Mine Ventilation

• Dust Control
Mine Ventilation is used to Dilute and Render Harmless

- All Noxious Gases
- Dusts!!!!
Dust Concentrations are Inversely Proportional to Air Quantity
(under ideal situations)

Double the Air Quantity, Dust Concentration is Cut in Half!!!

N X Air Quantity = 1/N Concentration

• N=2
• 2 Quantity = ½ Concentration
- 20,000 cfm - 2.0 mg/m³ Concentration
- 40,000 cfm - 1.0 mg/m³ Concentration
- 10,000 cfm - 4.0 mg/m³ Concentration
Practical Ways To Increase Air Quantities

• Increase Fan Quantity
• Mine Design
• Reduce Leakage
Basic Mine Ventilation Equations

\[ H = R \ Q^2 \]

- \( H \) – Pressure Loss (Inches of Water)
- \( R \) – Resistance
- \( Q \) – Quantity of Air
Parallel Flow in Airways

- \( R_n = \frac{1}{n^2} \times R_1 \)

- \( R_1 \) is Original Resistance (1 entry)
- \( N \) is number of Entries
Multiple Entries

• One to Two Entries
  – $R_2 = \frac{1}{4} R_1$
    • You have reduced your resistance to $\frac{1}{4}$ original resistance

• One to Three Entries
  – $R_3 = \frac{1}{9} R_1$
    • You have reduced your resistance to $\frac{1}{9}$ original resistance
Single Entry (Intake and Return)

1" H20 Pressure
30,000 cfm

1" H20 Pressure
30,000 cfm
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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</table>

**Double Entry (Intakes and Returns)**

**1” H20 Pressure**

60,000 cfm

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**1” H20 Pressure**

60,000 cfm
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Cell 1" /></td>
<td><img src="image2.png" alt="Cell 2" /></td>
<td><img src="image3.png" alt="Cell 3" /></td>
<td><img src="image4.png" alt="Cell 4" /></td>
<td><img src="image5.png" alt="Cell 5" /></td>
<td><img src="image6.png" alt="Cell 6" /></td>
<td><img src="image7.png" alt="Cell 7" /></td>
<td><img src="image8.png" alt="Cell 8" /></td>
<td><img src="image9.png" alt="Cell 9" /></td>
<td><img src="image10.png" alt="Cell 10" /></td>
<td><img src="image11.png" alt="Cell 11" /></td>
</tr>
</tbody>
</table>

**Single Entry (Intake and Return)**

- **1” H₂O Pressure**
  - 30,000 cfm

- **1” H₂O Pressure**
  - 30,000 cfm
Double Entry
(Intakes and Returns)

0.25” H₂O Pressure
30,000 cfm

0.25” H₂O Pressure
30,000 cfm
Leakage

• Patch Holes in Stopping

• Lower Pressure Drop Across Entries
  – Multiple Entries
  – Do not locate Intakes and Returns side by side
  – One open air split
    • No Regulator
    • Also reduces energy costs
Face Ventilation

• Get the Air where you Need it!
  – Tight Check Curtains
  – Good Run Through Curtains
  – Curtain tight to the roof
  – Do not Park Equipment in Last Open Entries
  – Keep curtains close to the face
Exhaust or Blowing Ventilation

- Blowing is better for Methane Control
- Exhaust is better for dust Control
Blowing Curtain

- Blowing curtain is easier to maintain
  - Less manpower to hang curtain
  - No need for frame work
  - “Cheap Man’s Ventilation!”

- Miner Operator should always be in fresh air!
- Higher possibility for Roof Bolters, Shuttle Car and Ram Operators to be out!
  - Especially Important in high silica faces!!!!

- Generally Better for Methane Control!
- Scrubber must be used with Blowing Curtain and the use of Scrubber results in less return float dust!
Exhaust Ventilation

• Better for Dust Control
  – May be necessary in high silica areas

• Allows most workers to always be in intake air
  – Exception may be the roof bolters

• At same curtain set back distances, exhaust ventilation is not as efficient in removing methane
Airflow Patterns Blowing Vrs. Exhausting

**A BLOWING**

Airflow patterns independent of air volume

- ○ Turbulence
- → Primary airflow
- — Secondary airflow

**B EXHAUSTING**
Accurate Face Air Measurements
Scrubber, Tubing and Curtain Measurements

• A Pitot Tube Traverse must be used to accurately measure airflow in ventilation tubing and the ducting of dust scrubbers; especially where there are > 3000 fpm velocities

• An accepted method must be utilized and those at the mine that are tasked to conduct the measurements must be given hands-on training
Why not use a Vane Anemometer?

- According to the ACGIH Industrial Ventilation Recommended Practice
  - This instrument is accurate to determine air flow through large supply and exhaust openings
  - The cross-sectional area of the instrument should not exceed 5% of the measured area.
  - Standard 4” anemometer is unsuited for measurements in ducts below 20” diameter
  - Generally, Useful range is below 3,000 fpm
  - Velocities vary dramatically throughout scrubber
  - Pitot tube has less error at higher velocities!
Pitot Tube used to Measure Air Speed (Velocity)
Proper Scrubber Air Quantity

- Full Pitot Tube Traverse
  - Machine is New (baseline)
  - Clean
  - Water is on
- Pitot tube faces direction of Air Flow
- Get a Proper Area
- Scrubber Exhaust Clear
Full Pitot Tube Traverse
Equal Circular Areas

10 POINT PITOT TRAVERSE IN A CIRCULAR DUCT.
(GREATER THAN 6" DIAM.)
10 OR 20 LOCATIONS IN CENTERS OF EQUAL ANGULAR AREA.

FIGURE 9-10A. 10-point Pitot traverse in a circular duct

6 POINT PITOT TRAVERSE IN A CIRCULAR DUCT.
(6" DIAM. OR LESS)
6 OR 12 LOCATIONS IN CENTERS OF EQUAL ANGULAR AREA.

FIGURE 9-10B. 6-point Pitot traverse in a circular duct
• After a proper full pitot tube traverse has been conducted, a single point measurement may then be correlated to ascertain the scrubber air quantity
What Should the Line Brattice Air Quantity Be

• Typically on blowing this quantity has been +/- 1,000 cfm of scrubber capacity
  – Lower limit recently changed to be at least the scrubber air quantity (reduce recirculation)
  – MSHA policy is that this upper quantity can be greater than scrubber capacity by 15% or 1,000 cfm
  – Upper limit to reduce “overpowering” of the scrubber
    • Excessive air quantities
    • 400 fpm
    • Overpower when Curtain close to the cutting face

• On exhausting
  – Tech support advises this minimum quantity be at least the scrubber air quantity

• Take Line Brattice Air Reading with the Scrubber Off!!!!
Higher Air Quantities can overpower the scrubber if
Line Brattice Air Velocity is too high
or
Curtain too close to Cutterhead

Effects Ram Car Operators & Downwind Personnel (Roof Bolters)

Higher air quantity than the scrubber
AND
Curtain to close to cutting head
OR
Velocity exceeds 400 fpm
How to Stop Over Powering of Scrubber

Balanced Airflow
Or
Higher Air Quantities with

Low Air Velocity (below 400 fpm)
- increasing curtain area

Keep curtain away from cutterhead

Additional Step cuts allow curtain be held back!
- the deeper your sump cut the closer the curtain will be to your cutterhead on slab cut
Recently, MSHA has been requiring the line brattice air quantity be the minimum of the scrubber capacity measured with the scrubber off

Why????

This assures adequate Intake Air is being supplied to the face

Prior to this change, Recirculation of return air was contaminating the intake curtain and causing dust overexposures to the continuous miner operator
How was this recirculation Identified (4 ways)

1. By CMO’s going out of compliance!
2. Use of Chemical Smoke on the curtain for air currents
3. Air Measurements of the Line curtain
4. Inby and outby line curtain dust concentrations
Face Airflows

Scrubber Rating
7,500 cfm

Inadequate Intake Air

20,000 cfm

Inby End of Curtain
Scrubber Off 3,000 cfm
Scrubber On 7,500 cfm

Outby End of Curtain
Scrubber Off 4,000 cfm
Scrubber On 4,300 cfm

20,000 cfm
• Amount of Re-circulation will depend on
  – Air Quantity in the curtain area
  – Length of curtain
  – Integrity of hung curtain
  – Equipment position
  – Entry dimensions
# Air Measurements from a Dust Face Study

<table>
<thead>
<tr>
<th>Date</th>
<th>Cut No.</th>
<th>Curtain Length (feet)</th>
<th>Scrubber (on/off)</th>
<th>Airflow (cfm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Miner Line Curtain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Outby</td>
</tr>
<tr>
<td>8/2/05</td>
<td>1</td>
<td>151</td>
<td>on</td>
<td>6,200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>off</td>
<td>7,100</td>
</tr>
<tr>
<td>8/2/05</td>
<td>2</td>
<td>145</td>
<td>on</td>
<td>7,900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>off</td>
<td>8,300</td>
</tr>
<tr>
<td>8/2/05</td>
<td>3</td>
<td>192</td>
<td>on</td>
<td>8,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>off</td>
<td>7,400</td>
</tr>
<tr>
<td>8/2/05</td>
<td>4</td>
<td>161</td>
<td>on</td>
<td>7,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>off</td>
<td>8,000</td>
</tr>
<tr>
<td>8/2/05</td>
<td>1</td>
<td>159</td>
<td>on</td>
<td>7,900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>off</td>
<td>6,200</td>
</tr>
<tr>
<td>8/2/05</td>
<td>2</td>
<td>204</td>
<td>on</td>
<td>10,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>off</td>
<td>8,800</td>
</tr>
</tbody>
</table>
Factors that affect inby vs. Outby air Quantities

- Scrubber
- Line Brattice
  - Length of curtain
  - Condition of curtain
    - How well is curtain hung
  - Turning 90’s
    - Direction of scrubber exhaust

- Other Section Variables
  - Equipment location
    - Ram Cars
Face Airflows

Scrubber Rating
7,500 cfm

Proper Intake Air

Inby End of Curtain
Scrubber Off 7,500 cfm
Scrubber On 7,900 cfm

Outby End of Curtain
Scrubber Off 9,000 cfm
Scrubber On 9,200 cfm

20,000 cfm
## Dust Concentrations from a Face Dust Survey

<table>
<thead>
<tr>
<th>Area</th>
<th>Dust Concentration (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8/2/05</td>
</tr>
<tr>
<td>Section Main Intake</td>
<td>0.13</td>
</tr>
<tr>
<td>Section Main Return</td>
<td>0.67</td>
</tr>
<tr>
<td>Line Curtain Outby End</td>
<td>0.16</td>
</tr>
<tr>
<td>Line Curtain Inby End</td>
<td>2.81</td>
</tr>
<tr>
<td>CM Immediate Return</td>
<td>3.67</td>
</tr>
</tbody>
</table>
Summary - How do we Prove Inadequate Intake Air

- Outby curtain to inby curtain dust area dust concentrations
- Inby curtain vs. Outby curtain Air Quantity Readings
- Smoke the curtain
- Continuous Miner Operator Samples
How Does MSHA Enforce Taking Readings with Scrubber Off?

What is the Purpose of the Scrubber?

- Scrubber main function is to control dust
  - Scrubber is a Dust collection Device
  - Recirculation does not apply

- But, If Scrubber is used to obtain the line brattice air quantity, it is a ventilation device (auxiliary fan) and must meet Regulations!
  - 75.331(4) Located and Operated to avoid recirculation
  - 75.330(c) maintaining line brattice for proper ventilation (no recirculation)

- Take the line brattice air reading with the scrubber off!!! Assure Adequate Intake Air!!!!
2 Major Points

• **Minimum** Line Brattice air Quantity should be the Scrubber Capacity

• **Take Line Brattice Air Reading with the Scrubber Off!!!** Helps to assure Miner Operator is in fresh air!
  – Assures that Adequate Intake Fresh Air is Delivered to the Working Face
Exhaust Ventilation

• Generally better for dust control
  – All employees (except possibly roof bolters) should always be in intake air
  – May be necessary in high silica mining

• If blowing sections can not obtain compliance, Exhaust ventilation is recommended
  – Removes many variables
    • Balancing scrubber and line brattice air quantities
    • Miner Operator Work position
    • Other Employees removed from return air
    • If non compliance occurs, increase line brattice or tubing air quantity
Line Brattice Air Measurement
Intake or Exhaust

• Line Brattice Air Quantities are dynamic entities and may continually change depending on many conditions
Factors Influencing Line Curtain Air Quantities

- Movement through Outby Curtains or mandoors
- Position of other Equipment
- Movement of Outby Equipment
- Scrubber on or off
- Scrubber Capacity changing
- Person taking the Air Reading
  - Bad Measurements
  - Accuracy of Data
Starting Air Quantity 7,000 cfm

Air Quantity at Inby End of Curtain
- 7,000 cfm
- 6,800 cfm
- 2,000 cfm
- 6,300 cfm
- 6,100 cfm
- 9,000 cfm

Changes in Curtain Airflows

25,000 cfm

25,000 cfm
Body Size can Affect Air Readings

Miner’s Size  1 foot wide by 6 feet high
Takes up an area of 6 square feet

\[ V = 300 \text{ fpm} \]
\[ A = 18 \text{ square feet} \]
\[ Q = 5,400 \text{ cfm} \]

\[ V = 300 \text{ fpm} \]
\[ A = 12 \text{ Square feet} \ (18 - 6) \]
\[ Q = 3,600 \text{ cfm} \]

Foreman reports 5,400 cfm when he actually only has 3,600 cfm
Air Quantity Errors Will Add Up

• Scrubber Nameplate Rating 4,600 cfm
• Actual Scrubber Quantity 4,900 cfm
• Plan requires 4,600 cfm to +1000 cfm (5,600 cfm) of the nameplate rating
• Foreman takes an air reading of 4,600 cfm. He is good to go!

• Actual Air Quantity

  - 4,600 cfm Foreman’s Air Reading
  - 1,530 Foreman’s body increased area
  - 300 Adding 40 feet more curtain during cut
  - 460 Error in reading (10% error)

  **2,310 cfm Actual Line Brattice Air Quantity**

You actually have 2,310 cfm ventilating a 4,900 cfm scrubber!!!!

Recipe for recirculation and Poor Dust Control!!
- CM takes a normal sump cut
Offset Cut

- CM does not square face up on slab cut
- Leaves about 4 feet less than square face
At the start of next sump cut, the CM cutterhead is boxed in and the scrubber efficiency is increased.
Working downwind of CM is always discouraged!

When bolting downwind we actually ventilate roof bolter with the dirtiest air from the Continuous Miner

Clean air bypasses roof bolter
Add a curtain in LOX to mix dirty air!
Conclusions

• Dust Concentrations are Inversely Proportional to Air Quantity Ventilation. Increase your face ventilation and utilize it properly and you will reduce your dust concentrations!