Dust Division
Pittsburgh Safety and Health Technology Center

Mark Schultz
Senior Mining Engineer

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/m^3 Concentration
- 40,000 cfm - 1.0 mg/m^3 Concentration
- 10,000 cfm - 4.0 mg/m^3 Concentration

Practical Ways To Increase Air Quantities

- Increase Fan Quantity
- Mine Design
- Reduce Leakage

Fan Air Quantity

- Change Blade Setting
- May need more Motor HRSP.
  - Higher electrical costs

Mine Design

- Basic Mine Ventilation Equations

$$H = R\,Q^2$$

H – Pressure Loss (Inches of Water)
R – Resistance
Q – Quantity of Air

Parallel Flow in Airways

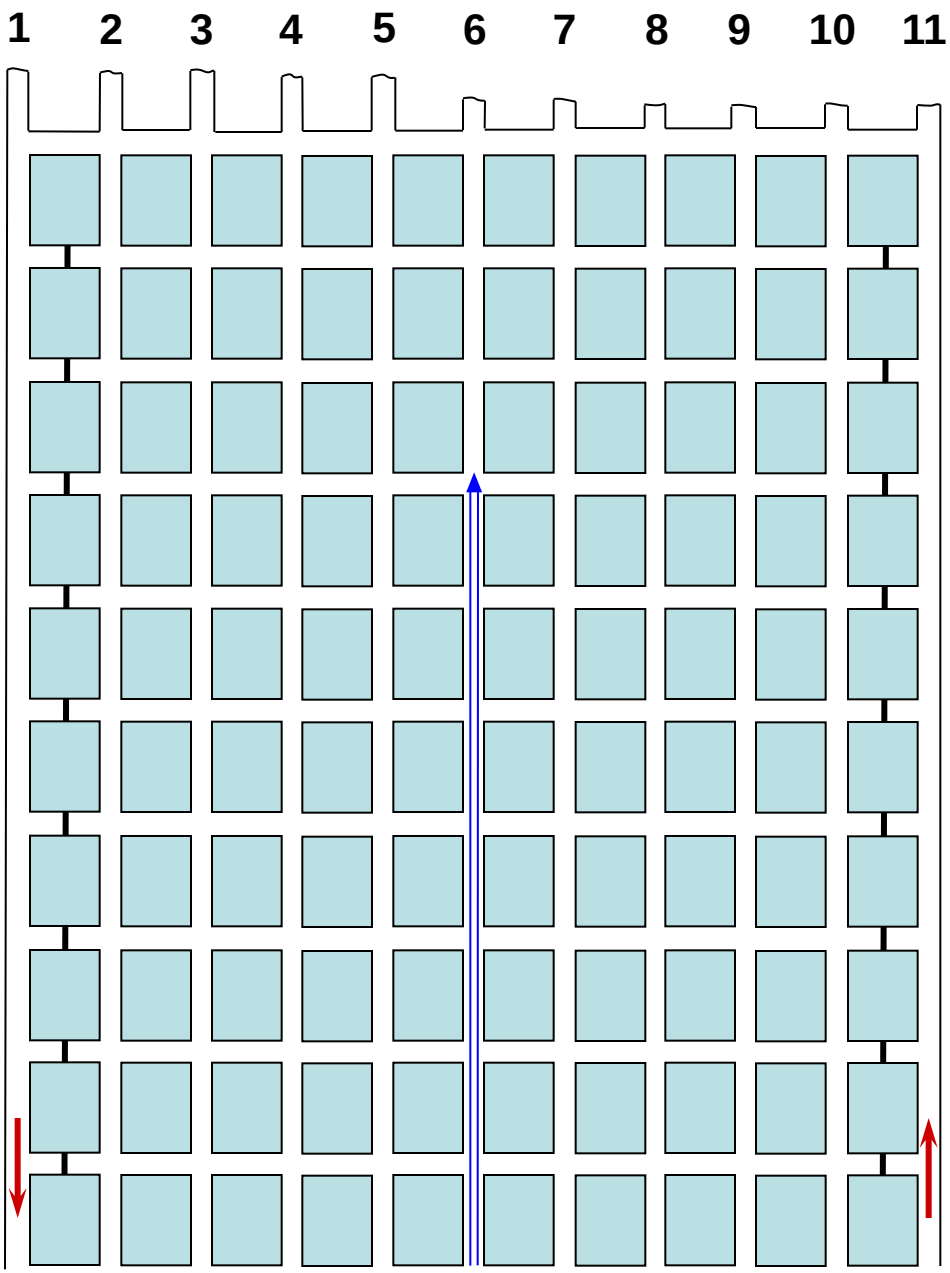
- $R_n = 1/n^2 \ X \ R_1$

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

Multiple Entries

- One to Two Entries
  - $R_2 = ¼ R_1$
    - You have reduced your resistance to ¼ original resistance
- One to Three Entries
  - $R_3 = 1/9 R_1$
    - You have reduced your resistance to 1/9 original resistance

Single Entry
(Intake and Return)



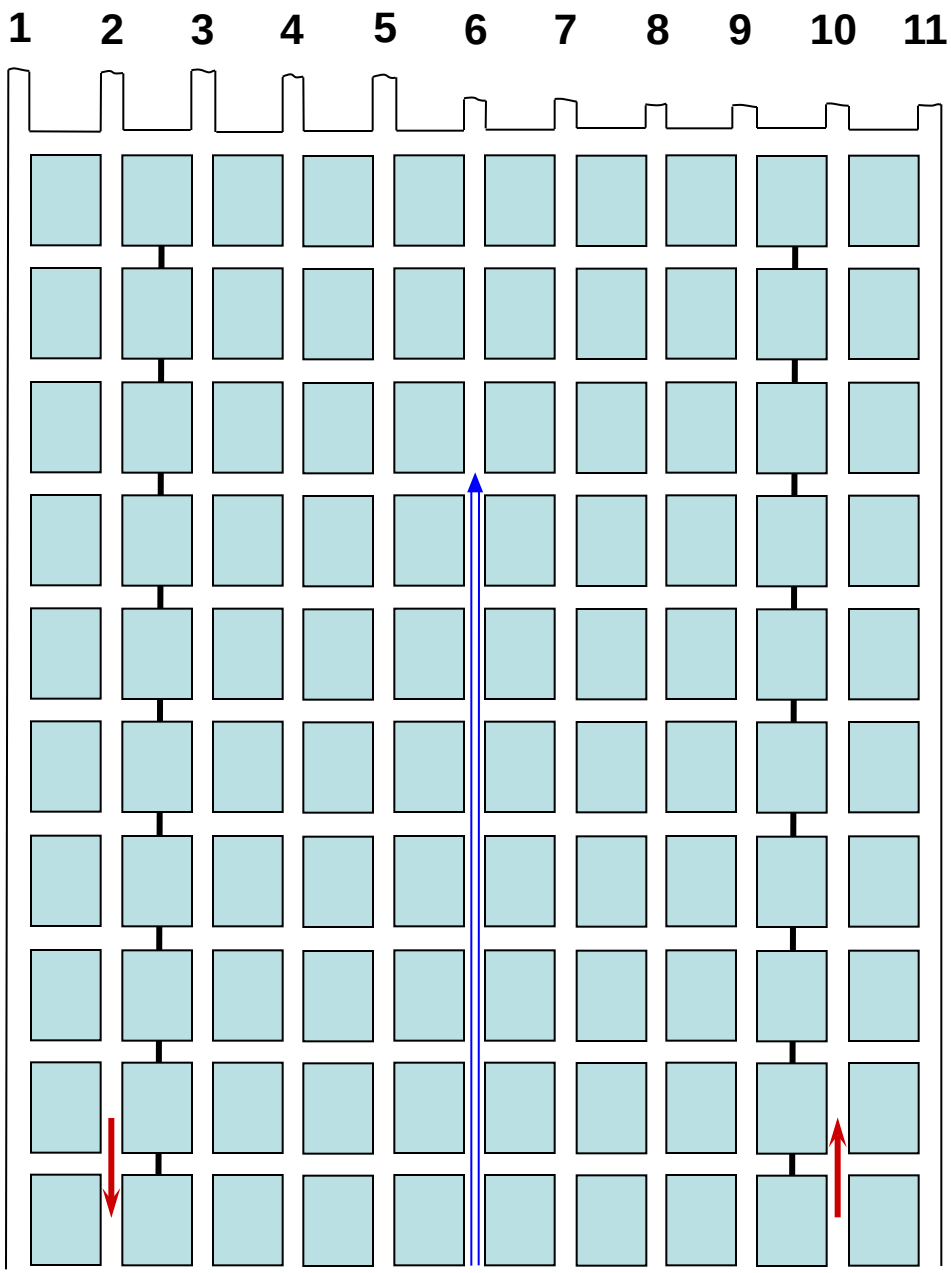
1” H_20 Pressure

30,000 cfm

1” H_20 Pressure

30,000 cfm

Double Entry
(Intakes and Returns)



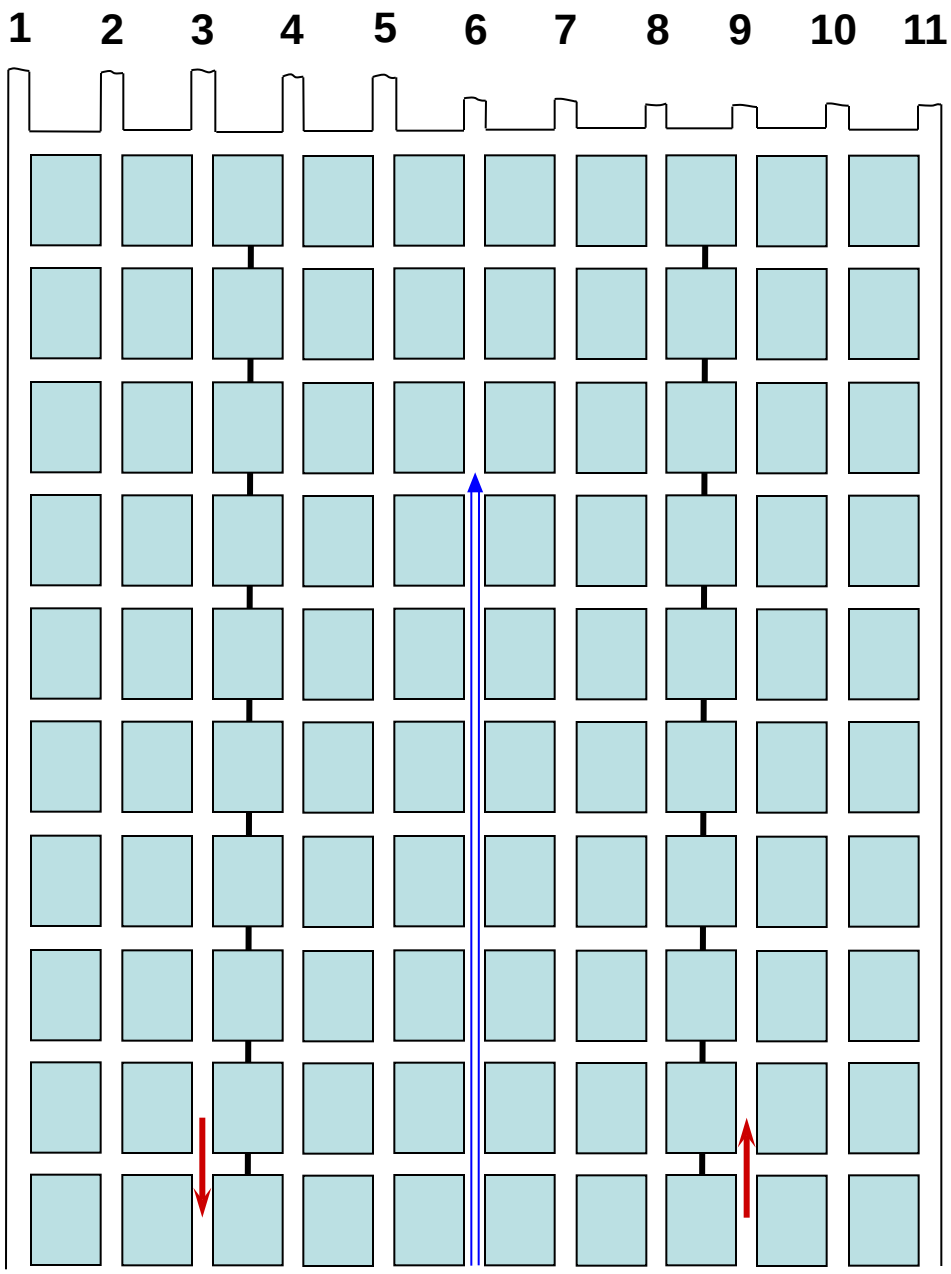
1” H_20 Pressure

60,000 cfm

1” H_20 Pressure

60,000 cfm

Triple Entry
(Intakes and Returns)



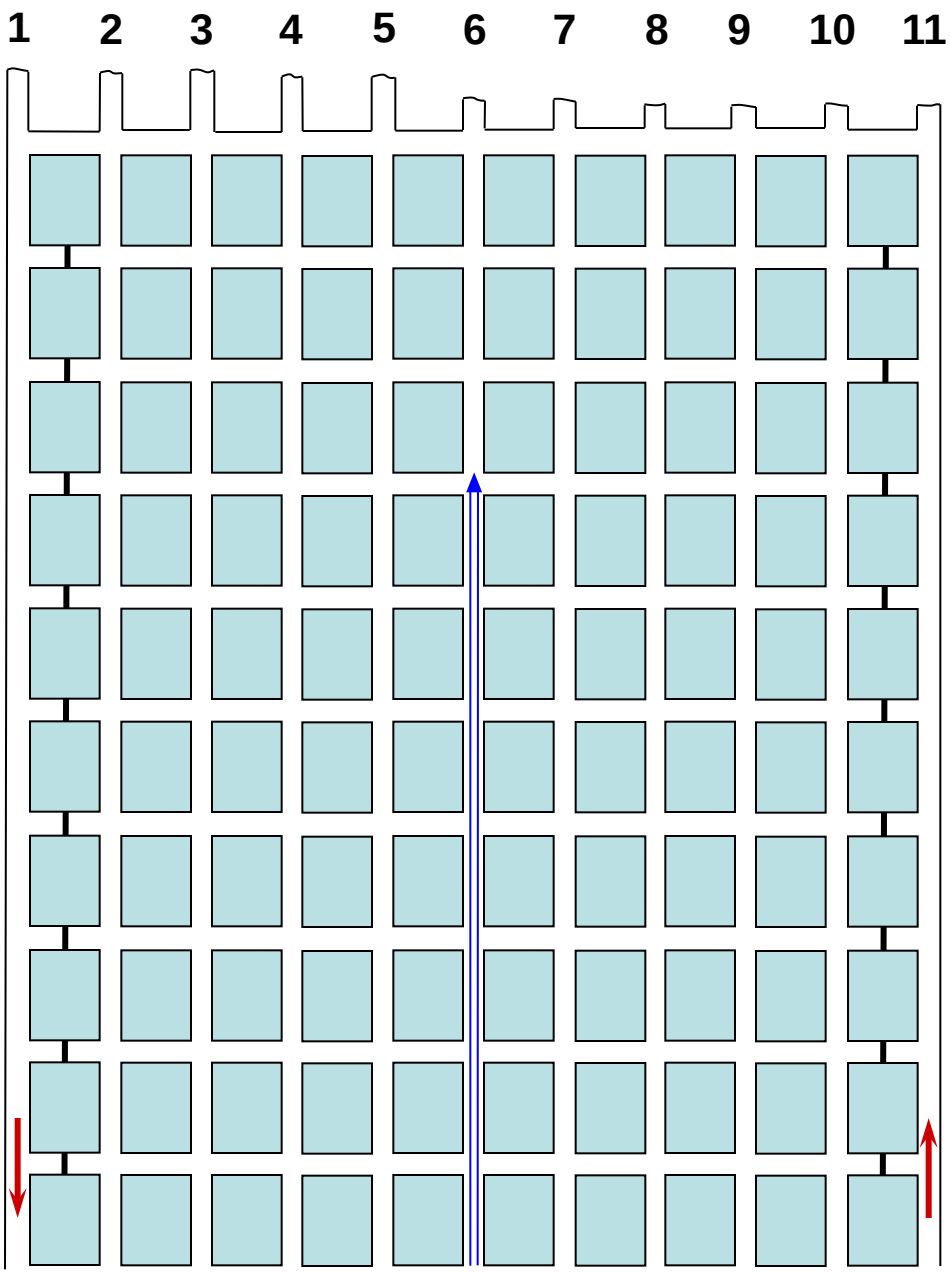
1” H_20 Pressure

90,000 cfm

1” H_20 Pressure

90,000 cfm

Single Entry
(Intake and Return)



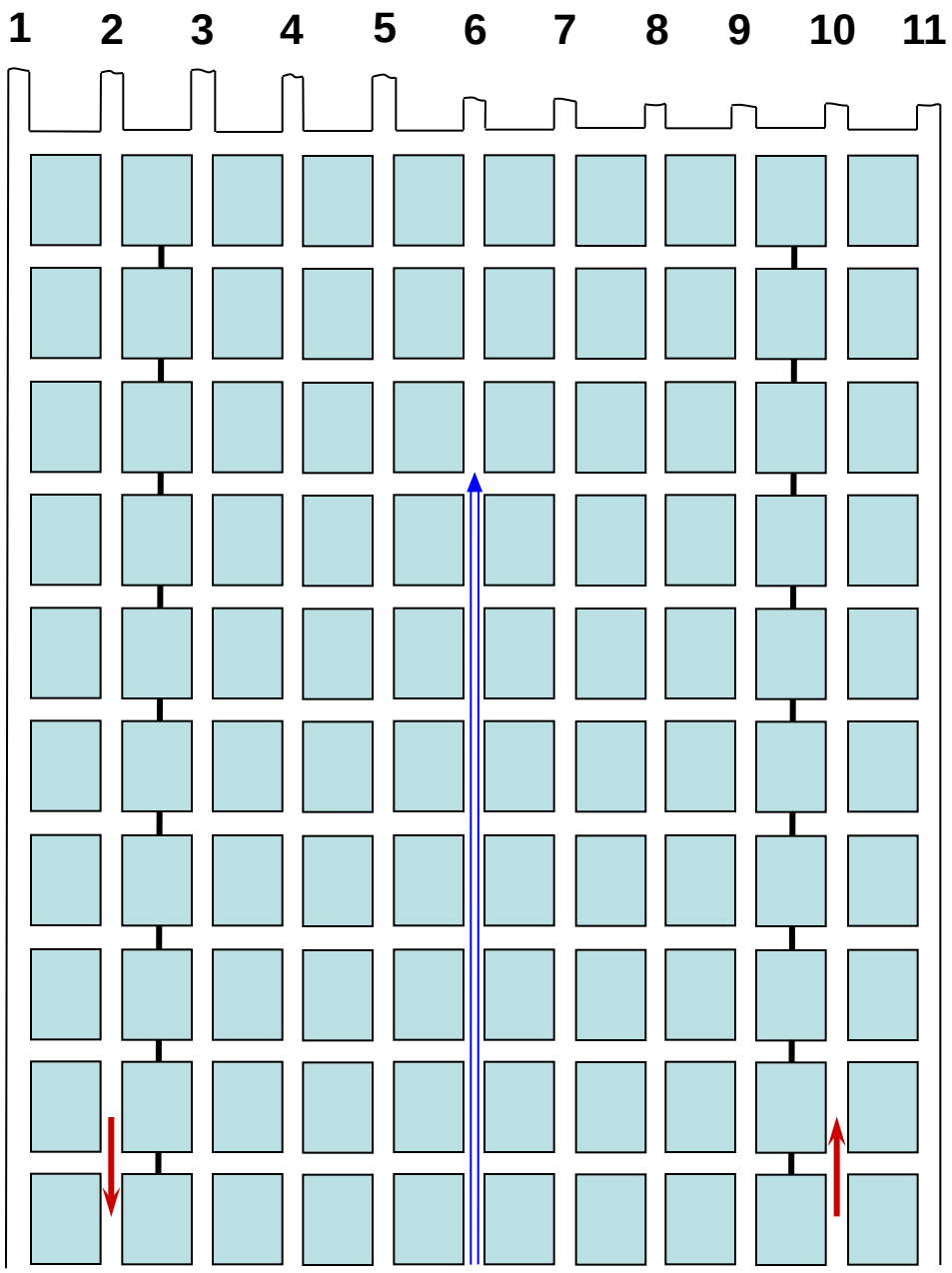
1” H_20 Pressure

30,000 cfm

1” H_20 Pressure

30,000 cfm

Double Entry
(Intakes and Returns)



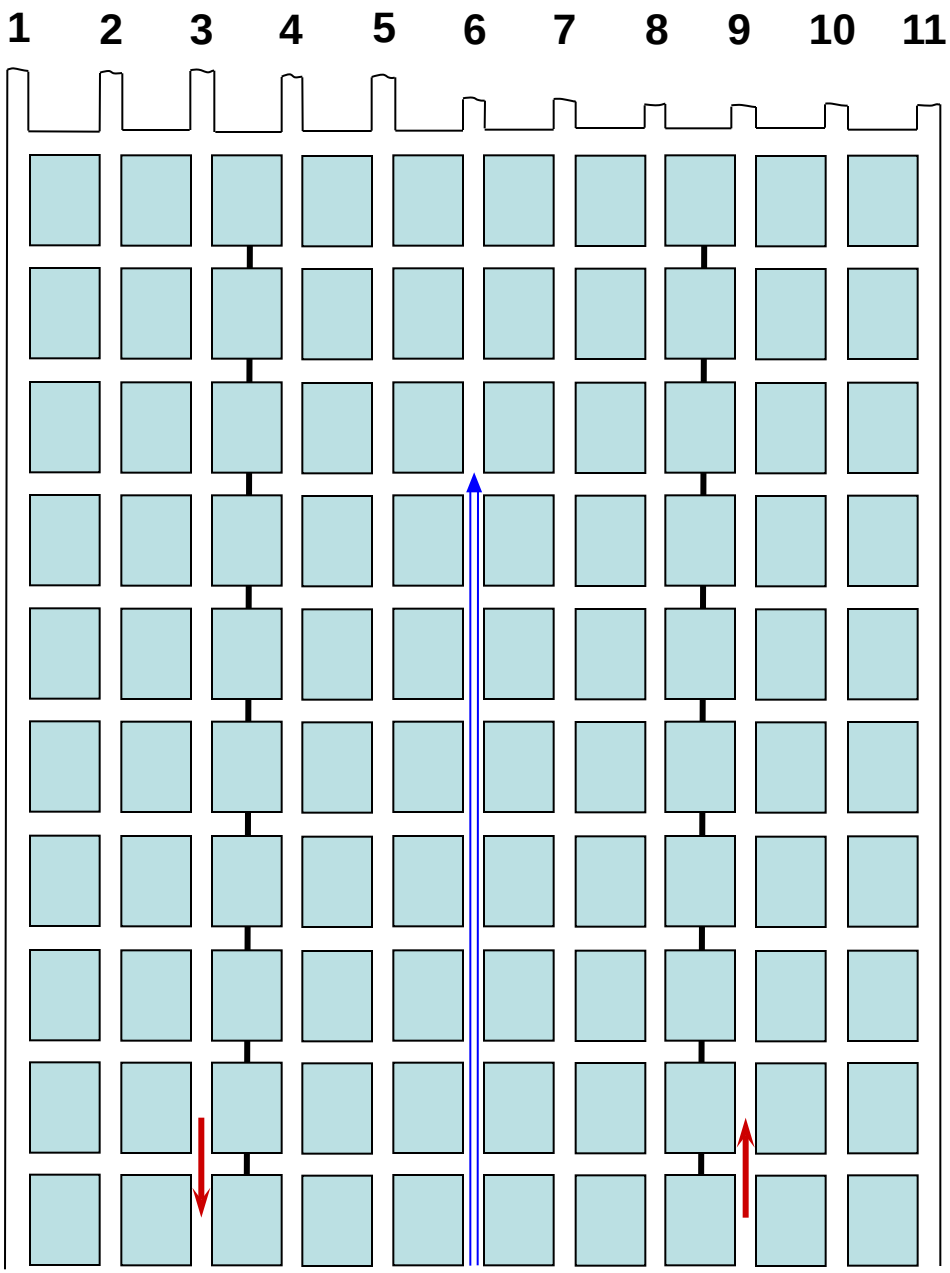
0.25” H_20 Pressure

30,000 cfm

0.25” H_20 Pressure

30,000 cfm

Triple Entry
(Intakes and Returns)



0.1” H_20 Pressure

30,000 cfm

0.1” H_20 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

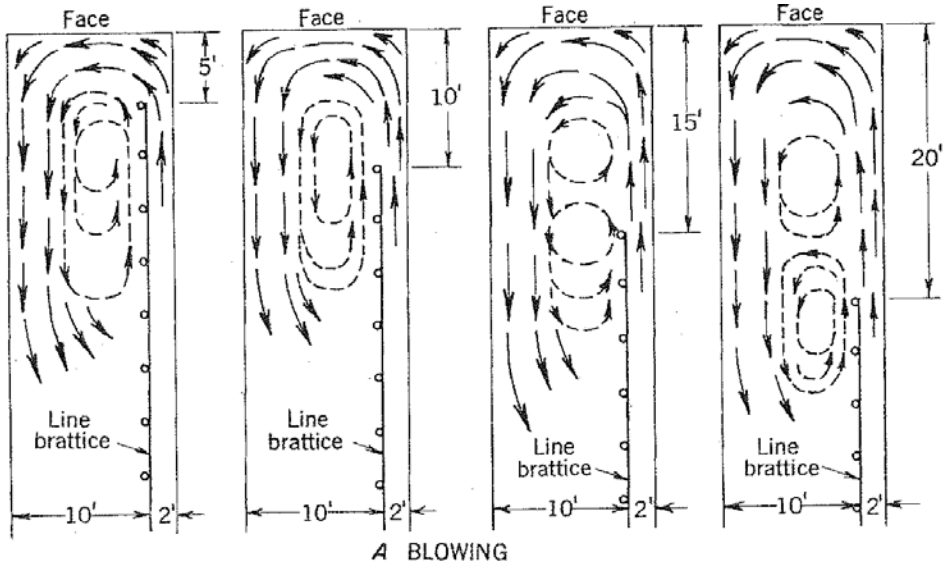
Blowing Curtain

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

Exhaust Ventilation

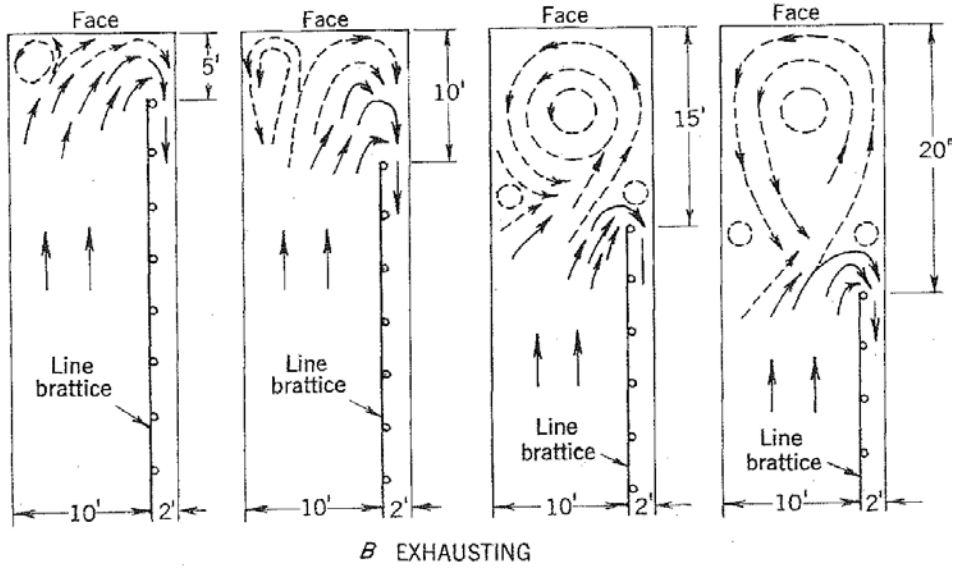
- Better for Dust Control
  - May be necessary in high silica areas
- Allows most workers to always be in intake air
  - Exception may be the roof bolters
- At same curtain set back distances, exhaust ventilation is not as efficient in removing methane
- Scrubber not required
  - More float dust in returns when scrubber is not used

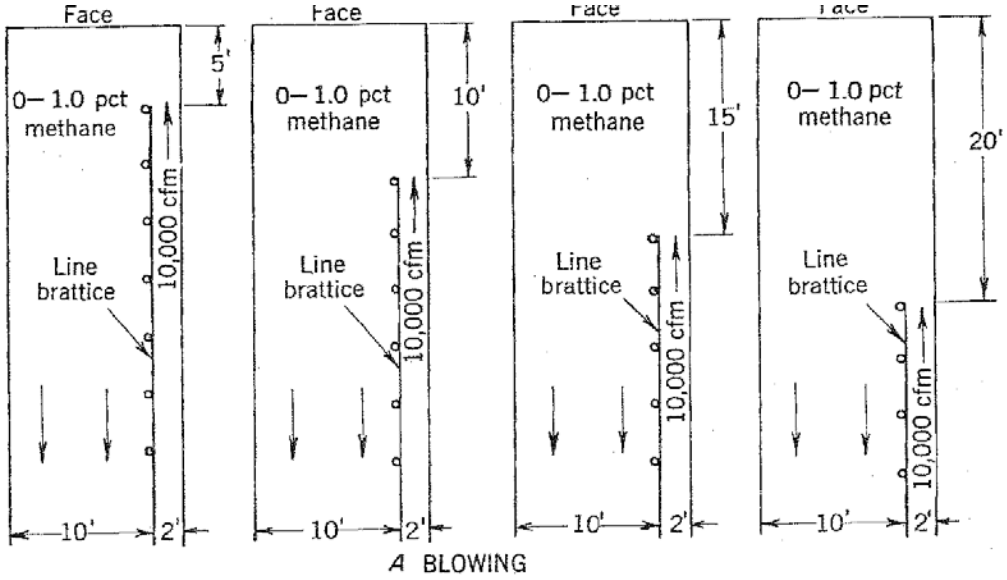
Airflow Patterns Blowing Vrs. Exhausting



Airflow patterns independent of air volume

Turbulence — Primary airflow - - - Secondary airflow





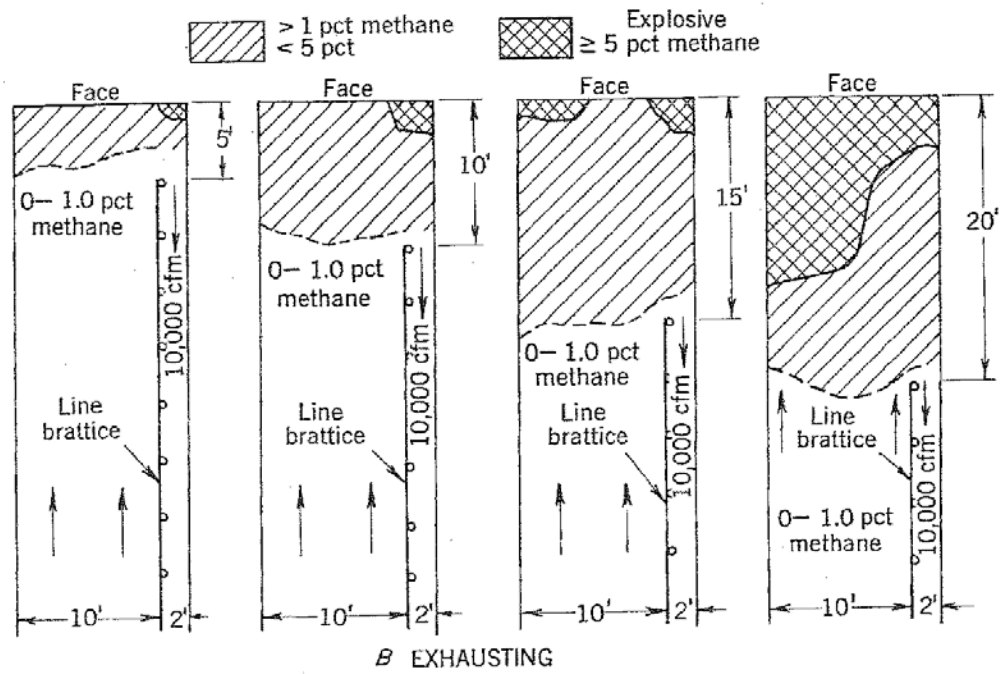


FIGURE 4. - Methane Distribution Patterns: Methane Release 30 cfm–Tight Rib 2 Feet.

Blowing Face Ventilation

- Line Brattice air quantity is based on the scrubber air quantity
- Must first determine your scrubber air quantity

Pitot Tube Air Measurements made to Measure Scrubber Air Velocity and Ventilation Tubing Velocity

- A Pitot Tube Traverse must be used to accurately measure airflow in ventilation tubing and the duct work of dust scrubbers; especially where there are greater than 3000 fpm velocities

Why not use a Vane Anemometer?

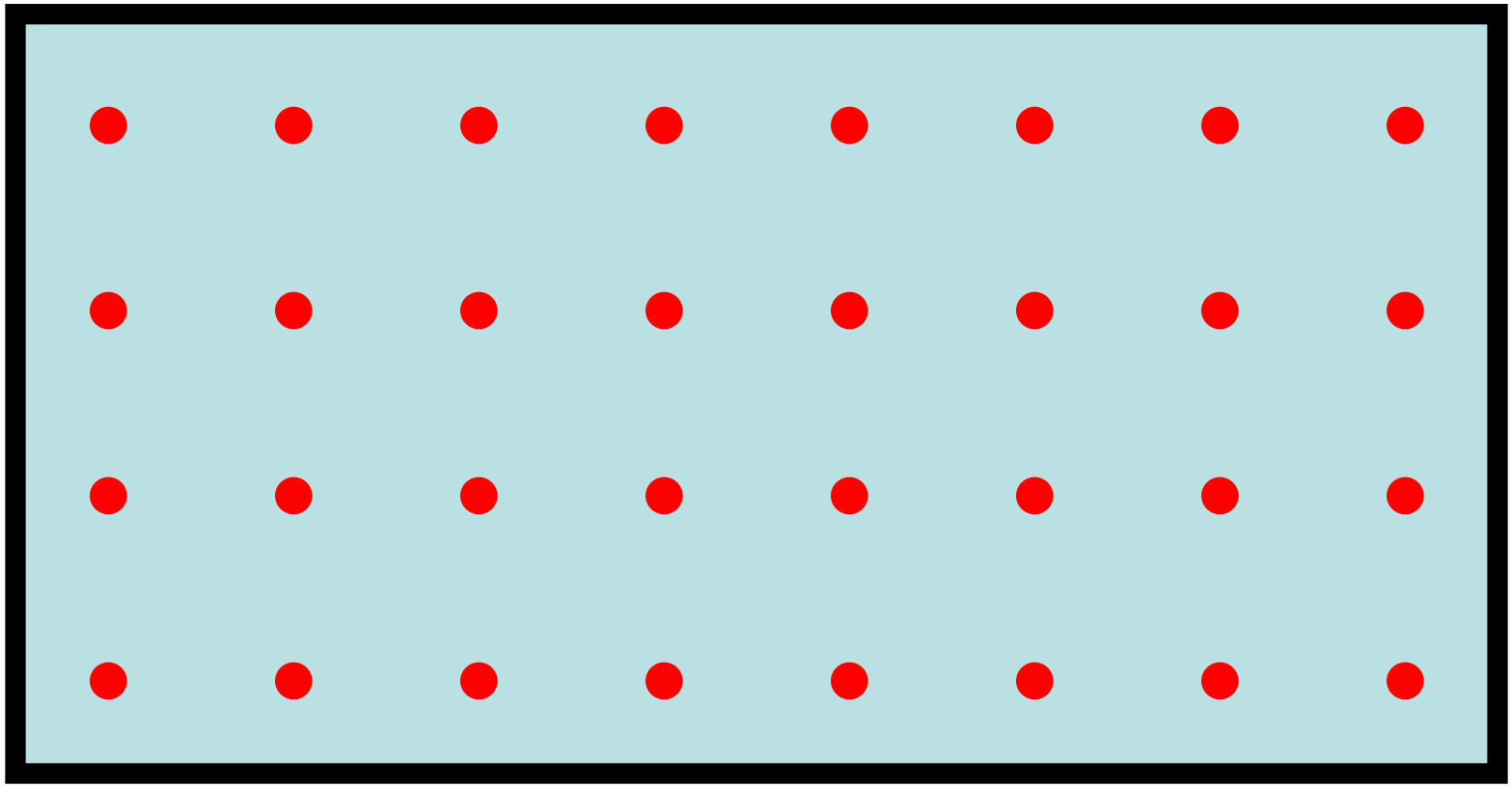
- According to the ACGIH Industrial Ventilation Recommended Practice
  - This instrument is accurate to determine air flow through large supply and exhaust openings
  - The cross-sectional area of the instrument should not exceed 5% of the measured area
  - Generally, useful range is below 3,000 fpm
  - Standard 4” anemometer is unsuited for measurements in ducts below 20” diameter
  - 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



Blowing Ventilation - What Should the Line Brattice Air Quantity Be

Minimum Line Brattice Air Quantity Is equal to Scrubber Air Quantity with Maximum of 1,000 cfm over or 15% over scrubber quantity

Minimum assures adequate intake air is delivered to face

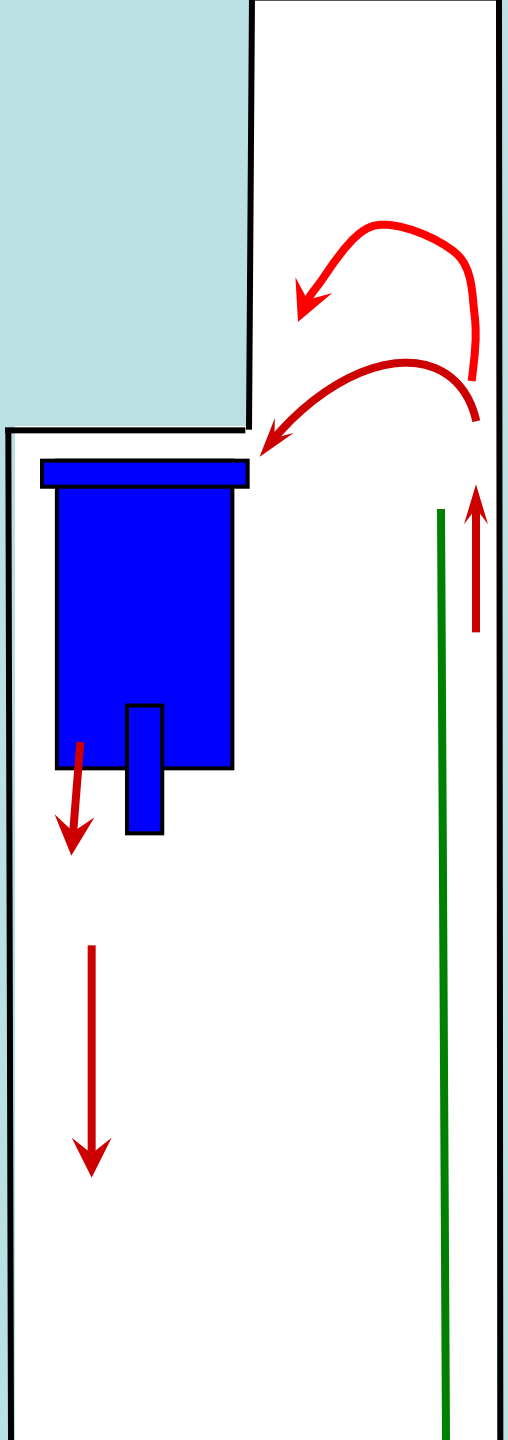
- Maximum Quantity prevents Overpowering of Scrubber (dust laden air bypasses scrubber and goes directly into return from face)
  - Occurs when
    - Line Brattice Air Quantity exceeds Scrubber Air Quantity and
      - Curtain too close to cutting head
      - Line Brattice air velocities over 400 fpm

Over Powering Scrubber

Higher Air Quantities can overpower the scrubber if

Line Brattice Air Velocity is to high and
Line Curtain hung 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

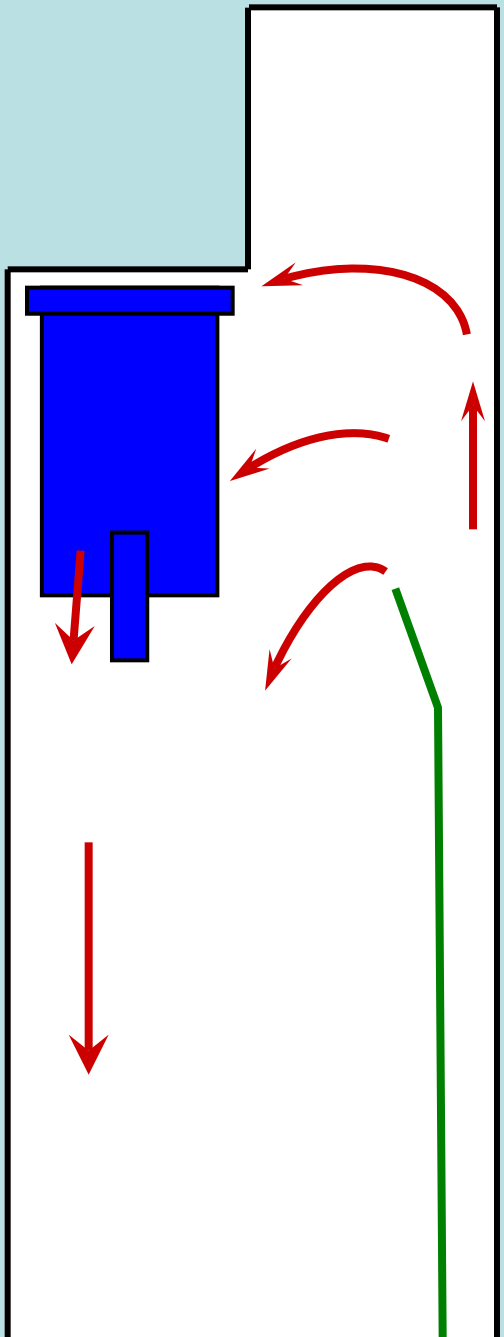
How to Stop Over Powering of Scrubber

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**



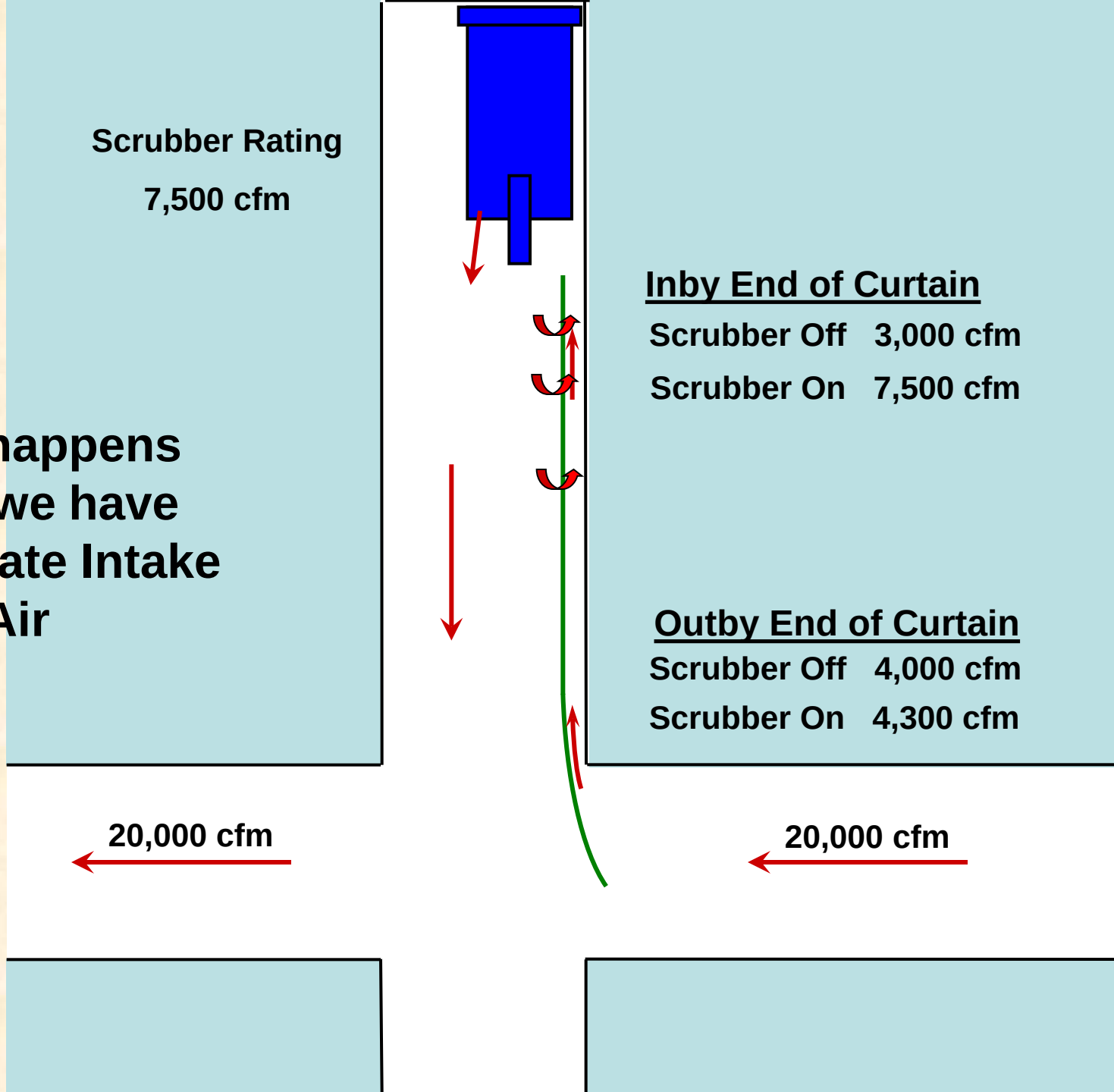
On Blowing Ventilation Systems, MSHA has been requiring the line brattice air quantity be the minimum of the scrubber capacity measured with the scrubber off

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

Face Airflows



What happens when we have Inadequate Intake Air

- Amount of Recirculation will depend on
  - Air Quantity in the curtain area
  - Scrubber Air Quantity
  - Length of curtain
  - Integrity of hung curtain

How was this recirculation Identified (4 ways)

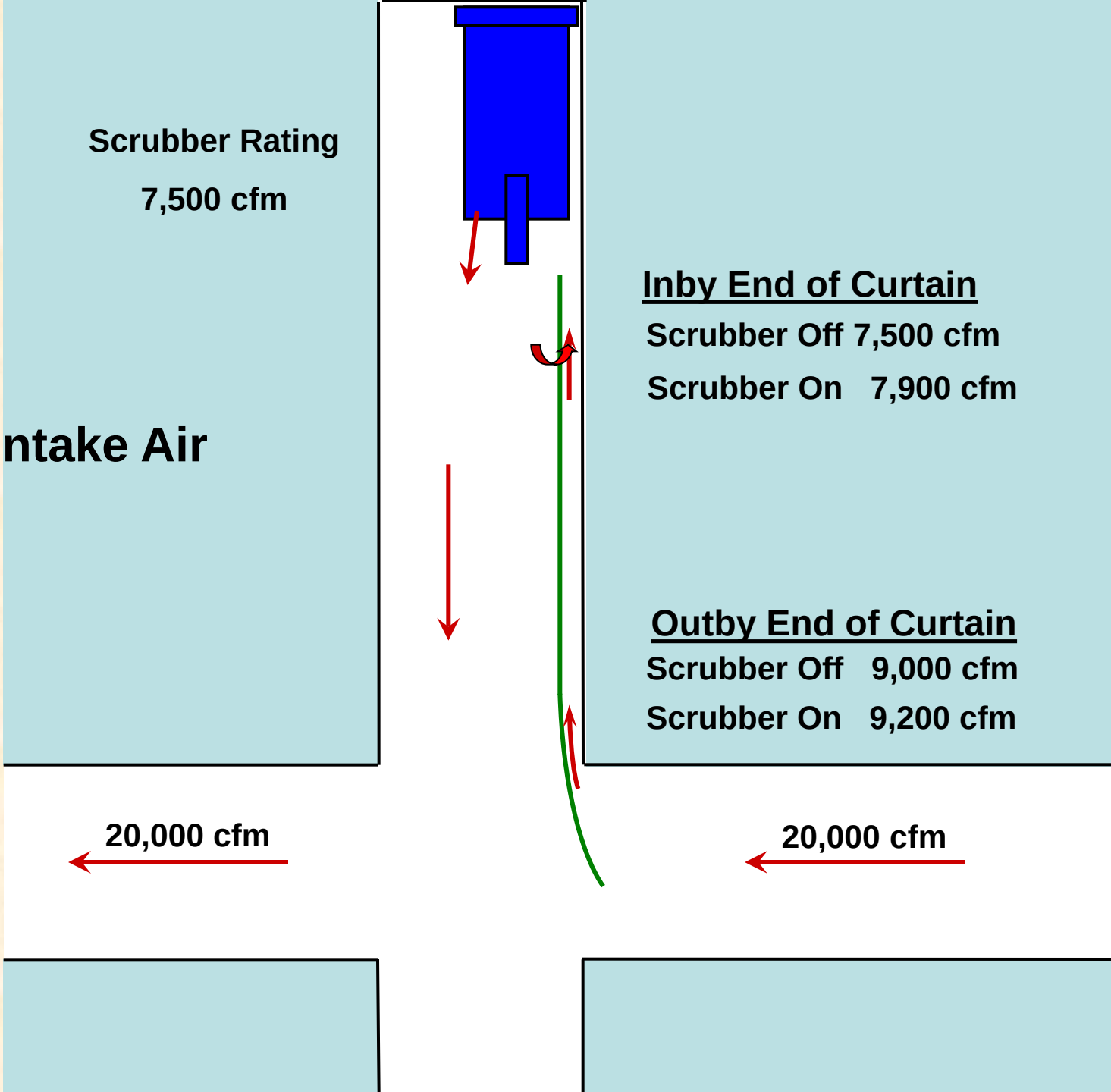
1. Air Measurements of the Line curtain
2. Inby and outby line curtain dust concentrations
3. Use of Chemical Smoke on the curtain for air currents
4. By CMO’s going out of compliance!

Air Measurements from a Dust Face Study

Date	Cut No.	Curtain Length (feet)	Scrubber (on/off)	Airflow (cfm)				
				Miner Line Curtain		Section Main Intake	Section Main Return	
				Outby	Inby			
8/2/05	1	151	on	6,200	7,800	34,100	39,200	
			off	7,100	movement inby			
	2	145	on	7,900	7,900			
			off	8,300	3,300			
	3	192	on	8,300	8,900			
			off	7,400	movement inby			
	4	161	on	7,000	6,000			
			off	8,000	movement inby			
	1	159	on	7,900	10,700			
			off	6,200	3,600			
	2	204	on	10,000	6,200			
			off	8,800	movement inby			

- Factors that affect inby vrs. 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



Proper Intake Air

Dust Concentrations from a Face Dust Survey

Area	Dust Concentration (mg/m^3)		
	8/2/05	8/3/05	Average
Section Main Intake	0.13	0.07	0.10
Section Main Return	0.67	0.57	0.62
Line Curtain Outby End	0.16	0.09	0.12
Line Curtain Inby End	2.81	4.31	3.56
CM Immediate Return	3.67	3.87	3.77

3. Artificial Smoke to determine airflows at the curtain

4. CMO going out of Compliance (should always be in intake air)

Summary - How do we Prove Curtain recirculation "Inadequate Intake Air"

- Inby curtain vrs. Outby curtain Air Quantity Readings
- Outby curtain to inby curtain dust area dust concentrations
- 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 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!!! Assures Adequate Intake Air!!!!**

2 Major Points
Blowing Ventilation

- 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

- Line Brattice air quantity minimum of 3,000 cfm or enough to meet 60 mean air velocity
- 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 in exhaust vent., increase line brattice or tubing air quantity

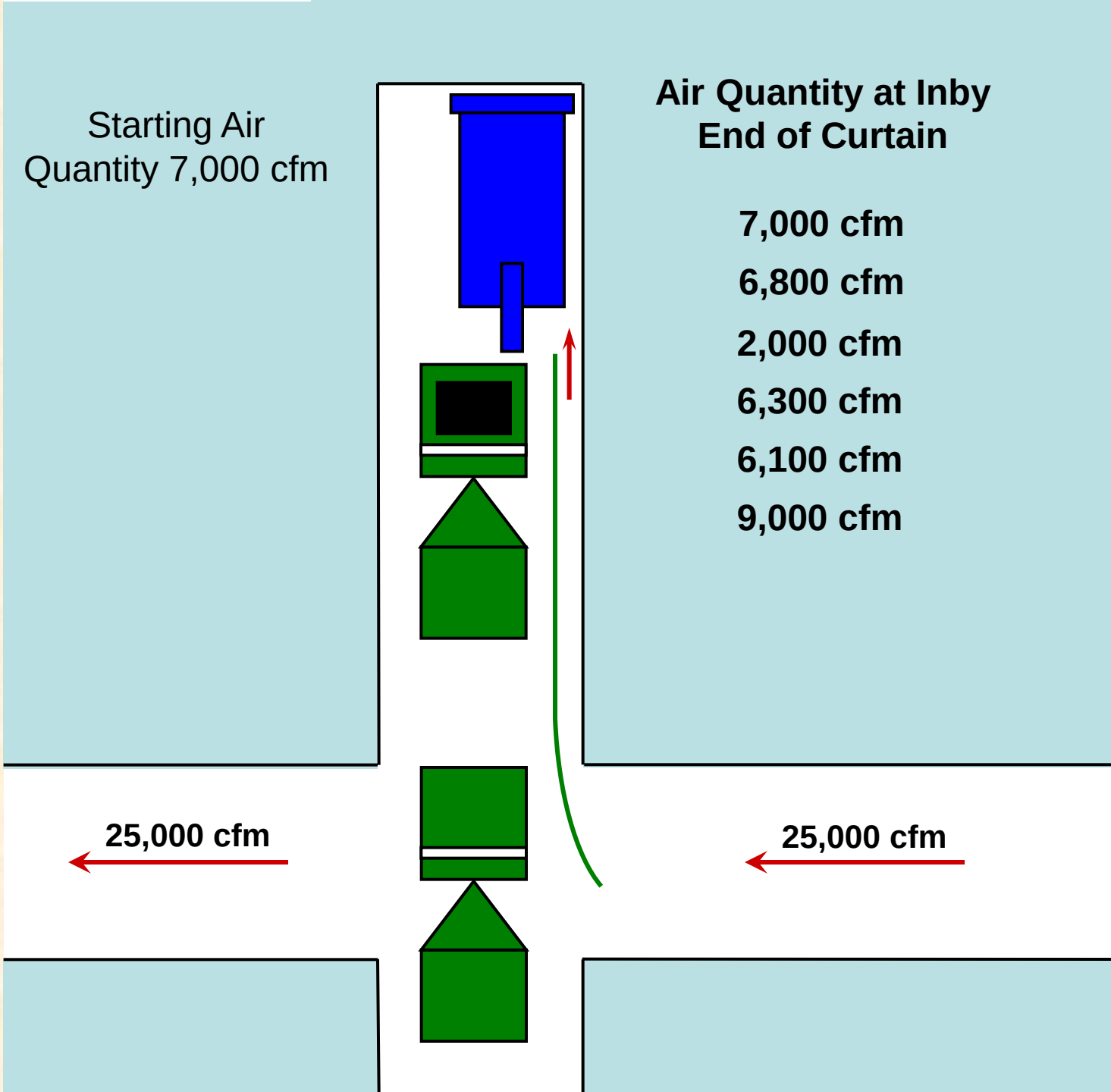
Line Brattice Air Measurement Intake or Exhaust

- Line Brattice Air Quantities are dynamic entities and may continually change depending on many conditions
- Air Quantities must be maintained throughout your cut

Factors Influencing Line Curtain Air Quantities

- Adding additional curtain
- 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 due equipment error

Changes in Curtain Airflows



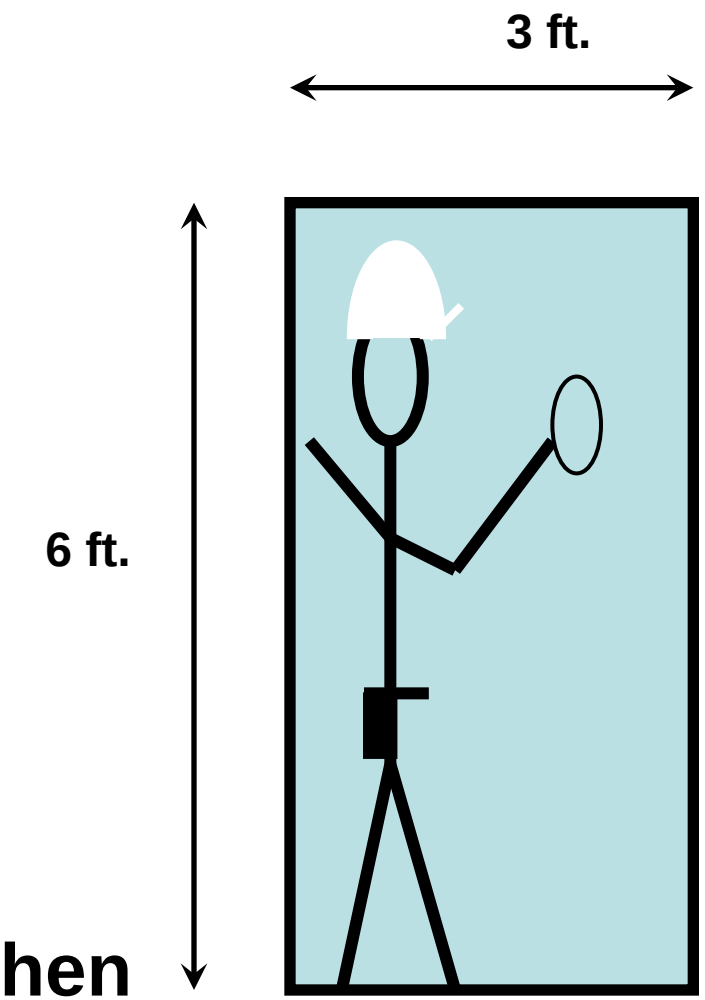
Need Accurate Line Brattice Air Quantity Measurements

- Human and Mechanical errors
- Calibrated Anemometer
- Accurate 1 minute timing
- Accurate Area Measurement
- Minimal movement of outby equipment and miners
- Keep you body out of measured area

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 fpm

A = 18 square feet

Q = 5,400 cfm

V = 300 fpm

A = 12 square feet (18 - 6)

Q = 3,600 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)

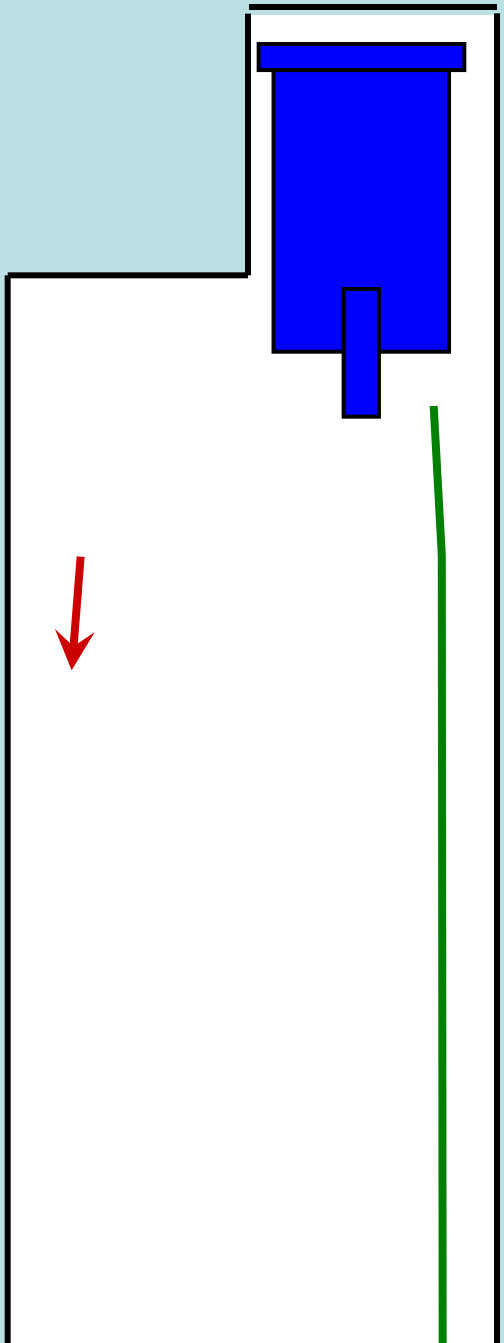
2,310 cfm Actual Line Brattice Air Quantity

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

Recipe for recirculation and Poor Dust Control!!

Offset Cut

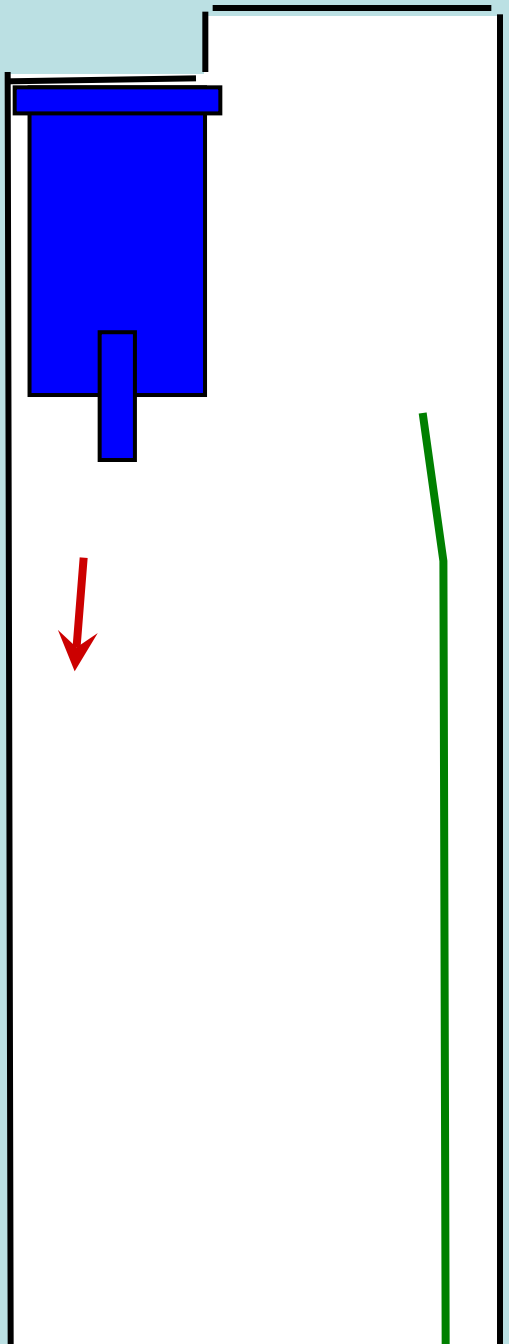
- CM takes a normal sump cut



Offset Cut

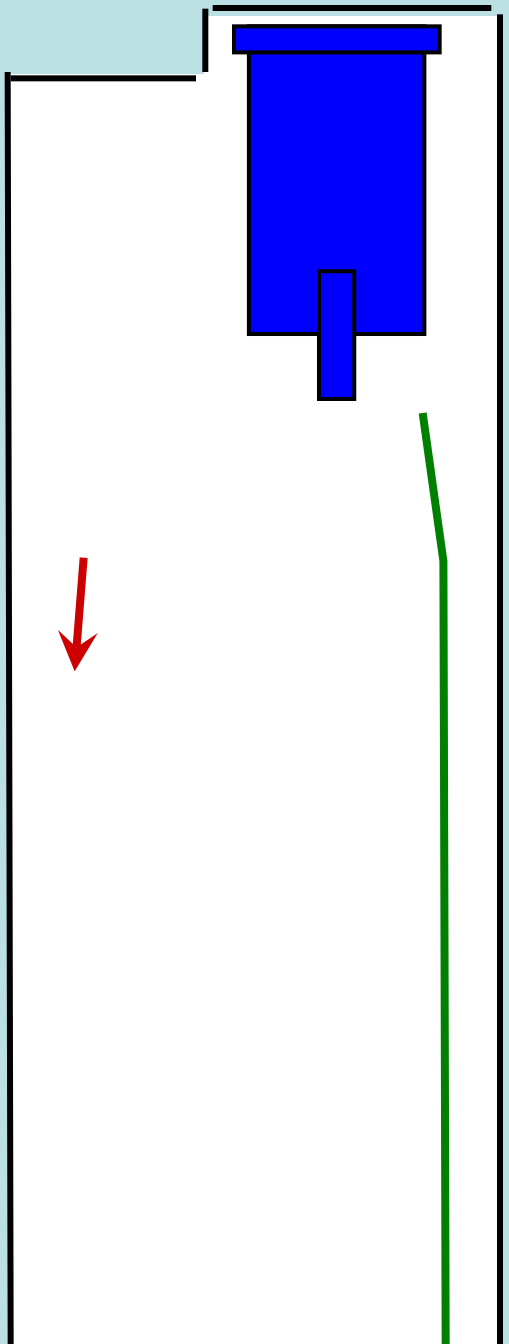
-CM does not square face up on slab cut

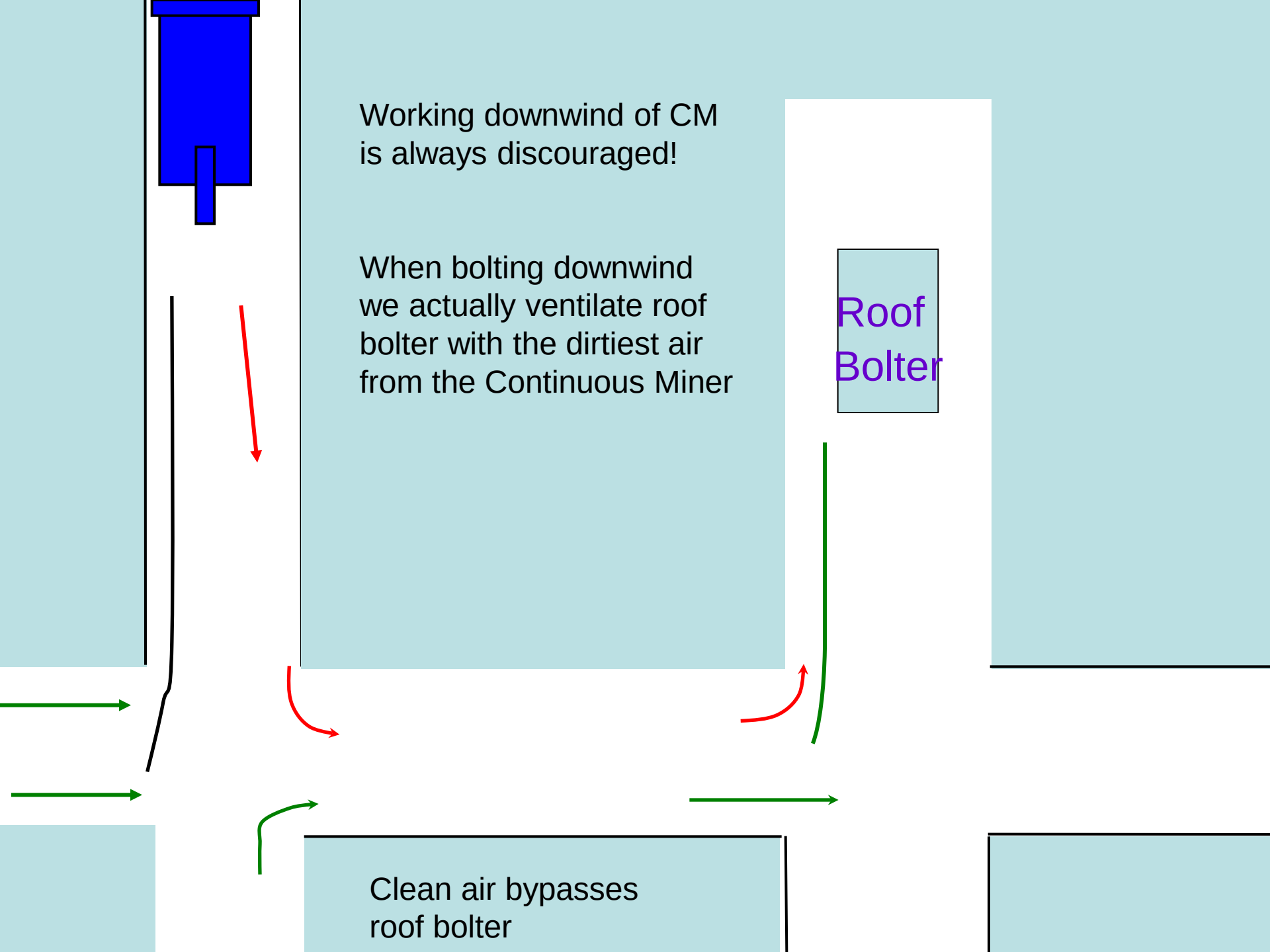
-Cuts about 3 - 4 feet less than square face

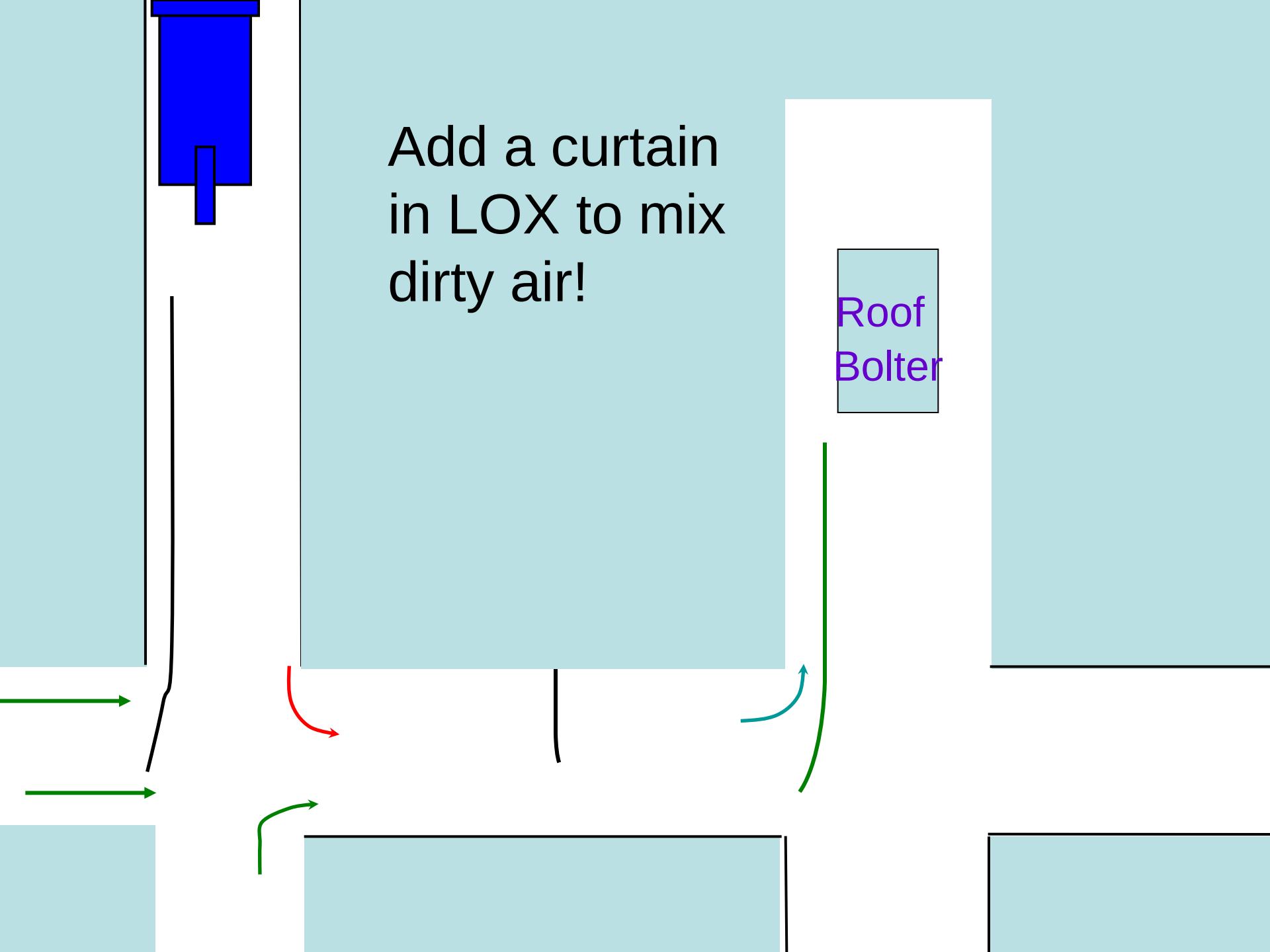


Offset Cut

-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
Roof Bolter
Clean air bypasses roof bolter


Add a curtain in LOX to mix dirty air!
Roof Bolter

Conclusions

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

Questions?

- Mark Schultz, P.E.
- Schultz.mark.j@dol.gov
- 412 386 6807