Dust Control Strategies for Continuous Miners in High Mining Areas and Longwall Shearers

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Acknowledgements

- Illinois Department of Commerce and Economic Opportunity
  - Office of Coal Development
  - Illinois Clean Coal Institute
- Cooperating Mining Companies

Presentation Outline

- Dust Control for Continuous Miners: High Mining Areas
  - In-mine studies
  - CFD modeling
  - Design of SIUC Sprays System
- Longwall Mining Dust Control
  - Development of dust control facility
  - Dust control on shearers: Studies to date
  - Future plans

Mining in High Seam Heights

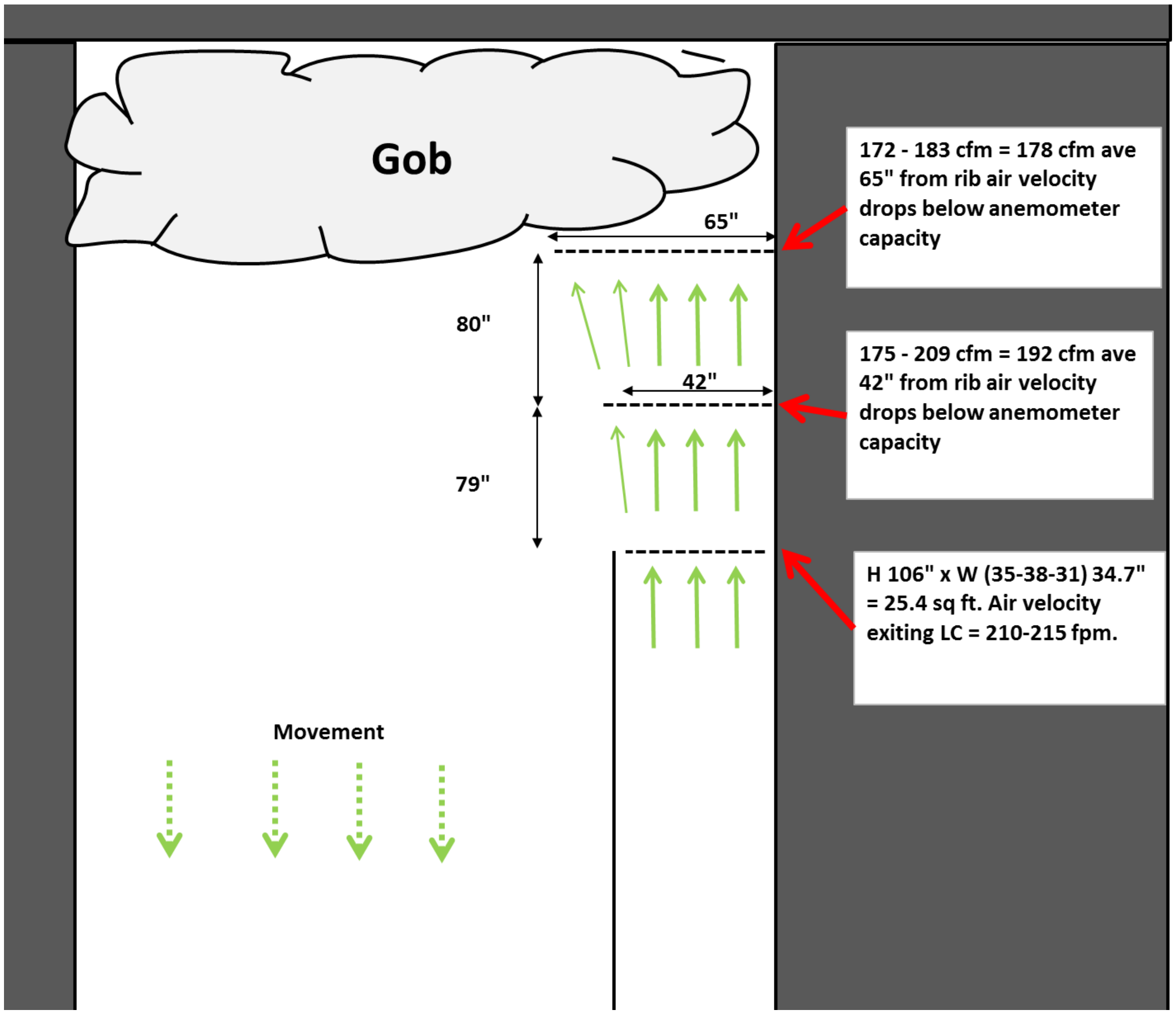
Background and Problem Statement

- Most Illinois Basin seams range 5-7 feet thick.
- Several mines have incompetent roof strata overlying the coal seam that falls out or is cut out. Its thickness ranges few inches to several feet.
- Additional height required for mining equipment.
- Cutting belt headers, belt drives and storage units, overcasts.
- High heights typically are result of cutting roof and/or floor.
- Resulting mining heights can range 10-14 ft. particularly in longwall entry developments areas.

Dust control challenges: High Mining Areas

- Low air velocity at the end of line curtain.
- Difficult to achieve adequate LC air volumes. Installation of LC is difficult and results in gaps near roof and floor.
- Air does not travel much beyond end of LC.
- Air is pulled toward scrubber rather than toward the face.
- Takes much longer for dust to exit the face area.
- Tendency for recirculation behind LC. Less ventilating pressure gradient.
- Large amount of dust created when cutting roof.
- Increased area for dust to escape from around the CM.

Large Cross-sectional Area Effect on End of Line Curtain Air



Data collected from idle mining face.

Air velocity loses energy fast and does not extend very far across entry width.

Air turns quickly and velocity reduces to less than 40 fpm.

For a face 100 feet past LOXC time for air to exit cut can be over 2 minutes.

Field Observations on Increase in LC Air Volume Due to Scrubber Operation in High Mining Areas

CM Idle	CM Running	% Increase
6,712	10,823	61
1,375	5,619	309
4,394	14,228	224
3,241	5,900	82
3,278	6,482	98
2,277	8,625	279

Field Observations on Effect of Haulage Unit on LC Air Volume

Distance face to LOXC (ft.)	LC Dimensions			End of LC air velocity (fpm)			
	Height (in)	Distance to rib (in)	Area (ft ^{2})	NO HU	HU Entering	HU Loading	HU Exiting
45	140	40	38.9	205	0-75	197	235
70	138	42	40.3	236	0-55	177-197	374-315
140	145	45	45.3	0-59	0-<50	217-236	335-394

Note: Values are highest and lowest recorded. 0 represents movement that is less than 50 fpm. Readings taken with MSA digital vane type anemometer and ExTech digital anemometer.

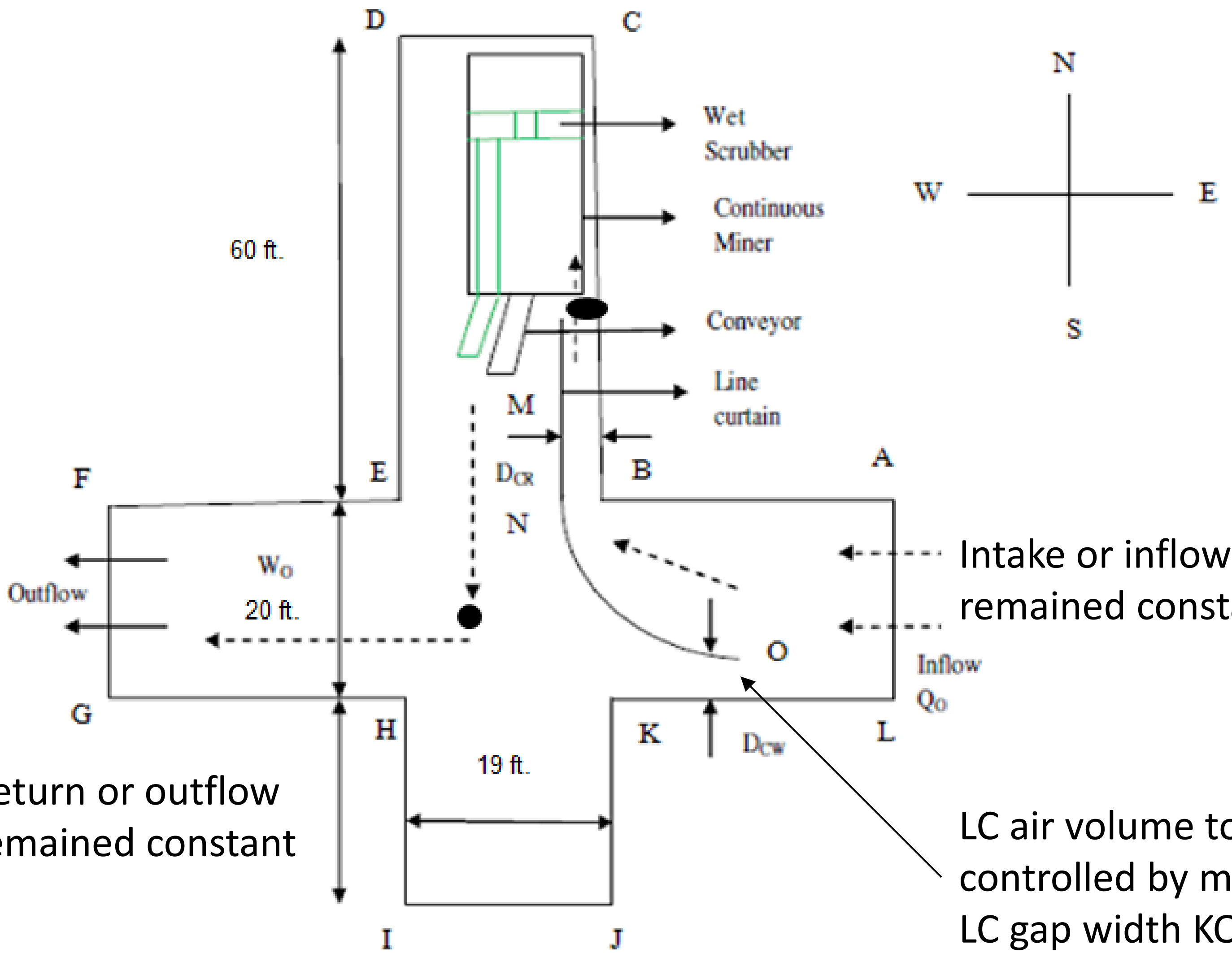
Scrubber Efficiency in High Mining Areas

- Influence of suction inlets can not reach dust near the roof allowing it to escape over top of CM.
- Time for one air change at face (40ft x 10ft x 19ft minus volume of CM) at 10 feet height is about 49 seconds for scrubber operating at 7500 cfm.
- For 7 feet height, time is reduced to about 31 seconds…. 37% less time but only 30% less height.
- Dust from cutting large amounts of roof overloads scrubber and reduces its dust capture efficiency.
- Scrubber exhaust can contain dust which affects LOXC.

CFD Modeling of Air Flow Patterns in the High Mining Areas

- CFD modeling used to identify changes in air flow patterns in the face area at:
  - Three end of line curtain volume to scrubber volume (Q_{LC}:Q_S) ratios of: 0.85:1, 1:1, and 1.15:1
  - Mining heights: 8 and 14 feet
  - Air flow patterns at 5 feet above the floor, about where human suction inlets are located.
  - Intake and return volumes remain constant. LC volume is changed by closing gap in LOXC.

Face Configuration Modeled

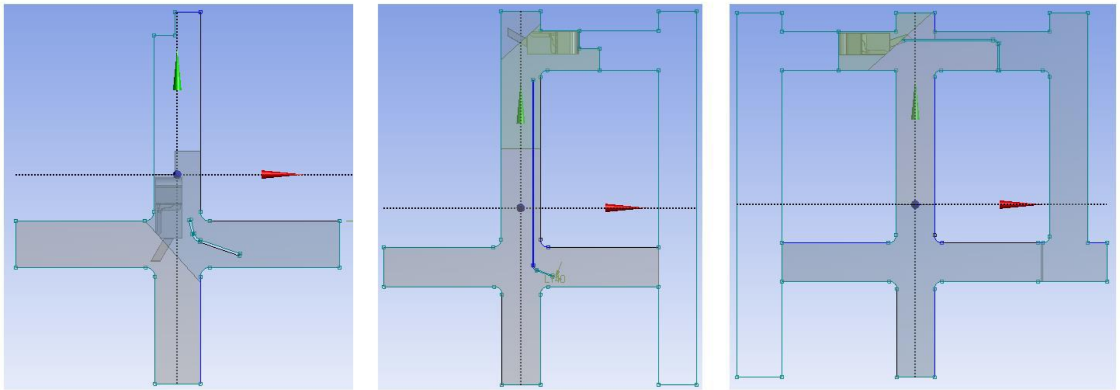


Intake or inflow remained constant

Return or outflow remained constant

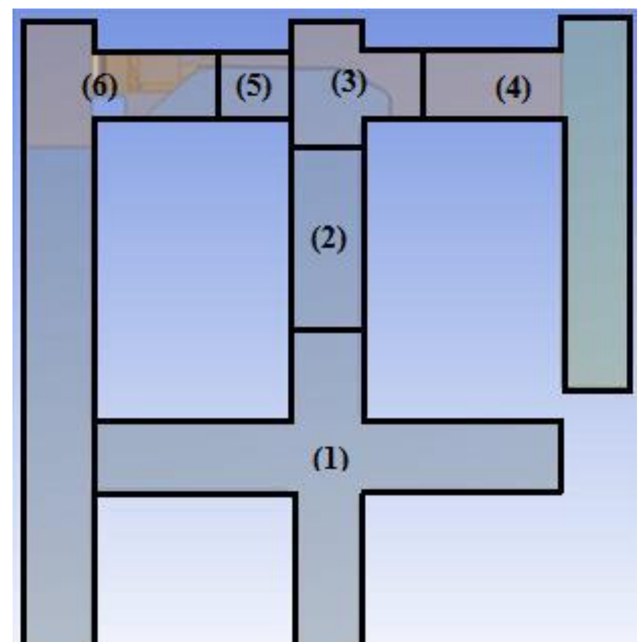
LC air volume to face controlled by manipulating the LC gap width KO in LOXC

Different Cuts Modeled



a) Straight deepest cut b) Right turn cross cut c) Left turn cross cut head on

Mining geometry modeled

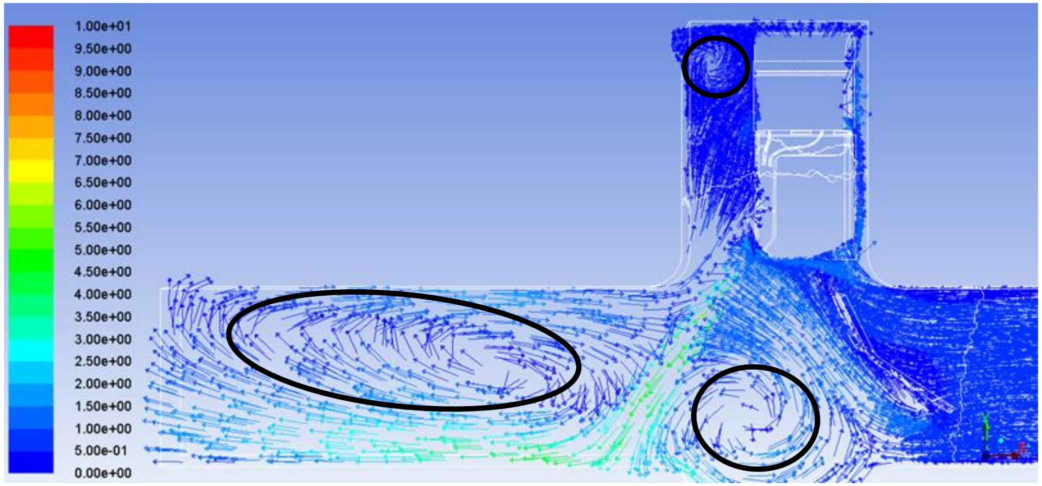


1) Straight initial – first 40 ft. cut into entry from LOXC
2) Straight deepest – face over 40 ft. past LOXC
3) Turn XC right
4) XC right second cut and hole through
5) XC right mined straight ahead
6) Second cut in XC right and hole through

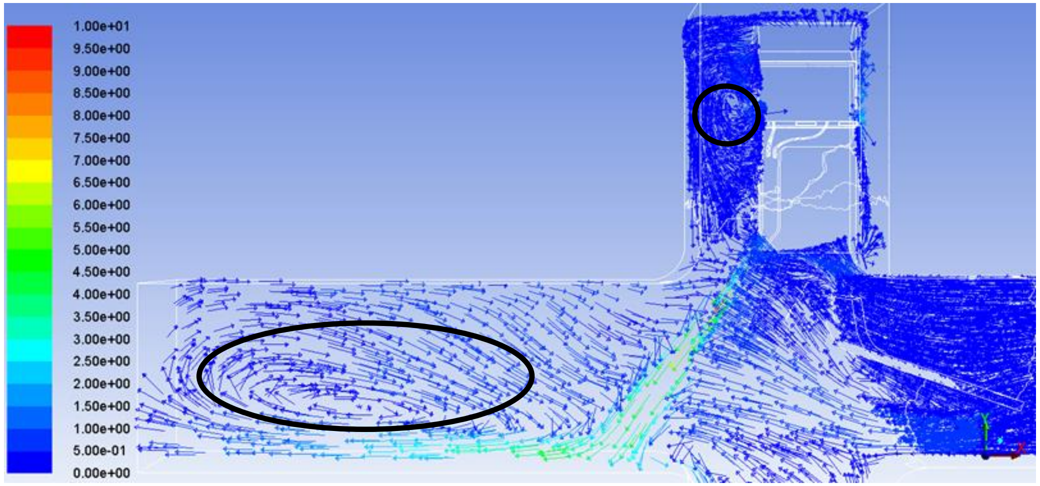
End of Line Curtain Air Volume to Scrubber Capacity Ratio

- Scrubber capacity (Q_s) is constant at 7,400 cfm.
- Line curtain volume (Q_{LC})
  - @ 0.85:1 = 6,290 cfm
  - @ 1:1 = 7,400 cfm
  - @ 1.15:1 = 8,510 cfm
- Distance between LC and rib in last open crosscut manipulated to change end of LC volume to simulate underground ventilation methods. Intake and return air volumes remained constant.

Some CFD Model Results Showing Different Air Flow Patterns for 8 and 14 ft. Mining Heights with $Q_{LC}:Q_S = 0.85:1$

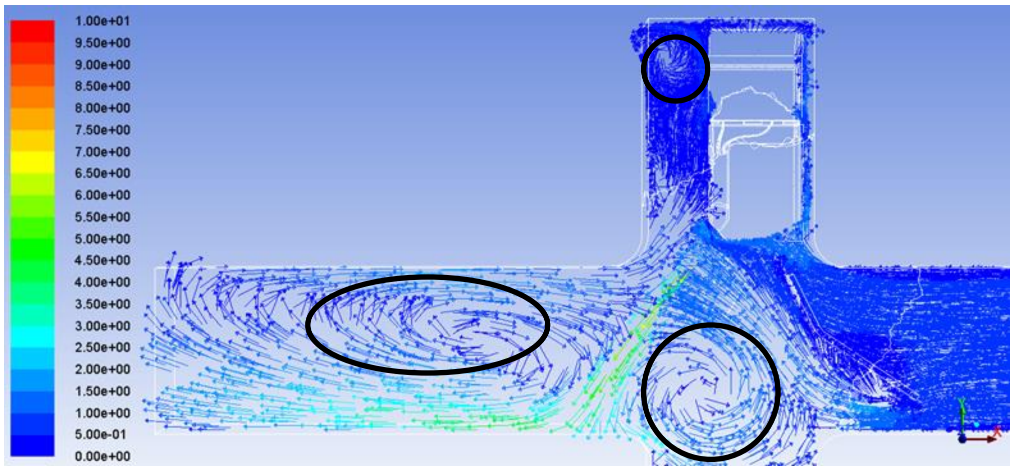


RC zones for a low mining height model of 8 ft. at 5 ft. from ground level. Recirculation zone near face, moves slightly outby in 14 ft. height.



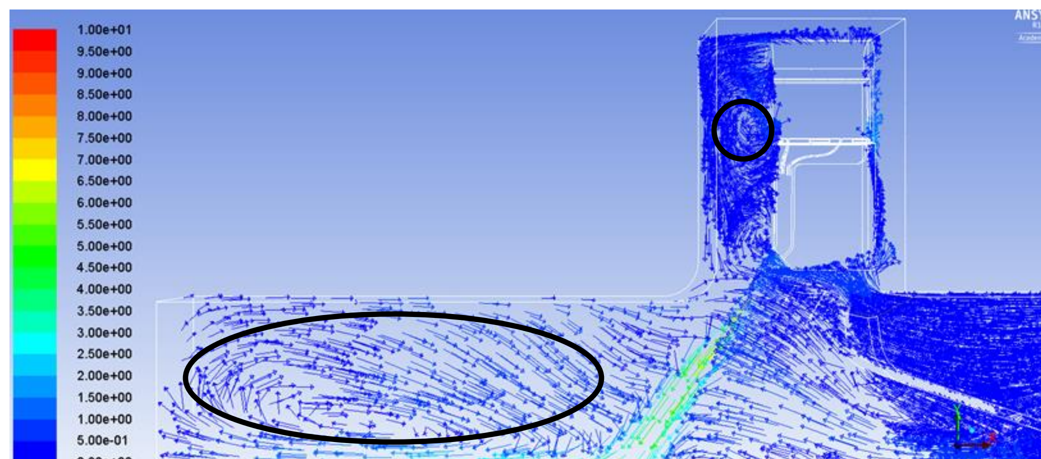
RC zones for a high mining height model of 14 ft. at 5 ft. from ground level. Recirculation zone behind the CM disappears.

CFD Models Showing Different Air Flow Patterns for 8 and 14 ft. Mining Heights with $Q_{LC}:Q_S = 1:1$



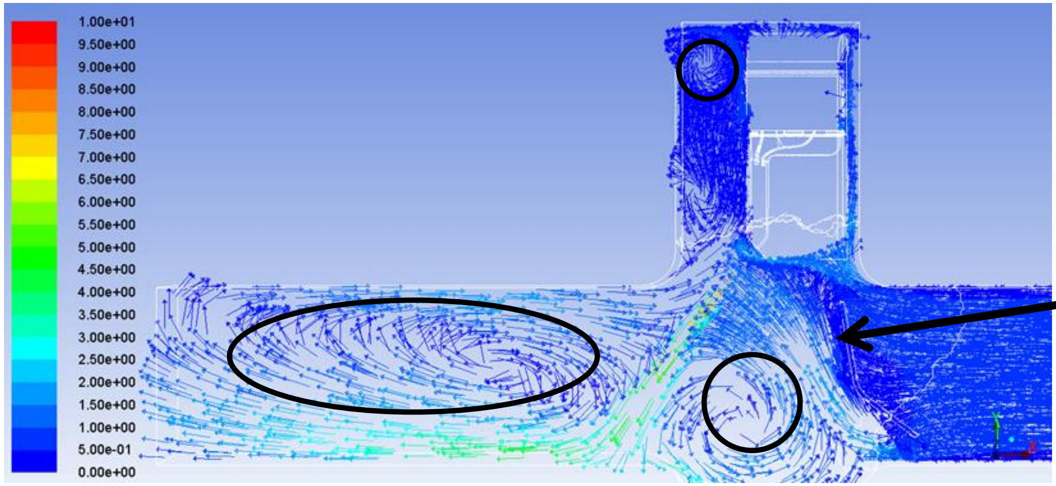
RC zones for a low mining height model of 8 ft. at 5 ft. from ground level.

Similar to 0.85:1 ratio.



RC zones for a low mining height model of 14 ft. at 5 ft. from ground level.

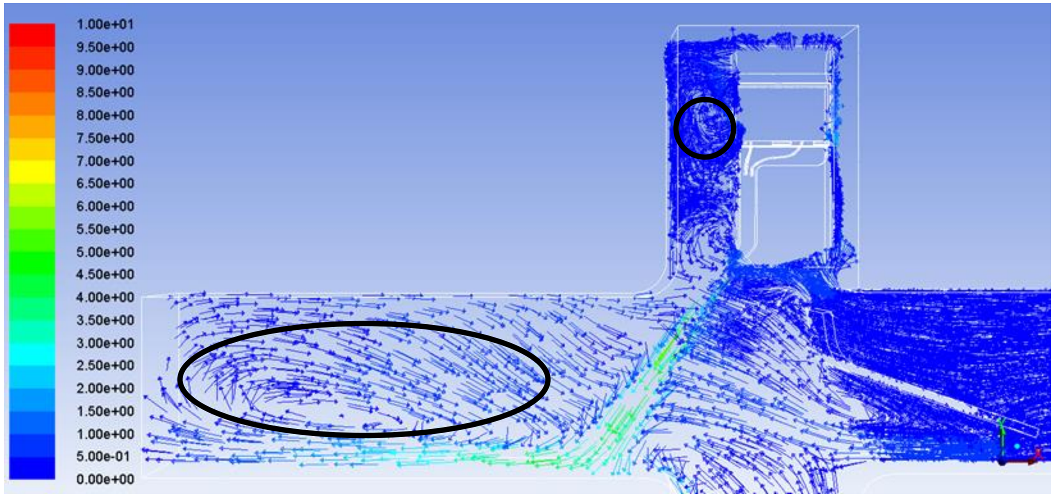
CFD Models Showing Different Air Flow Patterns 8 and 14 ft. Mining Heights with $Q_{LC}:Q_{S} = 1.15:1$



RC zones for a low mining height model of 8 ft. at 5 ft. from ground level.

More air is getting pulled from gap in LC into scrubber exhaust air stream.

RC zones for a low mining height model of 14 ft. at 5 ft. from ground level.

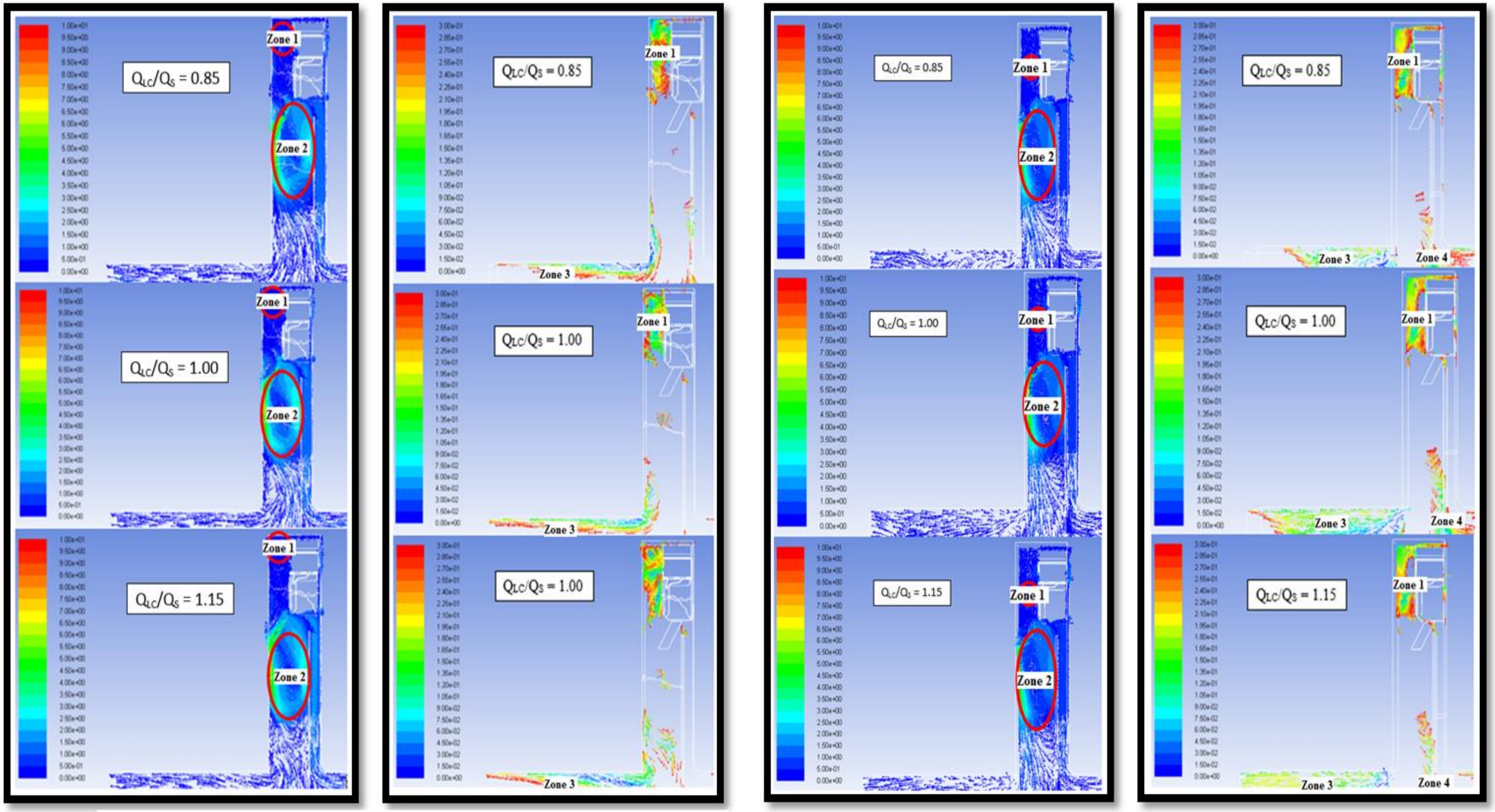


CFD Models When CM is Cutting 100 feet Past LOXC for Three $Q_{LC}:Q_{S}$ Ratios

Box cut @ mining heights

8 ft.

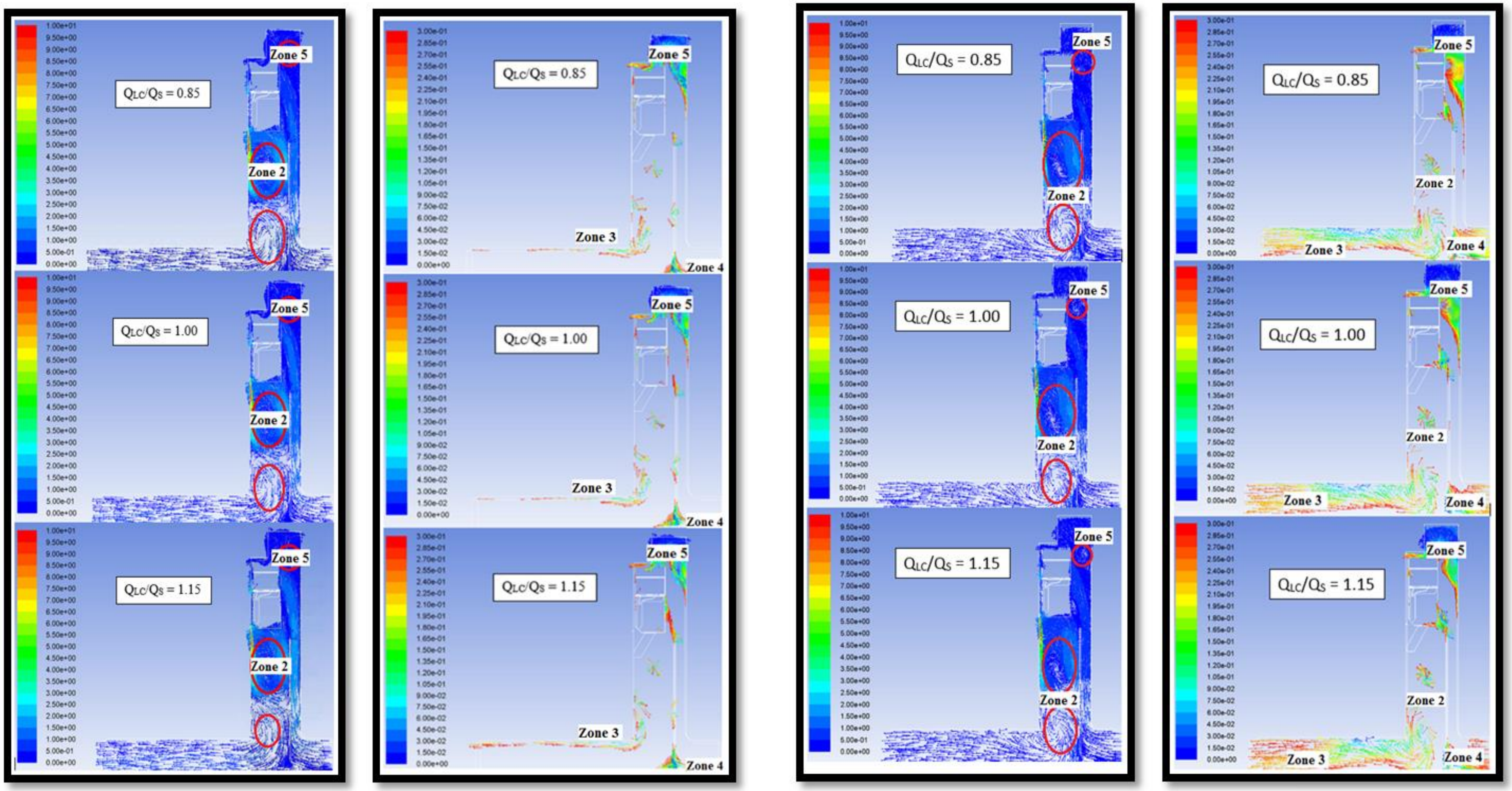
14 ft.



CFD Models When CM is Cutting 100 feet Past LOXC for Three Q_{LC}:Q_S Ratios

Slab cut @ mining heights

8 ft. 14 ft.



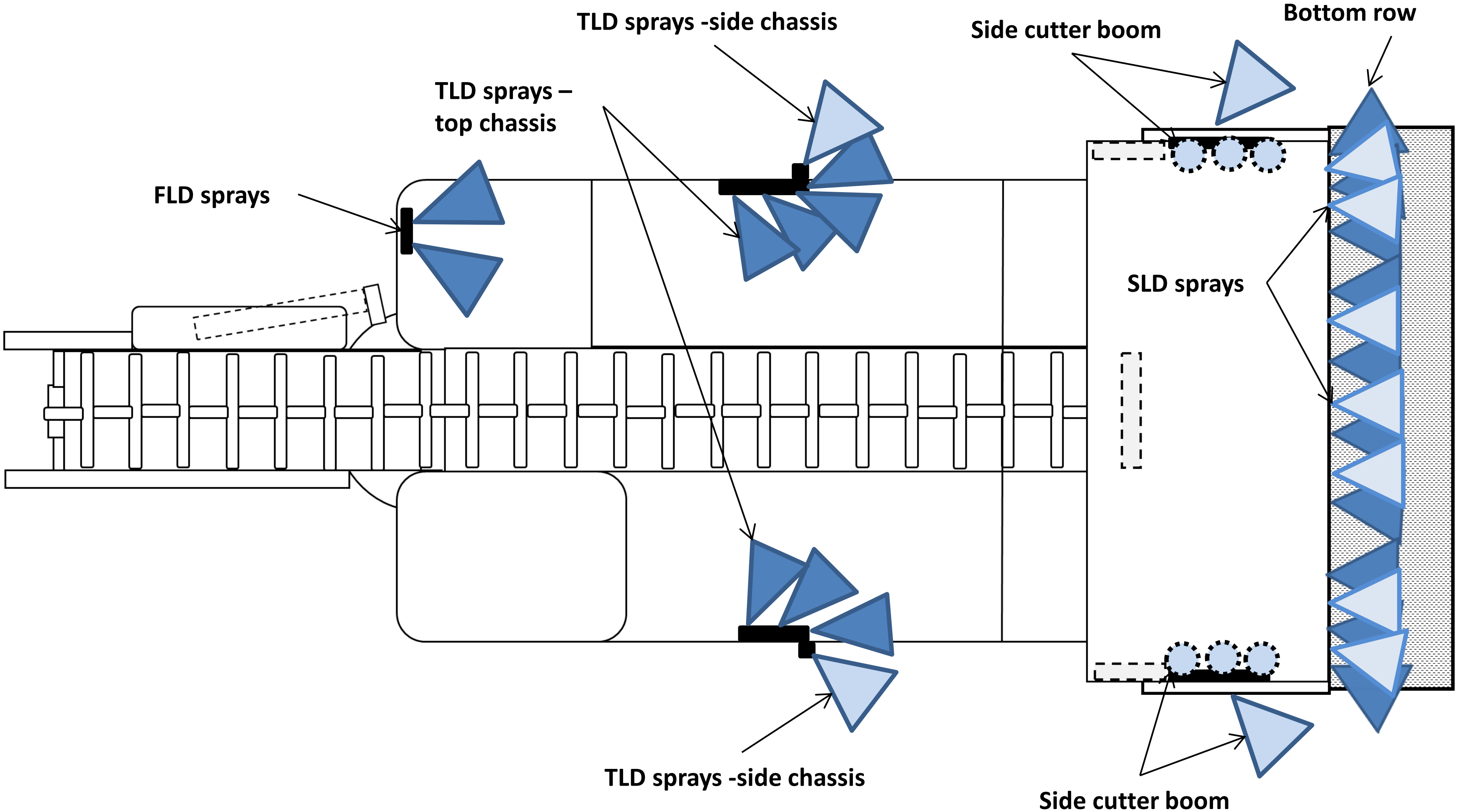
CFD Studies Needed (contd.)

- Continued CFD modeling is needed to simulate the entire dynamic face environment.
  - Include cutting drum rotation with and without sprays (wet-head CM)
  - Include chassis sprays
  - Entering, loading, and exiting of haulage units
  - Staging of haulage units in LOXC
  - Studies will require very large computing capacity

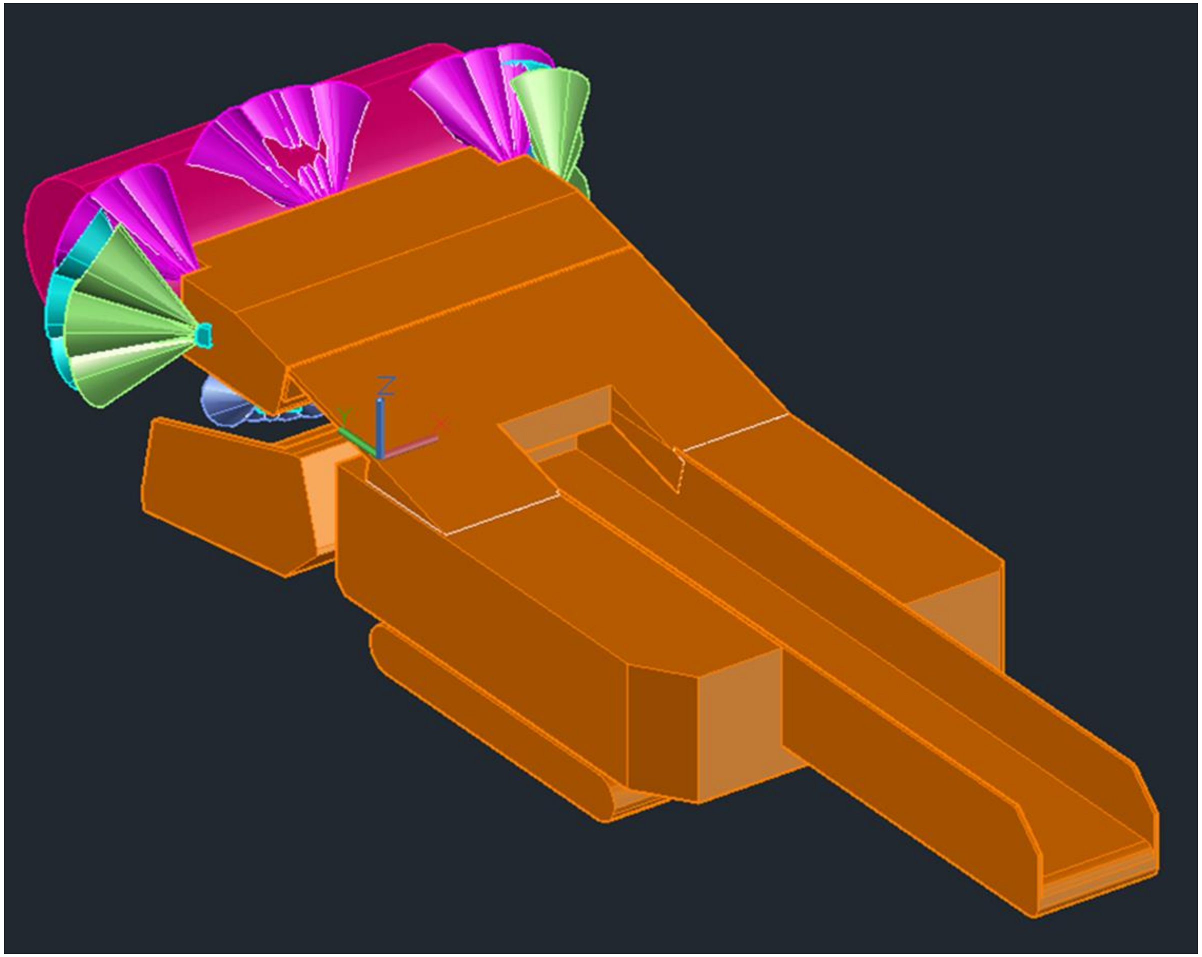
Design of SIUC Spray System Using CFD Modeling for High Mining Areas

- Used CFD modeling to guide in spray design.
- Significant differences in sprays design
  - Spatial location of sprays to minimize air recirculation and push air more toward the face.
  - Improved design of SLD sprays to envelope high mining areas.
  - Higher pressure on TLD sprays to reach high mining areas.
  - Fourth line of defense sprays to protect the HUO.
  - Modified scrubber discharge angle to reduce back pressure in the intake side of line curtain.
  - Used sprays with increased reach to create hydraulic curtain to contain dust near face.

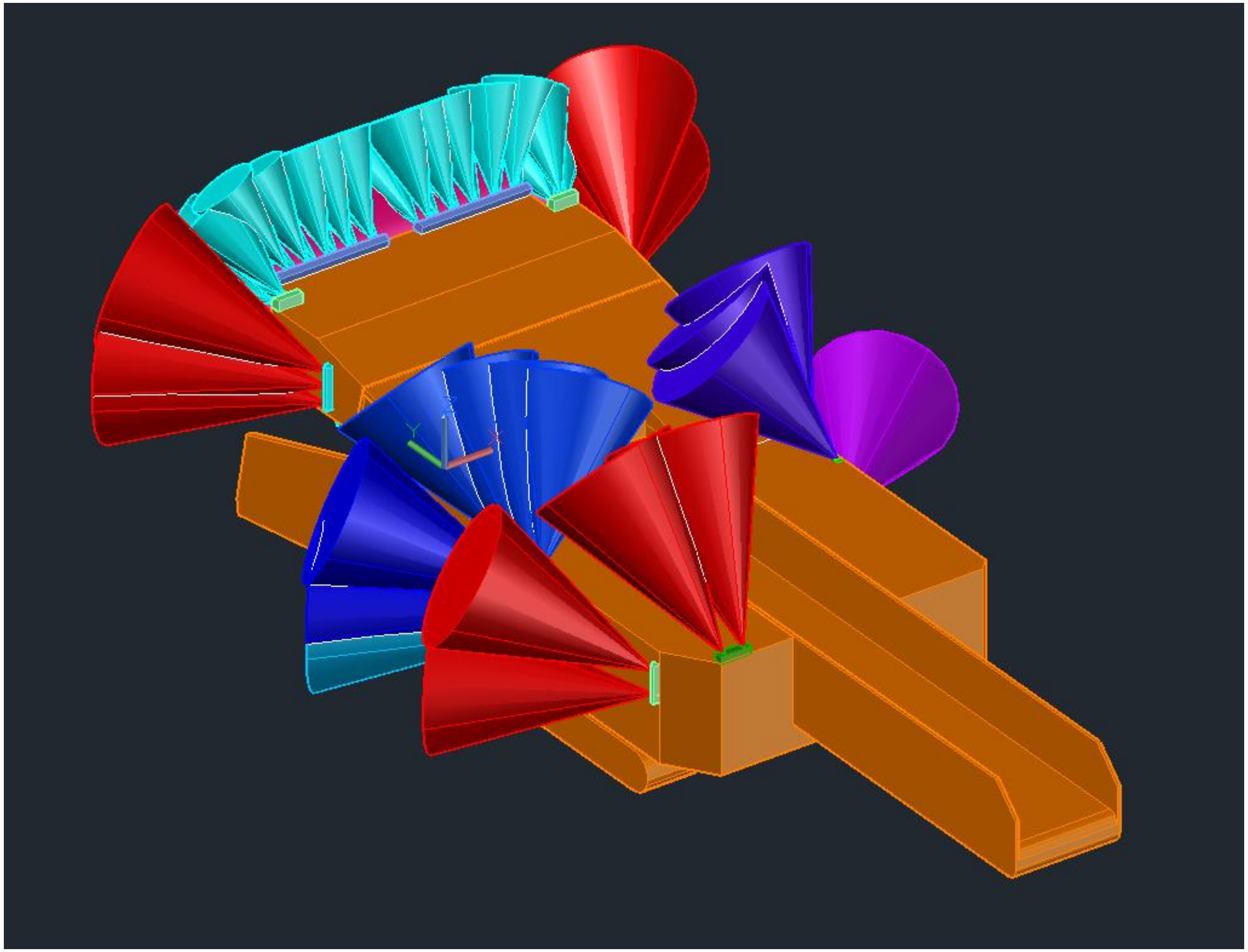
SIUC Innovative Spray System for High Mining Heights



Isometric View of Conventional Spray System for Joy 12CM27



Isometric View of SIUC Spray System for Joy 12CM27



Improved Dust Control for CMs Operating in High Mining Heights

- Improved water spray system: SIUC Innovative Spray System.
- Demonstrated the effectiveness of SIUC system in limited tests in mine with 12 to 14 feet mining height.
- Added a fourth line of defense (FLD) spray system.

Percent dust reduction using SIUC Innovative Sprays on 12CM27 Miner Operating in 12-ft High Mining Height

Location	Gravimetric sampling	PDM - TWA
CMO	17.9	23.4
HUO	55.5	67.9
Return	3.1	-19.5

Note: Above data based on study of temporary system that did not include all Innovative Spray System concepts. 6 cuts with conventional sprays and 3 cuts using temporary system.

Dust Control in Longwall Mining

Driving Force Behind Development of Longwall Dust Control Facility

- Implementation of new MSHA dust standards.
- Increase in the number of longwall faces in Illinois Basin.
- Research on longwall faces is difficult and very limited.

Longwall Dust Control Test Facility

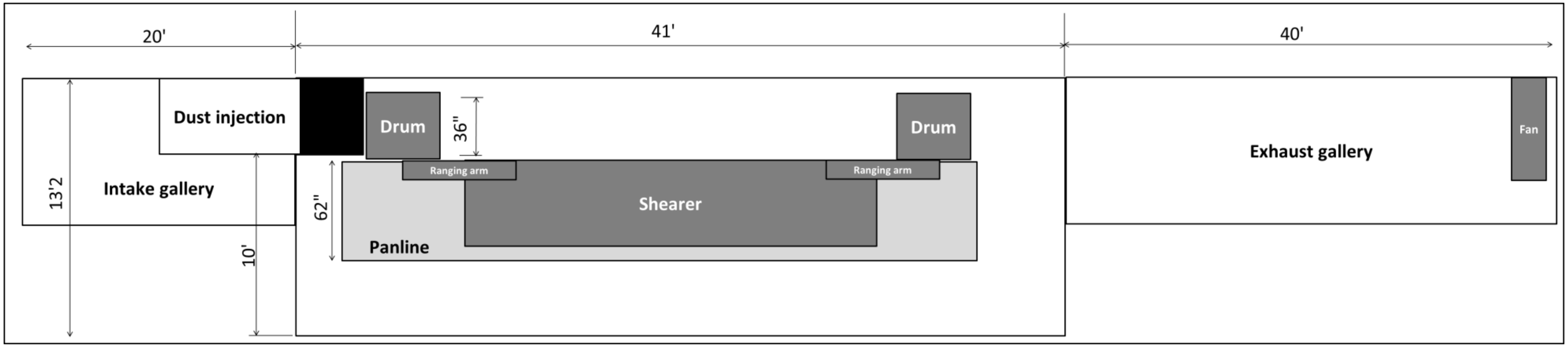
Construction of Facility

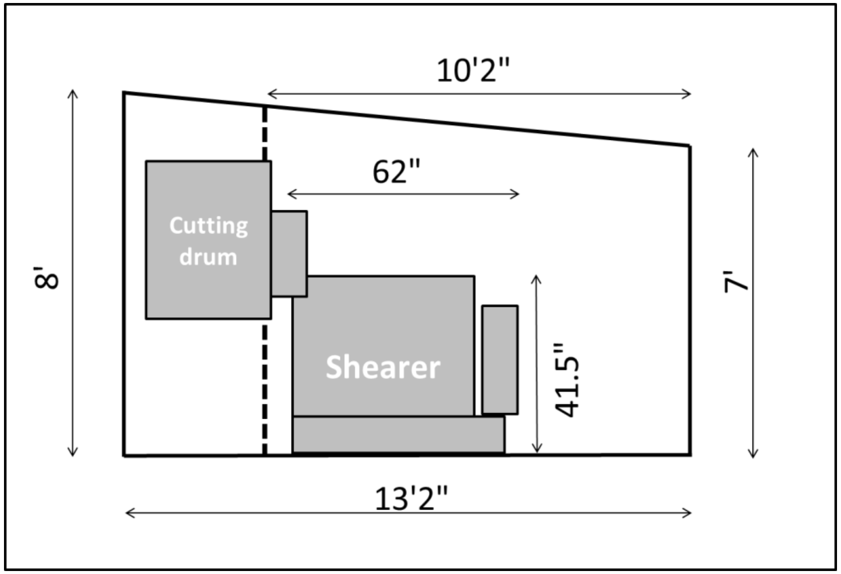
Construction of shearer frame

Shield support legs

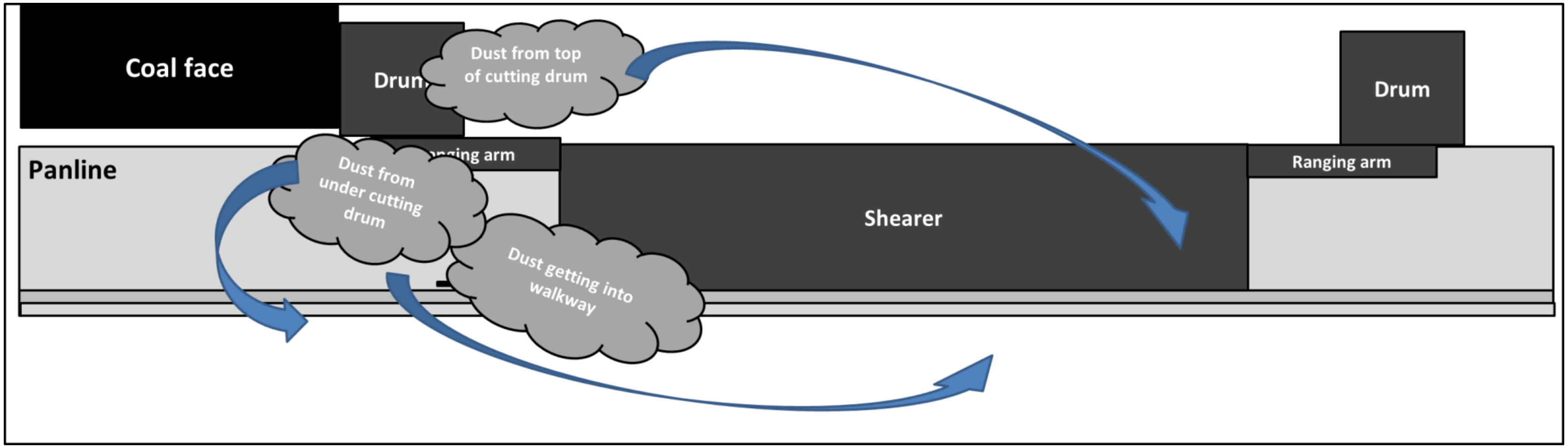
Painted shearer chassis

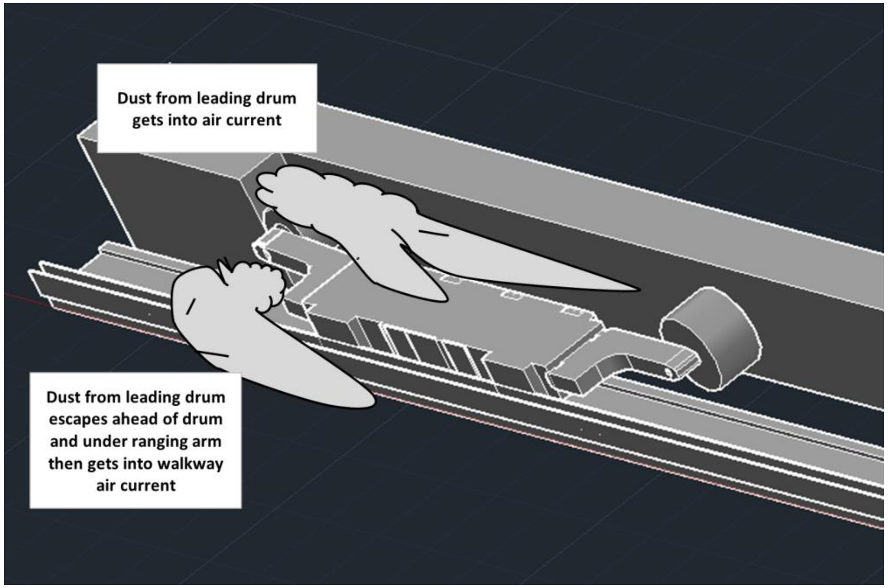
Dimensions of dust gallery





Dust Sources Around Longwall Shearer





Studies Conducted in Longwall Dust Facility

- Effect of air velocity on the effective reach of different type water sprays operating at different pressures.
- Effect of high air velocity on dust concentration and distribution on longwall face.
- Identify optimum location and operating pressure for sprays.
- Impact of spray type, location, and operating pressure on respirable dust at different air velocities.
- Identify dust escape paths around shearer cutting drum.
- Study effects of spray location and air velocities on dust concentrations at shearer headgate and tailgate drum operators and downwind.
- Study effects of wetting agents and surfactants.

Some Observations to Date

- Wettability of coal, roof, and floor has impact on dust control. Limited contact time between dust particles and water droplets in high velocity conditions.
- Dust can be easily blown into walkway by water sprays.
- Identifying the operating pressure of certain sprays that is required to overcome high air velocity but not displace dust into the walkway area.
- Proximity of sprays to cutting drum can impact dust. Initial studies show dust suppression improves with the location, type, and orientation of sprays.

Some Solutions

- Project team is currently evaluating air and dust flow patterns associated with current dust control systems and technologies.
- Recreating underground conditions as close as possible in a lab setting.
- Using historical data, previous studies, industry and MSHA knowledge base as guide along with scientific experimentation for finding solutions.
- Testing innovative ideas and identifying problems with applying them in the field.

Future Plans

- Continue with design of improved spray system and operational parameters to match mining conditions such as face air velocity, mining height, coal wettability, dust concentrations, etc.
- Work with mining companies to evaluate their dust control ideas in lab setting before making major changes underground.
- Create an effective dust control ***system*** for the longwall face.

Questions??