SILICA DUST CONTROLS FOR SURFACE MINES

By John A. Organiscak
NORMAL              SILICOSIS

Section of Freeze-Dried Human Lung
Silicosis
2004-2008 MSHA Dust Samples

<table>
<thead>
<tr>
<th>Mining Commodity</th>
<th>% of Dust Samples Exceeding the Standard Due to Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>11 %</td>
</tr>
<tr>
<td>Metal</td>
<td>21 %</td>
</tr>
<tr>
<td>Nonmetal</td>
<td>18 %</td>
</tr>
<tr>
<td>Stone</td>
<td>13 %</td>
</tr>
<tr>
<td>Sand &amp; Gravel</td>
<td>12 %</td>
</tr>
</tbody>
</table>

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

Drills

Bulldozers

Trucks & Loaders
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
DRILL DUST COLLECTION SYSTEMS

1. Dry Dust Collector System
2. Wet Suppression
1. Dry Dust Collector Systems
Dust Emissions From Dry Collection Systems

Collector Dump

Drill Shroud Leakage

Drill Stem Leakage
Drill Shroud Leakage

- Maintain tight shroud enclosure with the ground
- Maintain at least 3:1 collector-to-bailing airflow ratio
Shroud Height Effects
Shroud Height & Airflow Effects

Baseline

Inlet Hood

ARD, mg/m³

2:1 ratio
3:1 ratio
4:1 ratio
Baseline Inlet Hood

Shroud Gap Height, in

2" ht. 8" ht. 14" ht. 2" ht. 8" ht. 14" ht.

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Adjustable Height Shroud

✓ Dust emissions below 0.5 mg/m³
Horizontal Shelf Laboratory Testing

80% Dust Reduction @ 2:1 Collector to Bailing Air Flow Ratio
Horizontal Shelf Field Testing

Examining More Robust Retrofit Shelf Designs
Drill Stem Leakage

- Maintain good seal between drill stem and table
- Use air ring seal
Maintain Good Drill Stem and Table Seal
Air Ring Seal

- 41 – 70 % Dust Reduction
- Large Chip Elimination
Collector Dump

- Shroud dump discharge close to the ground

0.53 – 1.34 mg/m³

0.16 – 0.24 mg/m³

✓ Shroud dump discharge close to the ground
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 from excessive water
Water Separator Increases Roller Bit Life

- 98% With Separator
- 96% Without Separator
- Bit life increased 4.5 times

Limited to large drill stems
Smaller Drill Stem Water Separator
Smaller Drill Stem Water Separator Study

Wet vs Dry Drilling

Concentration, mg/m²

Wet

Dry

CDC

NIOSH
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
Refurbish Cabs

- Ceiling mounted heating and AC units
- External filter and fan units
- Improve cab enclosure seals
# Enclosed Cab Field Studies

<table>
<thead>
<tr>
<th>Cab Evaluation</th>
<th>Cab Pressure Inches w.g.</th>
<th>Equivalent Wind Vel. mph</th>
<th>Inside Dust Level mg/m³</th>
<th>Outside Dust Level mg/m³</th>
<th>Protection Factor Out/In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotary Drill</td>
<td>None Detected</td>
<td>0</td>
<td>0.08</td>
<td>0.22</td>
<td>2.8</td>
</tr>
<tr>
<td>Haul Truck</td>
<td>0.01</td>
<td>4.5</td>
<td>0.32</td>
<td>1.01</td>
<td>3.2</td>
</tr>
<tr>
<td>Front-End Loader</td>
<td>0.015</td>
<td>5.6</td>
<td>0.03</td>
<td>0.30</td>
<td>10.0</td>
</tr>
<tr>
<td>Rotary Drill</td>
<td>0.20 – 0.40</td>
<td>20.3 – 28.7</td>
<td>0.05</td>
<td>2.80</td>
<td>56.0</td>
</tr>
<tr>
<td>Rotary Drill</td>
<td>0.07 – 0.12</td>
<td>12.0 – 15.7</td>
<td>0.07</td>
<td>6.25</td>
<td>89.3</td>
</tr>
</tbody>
</table>

Ascending
Ensure Good Cab Integrity & Positive Pressurization

Hard to Seal Gaps
Utilize High Efficiency Respirable Dust Filters

- Intake filter $\geq 95\%$ on respirable-sized dusts
- Use an efficient recirculation filter
# Key Results of Laboratory Cab Testing

<table>
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<tr>
<th>Filters</th>
<th>Average Cab Performance Parameters</th>
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<tbody>
<tr>
<td>Intake</td>
<td>Recirculation?</td>
</tr>
<tr>
<td>Low (E_I) 38% No</td>
<td>1.7</td>
</tr>
<tr>
<td>Low (E_I) 38% Yes</td>
<td>13.4</td>
</tr>
<tr>
<td>High (E_I) 99% No</td>
<td>13.3</td>
</tr>
<tr>
<td>High (E_I) 99% Yes</td>
<td>168.4</td>
</tr>
</tbody>
</table>

90% Efficient Recirculation Filter Improved Both Cab Protection Factor & the Time to Reach It After the Door is Closed
Cab Mathematical Model

\[ PF = \frac{C_{\text{outside}}}{C_{\text{inside}}} = \frac{Q_I + Q_R \eta_R}{Q_I (1 - \eta_I + l \eta_I) + Q_w} \]  

(Ideal Conditions)

Where:

\( Q_I \) - Intake air quantity into the cab \((Q_I > 0)\), volume per unit time
\( \eta_I \) - 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
\( \eta_R \) - Recirculation filter efficiency, fractional
\( Q_W \) - Wind quantity infiltration into the cab, volume per unit time

Cab Model Calculations

1) Baseline Design:  $Q_I = 40 \text{ ft}^3/\text{min}$, $Q_R = 200 \text{ ft}^3/\text{min}$, $\eta_I = 0.95$, $l = 0$, 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:  $l = 0$; $PF = 95$
Additional Benefits of Good Filtration

Clean HVAC

Dirty HVAC
Minimize Dust Sources in Cab

- Seasonal dust level increased from 0.04 to 0.68 mg/m³
- Floor heater use increased dust levels from 0.03 to 0.26 mg/m³

- Use good housekeeping practices
- Remove floor heaters
- Rubber mats better than carpeting
- Gritless sweeping compounds
  *non-petroleum based*
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
CONTROLLING HAULAGE ROAD DUST
Average Airborne Particle Size Distribution

Cascade Impactor Particle Size Ranges (microns)

Mass Fraction (%)

- 0.00 - 1.55: 1.73%
- 1.55 - 3.50: 2.16%
- 3.50 - 6.00: 4.71%
- 6.00 - 9.80: 6.71%
- 9.80 - 14.80: 11.61%
- 14.80 - 21.3: 18.81%
- 21.3 - 50: 54.27%
Typical Gravimetric Dust Concentrations
Dust Dissipation Effect

Road Berm
50 ft
100 ft

Respirable Dust Concentration, mg/m³

Time Period Around Truck Passage, sec.

Time Truck Exited Sampling Grid

Total: Resp. ≈ 8 to 10:1    Thoracic: Resp. ≈ 3 to 4:1
Treatment of Unpaved Road Services

- Water effective with reapplications
- Salts, surfactants, soil cements, bitumens films (polymers) extend time of effectiveness
Increase Distance Between Vehicles
Enclose the Primary Hopper Dump

- Staging Curtains Reduce Dust Billowing Out

✓ Staging Curtains Reduce Dust Billowing Out
Use Water Sprays to Suppress the Dust

- Start by adding 1% moisture by weight
- Use photo cell or mechanical controlled sprays
Prevent Dust Roll Back Under Vehicle

- Tire stop reduces rollback underneath equipment
- Water sprays knockdown and redirect dust
CONCLUSIONS

- Dry and Wet Drill Dust Collection Systems 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
Questions or Comments?

John A. Organiscak, 412-386-6675, jorganiscak@cdc.gov

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