Respirable Dust Control

June 8, 2008

Workshop conducted by:

CDC - National Institute of Occupational Safety and Health –
Pittsburgh Research Laboratory staff and invited guests

Sponsored by:
The 12th US/North American Mine Ventilation Symposium

We wish to thank the sponsors of the 12th US/North American Mine Ventilation Symposium for hosting the workshop. In addition we would like to thank the mine owners, manufacturers, mine workers and many dedicated employees of NIOSH who help expand our knowledge of the safe and healthy production of this country's mineral resources.

Dust Control Workshop Agenda

8:30 **Welcome and Introduction**
Jay Colinet, Respiratory Hazards Control Branch, NIOSH

8:40 **Health Effects of Respirable Dust Exposure**
Dr. Lee Petsonk, Division of Respiratory Disease Studies, NIOSH

9:40 **Dust regulations and control strategies**
Jay Colinet, Respiratory Hazards Control Branch, NIOSH

10:00 **Break**

10:15 **Dust controls for metal/nonmetal mining**
Andrew Cecala, Respiratory Hazards Control Branch, NIOSH

11:15 **Longwall dust control technology**
James Rider, Respiratory Hazards Control Branch, NIOSH

12:00 **Lunch**

1:00 **Dust control for continuous mining operations**
Jeffrey Listak, Respiratory Hazards Control Branch, NIOSH

1:45 **Application of dust controls in mines**
Mike Dezeeuw, Twentymile Coal Company

2:45 **Break**

3:00 **Real-time dust sampling instrumentation**
Jon Volkwein, Respiratory Hazards Control Branch, NIOSH

3:30 **Discussion and questions**

Respirable Dust Control Workshop

Goal: Reduce respirable dust exposure through the development and application of engineering controls.

12th US/North American Mine Ventilation Symposium
Reno, Nevada
June 8, 2008

Pittsburgh Research Laboratory (PRL)

180 Employees

Workshop Agenda

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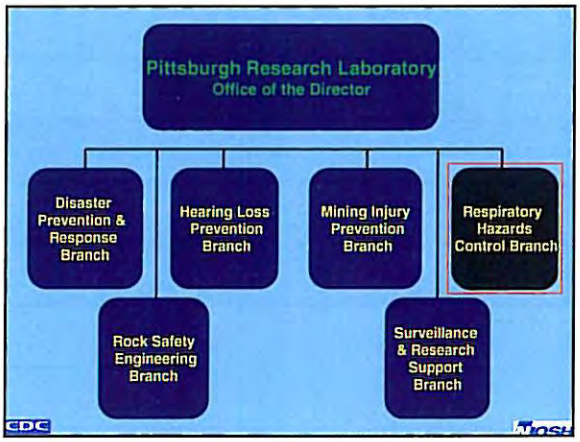
PRL Mission…

To eliminate occupational diseases, injuries & fatalities from the mining workplace through a focused program of research & prevention

NIOSH Locations

Washington, DC
Atlanta, GA
Cincinnati, OH
Pittsburgh, PA
Morgantown, WV
Spokane, WA

NIOSH Staff: ~1,400



Respiratory Hazards Control Branch

- Mission....eliminate the adverse health effects to mine workers resulting from exposure to dust, diesel emissions and workplace contaminants.
- 30 employees
- Three focus areas
  - Dust control technology
  - Instrumentation
  - Diesel research

Full-scale laboratories

Division of Respiratory Disease Studies

Provides national and international leadership toward the identification, evaluation, and prevention of occupational respiratory disease, such as asthma, chronic obstructive pulmonary disease, and pneumoconiosis.

Lung Diseases of Coal Miners

12th U.S./North American Mine Ventilation Symposium

June 8, 2008

Edward L. Petsonk, MD, Team Leader
Workforce Screening and Surveillance Team
Senior Medical Officer
Division of Respiratory Disease Studies

The findings and conclusions in this presentation have not been formally disseminated by NIOSH and should not be construed to represent any agency policy or determination.

CDC

NIOSH

Understanding, detecting, and preventing lung disease from coal mining

- Definitions
- Causes
- Disease course
  - Role of smoking
  - Impact on life quality
- Diagnosis
- Treatment
- Prevention
- Recent findings (from medical monitoring)

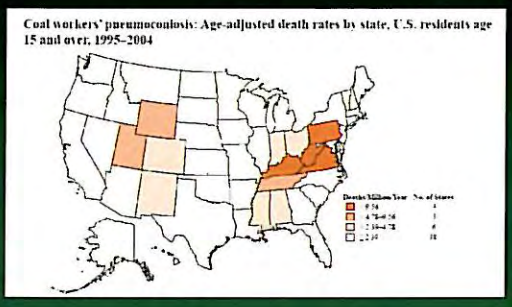
Public Health Importance

- 47,000 underground coal miners in the US
- Prevalence of CWP: recently up to 9%
- Age-adjusted mortality rate: 4.7/million/year
- Costs (1999):
  - Over $1.5 billion in federal benefits
  - 8,000 discharges from non-federal hospitals
- Preventability: primary and secondary prevention

Diseases caused by: Inhalation of coal mine dust and the body's reaction to it

- The Mine Act – Title IV
  - "chronic dust disease of the lung arising out of employment in an underground coal mine"

Public Health Importance

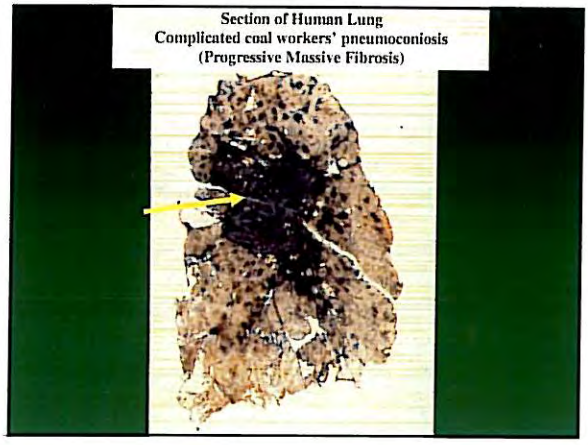


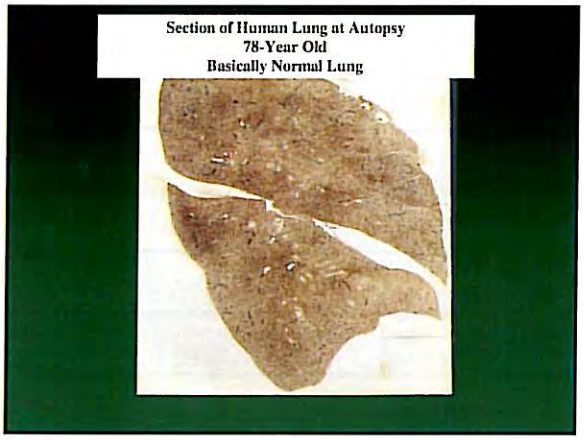
Diseases caused by: Inhalation of coal mine dust and the body's reaction to it

- Fibrotic diseases – damage/destroy lung tissue
  - Silicosis
  - Coal workers' pneumoconiosis "CWP"
- Airflow diseases "COPD" – block movement of air in and out of lungs
  - Bronchitis
  - Emphysema
  - Mineral dust airway disease
- Infectious diseases – dust reduces immunity
  - Tuberculosis in other countries, previously in U.S.

Diseases Caused by Inhalation of coal mine dust

- Fibrotic lung diseases
  - Silicosis
  - Coal workers' pneumoconiosis
  - Both diseases:
    - Similar patterns on chest x-ray
    - Simple and Complicated forms
    - Complicated = Progressive Massive Fibrosis (PMF)

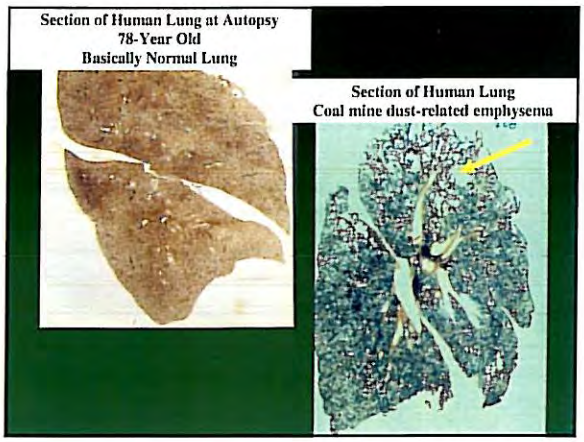




Diseases Caused by Inhalation of coal mine dust

- Airflow obstructive diseases "COPD"
  - Bronchitis
  - Mineral dust airway disease
  - Emphysema

If a miner has emphysema – Air is trapped in the lung



Course of Dust Disease in Miners

Years of over-exposure

5 10 15 20 25 30 35

Symptoms

X-ray changes

Functional impairments

Disability/death

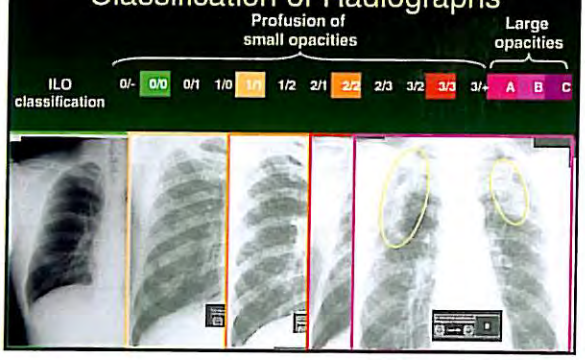
Course of Dust Disease in Miners

- Symptoms
- Physical examination
- Breathing tests
- X-rays

All findings may be NORMAL in early disease

Death: respiratory failure or heart failure

International Labour Office Classification of Radiographs



Course of Dust Disease in Miners

- Symptoms
  - Cough, phlegm, wheeze
  - Shortness of breath
  - Swelling
- Physical examination
  - Lung sounds often normal until late
  - Heart failure, fluid retention
- Breathing tests
  - Decreased breathing capacity
  - Low oxygen uptake

Course of Dust Disease in Miners

- Development and progression depend on
  - Level of respirable dust exposure
  - Toxicity of dust
  - Age of miner and years of mining
  - Clearance of dust from the lung
  - Other diseases/exposures/complications
- Miners often develop more than one disease

Among Smoking Miners: Impact of Tobacco Smoking on Dust Diseases

- Coal Workers' Pneumoconiosis and Silicosis
  - Smoking does not cause these diseases
  - Smoking does not accelerate progression
- Airway obstructive diseases
  - Both smoking and dust can cause these diseases
  - Lung damage from smoking adds to damage caused by dust

Prevention of Dust Disease in Coal Miners

- Reduce the level of dust exposure ***
- Reduce the toxicity of the dust
- Allow time for dust to clear from lungs

Diagnosis of Coal Workers' Pneumoconiosis

- History of inhalation of coal mine dust
- Latency period usually 10 years or more
- Radiographic pattern of abnormality
- Lung function test results
- Other medical history
- No specific findings on lung examination

Prevention of Dust Disease in Coal Miners

- Reduce the level of dust exposure ***
  - Continuous attention to effective controls
  - Accurate and extensive dust monitoring
    - Personal continuous dust monitoring
  - Respirators when dust levels exceed PELs
    - Least reliable approach to reducing exposure

Treatment of Dust Disease in Coal Miners

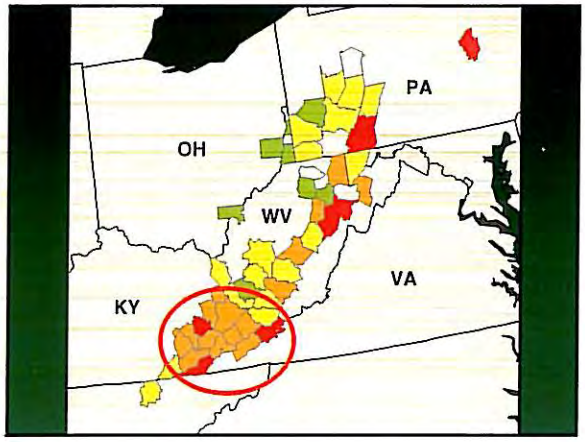
- No medication can reverse dust damage
- Treatment directed at reducing symptoms and prevention of complications
  - Vaccines against flu and pneumonia
  - Antibiotics for infections and congestion
  - Bronchodilators for airway spasm
  - Oxygen supplementation
  - Treatment for heart failure
- Lung/heart transplant

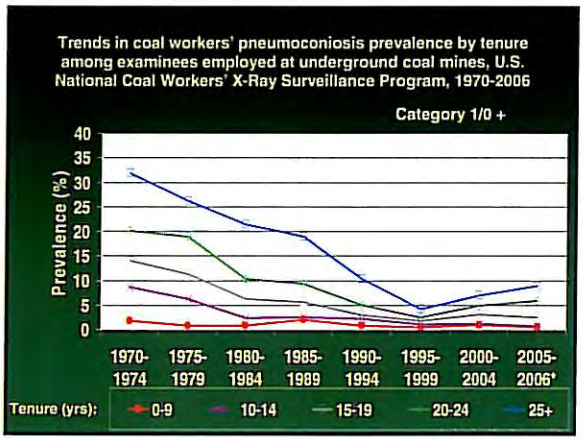
Prevention of Dust Disease in Coal Miners

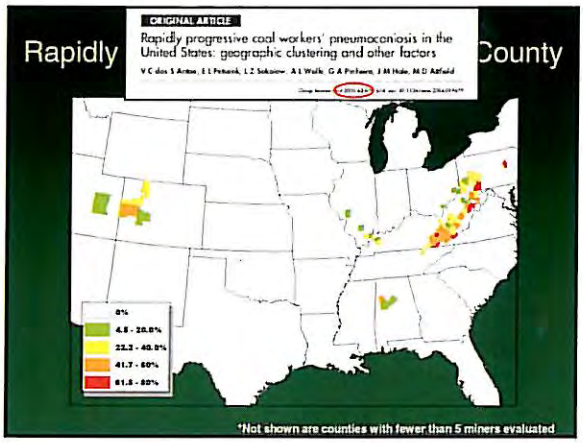
- Reduce the level of dust exposure ***
- Reduce the toxicity of the dust
  - Silica is 20 times more toxic than coal
  - Reduce potential exposures to silica (drilling/cutting rock)
  - Reduce fresh fractured rock/coal exposures
  - Smaller particles are more toxic

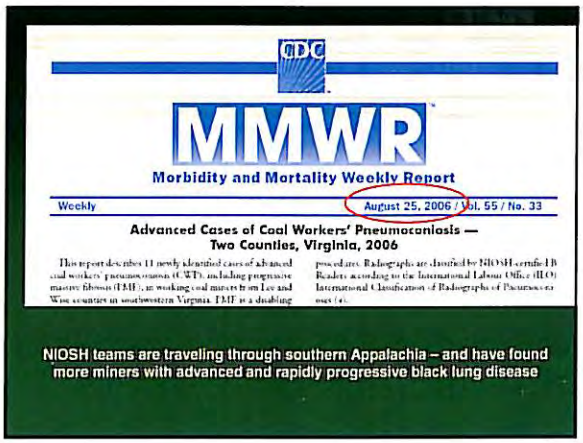
Prevention of Dust Disease in Coal Miners

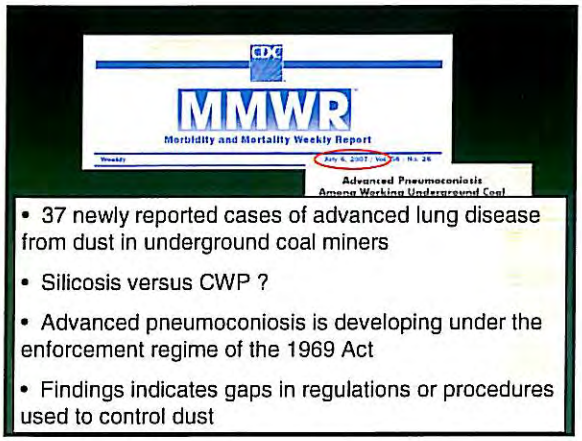
- Reduce the level of dust exposure ***
- Reduce the toxicity of the dust
- Allow time for dust to clear from lungs
  - Long shifts and extended work weeks
    - Increases dust inhaled
    - Reduces time between shifts to clear dust from lungs











- 37 newly reported cases of advanced lung disease from dust in underground coal miners
- Silicosis versus CWP ?
- Advanced pneumoconiosis is developing under the enforcement regime of the 1969 Act
- Findings indicates gaps in regulations or procedures used to control dust

Thanks to the Staff - who do the work of NIOSH!

"The first priority and concern of all in the coal or other mining industry must be the health and safety of its most precious resource – the miner."
Federal Coal Mine Health and Safety Act of 1969 – amended in 1977

In 2002, 27 deaths from coal mining accidents – and 854 deaths from black lung.

We can't eliminate dust in coal mining.
But by controlling dust we can eliminate cases of advanced black lung!

Dust Regulations and Control Strategies

Jay Colinet
Respiratory Hazards Control Branch

12th US/North American Mine Ventilation Symposium
Reno, Nevada
June 8, 2008

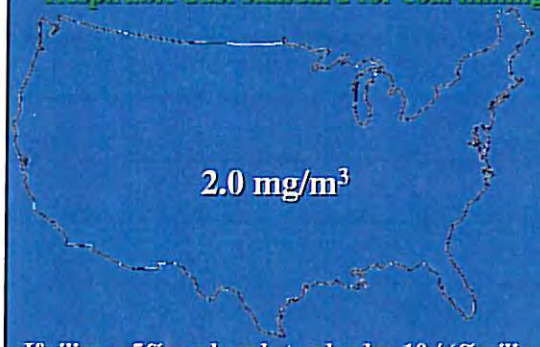
CDC NIOSH

Metal/Nonmetal dust sampling

- 10 mg/m³ total airborne dust standard
- If silica > 1%, calculate respirable dust standard
- 10/(%Quartz + 2) = respirable standard
- Periodic sampling not required by mine

CDC NIOSH

Respirable dust standard for coal mining



If silica > 5%, reduced standard = 10 / (% silica)

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Personal Dust Sampler

CDC NIOSH

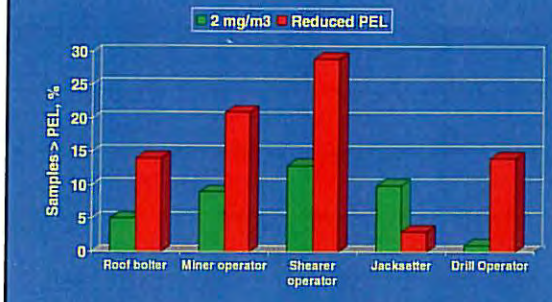
Sampling requirements for coal mines

- MSHA inspector samples multiple occupations to identify Designated Occupation (DO)
- MSHA samples each MMU four times per year
- Operator samples DO for five shifts on bi-monthly basis

CDC NIOSH

Overexposures for high risk occupations

(MSHA Compliance Sampling Data from 2000 – 2004)



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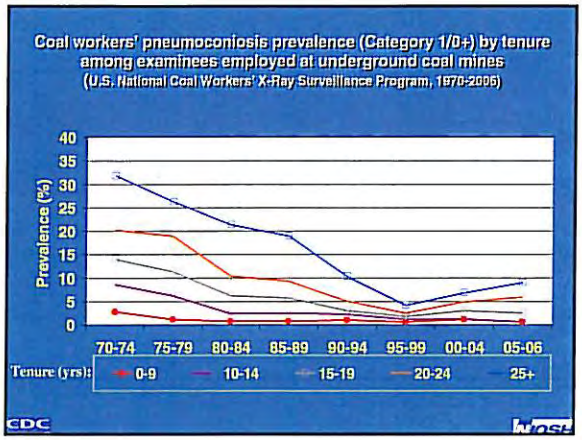
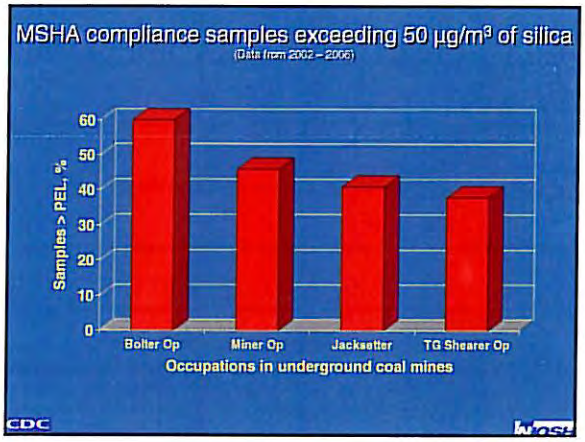
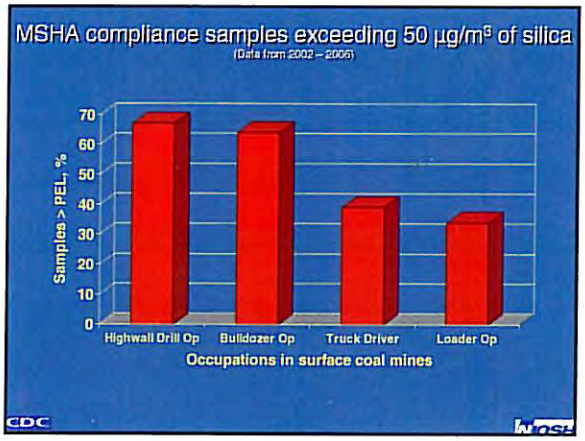


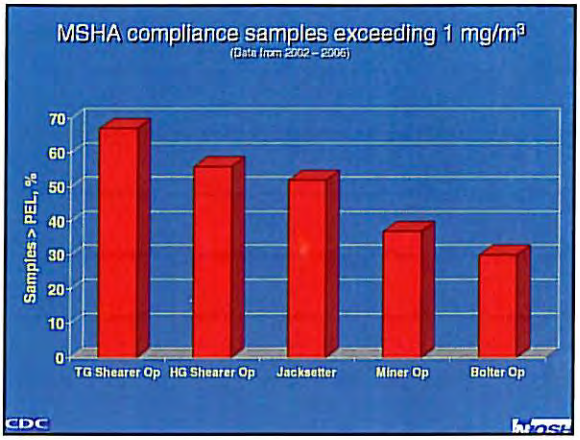


Proposed S-Miner legislation

- Reduces coal dust standard to 1 mg/m³
- Establishes silica dust standard of 50 µg/m³
- Requires use of PDM for compliance sampling

CDC





Approaches 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

CDC

Cutting - minimize dust generation

Confine - modified collector dump on surface drill

Impact of water sprays on dust

- Suppression (volume)
- Redirection (pressure)
- Airborne capture (type & pressure)

Approach to Dust Control

- Minimize dust liberation
  - Cutting
  - Wetting
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- Direct dust clouds away from workers
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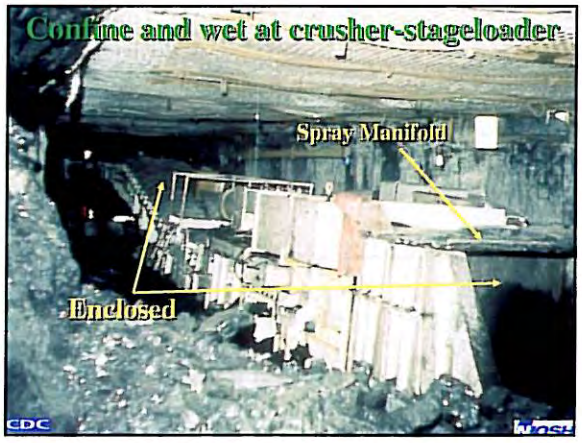
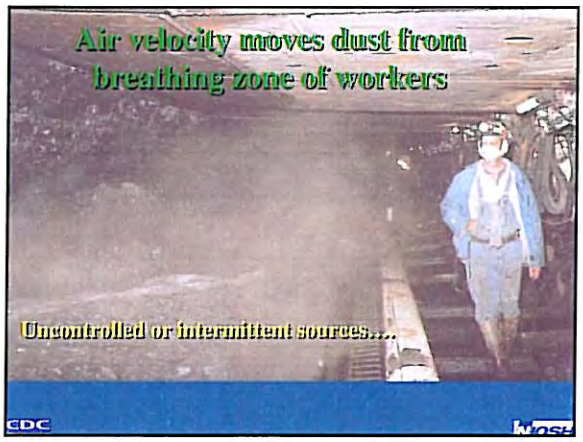
Confine and wet at crusher-stageloader



Lack of air movement allows dust to build...

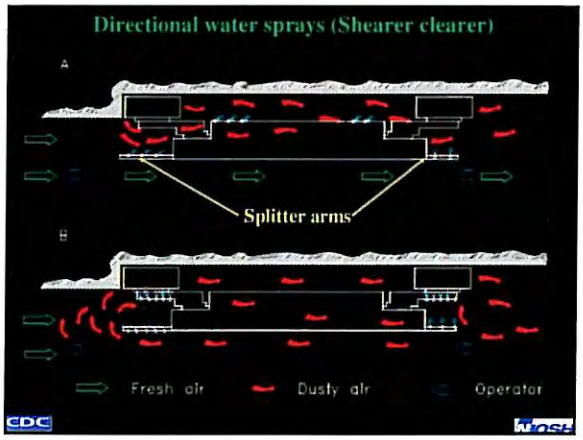
Air velocity moves dust from breathing zone of workers



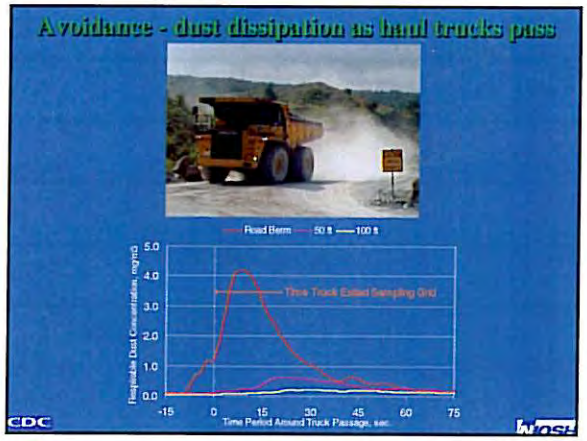
Dust avoidance

- worker positioning (ventilation)
- worker rotation
- personal protective equipment

Directional water sprays (Shearer clearer)



Avoidance - dust dissipation as haul trucks pass



Physical barrier and enclosed work areas

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

Dilution - maximize air quantity to mining faces


Gob curtain


Belt air


Limestone mines

CDC NIOSH

Thank you!

Questions???

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

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Capture - powered dust collectors

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Commitment to dust control

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

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Dust Control for Metal/Nonmetal Mining

Respirable Dust Control Workshop

12th U.S./North American

Mine Ventilation Symposium

Sunday, June 8, 2008

CDC

NIOSH

Improving The Air Quality in Enclosed Cabs of Mobile Equipment

CDC

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Silicosis Prevention

PROGRAM ELEMENTS

- Commitment
- Dust Surveillance
- Medical Surveillance
- Control of Dust Exposure
- Employee Involvement
- Smoking Cessation

CDC

NIOSH

Dozers

Shovels

Loaders

Haul Trucks

CDC

NIOSH

Research to be Presented

- Improving The Air Quality in Enclosed Cabs of Mobile Equipment
- Clothes Cleaning System
- Low Velocity Exhaust Ventilation System (EVS)
- Total Mill Ventilation System (TMVS)
- Background Dust Sources
- Reducing Dust Levels in Iron Ore Processing Plant
- IMA-NA/NIOSH Mineral Processing Dust Control Handbook

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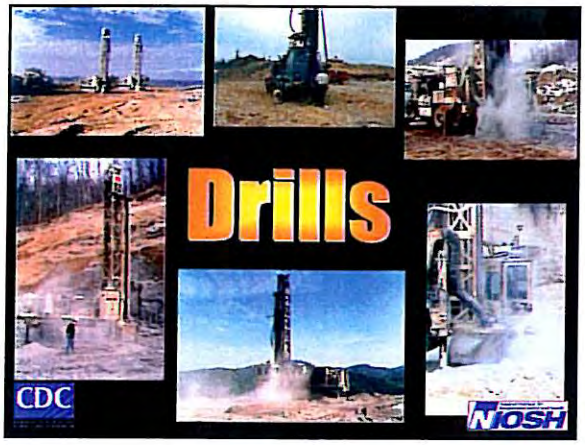

Drills

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Davey M8B Drill Study

BASELINE

- Floor heater
- No AC or filtration system

MODIFICATIONS

- Roof mounted heating & AC unit
- External filter, fan unit, & re-circulation filter
- Poorly sealed cab enclosure with no positive pressure achieved

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RELATIVE PERFORMANCE MEASURES

$$PF = \frac{C_O}{C_I} \quad ; \quad \eta = \frac{C_O - C_I}{C_O}; \quad Pen = 1 - \eta$$

$$PF = \frac{C_O}{C_I} = \frac{1}{1-\eta} = \frac{1}{Pen}$$

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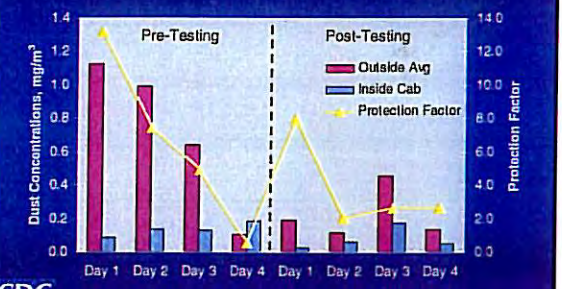
Respirable Dust Results

Insignificant change, from 0.14 to 0.08 mg/m³



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Comparison of Cab Performance Measures

Protection Factor	Efficiency, Pct.	Penetration, Pct.
2	50	50
5	80	20
10	90	10
100	99	1
1000	99.9	0.1

CDC NIOSH

CAT 980B Front-End Loader Study

BASELINE

- Floor heater
- No AC or filtration system

MODIFICATIONS

- Roof mounted heating & AC unit
- External filters, fan unit, & re-circulation filter
- Sealed cab enclosure & achieved 0.015" w.g. positive pressure

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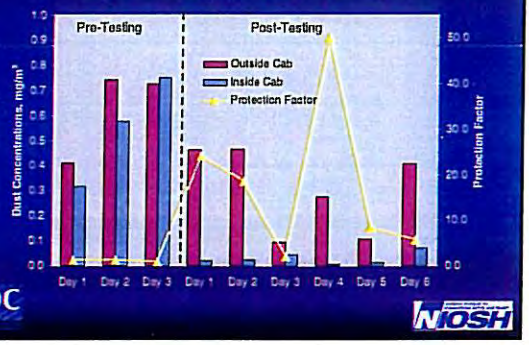
Respirable Dust Results

Significant change, from 0.55 to 0.03 mg/m³



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Problem Identified – Floor Heaters

- Respirable dust level increase from 0.04 to 0.68 mg/m³
- Optical Particle Counter in shop - dust levels increased from 0.03 to 0.26 mg/m³

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Drill Tech D40K

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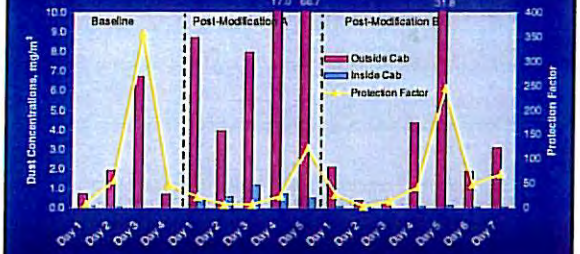
Respirable Dust Results

Significant changes, from 0.04 to 1.16 to 0.07 mg/m³



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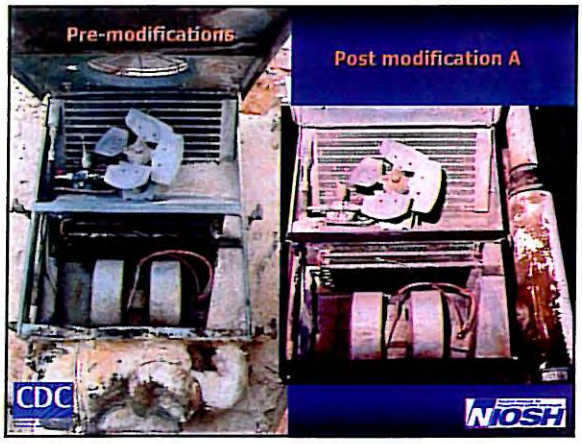

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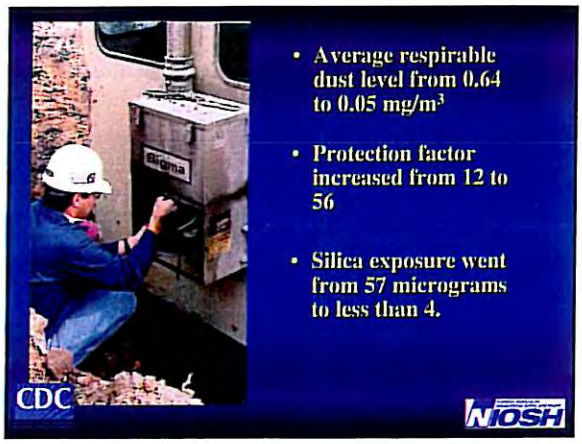
Ingersoll-Rand DM 45E Drill

BASELINE
- Older filtration unit not in good working order.

MODIFICATIONS
- Roof mounted heating & AC unit
- External filters, fan unit, & re-circulation filter
- Achieved cab pressure of between 0.2 and – 0.4 "

CDC NIOSH



- Average respirable dust level from 0.64 to 0.05 mg/m³
- Protection factor increased from 12 to 56
- Silica exposure went from 57 micrograms to less than 4.

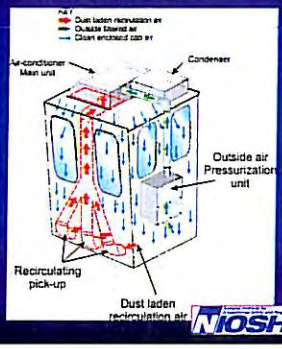
Cooperative Research Effort

Uni-directional airflow design

Sy-Klone International

Clean Air Filter Company

Both Sy-Klone & Clean Air Filter are donating their time and costs associated with this research effort.



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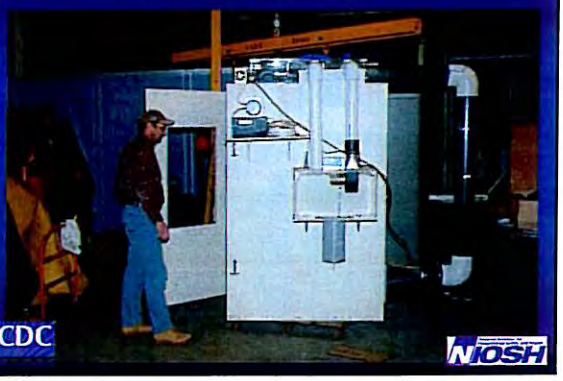
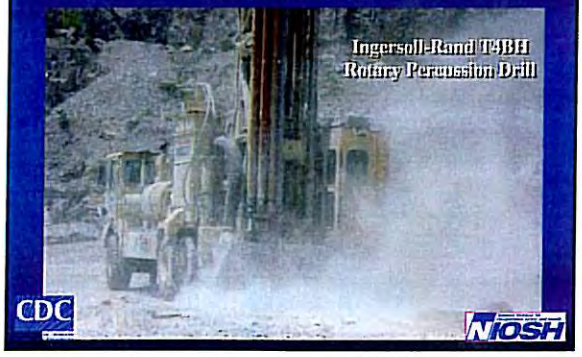
Laboratory Test Chamber

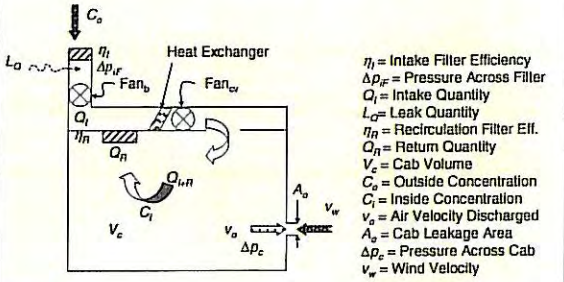


Vulcan's Southern and Gulf Coast Division

Birmingham, Alabama



Laboratory study to optimize cab filtration and pressurization parameters



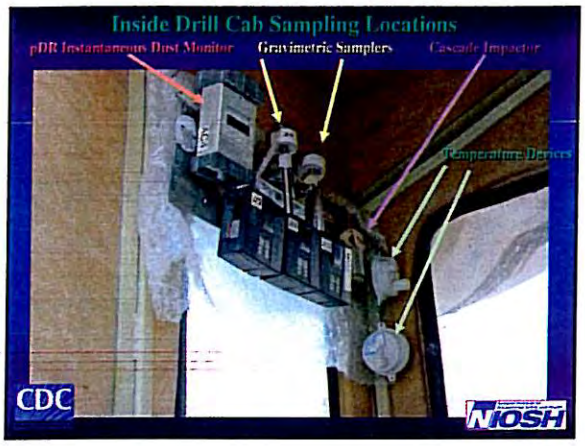
η_I = Intake Filter Efficiency
Δp_{iF} = Pressure Across Filter
Q_I = Intake Quantity
L_o = Leak Quantity
η_R = Recirculation Filter Eff.
Q_R = Return Quantity
V_c = Cab Volume
C_o = Outside Concentration
C_i = Inside Concentration
v_o = Air Velocity Discharged
A_o = Cab Leakage Area
Δp_c = Pressure Across Cab
v_w = Wind Velocity

CDC NIOSH

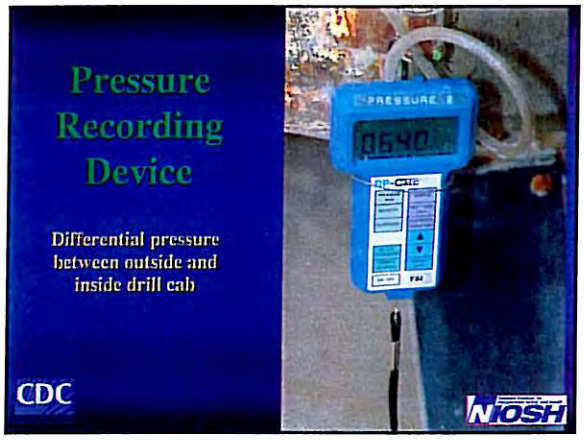
Baseline Testing

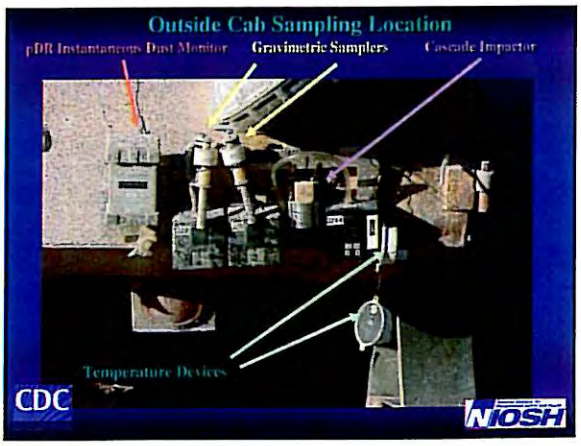
Sept. 26-28, 2006


Outside Drill Cab Sampling Locations
Left
Outside Cab
CDC
NIOSH


Inside Drill Cab Sampling Locations
pDR Instantaneous Dust Monitor
Gravimetric Samplers
Cascade Impactor
Temperature Devices
CDC
NIOSH


Outside Left Sampling Location
pDR Instantaneous Dust Monitor
Gravimetric Samplers
CDC
NIOSH


Pressure Recording Device
Differential pressure between outside and inside drill cab
CDC
NIOSH


Outside Cab Sampling Location
pDR Instantaneous Dust Monitor
Gravimetric Samplers
Cascade Impactor
Temperature Devices
CDC
NIOSH


Old unit as removed from drill
October 2006
CDC
NIOSH

Installation of one-directional flow filtration & pressurization system – October 2006

CDC

NIOSH

One-directional filtered airflow inside the enclosed cab

Post-Testing

Dec. 12-14, 2006

CDC

NIOSH

Two Sy-Klone Gideon pre-filter units

Removes oversized particles through centrifugal separation

CDC

NIOSH

Poor dust sampling conditions

(surface water & wet drill holes)

CDC

NIOSH

Hour meter – filter life. Pressure and velocity indicator to inform drill operator that filter needs to be changed.

CDC

NIOSH

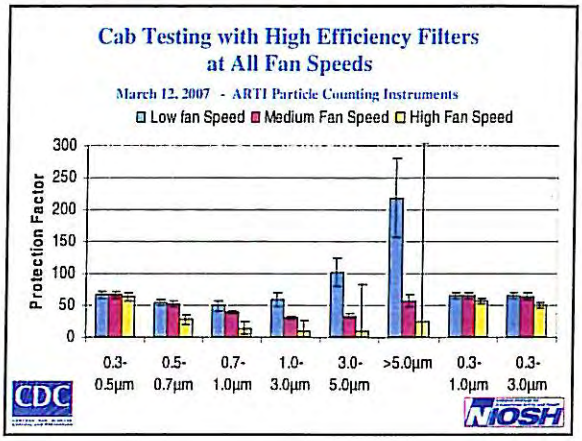
Testing During Actual Drilling

March 13-15, 2007

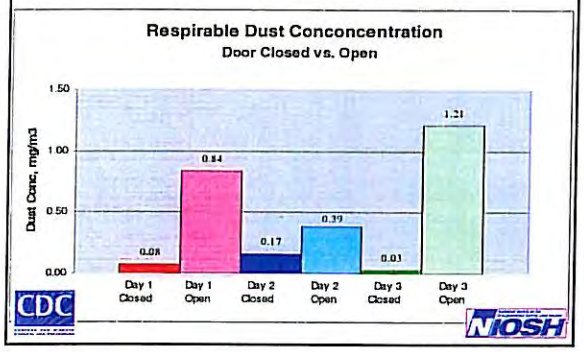
CDC

NIOSH

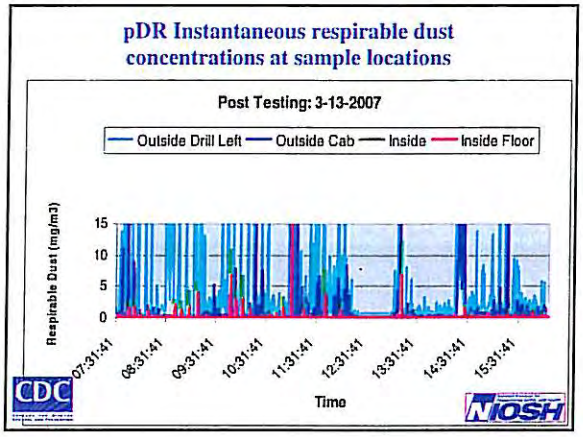
Cab Testing with High Efficiency Filters at All Fan Speeds

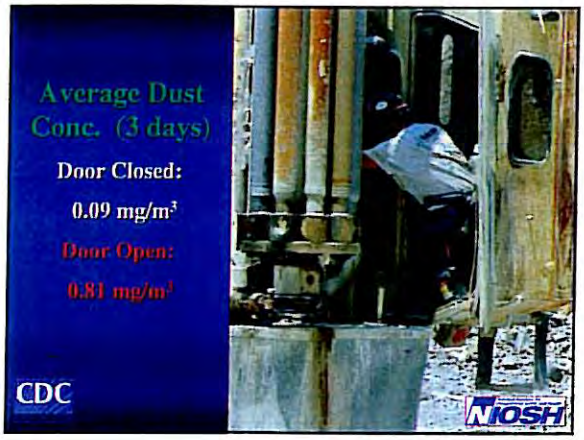


Respirable dust concentration inside the drill cab with the door open and closed

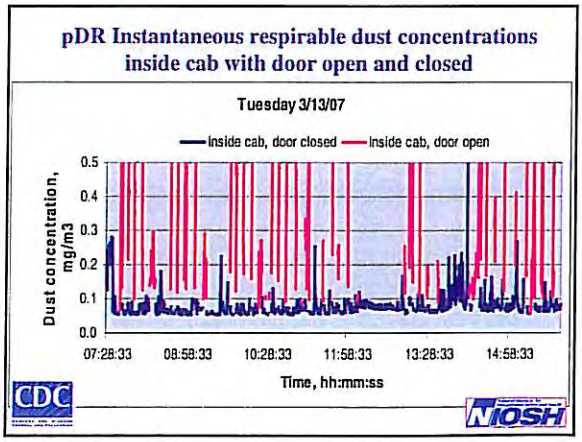


pDR Instantaneous respirable dust concentrations at sample locations

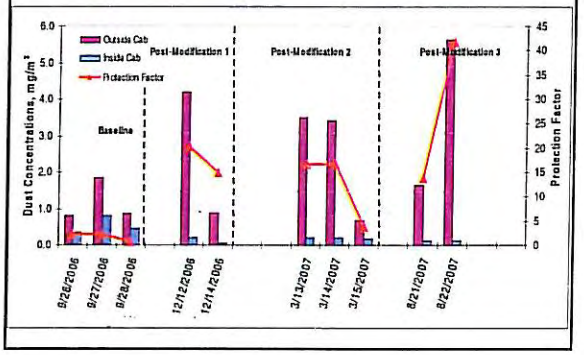




pDR Instantaneous respirable dust concentrations inside cab with door open and closed



Respirable Dust Level and Protection Factor with Uni-Directional Filtration and Pressurization System



Clothes Cleaning System

A safe and effective method for removing dust from work clothes

Keys for Effective Enclosed Cab Dust Control

- Filtered ventilation
  - Recirculated cab air
  - Outside air
- Cab integrity
  - Replace door seals
  - Plug holes in cab
- Develop positive pressure

CDC

NIOSH

Research Efforts in Enclosed Cabs

CDC

Manufacturers/Government:

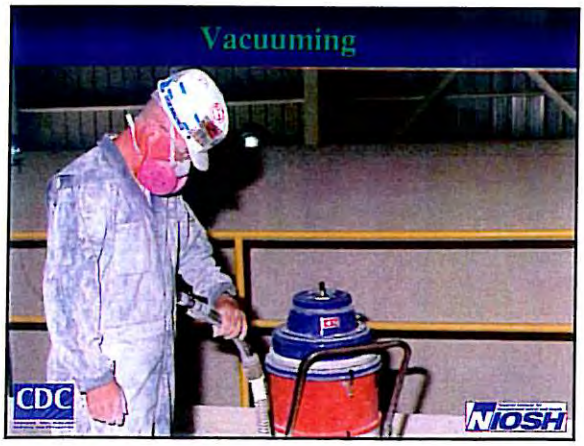
- Clean Air Filter Company
- Red Dot Corp.
- Bergstrom Air International Transit/Sigma Air Condition
- SCS Frigette
- SYKLONE International Inc.
- John Deere Product Engineering Center
- Nelson Manufacturing
- Red Dot Corporation
- California EPA
- Mine Safety and Health Administration

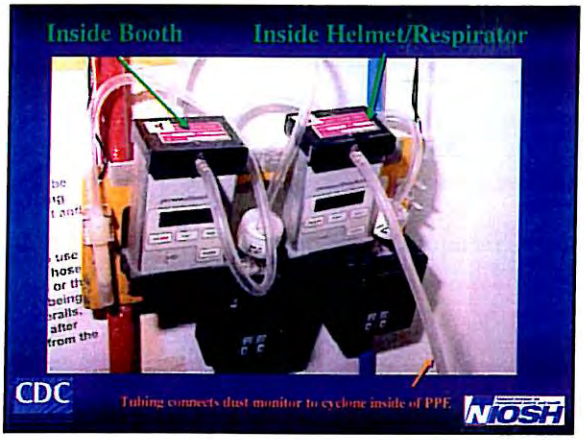
Companies:

- U.S. Silica Company
- Al Hamilton Contracting Company
- Lodestar Energy, Inc.
- Leslie Resources
- Powder River Coal Company
- Vulcan Materials Corporation

NIOSH

Vacuuming





Testing Procedures

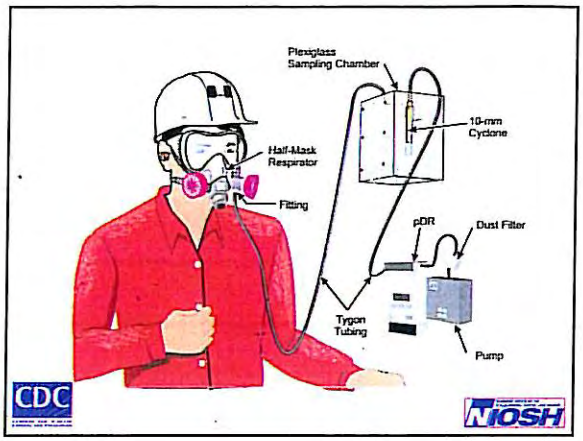
Dust Sampling Locations:

- Outside cleaning booth
- Inside cleaning booth
- PPE of worker

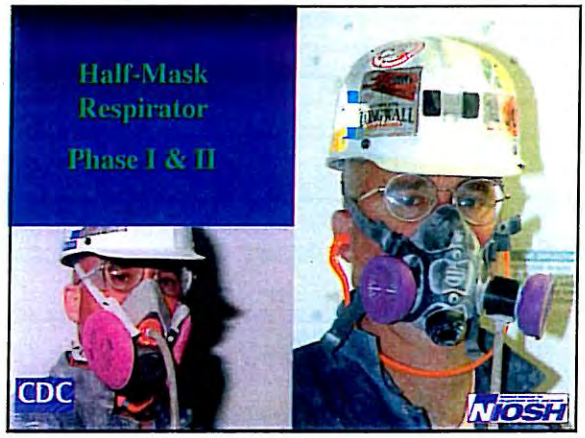
Clothes Cleaning Effectiveness:

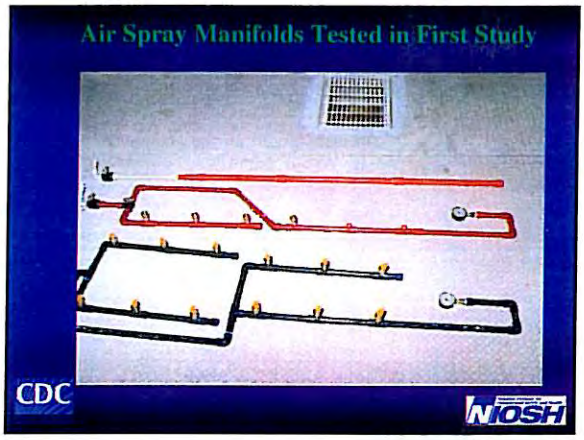
Weighing procedures to determine weight loss to coveralls for three cleaning methods (vacuuming, air hose, & air nozzle manifold.)

CDC NIOSH


Plexiglass
Sampling Chamber
10-mm
Cyclone
Half-Mask
Respirator
Fitting
pDR
Dust Filter
Tygon
Tubing
Pump
CDC
NIOSH


Weighing process to determine weight added to coveralls and then removed by clothes cleaning process
CDC
NIOSH

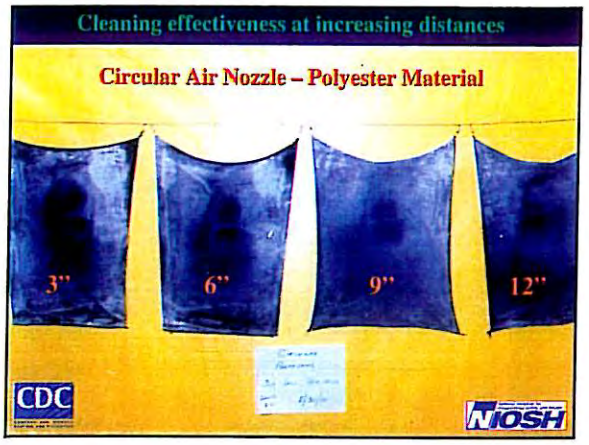

Half-Mask
Respirator
Phase I & II
CDC
NIOSH


Air Spray Manifolds Tested in First Study
CDC
NIOSH

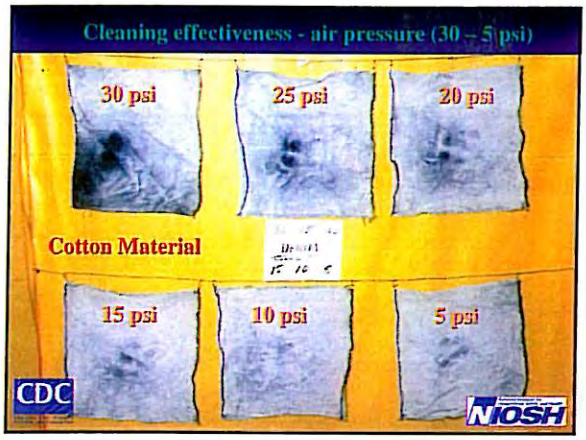

Soiling clothes with crushed limestone dust (rockdust) for testing
CDC
NIOSH


Vacuuming
4 minutes 24 seconds
Air Spray Manifold
2 minutes 3 seconds
CDC
NIOSH


Laboratory Testing
Pittsburgh Research Laboratory
CDC
NIOSH


Cleaning effectiveness at increasing distances
Circular Air Nozzle – Polyester Material
3"
6"
9"
12"
CDC
NIOSH


CDC
NIOSH

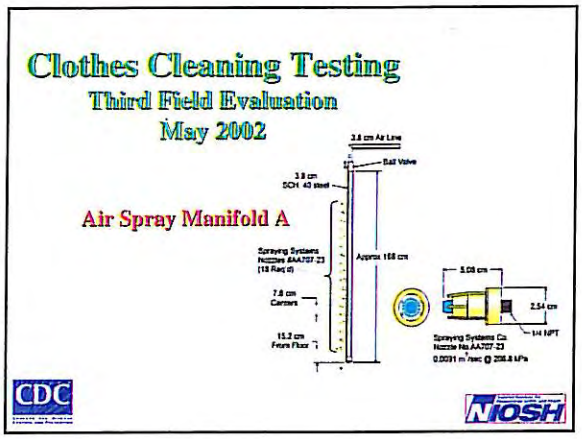

Cleaning effectiveness - air pressure (30 – 5 psi)
30 psi
25 psi
20 psi
Cotton Material
15 psi
10 psi
5 psi
CDC
NIOSH

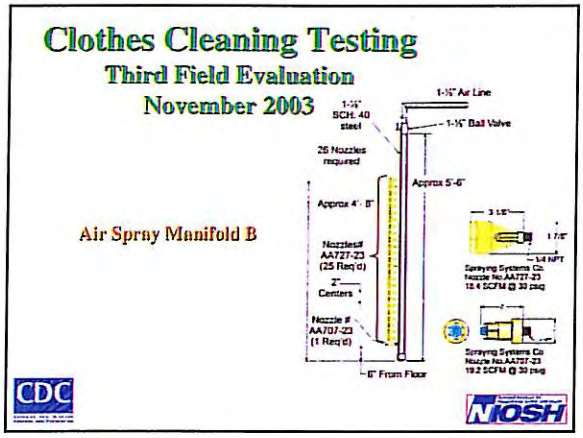

Analysis of three air spray nozzles (Brass V, Flat, & Circular)
3 inch Distance
Brass V
Flat fan
Circular
Polyester Material
CDC
NIOSH


Cleaning effectiveness – nozzle operating time (5 – 30 seconds)
5 sec
10 sec
15 sec
Polyester
Material
20 sec
25 sec
30 sec
CDC
NIOSH


CDC
NIOSH


Final Field Testing - Marston
26 Nozzles
30 psi = 480 scfm
CDC
NIOSH


Clothes Cleaning Testing
Third Field Evaluation
May 2002
Air Spray Manifold A
CDC
NIOSH


Clothes Cleaning Testing
Third Field Evaluation
November 2003
Air Spray Manifold B
CDC
NIOSH


120-gallon air reservoir tank to supply air spray manifold
CDC
NIOSH


Pre- Cleaning
Vacuum
Cleaning Time:
7 minutes 48 seconds
Post- Cleaning
CDC
NIOSH

Cleaning Effectiveness and Time for Air Spray Manifold A & B

Poly Blend Coveralls

Cleaning Method	Remaining Weight, grams	Time, seconds
Air Spray Manifold A	38.7 n = 48	27
Air Spray Manifold B	29.7 n = 48	17

CDC NIOSH

Statistical Analysis

(ANOVA, Tukey's test, t-test)

- No statistical difference between air hose and vacuuming.
- Statistical difference between Air Spray Manifold A and air hose.
- Statistical difference between Air Spray Manifold A and vacuuming.
- Statistical difference between Air Spray Manifold A and Air Spray Manifold B.
- Polyester/cotton blend type coveralls were significantly cleaner than 100 pct. cotton type.

CDC NIOSH

Cleaning Effectiveness and Time for Three Clothes Cleaning Methods

Cleaning Method	Cotton Coveralls: Remaining Weight, grams	Cotton Coveralls: Time, seconds	Poly Blend Coveralls: Remaining Weight, grams	Poly Blend Coveralls: Time, seconds
Vacuuming	63.1 n = 12	393	45.5 n = 12	349
Air Hose	68.8 n = 12	183	48.4 n = 12	173
Air Spray Manifold A	46.3 n = 12	25	36.2 n = 36	27

CDC NIOSH

Noise Measurement - Dosimeter

General Mill Levels:	91.5 dB
Inside Booth – not operating:	86.5 dB
Inside Booth – operating	101.4 dB
Outside Booth – operating	91.4 dB
Outside Booth – not operating	90.6 dB

* Hearing protection is required when using clothes cleaning system.

CDC NIOSH

Federal Regulations

- CFR Part 56.13020 - "At no time shall compressed air be directed toward a person. When compressed air is used, all necessary precautions shall be taken to protect persons from injury." Notification submitted to MSHA District Manager informing of test program
- 29 CFR 1910.242(b) – "Compressed air shall not be used for cleaning purposes except where reduced to less than 30 p.s.i. and then only with effective chip guard and personal protective equipment."

CDC NIOSH

Clothes Cleaning System

Stand-Alone Design

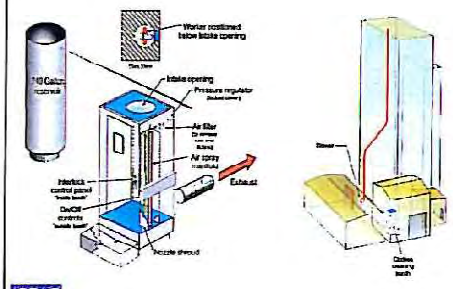
- ✓ Most facilities will not have the luxury of having excess baghouse capacity.
- ✓ Installation of a baghouse is very costly.
- ✓ Exhaust dust from booth outside plant – up stack.
- ✓ EPA opacity measurement (should not see visible plume except for extremely brief periods).

CDC NIOSH

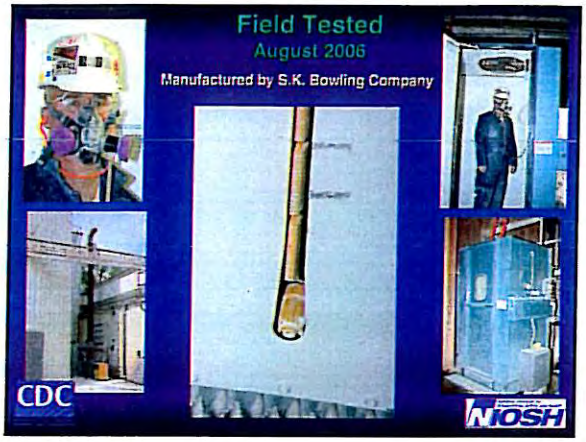
Clothes Cleaning Video

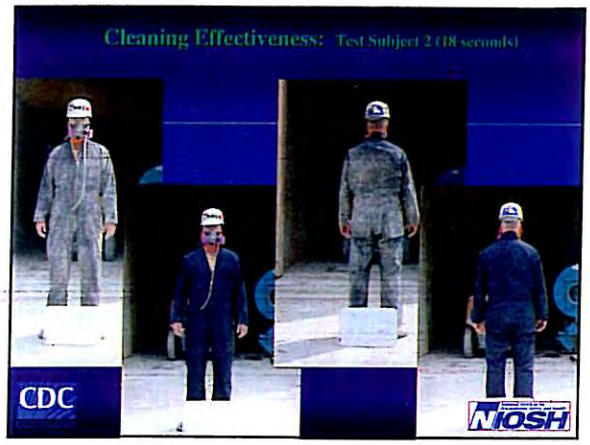
CDC NIOSH

Modification - Exhaust air outside



CDC NIOSH



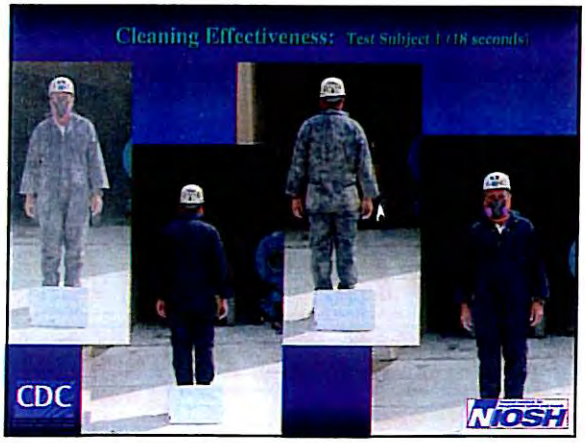


Commercialization of Clothes Cleaning System

- SK Bowling is manufacturing the system and is forming a new company called Clothes Cleaning Systems, Inc.
- Started national advertising of this system in many major mining/ industrial hygiene journals in April 08.
- Approximately 10 units have been sold to date with 20 quotes out for additional units including in Australia and England.

The Clothes Cleaning Booth was developed through a cooperative research effort between NIOSH (National Institute for Occupational Safety and Health) and Unimin Corporation, an industrial minerals mining company. NIOSH is part of the Centers for Disease Control and Prevention (CDC) in the U.S. Department of Health and Human Services. More details of this project and a video are at their website. (www.cdc.gov/niosh)

CDC NIOSH



Unimin/NIOSH Clothes Cleaning Research Effort:

- The air spray manifold designed under this cooperative study statistically cleaned better than the MSHA recommended HEPA vacuuming or single air hose techniques.

CDC NIOSH

Unimin/NIOSH Clothes Cleaning Research Effort:

- The air spray manifold designed under this cooperative study statistically cleaned better than the MSHA recommended HEPA vacuuming or single air hose techniques.
- Verified that a worker wearing a half-mask respirator (N100 filters), hearing protection, and full seal goggles could safely perform this technique without any increased health/safety risks.
- Determined that polyester/cotton blend material cleaned more effectively than 100 pct. cotton material.
- Verified that when this clothes cleaning technique was performed in a cleaning booth under negative pressure at an exhaust volume of 2,000 cfm, it did not create any increased risk of dust or noise exposure to the work environment or co-workers.

CDC NIOSH

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- Determined that polyester/cotton blend material cleaned more effectively than 100 pct. cotton material.
- Verified that when this clothes cleaning technique was performed in a cleaning booth under negative pressure at an exhaust volume of 2,000 cfm, it did not create any increased risk of dust or noise exposure to the work environment or co-workers.
- Designed, tested, and received MSHA approval on a system that exhausted to a LEV system and one that was ducted outside the facility.

CDC NIOSH

Unimin/NIOSH Clothes Cleaning Research Effort:

- The air spray manifold designed under this cooperative study statistically cleaned better than the MSHA recommended HEPA vacuuming or single air hose techniques.
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CDC NIOSH

In the Future!

- That MSHA will change the Code of Federal Regulation to incorporate the use of this technique.
- This clothes cleaning technique will become a common operating practice to clean worker clothing at mineral processing operations.

CDC NIOSH

Low Velocity Exhaust Ventilation System

UNIMIN Corporation

CDC

NIOSH

CDC

NIOSH

High Velocity

Low Velocity

CDC

NIOSH

High Velocity Disadvantages

- High Electrical Cost
  - Large pressure drop
    - Larger fan required
    - Increased power requirement
    - Greater energy consumption

CDC

NIOSH

High Velocity Disadvantages

- High Wear and Maintenance Costs
  - Abrasive wear by larger dust particles at high speed
  - Particularly at elbows & branch entries

CDC

NIOSH

Low Velocity Characteristics

Low Velocity Does *NOT* mean Low Airflow!!!!

Ventilation is the *SAME* in either transport system

CDC

NIOSH

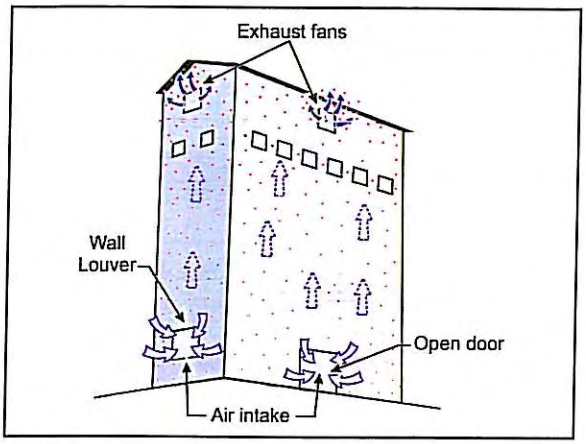
Low Velocity Characteristics

"Saw tooth" duct design

Minimum upflow angle is 45° and downflow angle is 30°

CDC

NIOSH



Low Velocity Advantages

- Lower Wear and Maintenance Cost
  - Smaller sized suspended particles and low particle velocity
    - Less abrasion
    - Able to use short radius and mitered elbows without noticeable wear
- Lower Energy Cost
  - Reduced friction losses
  - Reduced pressure drop

CDC

NIOSH

Evaluation Site - Clay Processing Structure

- Three, 8,500 cfm roof exhaustors
- 25,500 cfm system, 10 ACPH
- Three wall louvers – inlet for makeup air

CDC

NIOSH

Total Mill Ventilation System

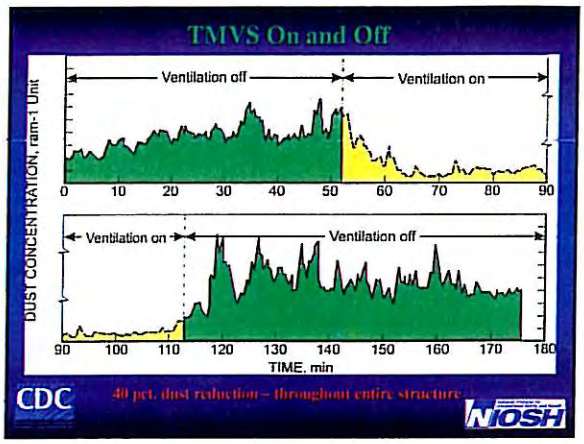
CDC

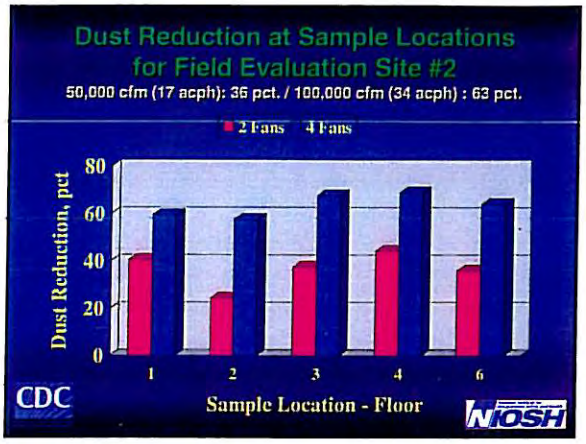
NIOSH

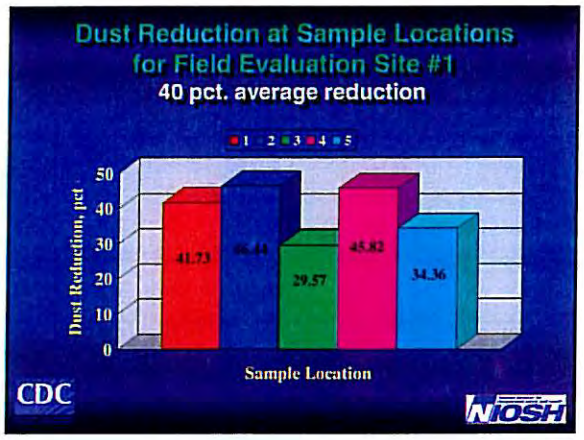
Wall Louvers for intake air.

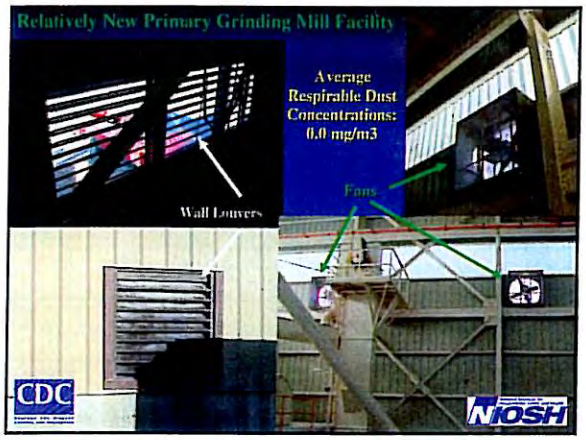
CDC

NIOSH

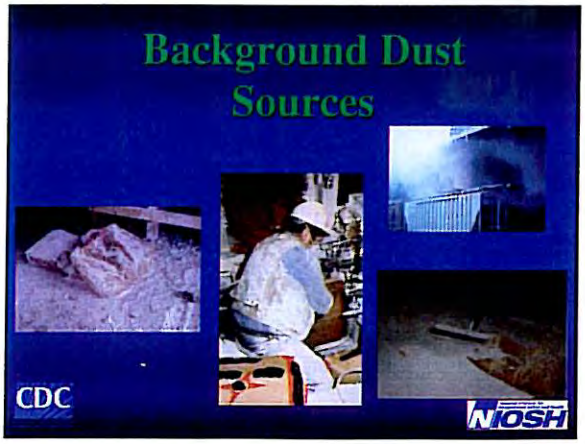

TMVS On and Off
Ventilation off
Ventilation on
DUST CONCENTRATION, ram-1 Unit
0 10 20 30 40 50 60 70 80 90
Ventilation on
Ventilation off
90 100 110 120 130 140 150 160 170 180
TIME, min
CDC
40 pct. dust reduction – throughout entire structure
NIOSH

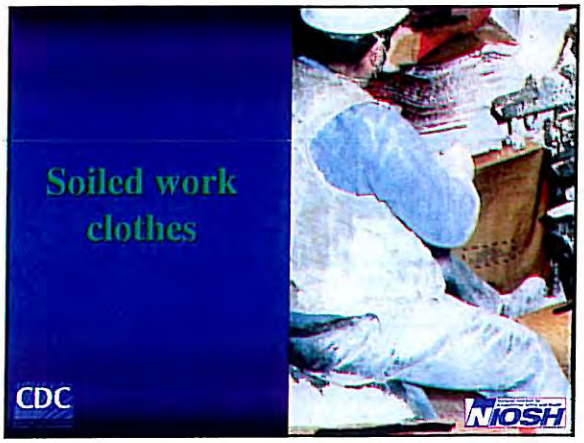

Dust Reduction at Sample Locations
for Field Evaluation Site #2
50,000 cfm (17 acph): 36 pct. / 100,000 cfm (34 acph) : 63 pct.
2 Fans 4 Fans
Dust Reduction, pct
0 20 40 60 80
1 2 3 4 6
Sample Location - Floor
CDC
NIOSH

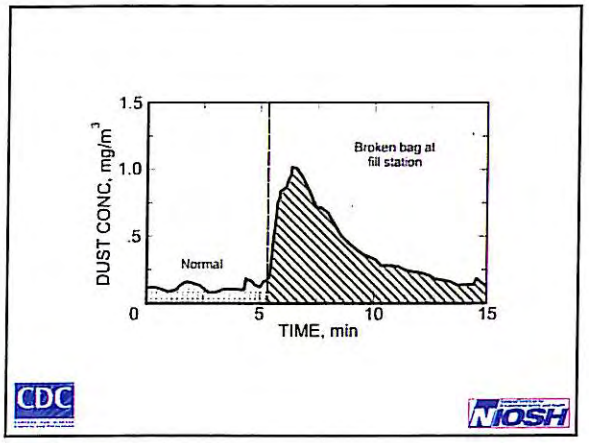

Dust Reduction at Sample Locations
for Field Evaluation Site #1
40 pct. average reduction
1 2 3 4 5
Dust Reduction, pct
0 10 20 30 40 50
41.73
66.44
29.57
45.82
34.36
Sample Location
CDC
NIOSH

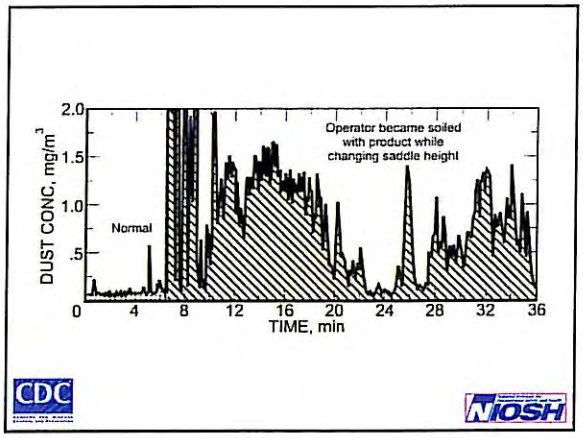

Relatively New Primary Grinding Mill Facility
Average
Respirable Dust
Concentrations:
0.0 mg/m3
Wall Louvers
Fans
CDC
NIOSH

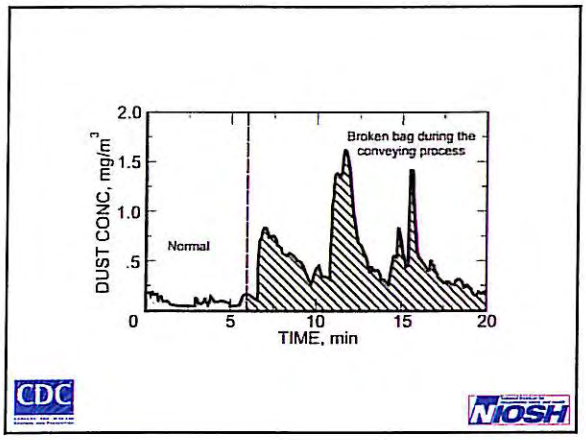

Site #2
100,000 cfm system,
34 ACPH
Four 25,000 cfm
propeller type wall
exhaustors
Open bay doors – inlet
for makeup air
Cost: $6,000 – Material
& Installation (Inhouse)
CDC
NIOSH


Background Dust
Sources
CDC
NIOSH


Soiled work clothes
CDC
NIOSH


DUST CONC, mg/m3
1.5
1.0
.5
0
5
10
15
TIME, min
Normal
Broken bag at fill station
CDC
NIOSH


DUST CONC, mg/m3
2.0
1.5
1.0
.5
0
4
8
12
16
20
24
28
32
36
TIME, min
Normal
Operator became soiled with product while changing saddle height
CDC
NIOSH


DUST CONC, mg/m3
2.0
1.5
1.0
.5
0
5
10
15
20
TIME, min
Normal
Broken bag during the conveying process
CDC
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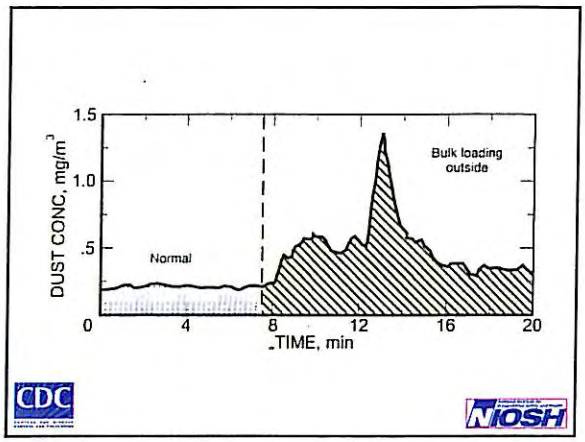
Broken Bags
CDC
NIOSH


Bulk Loading Outside
CDC
NIOSH



Background Dust Sources

- Aware of Problem
- Identify the Problem
- Control the Problem

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Increase in Worker's Dust Exposure from Secondary Dust Sources

CASE	Increase Factor	TLV Exposure Time
Contaminated Work Clothes	10.1	1 hr 35 min
Blowing Clothes with Compressed Air	2.4	3 hr 33 min
Broken Bag (Fill Station)	3.2	4 hr 34 min
Broken Bag (Conveyor)	6.9	3 hr 20 min
Bulk Loading Outside	2.5	3 hr 48 min
Bag Hopper Overflowing	12.2	2 hr 11 min
Dry Sweeping Floor	5.7	9 hr 24 min

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Number of Occurrence from Secondary Dust Sources to Over-expose Workers

Sources of Dust	Estimated Occurrences Exceed TLV
Contaminated Work Clothes	1
Bag Breakage During Filling	14-18
Bag Breakage During Conveying	6-10
Bulk Loading Outside	3-4
Bag Hopper Overflowing	3-4

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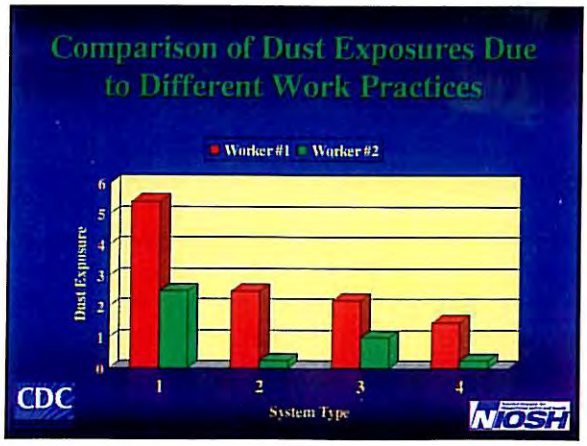
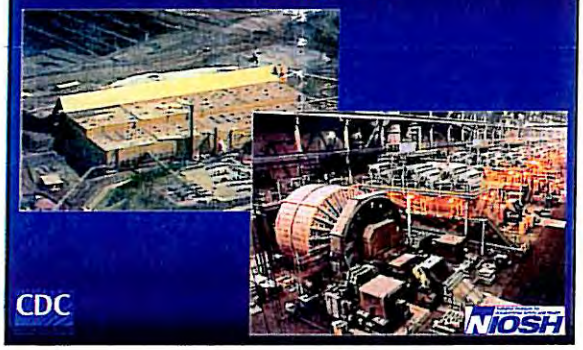
Comparison of Dust Exposures Due to Different Work Practices



Reducing Dust Levels in Iron Ore Processing Plant



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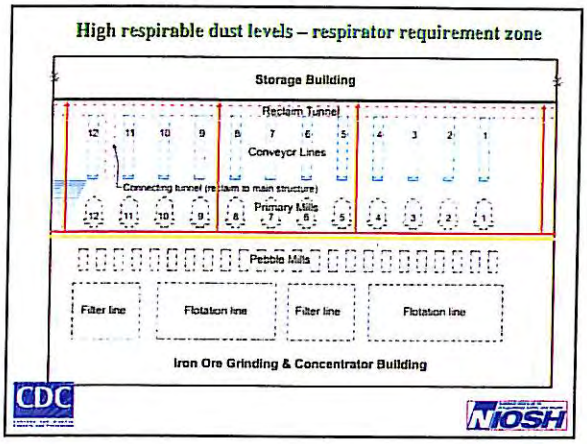
High respirable dust levels – respirator requirement zone



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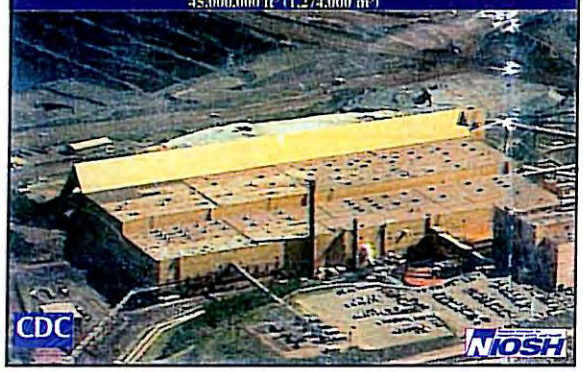
Unique Facility:

940,000 ft² (87,300 m²) structure with an internal air volume of 45,000,000 ft³ (1,274,000 m³)



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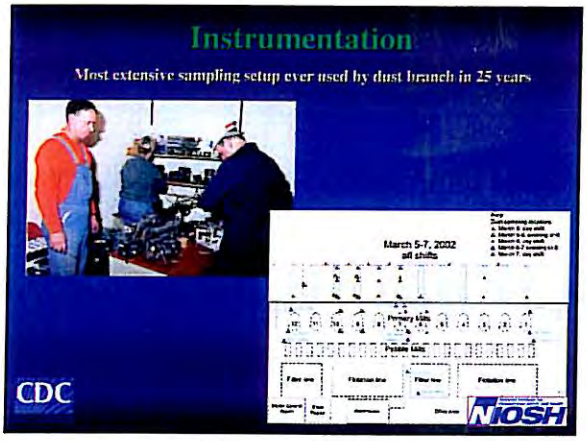
Instrumentation

Most extensive sampling setup ever used by dust branch in 25 years



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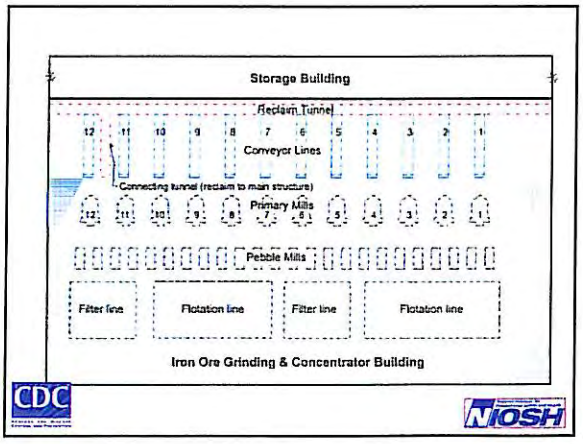

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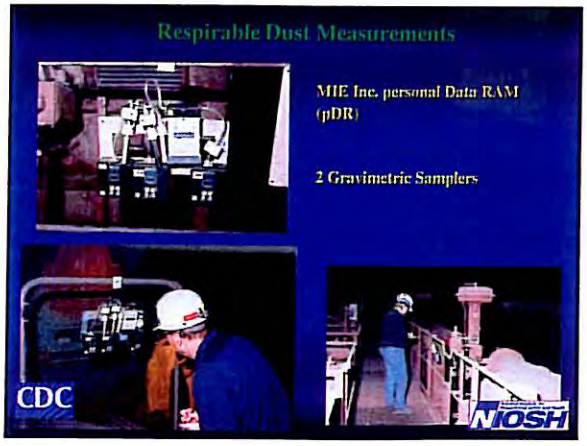
Respirable Dust Measurements



MIE Inc. personal Data RAM (pDR)

2 Gravimetric Samplers

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Airflow Measurements

"Solent Volometer" (Gill Instruments Ltd): ultrasonic anemometer

Vane Anemometer (Davis Instruments): eight-blade

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Roof Fan Set up At Tilden
Tuesday, March 9

3.2 times more air exhausted

Intake: 2 intake heaters/3 intake roof fans - 600,000 cfm (280 m³/s)

Exhaust: 39 exhaust fans – 1,930,500 cfm (910 m³/s)

Key
- Intake Fan
- Exhaust Fan

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Major Objective: Optimize and balance airflow throughout structure

Secondary Objective: Lower respirable dust levels in and around the twelve primary grinding mills

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Roof Fan Set up At Tilden
as of 9:30 a.m.
Wednesday, March 10

1.1 times more intake air

Intake: 2 intake heaters/12 intake roof fans – 1,045,000 cfm (490 m³/s)

Exhaust: 19 exhaust fans – 940,500 cfm (440 m³/s)

Key
- Intake Fan
- Exhaust Fan

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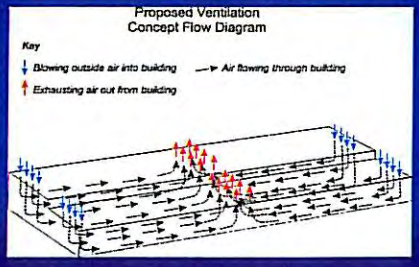
Ventilation Recommendation

- Proposed a significant change to concentrator structure ventilation – balance intake and exhaust volumes, create a directional flow pattern

Proposed Ventilation
Concept Flow Diagram



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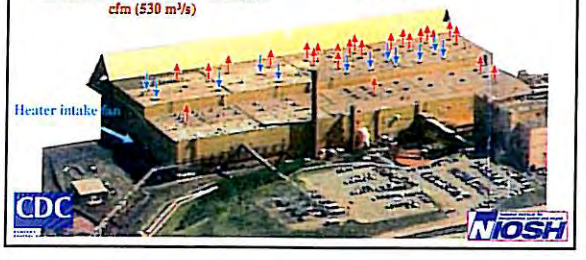
Roof Fan Set up At Tilden
as of 7:00 a.m.
Thursday, March 11

1.1 times more air exhausted

Intake: 2 intake heaters/12 intake roof fans – 1,045,000 cfm (490 m³/s)

Exhaust: 24 exhaust fans – 1,128,000 cfm (530 m³/s)

Key
- Intake Fan
- Exhaust Fan



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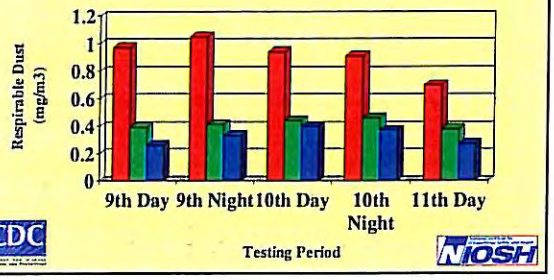
Respirable Dust Averages



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Results from Ventilation Change to Balance and Optimize Airflow

- Respirable dust levels lowered by 31% in the primary grinding area - third ventilation design
- Respirable dust levels slightly lowered in pebble mill and flotation areas

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IMA-NA Committee: Mineral Processing Dust Control Handbook

Committee Members (Fall 2006):

Chairman: Andy O'Brien, Unimin Corporation
Roger Bresee, Unimin Corporation
Rick Fox, Unimin Corporation
Chris Bryan, U.S. Silica Company
Mark Shultz, Mine Safety and Health Administration
Robert Franta, Spraying Systems Company (new member)
Randy Reed, NIOSH (new member)
Andy Cecala, NIOSH
Joe Schall, Technical Writer/Editor, Penn State University (paid)

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Poor dumpster placement (used collector bags)

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Handbook Chapters

- Introduction
- Fundamental of Dust Collector Systems
- Water Application
- Drilling & Blasting
- Crushing & Screening
- Milling
- Conveying and Transport
- Dust Control for Bagging Operations
- Bulk Loading into Railcars and Trailer Trucks
- Secondary Source Control
- Enclosed Cabs and Booths
- Fugitive Dust Emissions
- Appendices

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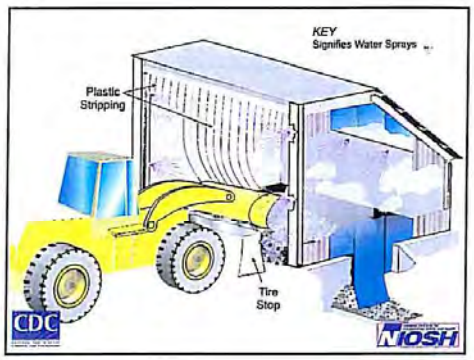

Committee Meetings

- November 29, 2006 - Winchester, VA
- March 20, 2007 - Winchester, VA
- December 5, 2007 - Winchester, VA
- April 17, 2008 - Pittsburgh, PA
- June 4, 2008 – Berkeley Springs, WV
- First draft - End of 2009

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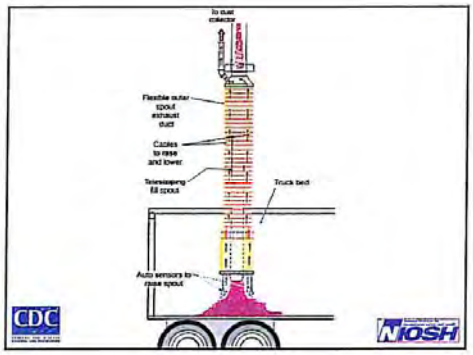


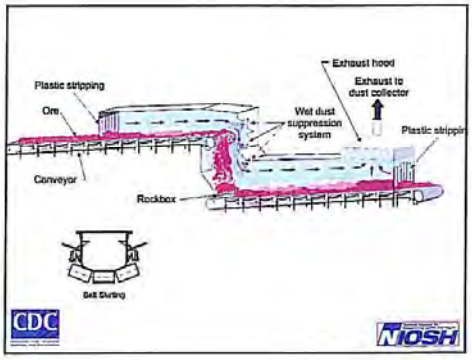
Andy Cecala

CDC/NIOSH

Respiratory Hazards Control Branch

E-mail: ACecala@cdc.gov

CDC NIOSH



Dust Control for Longwalls

Pittsburgh Research Laboratory
NIOSH

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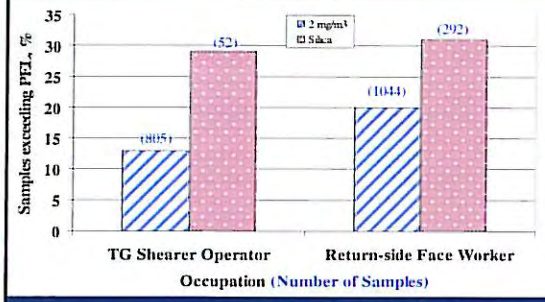
MSHA inspector samples exceeding PEL, 2000 - 2004



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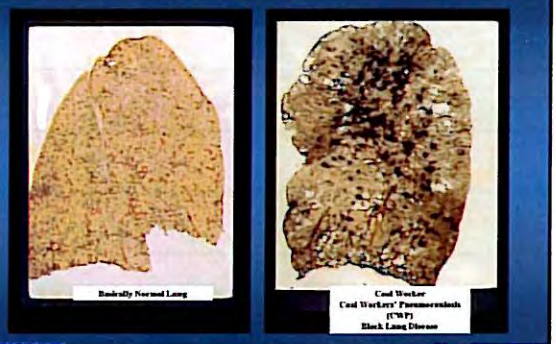
Impact of Overexposure to Respirable Coal Dust



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Designated Occupation [D.O.] Dust Samples

MSHA Inspectors
1995-1999

9,799 Dust Samples

1,957 (20 %) Exceeded
2 mg/m³ dust standard

MSHA Inspectors
2000-2004

7,421 Dust Samples

1,072 (14 %) Exceeded
2 mg/m³ dust standard

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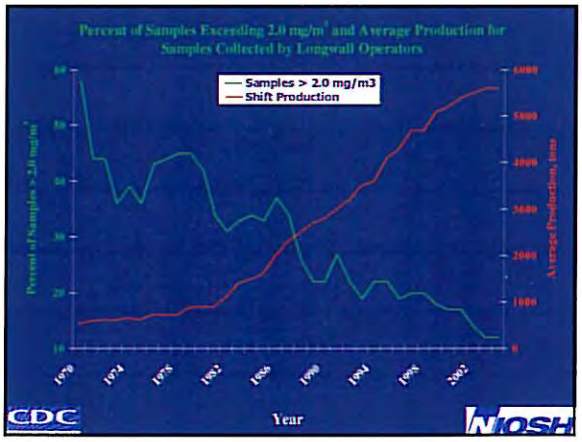
Percent of Samples Exceeding 2.0 mg/m³ and Average Production for Samples Collected by Longwall Operators



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Designated Occupation [D.O.] Dust Samples

Mine Operators
1995-1999

1,358 Dust Samples

258 (19 %) Exceeded
2 mg/m³ dust standard

Mine Operators
2000-2004

1,587 Dust Samples

235 (15 %) Exceeded
2 mg/m³ dust standard

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Longwalls

51 % of Underground Production

17 % of Total US Production

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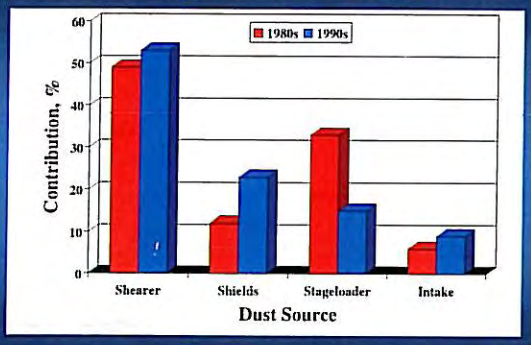
Longwall Dust Sources



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Longwalls

Overall Production

2004 – 187.9 million tons

2006 – 175.7 million tons

2007 – 170.9 million tons

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Benchmarking Longwall Surveys

- Quantify dust from major sources
- Identify controls and level of application
- Provide suggestions for improved dust control

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Longwalls

Panel Widths

1994 -- 750 ft

2002 -- 940 ft

2007 -- 967 ft

Panel Lengths

1994 -- 7000 ft

2002 -- 10,000 ft

2007 -- 10,132 ft

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Benchmarking Longwall Surveys

Gravimetric dust samplers

- 10 mm Dorr-Oliver nylon cyclones
- 2 L/min

Personal DataRAMS (pDRs)

- Time related profile of dust levels
- Data stored at 10 second intervals in an internal data logger

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Stationary Sampling Locations

- Intake
- Belt Entry
- Shield 10
- 10 Shields From Tailgate

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Observations to Date

- 7 mines utilized bidirectional cutting sequence
- 3 mines used unidirectional cutting
- Panel widths ranged between 780 and 1000 ft
- Cutting height averaged 9 ft and ranged between 7 and 11 ft

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Mobile Sampling Locations

OUTBY
- H to T – Outby shield movement

SHEARER
- Between mid-shearer and tailgate drum

UPWIND
- 5 shields upwind of headgate drum

DOWNWIND
- 5 shields downwind of tailgate drum

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Observations to Date

Air Velocity
- Average - 637 ft/min
- 8 of 10 Longwall > 600 ft/min
- 2 Longwall > 800 ft/min

Air Quantity
- Average – 65,000 ft³/min
- 65 % increase when compared to the 1995 longwall study

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Baseline Surveys

Spot Air Velocity Readings
- Each sampling shift
- 10 shield intervals
- Measured 1-6 ft above spill plate
- Rough estimate of the area at each velocity sampling location

MONITOR WATER QUANITIES
- Shearer
- Stageloader / Crusher

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Observations to Date

- Average water usage at shearer – 130 gpm
- Shearer drum sprays ranged between 35 and 62
- Average drum spray pressure – 150 psi
- 4 operations utilized between 6 and 8 crescent sprays on the ranging arms

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Observations to Date

- Directional water spray systems evident on all surveyed longwall
- Unique to each mining operation
- 9 out 10 Longwall using splitter arm on the headgate side
- Length, number, and type of sprays were mine specific
- 4 Longwalls had splitter arm extension arms
- 2 Longwalls utilized venturi sprays

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Longwall Dust Control

- Minimize dust generated and liberated
  - Cutting
  - Enclosures
- Direct dust clouds away from workers
  - Airflow
  - Directional sprays
  - Barriers
- Reduce airborne dust levels
  - Dilution
  - Capture

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Observations to Date

- Type, number, and location of the shearer sprays varied greatly
  - Deflector plates observed at 3 western mine sites
  - Spray block manifolds and venturi sprays were utilized
- 2 Operations used tailgate splitter arm
- All other operations used a block manifold located above the lump breaker

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Longwall Dust Control

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

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Stationary Sampling Observations (gravimetric)

- Average dust levels
  - Intake - 0.20 mg/m³
  - Belt - 0.47 mg/m³
  - Shield 10 - 0.70 mg/m³
  - Tailgate - 2.48 mg/m³
- Reduction in dust levels ranged between 27 and 53 % when compared to the survey conducted in the 90's
- Dust Attributed to the stageloader/crusher was 0.48 mg/m³

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Impact of Water Sprays on Dust

- Suppression (volume)
- Redirection (pressure)

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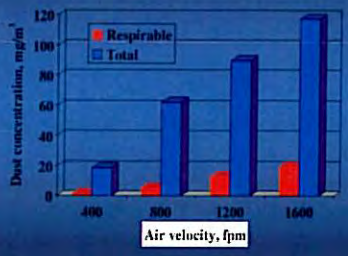
Impact of Water Sprays on Dust

- Capture (type and pressure)

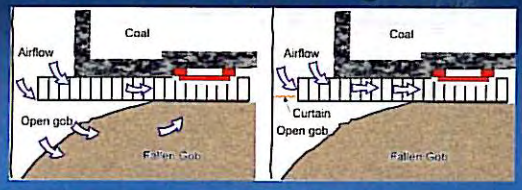
Percent of Respirable Dust



Higher Velocities Confine Dust Near Face

- Minimum velocity : 400 to 450 ft/min
- German Study : 700 to 900 ft/min if moisture content is 5 to 8 %
- As velocities increase it is important to ensure sufficient wetting of the coal

Maximize Air Flow to Longwall Face



Maintain Gob Curtain

Dust Entrainment in High Velocity Airstreams

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

Maximize Air Flow to Longwall Face

- Belt air utilized on 5 of 10 longwalls
- Average concentration : 0.47 mg/m³
- Belt maintenance is critical
- Wetting the coal product during transport
- Belt cleaning by scraping and washing

Confine Dust –Stageloader Crusher

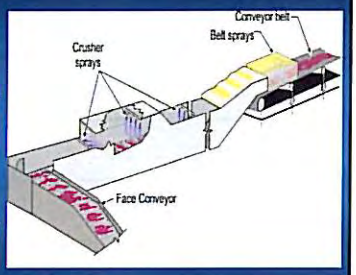
- Evident on all longwall
- Enclosures unique to mine operation
- Sprays : quantity over pressure ... large orifice, full cone sprays

Directional Water Spray Systems

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

Stageloader-Crusher Controls

- Sprays bars located above crusher hammer, entrance, and discharge
- Span the width of the enclosure
- Spray pressure : <= 60 psi, low pressure / high volume



Minimize Dust Generation

- Sharp Bits
  - maintenance
- Drum Design
  - water distribution
  - bit lacing
  - vanes
  - rpm

Stageloader-Crusher Controls

- Flooded bed scrubbers
  - 6500 to 8500 ft³ / min
- Crusher discharge and/or stageloader to belt transfer area

Drum Sprays

- Quantity more important than pressure
- Drum sprays operated at maximum of 100psi
- Use larger orifice nozzles to increase spray quantity to drum
- Full-cone or solid stream spray patterns

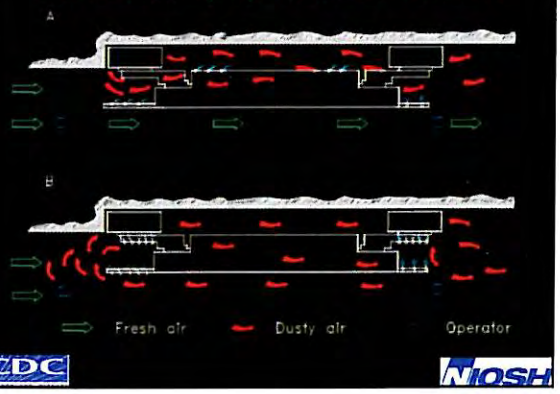
Crescent Sprays

- Observed on 50 % of surveyed longwalls
- Flat fan spray pattern aimed inward toward cutting drum

Directional Spray System

- Length of splitter bar ; type and number of sprays is mine specific
- Extend splitter beyond headgate drum
- Utilize enough sprays to prevent dust from headgate drum from migrating into walkway
- Spring mount rigid steel spray bar
- Utilize belting to separate air

Directional Sprays (Shearer Clearer)



Directional Spray System

- Orient sprays with airflow
- Hollow cone or venturi sprays
- Spray pressure at least 150 psi
- Sprays should not impact ranging arm

Directional Spray System

Directional Spray System

- Shearer sprays unique to each operation
- Sprays blocks consisting of 4 to 6 sprays position on shearer
- Direct with airflow

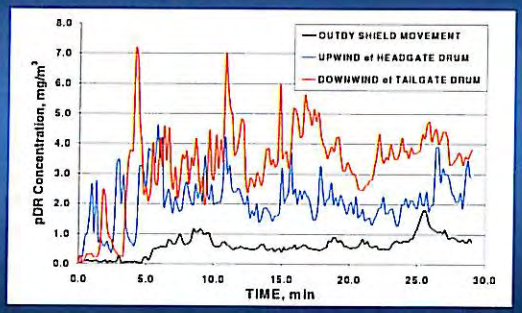
Directional Spray System

Controlling Respirable Shield Dust

- Canopy spray systems
  - Activate sprays on top of shields
  - Hard to maintain; not very effective
- Air Dilution
  - Advance shield as far upwind as possible without causing operational problems
- Unidirectional cutting
- Shield sprays on underside of canopy

Dust Concerns with Advancing Shields

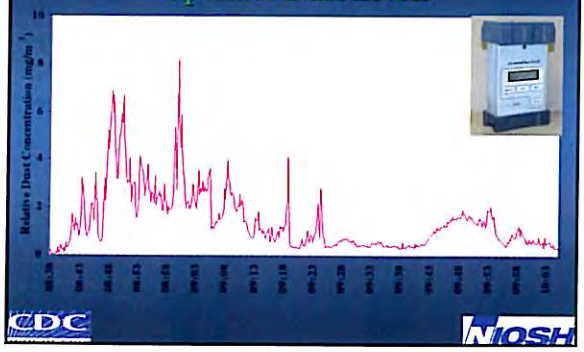
Typical Bi-Directional H to T Pass



Shield Sprays

- Shield sprays utilized to enhance directional spray system
  - Activated to create a water curtain
  - Shearer activated
- Location varied between the tip of shield to spill plate
- On/Off sequencing is critical

Impact of Shield Advance on Shearer Operator Dust Levels



Effective directional spray systems

Ineffective directional spray systems

Deflector plate

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Control guidelines - upwind

- Minimize intake/belt dust
- Confine stageloader/crusher dust
- Quantity of water in crusher
- Gob curtain at HG and beyond
- Shield advance/cutting sequences to minimize exposures of high risk workers

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Maximize Benefits of Available Controls

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Control guidelines - shearer

- Optimize cutting parameters (bits, rpm)
- Maximize water quantity to drums (larger orifice nozzles)
- Drum spray pressures @ 100 psi or less
- External sprays @ 150 psi or higher
- Caution using crescent sprays on HG drum

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Effective Water Management

Utilize available water to optimize dust control

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Control guidelines - shearer

- HG side splitter arm
  - as far upwind of drum as possible
  - maintain correct height
  - appropriate angle for sprays
  - maintain belting
- Sloughing plate/deflector as high as possible
- Utilize TG splitter arm or manifold sprays
- Shearer operators positioned as far upwind as possible

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Commitment to Dust Controls

- Worker and management involvement – knowledge and attitude (safety => immediate vs. health => long term)
- **Maintenance is critical**

Questions?

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jrider@cdc.gov

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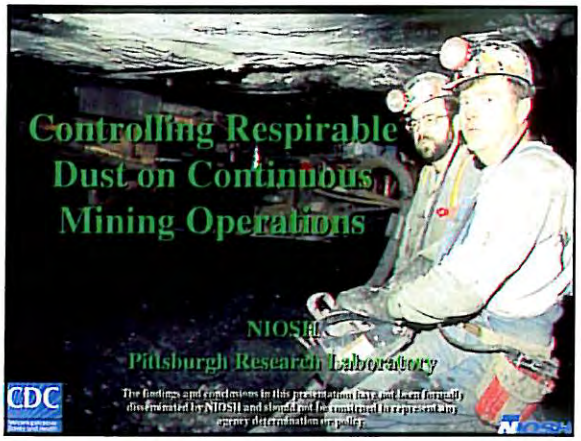
jcolinet@cdc.gov



Course 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)

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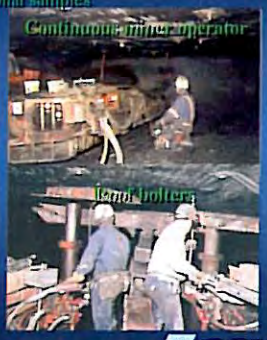
MSHA Data

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/m³



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Limiting Dust Exposure

- Water – Suppresses, redirects, and captures
- Air – Dilutes and transports

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Course Objective

- To describe and illustrate proven methods and engineering controls to minimize respirable dust concentrations on continuous mining operations (CM and bolter operators)

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Impact of Water on Dust

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

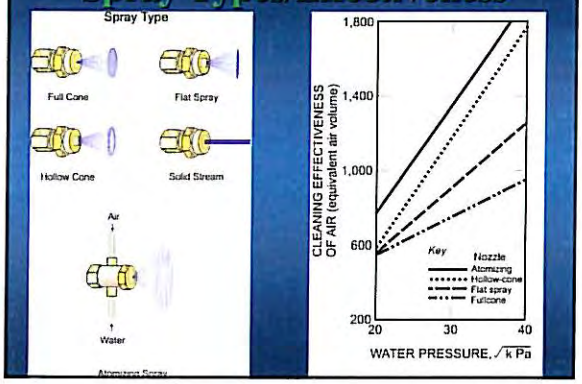
CDC NIOSH

Water sprays on continuous miners

Spray Nozzles, cont.
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 Types/Effectiveness



Spray Nozzles, cont.
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

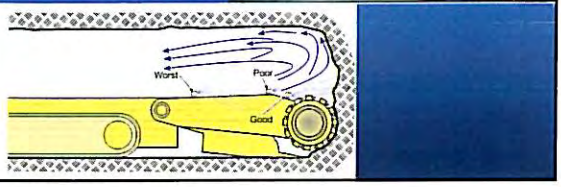
Spray Nozzles
Hollow Cone

- 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, cont.
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

Sprays close to cutting head

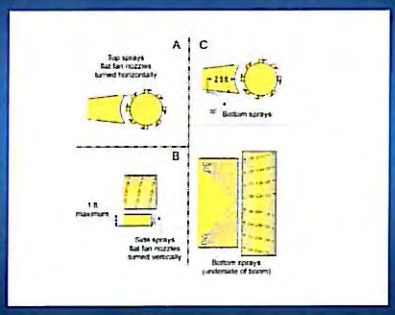


Wetting/Suppression

- flat-fan sprays on top of boom
- deluge sprays under boom
- throat sprays
- surfactants (wetting agents)

- **Flow rate most important**

Spray Locations



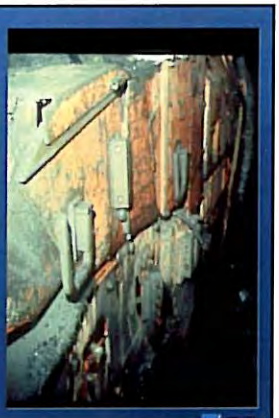
Redirecting/Moving Air

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

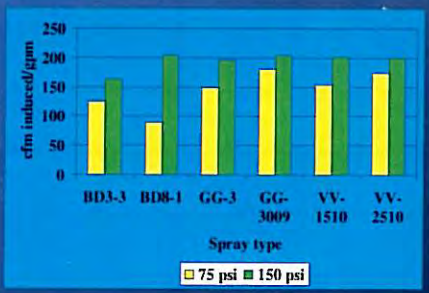
- **Pressure/location important**

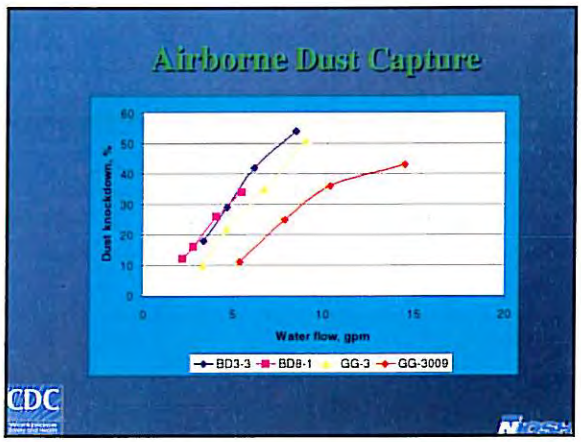
Blocking Sprays

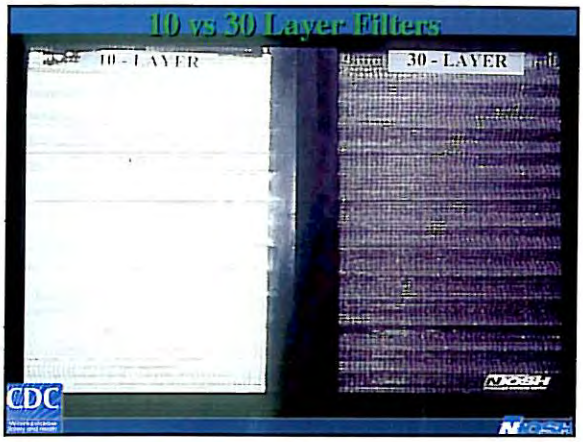
- Contains dust beneath boom
- Lower dust levels at operator and around machine

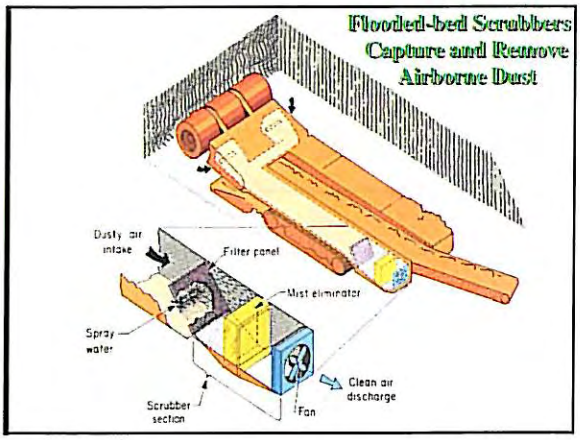


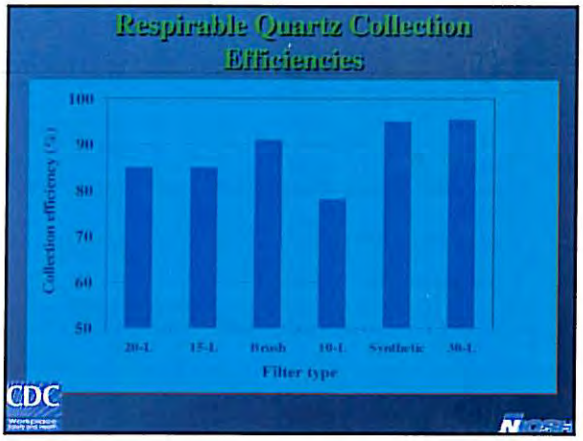
Airmoving Effectiveness



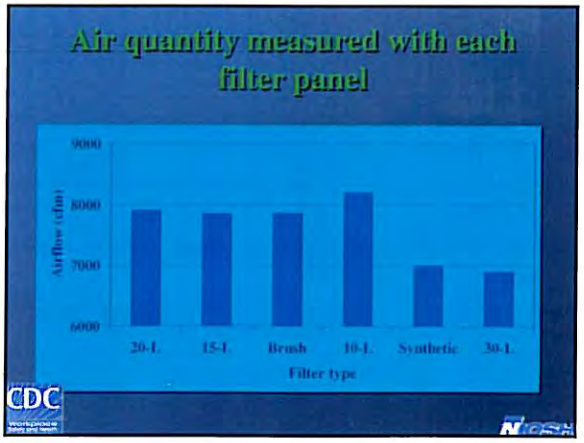

Airborne Dust Capture
Dust knockdown, %
Water flow, gpm
BD3-3
BD8-1
GG-3
GG-3009
CDC


10 vs 30 Layer Filters
10 - LAYER
30 - LAYER
CDC


Flooded-bed Scrubbers Capture and Remove Airborne Dust
Dusty air intake
Filter panel
Mist eliminator
Spray water
Clean air discharge
Scrubber section
Fan


Respirable Quartz Collection Efficiencies
Collection efficiency (%)
Filter type
CDC

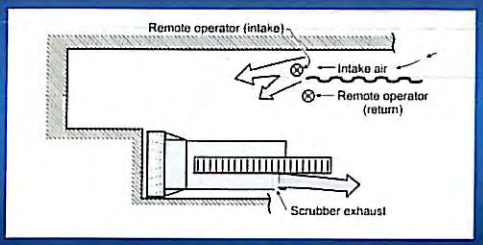

Scrubber Filter Study
Filters Tested
30-layer
20-layer
10-layer
Bottle-brush
15-layer
Bondina
CDC


Air quantity measured with each filter panel
Airflow (cfm)
Filter type
CDC

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.

Air
Blowing Ventilation

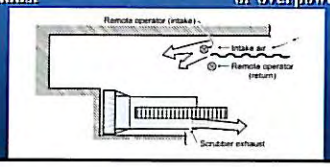


Clean and maintain scrubber filter and demister

- 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

Blowing Ventilation

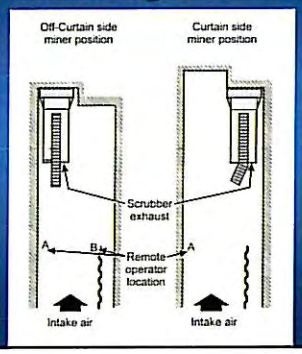
- Advantages
  - Greater penetration to face > 800 fpm
  - Effectively sweeps dust and methane from the face
  - Easier to maintain than exhaust
- Disadvantages
  - Restricts operator movement
  - Shuttle car operators must work in return air
  - Incorrect air balance may cause recirculation or overpowering



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



Continuous Miner Studies, (cont.)
Wet Head Cutter

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

Potential Wethead Benefits

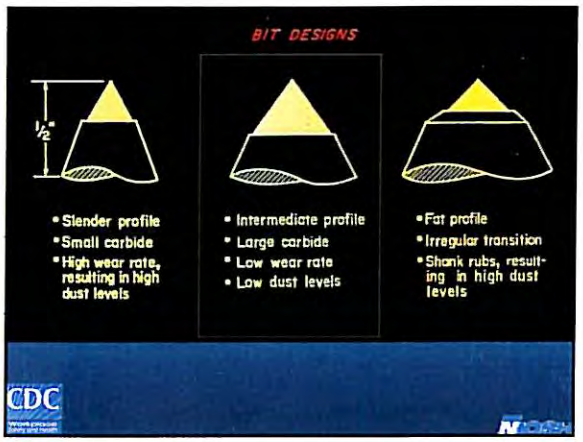
- Reduce frictional ignitions – bit cooling
- Increase bit life
- Reduce respirable dust – increased wetting
- Less water consumption

Exhausting Ventilation
Recommendations

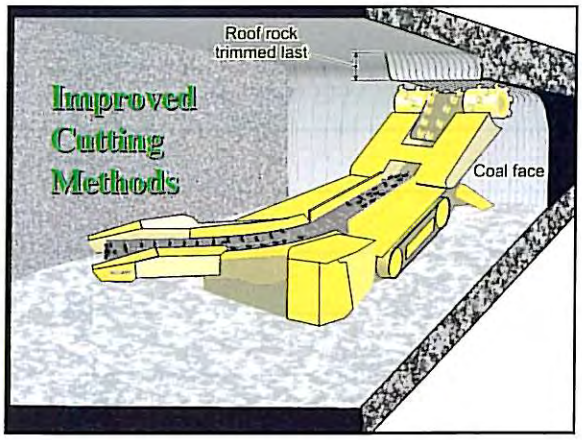
- Operator/helpers remain on intake side of entry
- Line curtain secured firmly to roof and floor
- Mean entry air velocity – 60 fpm minimum
- Curtain setback beyond scrubber discharge
- Shuttle car operator located on off curtain side of entry

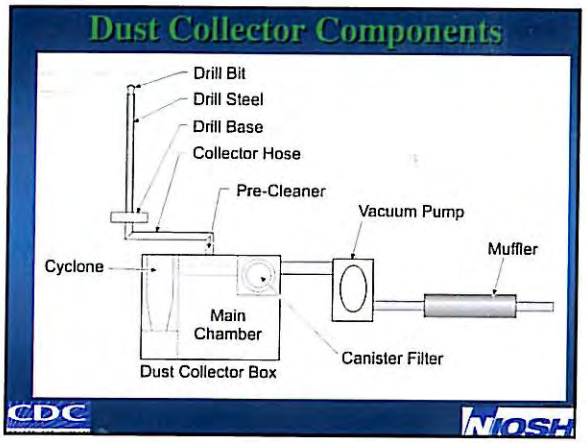
Other Considerations

- Bit design
- Cutting roof rock


BIT DESIGNS
½"
• 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
CDC


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
CDC
NIOSH


Improved Cutting Methods
Roof rock trimmed last
Coal face


Dust Collector Components
Drill Bit
Drill Steel
Drill Base
Collector Hose
Pre-Cleaner
Vacuum Pump
Muffler
Cyclone
Main Chamber
Canister Filter
Dust Collector Box
CDC
NIOSH

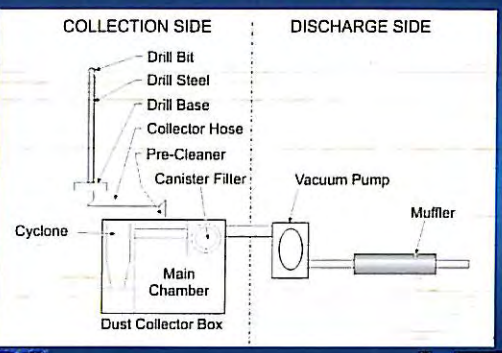

Roof Bolter Dust Control
CDC


Maintenance
• Eliminate Leaks in Vacuum System
• Check door gasket integrity
• Hoses and clamps
• Door latches intact
• Door not bent, seating tight
CDC
NIOSH

Improper Cleaning of Dust Box

- Insufficient air
- Downwind of ventilation
- Too close to source
- Clothes contamination

Dust Collector Components



Filter Removal and Replacement

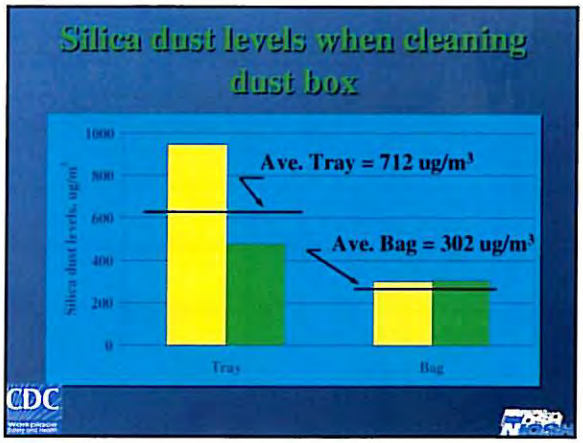
Cleaning the Filter?

Reusable brattice bag controls dust during box cleaning

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

Discharge Contamination

Silica dust levels when cleaning dust box



Disposable Collector Bag

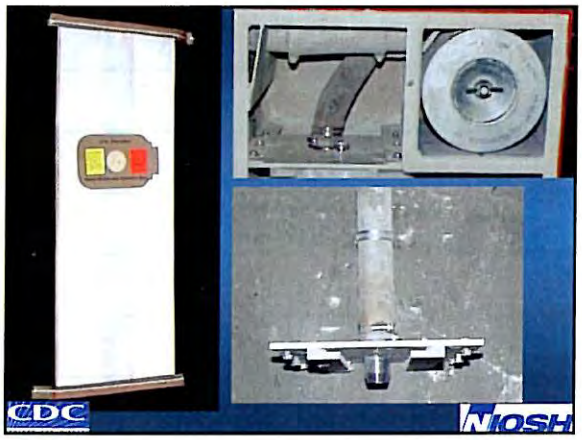
- Manufactured By Wildwood Industries
- Distributed by JH Fletcher for bolters
- Can be retrofitted to most Fletcher dust collectors
- Recommended to be used with pre-cleaner

Collector Box Tests

Before

After

Pittsburgh Research Laboratory



Collector Box Tests With Bag

Before

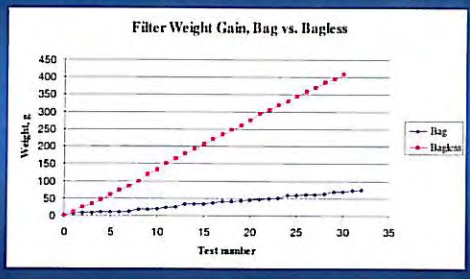
After

Pittsburgh Research Laboratory

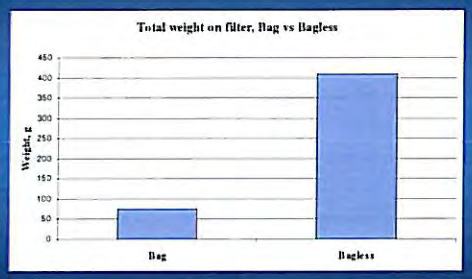
Bolter Bag Lab Study

- 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

Filter Weight Gain per Test



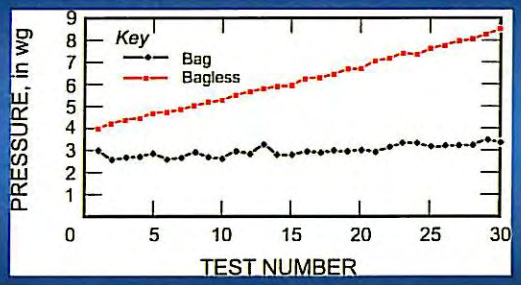
Total Filter Loading



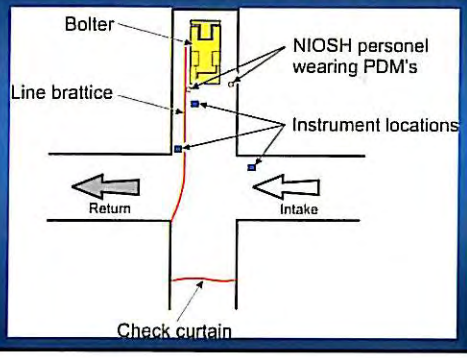
Bolter Bag Field Study

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

Pressure Drop Across Filter



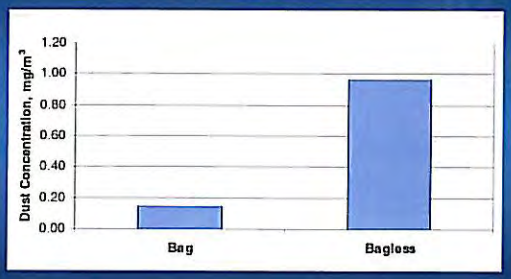
Instrument Locations



Lab Results Summary

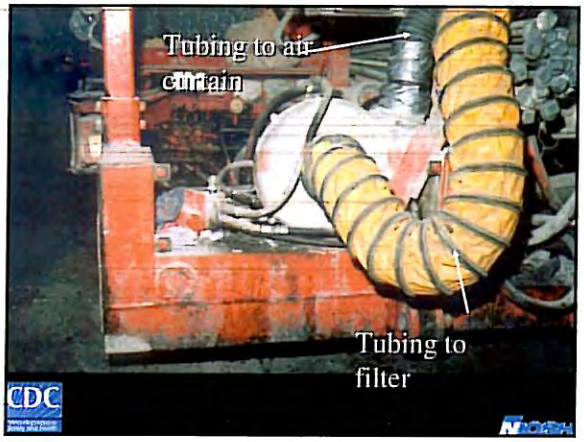
- Avg of 99.6% of feed dust contained in collector bag
- Dust concentration: 2 times higher when bag not installed
- Total dust particle counts of fine dust (< 2 microns) 3 times greater without bag in place
- Canister filter loading greatly reduced with bag in place
- Pressure drop across filter: 3.0 to 3.3 with bag in place, 4.0 to 8.4 without bag

Gravimetric Sample Results, Collector Emissions



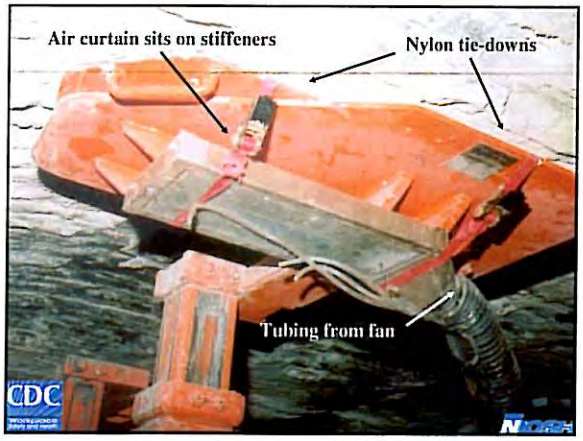
Field Results

- 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.



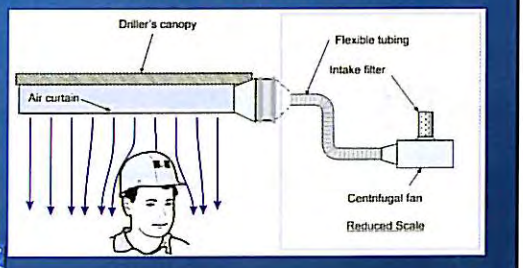
Overall Benefits of Collector Bags

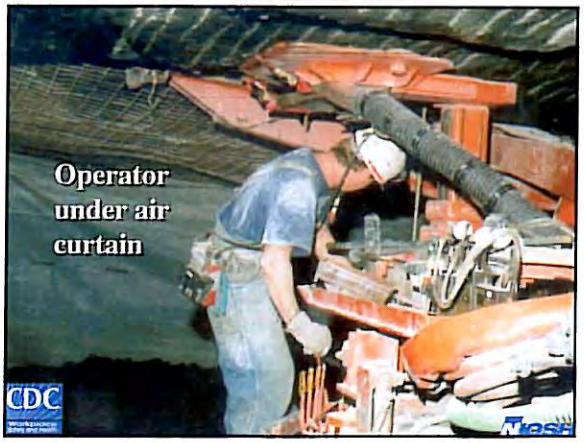
- Keeps dust contained during removal from box
- Keeps dust out of entry traffic preventing further entrainment
- Prolongs filter usage – reduces R/R frequency
- Reduces dust on outby collector components
- Reduces dust emissions from collector exhaust



Canopy Air Curtain

Limits exposures downwind of continuous miner





Findings from field evaluation

- Reduced dust under air curtain
- Must keep operator under air curtain
- Must increase air curtain size (improves protection)

Canopy Air Curtain Study

Results/findings to date

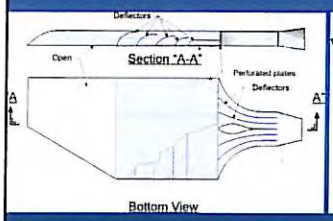
1. Completed CFD analysis
2. Currently being fabricated to include CFD modifications

Air Curtain Development

Original prototype

Current Design

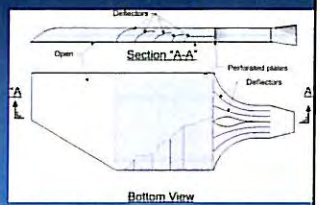
Second Generation Air Curtain Design

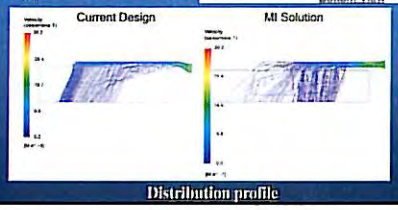


Pittsburgh Research Laboratory

Lab testing prototype

CFD Analysis





Distribution profile

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
CDC
Pittsburgh Research Laboratory
NIOSH

Dust Control at Twentymile Coal Company

Million gallon tanks

Main mine fan

"Water world"

Water supply

Pond A

Pit

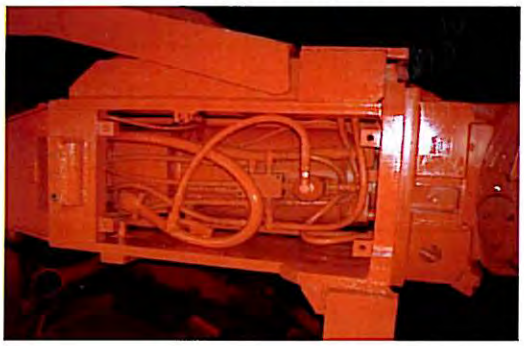
60 hp section pump

Wet head miner

Miner cooling sprays

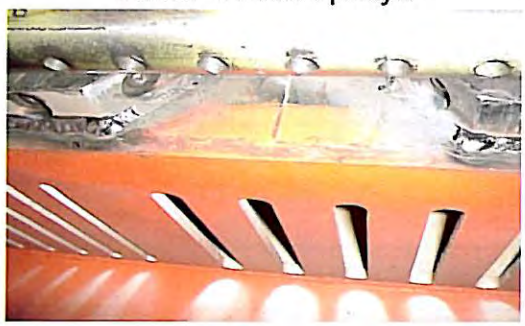
Wet head spray location

Cutter motor compartment



Wet head spray

Miner throat sprays

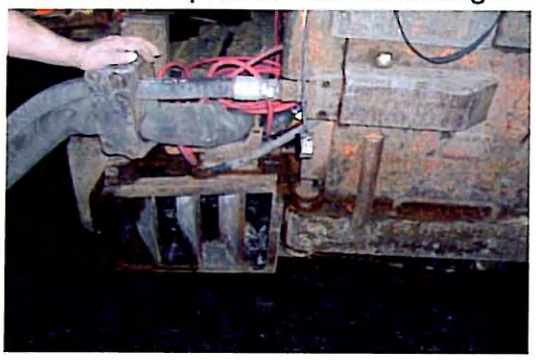


Conveyor belt door

Off-side scrubber gate

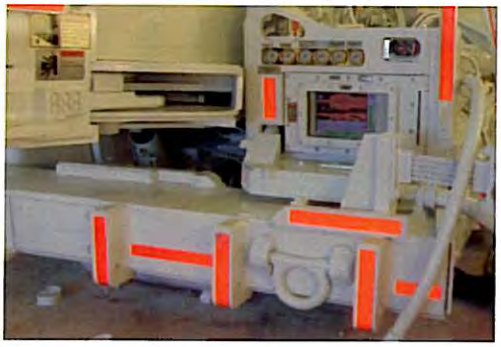
Scrubber sprays

Scrubber operator-side discharge

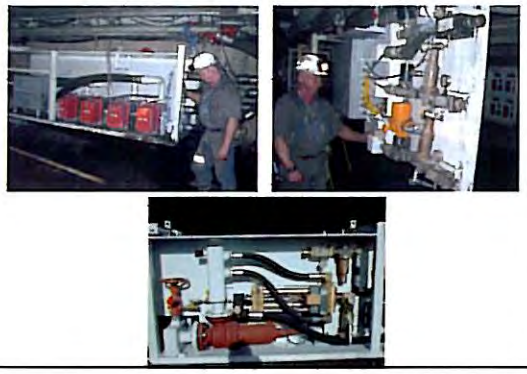


Scrubber off-side air discharge

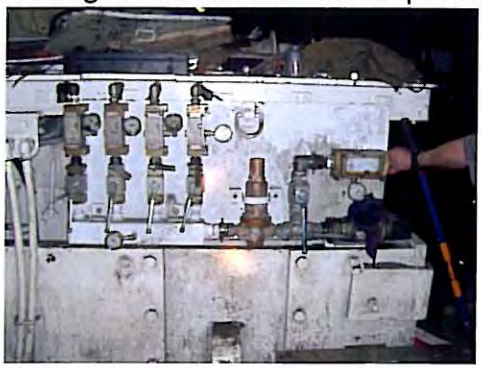
Miner water gauge panel



Longwall motor valve car



Headgate corner flow meter panel

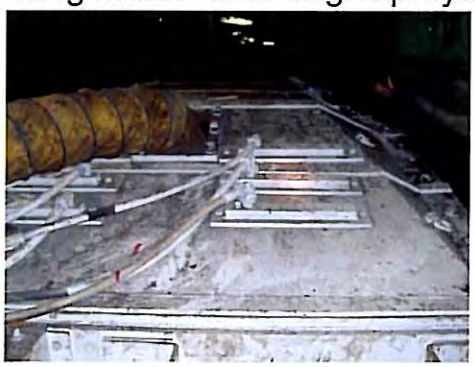


Longwall filter station

Stageloader discharge scrubber

Stageloader discharge flow meter panel

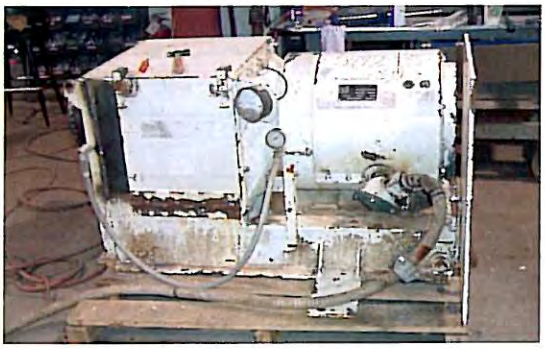
Stageloader discharge sprays



Crusher sprays

Shearer drum sprays

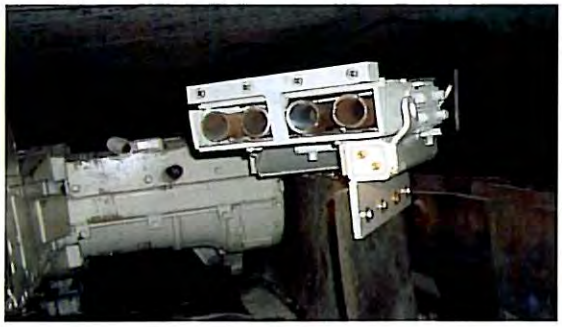
Crusher scrubber



Shearer headgate end spray bar

Plough sprays

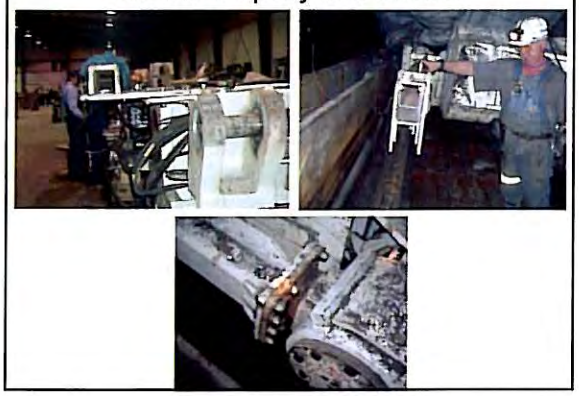
Shearer tailgate end spray bar



Shearer tailgate spray bar

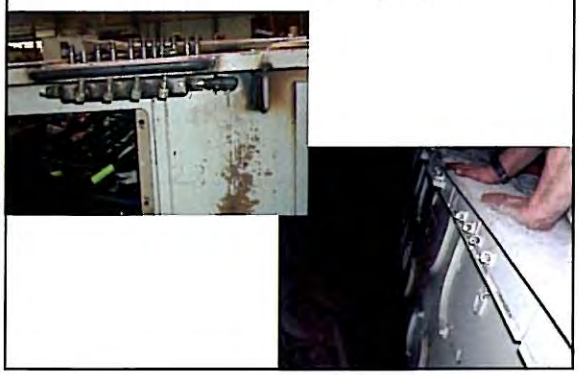
Shield sprays

Shearer spray bar holder



Shield sprays

Shearer-clearer sprays



Shield sprays

Questions?

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(970) 870 – 2738
mdezeeuw@peabodyenergy.com

Real-Time Dust Sampling to Reduce Exposures

Jon C. Volkwein

US / North American Mine Ventilation Symposium Workshop
June 8, 2008

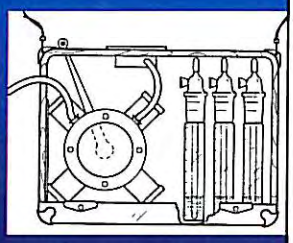
Mining Research Establishment in UK develops first sampler for mining

- Used gravity to size the aerosol
- Used filter to weigh the sized dust
- MRE 113A horizontal elutriator
- Extensive health effects data collected

CDC NIOSH

The beginnings

- 1556 Agricola recognized that dust had harmful effects on humans
- Bureau of Mines in 1911 began to discover that coal mine dust explodes
- And by 1936 BOM had developed a hand held impinger to measure dust
- Counted particles in liquid



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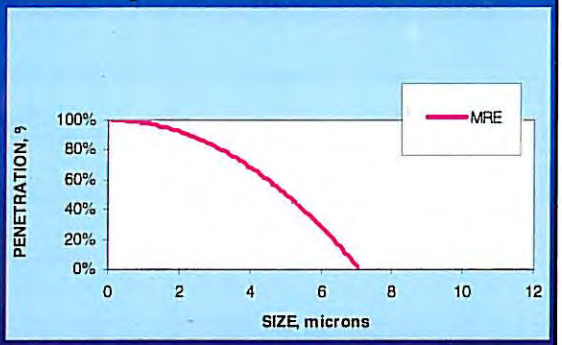
Respirable Dust Definitions



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New insights about dust diseases in early 1960's trigger major change in dust sampling

- Progression of dust diseases correlate with mass of dust
- Dust particles less than about 7 micrometers are the ones that enter inner lung space.
- Lead to samplers that measured mass less than a certain size.

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U. S. develops "personal sampler" for mining use in mid 1960's

- Centrifugal force used to size aerosol
  - Small and light weight
  - Less sensitive to orientation
  - Portable use
- Similar filter mass determination.
- Portable pump
- Incorporated into law

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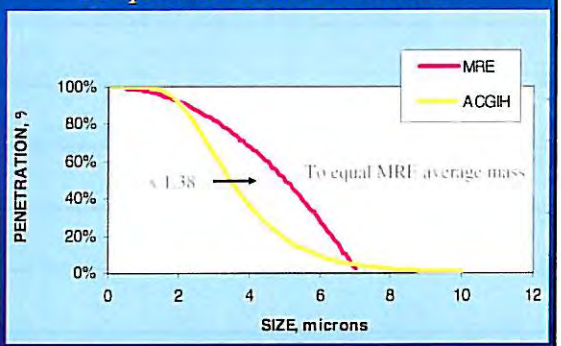
Respirable Dust Definitions



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Mid 1970's Bureau of Mines began development of short term dust monitors.

- Beta-attenuation mass monitor GCA-301
- SRI Light scattering photometer

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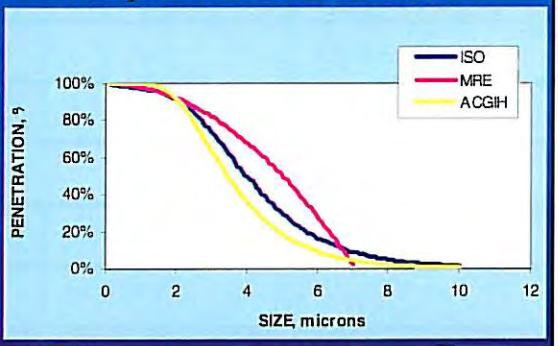
Respirable Dust Definitions



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Mid 1970's Bureau of Mines began development of short term dust monitors.

- Beta-attenuation mass monitor GCA-301
- SRI Light scattering photometer
- Real Time Aerosol Monitor (RAM-1)
- Personal Data Ram

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Advantage of Personal sampling

- Measures dust that worker actually breathes
- Provides incentive to control dust at the worker, and not at some arbitrary location

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Light Scattering Advantages/Disadvantages

- Real time dust concentration data
- Good for engineering measurements when dust is consistent and no water sprays are present.
- May be calibrated to specific dusts
- Response dependent on size of dust
- Response dependent on dust composition
- Responds to water droplets
- Field measurements show poor accuracy and precision.

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Compliance sampling unchanged

Little has changed in the last 30 years.

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New technology permitted portable base for dust sensor

- Miniaturization of sensor now possible
- Enabled placement of sensor on person.
- Benefits of personal sampling

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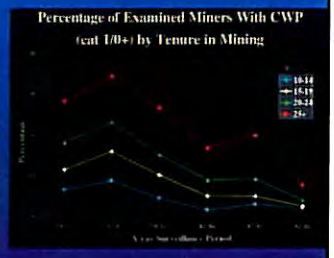
Continued concern reflected in continuing lung disease in miners

- 1969 H&S Act sets 2 mg/m^3
- 30 years later CWP still occurs
- Sec. of Labor urges better monitoring
- NIOSH "…more accurate and reliable measures of worker exposures…" needed



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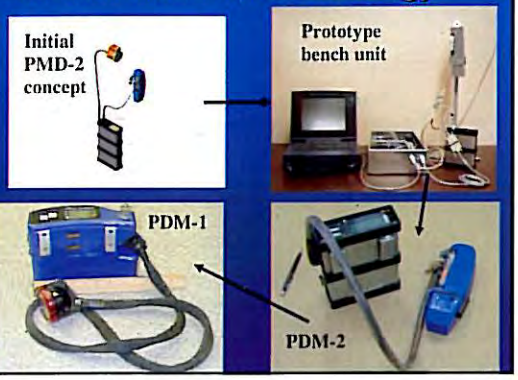
Evolution of PDM Technology



Decision by MSHA and BOM to develop a mass based sensor

- Jointly funded by MSHA and NIOSH
- Initial approach used existing fixed site environmental monitor
- Mount on mining machine much like a methane monitor
- 4 cu ft box weighing 160 lbs.
- Relied on area measurements, no data on personal exposure and not reliable

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PDM Design Goals

- Personal-wearable, make monitor part of the existing miners' cap lamp and battery system
  - Move the dust sample inlet from the lapel to the bill of the hard hat, within the industrial hygiene definition of the breathing zone
  - Sample stream transported through a tube to belt-mounted unit
- Equivalent to or better than the current sampler
- Provide accurate EOS reading
- Compliance with MSHA intrinsic safety requirements for both sampler and cap lamp
- Include cyclone with low bias relative to the MRE and ISO respirable dust convention

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What Does the PDM Do?

- Continuously monitors a worker's personal exposure to respirable dust
- Reports cumulative, current and projected information in numeric and graphic formats
- At the end of the work shift, detailed respirable dust exposure and diagnostic information can be saved and used for further analysis
- The device can be used either as a personal or area monitor, as an engineering tool, or potentially a compliance unit

R&D 100

Description of Monitor

- Belt wearable combination cap lamp and dust monitor
- Weight = 4.9 lb. (Wheat battery alone = 4.4 lb.)
- Measures mass on filter with TE
- Displays on monitor
- Stores data in memory for about a month

Principle of operation

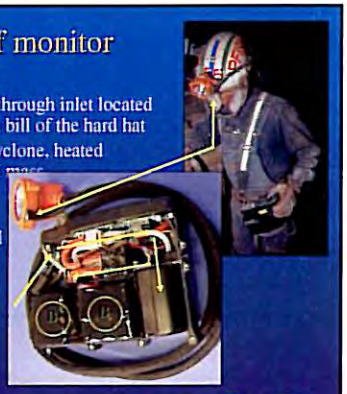
- Gravimetric-equivalent mass measurement
- Exchangeable filter cartridge mounted on the end of the tapered element collects particles as sample stream flows through hollow tube
- Tapered element always oscillates at its harmonic frequency -- like a tuning fork
- Frequency changes in *direct* relation to the mass collected on the filter
- Measurement principle does *not* respond to other particle characteristics such as optical properties, composition or size distribution

Evaluation methods

- Laboratory testing May 2003
  - Compare PDM mass to reference - accuracy criteria
  - Determine bias of cyclones to respirable definitions
  - Test water resistance, temperature, data displays, etc.
- In-mine testing Summer 2003
  - Durability / Wearability
  - Comparison to reference sampler
  - Determine bias of cyclones in mines
- Report published as NIOSH RI **9663** and http://www.cdc.gov/niosh/mining/ - Mining Spotlights

Description of monitor

- Sample enters system through inlet located beside the cap lamp on bill of the hard hat
- Next: HD respirable cyclone, heated internal tubing, TEOM mass sensor, and computer-controlled pump
- Two separate, identical batteries for cap lamp and dust monitor
- Weight of 2.3 kg including umbilical and cap lamp



Summary of Results

- Mass measurement by PDM meets NIOSH accuracy criteria – for an individual observation, the PDM method gives a result that is within +/- 25% with a probability of 0.95
- And, the individual result falls within an upper or lower confidence limit of 95%
- The bias of the HD cyclone is less than the DO cyclone
- Therefore, PDM-1 is equal to or better than existing method.
- In-mine results show that instruments are interchangeable.

How can real-time technology help control dust?

- Provides direct data
- Provides timely data
- Minimize propogation of error in dust reduction calculation
- Can isolate sources to improve accuracy
- Ability to replicate results adds confidence to interpretation of results

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Screen Display

- Average concentration for last 30 minutes
- Average concentration to the present time
- Projected exposure – final EOS exposure if no additional dust exposure

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Methods for This Work

- Results from mine used
- Combined with observations
- Used existing data
- Highlighted engineering applications
- Used display data while UG, and illustrated with stored data

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Bar graph of day

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Mine Testing - Guests

- No reference samplers worn
- Purpose was to allow interested parties opportunity to experience unit
- Limited experimentation with features

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Methods of Evaluation

- Normal A-B-A type of observation -- the A period is without control, and the B period is with a control
- PDM A-B-A method -- the A period is normal conditions and the B period is the detection of a control system out of adjustment
- Isolation of source and Upstream/Downstream measurements

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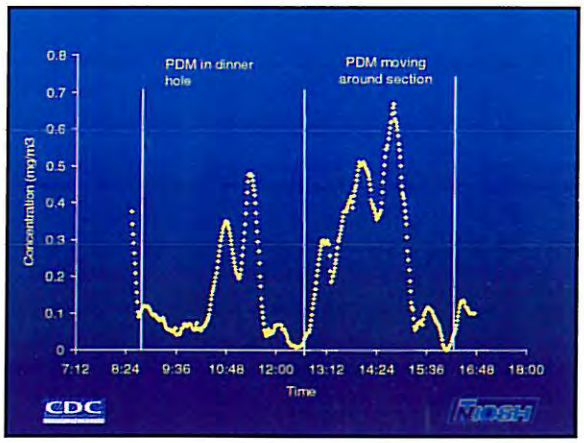
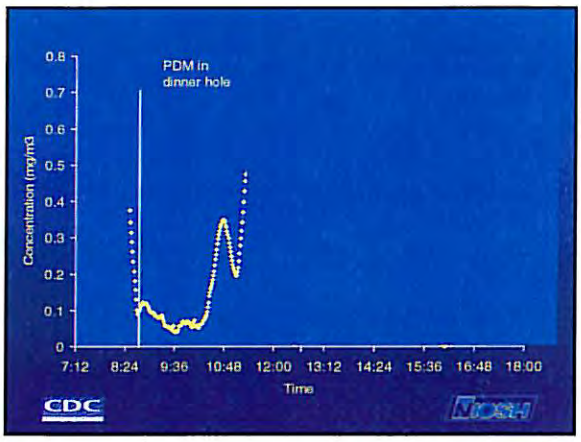
Discovery of a Leaking Curtain

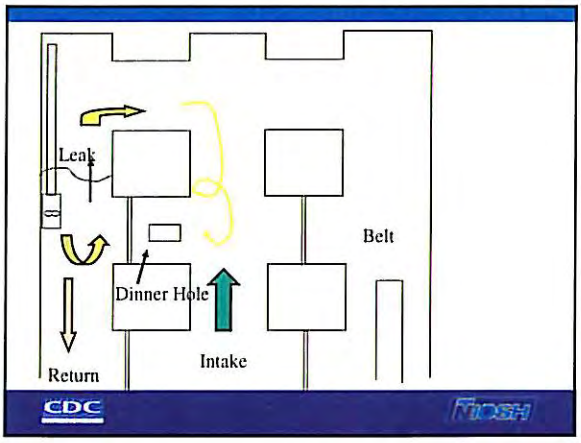
- PDM worn by a guest in the dinner hole
- Observed an increase in the dust levels while talking in the intake.
- Located source

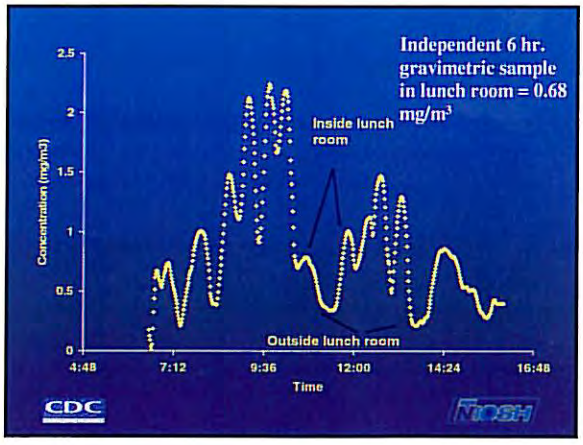


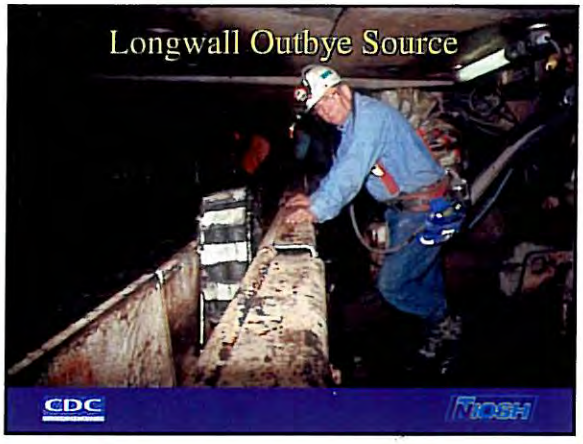


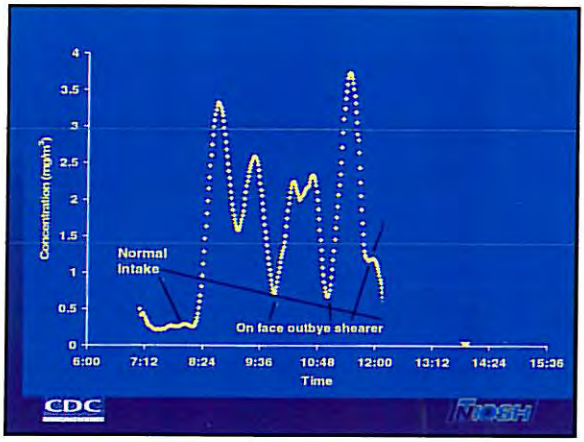
Another Dinner Hole Observation

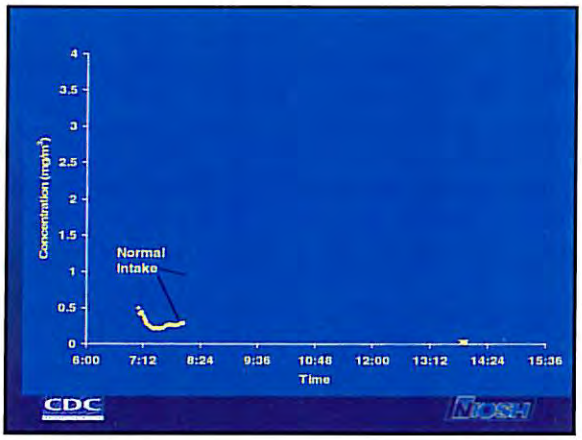
- Enclosed steel skid mounted shelter
- Cold mine
- Heated with infrared electric heater
- Noted high levels in room

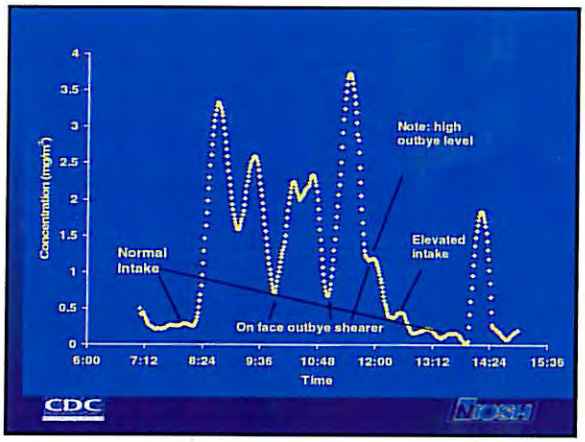


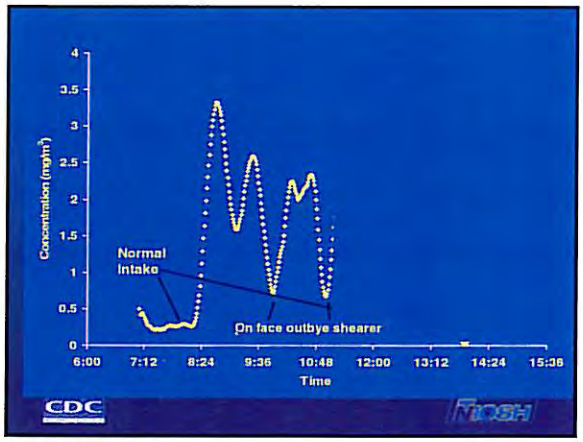






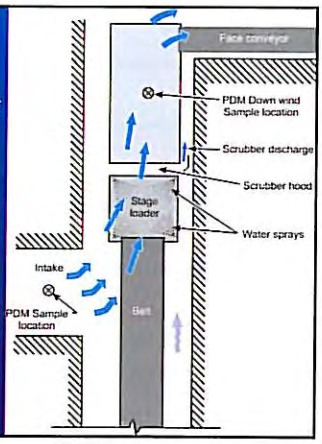






Stage Loader Evaluation

- Compare effectiveness of existing sprays to new low water use scrubber
- Use 2 PDM's in upstream/downstream comparison
- Use display and secondary data mode
- Time synchronize during normal production



Stage Loader Results

Test Description	Upstream Conc. (mg/m3)	Downstream Conc. (mg/m3)	Down – Up Conc. (mg/m3)
Scrubber with water	0.0697	0.3666	0.297
Scrubber with no water	0.0832	0.3212	0.238
Water only	0.0753	0.5288	0.453

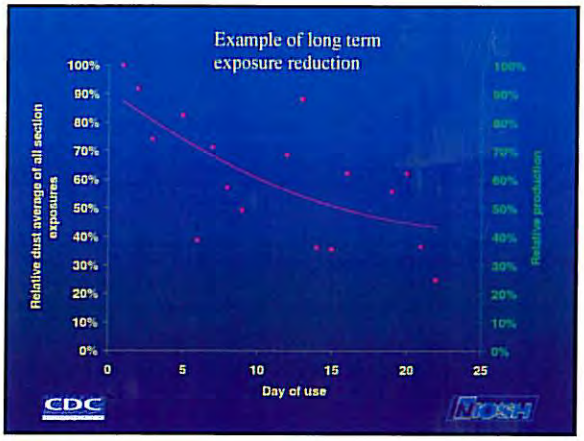
EVALUATION

Did miners use their PDM to evaluate interventions?

- In 12 cases, miner reported looking at his PDM to see the effect of the change.
- What did he see?
  - In 8 cases, the numbers went down
  - In 1 case, the numbers stopped rising
  - In 3 cases, no difference

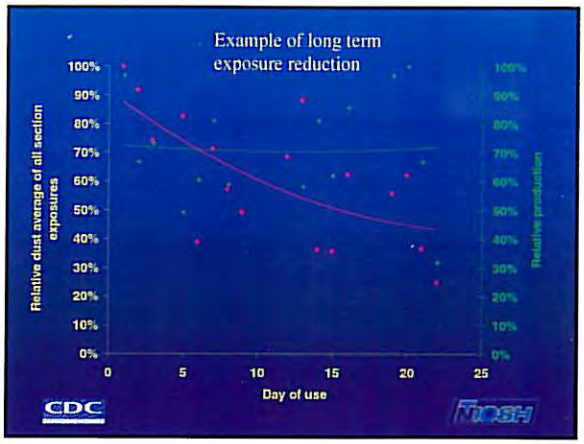
Stage Loader Evaluation Conclusion

- Test was preliminary in nature
- Conclude that scrubber was at least as effective as system currently approved and in use
- Be careful with short term evaluations



Miners Response to PDM Project Objective

Document how miners use real-time PDM information to reduce exposure to respirable dust



Take home

- PDM useful to diagnose dust sources
- Quick evaluation of dust sources
- Discovery of unexpected particulate sources
- Knowing exposure levels can result in lower overall concentrations

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