Best Practices for Dust Control in Metal/Nonmetal Underground Mining

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Overview

- Case studies of dust control in large-opening mines:
  - Dump/crusher
  - Production shots
  - Haulage cycle
  - Other sources
Dust Control in Large-opening Mines

Ventilation

- Dilute and transport dust from mine atmosphere

- Direct dust away from workers
Improvements in Ventilation to Remove Harmful Particulate

**Mine-wide** – Main fan to establish airflow on a mine-wide basis

**Local** – Booster fans for more direct and controlled air volume
Improvements in Ventilation to Remove Harmful Particulate

**Stoppings** – in key locations to more efficiently direct and control airflow

**Long Pillars** – reduce number of stoppings
Controlling Dust with Ventilation
Dump/Crushing Facility – Local Ventilation
UNDERGROUND CRUSHERS

- As mines become larger, crusher facilities are located underground
- Major point source of silica dust requiring engineering controls
Isolate crusher from general mine air using curtain stoppings.

Use booster fans to transport and dilute dust.
Evaluated Two Types of Fans

Axial Vane Fan
- 36-inch diameter
- 50 hp electric
- 50,000 cfm

Propeller Fan
- 60-inch diameter
- 27.2 hp diesel engine
- 50,000 cfm
Main Air
Return
Location of Crusher, 15 Stoppings, and Fans
Axial Vane or Propeller Fan
Sampling Strategy

Characterize dust levels and distribution around the crusher by area sampling at six key locations.

Sample for three days for each fan.

Fan approximately 100 ft from dump.
Area Sampling

1- Intake/crusher side

2 - Dump

3- Crusher: outside/inside booth

4- Belt

5- Return/crusher side

6- Adjacent entry
Pressurization and Dust Filtration System

Crusher: 300 hp – 1,000 tph

Operator’s Booth
## Daily Production Per Sampling Shift

<table>
<thead>
<tr>
<th>Shift number</th>
<th>Axial Vane Fan</th>
<th>Propeller Fan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Gravimetric sampling time, min</td>
<td>316 322 298</td>
<td>325 312 297</td>
</tr>
<tr>
<td>Measured tonnage</td>
<td>3780 3890 3890</td>
<td>3820 3785 3820</td>
</tr>
</tbody>
</table>
Velocity Measurements
<table>
<thead>
<tr>
<th>Fan type</th>
<th>Axial Vane</th>
<th>Propeller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average air velocity at</td>
<td>690</td>
<td>725</td>
</tr>
<tr>
<td>regulator, fpm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average Air Velocity Across Dump, fpm**

<table>
<thead>
<tr>
<th>Fan type</th>
<th>Left Side</th>
<th>Center</th>
<th>Right Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avial Vane</td>
<td>240</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Propeller</td>
<td>240</td>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>
Results: Gravimetric Samplers
Respirable Dust Concentrations
Gravimetric Sampling: 3-Day Average

Concentration mg/m³

Location

Intake -1  Dump -2  Crusher -3  Belt-4  Return -5  Adj. entry -6

Axial Vane Fan  Propeller Fan

- Intake -1: 14.9%
- Dump -2: 23.1%
- Crusher -3: 17.5%
- Belt-4: 3.7%
- Return -5: 24.4%
- Adj. entry -6: 21.2%
Respirable Silica Dust Concentrations
Gravimetric Sampling: 3-Day Average

Location

Concentration, mg/m³

Intake -1  Dump - 2  Crusher - 3  Belt-4  Return - 5  Adj. entry -6

Axial Vane Fan
Propeller Fan

22.3%  24.7%  17.9%  12.8%  27.5%  30.4%
Propeller Fan vs. Axial Vane Fan

Reductions in Dust
3-Day Average

Respirable Dust
Averaged 16% Reduction

Respirable Silica
Averaged 21% Reduction
Best Practices

1. Isolate the dump/crusher/belt from the general mine air

2. Provide ventilation to move dust to return air

3. Locate booster fans as close to the dump as possible for better air movement

To protect operator

Equip booth with a filtration/pressurization system
Controlling Dust with Ventilation

Production Shots: Mine-wide Ventilation
Dust Generated by Production Shots

• Can generate high quantities of dust depending on number of shots

• Inadequate ventilation may cause dust clouds to break up and disperse in mine

• Leads to higher background levels of silica that can recirculate in mine atmosphere
Thermo Scientific’s personalDataRam (pDR)

- The movement of shot dust through the mine can be monitored and evaluated using pDRs.
- pDR gives the time and average concentration over logged period.
Point Source of Dust
Dust Cloud Signature
Logged time, known distance, estimate velocity

Example:
pDR located 1500 ft from shot

<table>
<thead>
<tr>
<th>Time, min</th>
<th>Velocity, ft/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival</td>
<td>30</td>
</tr>
<tr>
<td>Peak</td>
<td>120</td>
</tr>
<tr>
<td>End</td>
<td>360</td>
</tr>
</tbody>
</table>

Average Velocity = 22.2 ft/min
Typical Results of Dilution of Respirable Dust from Shot Source

<table>
<thead>
<tr>
<th>Distance from Shot, ft</th>
<th>Concentration, mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>1.6</td>
</tr>
<tr>
<td>700</td>
<td>1.0</td>
</tr>
<tr>
<td>900</td>
<td>0.6</td>
</tr>
<tr>
<td>1100</td>
<td>0.4</td>
</tr>
<tr>
<td>1500</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Concentrations from pDR Sampling
Case Study

Determine influence of fan and curtain installation for improving both ventilation and shot dust removal from mine
Improving Mine-wide Ventilation

Curtain Stoppings

Propeller Fans
Objectives

• Monitor travel path of the dust cloud

• Determine average air velocity based on time-to-station dust data

• Establish the in-mine dust retention time
  – Time required to clear dust from the mine
Dust Sampling

Position pDRs around curtain perimeter to monitor dust
Estimated Air Velocities

- Red bars: Day 1 - 3 shots
- Blue bars: Day 2 - 1 Shot

Velocity, fpm

Site Location
Two Hartzell high volume/low pressure propeller fans each rated at 500,000 cfm

Over 40 curtain stoppings around perimeter of faces
Estimated Velocities After Installation of Propeller Fans and Curtain Line

Site Location

Velocity, fpm

Day 1 - 5 shots
Day 2 - 3 Shot
Propeller Fan and Curtain Line Air Velocity Enhancement

<table>
<thead>
<tr>
<th>Velocity, ft/min</th>
<th>Full Curtain</th>
<th>Partial Curtain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td></td>
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<td>7</td>
<td></td>
<td></td>
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<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dust Retention Time

120 min
No Propeller Fans and Partial Curtain Line

20 min
Propeller Fans and Completed Curtain Line
Best Practices

• Install a main fan to establish air circuits on a mine-wide scale

• Install permanent or brattice stoppings or long pillars in key locations throughout the mine to more efficiently direct and control airflow

• Use booster fans to assist main fan if needed
UNDERGROUND GOLD MINE

SAMPLING TRUCKS DURING THE HAULAGE CYCLE
OBJECTIVE: BASELINE STUDY

- Evaluate truck driver dust exposure during haulage cycle
- Determine the difference in silica dust levels between dry and wet stopes
- Use gravimetrics and pDRs
- Use pDRs to monitor trucks during haulage cycle
SAMPLING STRATEGY

- Record load, tram, and dump times
- Record tonnage
- Collect area samples at other locations in stope
Long-hole Open Stope

Sampling locations:
1. Intake
2. Trucks No. 1 and 2
3. Loading
4. Dump (1600 level)
5. Return

Booster fans

West vent raise

Truck load location

Intake air

Ramp to dump

East vent raise

Stope 3600

Dry Stope

Stope 21

Wet stope
Intake air:
560 fpm
180,000 cfm

Intake air supplemented by booster fans

Axial vane fan:
30,000 cfm
Results from Gravimetric Samplers
• Intake low indicating clean air
• Trucks 1 and 2 very similar for three days
• Load and dump locations were highest
• Day 3: Wet muck, high concentration at some locations

Respirable Dust

![Graph showing concentration levels for different days and locations.]

- Day 1 - Dry
- Day 2 - Dry
- Day 3 - Wet
• Trucks 1 and 2 similar; little decrease on day 3

• Quartz concentrations highest at dump

• No consistent pattern
Tonnage Per Sampling Period

Tonnage loaded on day 3 was almost twice the tonnage on days 1 and 2.

<table>
<thead>
<tr>
<th>Day</th>
<th>Trucks 1 and 2 Combined Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Dry</td>
<td>330</td>
</tr>
<tr>
<td>2 - Dry</td>
<td>198</td>
</tr>
<tr>
<td>3 - Wet</td>
<td>528</td>
</tr>
</tbody>
</table>
Dry Versus Wet Muck – Respirable Quartz, mg

- Quartz weight, (mg) vs. tonnage

- Trucks 1 and 2: 40% more tonnage on day 3

- Wet stope produced 28% less quartz by weight on filter
• Quartz generation normalized to 1,000 tons

• Wet muck: lower values at all locations

• Percent Decrease:
  Truck 1 – 170%
  Truck 2 – 200%
  Load – 30%
  Dump – 280%
HAULAGE CYCLE

1) Loading
2) Tramming full
3) Dumping
4) Tramming empty

Results from pDR
Time Study Using pDRs
Dry vs. Wet Stope

- Truck 1 and 2 combined

- Wet stope – lower dust at loading, tramming full and dumping

- Trucks 1 and 2 32% and 35% reduction in dust levels, respectively
Time-weighted-average Dust Contributions

Dump location had highest dust contribution despite having the shortest duration… (14% time vs. 34% dust)
Best Practices

To reduce quartz levels:

- Establish an air circuit with main mine fan
- Use auxiliary air keeping it as close to the loading area as possible
- Keep muck wet when loading
- Control haul road dust
Other Dust Sources

- Scalers
- Haul road dust
- Down-hole drills
Pick type
harder rock

Rotary head
softer rock
Dust Issues

- Visibility
- Nuisance dust >10 microns
Spray Systems

Sprays must be located as close to dust source as possible.
500 Gallon Tank

Refill 2.5 hrs
Move and dilute dust with booster fan

Fan placement: Location of face
Other Dust Sources

• Scalers

• Haul Road Dust

• Down-hole drills
...can be a significant source of dust liberation
Safety Hazards:
Impair operator’s visibility
Summer
High humidity

Winter
Road wetting to control dust generation
ROAD WETTING EFFECT
Sampling with pDR

Road Drying Out
Wet road

Respirable Dust Level, mg/m³

Time, hr:min:sec
Haul Road Dust Research

- 80% of dust is not respirable, > 10 microns
- Dust levels diminish approximately 50 feet from source
- Sampling shows that road wetting is an effective technique when practiced as required
Best Practices

• Road wetting is effective, but continual maintenance must be practiced

• Use traffic control as a dust control technique:
  – Max exposure occurs within 4–15 seconds behind a haul truck
  – Require trucks to maintain more than 20 seconds of separation
  – May result in a 40%–50% reduction in respirable dust exposure to the following truck
Other Dust Sources

• Scalers

• Haul road dust

• Down-hole drills
Down-hole Drills

Ninety percent of dust emissions from:

- Drill shroud leakage
- Drill stem bushing leakage
- Dust collector dump discharge
To Reduce Dust Exposure

Use booster fans to remove dust in poorly ventilated benches
Best Practices

• Maintain a tight drill deck shroud enclosure with the ground

• Maintain a collector-to-bailing airflow ratio of at least 3:1

• Maintain the dust collector as specified by the manufacturer
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Thank You

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Questions?