Dust Division
Pittsburgh Safety and Health Technology Center

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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

Basic Mine Ventilation Equations

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

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

Parallel Flow in Airways

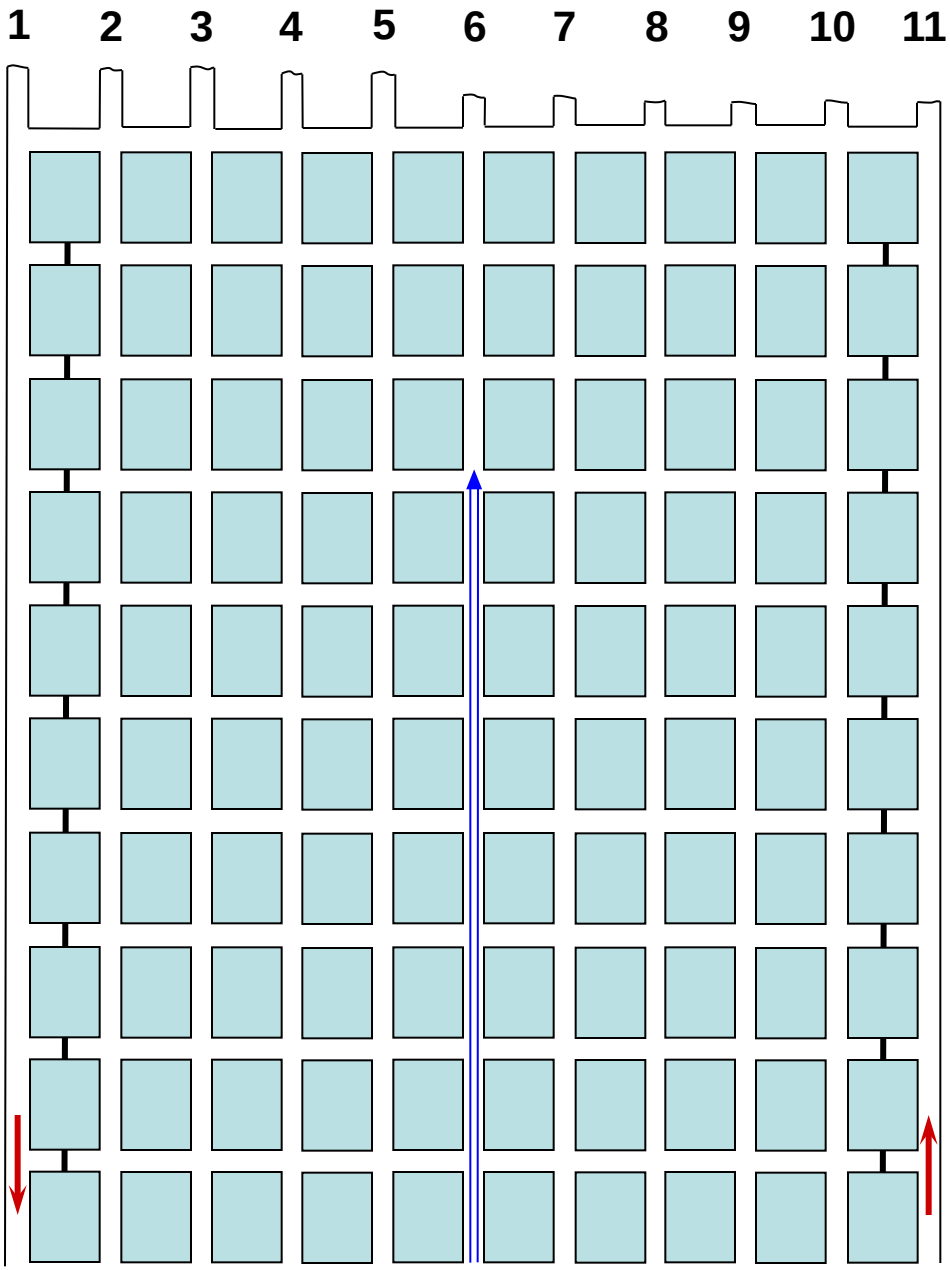
- $R_n = 1/n^2 \ X \ R_1$

- 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)



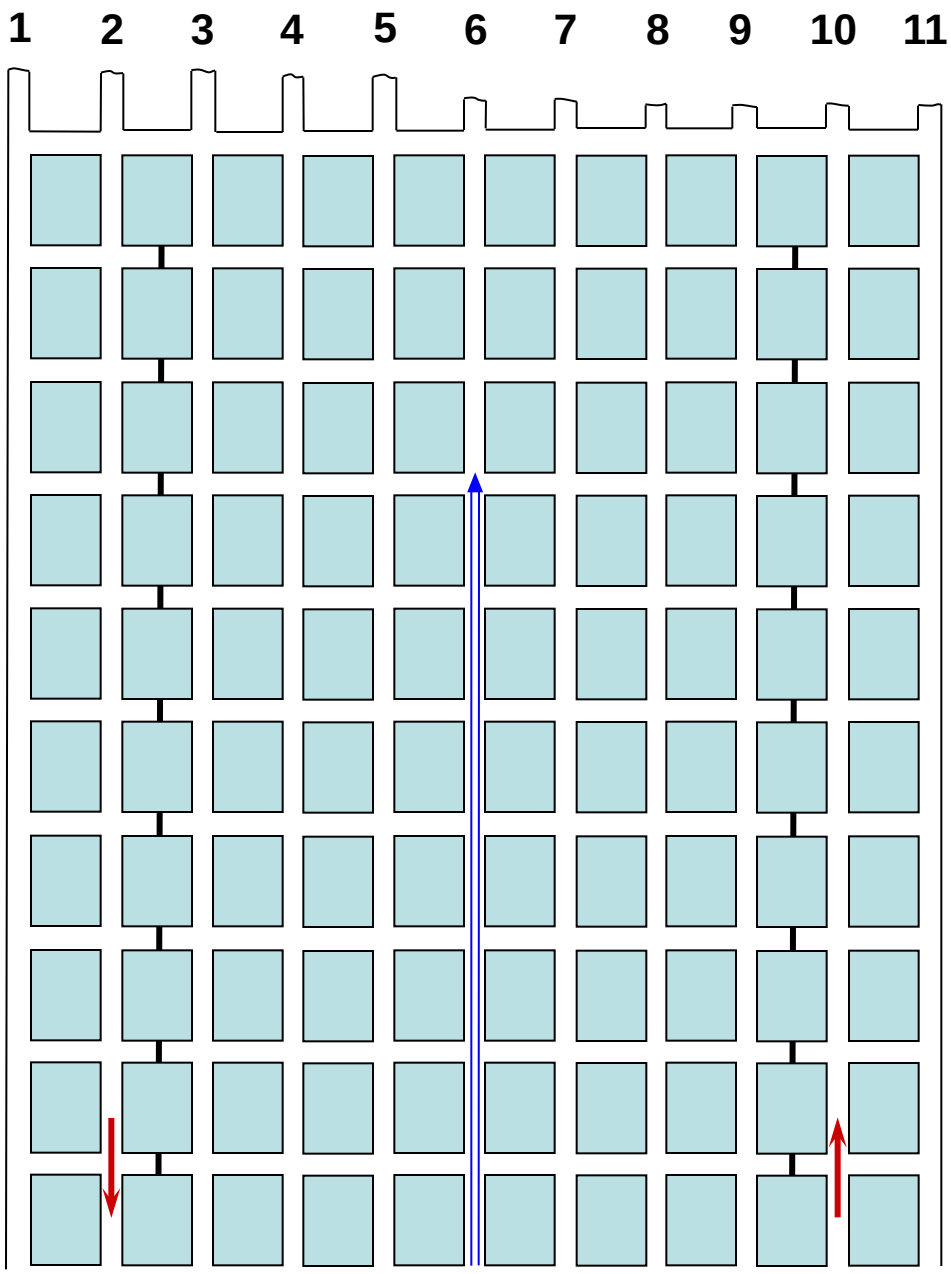
1” H20 Pressure

30,000 cfm

1” H20 Pressure

30,000 cfm

Double Entry
(Intakes and Returns)



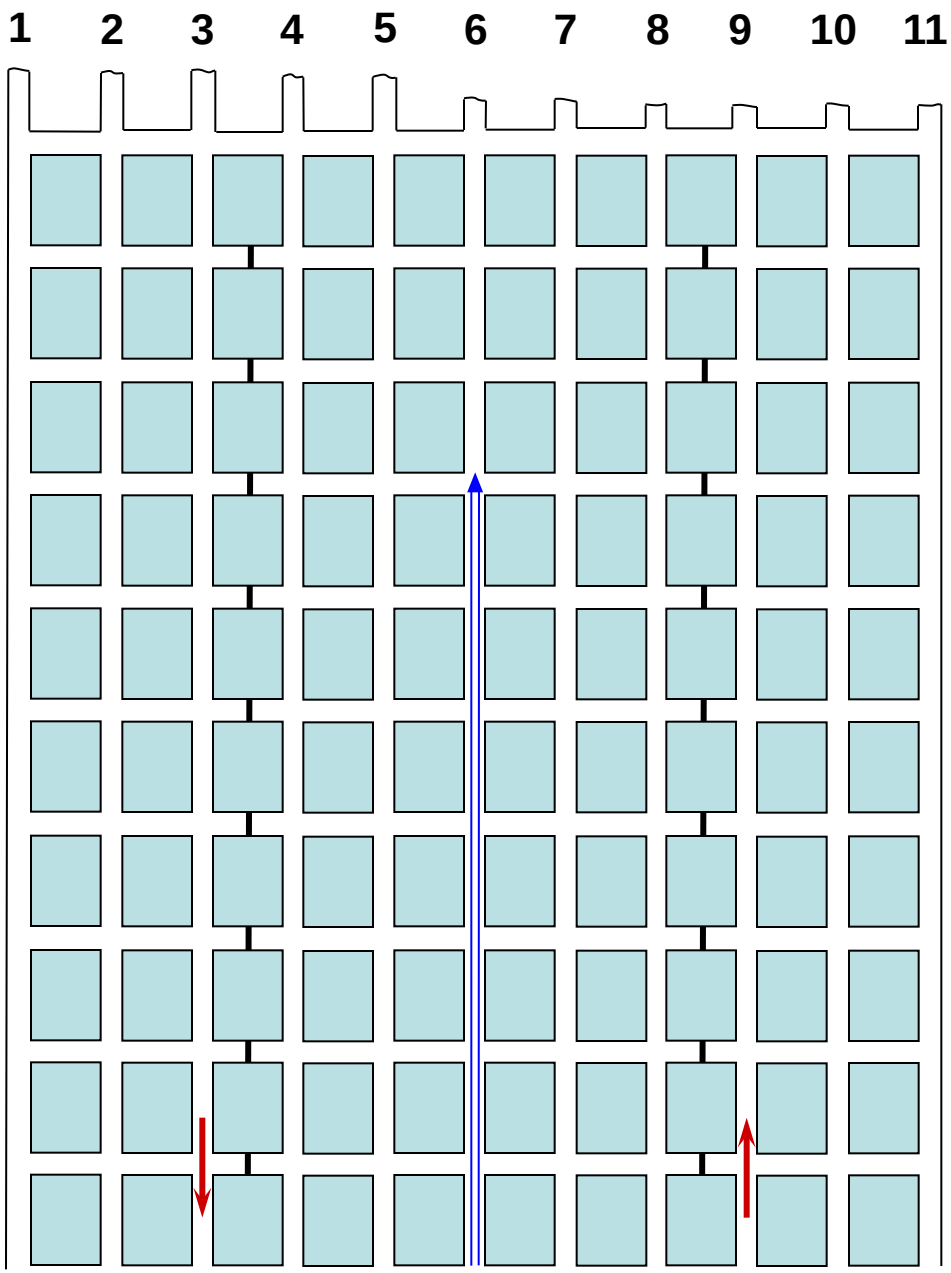
1” H20 Pressure

60,000 cfm

1” H20 Pressure

60,000 cfm

Triple Entry
(Intakes and Returns)



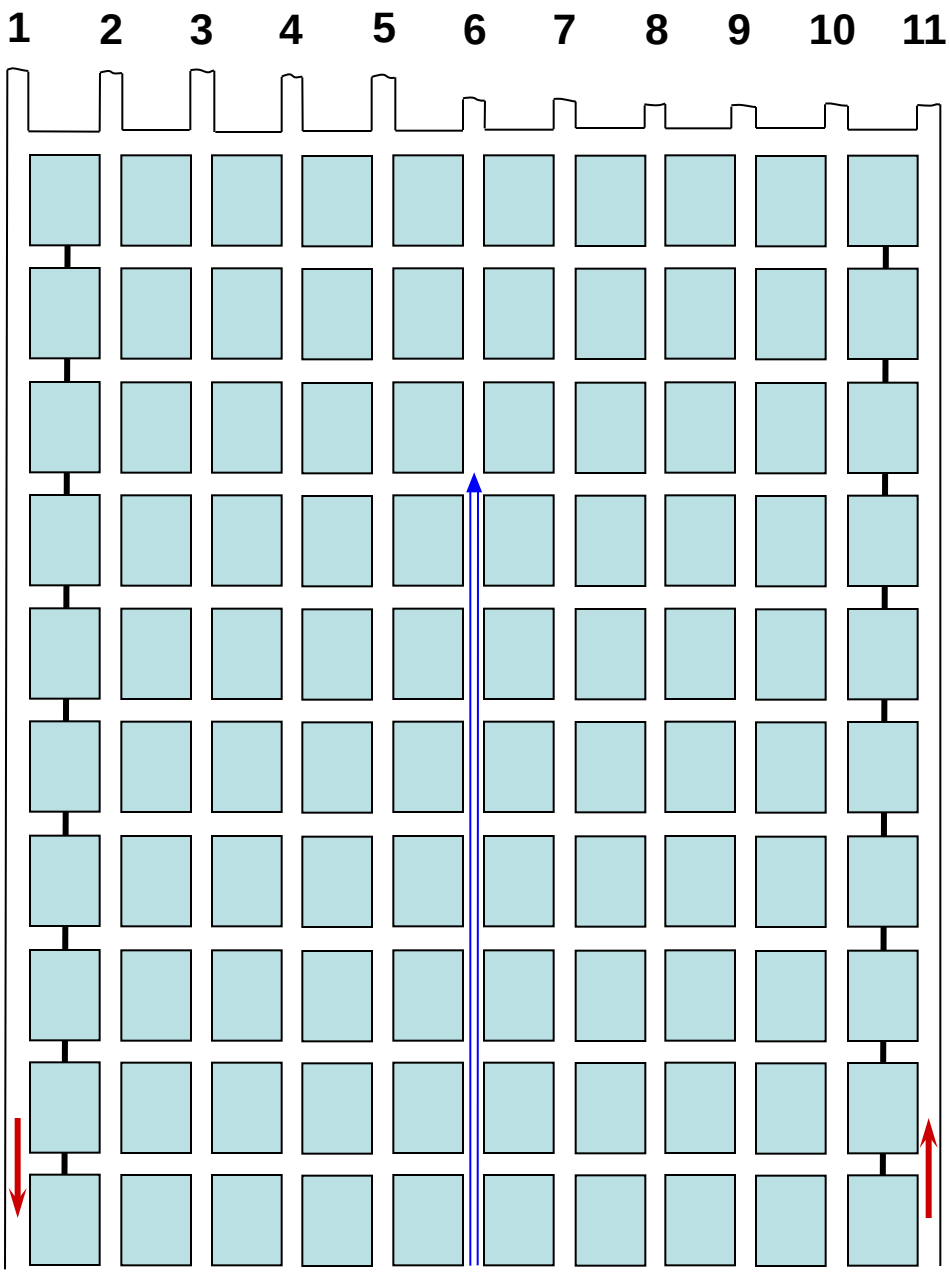
1” H20 Pressure

90,000 cfm

1” H20 Pressure

90,000 cfm

Single Entry
(Intake and Return)



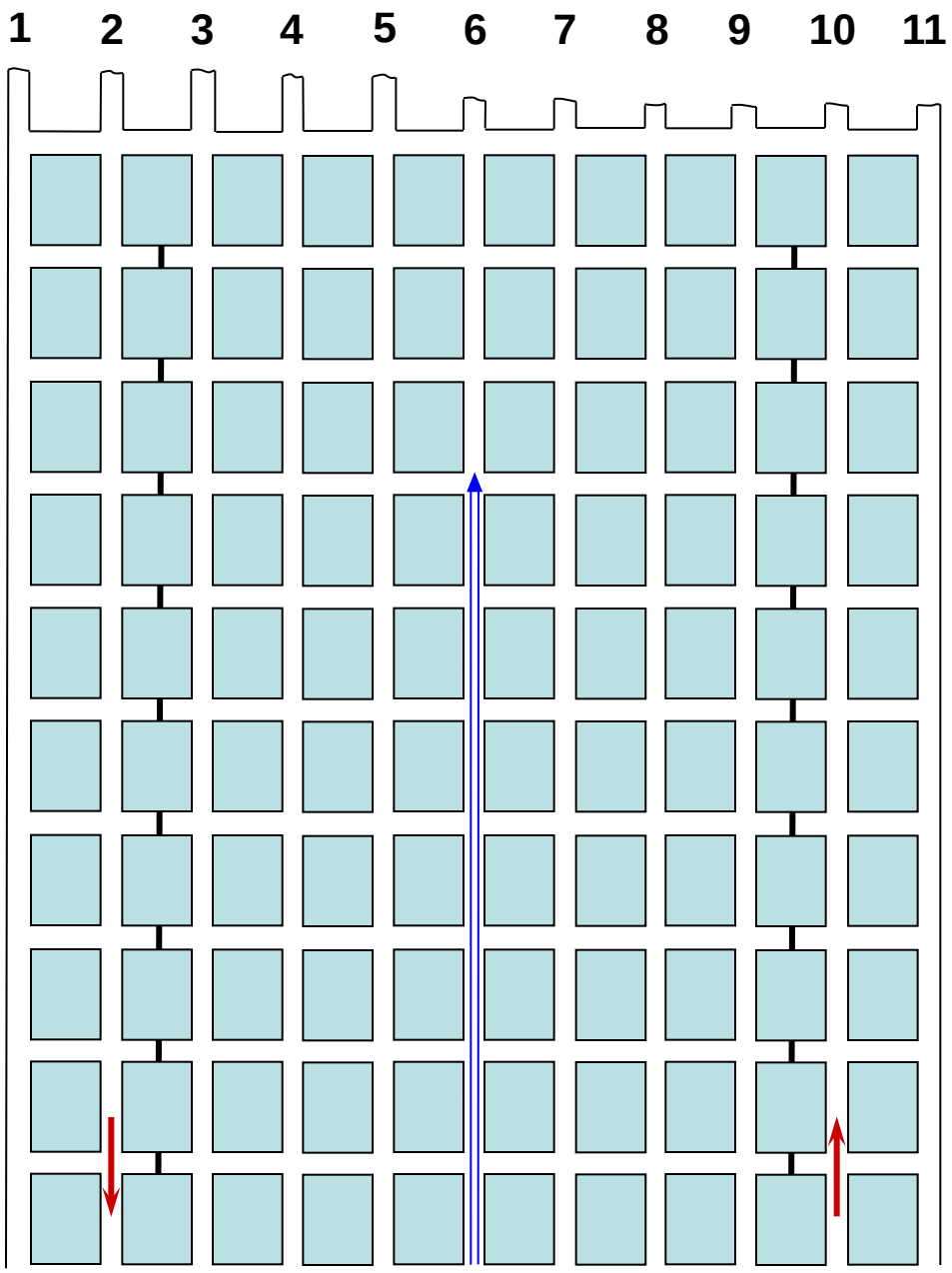
1” H_20 Pressure

30,000 cfm

1” H_20 Pressure

30,000 cfm

Double Entry
(Intakes and Returns)



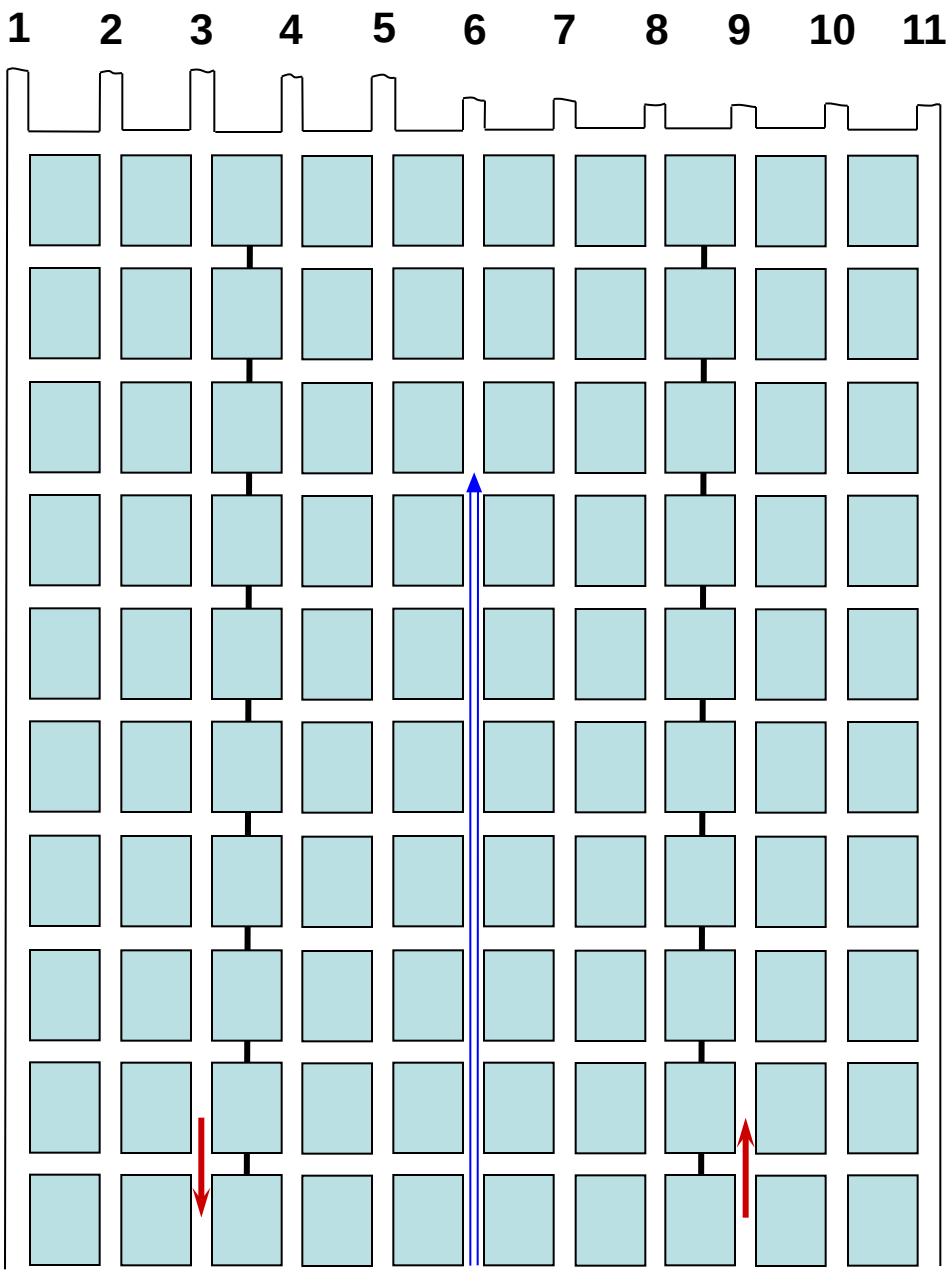
0.25” H_20 Pressure

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

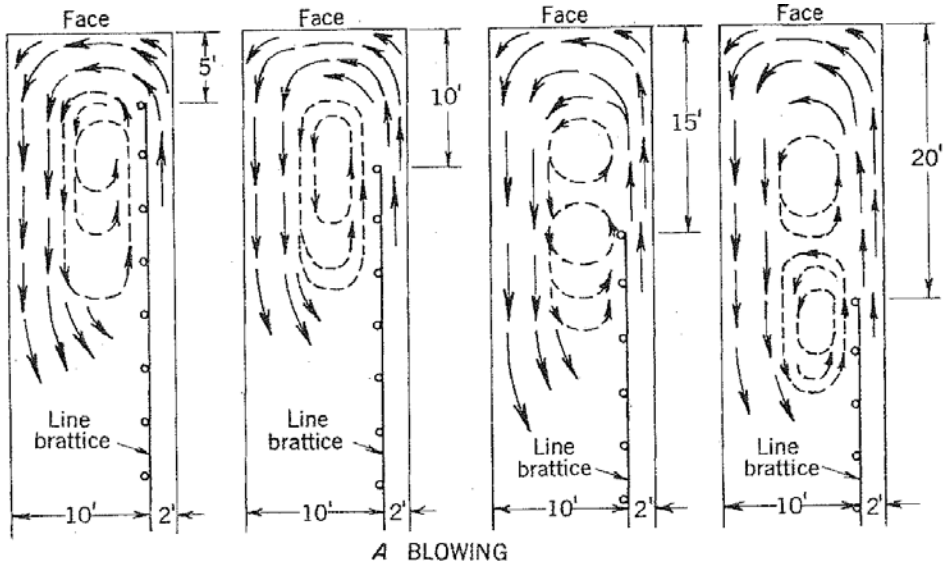
Blowing Curtain

- 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!!!!
- 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

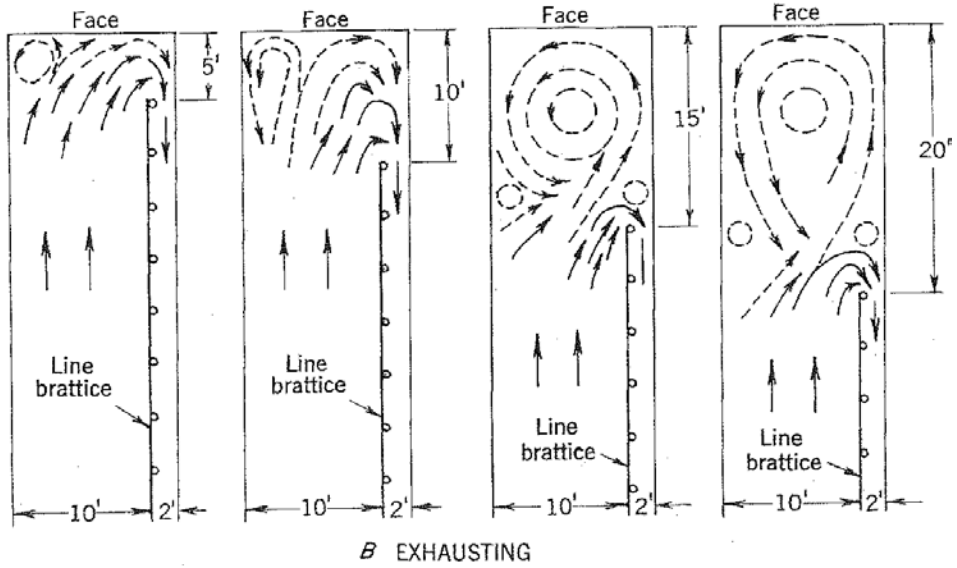
- Better for Dust Control
  - May be necessary in high silica areas
- Allows most workers to always be in intake air
  - Exception may be the roof bolters
- At same curtain set back distances, exhaust ventilation is not as efficient in removing methane

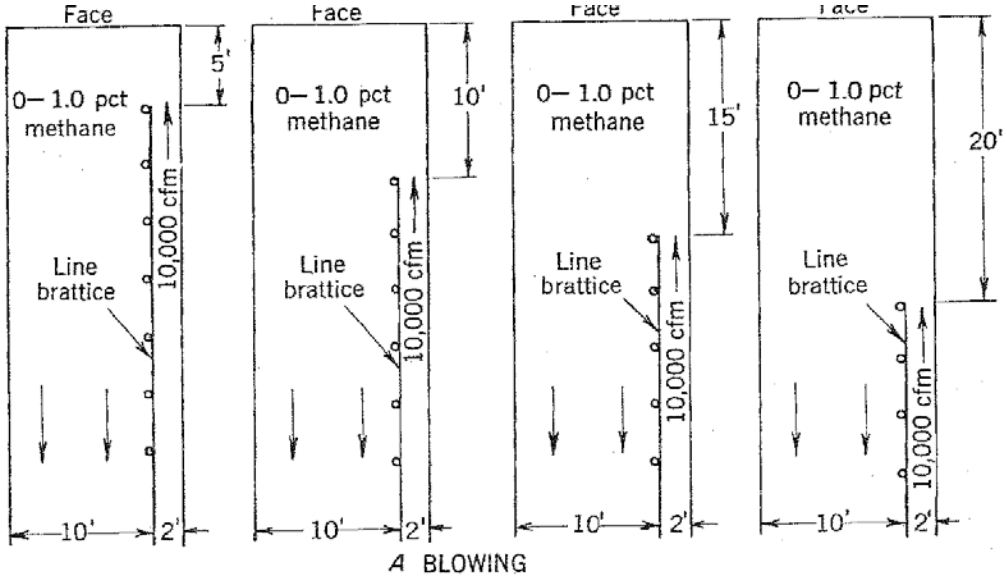
Airflow Patterns Blowing Vrs. Exhausting



Airflow patterns independent of air volume

Turbulence — Primary airflow - - - Secondary airflow





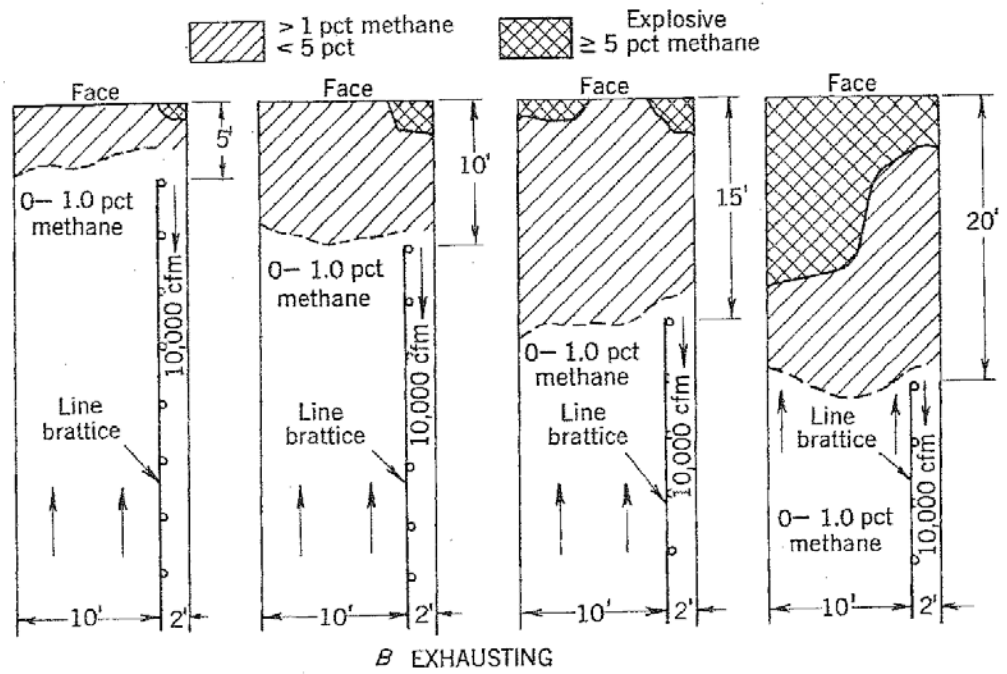


FIGURE 4. - Methane Distribution Patterns: Methane Release 30 cfm–Tight Rib 2 Feet.

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?

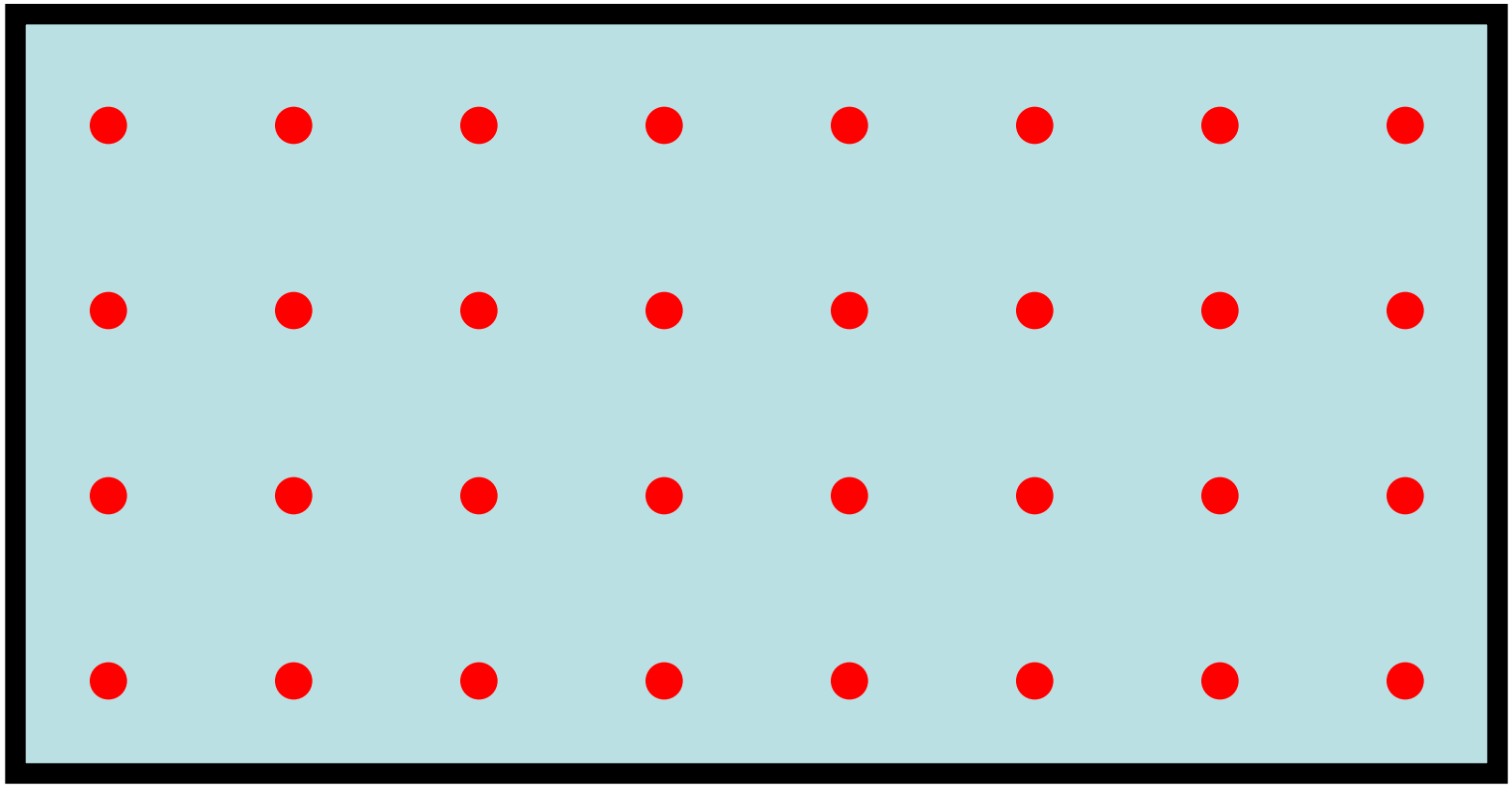
- According to the ACGIH Industrial Ventilation Recommended Practice
  - This instrument is accurate to determine air flow through large supply and exhaust openings
  - The cross-sectional area of the instrument should not exceed 5% of the measured area.
  - Standard 4” anemometer is unsuited for measurements 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

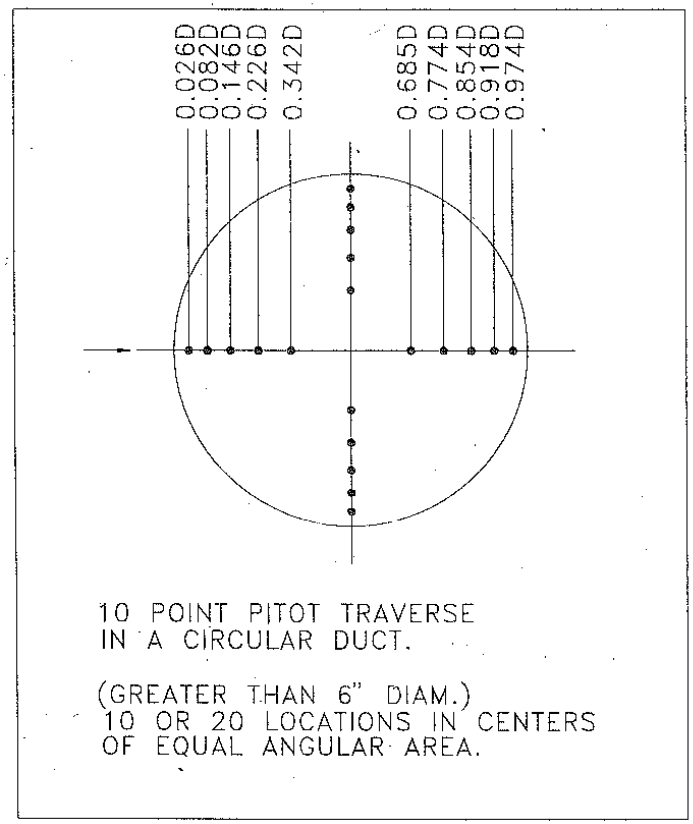


FIGURE 9–10A. 10-point Pitot traverse in a circular duct

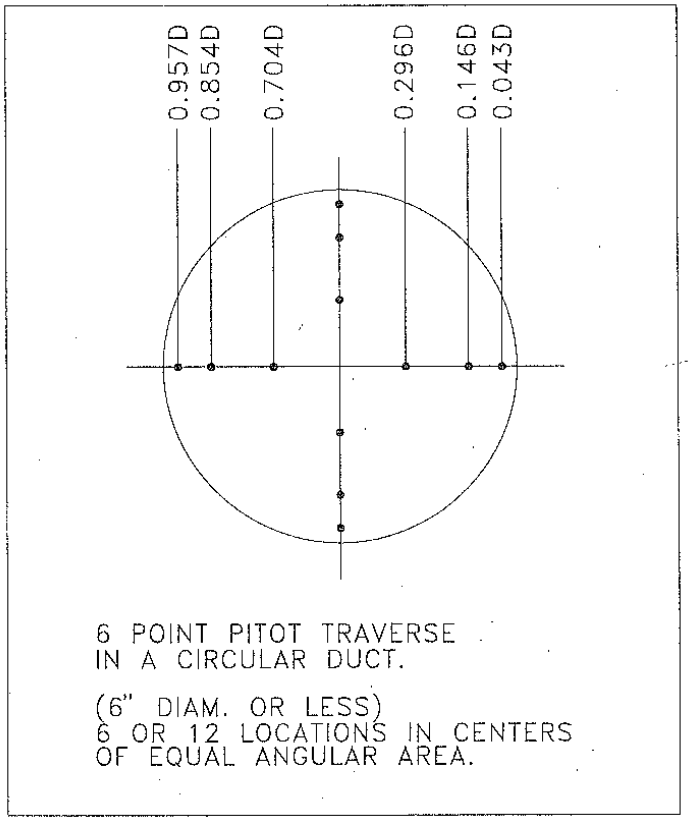


FIGURE 9–10B. 6-point Pitot traverse in a circular duct

- 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

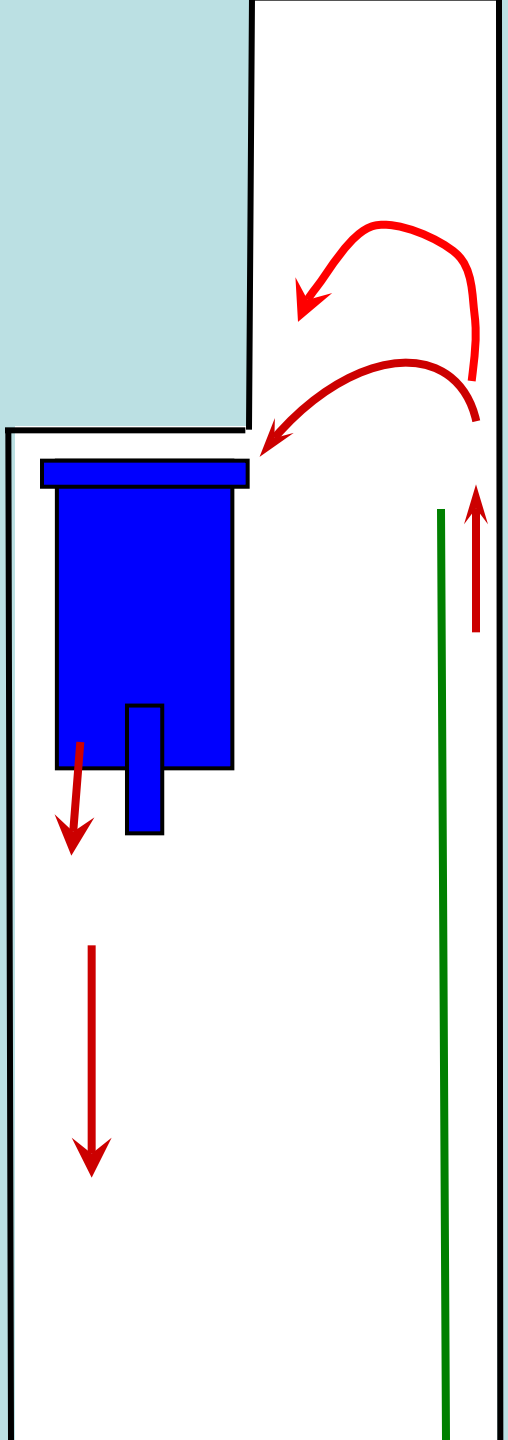
- Typically on blowing this quantity has been +/- 1,000 cfm of scrubber capacity
  - Lower limit recently changed to be at least the scrubber air quantity (reduce recirculation)
  - MSHA policy is that this upper quantity can be greater than scrubber capacity by 15% or 1,000 cfm
  - Upper limit to reduce “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!!!!

Over Powering Scrubber

Higher Air Quantities can overpower the scrubber if

Line Brattice Air Velocity is to 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

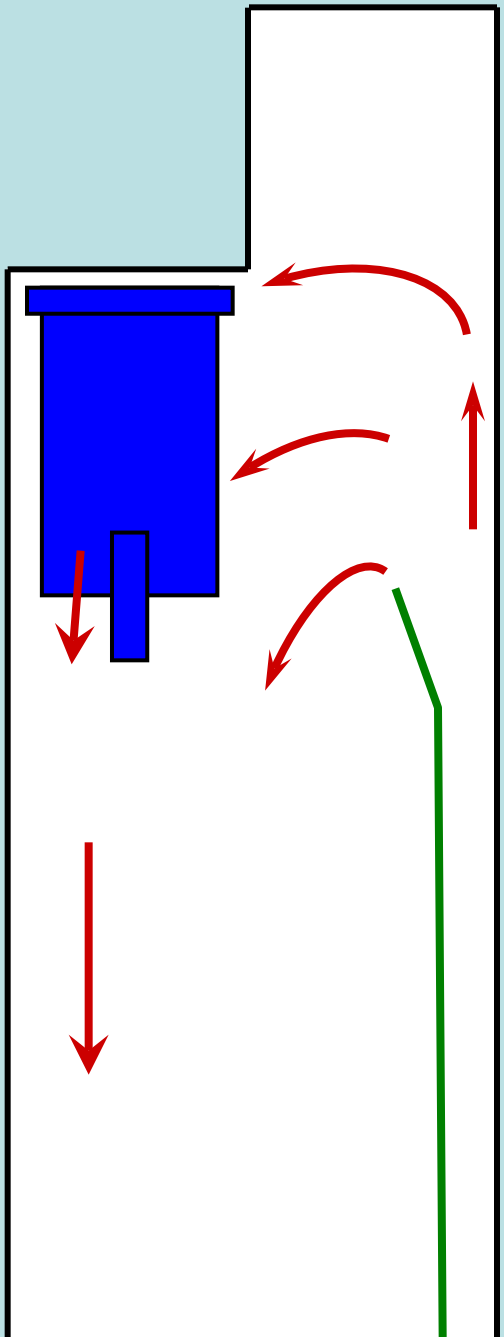
How to Stop Over Powering of Scrubber

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????

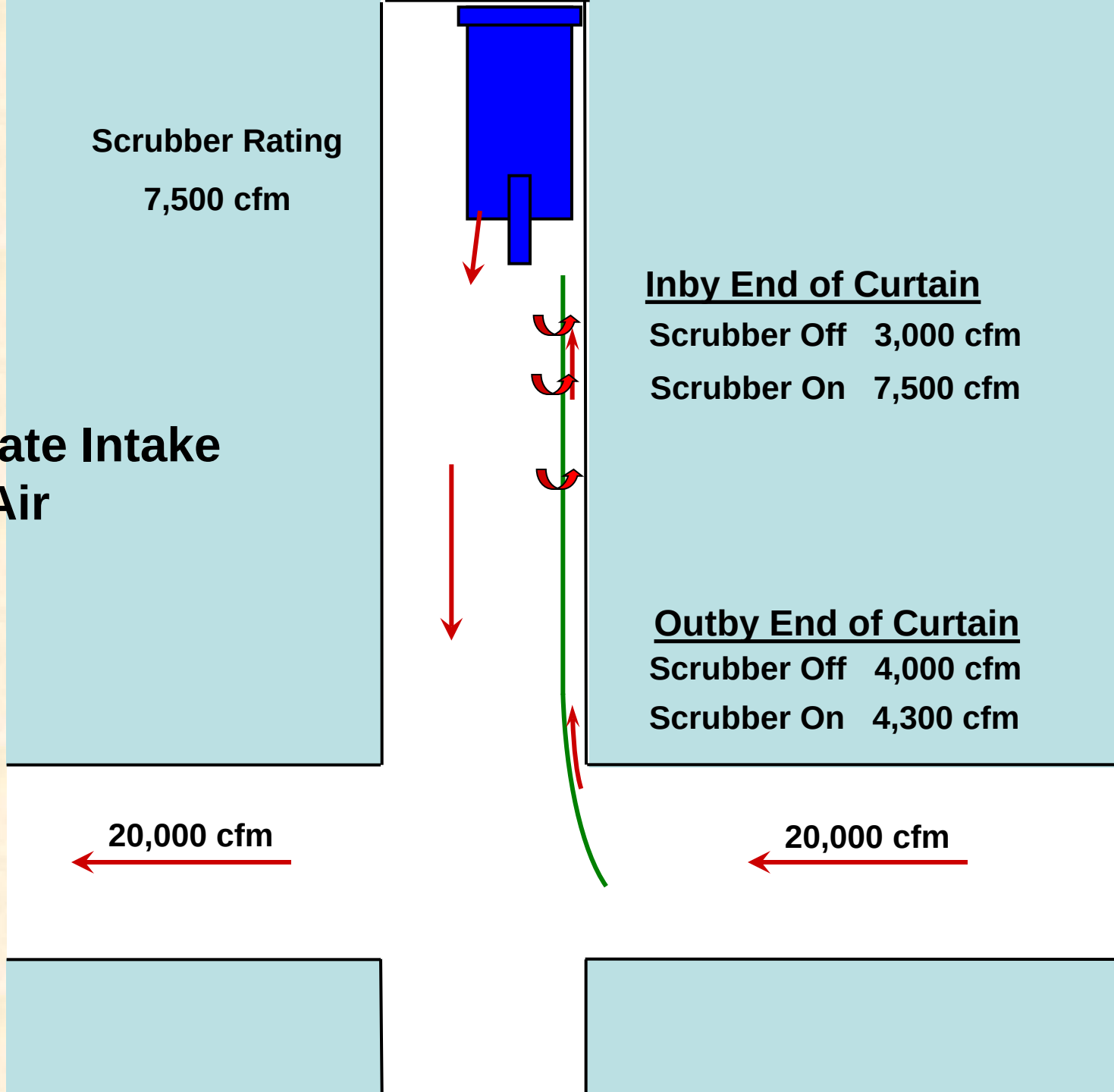
This assures adequate Intake Air is being supplied to the face

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



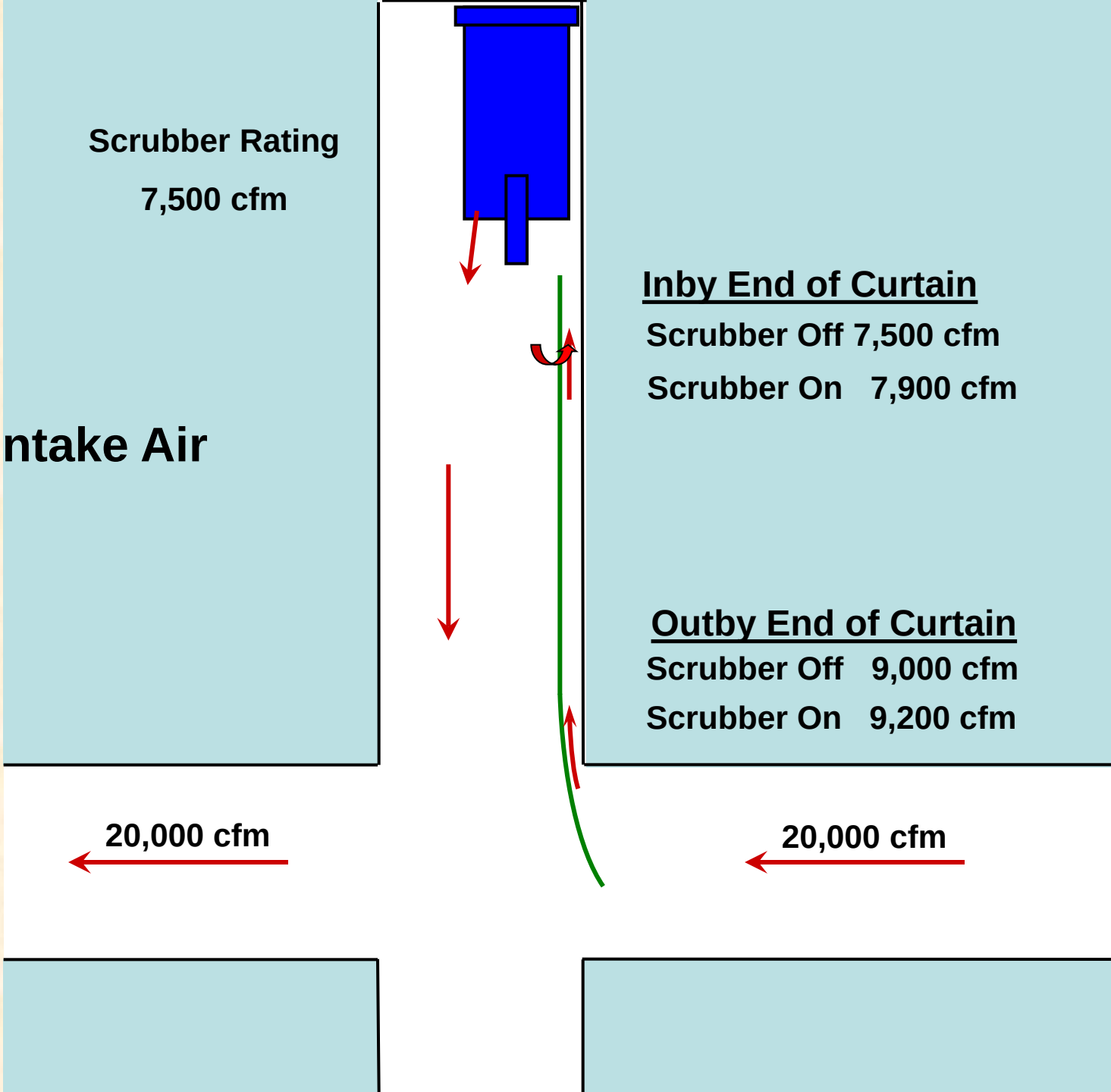
- Amount of Re-circulation will depend on
  - Air Quantity in the curtain area
  - Length of curtain
  - Integrity of hung curtain
  - Equipment position
  - Entry dimensions

Air Measurements from a Dust Face Study

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 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



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

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 re-circulation
    - 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

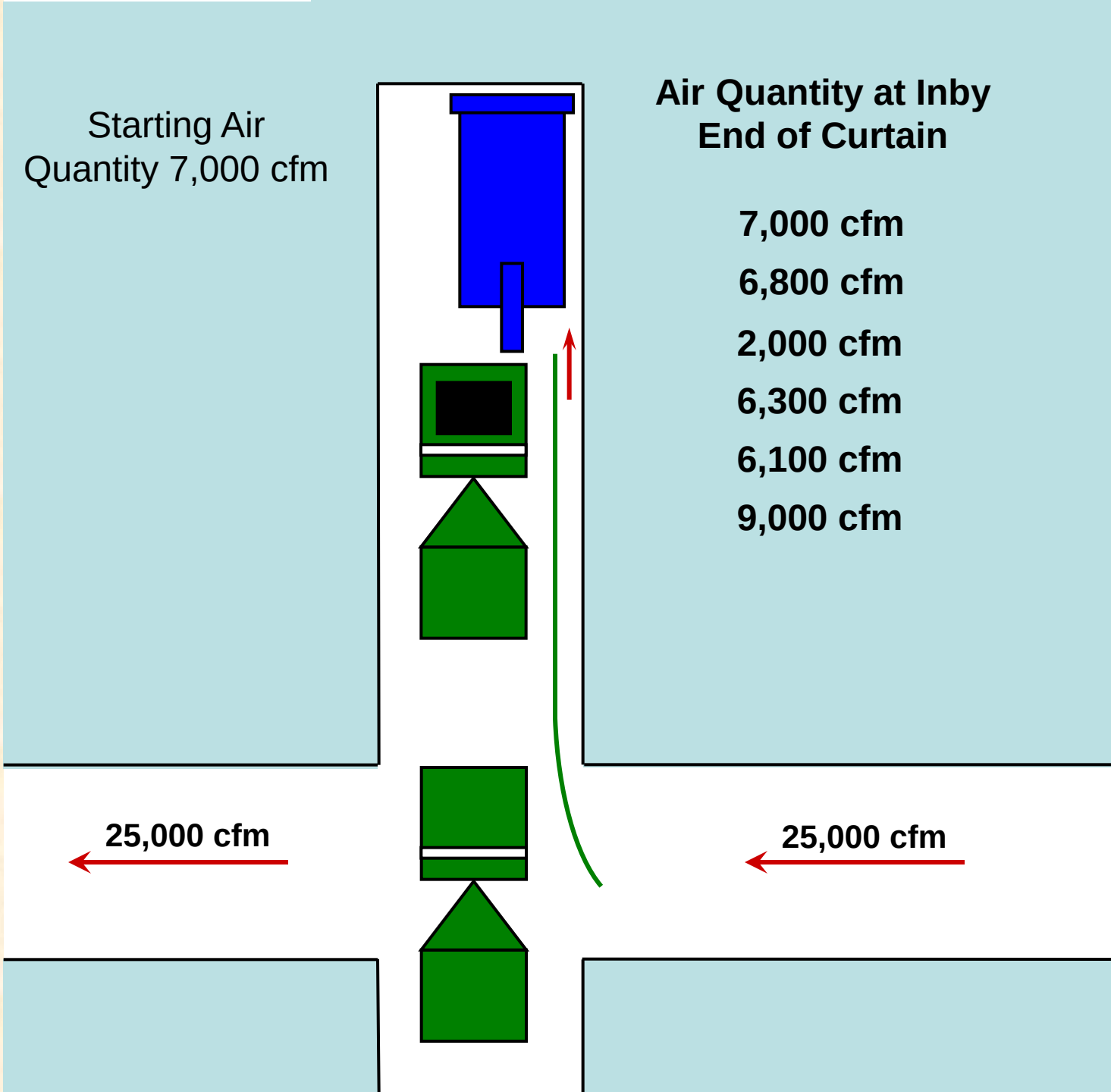
Line Brattice Air Measurement Intake or Exhaust

- 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

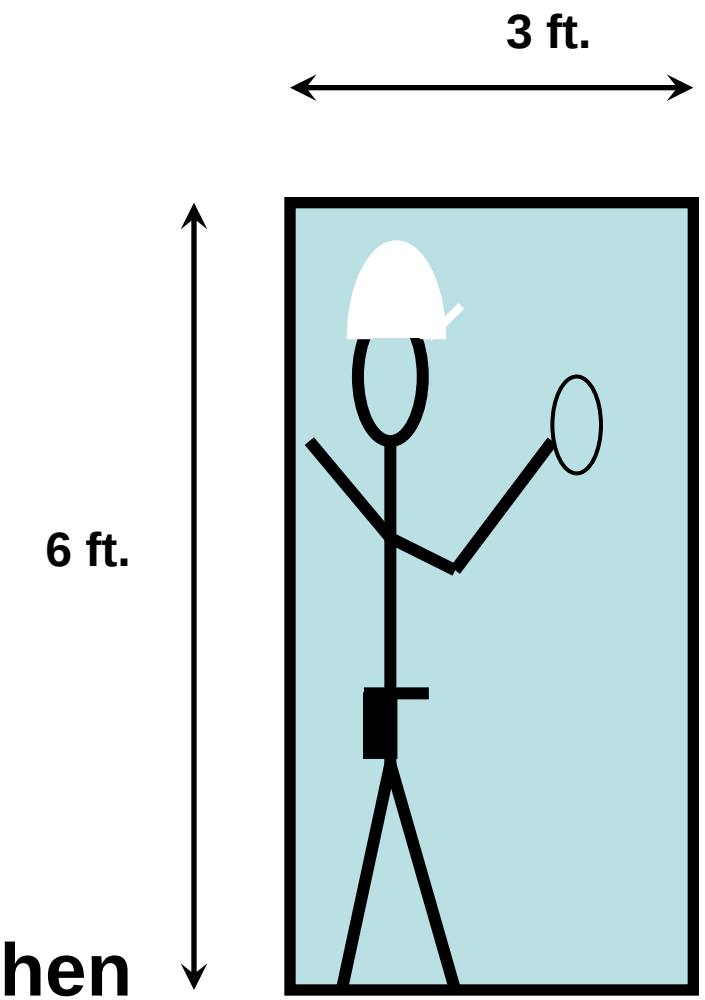
Changes in Curtain Airflows



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 +1000cfm (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)

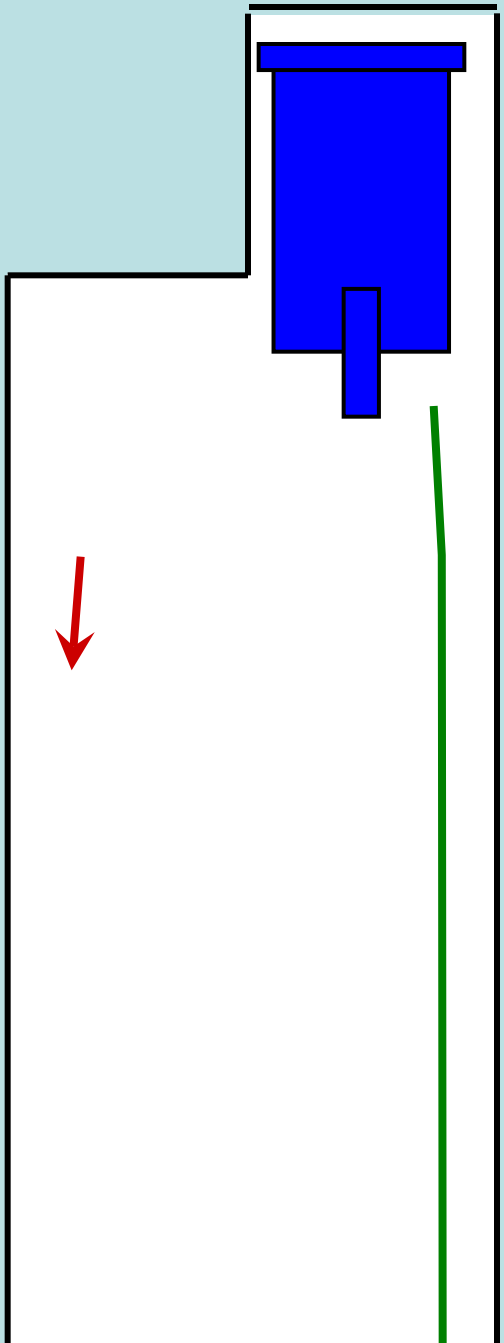
2,310 cfm Actual Line Brattice Air Quantity

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

Recipe for recirculation and Poor Dust Control!!

Offset Cut

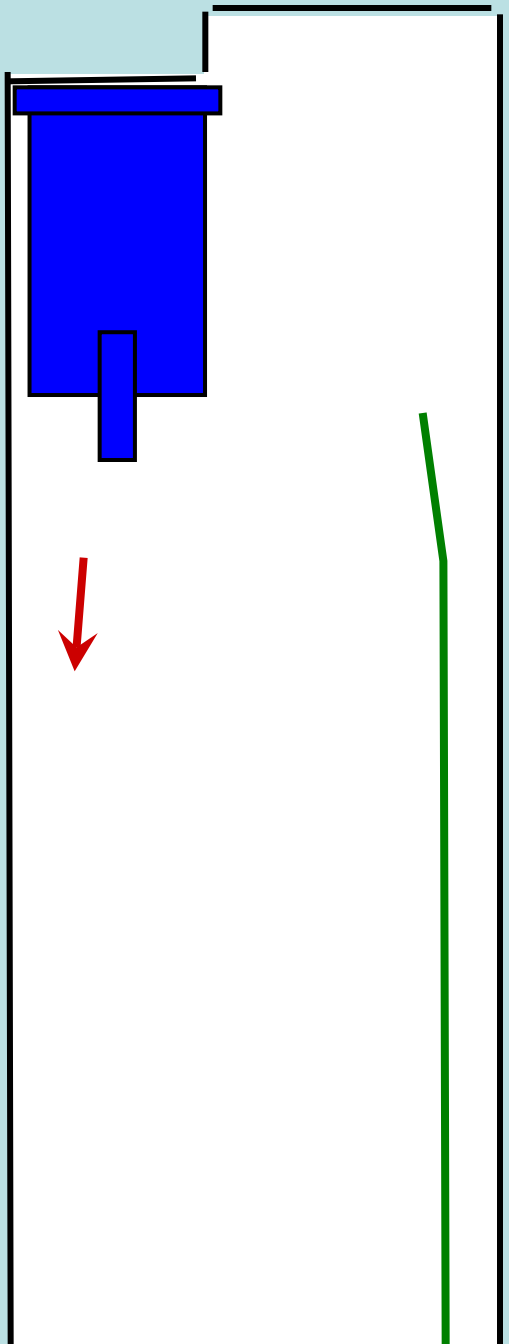
- CM takes a normal sump cut



Offset Cut

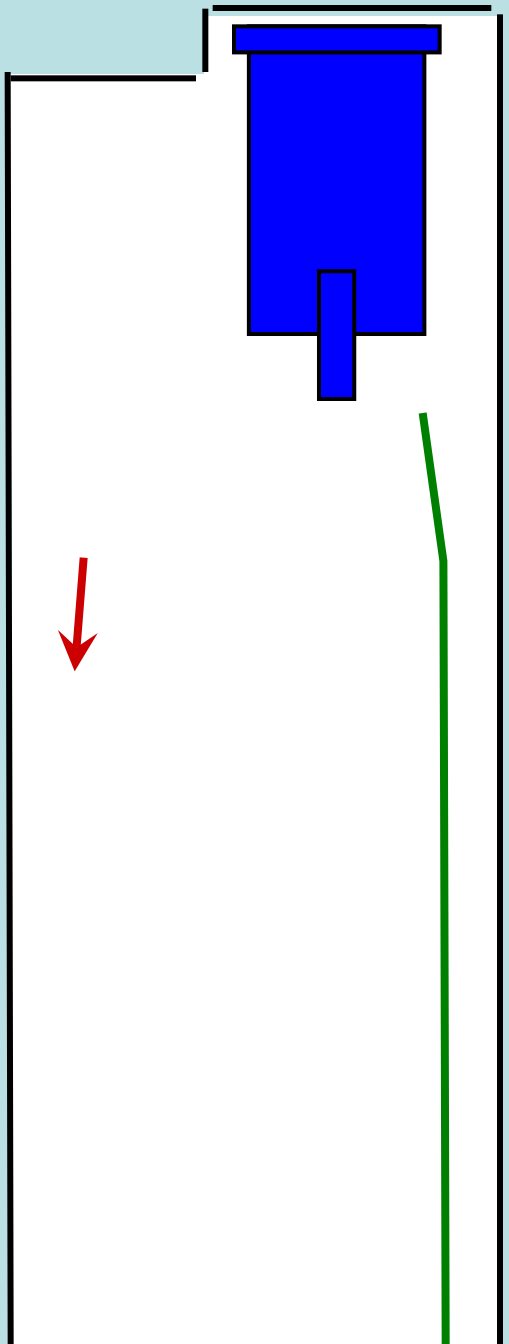
-CM does not square face up on slab cut

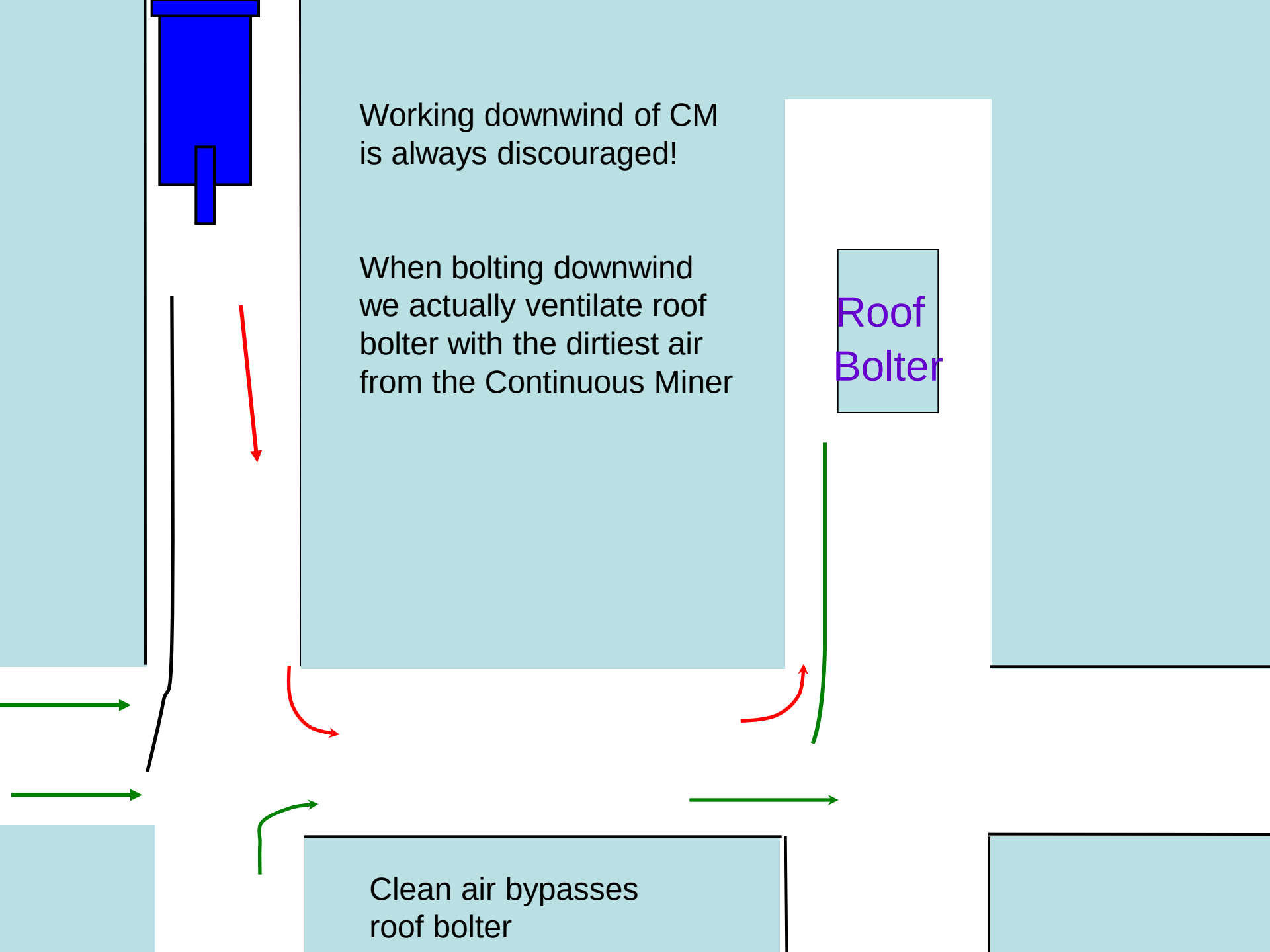
-leaves about 4 feet less than square face

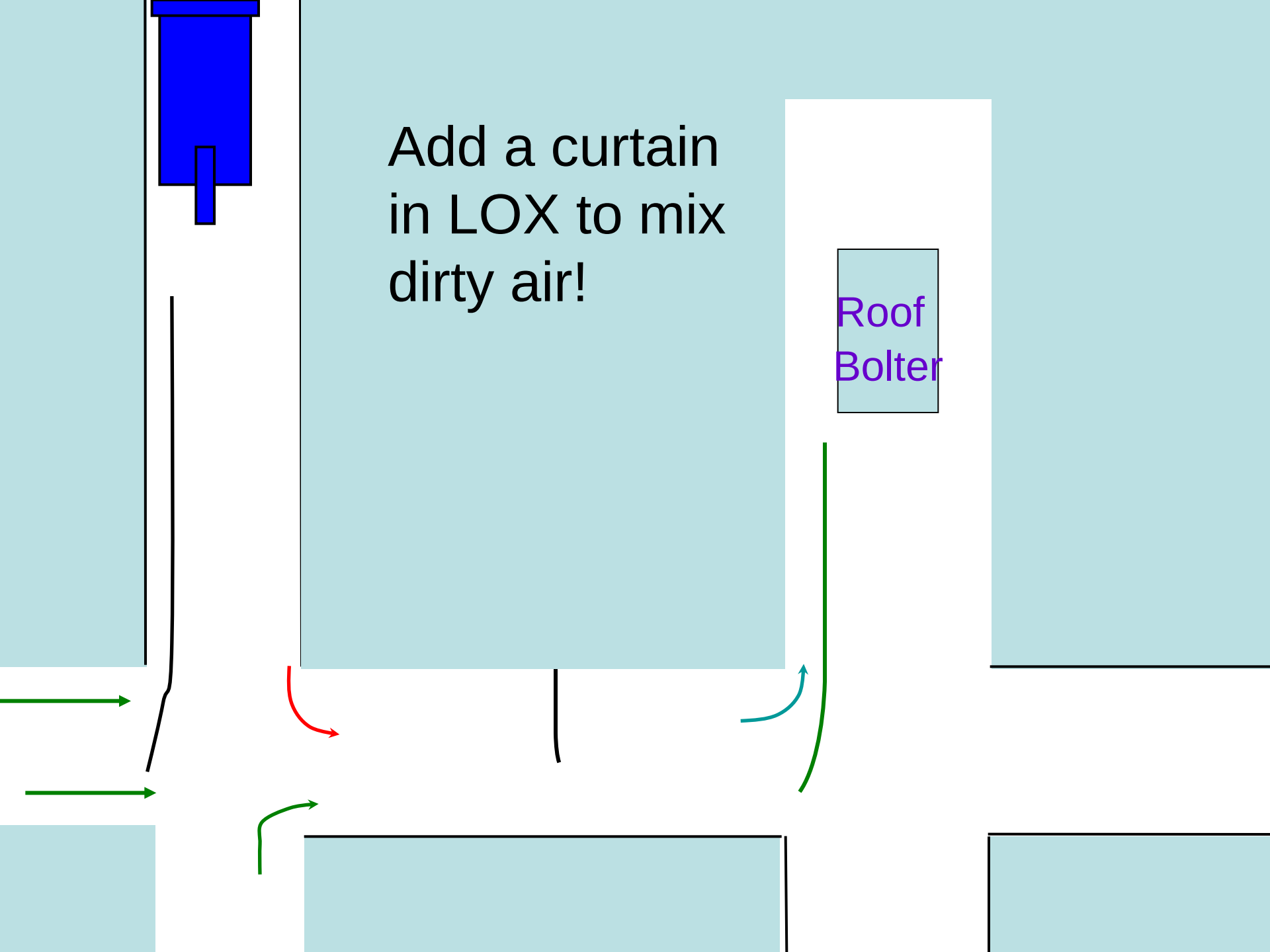


Offset Cut

-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 Ventilation. Increase your face ventilation and utilize it properly and you will reduce your dust concentrations!