SILICA DUST CONTROLS FOR SURFACE MINES

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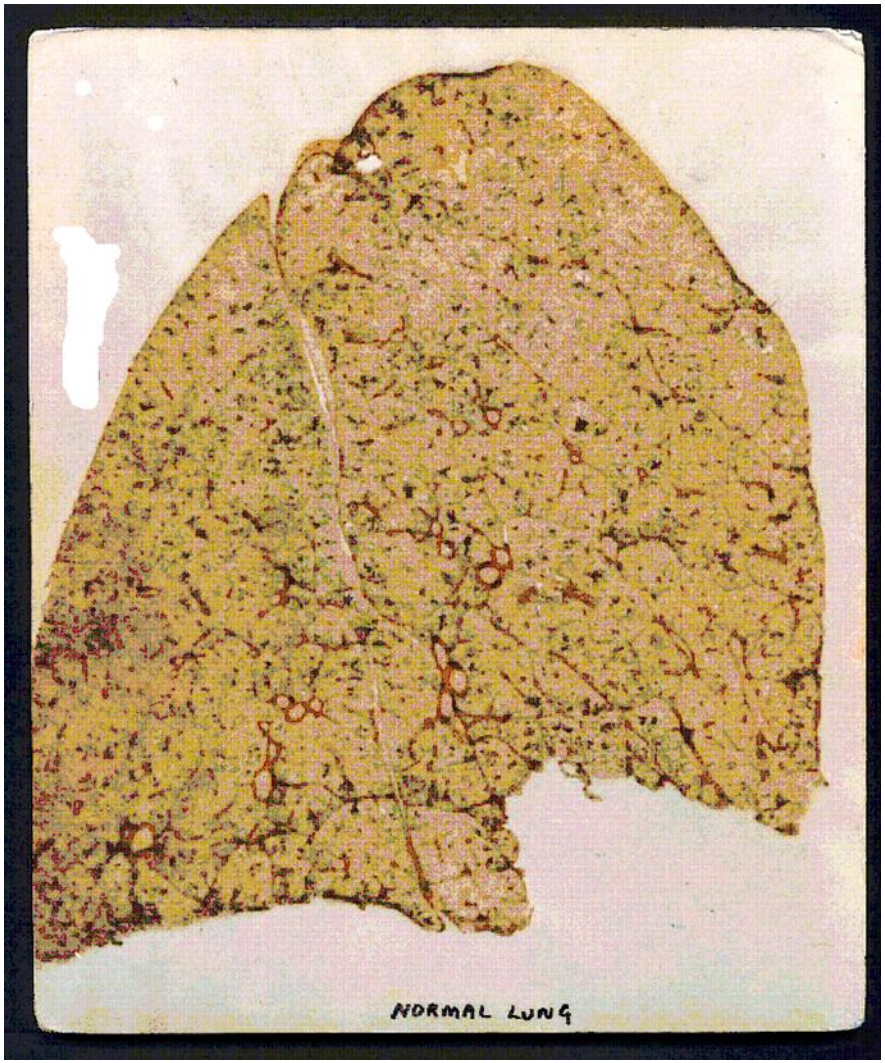
NORMAL



SILICOSIS

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2004–2008 MSHA Dust Samples

Mining Commodity	% of Dust Sample Exceeding the Standard Due to Quartz
Coal	11%
Metal	21%
Nonmetal	18%
Stone	13%
Sand & Gravel	12%

****Equipment operators most frequently exceed the standard.*

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Surface Mining Equipment

Drills

Bulldozers

Trucks & Loaders

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BEST PRACTICES FOR SURFACE MINE DUST CONTROL

- Drill dust collection systems
- Enclosed cab filtration systems
- Controlling haulage road dust
- Controlling dust at the primary hopper dump

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DRILL DUST COLLECTION SYSTEMS

1. Dry Dust Collector System
2. Wet Suppression

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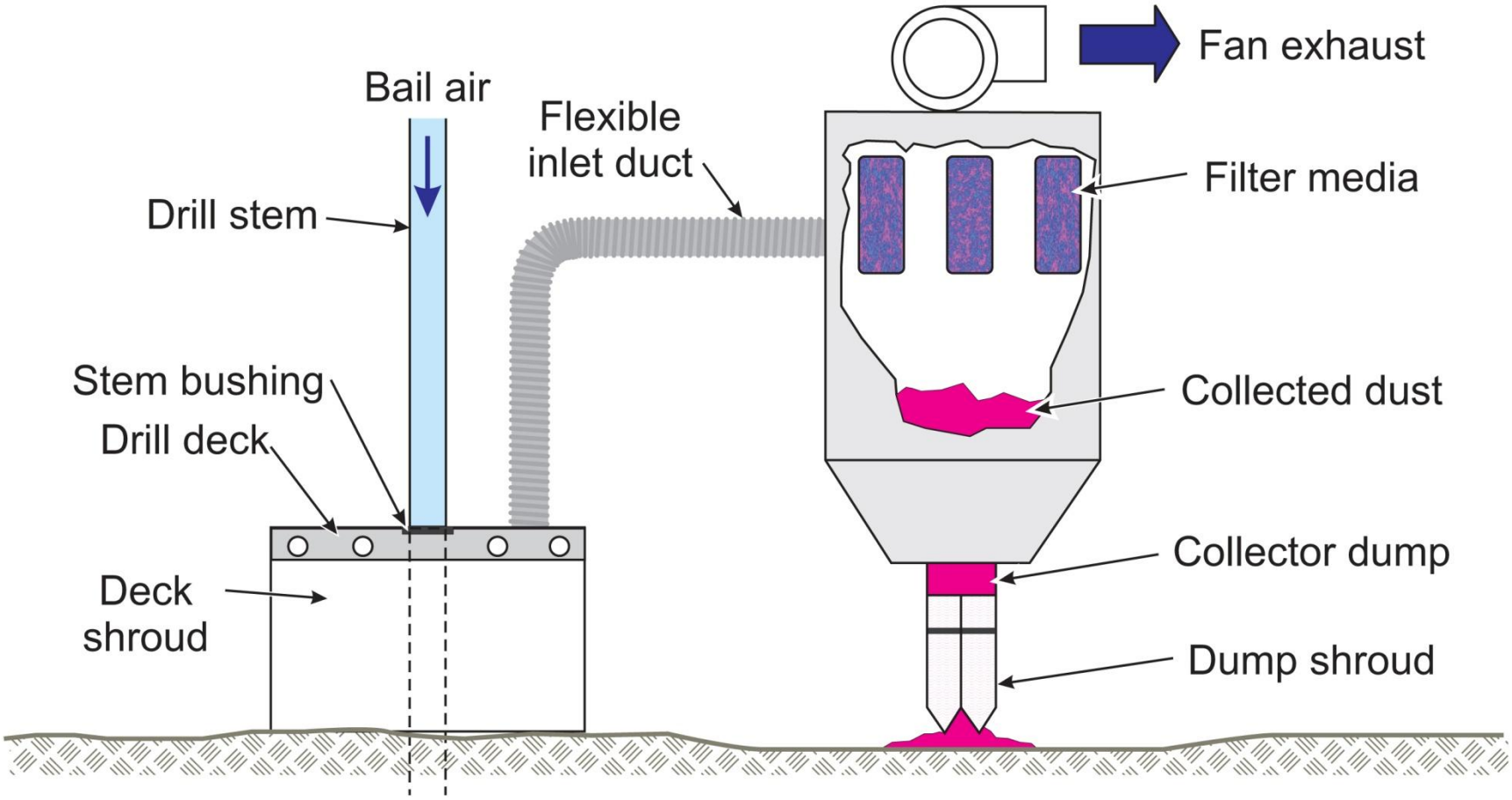
1. Dry Dust Collector Systems



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Dust Emissions From Dry Collection Systems

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Drill Shroud Leakage

- Maintain tight shroud enclosure with the ground
- Maintain at least 3:1 collector-to-bailing airflow ratio

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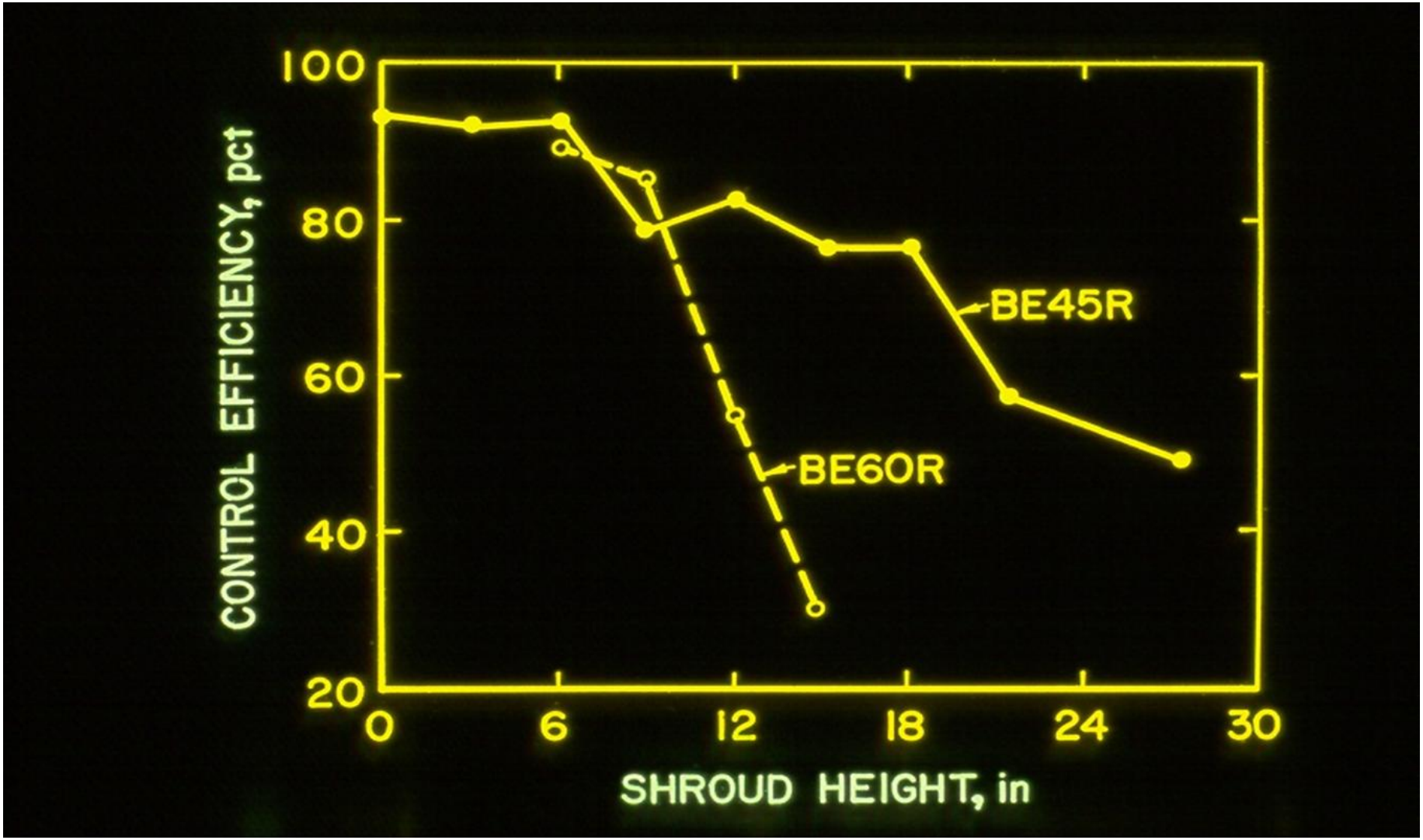
Shroud Height Effects



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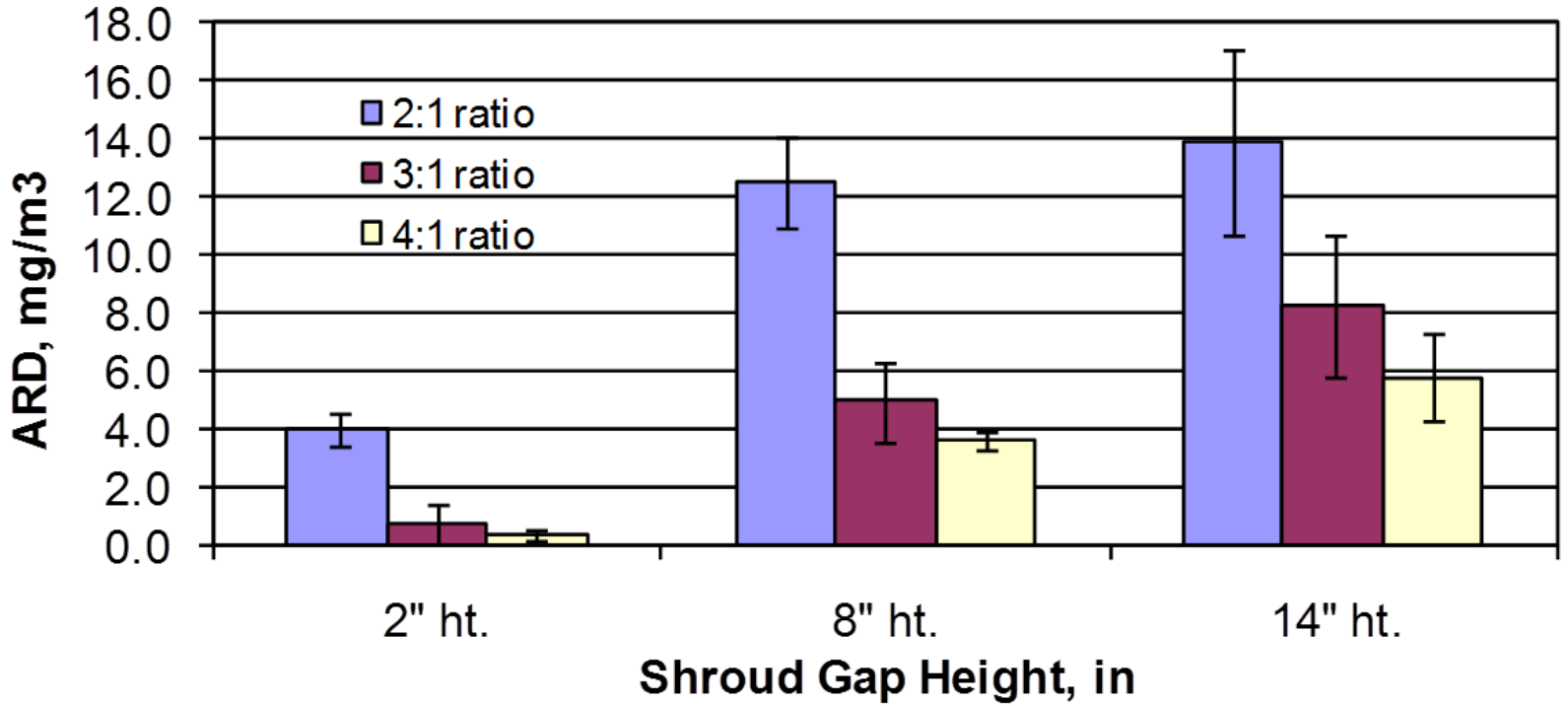
Shroud Height and Airflow Effects



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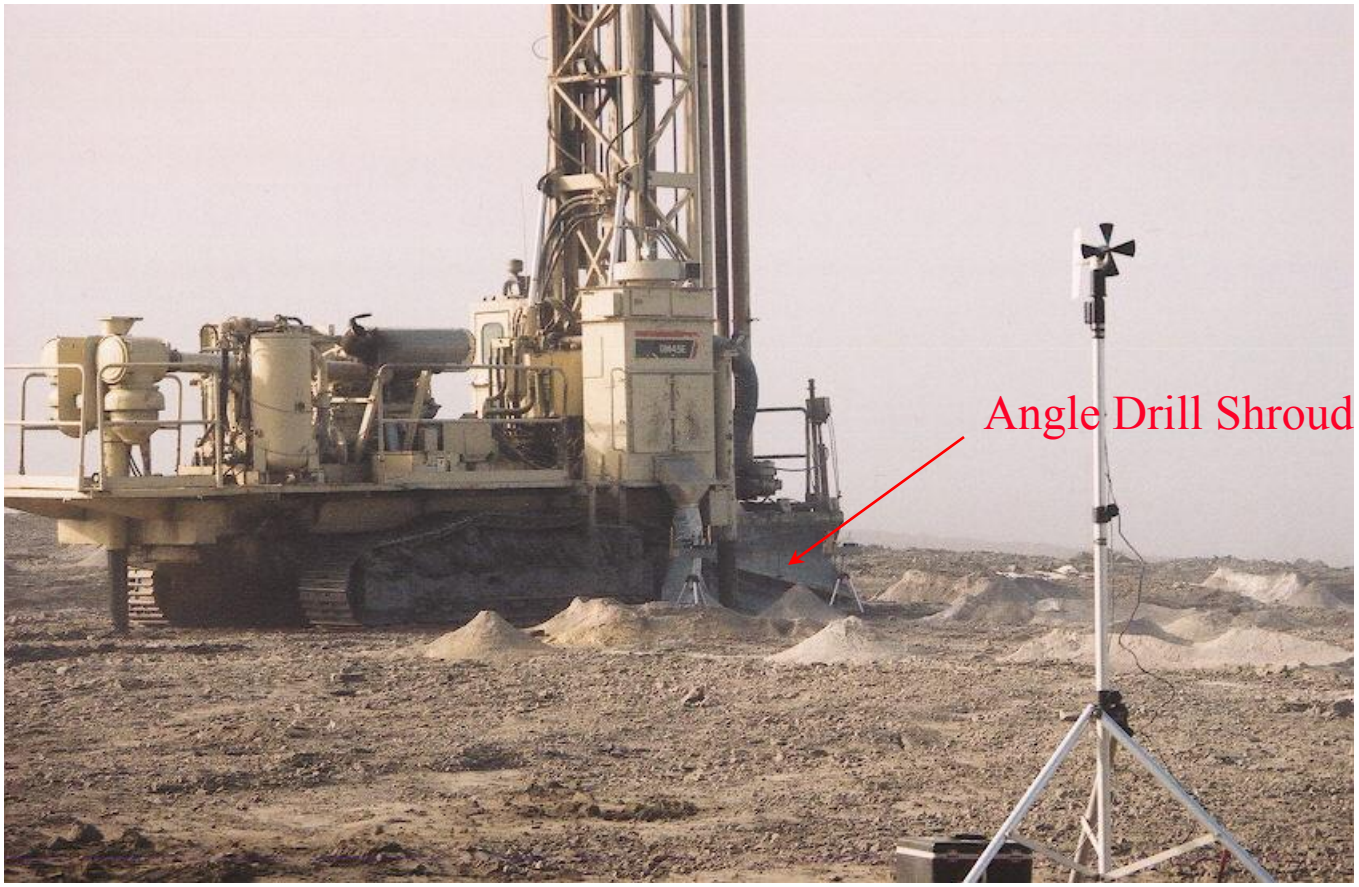
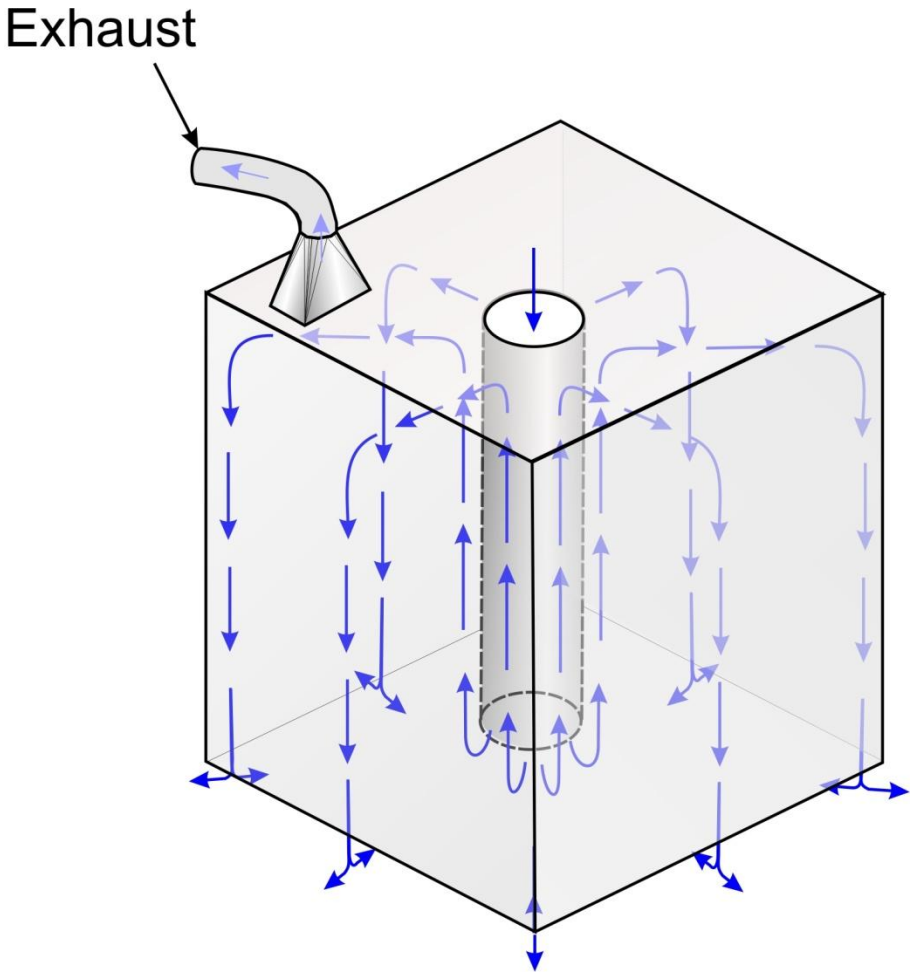
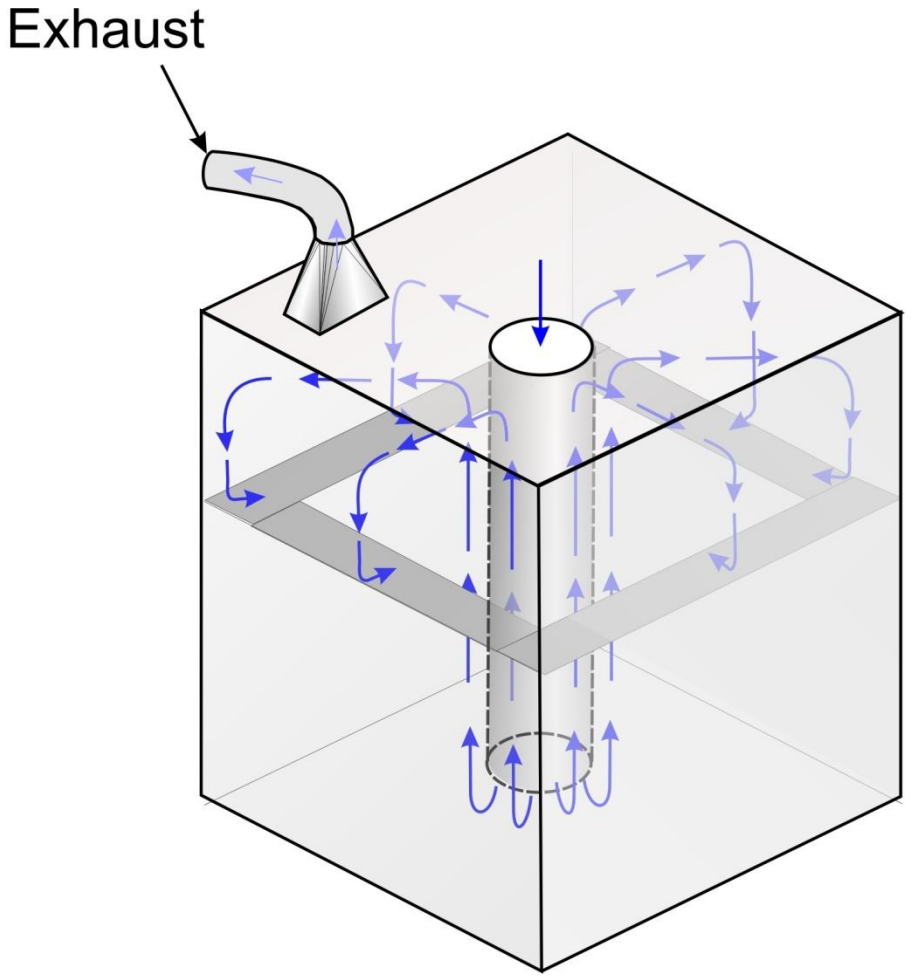
Adjustable Height Shroud



- Dust emissions below 0.5 mg/m^3

Horizontal Shelf Laboratory Testing





- 70%–80% dust reduction @ 2:1 collector-to-bailing airflow ratio

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Horizontal Shelf Field Testing

- 55%–66% dust reduction at two mines
- Examine more robust designs

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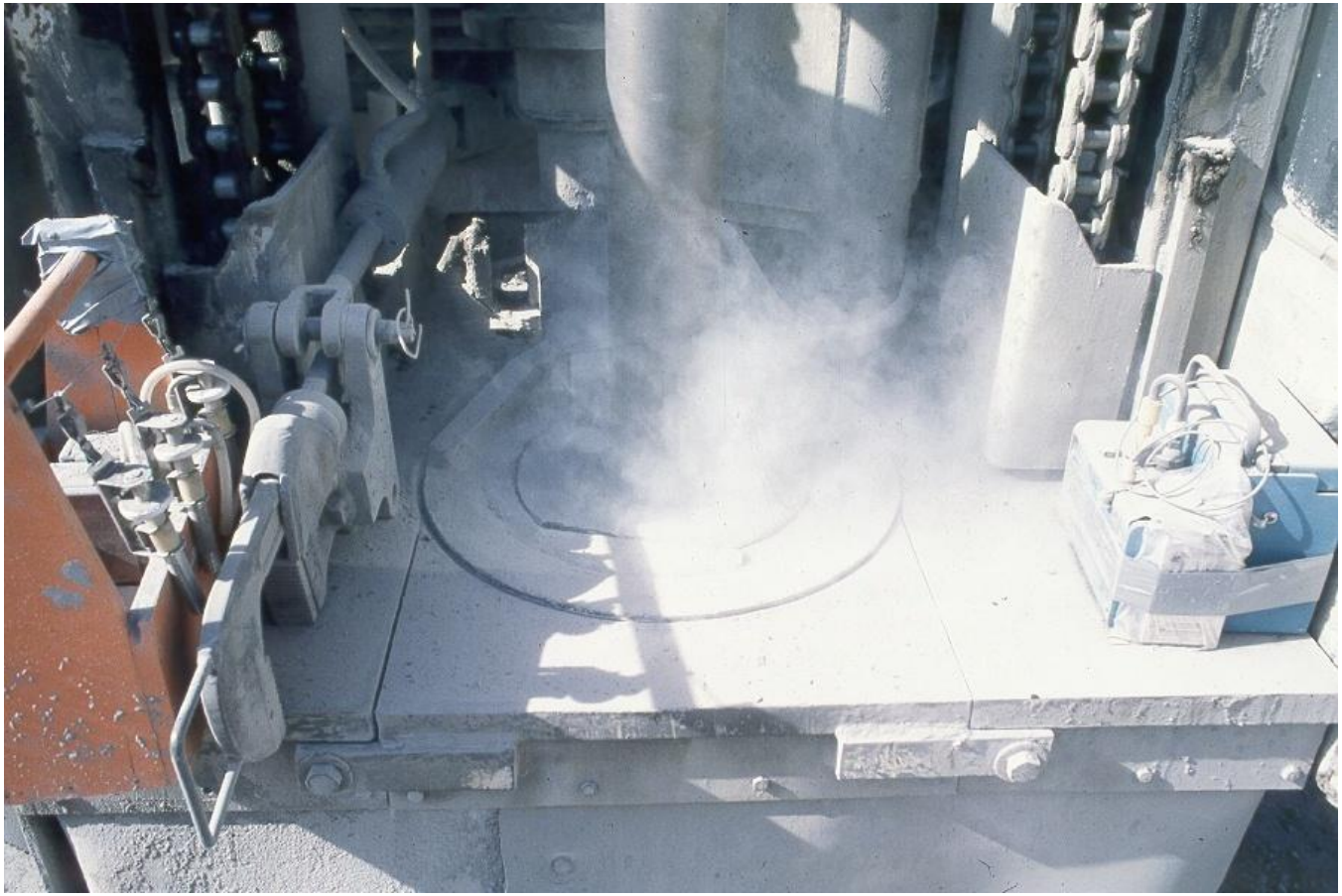
Drill Stem Leakage



- Maintain good seal between drill stem and table
- Use air ring seal

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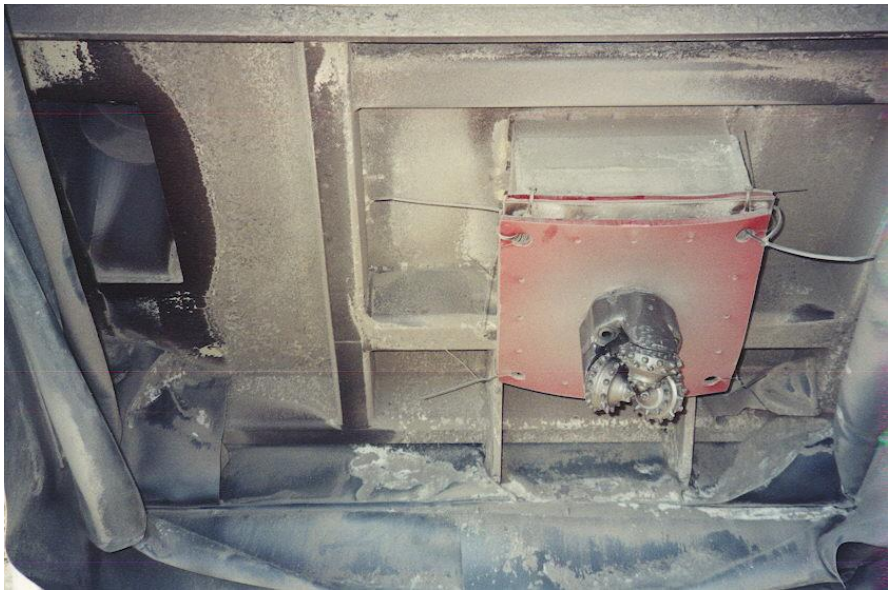
Maintain Good Drill Stem and Table Seal



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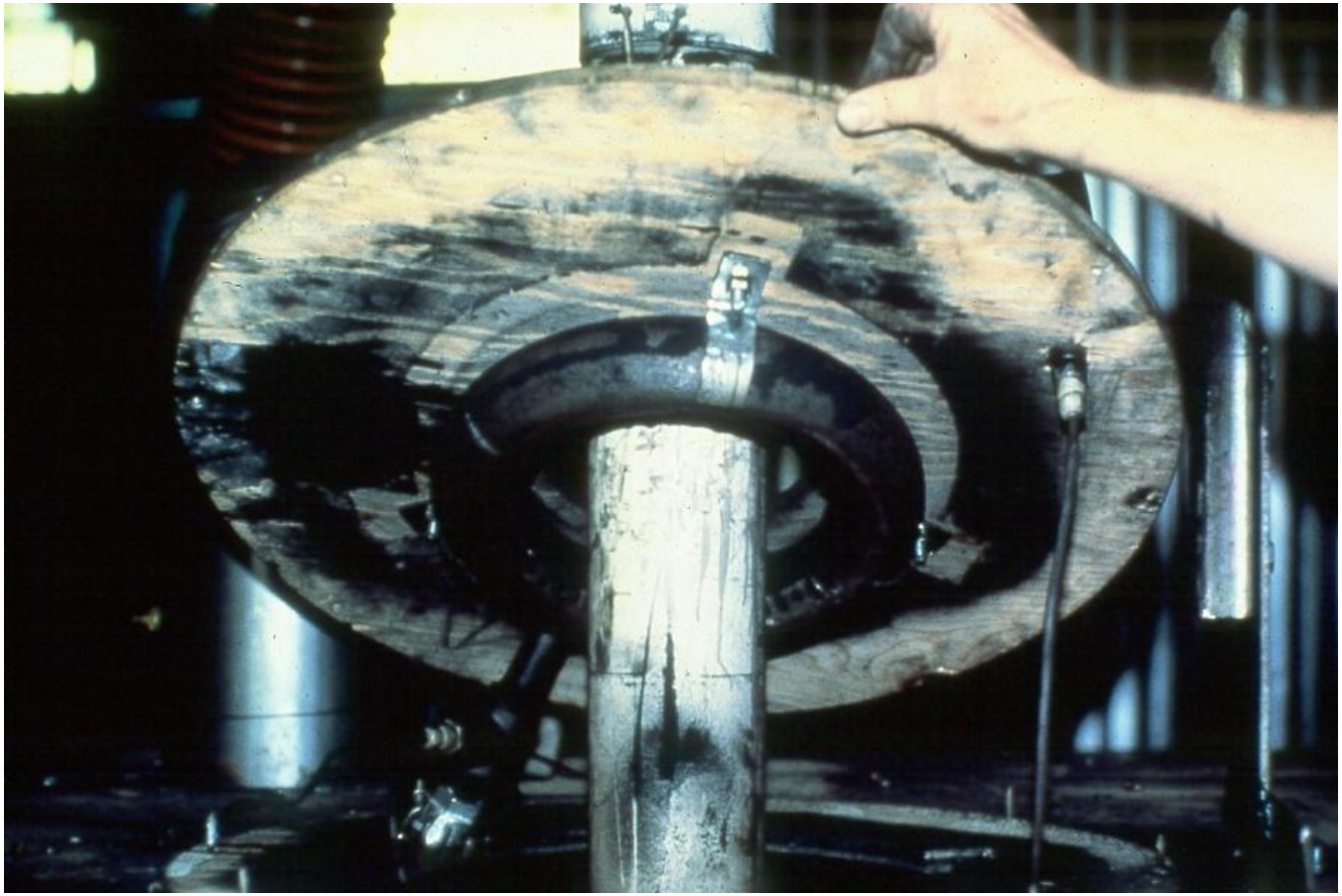
Air Ring Seal



- 41%–70 % dust reduction
- Large chip elimination

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Collector Dump

- Shroud dump discharge close to the ground

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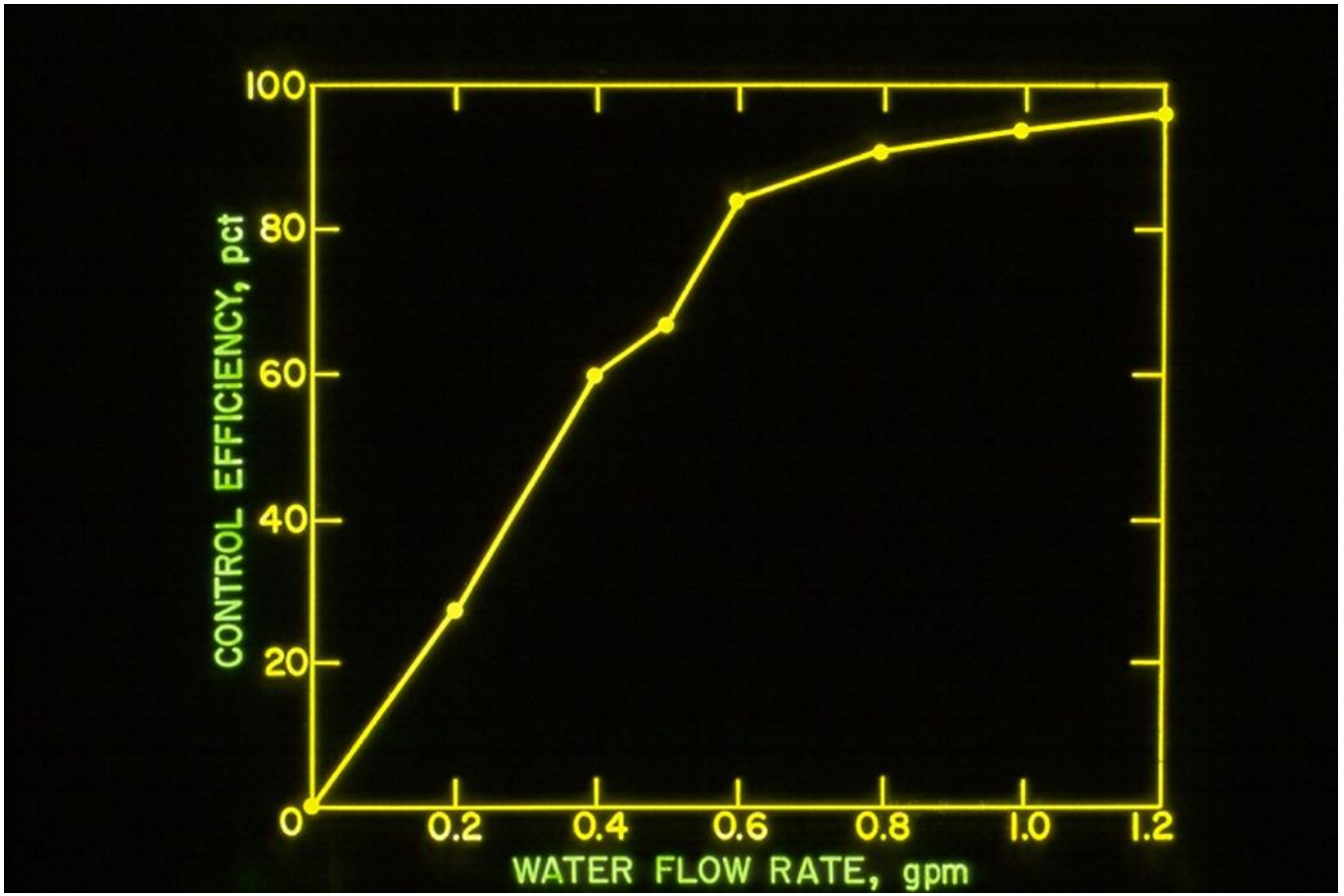
Maintain Dust Collector as Specified by Manufacturer

- 51% dust reduction after replacing broken collector fan belt
- 83% dust reduction from replacing torn deck shroud

2. Wet Suppression



- Add small amounts of water to reduce visible dust cloud
- Operational problems can occur from excessive water

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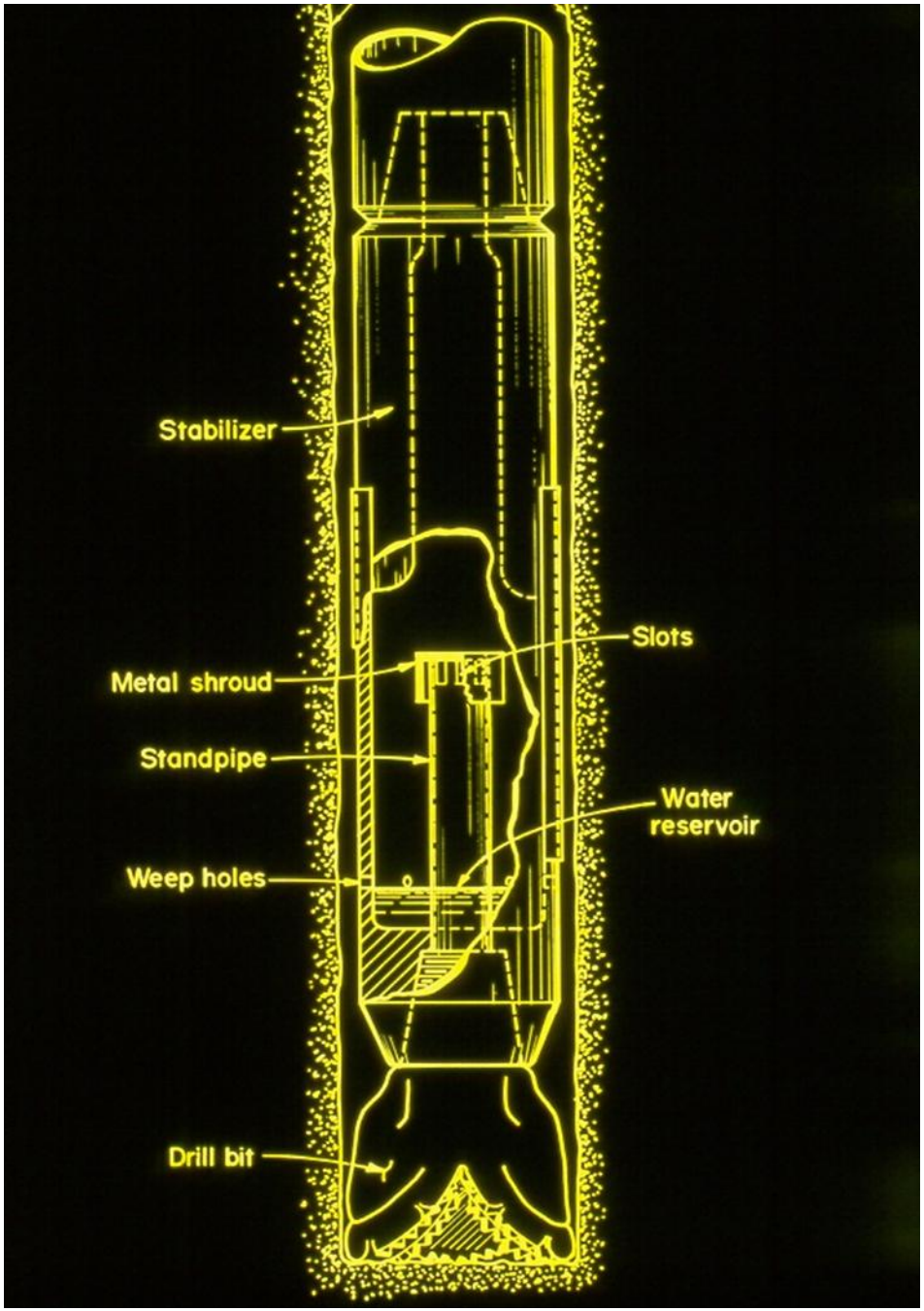
Water Separator Increases Roller Bit Life

- 98% with separator
- 96% without separator
- Bit life increased 4.5 times

Limited to large drill stems



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Smaller Drill Stem Water Separator

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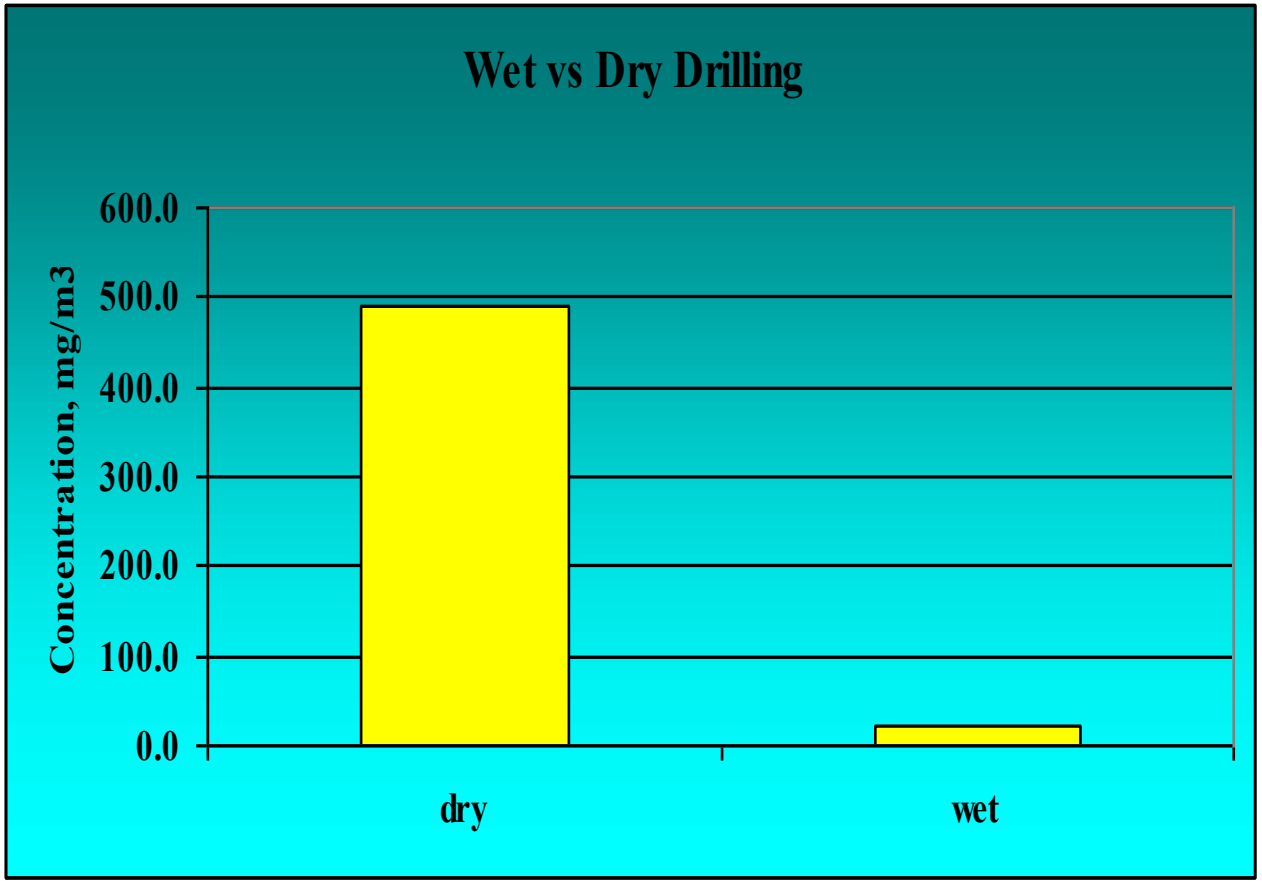
Smaller Drill Stem Water Separator Study



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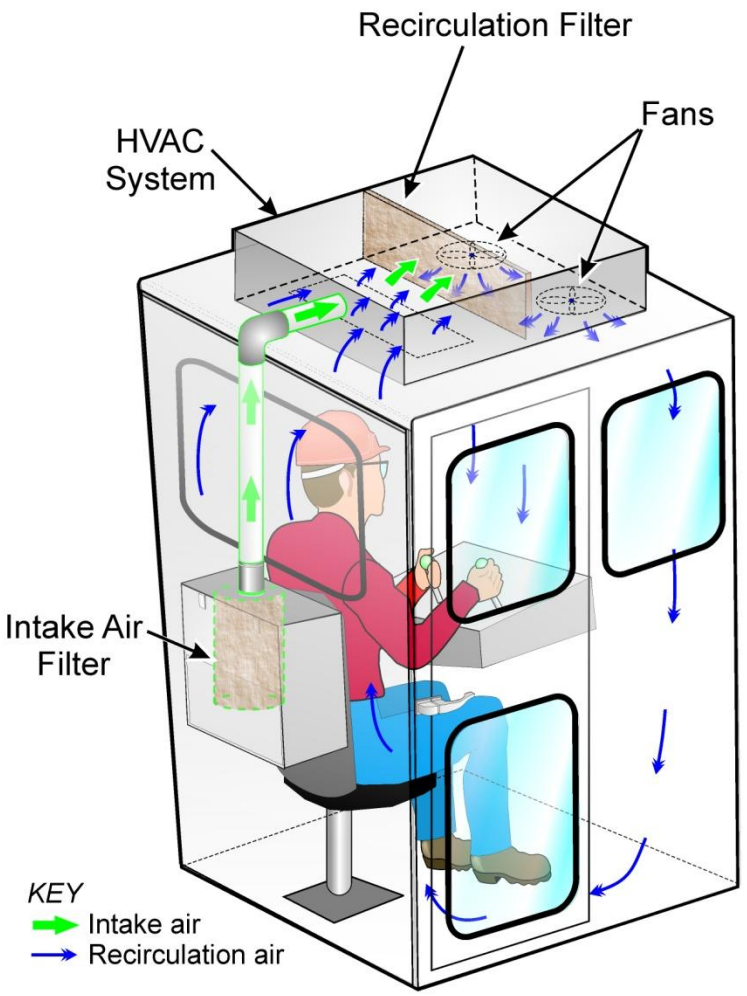
ENCLOSED CAB FILTRATION SYSTEMS

- Integrated into HVAC systems
- Protection factors vary:
  - Drills 2.5 to 84
  - Bulldozers 0 to 45
- Field studies of refurbishing old cabs
- Laboratory study of cab filtration systems



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Refurbish Cabs

- Ceiling-mounted heating and AC units
- External filter and fan units
- Improve cab enclosure seals

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Enclosed Cab Field Studies

Cab Evaluation	Cab Pressure Inches w.g.	Equivalent Wind Vel. mph	Inside Dust Level mg/m^3	Outside Dust Level mg/m^3	Protection Factor Out/In
Rotary Drill	None Detected	0	0.08	0.22	2.8
Haul Truck	0.01	4.5	0.32	1.01	3.2
Front-End Loader	0.015	5.6	0.03	0.30	10.0
Rotary Drill	0.20 – 0.40	20.3 – 28.7	0.05	2.80	56.0
Rotary Drill	0.07 – 0.12	12.0 – 15.7	0.07	6.25	89.3

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Ensure Good Cab Integrity and Positive Pressurization

Hard to Seal Gaps

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Use High Efficiency Respirable Dust Filters

- Intake filter ≥ 95% on respirable-sized dusts
- Use an efficient recirculation filter

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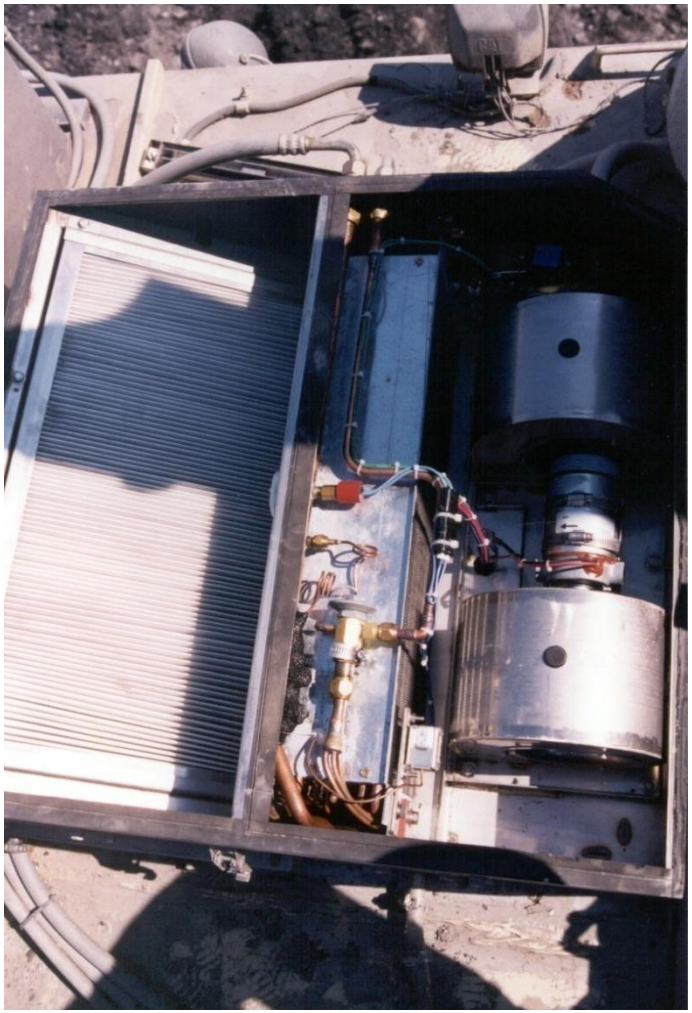
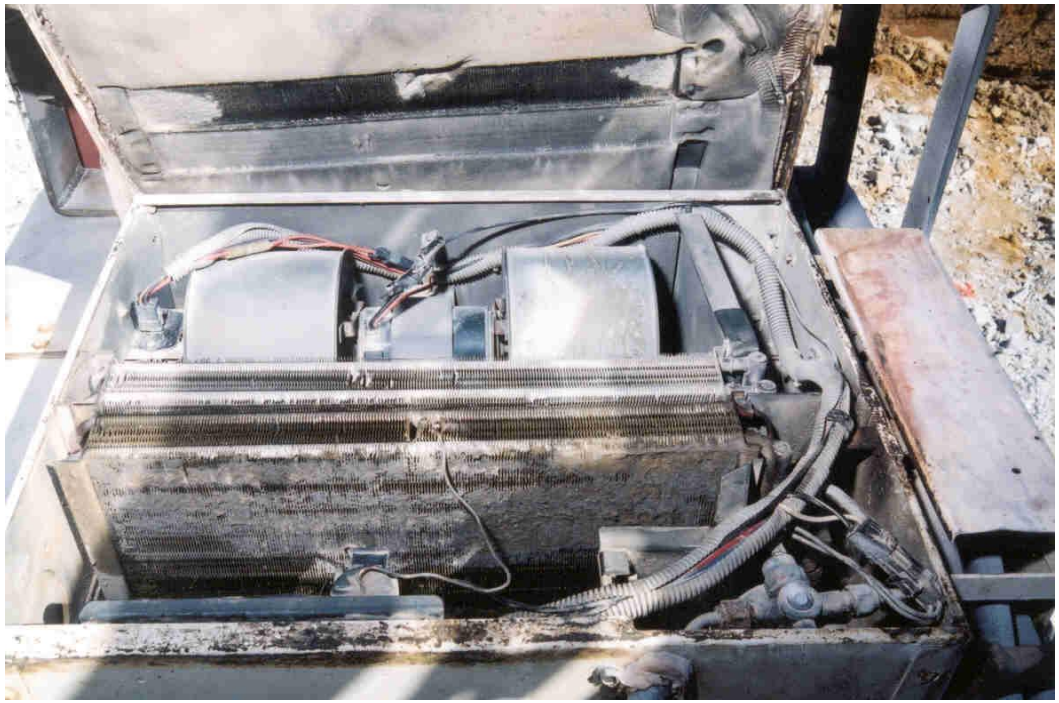
Additional Benefits of Good Filtration



Clean HVAC



Dirty HVAC

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Minimize Dust Sources in Cab

Test Results:

- Seasonal dust level increased from 0.04 to 0.68 mg/m^3
- Floor heater use increased dust levels from 0.03 to 0.26 mg/m^3

Solutions:

- Use good housekeeping practices
- Remove floor heaters
- Rubber mats better than carpeting
- Gritless sweeping compounds (non-petroleum based)

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Keep Doors Closed During Equipment Operation

- 0.81 mg/m^3 when briefly opened to add drill steels
- 0.09 mg/m^3 with door closed

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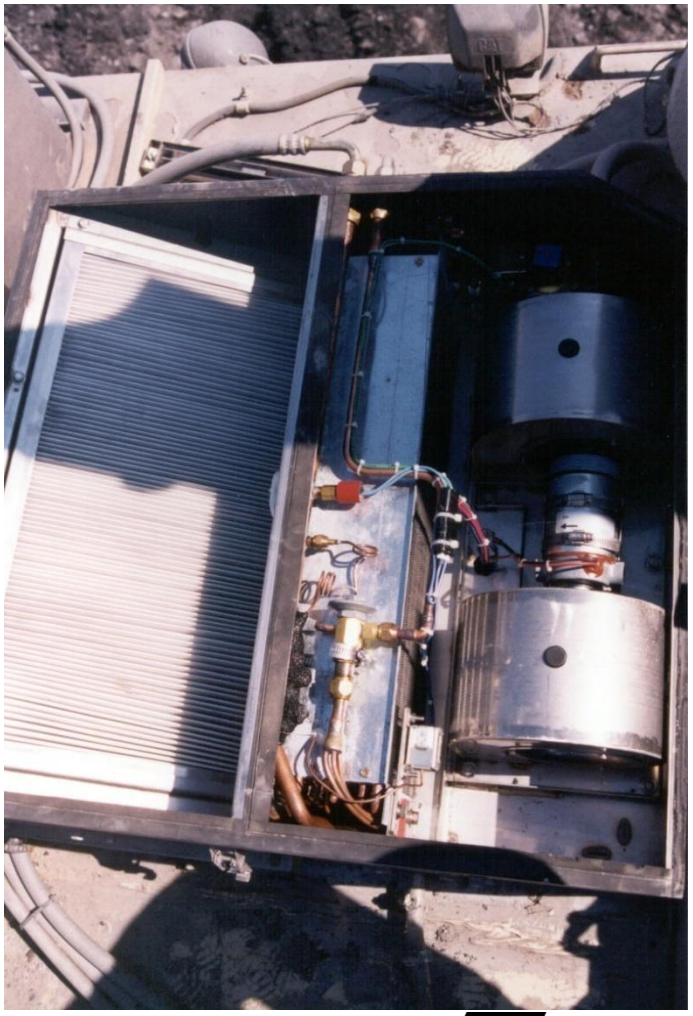
Link to enclosed cab video
http://www.cdc.gov/niosh/mining/products/product81.htm

Difficult to Field Quantify Cab Performance Factors



- Airflow
- Filter loading
- Leakage

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Cab Filtration System Experiments

Cab Performance Measure:

- Particle count penetration or protection factor

Laboratory Test Variables:

- Intake filter efficiency
- Intake filter resistance (Simulate filter loading)
- Intake air leakage
- Recirculation filter efficiency
- Wind infiltration
- Addition of an intake pressurizer

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Key Results of Laboratory Cab Testing

Filters		Average Cab Performance Parameters						
Intake	Recircu-lation ?	PF C_{out}/C_{in}	Q_{intake} cfm	Δp_{filter} "w.g.	L % Q_i	Q_{recir} cfm	Δp_{cab} "w.g.	Stability min
Low E_I *38%*	No	1.7	37.3	0.30	2.0	366	0.17	17
Low E_I *38%*	Yes	13.4	41.0	0.47	2.6	328	0.19	8
High E_I *99%*	No	13.3	18.1	0.52	3.6	386	0.07	29
High E_I *99%*	Yes	168.4	23.2	0.70	4.9	338	0.08	8

90% efficient recirculation filter improved both cab protection factor and the time to reach it after the door is closed

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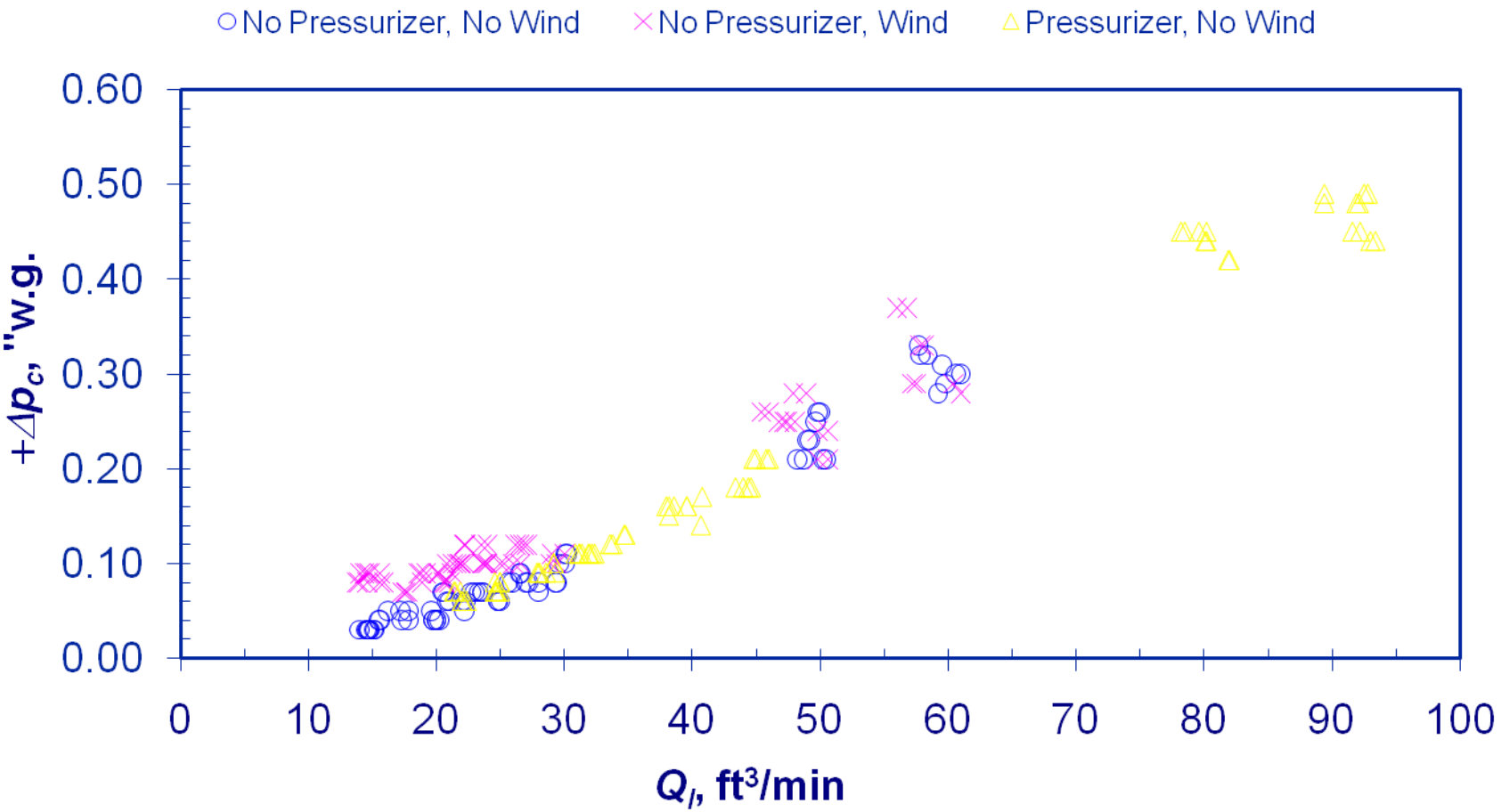
Intake Pressurizer Effects



Cab pressure reflective of enclosure integrity and intake air quantity, not intake air quality!

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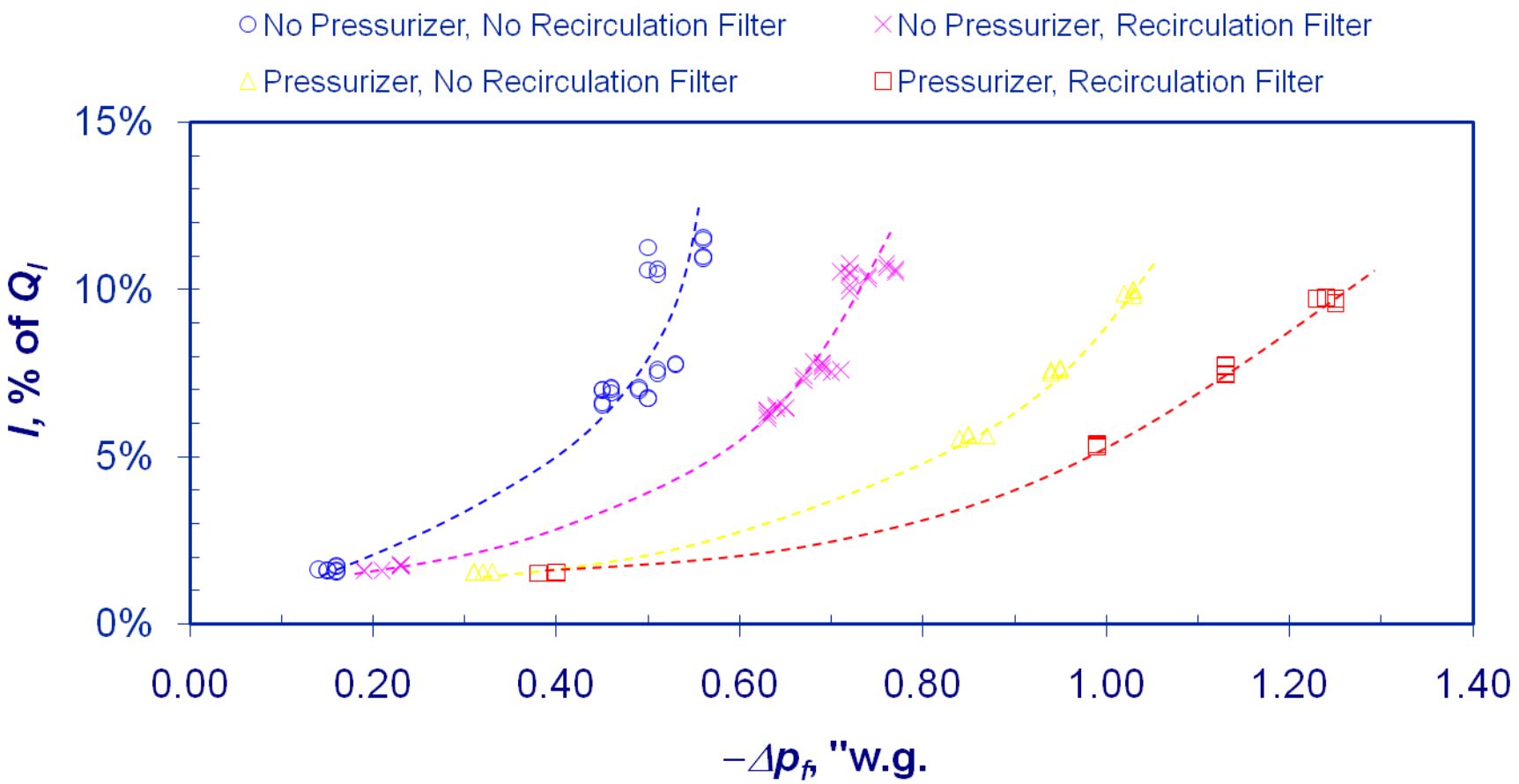
Intake Air Leakage Effects



Intake filter loading proportionally increases airflow through leakage areas!

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Cab Mathematical Model*

$$PF = \frac{C_{outside}}{C_{inside}} = \frac{Q_I + Q_R \eta_R}{Q_I\left(1 - \eta_I + l\eta_I\right) + Q_w} \quad \text{(Ideal Conditions)}$$

Where:

Q_I = Intake air quantity into the cab ($Q_I > 0$), volume per unit time,

η_I = Intake filter efficiency ($\eta_I < 1$), fractional,

l = Intake air leakage, fractional portion of intake air quantity,

Q_R = Recirculation filter airflow, volume per unit time,

η_R = Recirculation filter efficiency, fractional,

Q_W = Wind quantity infiltration into the cab, volume per unit time.

* Organiscak JA and Cecala AB. Doing the Math: The effectiveness of enclosed-cab air-cleaning methods can be spelled out in mathematical equations. Rock Products, October 2009, pp. 20-22.

Cab Model Calculations

1) Baseline Design: $Q_I = 40$ ft^3/min, $Q_R = 200$ ft^3/min, $\eta_I = 0.95$, $l = 0$, and $\eta_R = 0$; $PF = 20$

2) With a 5% air leak around the intake filter gasket: $l = 0.05$; $PF = 10$

3) Adding a 75% efficient recirculation filter: $\eta_R = 0.75$; $PF = 49$

4) A 75% efficient recirculation filter without a 5% leak: $l = 0$; $PF = 95$

CONTROLLING HAULAGE ROAD DUST

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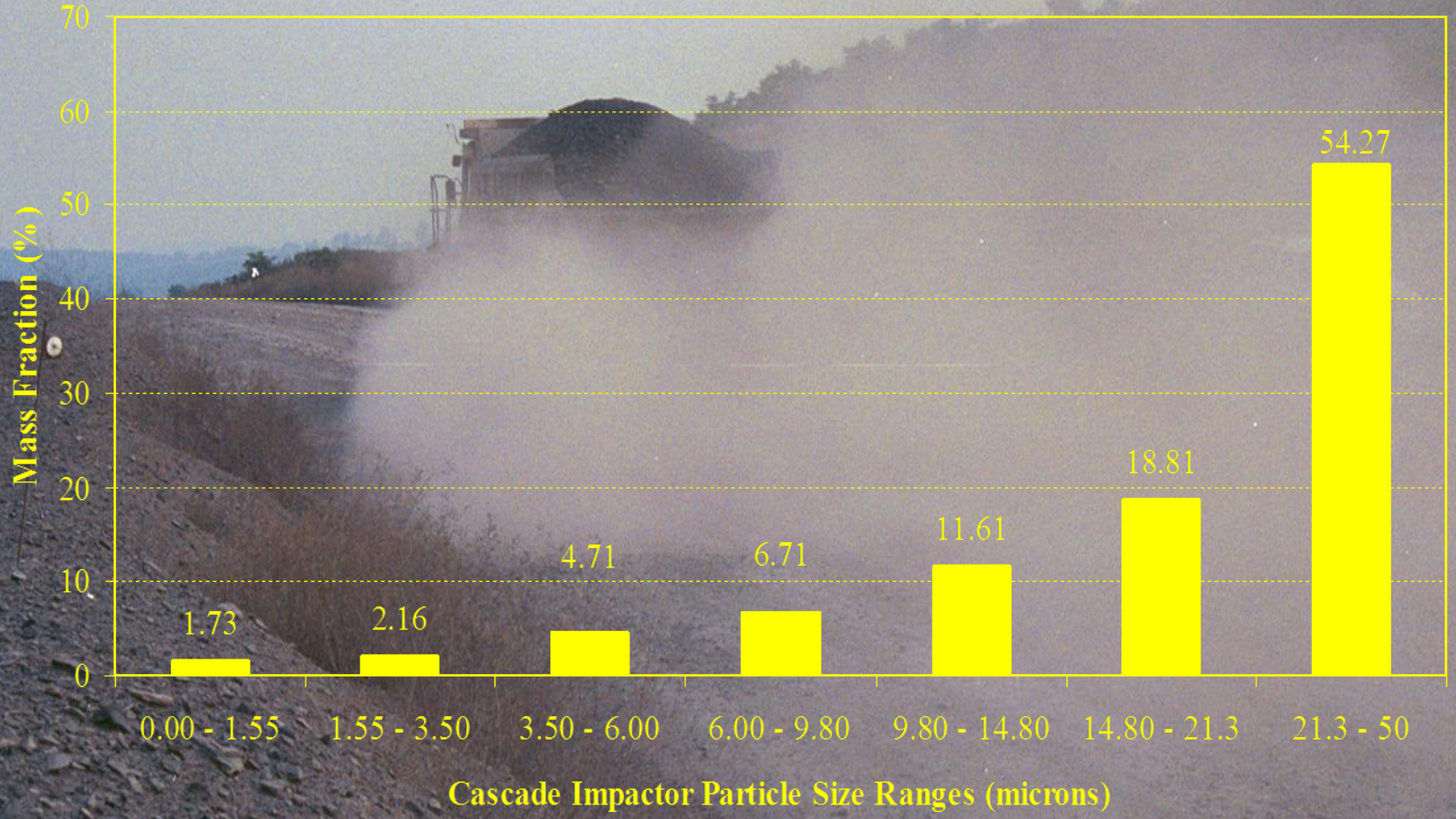
Average Airborne Particle Size Distribution



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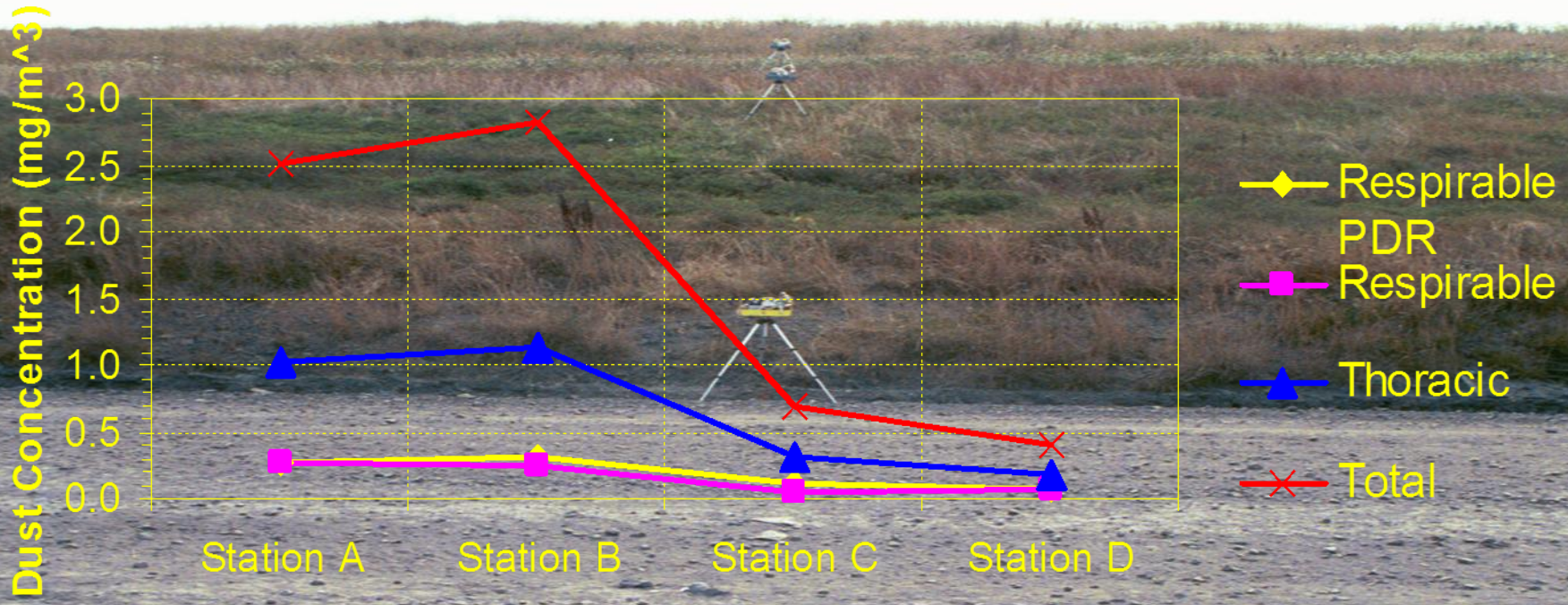
Typical Gravimetric Dust Concentrations



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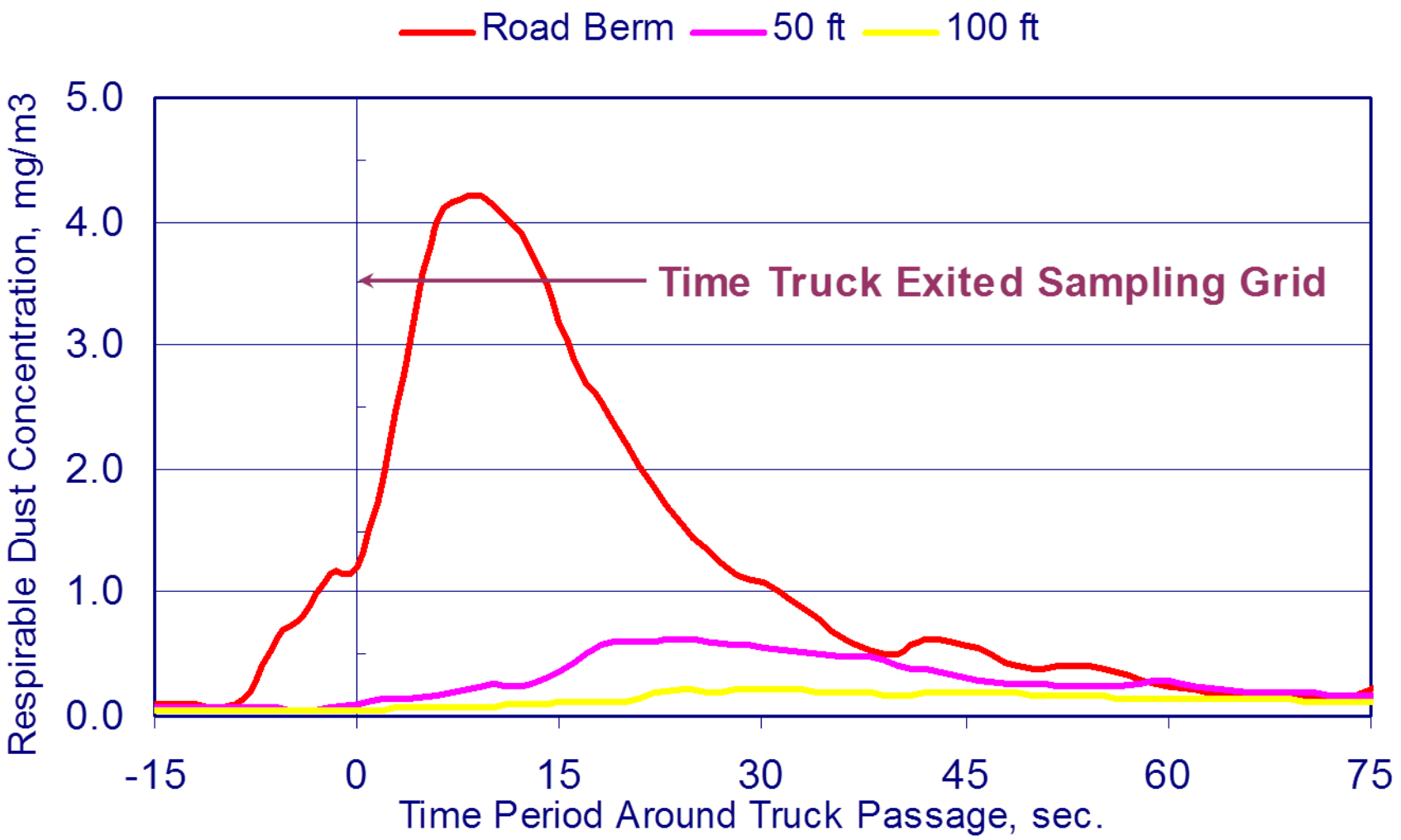
Dust Dissipation Effect



Total:Resp. ≈ 8 to 10:1 Thoracic:Resp. ≈ 3 to 4:1

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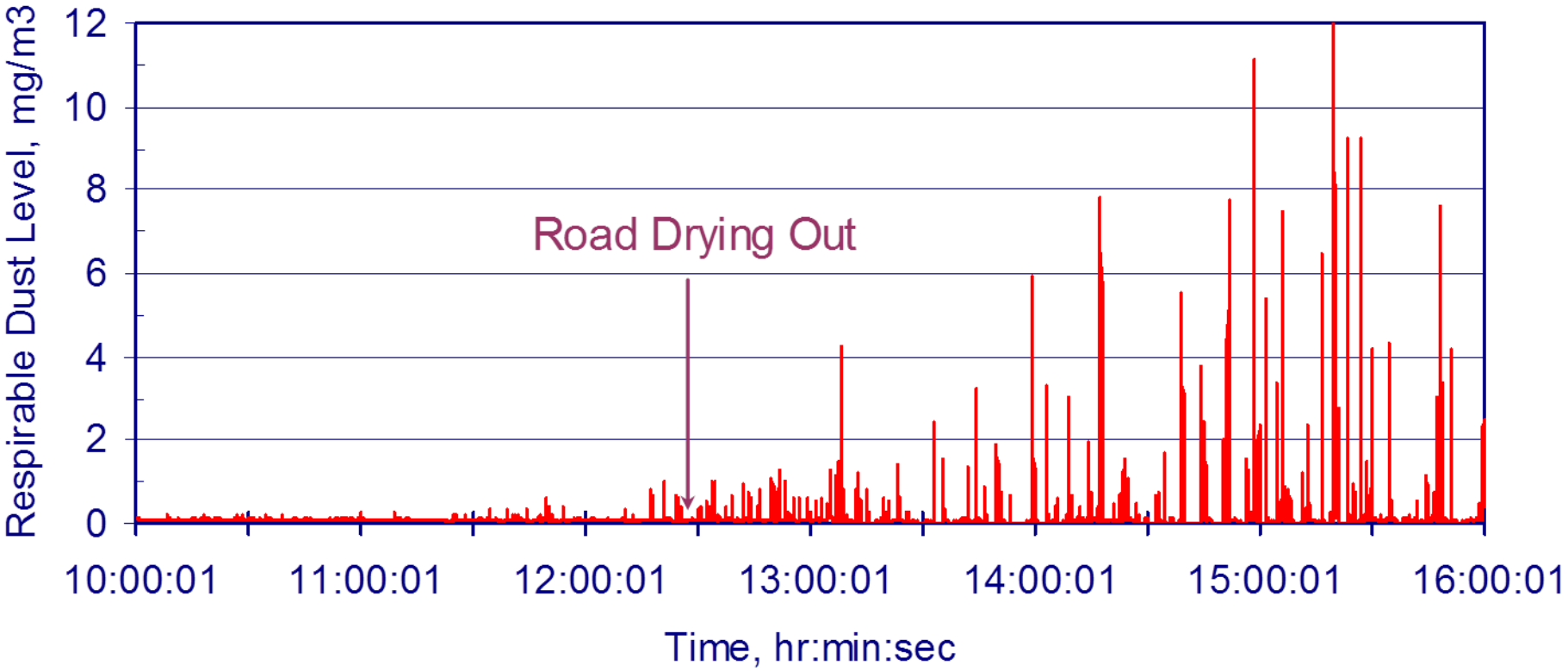
Treatment of Unpaved Road Services



- Water effective with reapplications
- Salts, surfactants, soil cements, bitumens, films (polymers) extend time of effectiveness

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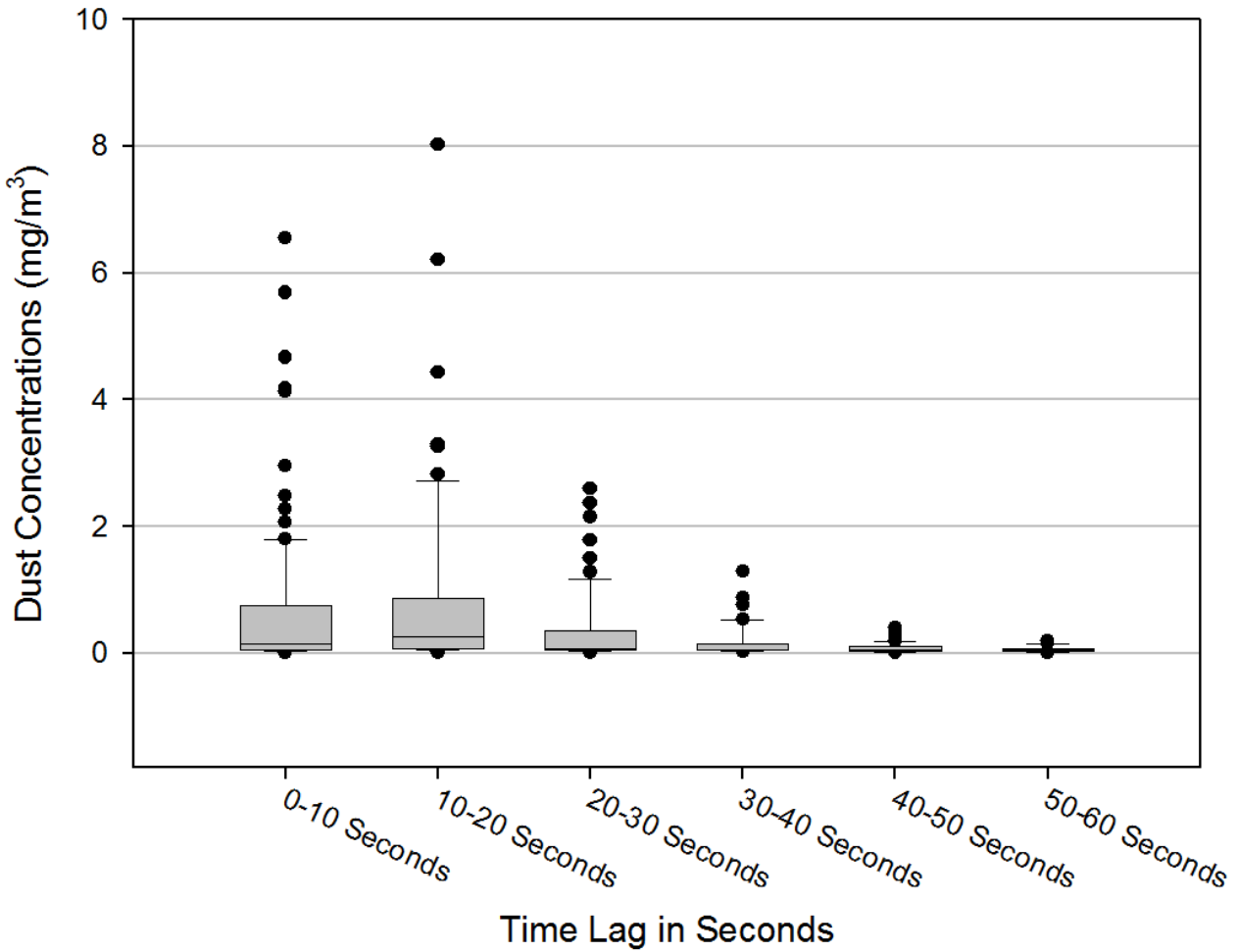
Increase Distance Between Vehicles



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PRIMARY CRUSHER HOPPER DUMP

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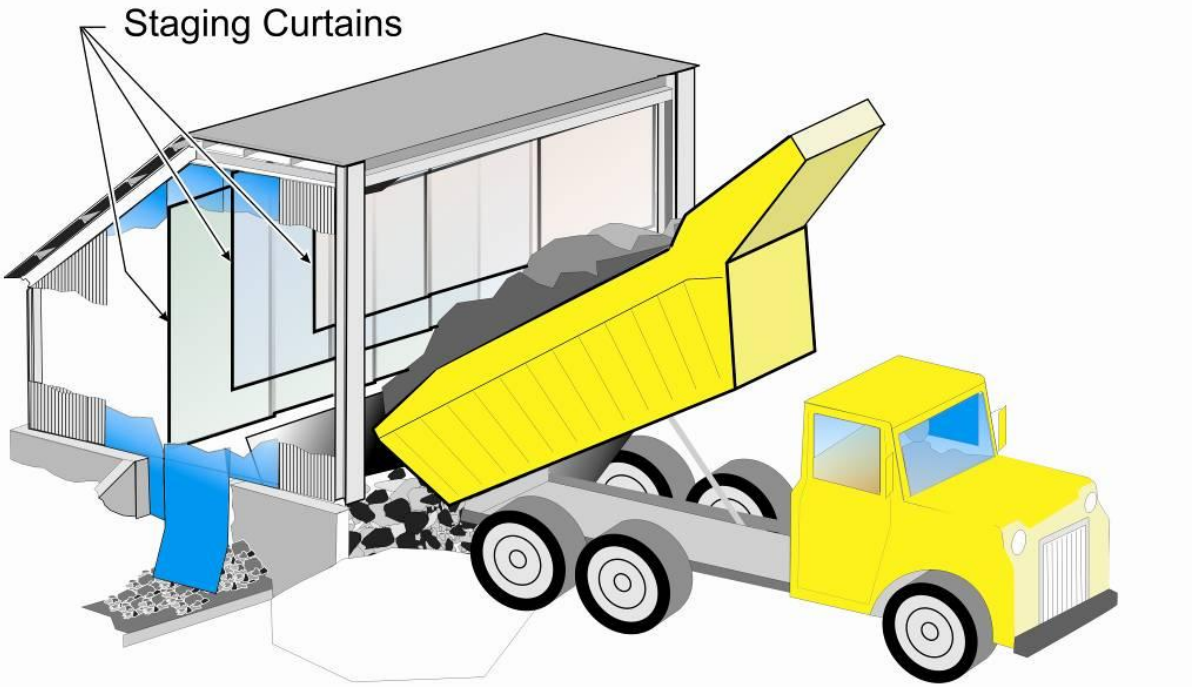
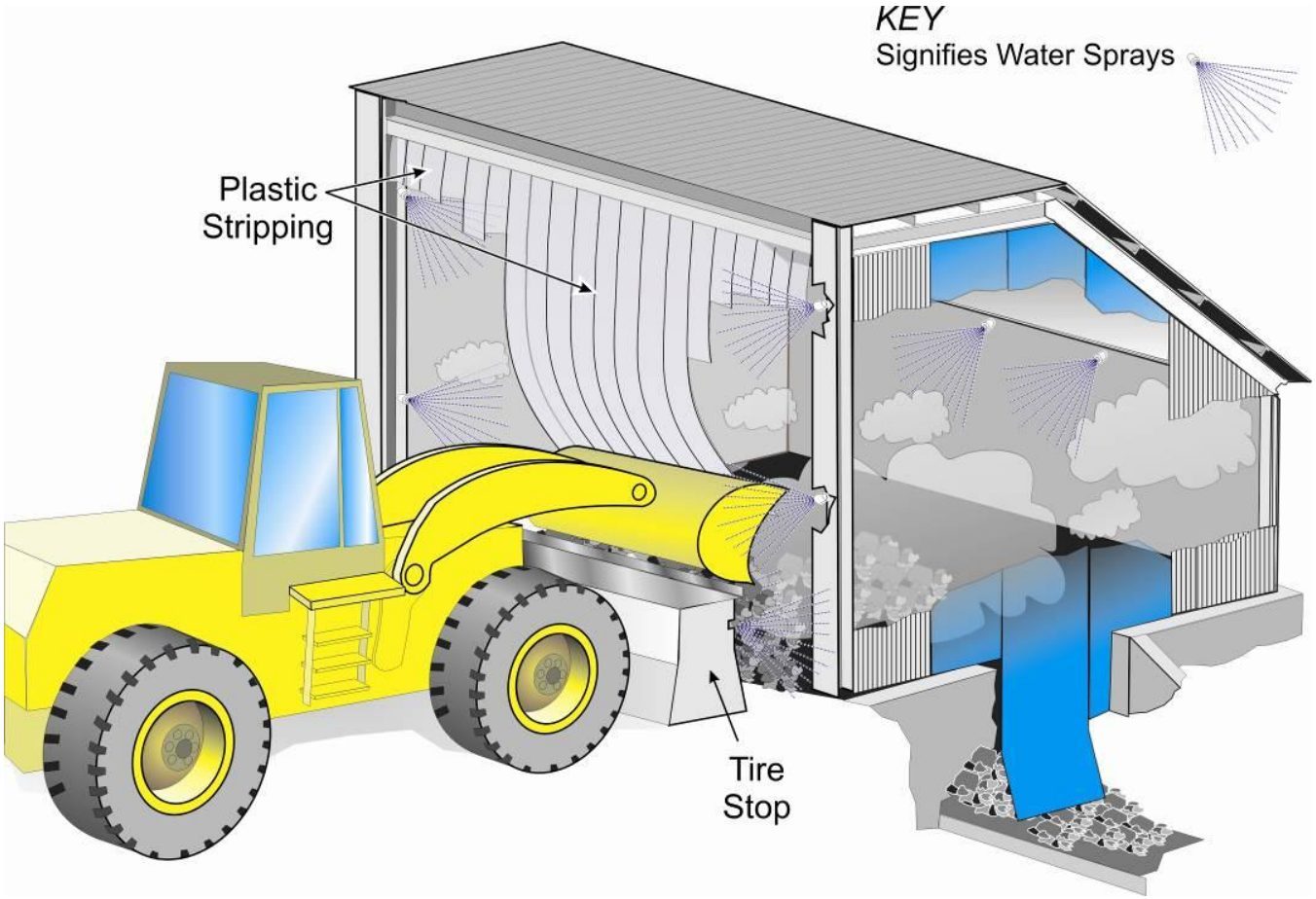
Enclose the Primary Hopper Dump



- Staging curtains reduce dust billowing out

Use Water Sprays to Suppress the Dust



- Start by adding 1% moisture by weight
- Use photocell or mechanically controlled sprays

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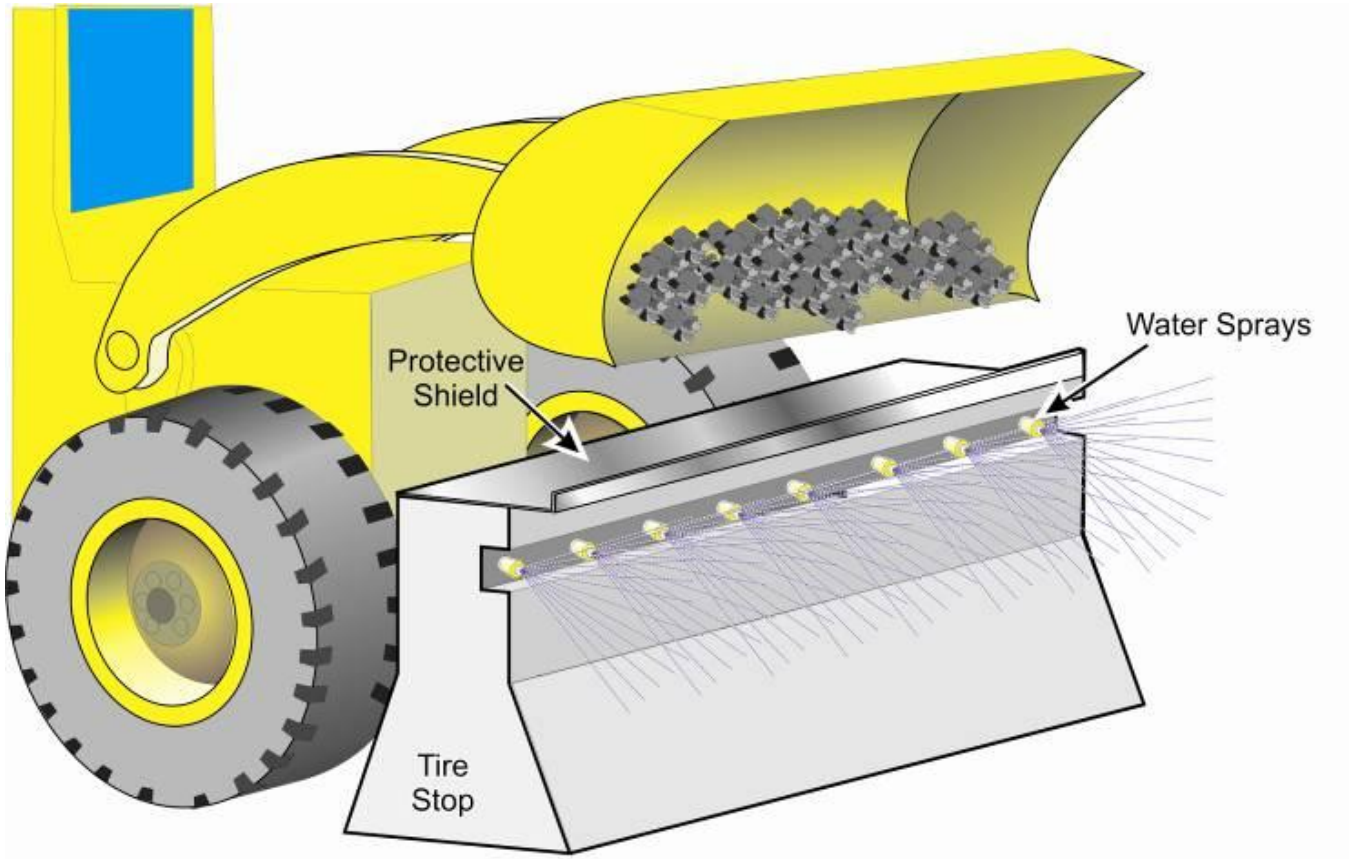
Prevent Dust Roll Back Under Vehicle



- Tire stop reduces rollback underneath equipment
- Water sprays knock down and redirect dust

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CONCLUSIONS

- **Dry and wet drill dust collection systems are very effective**
  - Tightly sealed shroud around drill hole critical for dry systems
  - Wet systems can increase bit wear, problematic in cold climates
  - Assumes quality control and maintenance programs
- **Cabs can provide a 10- to 50-fold dust reduction**
  - Good filtration system
  - Tightly sealed cab for achieving positive pressurization
  - Assumes quality control and maintenance programs
- **Road dust can effectively be mitigated by routine wetting**
- **Enclosed hopper dumps contain dust → spray capture**

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Questions or Comments?

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