Continuous Miner Ventilation
Dust Mitigation Research at UK

KY Professional Engineers in Mining Seminar

August 26, 2016

Dr. Chad Wedding

PEM

Moving Kentucky Forward

UK

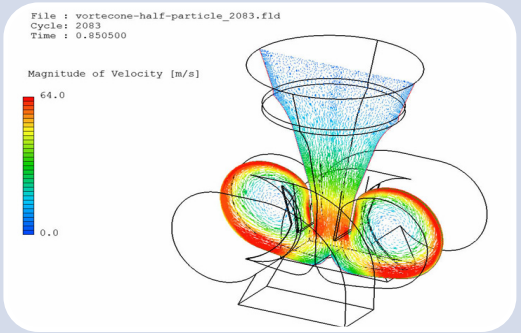
UNIVERSITY OF KENTUCKY

MSHA New Dust Rule

August 1st, 2014	• Revised full shift samplingImmediate corrective actions • Improved record keeping • Increased medical surveillance
February 1st, 2016	• Continuous personal dust monitor (CPDM) • High exposure occupations- more sampling.
August 1st, 2016	• Overall dust standard: 2.0 - 1.5 mg/m^3 • Miners workplace: 1.0 - 0.5 mg/m^3

Source: http://www.msha.gov/endblacklung/docs/summaryEffectiveDates.pdf

UK Dust Mitigation Research



Flooded Bed Scrubber for Longwall Shearer

Novel Vortecone Scrubber Technology Transfer

Passive Wing Regulator

Passive Wing Regulator

- Full scale test gallery for testing dust and methane controls
- 1:1 continuous miner
  - Body sprays
  - Rotating drum
- Combination of engineering controls
  - Scrubber
  - Wing Regulator
  - Sprays

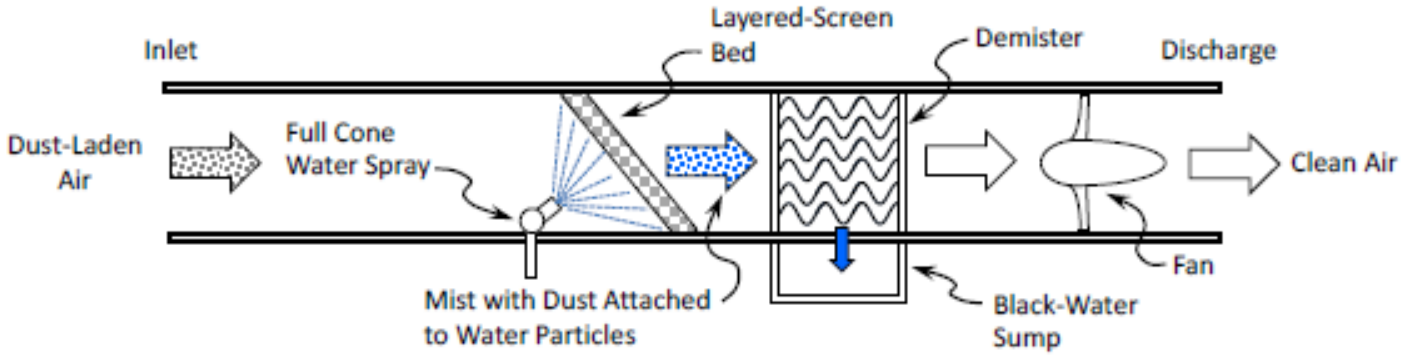
Longwall Dust Control Challenges

Longwall

Air Quantity, 67 kcfm	Air Quantity, 7 kcfm
High Production	Relatively lower production
Airflow along the face	Blind heading
Multiple, scattered sources of dust	Localized source

Room and Pillar

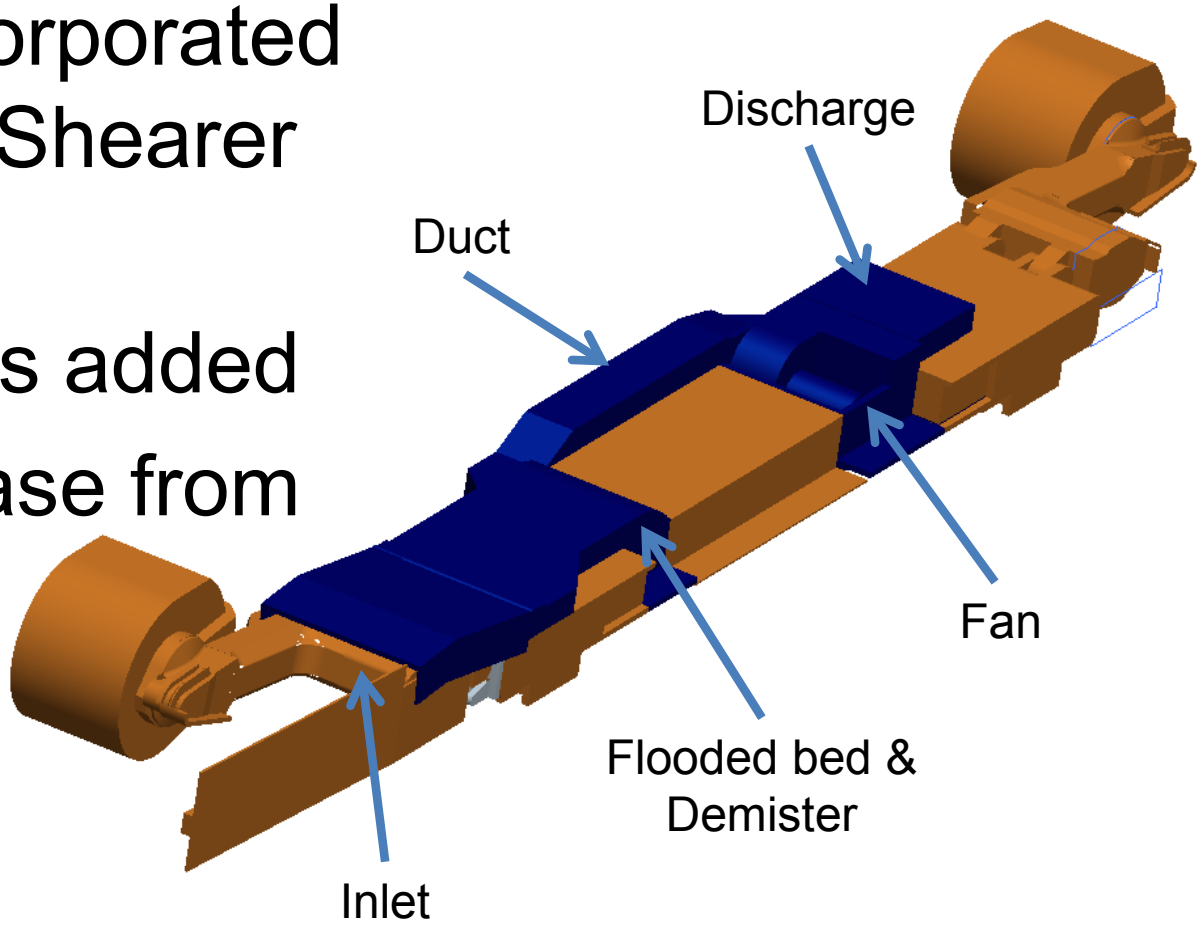
Flooded Bed Scrubber for Longwall Shearer



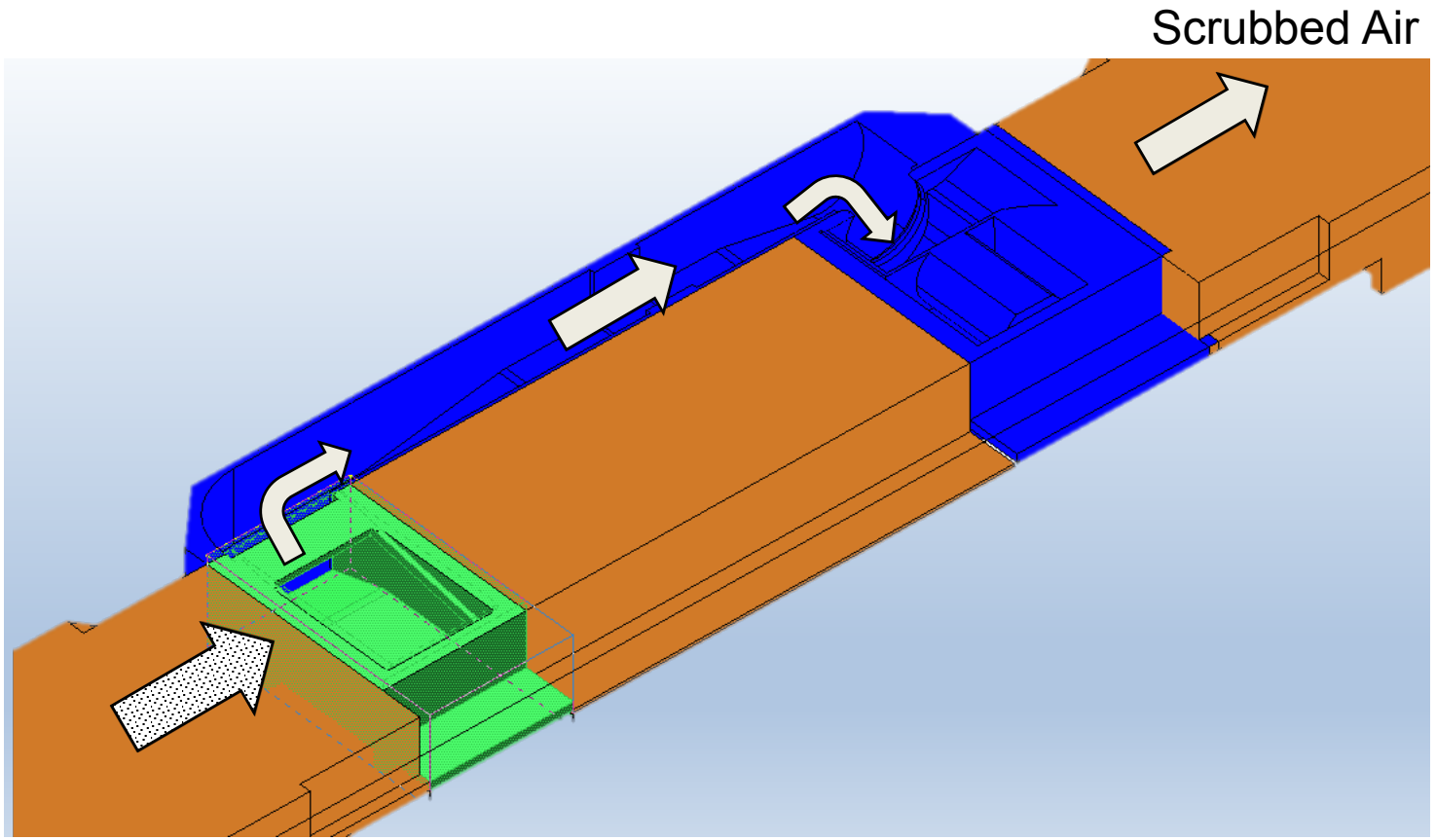
- Along with dilution and water sprays, common dust capture technology for continuous miner units
- Cleaning efficiencies between 60% and 90% (NIOSH 1997)(USBM, 1990)
- Potential for longwall shearer

Conceptual Layout

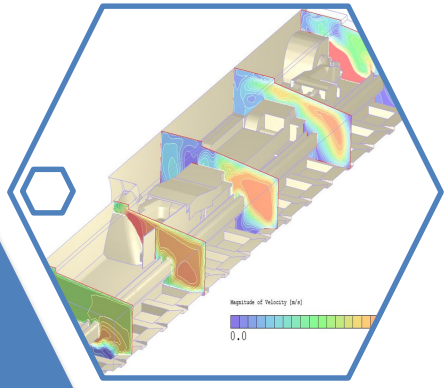
- Scrubber incorporated into Joy 7LS Shearer
- Two new compartments added
- Length increase from 55’ to 62’



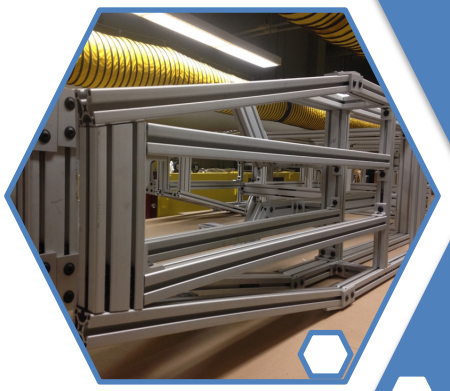
Airflow Arrangement



Research Approach



CFD Modeling

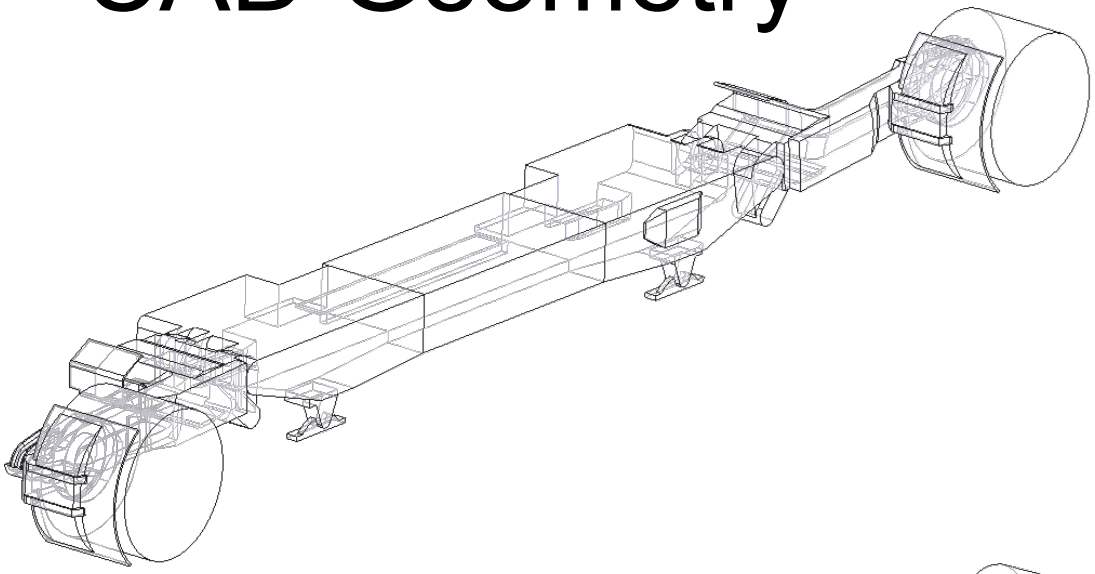


Reduced Scale Modeling

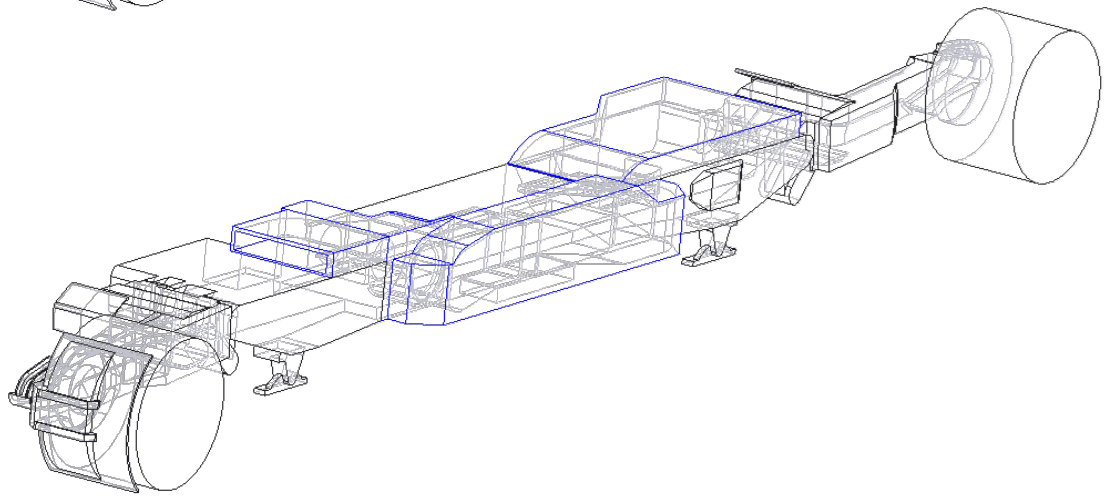
Full Scale Prototype

CAD Geometry

Original

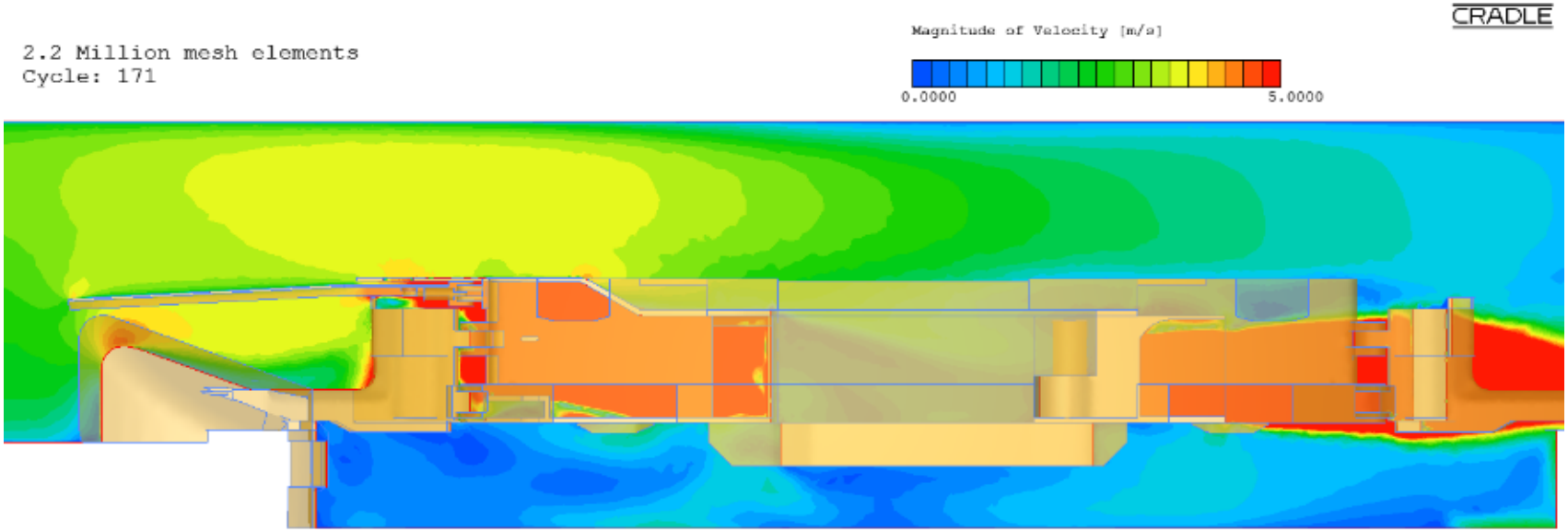


UK Modifications

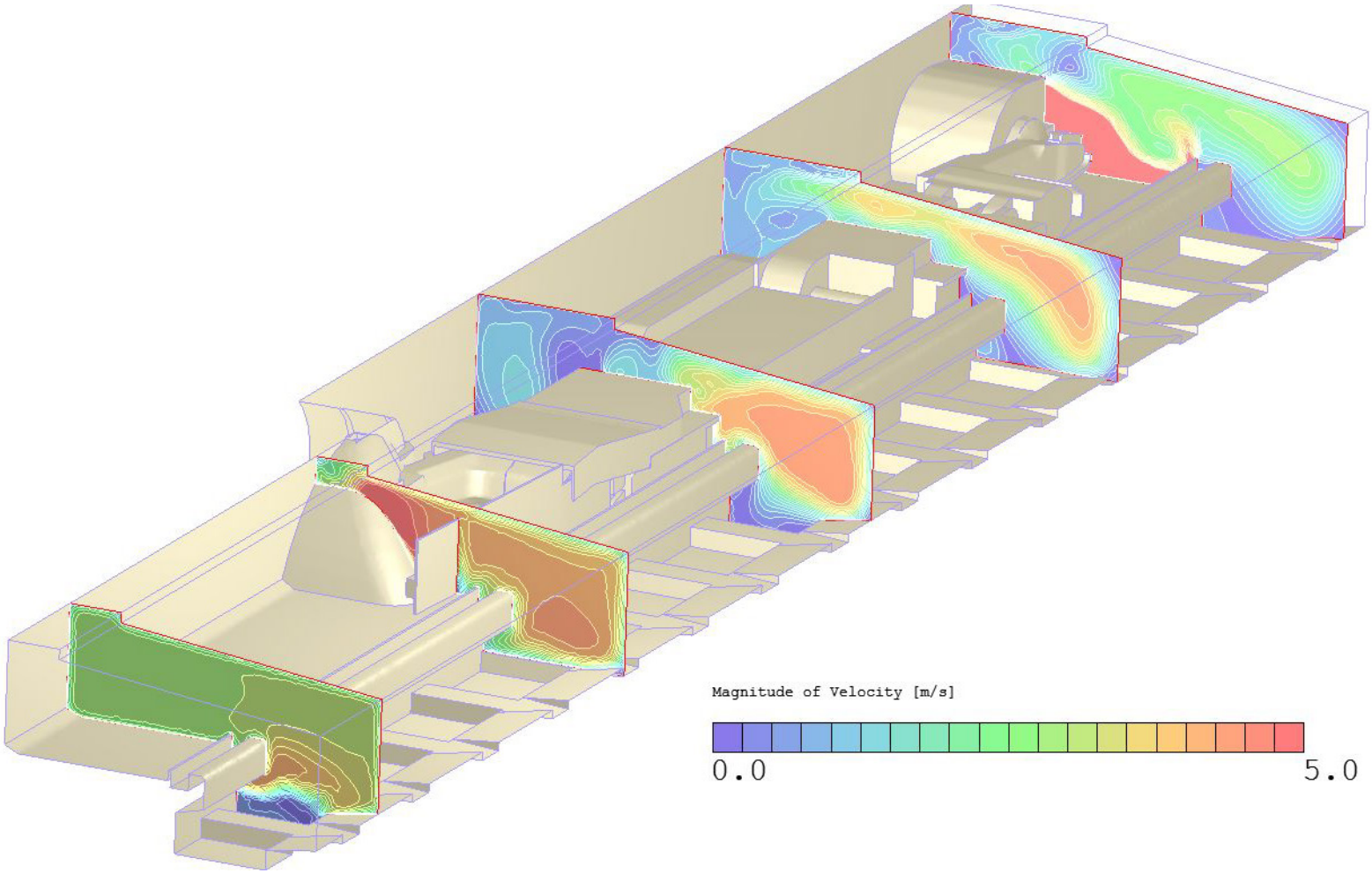


Original shearer model provided by JOY

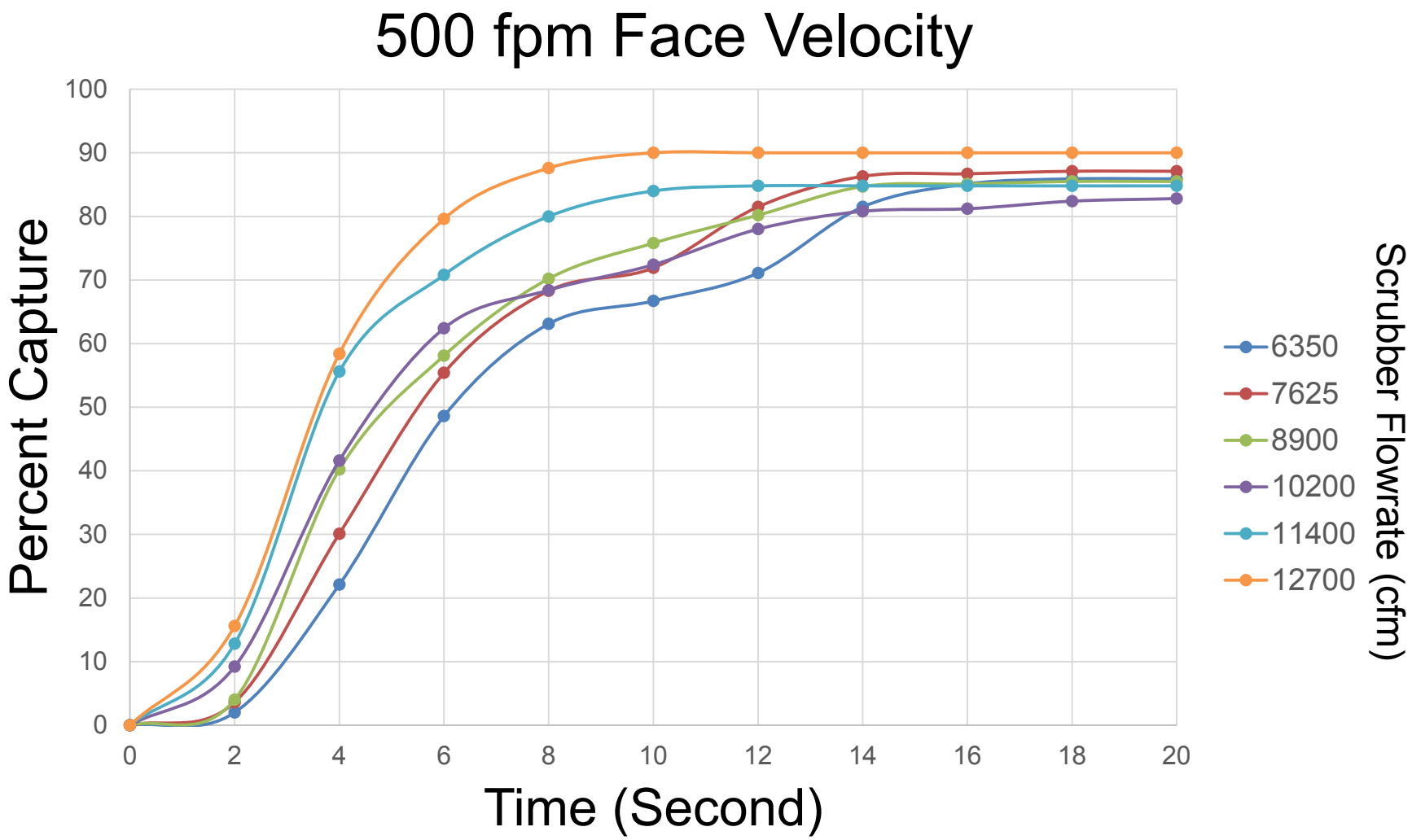
Velocity Contours



Velocity Contours



Dust Capture wrt Time & Flow through Scrubber



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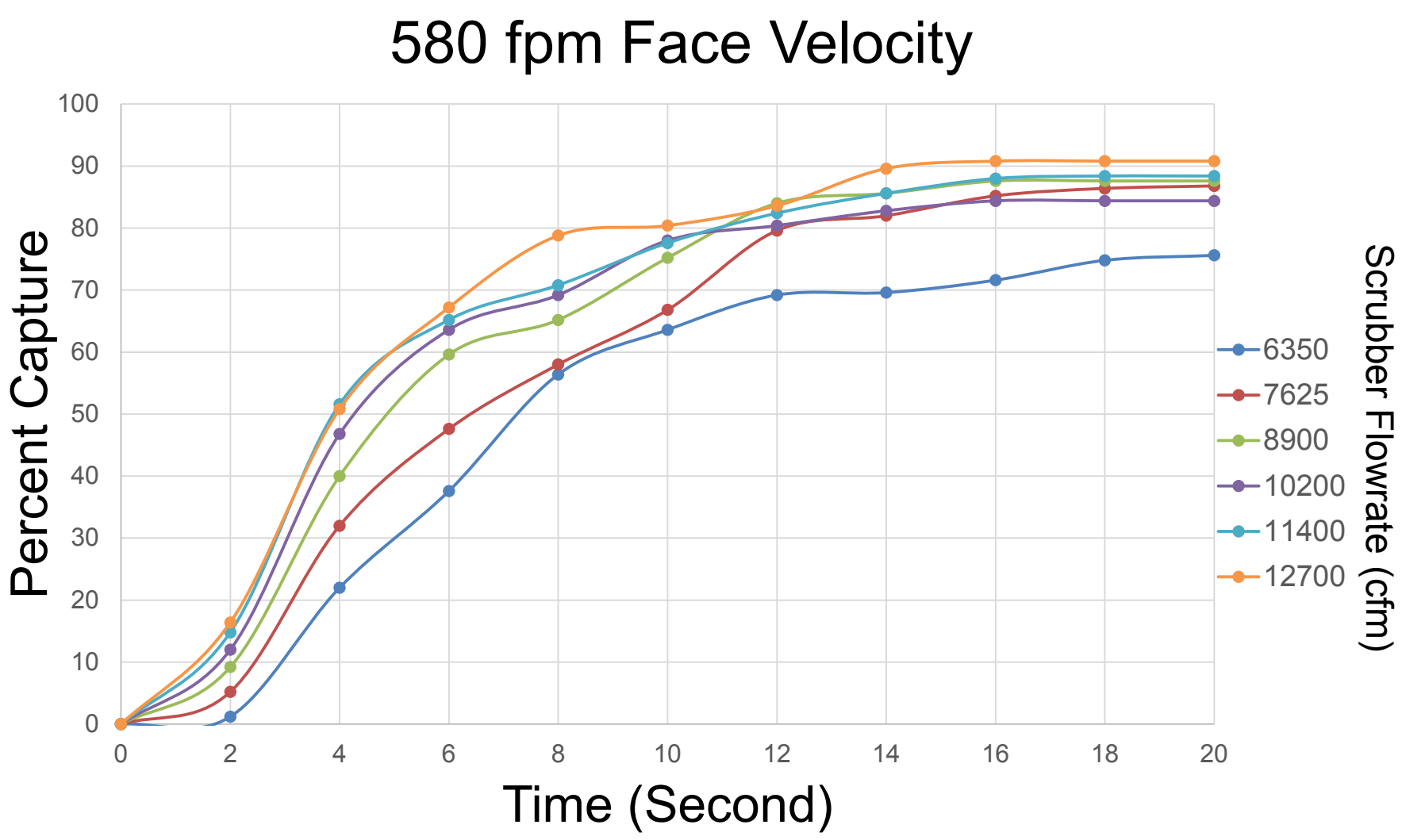
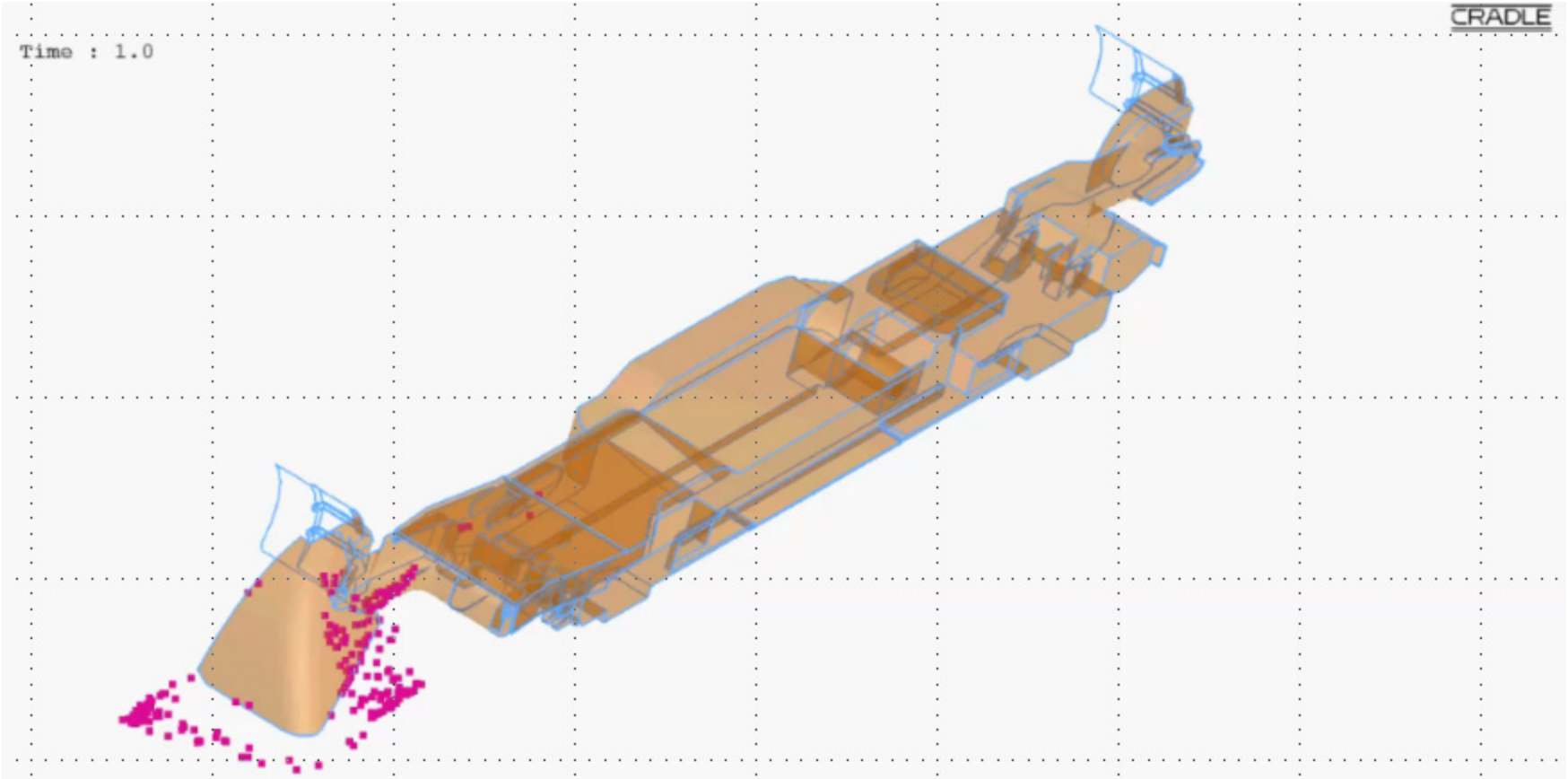


Dust Capture

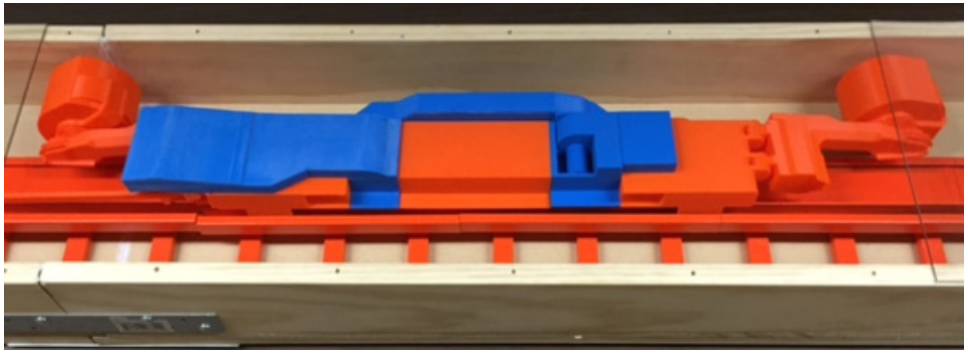


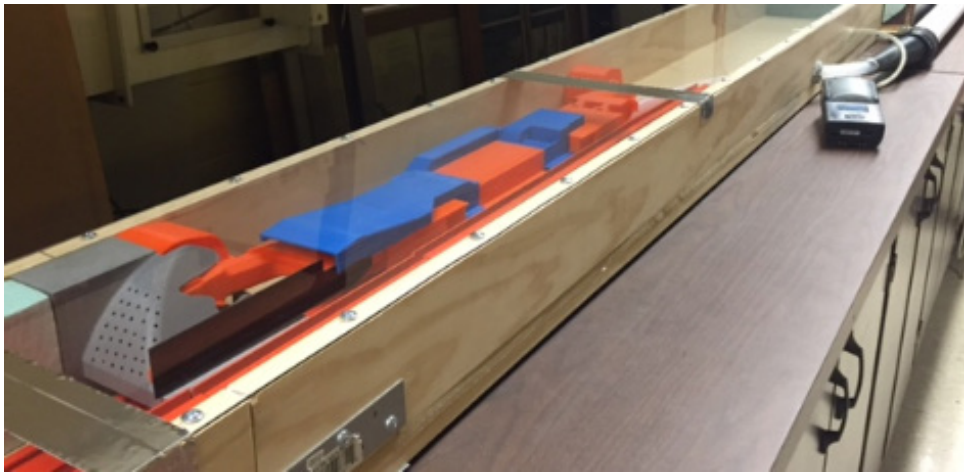
Projected Captures

Scrubber Flow Rates							
Average flow at the face		6,350 cfm	7,625 cfm	8,900 cfm	10,200 cfm	11,400 cfm	12,700 cfm
	500 fpm	85.9	87.1	85.5	82.8	84.8	90.0
	580 fpm	75.6	86.8	87.6	84.4	88.4	90.8

Reduced Scale Modeling

- 1:20 scaled model of the setup
- Replicates problem set up in CFD
- Used the same velocities encountered in the mine, all other surfaces stationary.
- CO2 [tracer gas] mimics the dust particles under the suction of shop vacuum [scrubber].
- Flow volumes calculated and concentrations measured using gas monitors.





Reduced Scale Results

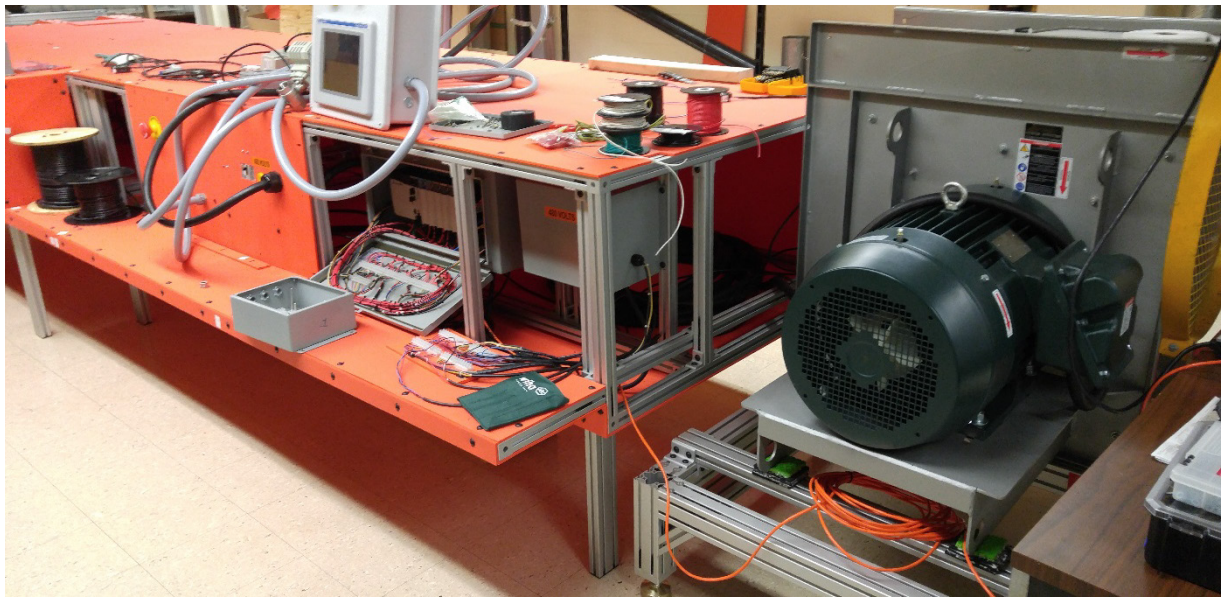
No Scrubber w/CO2			Scrubber w/CO2			Capture Efficiency
Air Velocity		CO2 Content (%)	Air Velocity (fpm)		CO2 Content (%)	
m/s	fpm		m/s	fpm		
2.06	405	0.60	2.06	406	0.08	94.55%
2.32	456	0.52	2.34	460	0.11	87.23%
2.54	500	0.52	2.57	505	0.11	87.23%
2.82	555	0.47	2.79	550	0.14	78.57%
3.07	605	0.41	3.05	600	0.14	75.00%

Reduced scale results agree with CFD model results

Full Scale Prototype

- Concept verification to be completed at the NIOSH campus in Pittsburgh
- Full-scale testing with functional scrubber prototype
- Mock up miner constructed from 80/20 Al extrusion and PVC plastic

Full Scale Prototype

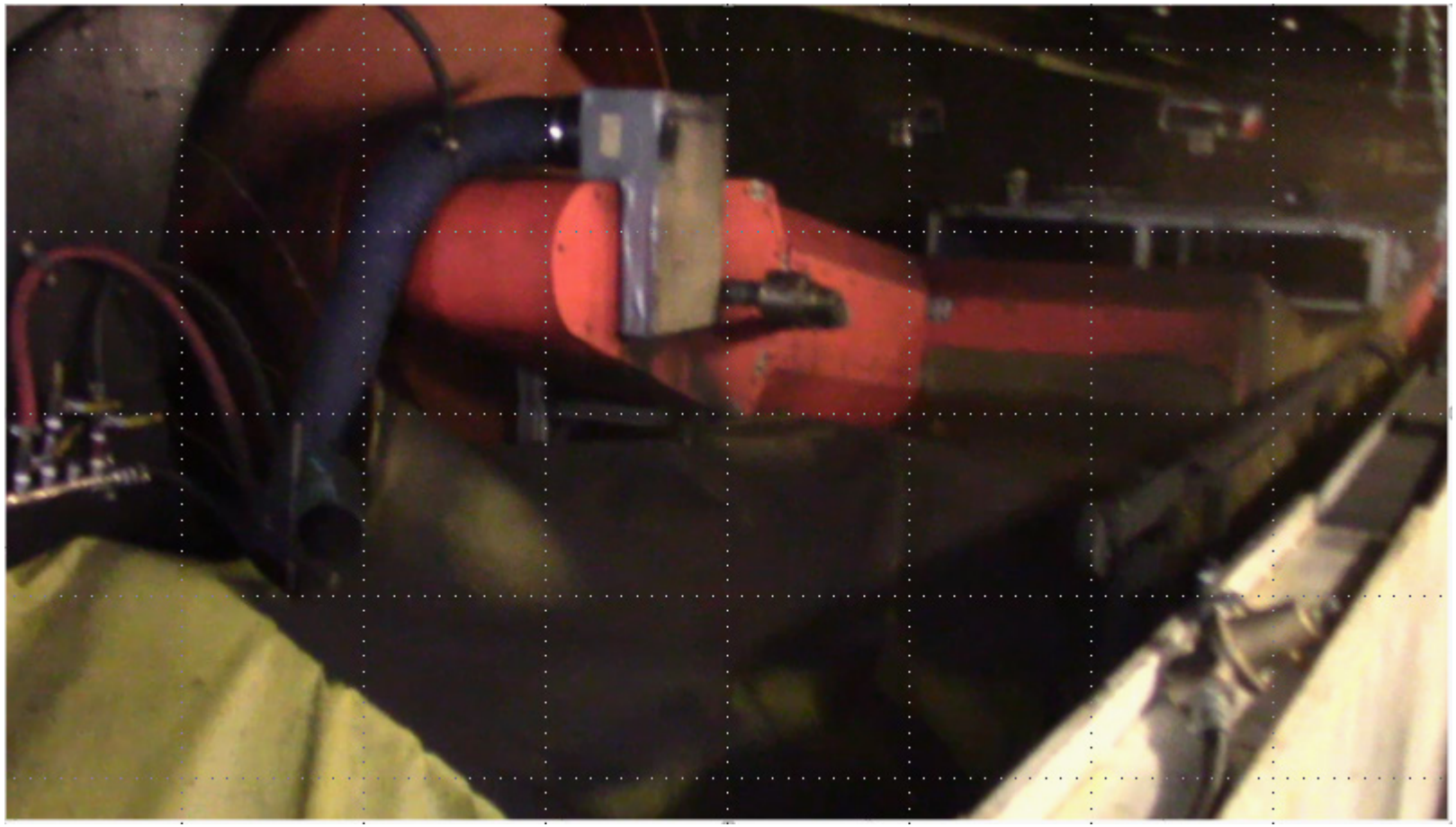


- 50HP centrifugal fan with VFD for powering scrubber
- Allen Bradley PLC for control and instrumentation

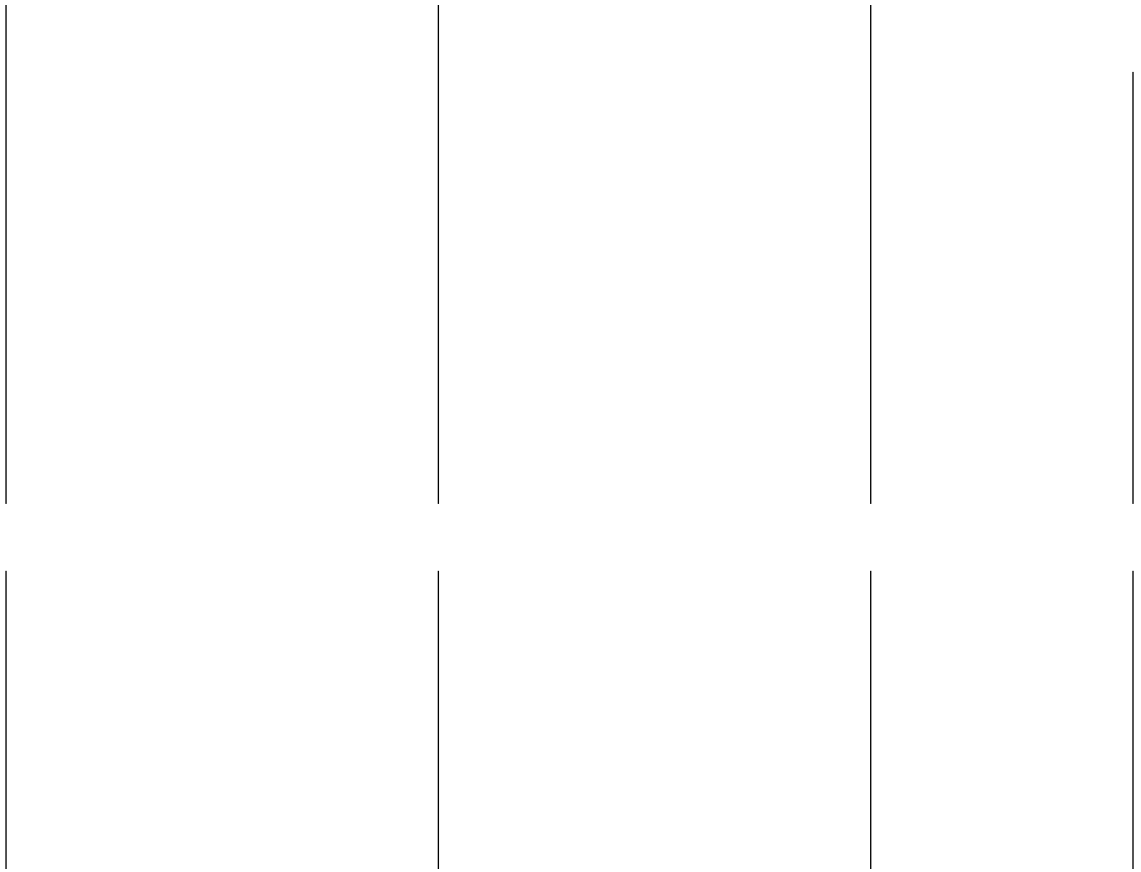
Preliminary Experiments

NIOSH Dust Gallery in Pittsburgh

Preliminary Testing



Preliminary Results



Dust concentrations (—)

Vortecone Scrubber for Mining

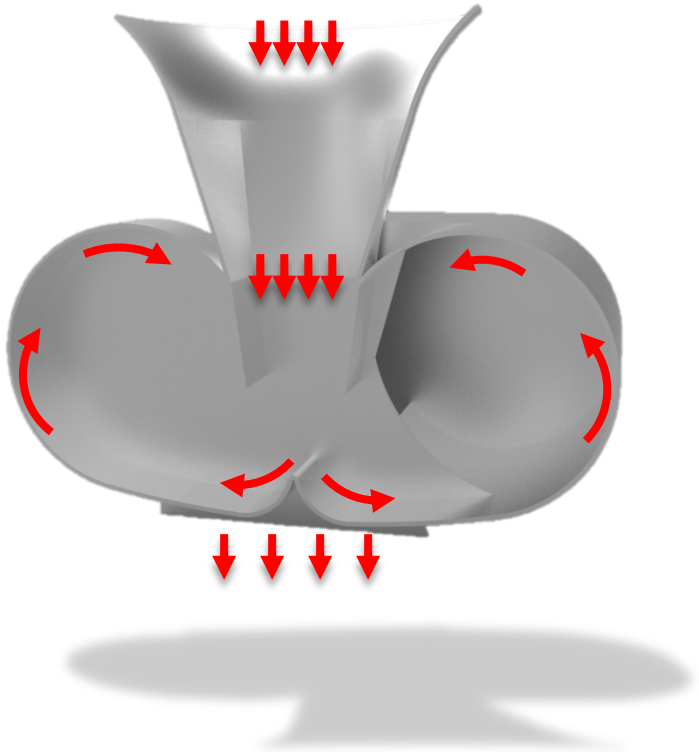
- UK/Toyota Joint development
- Applicable for respirable size fraction
- High cleaning efficiency
- Minimal maintenance
- Scalable in match air requirements
  - From 200 cfm lab models to 60,000 cfm at Toyota

Novel Vortecone Scrubber

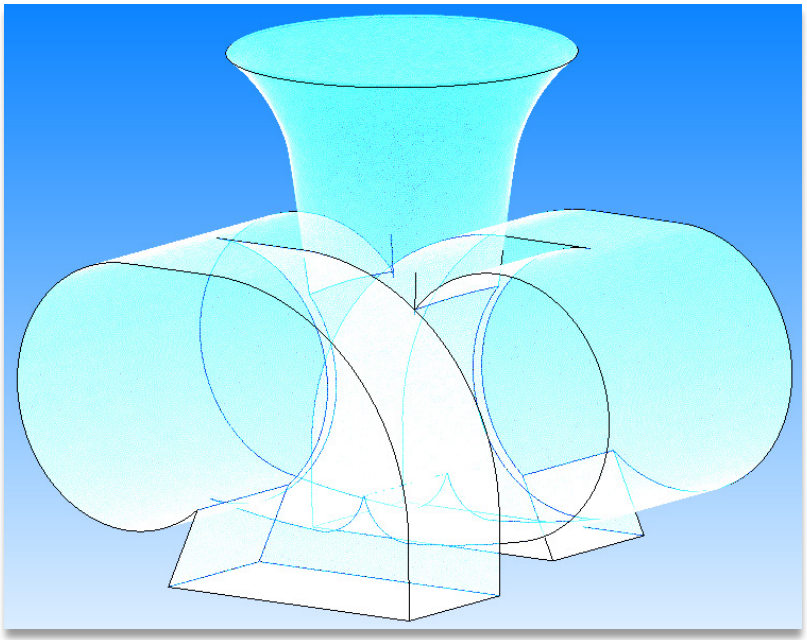
Four main components:

1. Cone shape inlet
2. Mixing chamber
3. Vortex chamber
4. Discharge

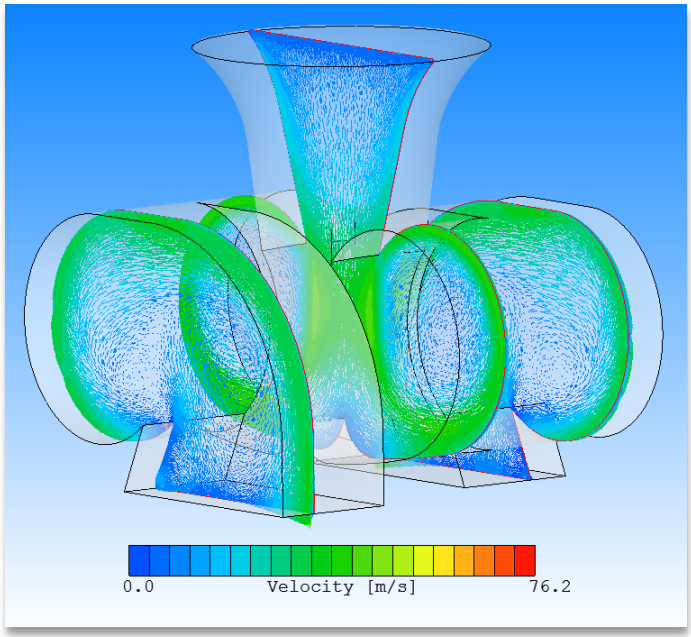
Works on the principle of vortex interaction of particle-laden airflow with water



CFD Modeling (cont.)

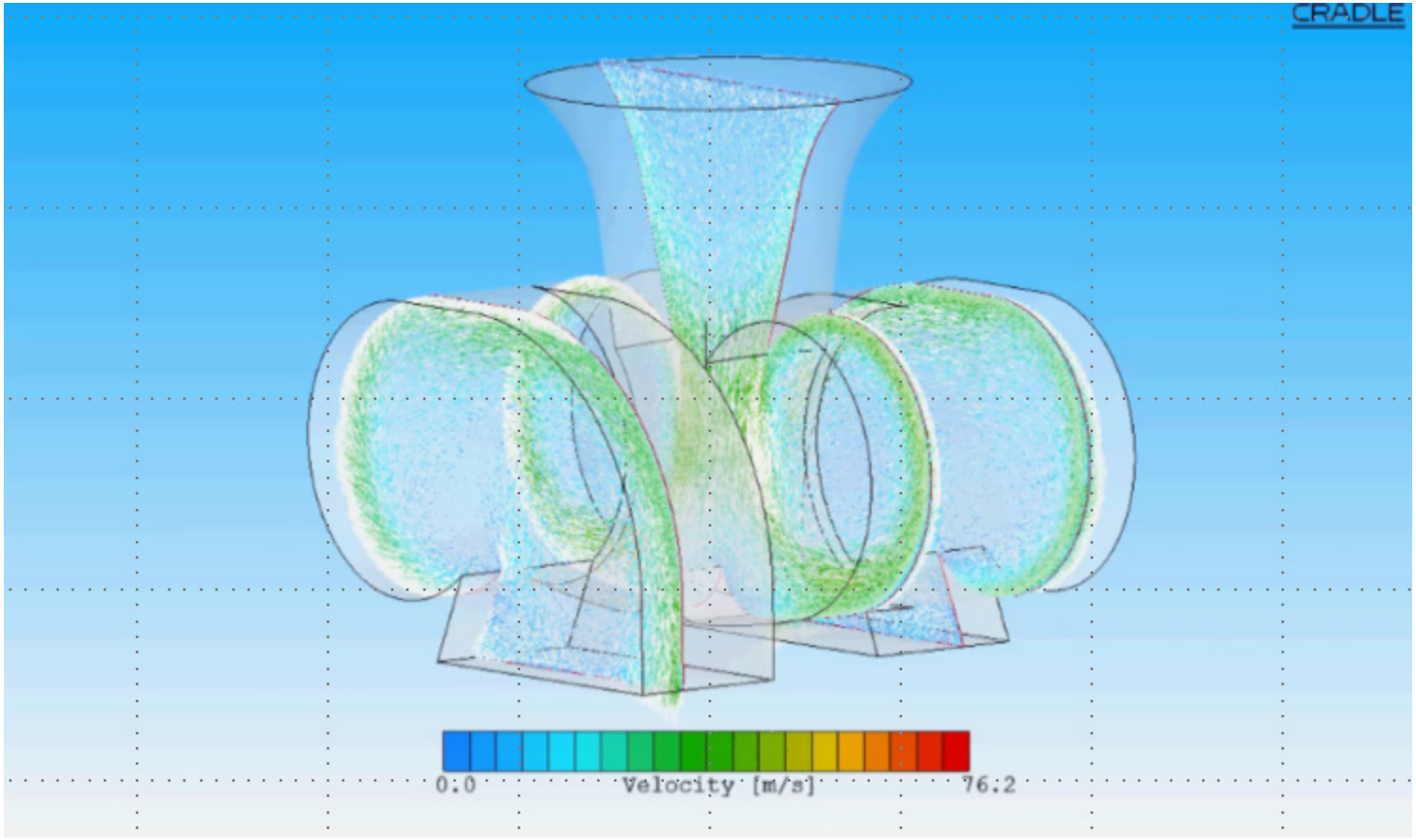


Computational mesh employed in the computational domain

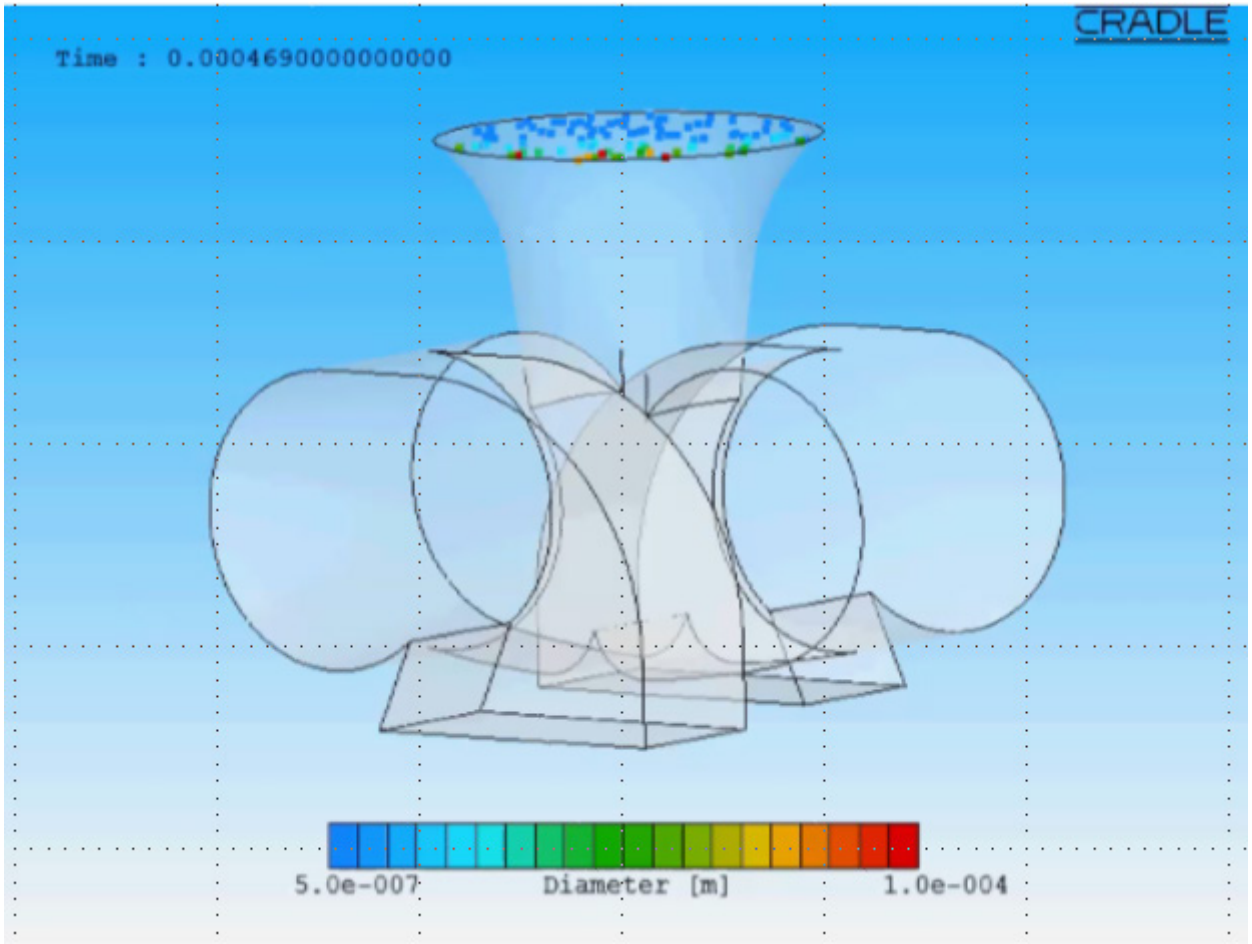


Velocity vectors on three parallel Planes

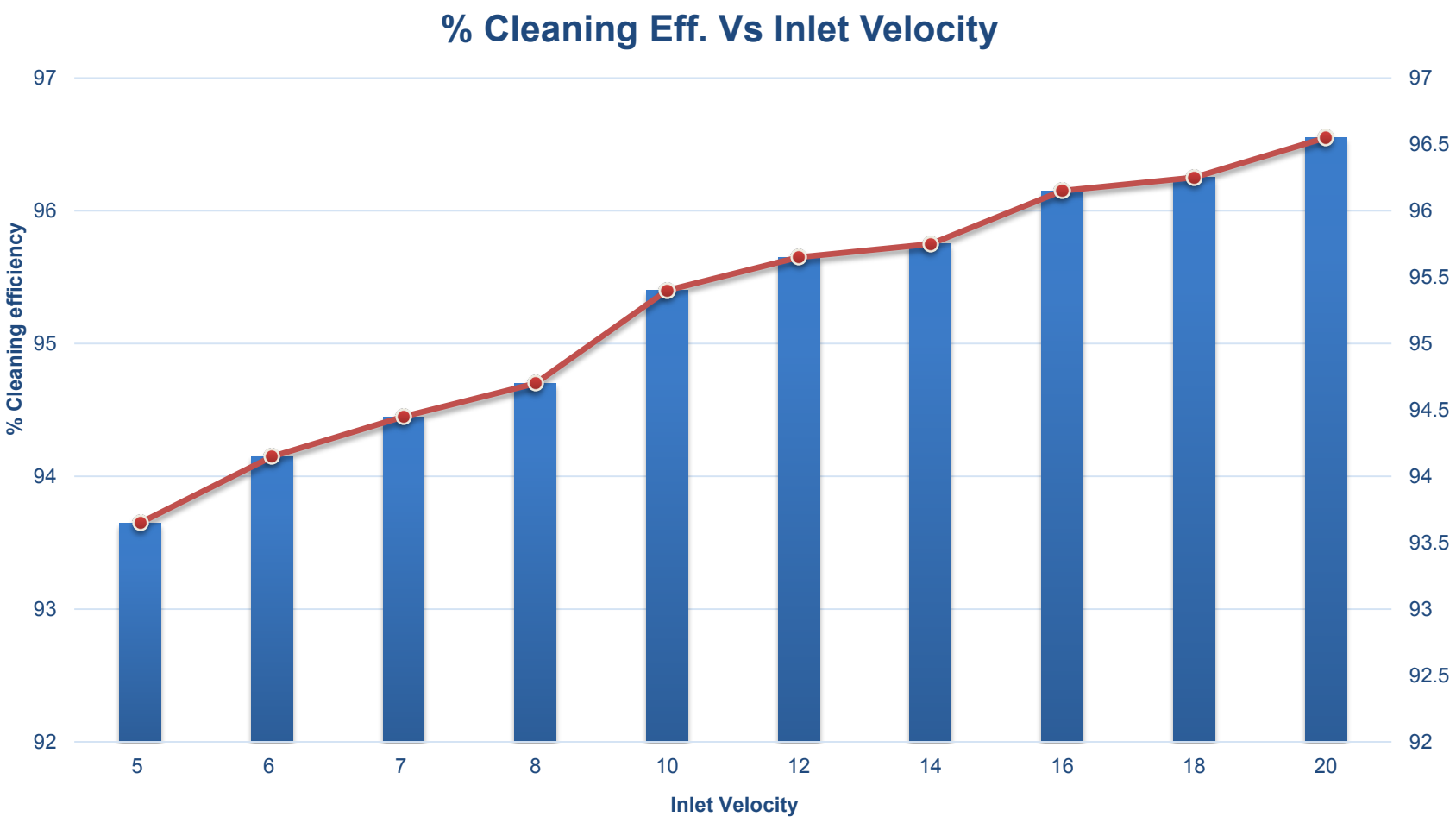
Representative Velocity Contours



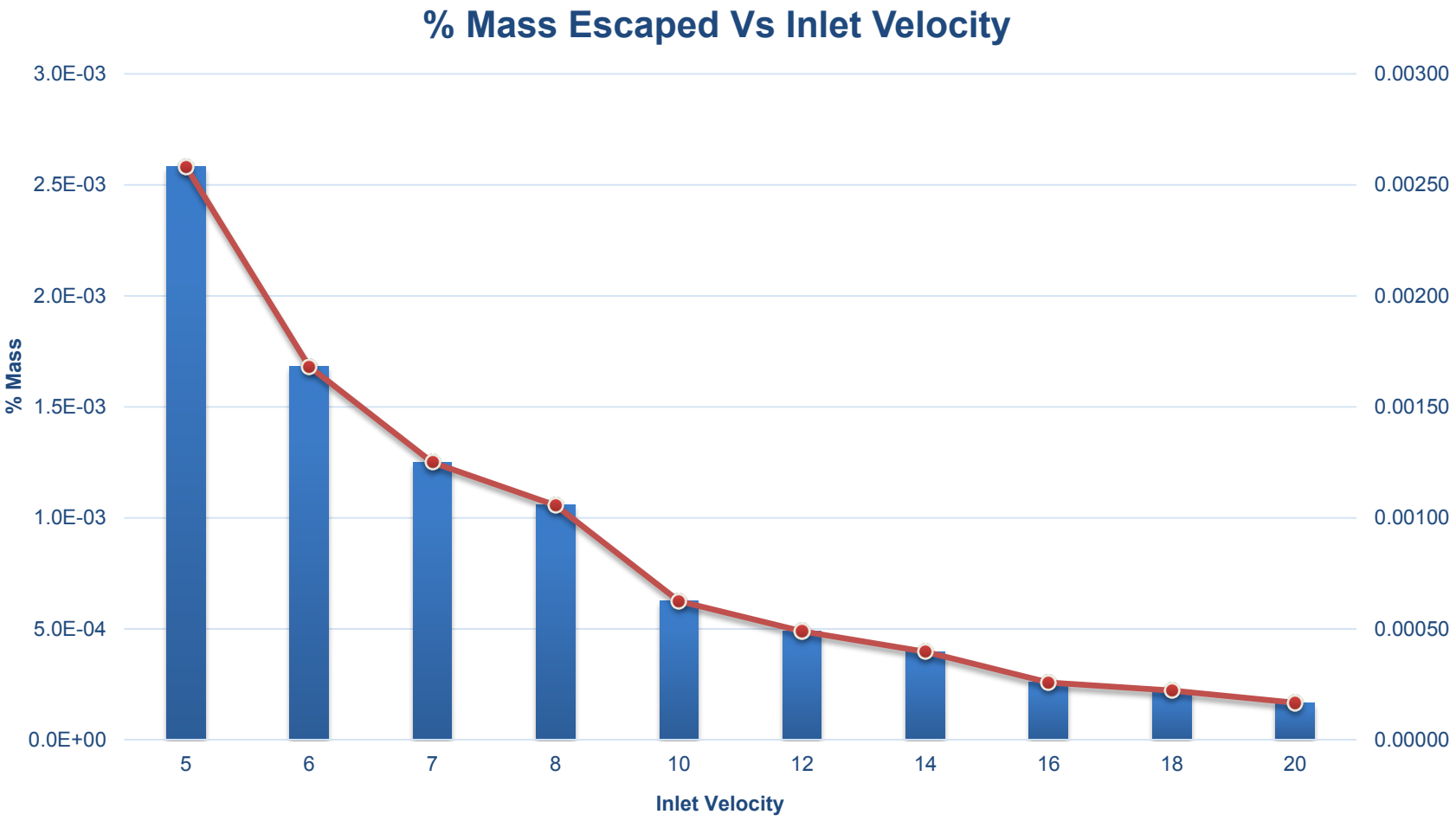
Particle Tracking



Cleaning Efficiency by Count



Cleaning Efficiency by Mass



Results / Conclusions

- Solid concept for flooded bed scrubber incorporated into a longwall shearer
- Capture efficiency of dust generated from the headgate drum exceeds 70-80%
  - CFD, reduced scale model, full scale prototype
- Vortecone CFD modeling suggests high cleaning efficiency

Acknowledgement

On behalf of those who have worked on the material presented, I would like to express our gratitude to those who have made our research possible.

- Alpha Foundation
- Alliance Coal
- NIOSH
- JOY Global