CPWR

THE CENTER FOR CONSTRUCTION
RESEARCH AND TRAINING

Protecting Workers in Enclosed Cabs from Silica Exposure: Leveraging Research from the Mining Industry

October 18, 2017

Respirable Crystalline Silica Standards

- Published March 25, 2016
- Effective dates:
  - Construction – Sept 23, 2017
  - General Industry – June 23, 2018

1926.1153 Respirable Crystalline Silica - Construction

(a) Scope
(b) Definitions
(c) Specified exposure control methods (Table 1) - OR -
(d) Alternative exposure control methods (PEL)
e) Respiratory protection
(f) Housekeeping
(g) Written exposure control plan
(h) Medical surveillance
(i) Communication of silica hazards
(j) Recordkeeping
(k) Dates

1926.1153 Respirable Crystalline Silica

(c) Specified exposure control methods.
(1) For each employee engaged in a task identified on **Table 1**, the employer shall fully and properly implement the engineering controls, work practices, and respiratory protection specified for the task on Table 1, unless the employer assesses and limits the exposure of the employee to respirable crystalline silica in accordance with paragraph (d) of this section.

Specified Exposure Control Methods

- **Table 1** in the construction standard matches 18 tasks with effective dust control methods and, in some cases, respirator requirements.
- Employers that fully and properly implement controls on Table 1 do not have to:
  - Conduct exposure assessments for employees engaged in those tasks
  - Comply with the PEL

List of Table 1 Entries

- Stationary masonry saws
- Handheld power saws
- Handheld power saws for fiber cement board
- Walk-behind saws
- Drivable saws
- Rig-mounted core saws or drills
- Handheld and stand-mounted drills
- Dowel drilling rigs for concrete
- **Vehicle-mounted drilling rigs for rock and concrete**
- Jackhammers and handheld powered chipping tools
- Handheld grinders for mortar removal (i.e. tuckpointing)
- Handheld grinders for other than mortar removal
- Walk-behind milling machines and floor grinders
- Small drivable milling machines
- Large drivable milling machines
- **Crushing machines**
- **Heavy equipment and utility vehicles to abrade or fracture silica materials**
- **Heavy equipment and utility vehicles for grading and excavating**

Heavy Equipment used for Demolition

Heavy Equipment used to demolish, fracture or abrading silica containing materials

TABLE 1: SPECIFIED EXPOSURE CONTROL METHODS WHEN WORKING WITH MATERIALS CONTAINING CRYSTALLINE SILICA			
Equipment / Task	Engineering and Work Practice Control Methods	Required Respiratory Protection and Minimum Assigned Protection Factor (APF)	
		≤ 4 hours /shift	> 4 hours /shift
(xvii) Heavy equipment and utility vehicles used to abrade or fracture silica-containing materials (e.g., hoe-ramming, rock ripping) or used during demolition activities involving silica-containing materials	Operate equipment from within an enclosed cab.	None	None
	When employees outside of the cab are engaged in the task, apply water and/or dust suppressants as necessary to minimize dust emissions.	None	None

Heavy Equipment used for Earthmoving

Heavy Equipment used for earthmoving tasks such as grading and excavating, but not demolition

TABLE 1: SPECIFIED EXPOSURE CONTROL METHODS WHEN WORKING WITH MATERIALS CONTAINING CRYSTALLINE SILICA			
Equipment / Task	Engineering and Work Practice Control Methods	Required Respiratory Protection and Minimum Assigned Protection Factor (APF)	
		≤ 4 hours /shift	> 4 hours /shift
(xviii) Heavy equipment and utility vehicles for tasks such as grading and excavating but not including: demolishing, abrading, or fracturing silica-containing materials	Apply water and/or dust suppressants as necessary to minimize dust emissions. - OR - When the equipment operator is the only employee engaged in the task, operate equipment from within an enclosed cab.	None None	None None

Specifications for Enclosed Cabs

(c)(2)(iii) For measures implemented that include an enclosed cab or booth, ensure that the enclosed cab or booth:

(A) Is maintained as free as practicable from settled dust;

(B) Has door seals and closing mechanisms that work properly;

(C) Has gaskets and seals that are in good condition and working properly;

(D) Is under positive pressure maintained through continuous delivery of fresh air;

(E) Has intake air that is filtered through a filter that is 95% efficient in the 0.3-10.0 μm range (e.g., MERV-16 or better); and

(F) Has heating and cooling capabilities.

Written Exposure Control Plan

Intended to help employers consistently control exposures by describing tasks resulting in exposure and controls for those exposures, as well as housekeeping measures.

Must include a description of:

- All tasks with silica exposure; and
- The controls used to reduce exposures.

Must also include the procedures for

- Frequent and regular inspections of the cabs; and
- Maintaining and cleaning the cab.

Mining Research – Benefits for Construction

Filtration and Pressurization Systems for Enclosed Cabs and Environmental Enclosures

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Dust, Ventilation, and Toxic Substances Branch, Pittsburgh Mining Research Division, NIOSH, CDC

The Centers for Construction Research and Training:
Webinar – October 18, 2017

Presentation Outline

Filtration and Pressurization Research

- Background
- Field Studies
- Key Components
- MERV16 vs HEPA
- Application to Control Rooms/Operator Booths
- Pressure Monitoring System to Optimize Performance

Research Goal

Optimizing filtering and pressurization efficiency to minimize respirable (silica) dust exposure and provide maximum air quality in enclosed cabs, operator booths, and control rooms.

NIOSH's Research

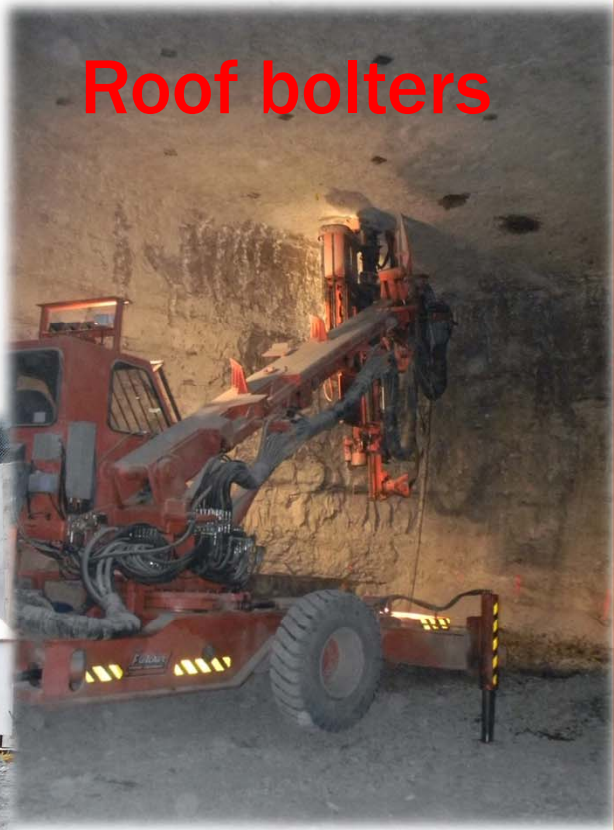
Drills

Underground Mining

Drills

Scalers

Roof bolters



What Level of Improvement is Achieved with a Filtration System?

Relative Performance Measures

Protection Factor; Efficiency; Penetration

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

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

Comparison of Cab Performance Measures

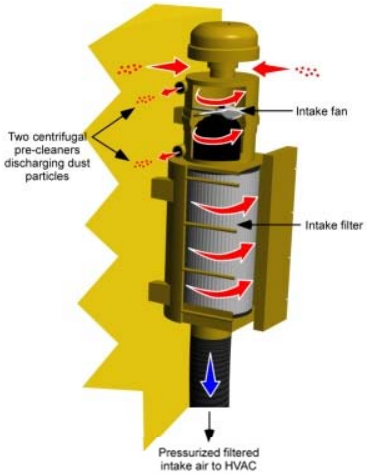
Protection Factor	Efficiency, Pct.	Penetration, Pct.
2	50	50
5	80	20
10	90	10
100	99	1
1000	99.9	0.1

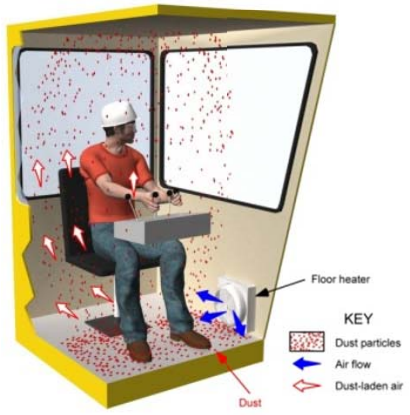
Field Studies: Cooperative Efforts with Cab Filtration Manufacturers, OEMs, Mining Companies, & Government Agencies

Results from Field Studies

Cab Evaluation	Mining Type	New vs. Retrofit	Cab Pressure, inches w.g.	Average Inside Cab Dust Level, mg/m^3	Average Outside Cab Dust Level, mg/m^3	Protection Factor
Rotary Drill	Surface	Retrofit	None Detected	0.08	0.22	2.8
Haul Truck	Underground	Retrofit	0.01	0.32	1.01	3.2
Roof-bolter	Underground	New	0.05 - 0.10	0.12	0.92	8
Front-end Loader	Surface	Retrofit	0.015	0.03	0.30	10
Face Drill	Underground	New	0.05 - 0.20	0.19	2.43	28
Rotary Drill	Surface	Retrofit	0.20 - 0.40	0.05	2.80	56
Rotary Drill	Surface	Retrofit	0.07 – 0.12	0.70	6.125	89.3

Key Components for Effective Cab Filtration and Pressurization Systems



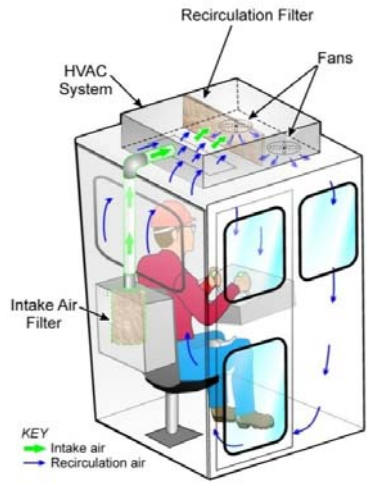


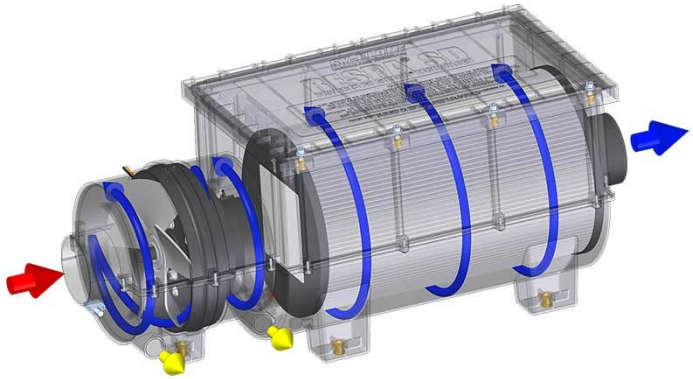
Effective Filtration

1. Pressurized Intake
2. Recirculated Cab Air

Pressurized Intake(Outside) Air

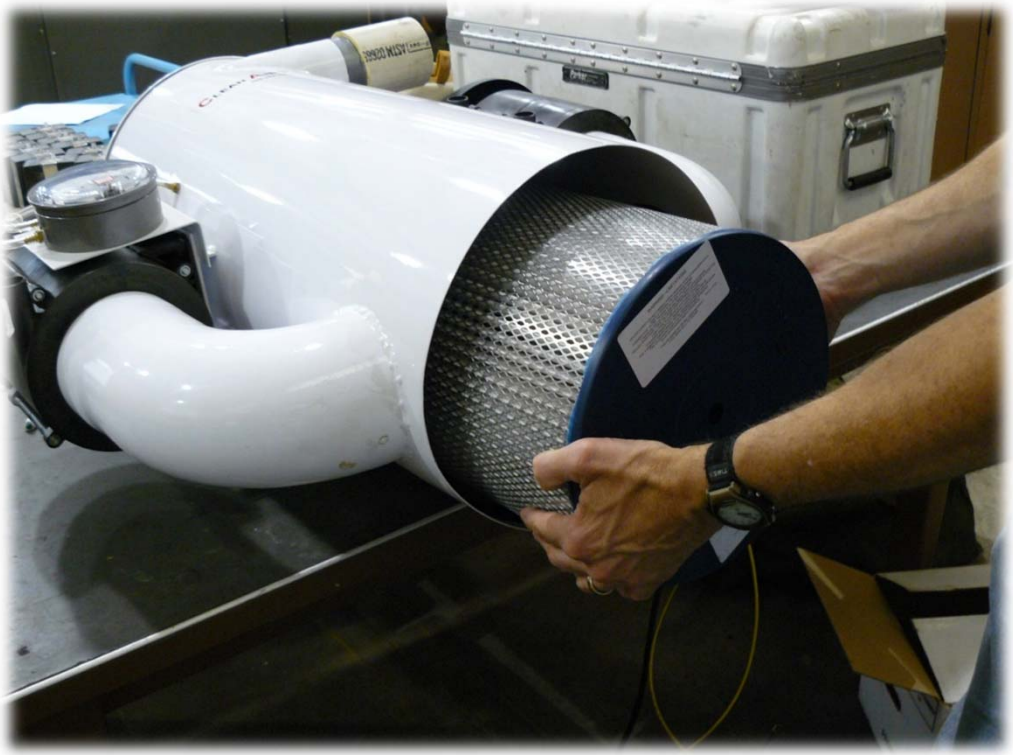
- 40 – 140 cfm
- At least 25 cfm dilute CO_2 exhaled per worker
- MERV-16 mechanical filter
- Powered Unit : Self-cleaning or centrifugal design





Intake Air: 40 – 140 cfm

Cab Positive Pressure (Reasonable Range): 0.08 to 0.25 inches wg

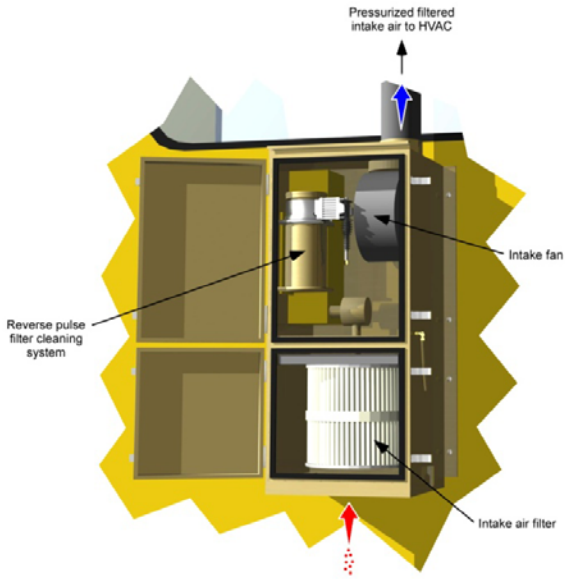


25 cfm Intake/Outside Air to Dilute CO_2 Exhaled by Each Worker

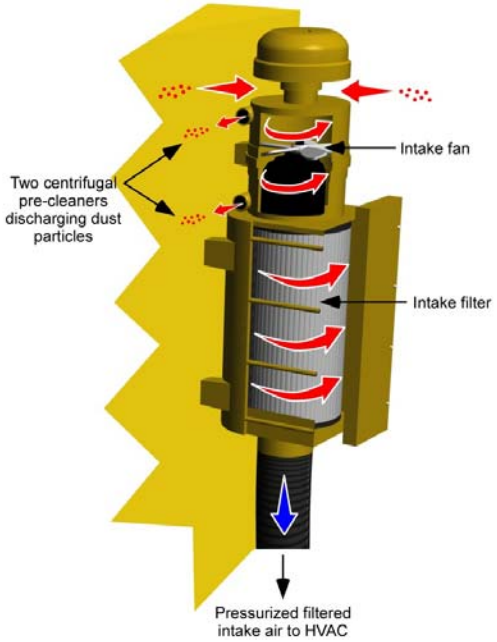
ASABE 2003 – Agricultural Cabs – Engineering Controls of Environment Air Quality, Part 1: Definitions, Test Methods, and Safety Practices [Standard 5525-1.1]: American Society of Agricultural and Biological Engineers.

Powered Unit : Self-cleaning or Centrifugal Design

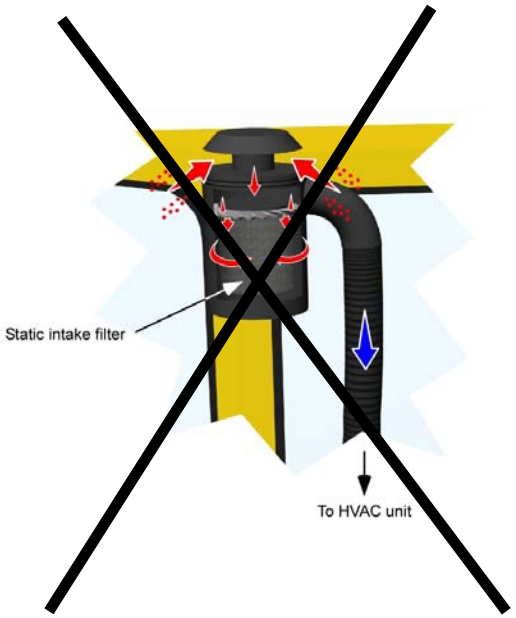
Self-cleaning



Centrifugal

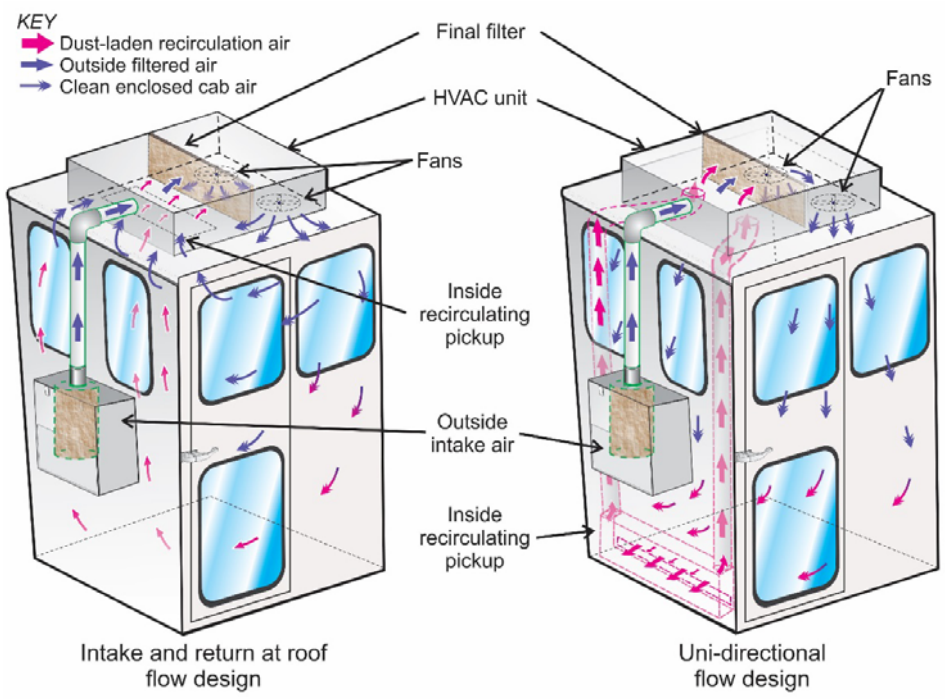


Static



Recirculated Cab Air

- Effectiveness is by multiple passes through filter media
- Substantial reduction in cleaning time from in-cab dust sources
- MERV 14 -16 rated filter media
- 3-4 times the intake airflow quantity (200-300 cfm typical)



Cab Integrity

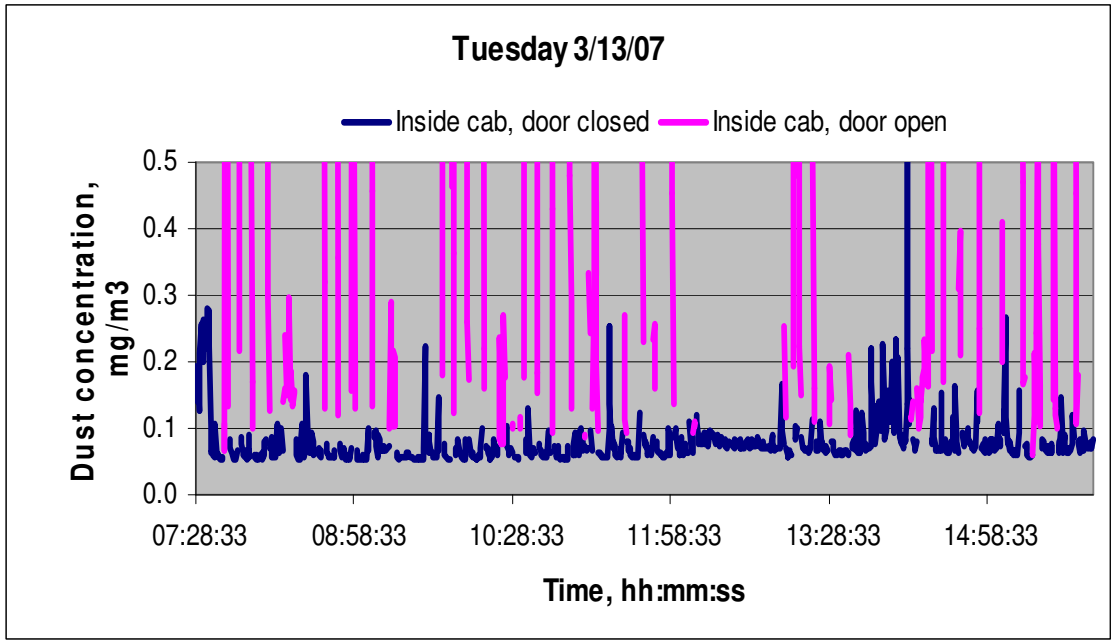
Installing new doors gaskets and seals/plugging and sealing cracks and holes

Secondary Design Considerations

Intake air inlet location

Locate intake inlet air away from major dust sources to minimize dust loading and require filter cleanings and changes

Keep Doors and Windows Closed



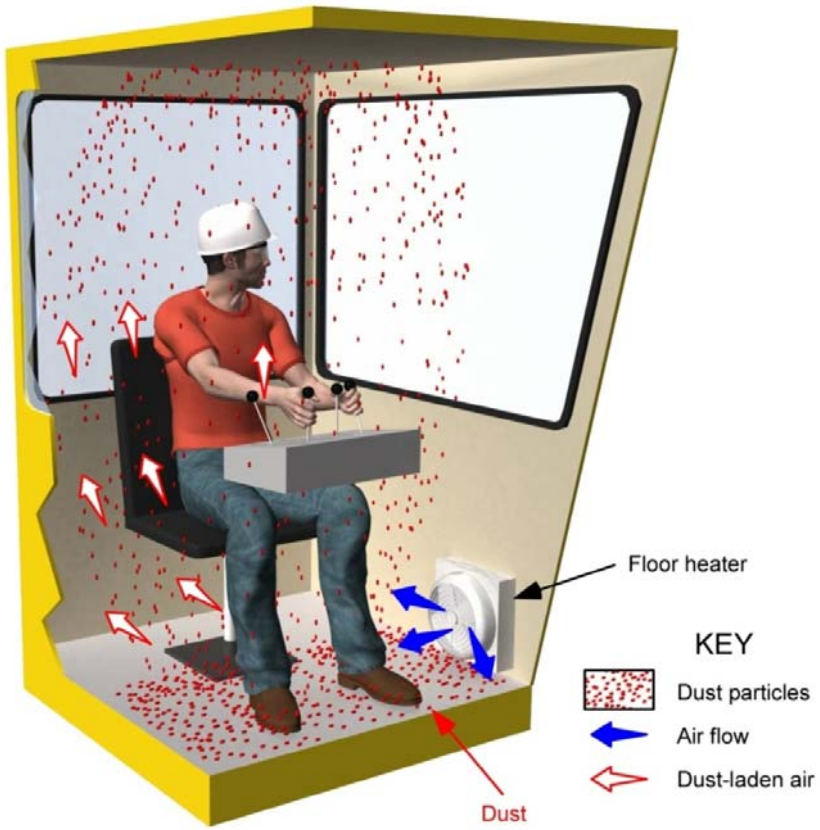
Drill Operator: (adding drill steels – 3 days)

Door closed: 0.09 mg/m^3

Door open: 0.81 mg/m^3

Removing In-cab Dust Sources

Floor Heaters



Ease of Filter Changes

Recommend MERV-16 Mechanical Filters

Pressure Drop and Loading Efficiency

MERV Rating Efficiency

Minimum efficiency reporting values (MERV) according to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)				
Group	MERV Rating	Average particle size efficiency (PSE) 0.3–1.0 microns	Average particle size efficiency (PSE) 1.0–3.0 microns	Average particle size efficiency (PSE) 3.0–10.0 microns
1	1			< 20%
	2			< 20%
	3			< 20%
	4			< 20%
2	5			20–34.9%
	6			35–49.9%
	7			50–69.9%
	8			70–84.9%
3	9		< 50%	≥ 85%
	10		50–64.9%	≥ 85%
	11		65–79.9%	≥ 85%
	12		80–89.9%	≥ 90%
4	13	< 75%	≥ 90%	≥ 90%
	14	75–84.9%	≥ 90%	≥ 90%
	15	85–94.9%	≥ 90%	≥ 90%
	16	≥ 95%	≥ 95%	≥ 95%
HEPA		≥99.97%	≥99.97%	≥99.97%

Testing

MERV16 Testing – May thru November 2013
HEPA Testing – May thru November 2014

Static Test Mode

Mobile equipment was running without anyone in the enclosed cab to stir up or create any in-cab dust sources. Provides the highest PF for each of the enclosed cabs.

Equipment Outside Mine

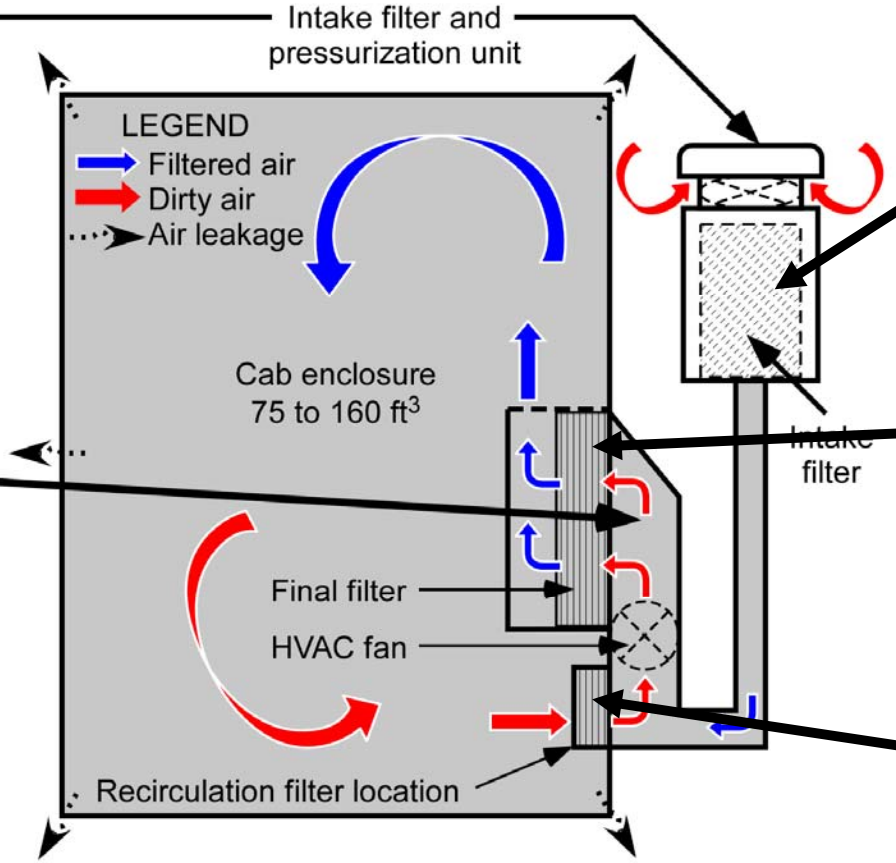
Note: HVAC Fan Operated on "High" Setting

Outside Cab

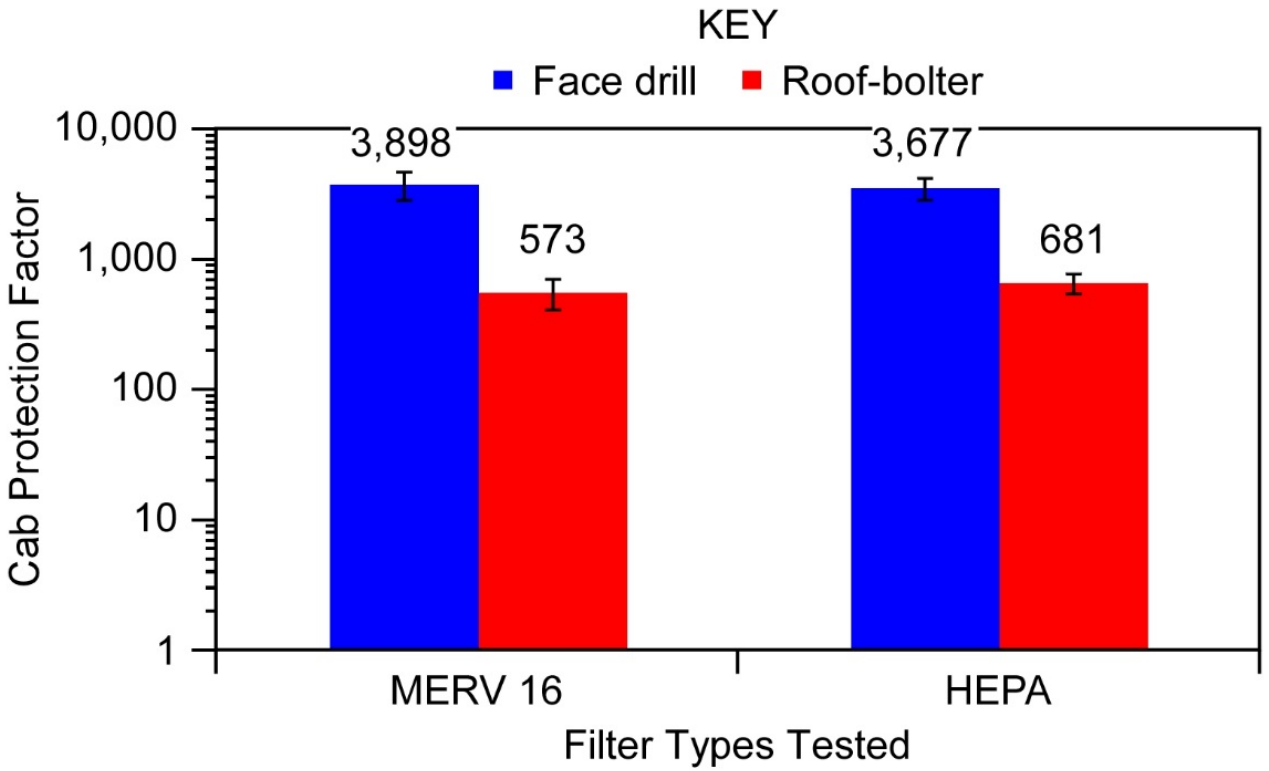
Inside Cab

Particle Count Instruments

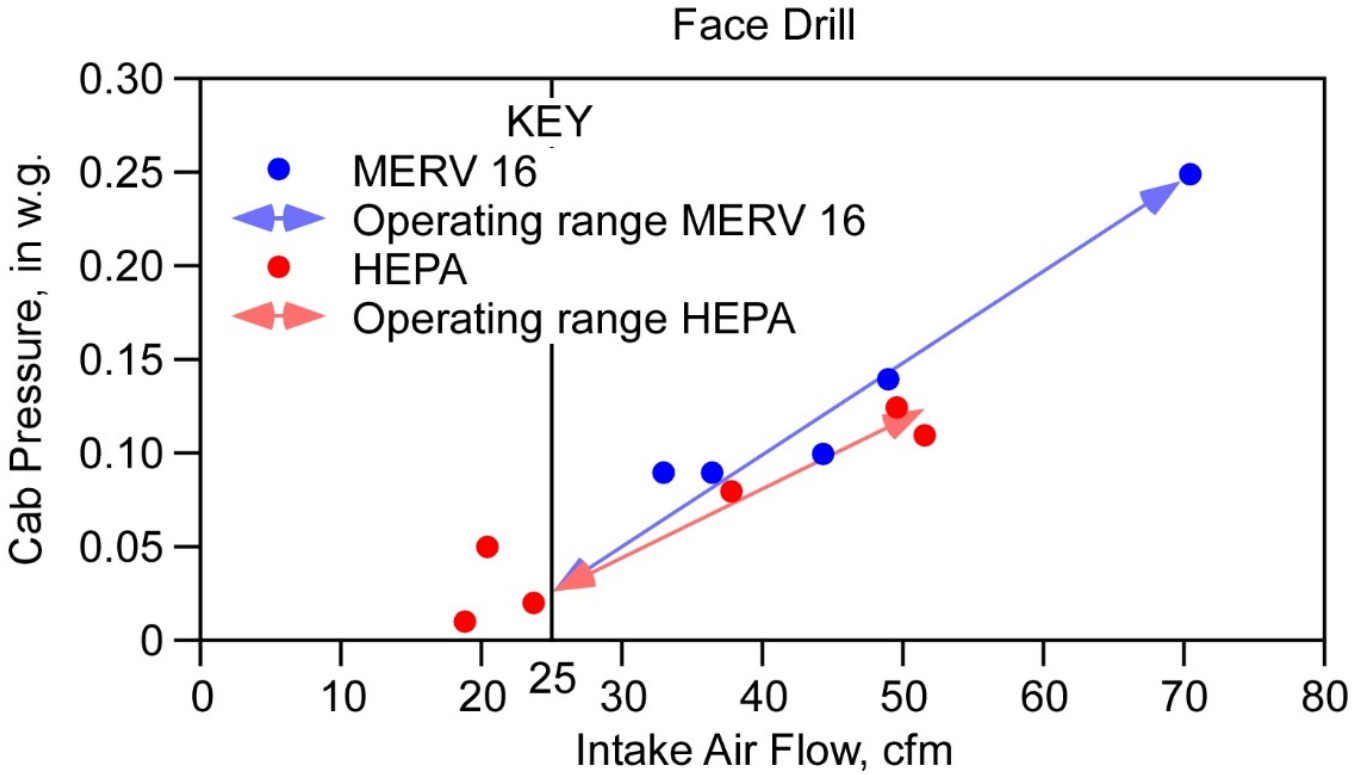
Filtration and Pressurization Design



Average PF Comparing MERV 16 and HEPA Filters



Comparing Intake Airflow and Positive Cab Pressure on Face Drill



Taking Information and Knowledge from Enclosed Cabs and Apply it to Operator Booths and Control Rooms

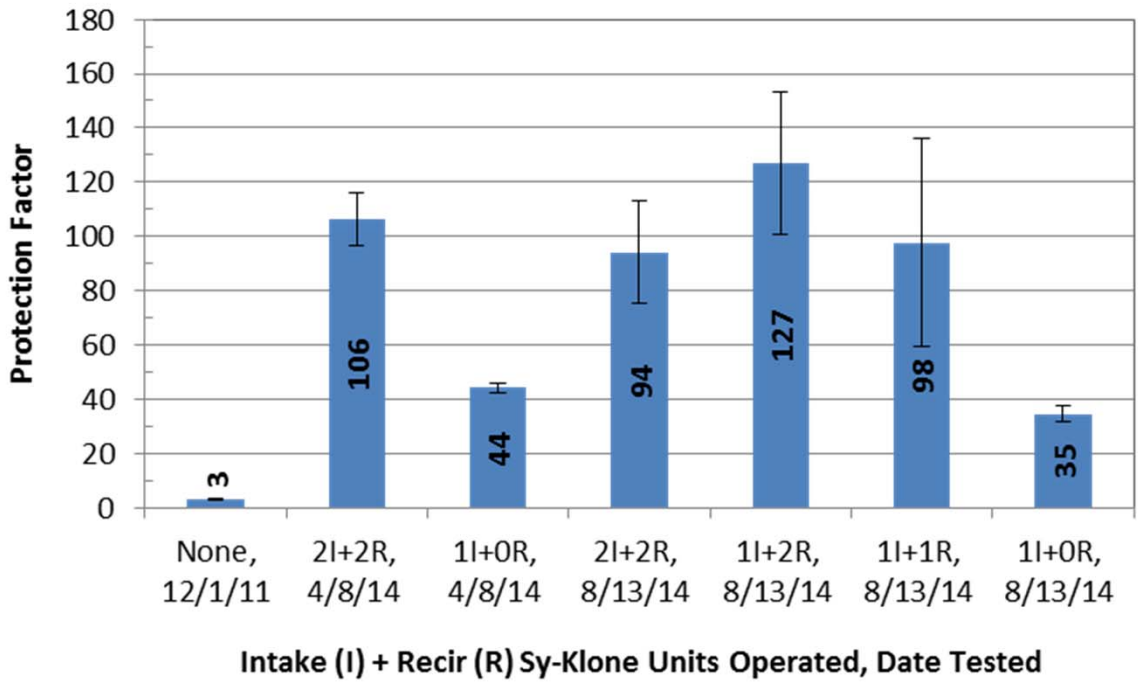
Crusher Operator Booth – surface (Wisconsin)

Control Room - surface facility (New Jersey)

Crusher Operator Booth – underground (Pennsylvania)

Filtration and Pressurization System at Crusher Operator Booth

Installation of Polar Mobility Unit



Protection Factors: 35 - 127

Retrofit Filtration and Pressurization System at Control Room at Industrial Minerals Processing Facility

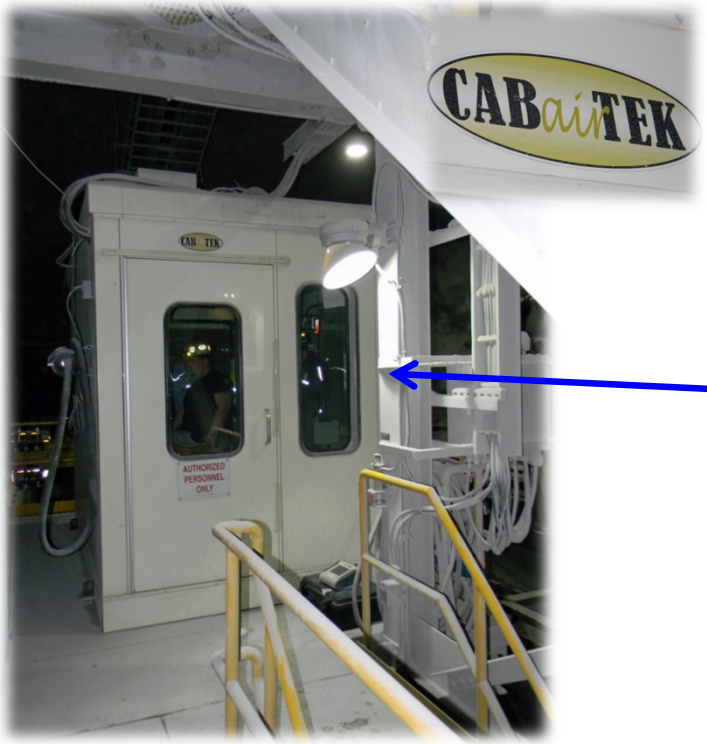
RESULTS:

Table 1 : Efficiency and Protection Factor of the Control Room via Particle Counting

Sample	Description	Efficiency (%)	Protection Factor
Baseline	no filtration pressurization unit	-36±29	0.79±0.17
Post 1	the first two days of operating the filtration pressurization unit	87±4	8±3
Post 2	one year after installation of filtration pressurization unit	94±4	25±15

Protection Factors: 8 - 25

Retrofit Filtration and Pressurization System at Primary Crusher Operator Booth – Limestone Mine



Primary Crusher Operator's Booth

Original System Effectiveness

Fan On: 6560 µg/m^3

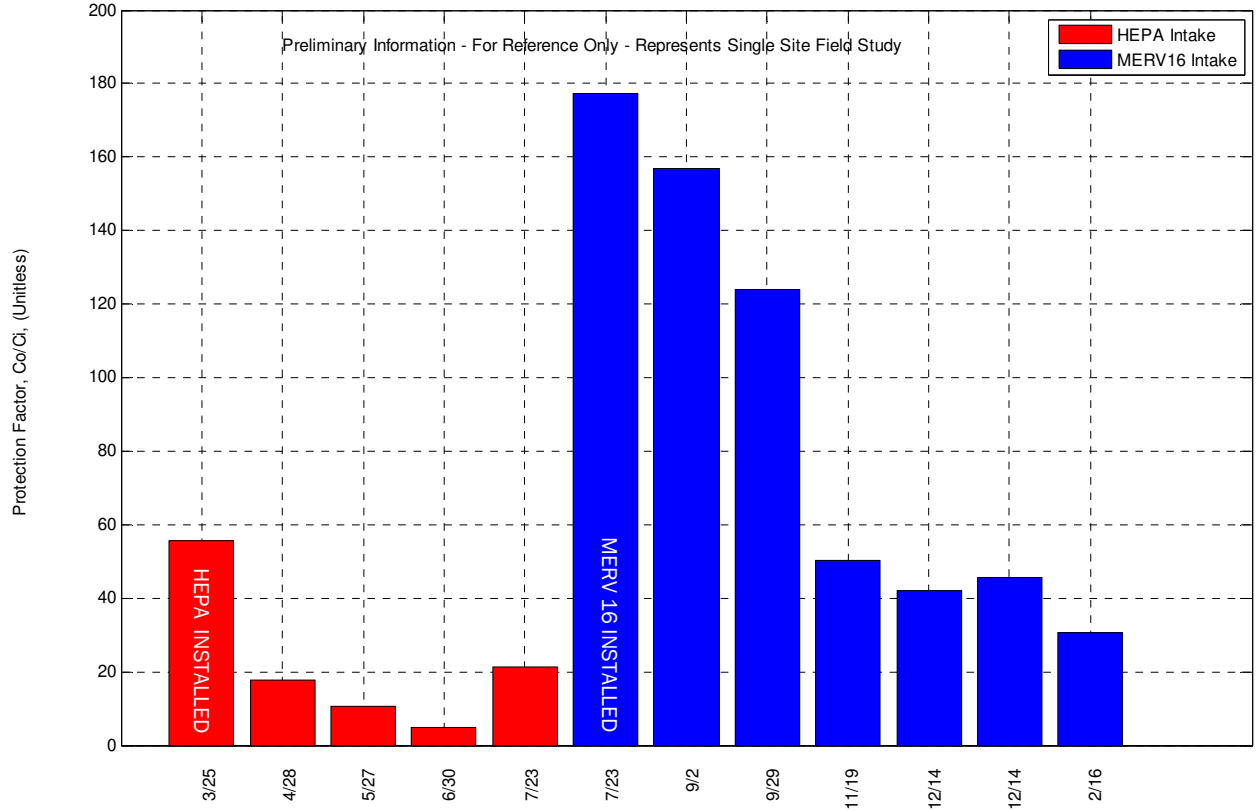
Fan Off: 530 µg/m^3

Crusher Booth: System Upgrade

RECIRCULATION

INTAKE

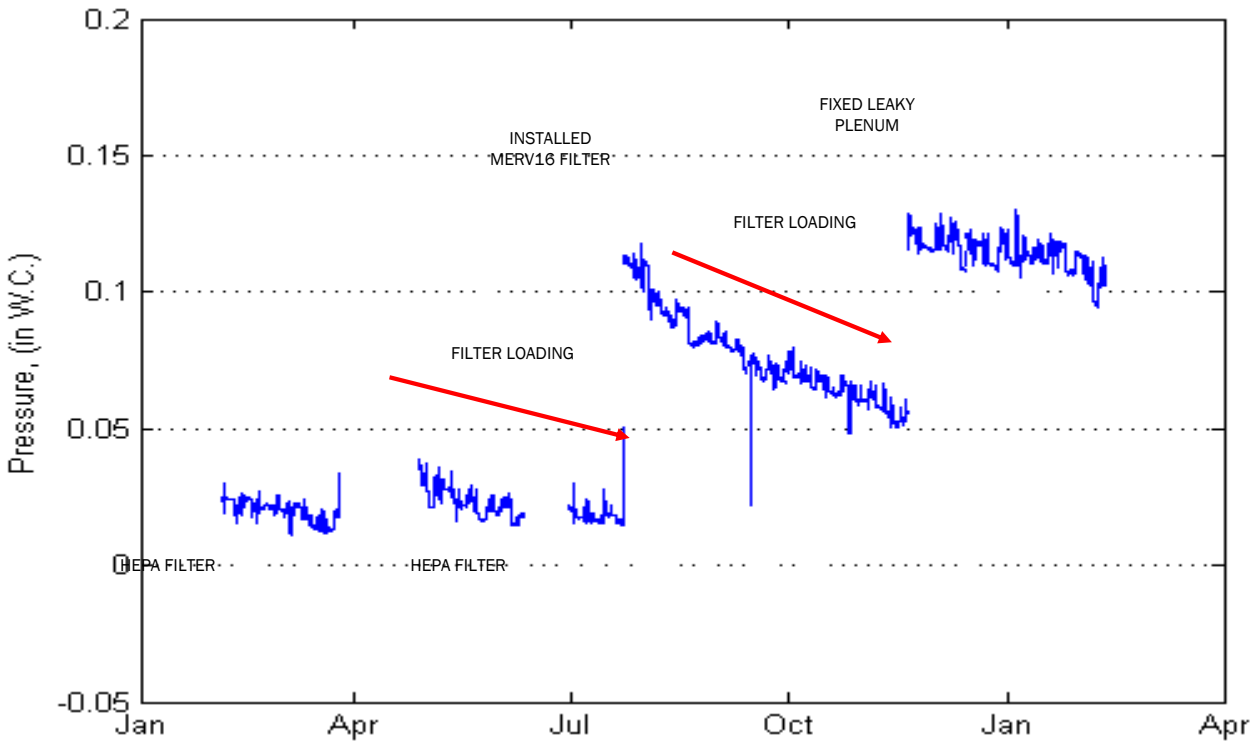
Crusher Booth: Protection Factors

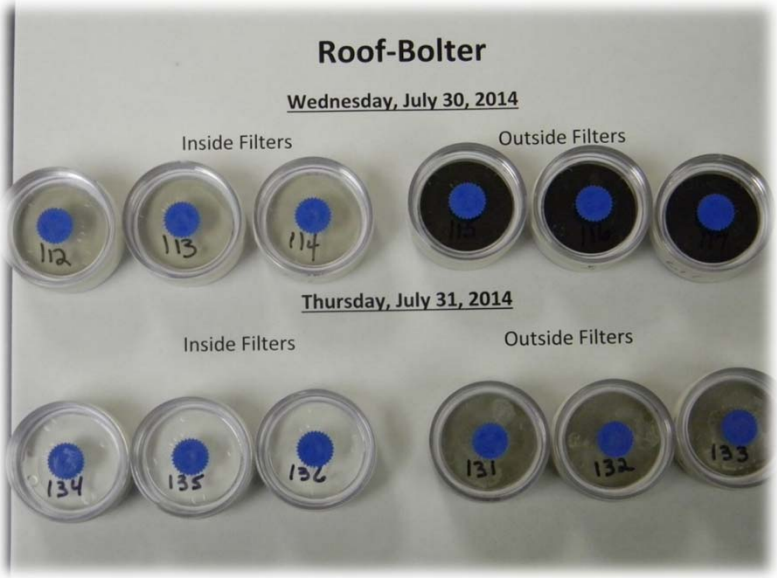


Protection Factors with MERV16 over <u>4X greater</u> compared to HEPA

Protection Factors: 5 - 178

Pressure Monitor Testing

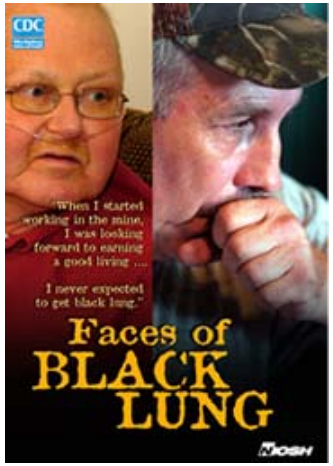




The Bottom Line

Miners' Attention

"Where the dust meets the lungs"



Chester Fike

IMPACT: Major Mining OEMs Adopting Technology

1. Daniel Spurgeon, Manager of Cab Climate Systems
2. Meeting @ CAT Cab Summit 2015 – Peoria, Illinois
3. Delivered 30 min presentation on NIOSH cab filtration research
4. Met with Cab Climate Engineering team for 4 hours to discuss advances in technology

1. 7 yr. relationship initiated by Douglas Hardman – President
2. Coordination with Ward Morrison, Marc Endicott, Sean Farrell, Ben Newlow, M/Non-metal Division – Engineering (Most recent meeting: March 29, 2016 – Huntington, WV).

Improving the health of miners through the implementation of the filtration and pressurization technology through OEMs such as CAT, J.H. Fletcher, Atlas Copco, Volvo, Sandvik, Kawasaki, DUX Machinery, Terex, Hitachi, Elgin, XCMG, and after market distributors such as Sy-Klone International, Polar Mobility Research LTD, Clean Air Filter Company, MI Air Systems LLC, Red Dot Corporation, Bergstrom Climate Control Systems Corp, and Sigma Air Filters. This technology is being used around the world.

Questions?

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