Development of a Canopy Air Curtain to Reduce Roof Bolters' Dust Exposure

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Problem

Roof bolter operators' rate of over-exposure to respirable dust is second only to the continuous miner operator.

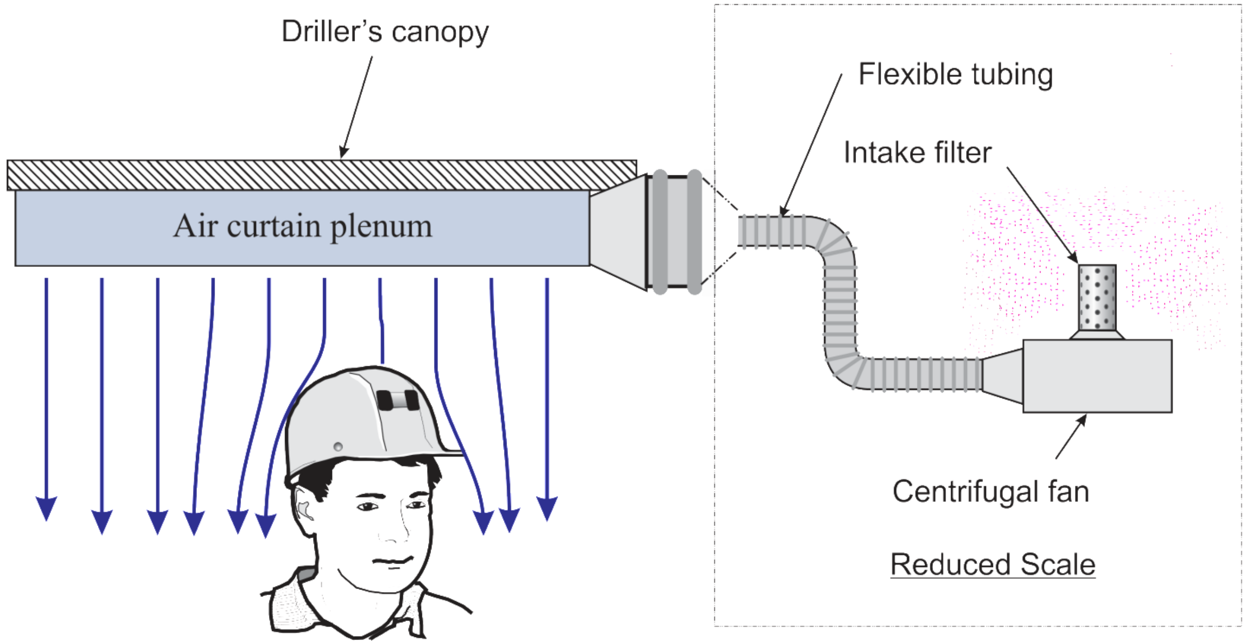
The main source of this over-exposure is working downwind of the continuous mining machine.

Operational Facts

- Roof bolter operators continue to work downwind of the CM.
- MSHA is requiring more CM machines to operate without scrubbers, even though scrubbers greatly reduce respirable dust in the return.
- The impending dust rule will reduce respirable dust exposure lower than the current 2 mg/m^3 standard.

Addressing the Problem

Develop a retrofit system to deliver a curtain of clean air over operators when performing drilling activities beneath the canopy.

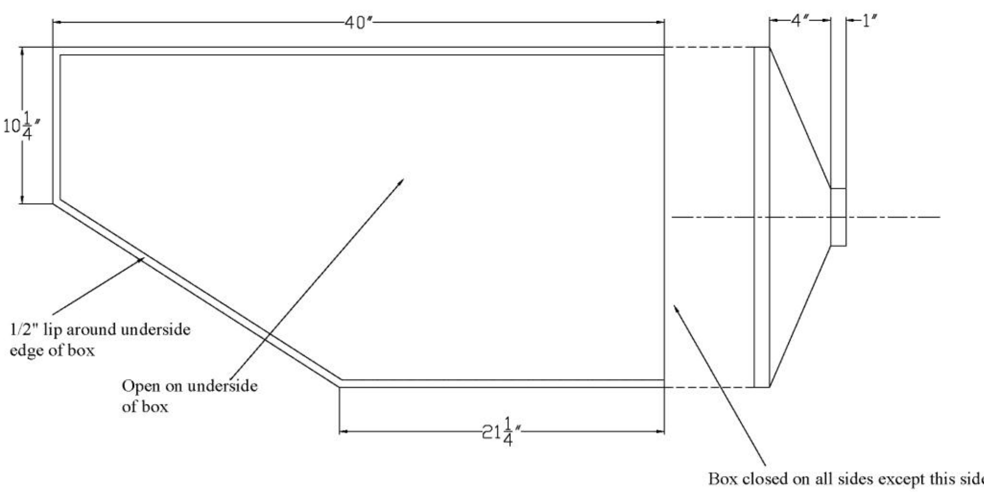


Air Curtain Development

- 1975 – The Donaldson Co. Inc., under contract from the USBM, demonstrates that air curtain technology can protect CM operators from respirable dust while working in onboard cabs.
- 1982 – USBM report shows respirable dust reductions on gathering-arm loaders operators fitted with air curtain system.
- 1987 – The Donaldson Co. Inc. improves original air curtain design. Newer design improved airflow, decreased thickness, and decreased noise levels.


Design Changes for Bolters

- Plenum geometry dimensions based on typical canopy size and shape.
- Inlet port located parallel to length of plenum length.
- Blower powered by a dedicated hydraulic motor and reservoir.



Laboratory Test Apparatus

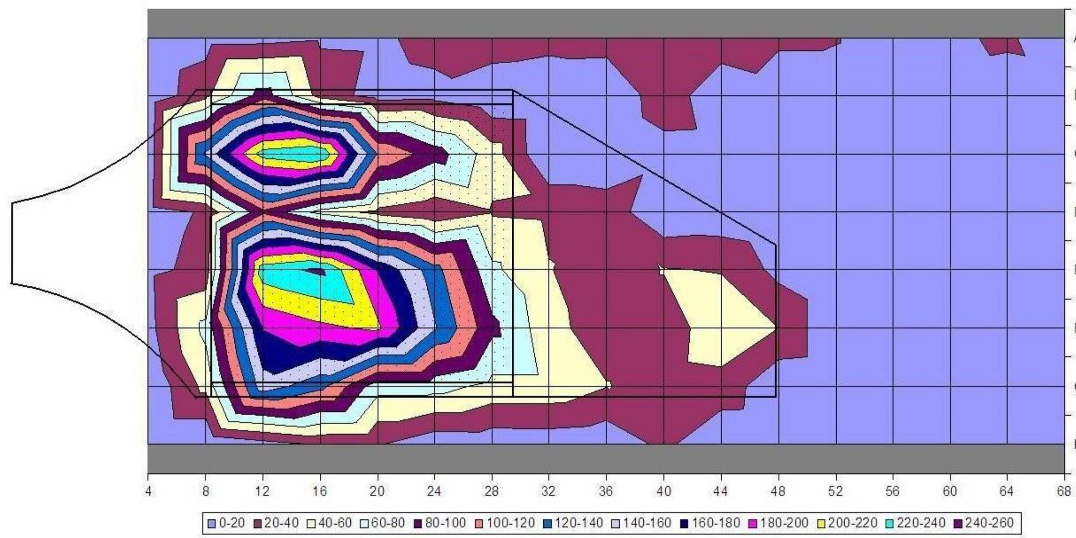
Air Curtain Test Setup

Fan-Filter Assembly

Plenum Test Stand

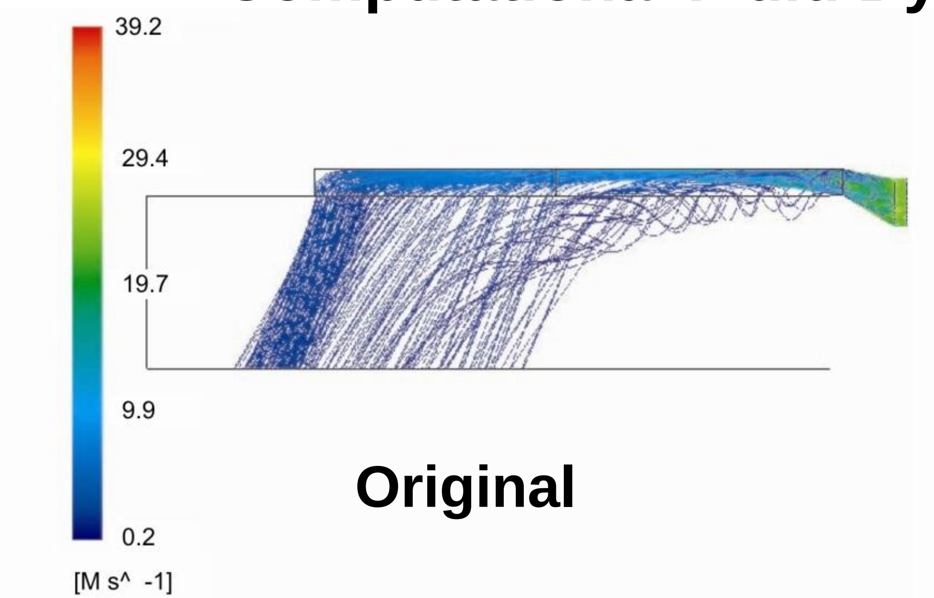
Plenum Design Objective

Achieve even airflow distribution beneath the plenum

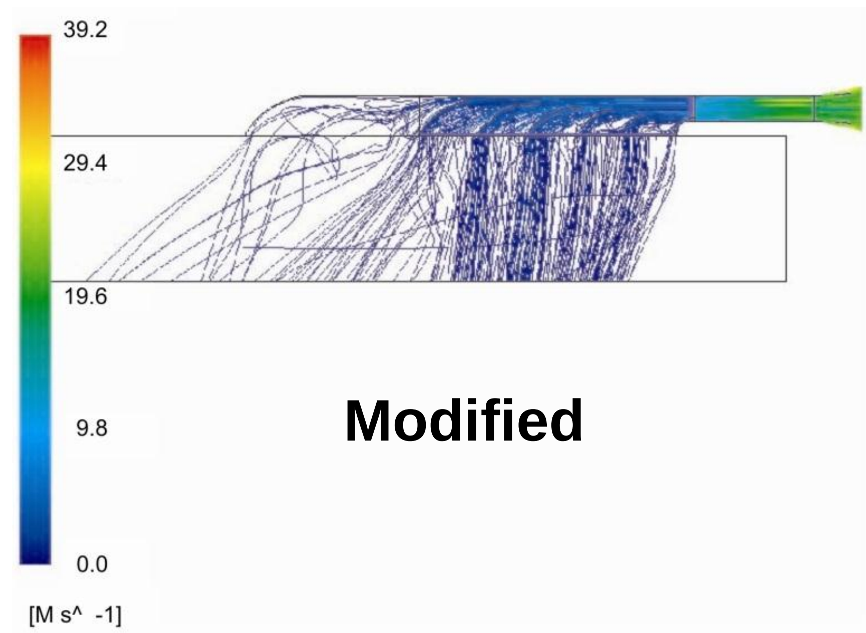


Plenum Testing

Computational Fluid Dynamics (CFD) Analysis



Original



Modified

Plenum Testing

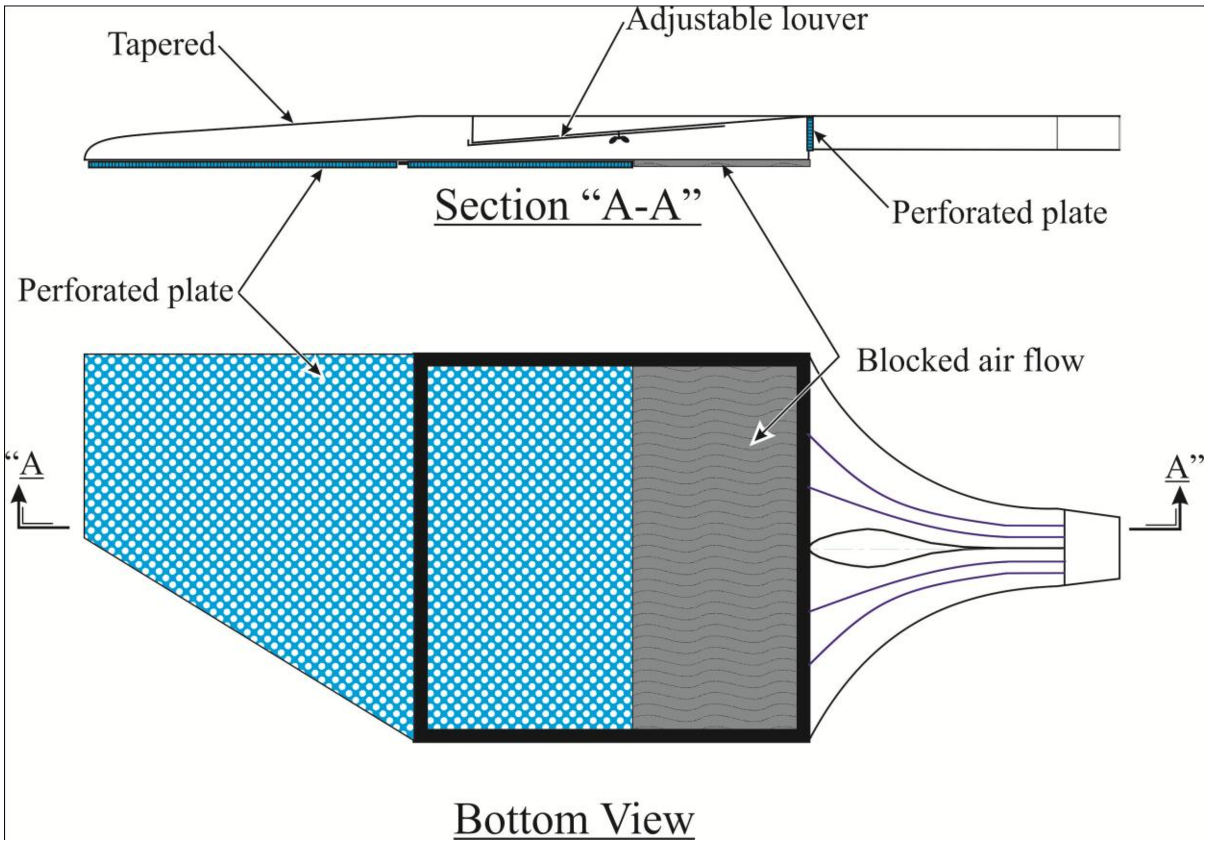
Airflow visualization using smoke

Preliminary Field Trials

- **Identified region of unneeded coverage**
  - Canopy overlaps operator's tool tray
- **Demonstrated feasibility of design**
  - Acceptable impact on overhead clearance
  - Hydraulic fan provides adequate air quantity

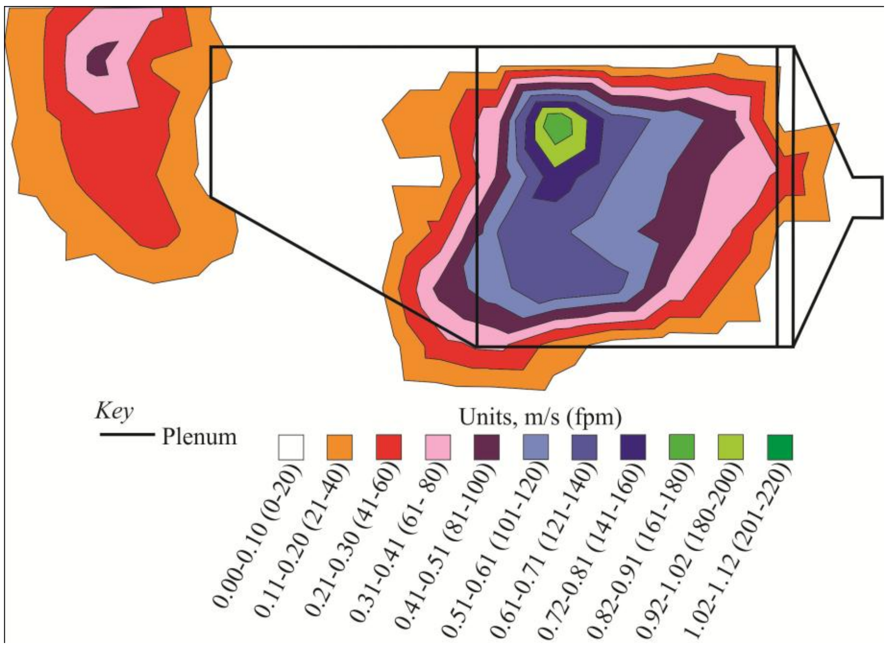
Plenum Testing

Final Plenum Design

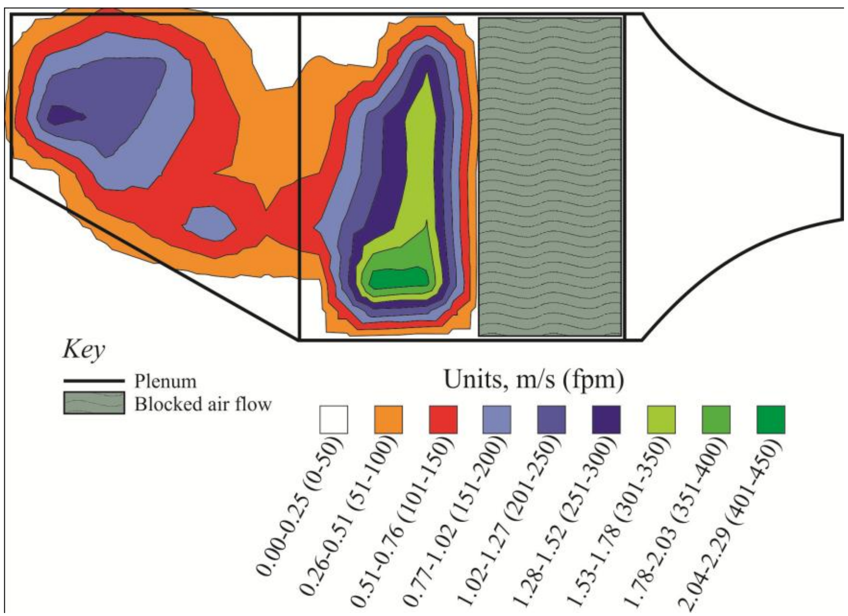


Air Distribution

Post-CFD Design

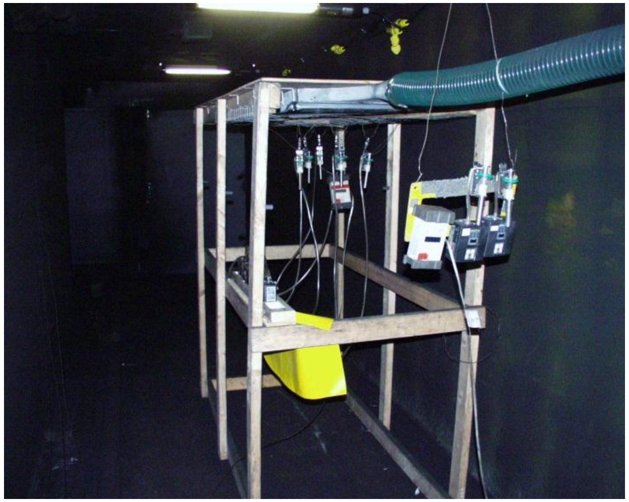


Final Design

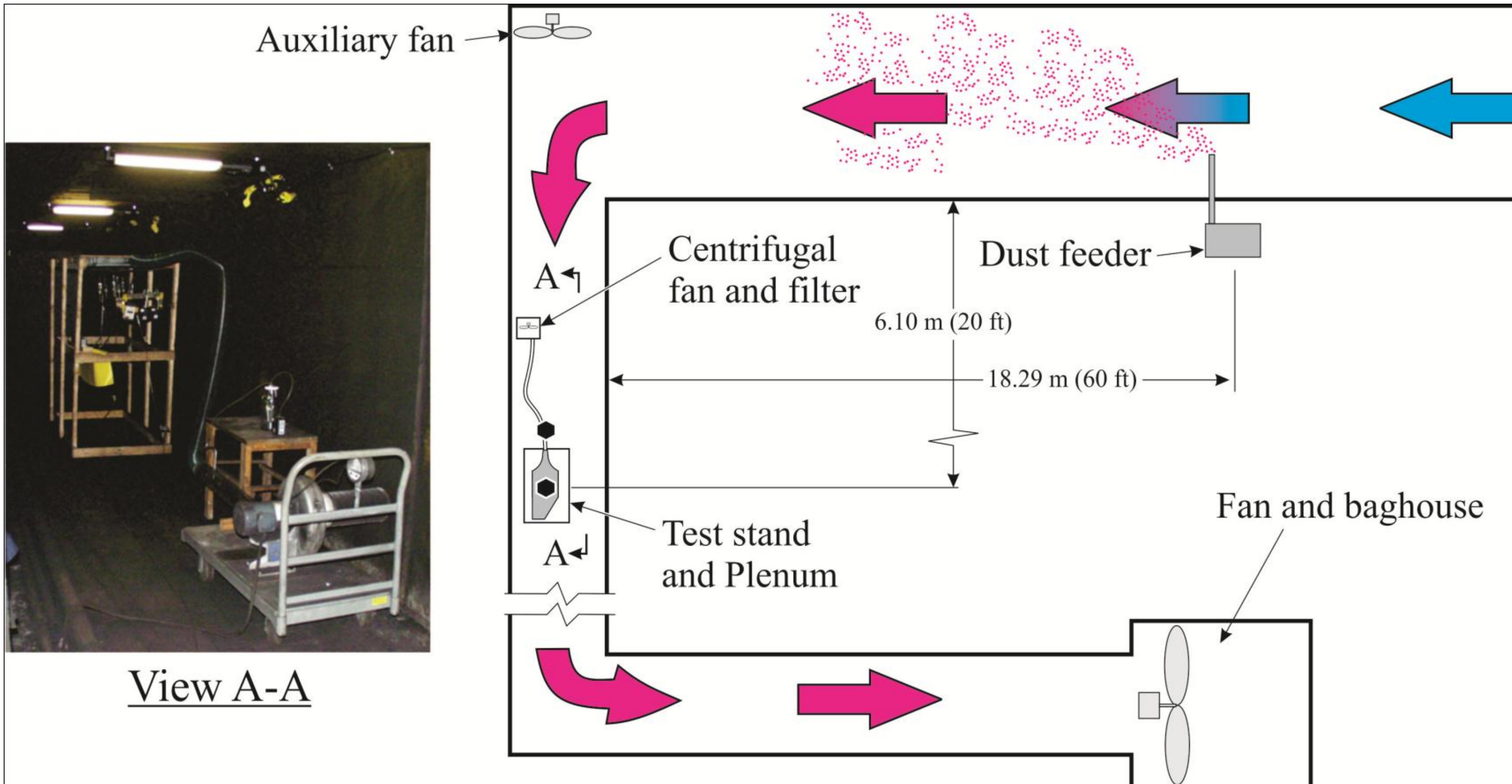


Full-Scale Testing





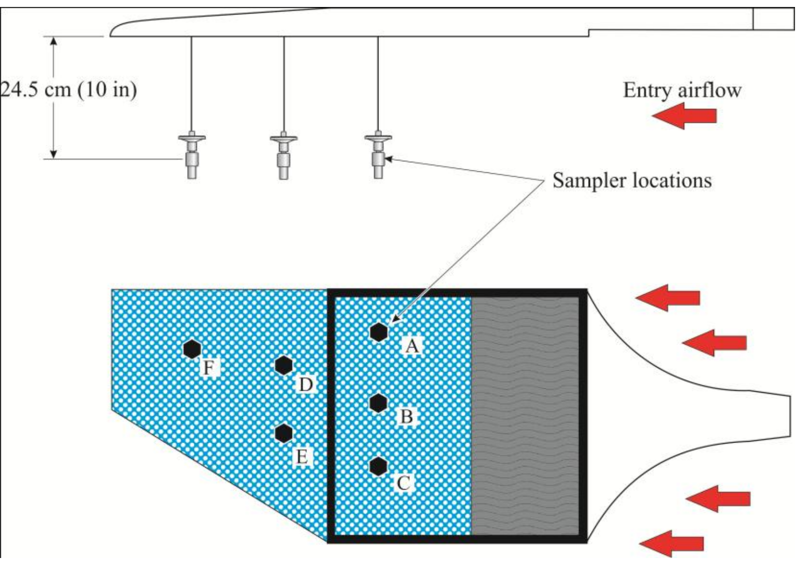
Sampling for Dust Reduction

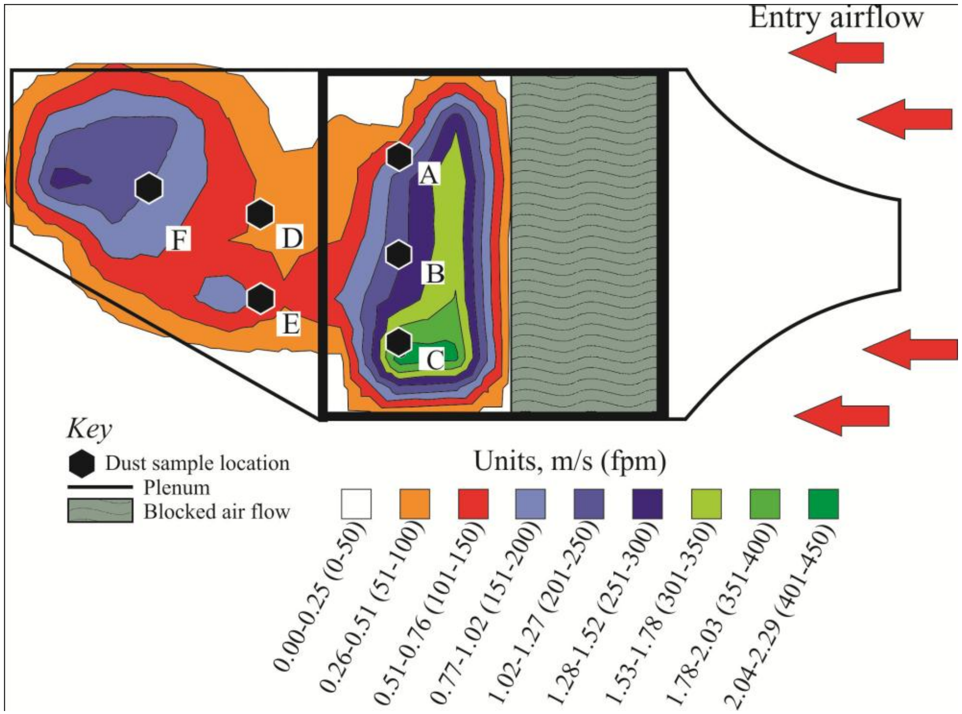


Test Methods

- Full-scale testing conducted in the continuous mining simulation gallery at the OMSHR laboratory.
- Respirable dust sampled at entry velocities of 0.03 (10), 0.30 (60), and 0.61 (120) m/s (fpm).
- Respirable dust concentration held constant for all test velocities (average of 6.0 mg/m^3).
- Respirable dust concentrations measured with gravimetric samplers and Personal Data Ram.
- Six test replicates for each velocity.
- Sample in open entry and beneath the plenum.

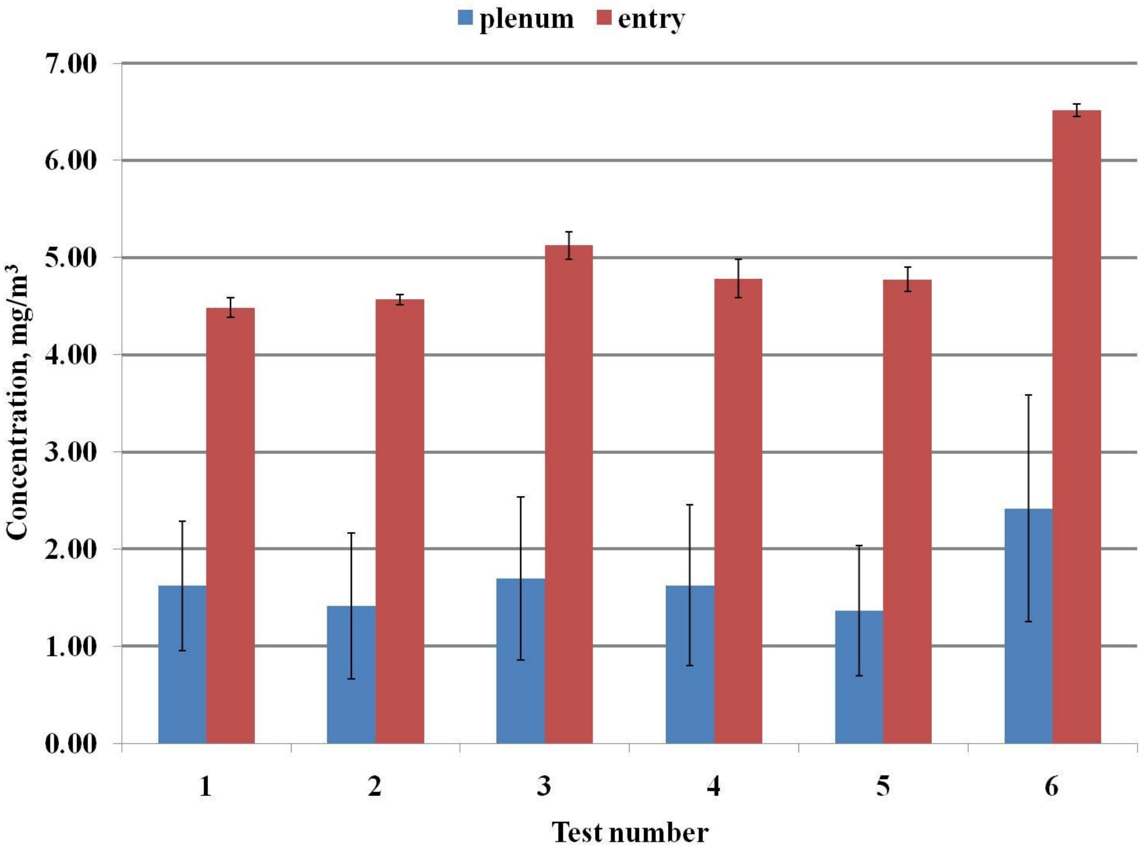
Sampling Locations



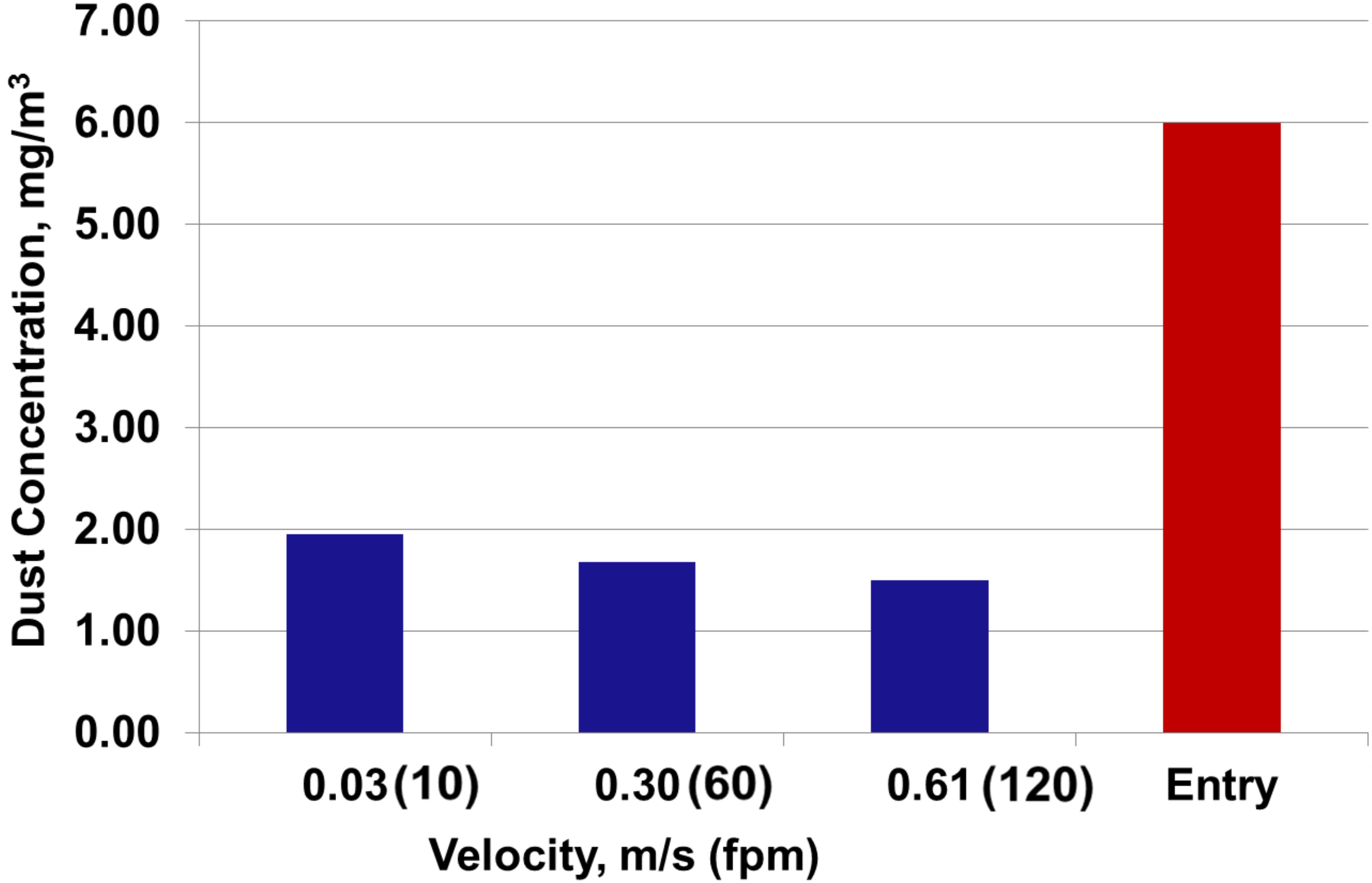


Dust Reduction
Across Tests

	Dust Concentration, mg/m^3	
Test	Plenum	Entry
1	1.62	4.48
2	1.41	4.57
3	1.70	5.13
4	1.63	4.78
5	1.36	4.56
6	2.42	6.52



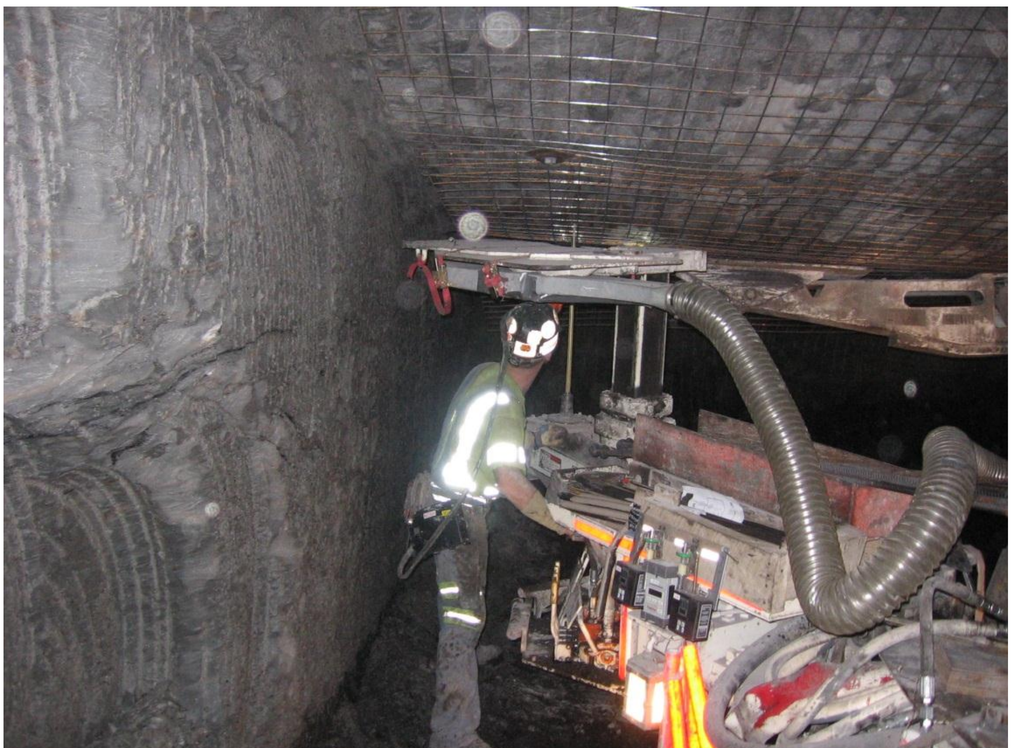
Dust Reduction
Across Entry Velocities



Laboratory Results

- Final design provides filtered air coverage over 70% of plenum area: velocity > 0.51 m/s (100 fpm).
- Plenum provides area of confirmed dust reductions at entry velocities up to 0.61 m/s (120 fpm).
- No significant difference in dust exposure reductions in the three entry velocities tested.
- Dust reductions of 67% to 75% was achieved beneath the plenum at each of the test velocities.

Field Testing



Field Testing Results

- Based on time studies, bolter operators spent about 66% of a complete bolting cycle beneath the plenum (tram in to tram out of place).
- Integrating the blower into the machine's hydraulic system proved to be problematic.
- Limited PDM (194 min) data showed a reduction of 34% between the dual boom bolter operators (left side vs right side) during sampling.

Alternate Design

Questions?

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