SILICA DUST CONTROLS FOR SURFACE MINES

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2004–2008 MSHA Dust Samples

<table>
<thead>
<tr>
<th>Mining Commodity</th>
<th>% of Dust Sample 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
Drill Shroud Leakage

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

![Graph showing the effect of shroud height on control efficiency. The graph compares two curves labeled BE45R and BE60R.]
Shroud Height and Airflow Effects

![Bar chart showing ARD (mg/m³) for different shroud gap heights and ratios.](chart.png)
Adjustable Height Shroud

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

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

- 55%–66% dust reduction at two mines
- Examine more robust 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
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
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/m³

Wet

Dry
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>
Ensure Good Cab Integrity and Positive Pressurization

Hard to Seal Gaps
Use High Efficiency Respirable Dust Filters

- Intake filter $\geq 95\%$ on respirable-sized dusts
- Use an efficient recirculation filter
Additional Benefits of Good Filtration

Clean HVAC

Dirty HVAC
Minimize Dust Sources in Cab

Test Results:
• 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

Solutions:
• 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
Link to enclosed cab video
Difficult to Field Quantify Cab Performance Factors

- Airflow
- Filter loading
- Leakage
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
### Key Results of Laboratory Cab Testing

#### Filters

<table>
<thead>
<tr>
<th>Intake</th>
<th>Recirculation?</th>
<th>$PF$ $C_{out}/C_{in}$</th>
<th>$Q_{intake}$ cfm</th>
<th>$\Delta p_{filter}$ “w.g.”</th>
<th>$L$ %</th>
<th>$Q_{recir}$ cfm</th>
<th>$\Delta p_{cab}$ “w.g.”</th>
<th>Stability min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low $E_I$ 38%</td>
<td>No</td>
<td>1.7</td>
<td>37.3</td>
<td>0.30</td>
<td>2.0</td>
<td>366</td>
<td>0.17</td>
<td>17</td>
</tr>
<tr>
<td>Low $E_I$ 38%</td>
<td>Yes</td>
<td>13.4</td>
<td>41.0</td>
<td>0.47</td>
<td>2.6</td>
<td>328</td>
<td>0.19</td>
<td>8</td>
</tr>
<tr>
<td>High $E_I$ 99%</td>
<td>No</td>
<td>13.3</td>
<td>18.1</td>
<td>0.52</td>
<td>3.6</td>
<td>386</td>
<td>0.07</td>
<td>29</td>
</tr>
<tr>
<td>High $E_I$ 99%</td>
<td>Yes</td>
<td>168.4</td>
<td>23.2</td>
<td>0.70</td>
<td>4.9</td>
<td>338</td>
<td>0.08</td>
<td>8</td>
</tr>
</tbody>
</table>

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

Cab pressure reflective of enclosure integrity and intake air quantity, not intake air quality!
Intake Air Leakage Effects

Intake filter loading proportionally increases airflow through leakage areas!
Cab Mathematical Model*

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

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: \( l = 0; \ PF = 95 \)
CONTROLLING HAULAGE ROAD DUST
Average Airborne Particle Size Distribution

- 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%

Cascade Impactor Particle Size Ranges (microns)
Typical Gravimetric Dust Concentrations

- Respirable
- PDR
- Respirable
- Thoracic
- Total

Dust Concentration (mg/m^3)
Dust Dissipation Effect

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

![Graph showing dust concentrations over time lag in seconds, with an increase in distance between vehicles as a significant factor reducing dust concentrations.](image)
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
 Prevent Dust Roll Back Under Vehicle

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