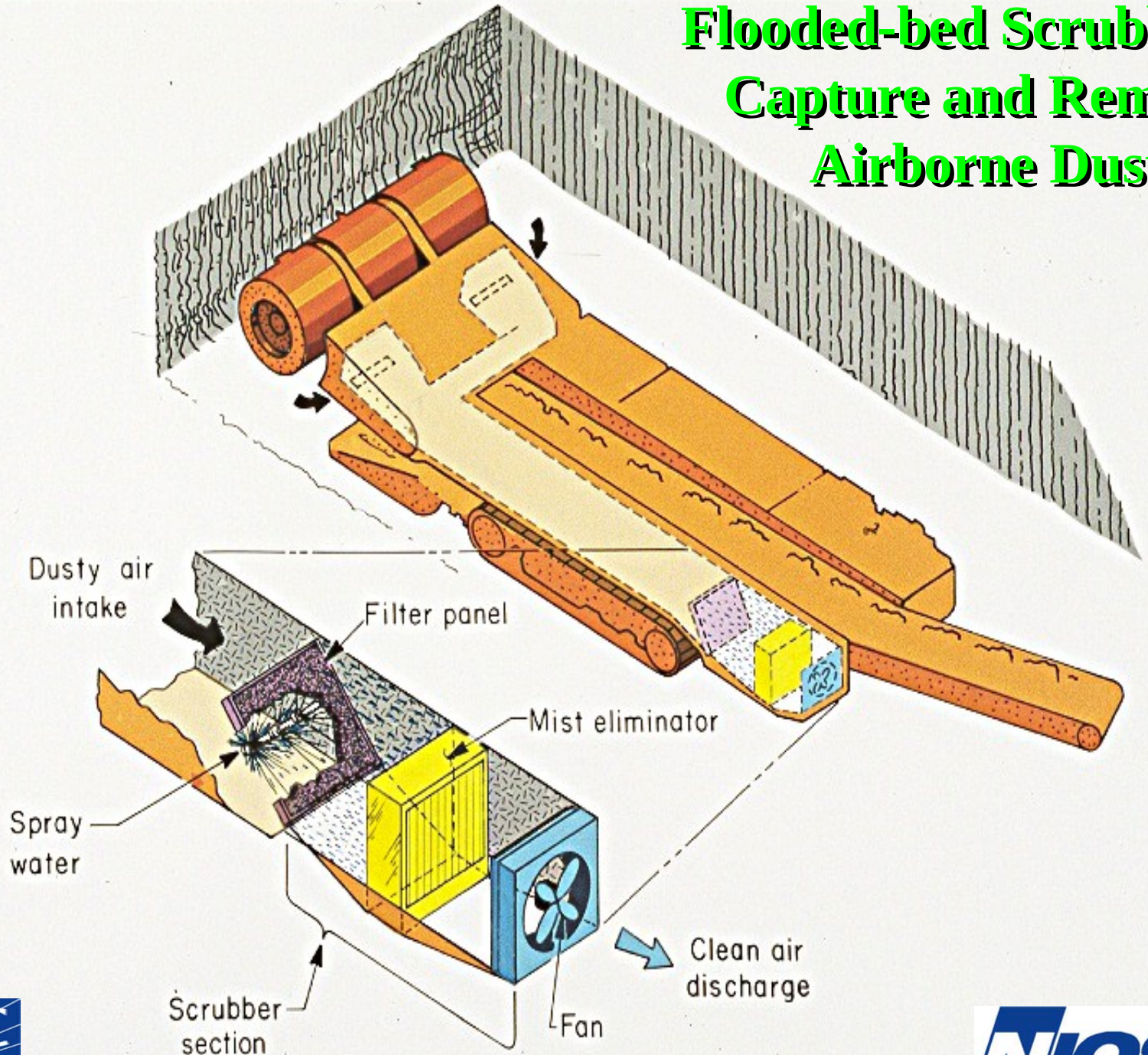
Spray Type



CDC Workplace Safety and Health

NIOSH

Flooded-bed Scrubbers Capture and Remove Airborne Dust



CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Filters Tested

CDC Workplace Safety and Health

NIOSH

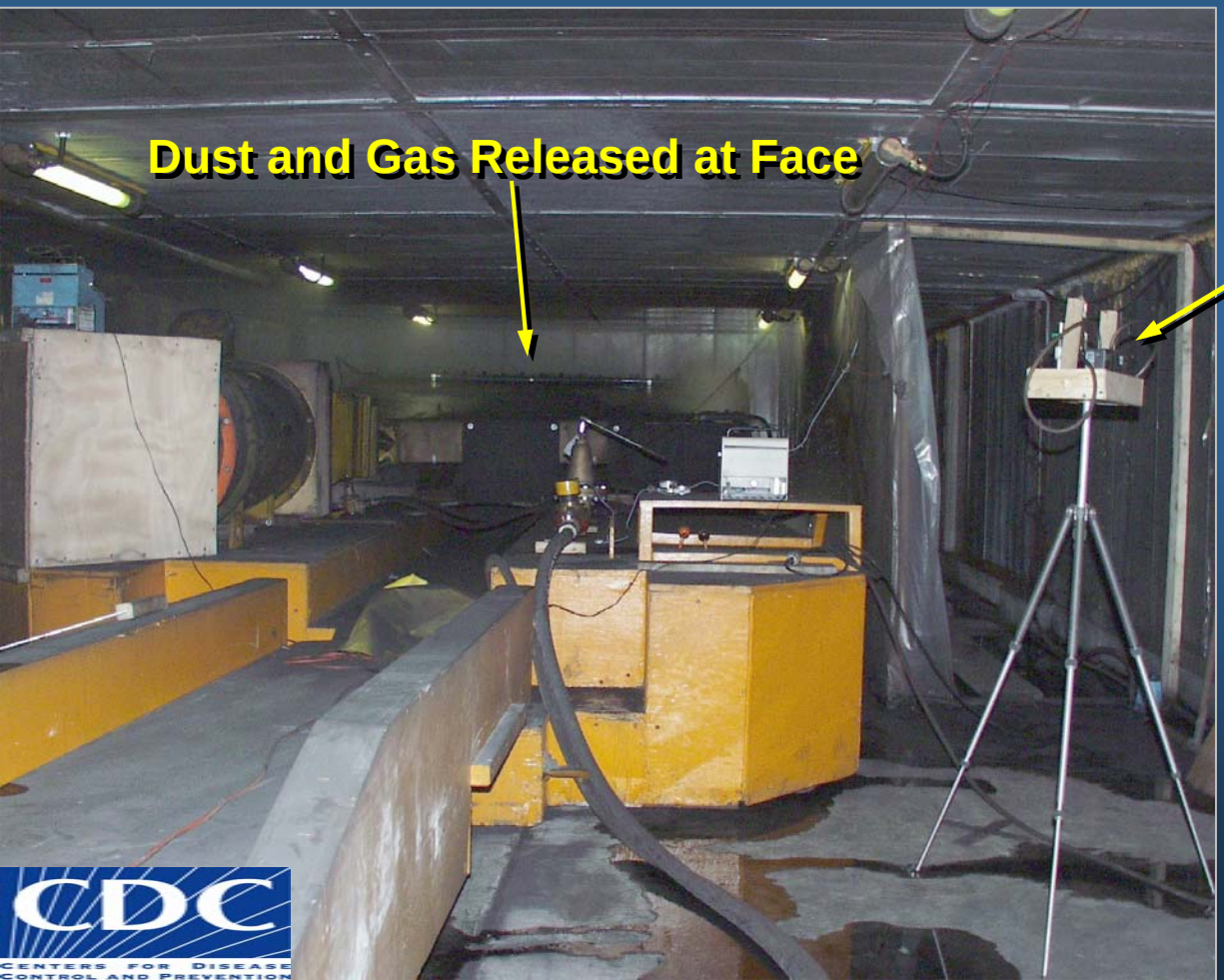
Continuous Miner Dust Control Research

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Continuous Miner Dust Gallery

Evaluate impact of sprays and scrubber on dust and gas for different operating parameters.



Dust Gas

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Wet head cutting technology

- Locates water sprays directly behind cutting bits
- Benefits – reduce frictional ignition frequency and reduce dust


Most boom sprays plugged
for wethead machine

Wet Head Continuous Miner

Test conditions

- **baseline sprays**
- **wet head sprays with scrubber**
- **wet head sprays without scrubber**

CDC Centers for Disease Control and Prevention

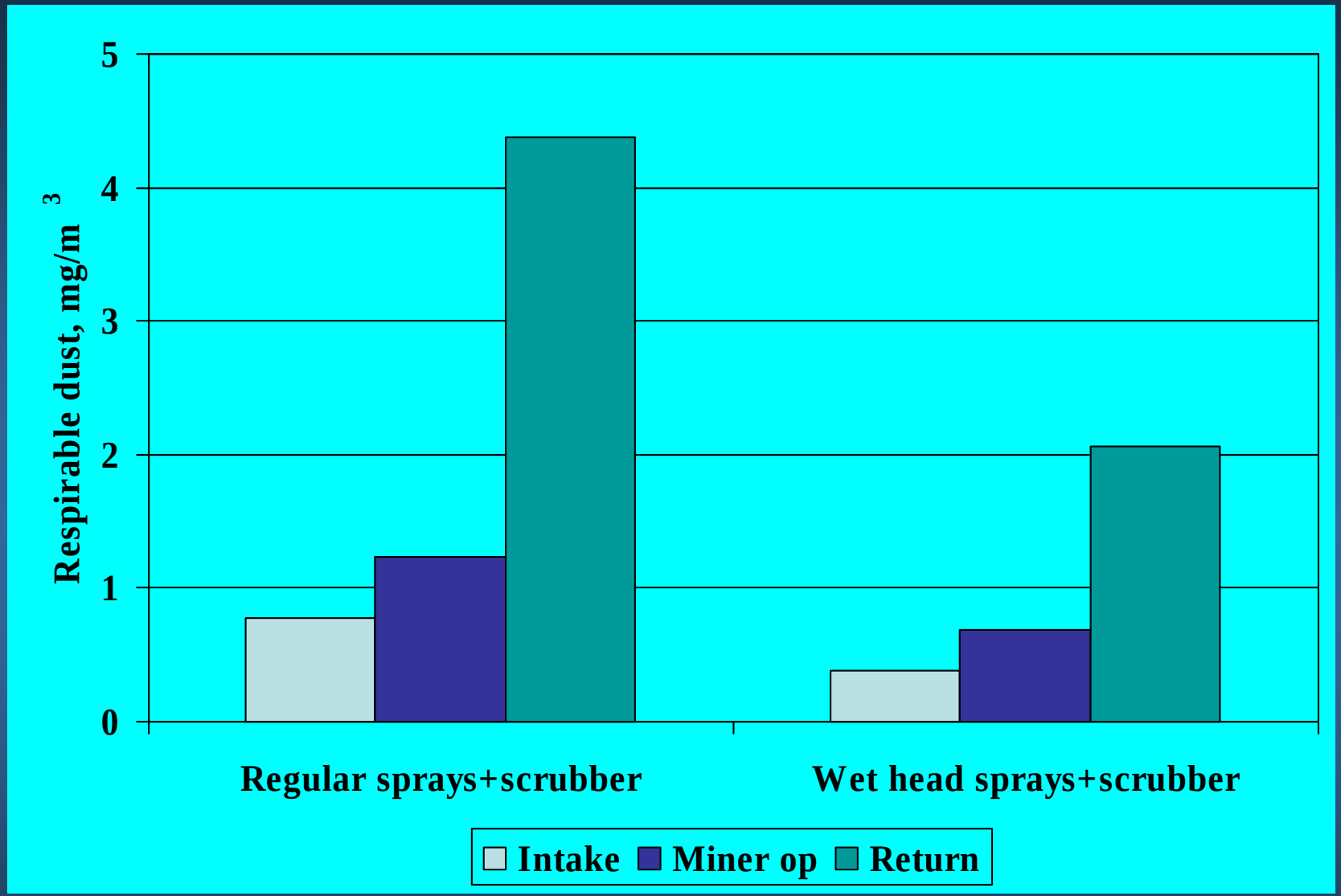
NIOSH

Wet Head Miner Sprays

- 1 machine (wethead vs regular)
- 73 small orifice solid stream sprays at 95 psi
- 27 external sprays at 150-185 psi
- 50 gpm

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

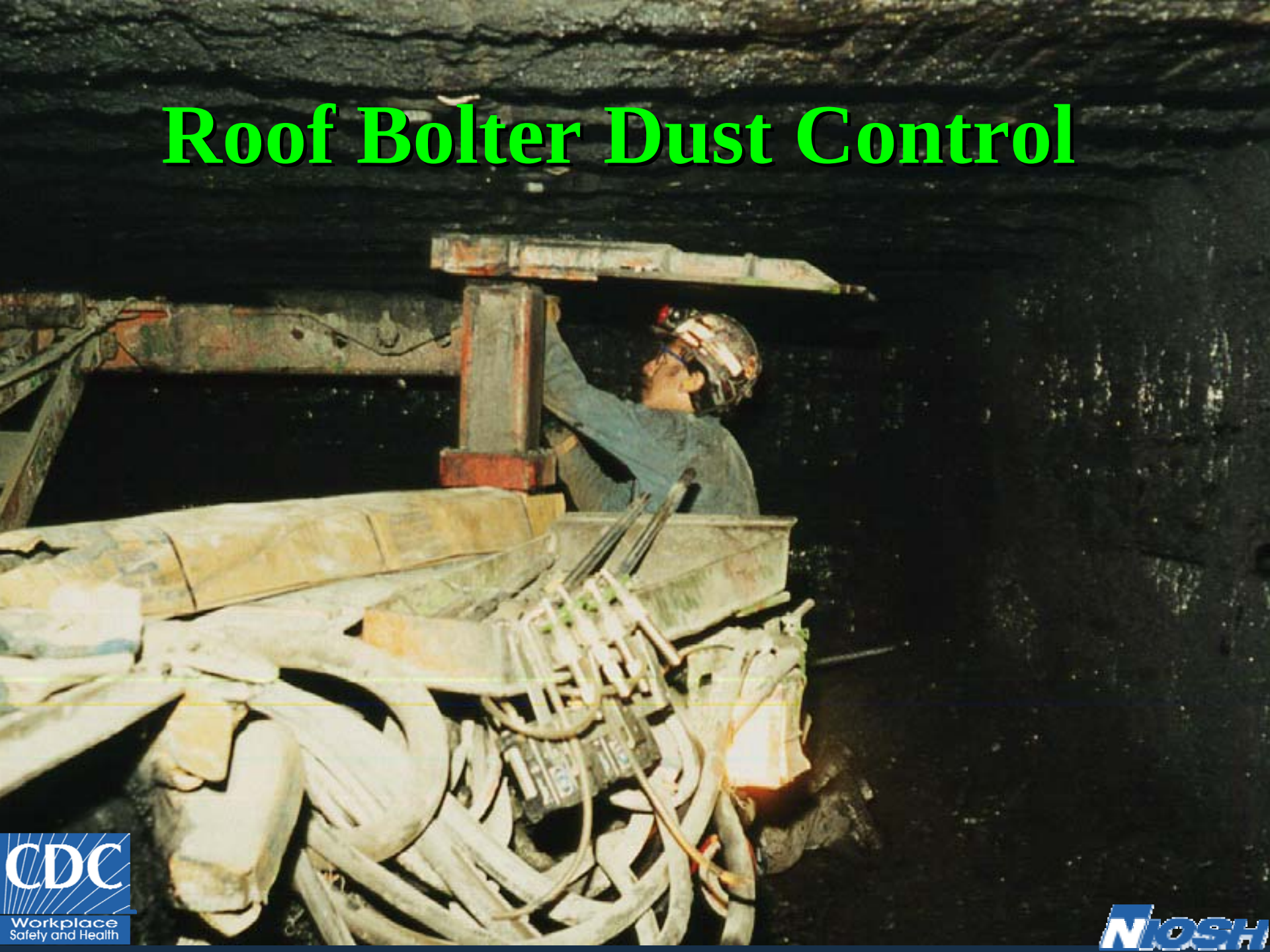

5
4
3
2
1
0
Respirable dust, mg/m 3
Regular sprays+scrubber
Wet head sprays+scrubber
Intake
Miner op
Return

Redirected scrubber exhaust- Colorado operation

CDC Workplace Safety and Health

NIOSH

Roof Bolter Dust Control



CDC Workplace Safety and Health

NIOSH

Operator Overexposures

- Poor maintenance of vacuum dust collector
- Cleaning out collector compartment
- Working downwind of miner

CDC Workplace Safety and Health

NIOSH

Eliminate Leaks in Vacuum System


Clean the dust box:
-frequently
-carefully (avoid exposure)

Cleaning the filter

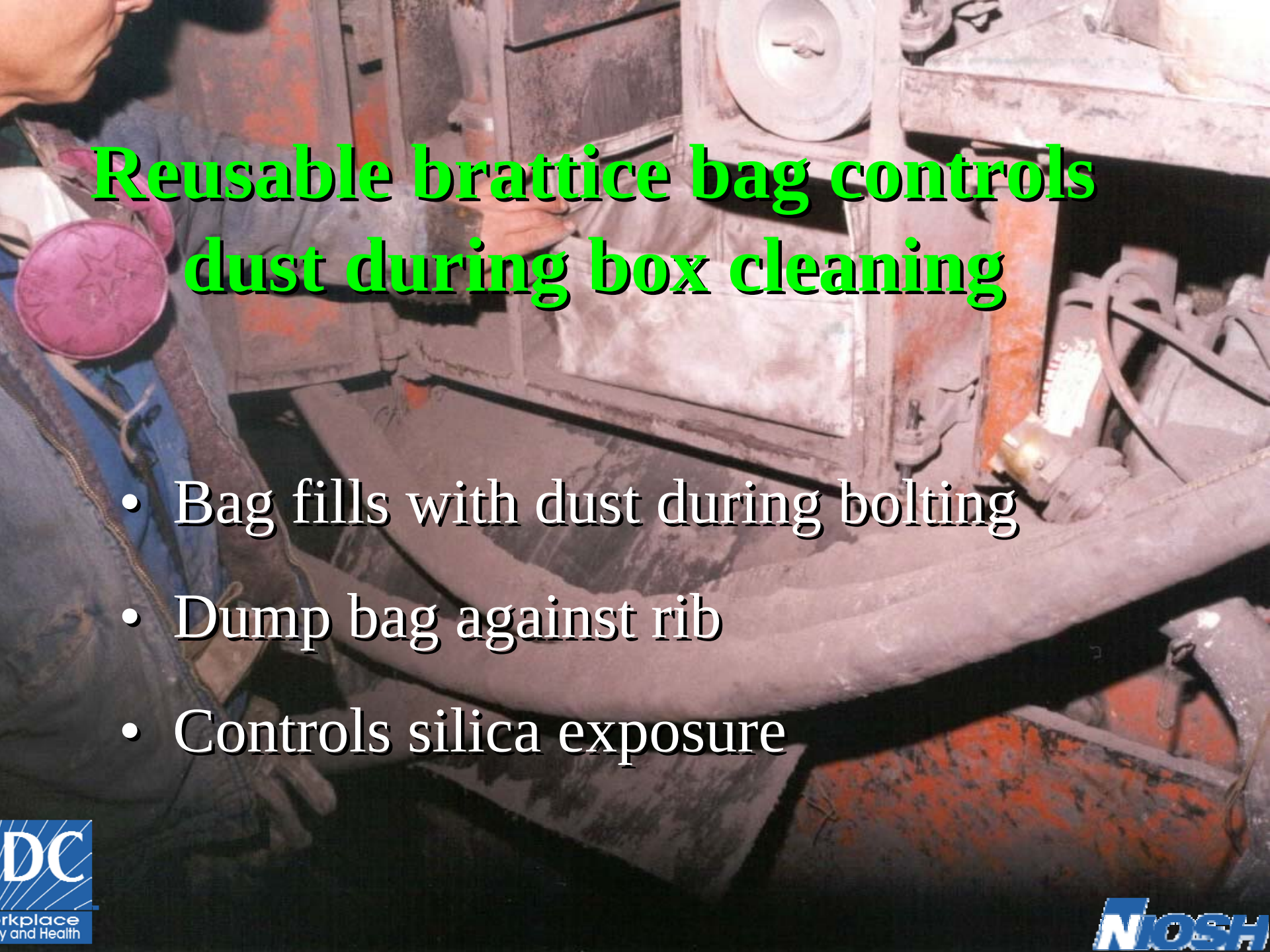
CDC Workplace Safety and Health

NIOSH

Predump Dust Shroud

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH



Reusable brattice bag controls dust during box cleaning

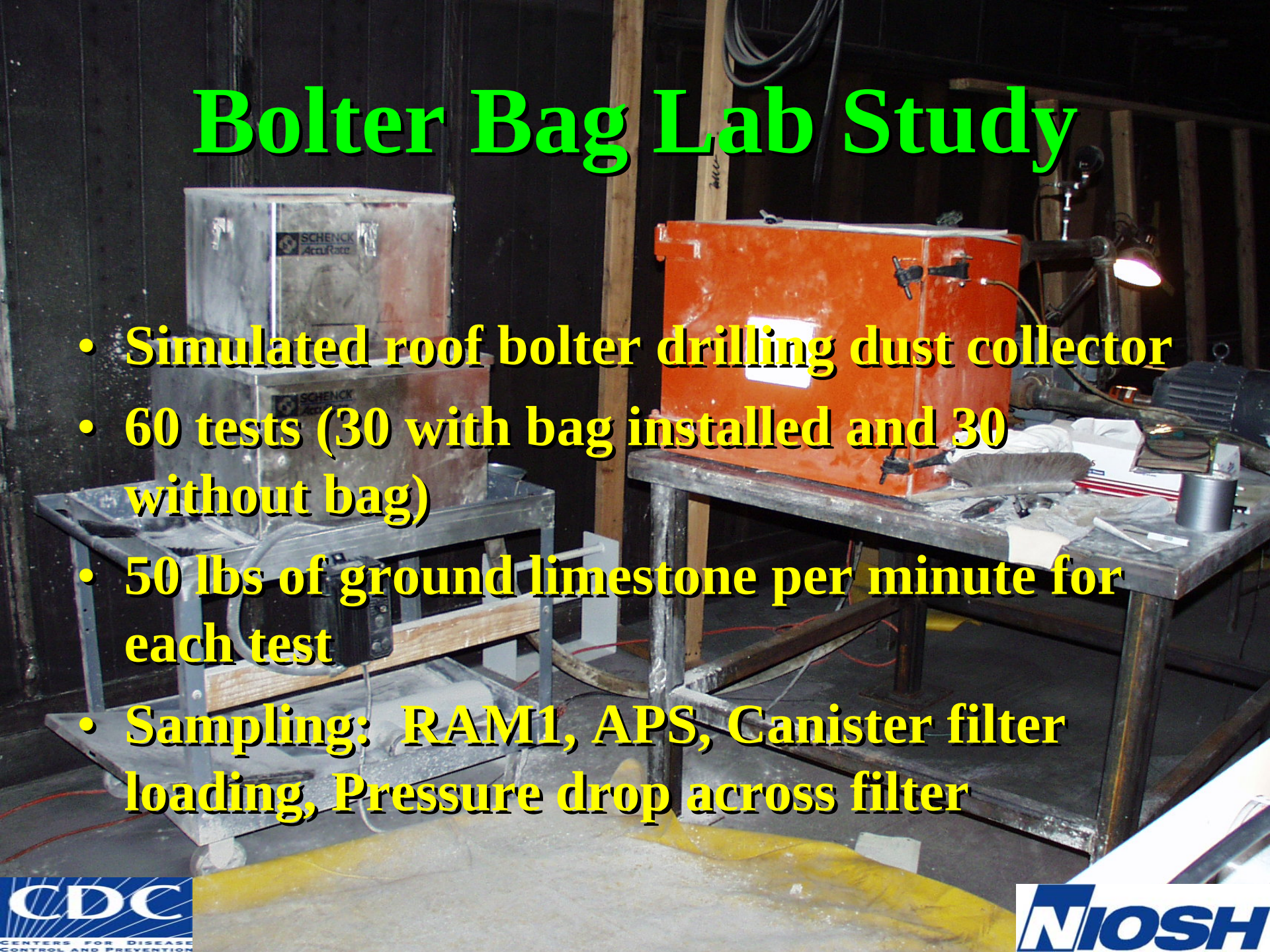
- Bag fills with dust during bolting
- Dump bag against rib
- Controls silica exposure

Silica dust levels when cleaning dust box

Disposable collector bag

- Manuf. By Wildwood Industries
- Used with Fletcher bolters
- Must be used with pre-dump

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

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Collector Box Tests Without Bag

Before

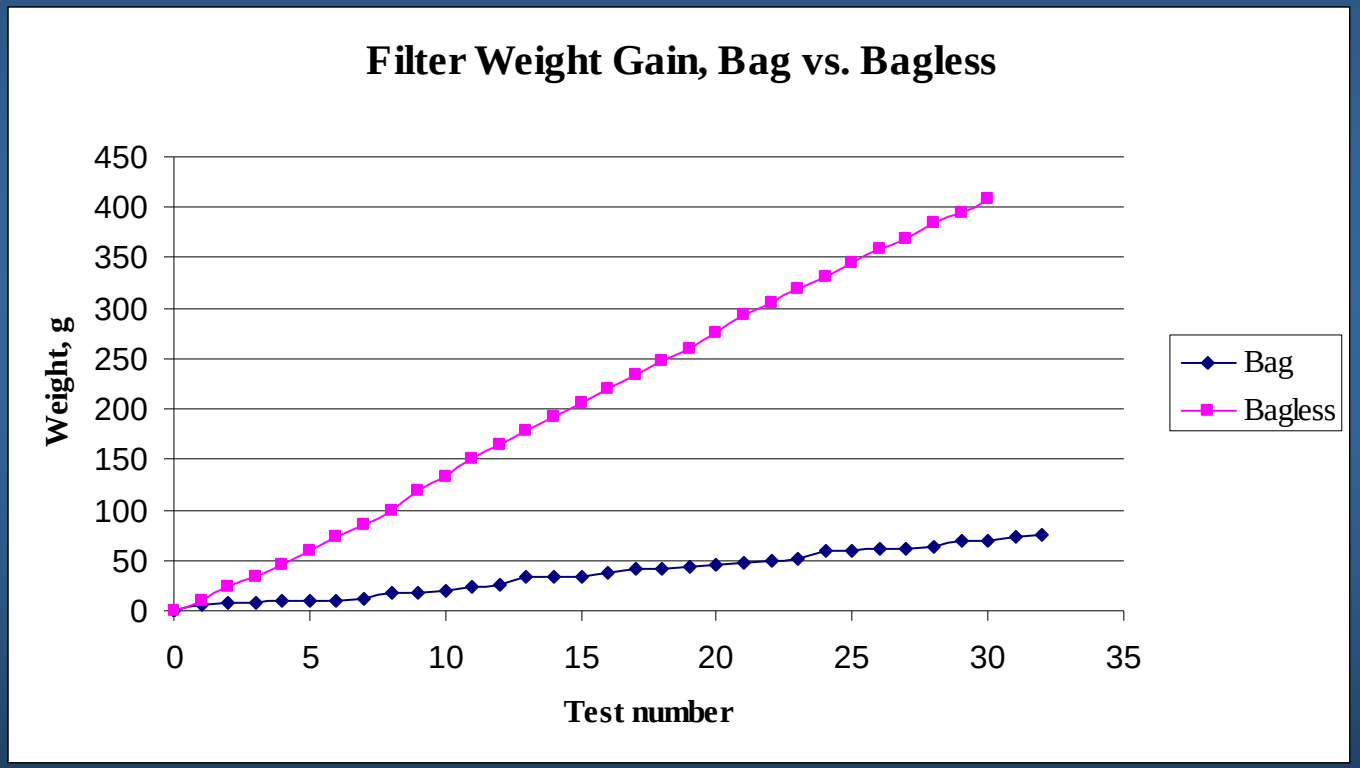
After

Collector Box Tests With Bag

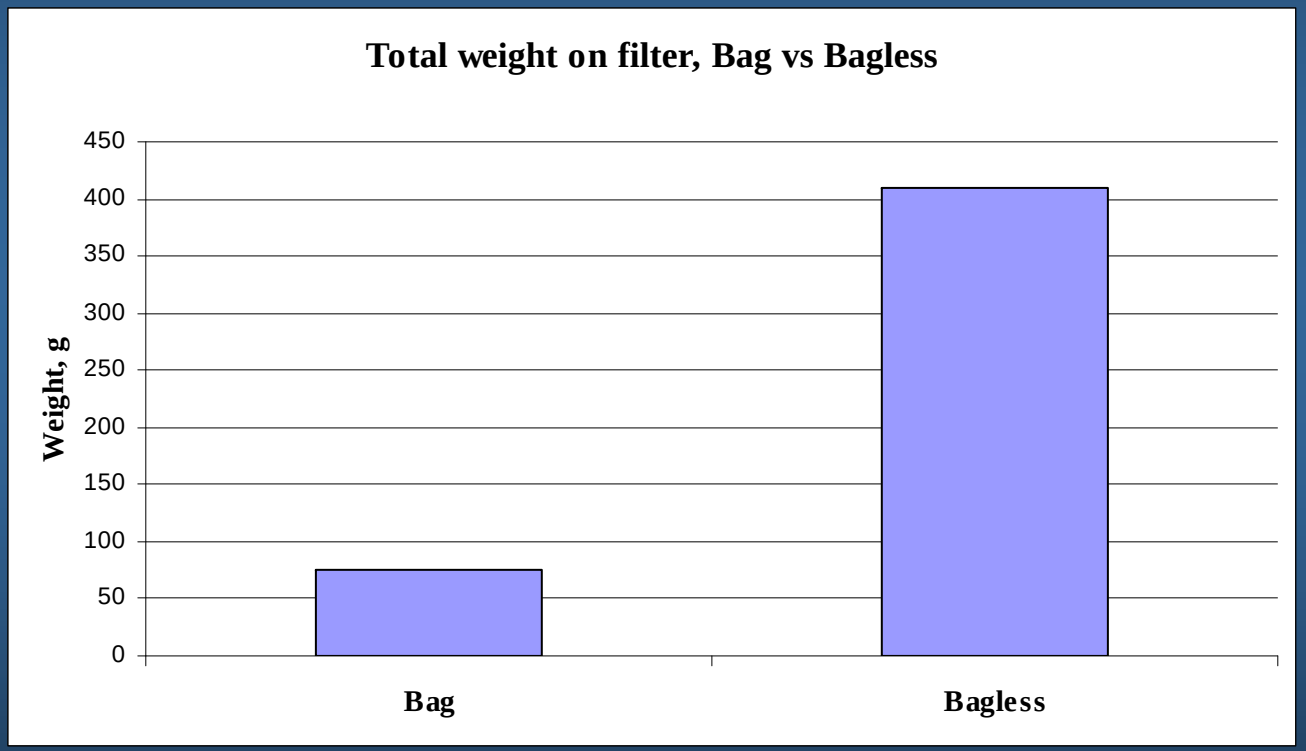
Before

After

Filter Weight Gain per Test



Canister Filter Loading



Lab Results – Collector Emissions

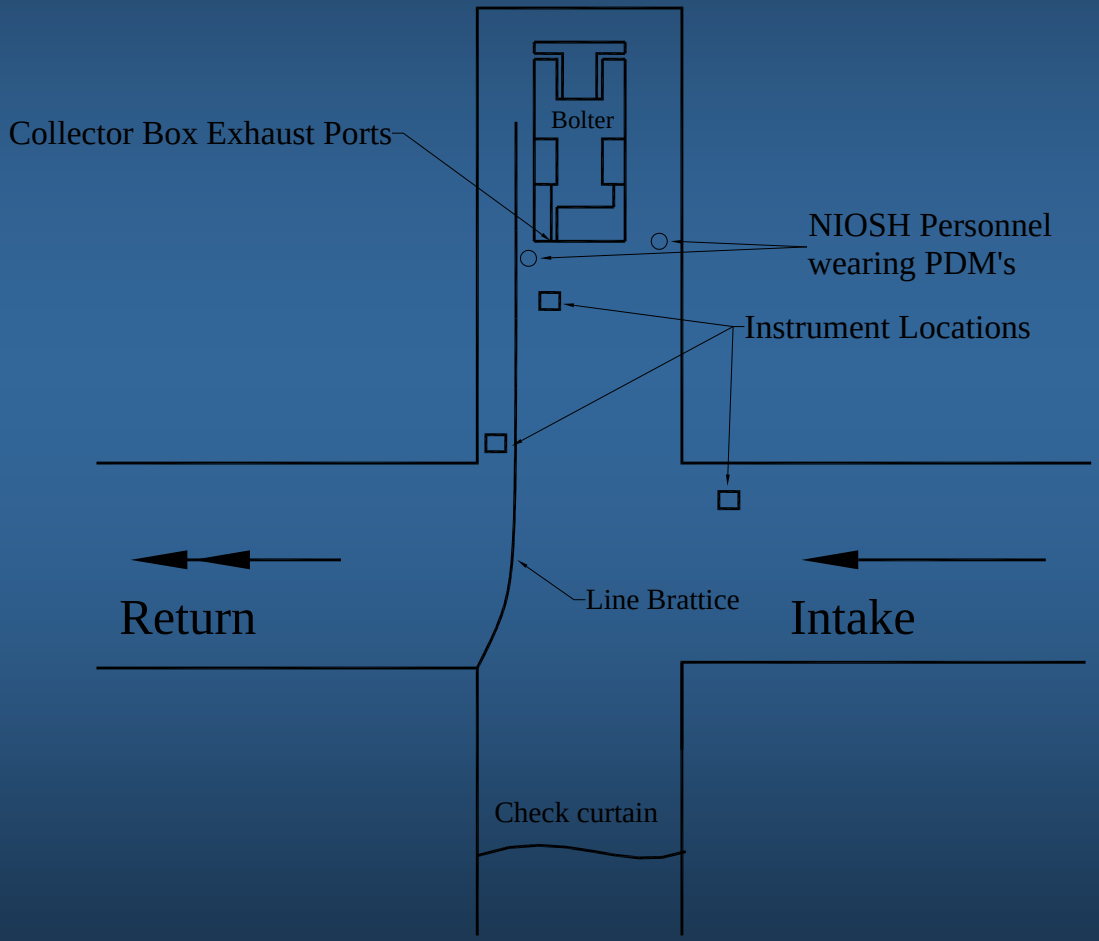
- Dust concentration: 2 times higher when bag not installed
- Total dust particle counts 2 times greater without bag in place
- Canister filter loading greatly reduced with bag in place
- Pressure drop across filter: 3.0 to 3.3 with bag in place, 4.0 to 8.4 without bag

Bolter Bag Field Study

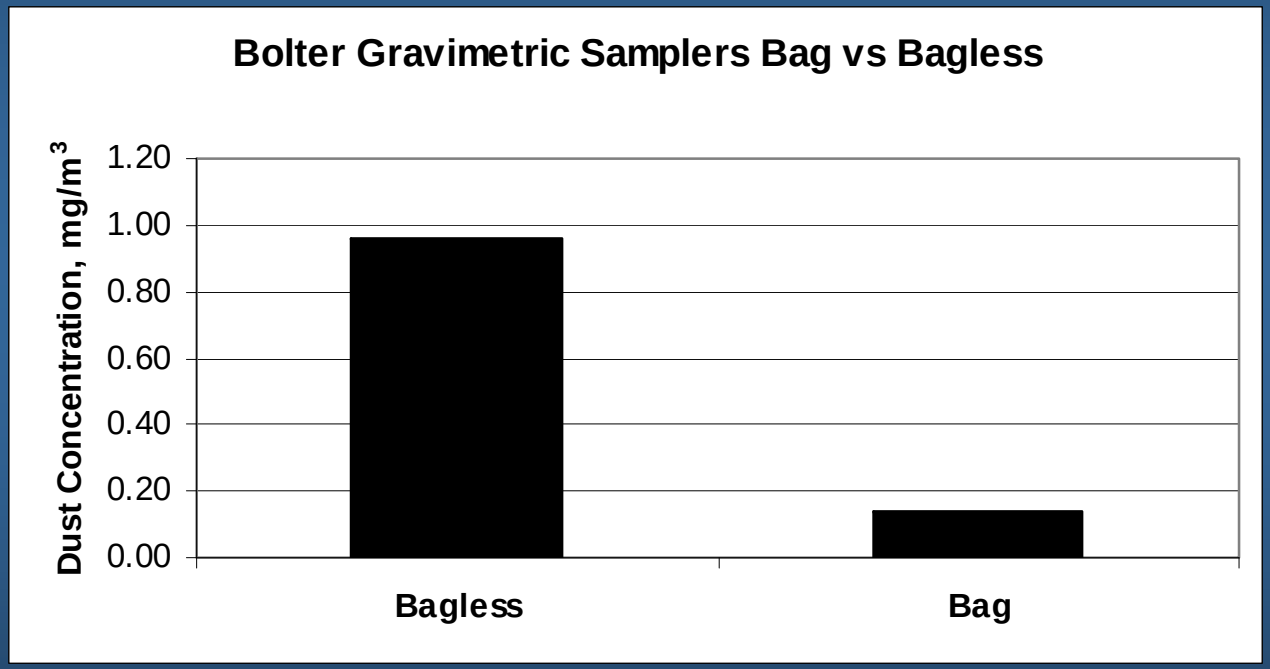
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

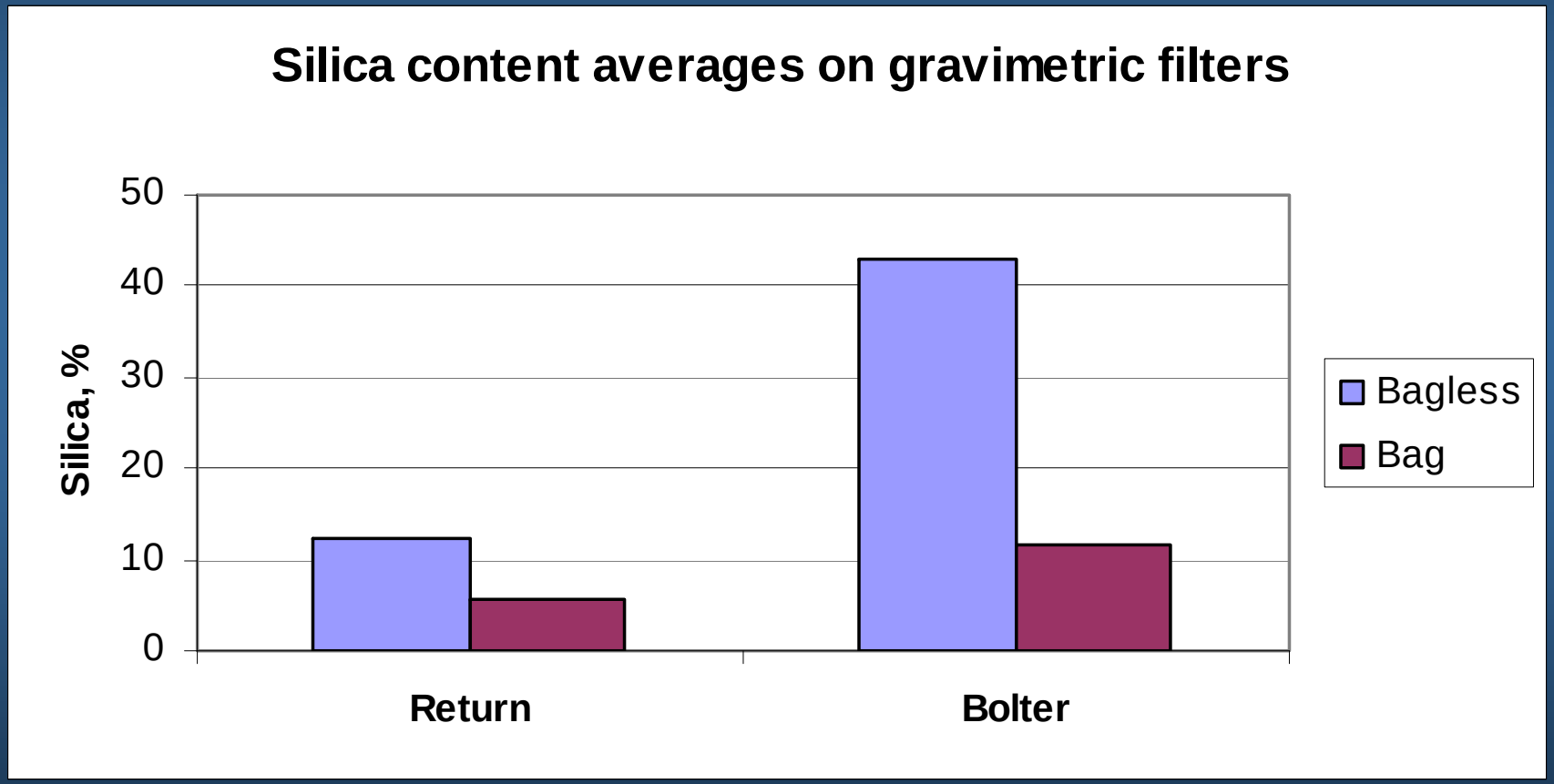
Instrument Locations



Gravimetric Samples, Collector Emissions



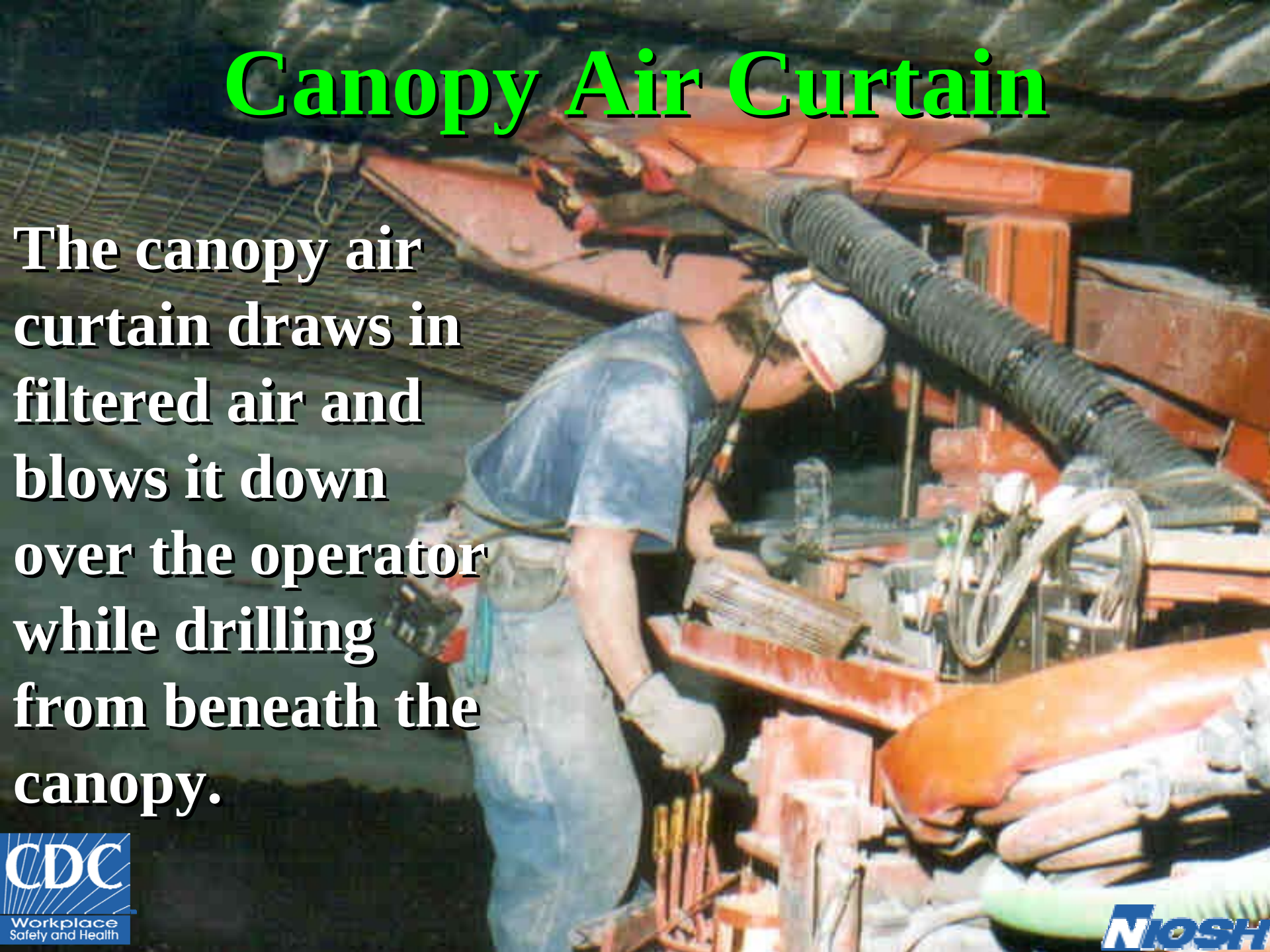
Percent Silica on Sampler Filters



Field Results

- Gravimetric samplers: respirable dust improved from 0.96 mg/m3 to 0.14 mg/m3 when the bag is in use.
- Personal samples from the PDMs: left side (exhaust side) of the bolter experienced nearly 2 times the amount of respirable dust than the right side.
- Collector box cleaning time reduced from 4 minutes to 30 seconds.

Canopy Air Curtain



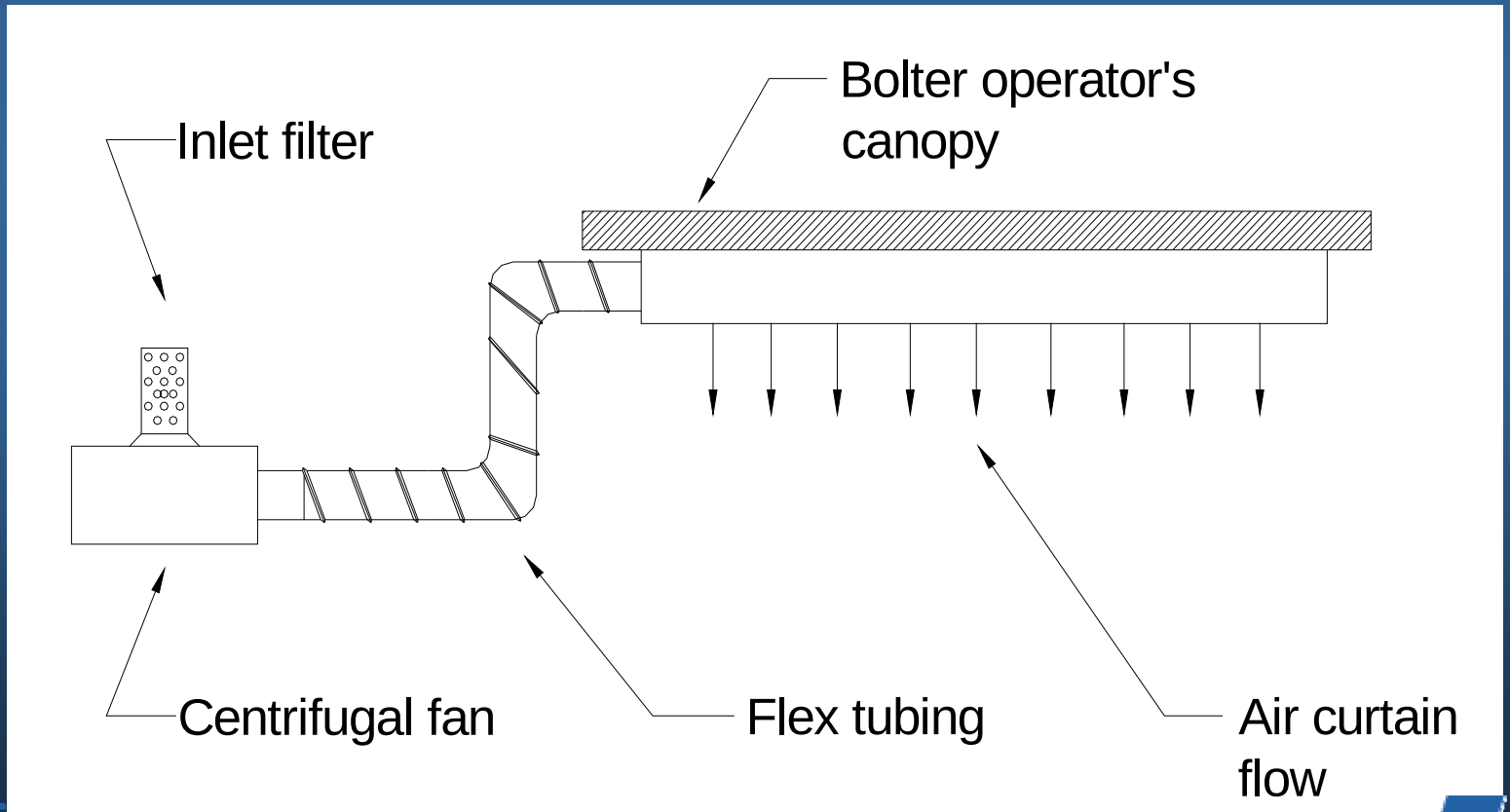
The canopy air curtain draws in filtered air and blows it down over the operator while drilling from beneath the canopy.

CDC Workplace Safety and Health

NIOSH

Canopy Air Curtain Components

- System consists of a filter, fan, tubing and plenum
- Filtered air is blown over the operator from beneath the canopy



Laboratory Study of CAC

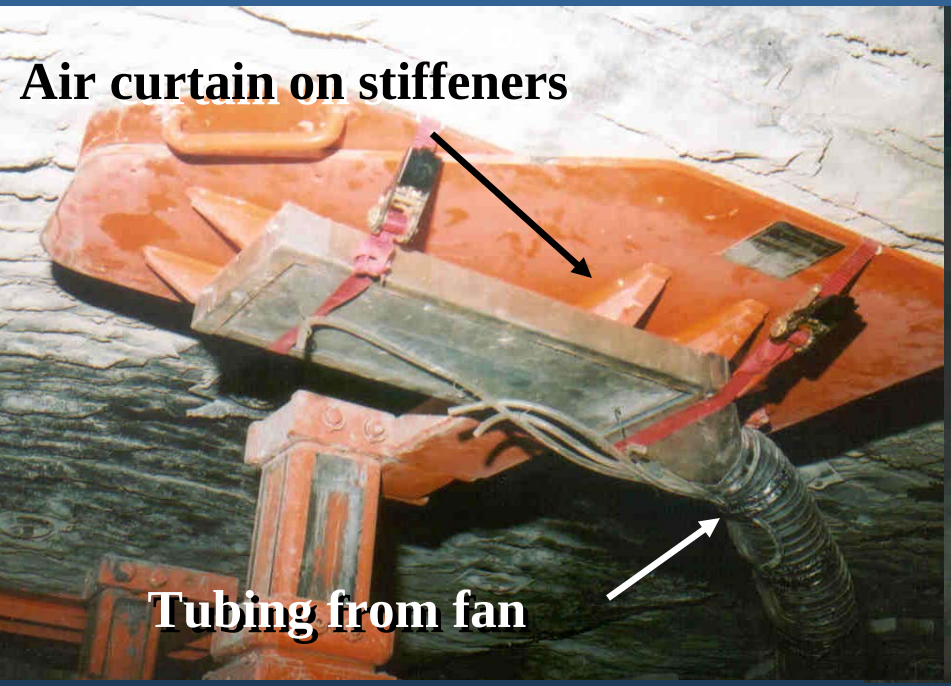
- Tests of prototype showed dust reductions of 40% to 60% at an entry air velocity of 0.3 m/s (60 ft/min)

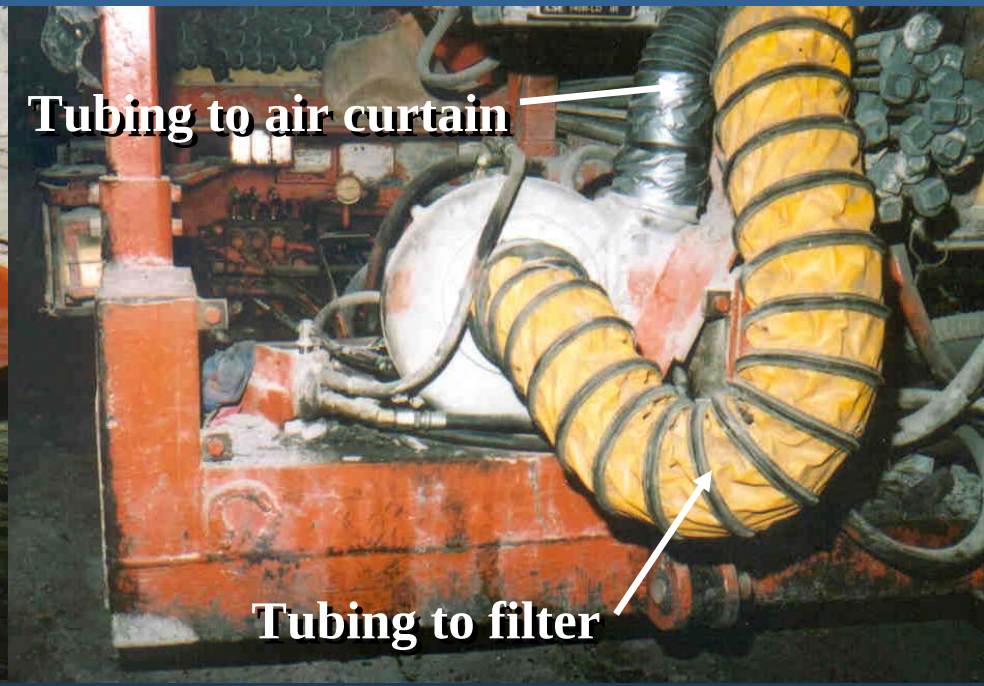
CDC Workplace Safety and Health

NIOSH

Field Testing of CAC

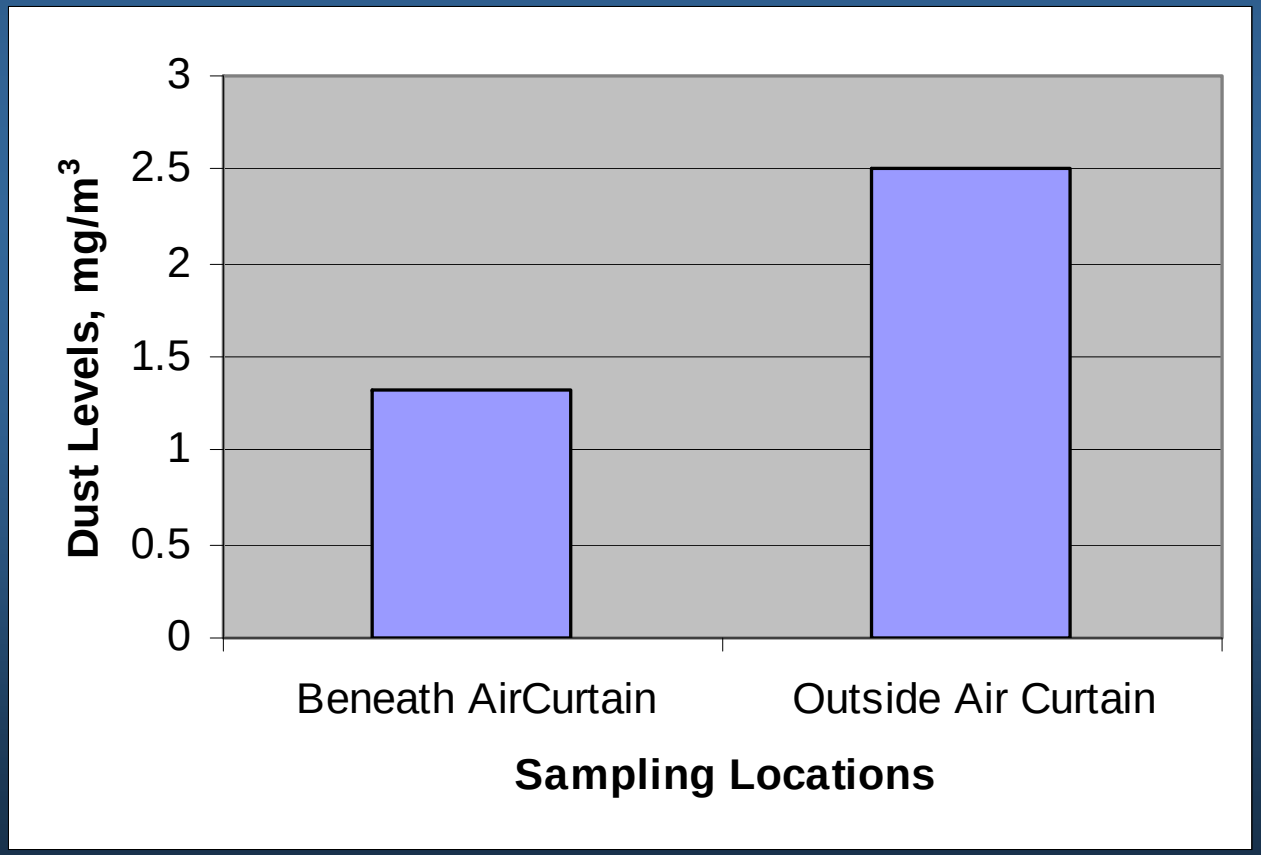
Machine mounted components for CAC for field testing in cooperation with J. H. Fletcher & Company





Mine Study Results

Nearly a 50% reduction in dust levels under the air curtain



CDC Workplace Safety and Health

NIOSH

Findings from field evaluation

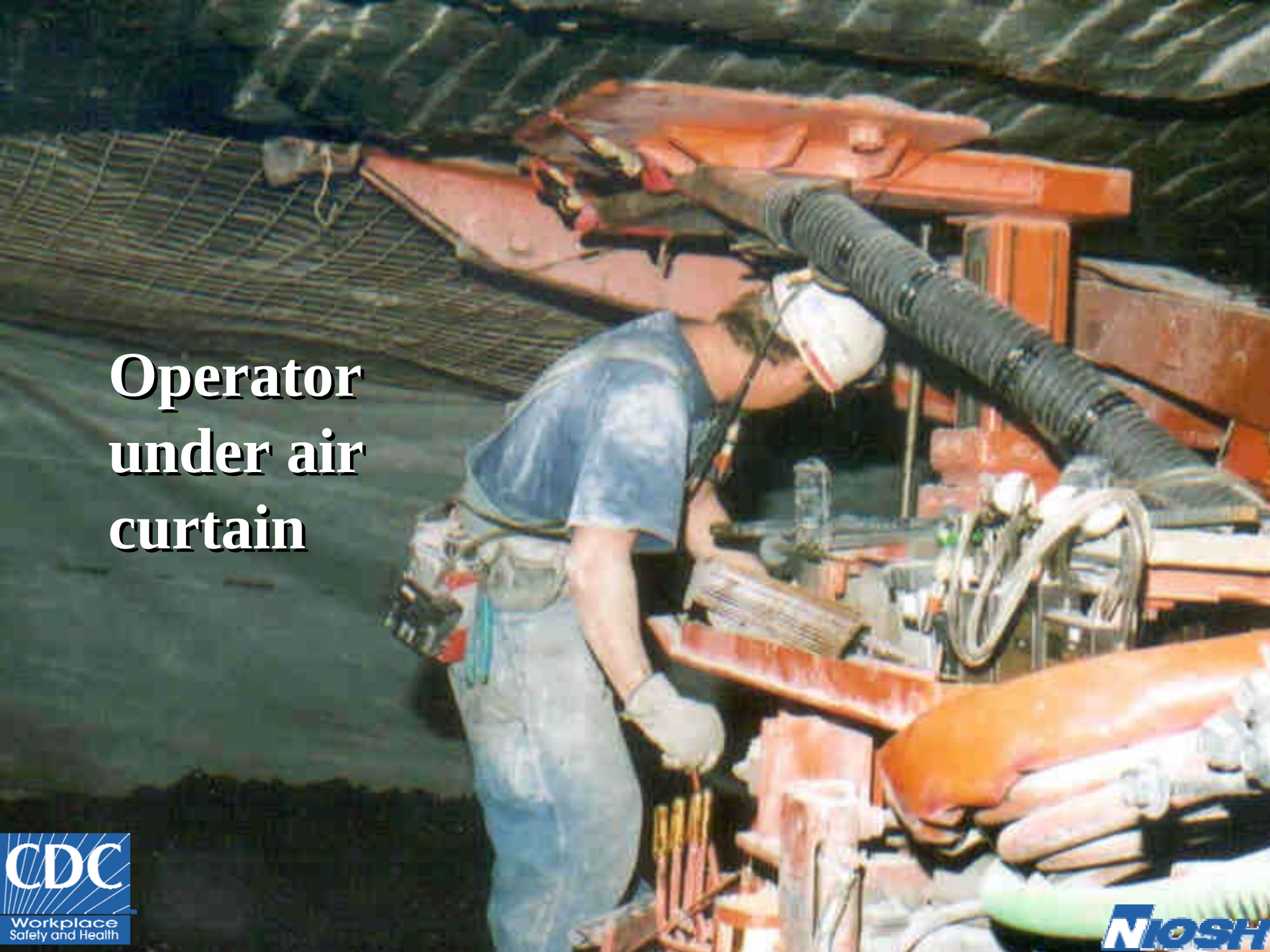
- Reduced dust under air curtain
- Must keep operator under air curtain
- Must increase air curtain size and shape to increase area of protection

Continued Laboratory Testing

Modifications: Reconfigured air curtain has same dimensions and profile as roof bolter canopy for increased coverage and protection

Anticipated Benefits

- Dust exposure reductions for roof bolt operators during bolting and when down wind of CM
- Existing components can be retrofitted to current roof bolting machines
- Cooperation with J. H. Fletcher will allow for integration of system on newly produced roof bolters

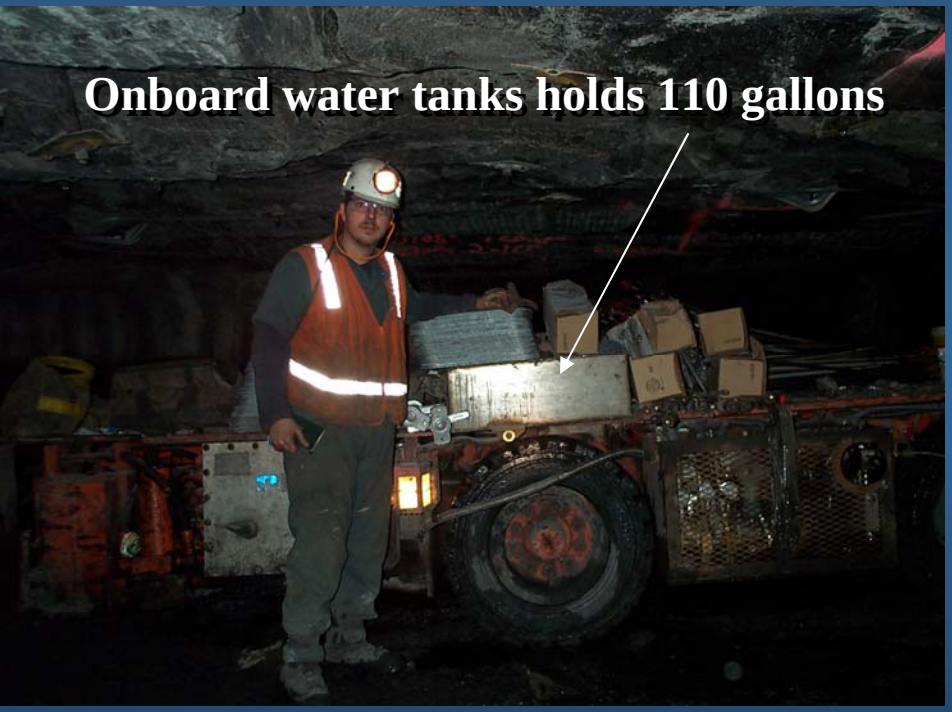

Operator
under air
curtain
CDC
Workplace
Safety and Health
NIOSH

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

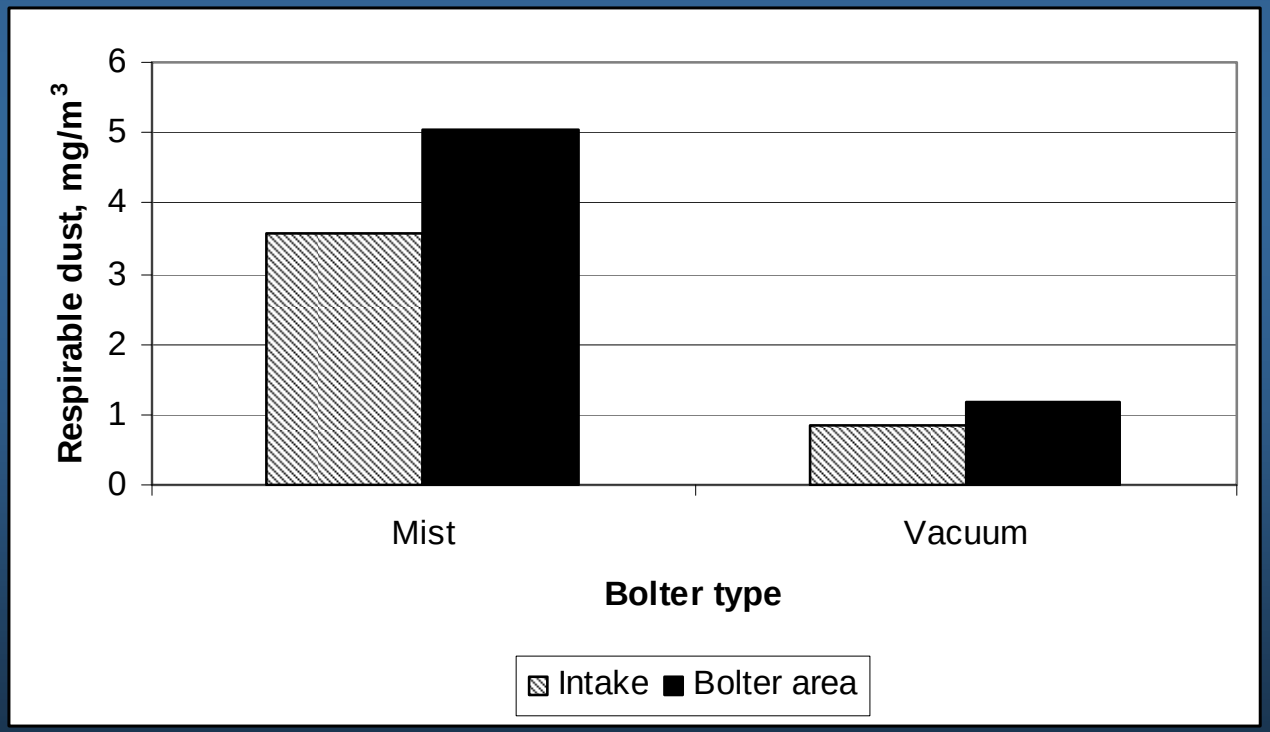


Mist Drilling Mine Study

- 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
- Further testing required to confirm field observations



Commitment to Dust Control

- Worker and management involvement
- Knowledge and attitude (safety is immediate vs. health is long term)
- Maintenance is critical

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH

Questions or Information

Jay Colinet
412 – 386- 6825
jcolinet@cdc.gov

Jeff Listak
412 – 386 – 5082
jlistak@cdc.gov

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH