OMSHR

Office of Mine Safety and Health Research

Rock Dust Partnership Meeting:

Essential Attributes of Rock Dust to Prevent Coal Dust Explosions

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CDC Workplace Safety and Health NIOSH

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Meeting Goals

- Provide Partnership with recent updates
- Discuss concerns and identify solutions
- Discussion of steps moving forward

Key Factors for Effective Rock Dust Inerting

- Must consist of inert material(s)
- Must be of fine enough size to rapidly extract heat from the combustion front
- Must be dispersible in sufficient quantity to inert
- Must not contain combustible matter that reduces inerting effectiveness

Current Rock Dust Definition (30 CFR 75.2)

- Pulverized limestone, dolomite, gypsum, anhydrite, shale, adobe, or other inert material, preferably light colored
- 100% <20 mesh, 70% <200 mesh
- When wetted and dried will not cohere to form a cake which will not be dispersed into separate particles by a light blast of air
- Does not contain more than 5 percent combustible matter or more than a total of 4 percent free and combined silica (SiO_2)

Recommended Attributes

- Pulverized limestone, dolomite, or other inert material, preferably light colored,
- 95% < 200 mesh sieve and have a minimum specific surface area of 2,600 cm^2/g
- the particles of which when wetted and dried will not cohere to form a cake
- does not contain more than 1% combustible matter,
- or more than a total of 4 percent free and combined silica (SiO_2)

Material

- Pulverized limestone, dolomite, or other inert material, preferably light colored
  - Other materials may be available but are not in use

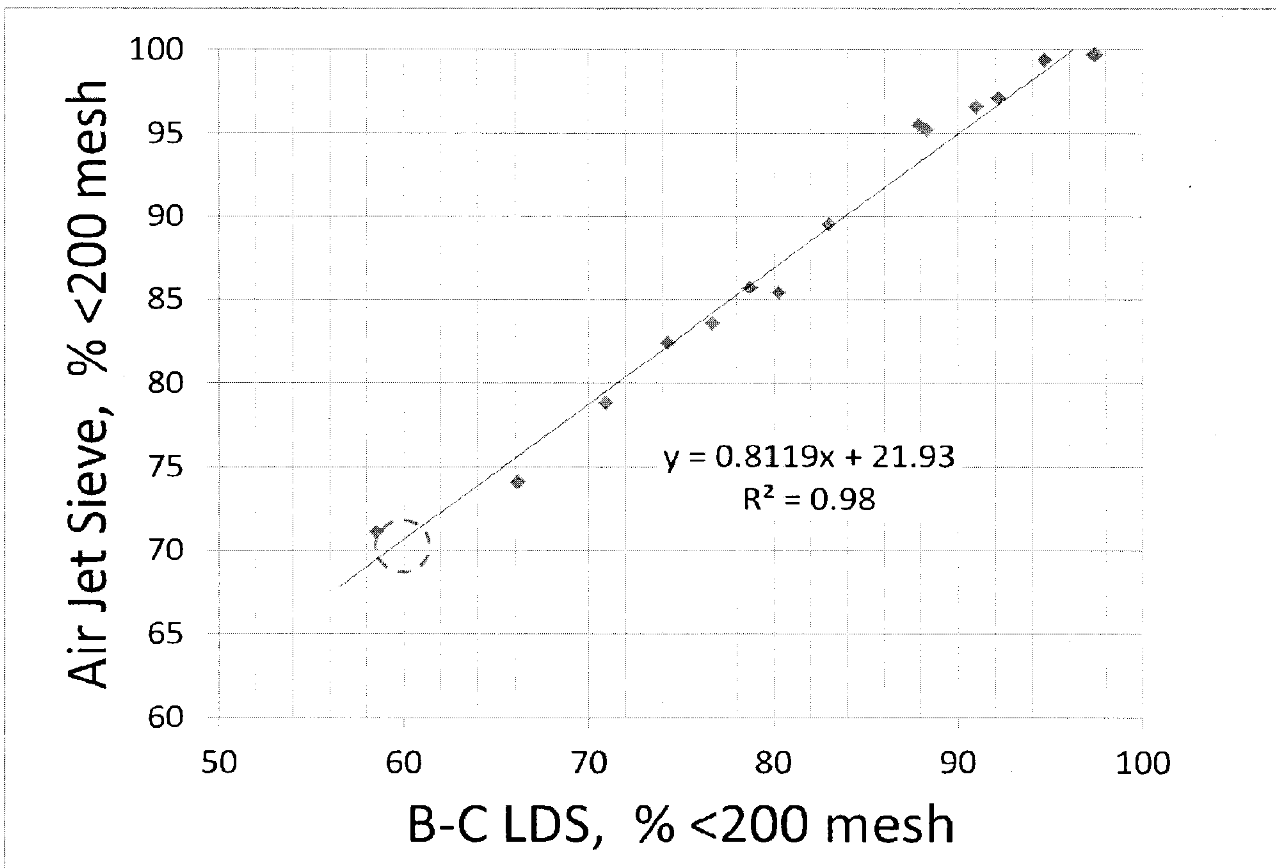
Size

- 95% < 200 mesh sieve
  - Particles > 200 mesh contribute little to inerting
  - Rock dust partnership members indicate this is attainable given current grinding technologies

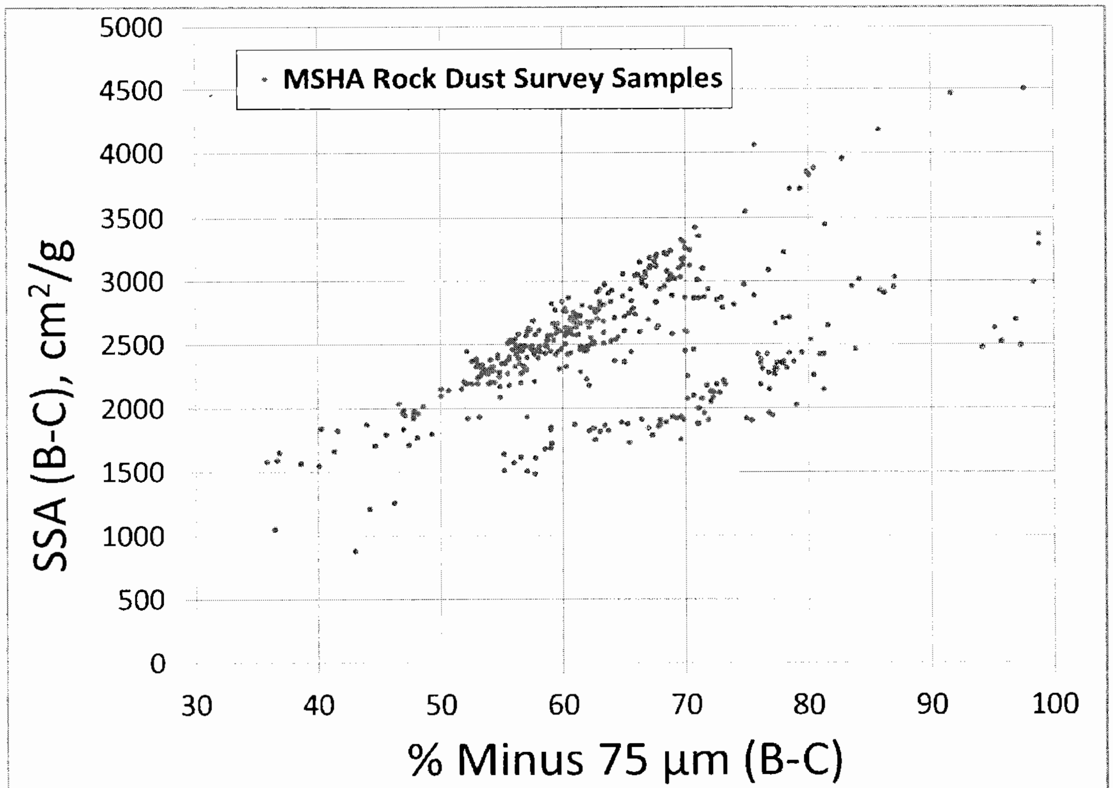
Size

- Have a minimum specific surface area of 2,600 cm^2/g
  - Variations in particle size distributions of current supply
  - Significant impact on surface area

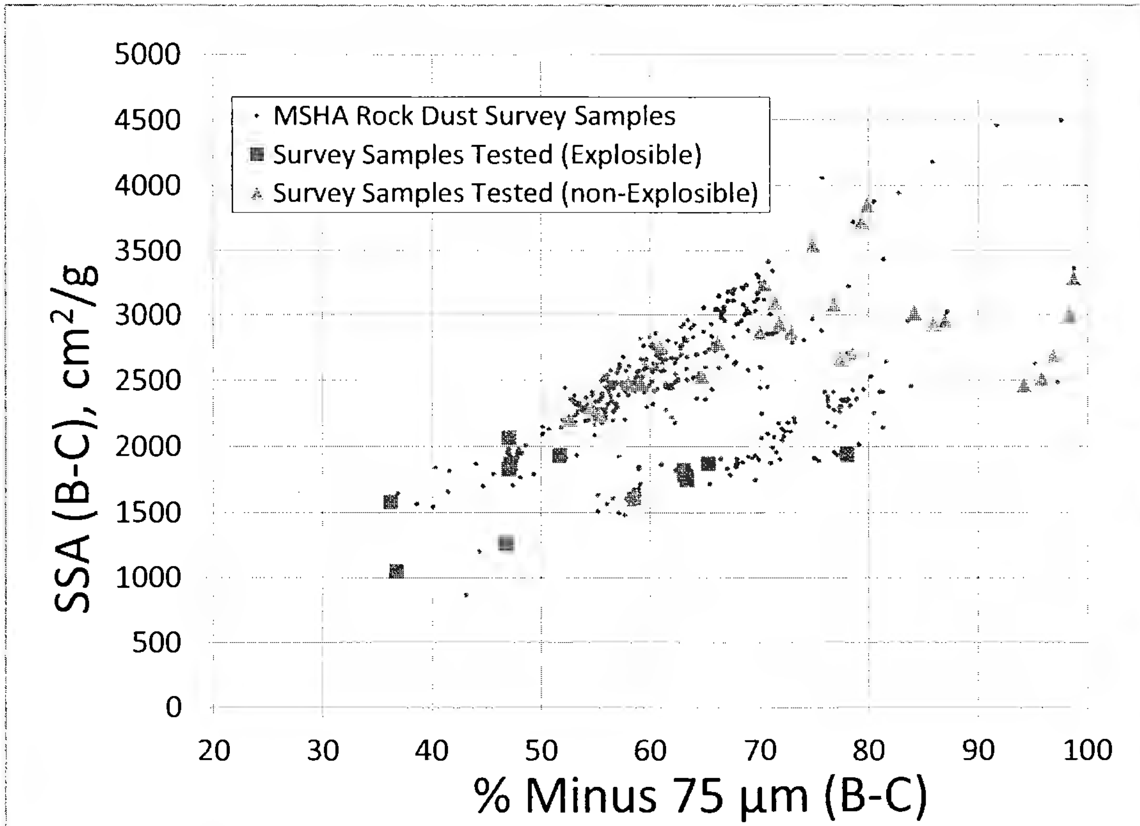
Correlation: Mechanical Sieve vs B-C LDS



Rock Dust Spot Survey



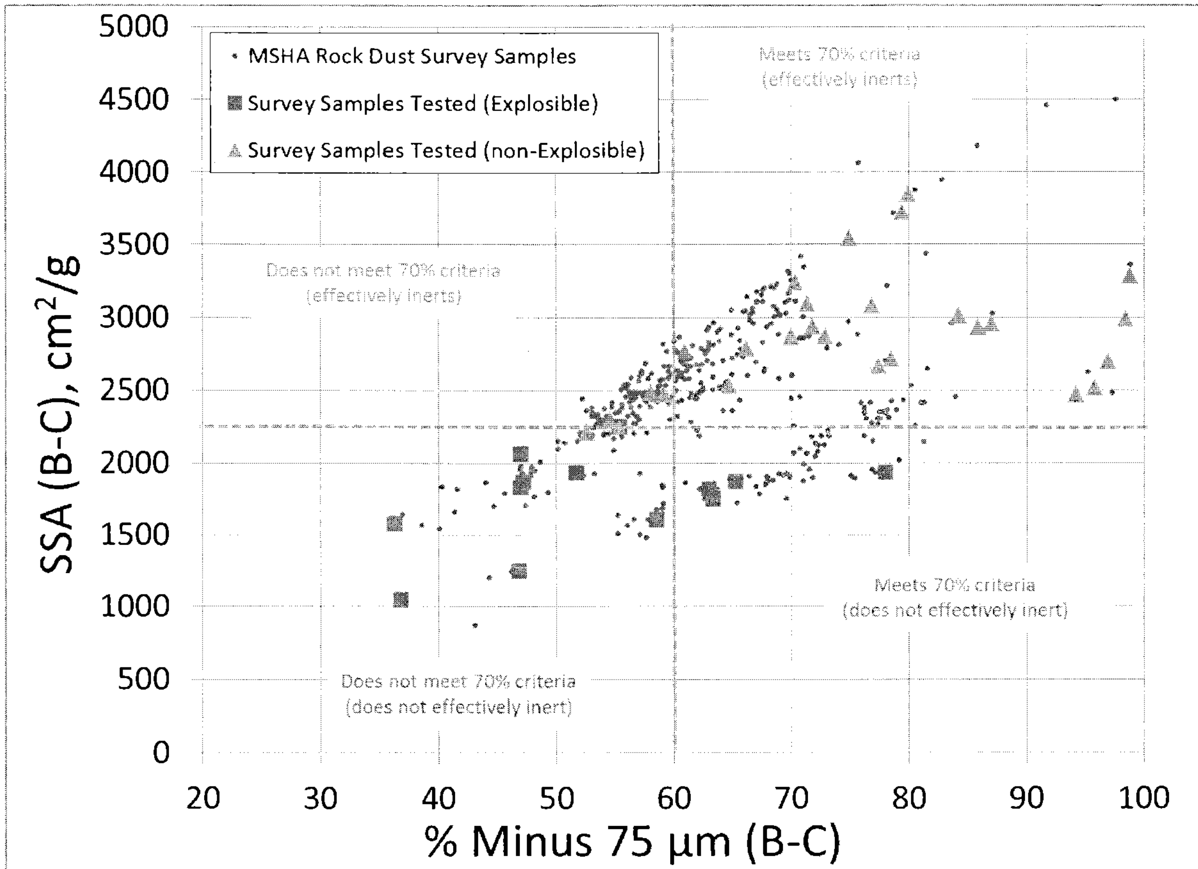
Rock Dust Spot Survey



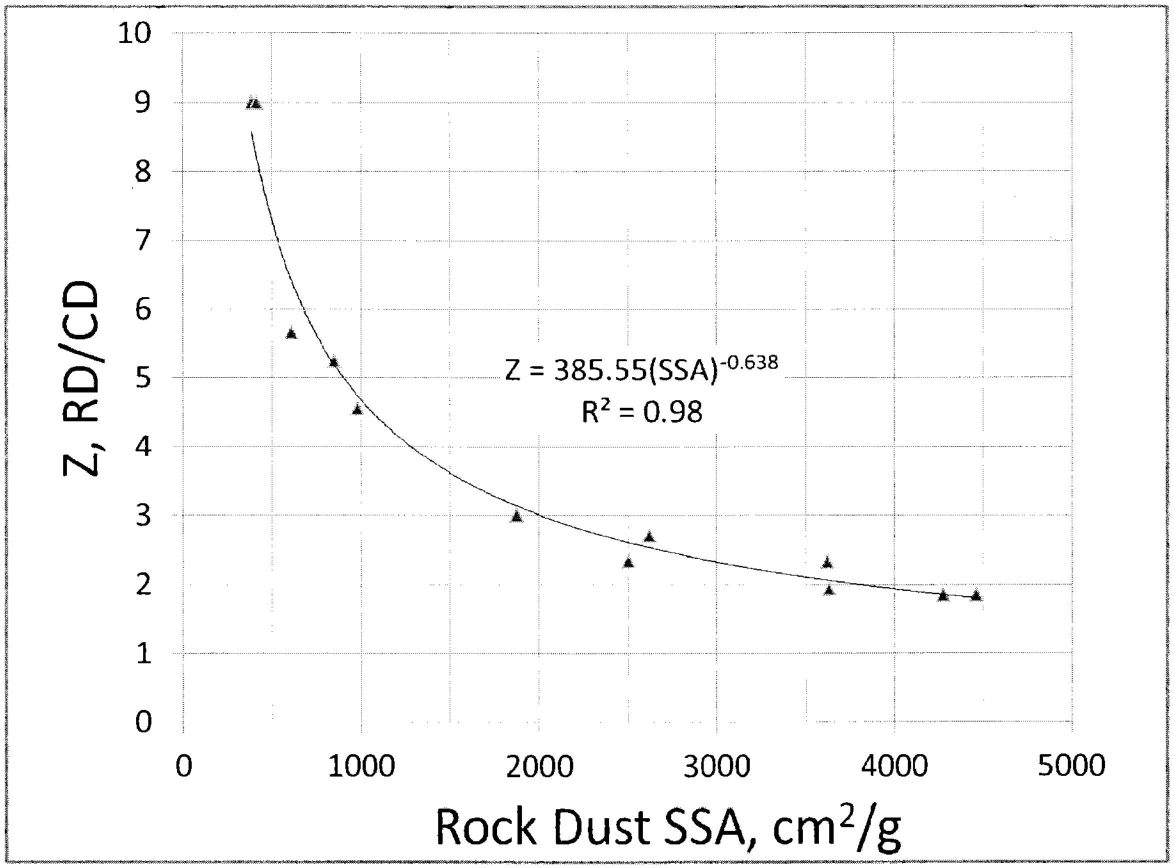
Inerting Effectiveness

20-L Explosibility Chamber

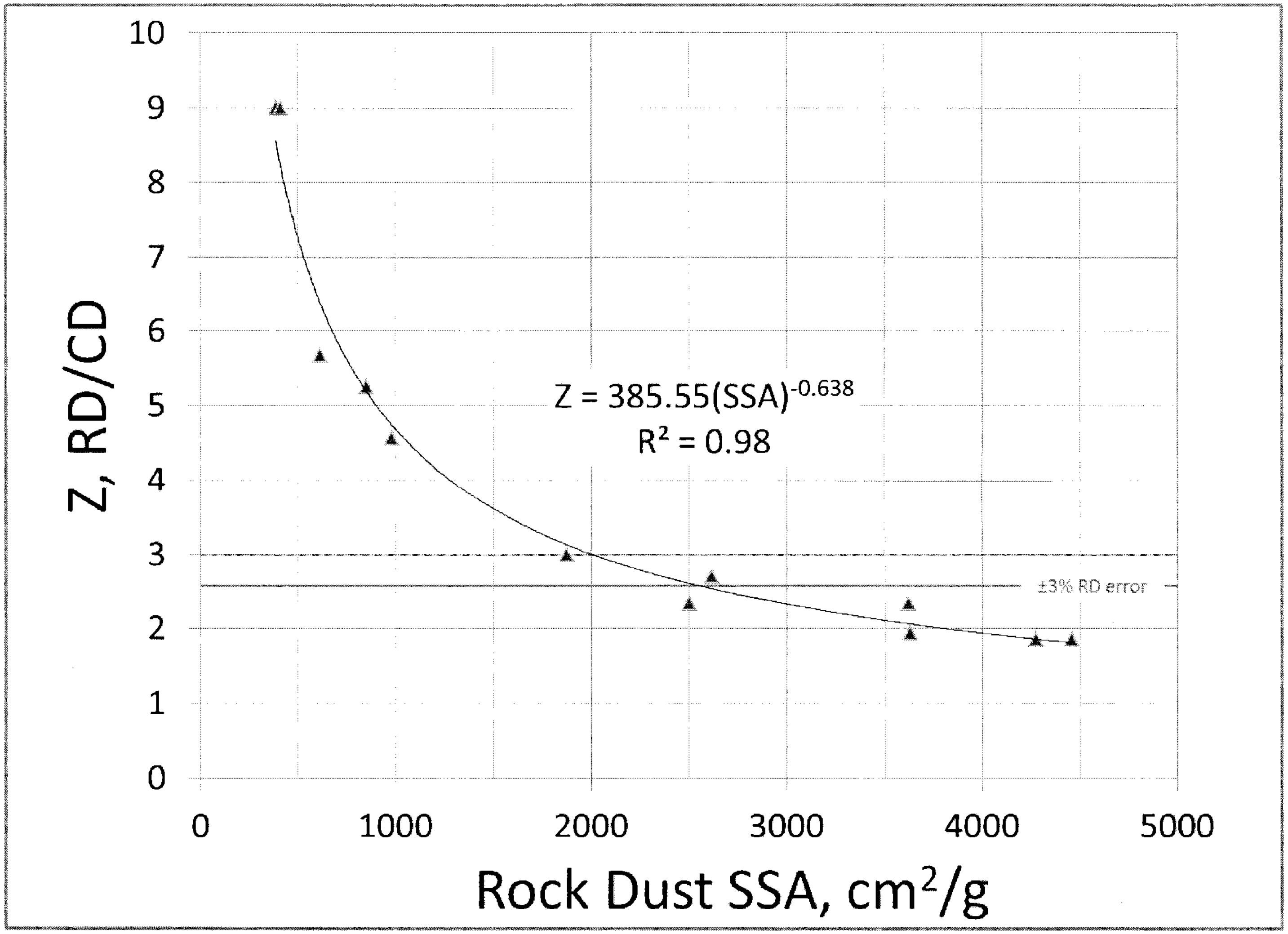
Rock Dust Spot Survey



Inerting Requirement as a Function of Rock Dust Surface Area



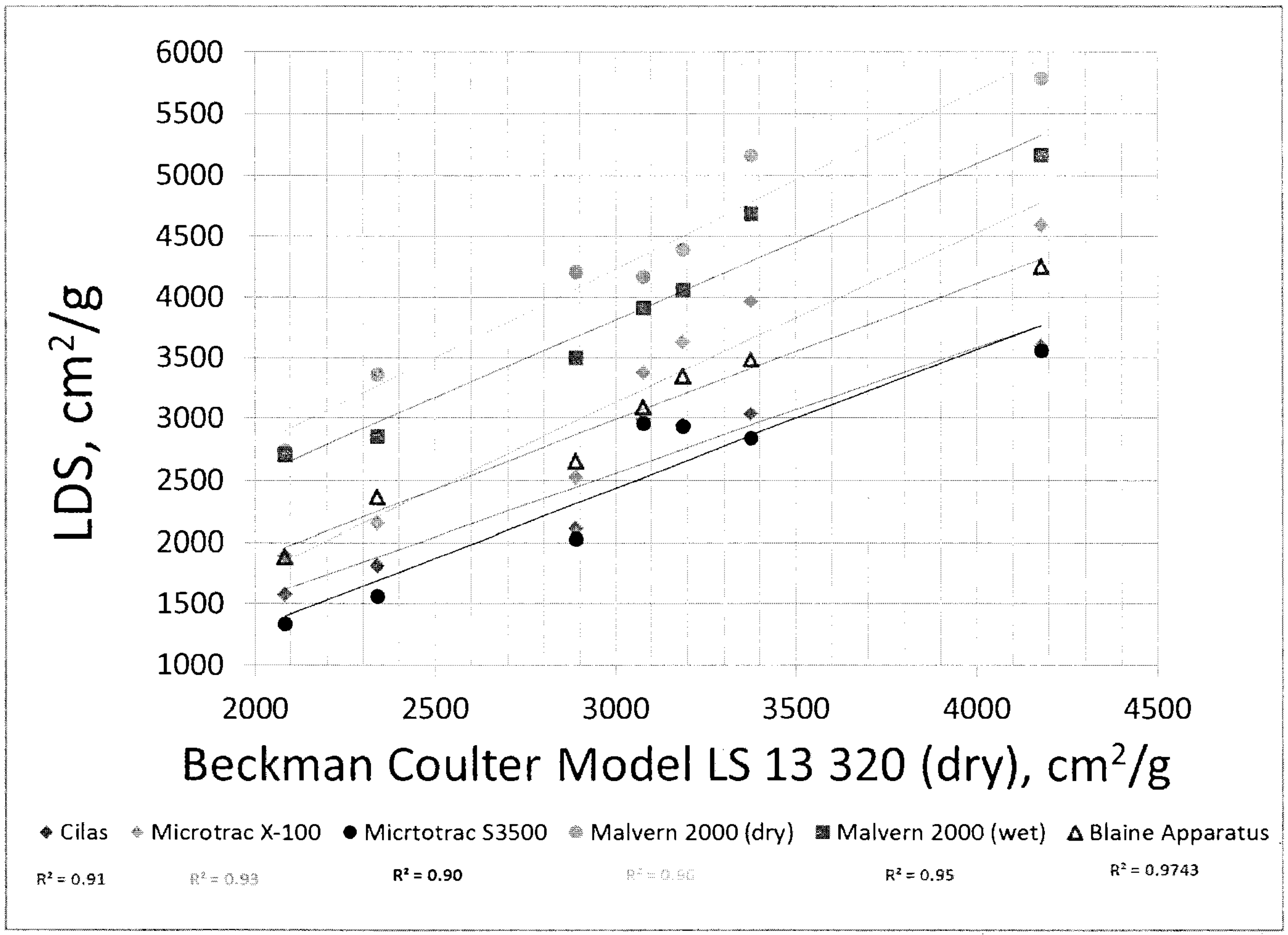
Inerting Requirement as a Function of Rock Dust Surface Area



Determination of Size Element

- % < 200 mesh
  - Air-jet sieve
- SSA
  - Laser Diffraction System or equivalent method

Comparison of Instruments



Dispersibility

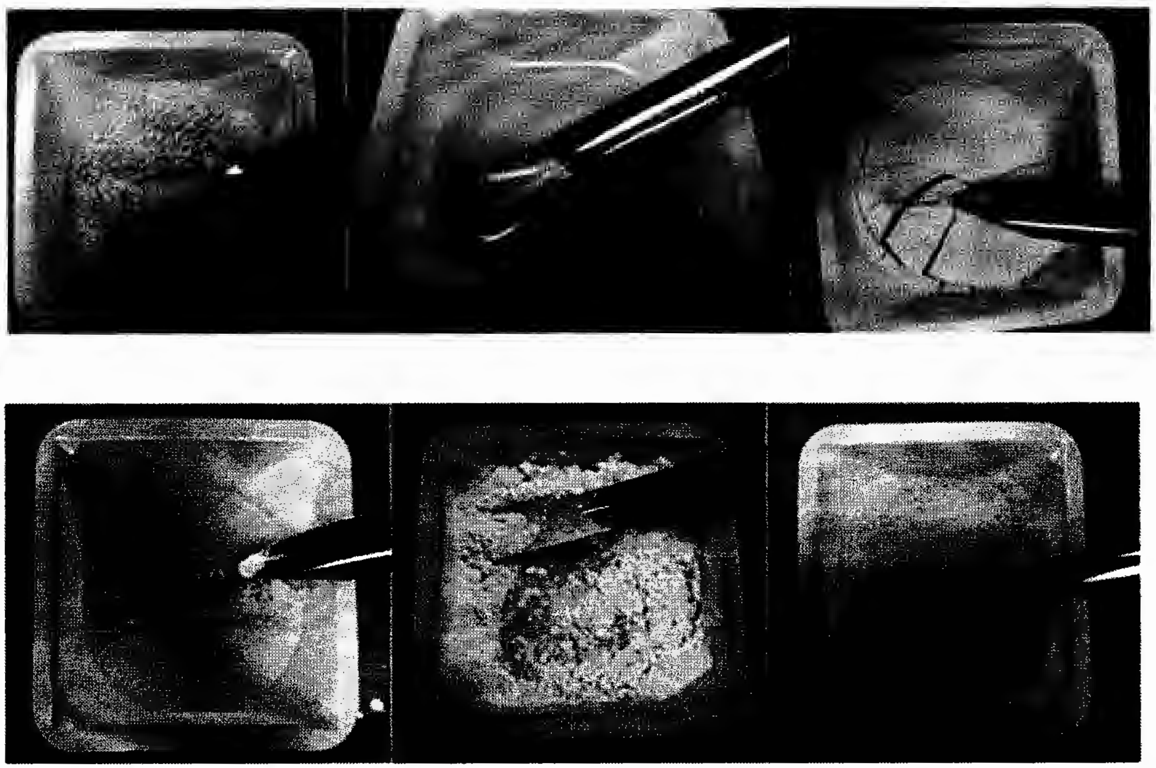
- The particles of which when wetted and dried will not cohere to form a cake
  - All rock dust in the current supply cakes when exposed to moisture

Potential Solution?

- Use of anti-caking additives
  - Stearates
  - Other proprietary materials
- Determination
  - Qualitative
  - Controlled dispersion

Qualitative Assessment

Not wetted | Wetted | Wetted then dried



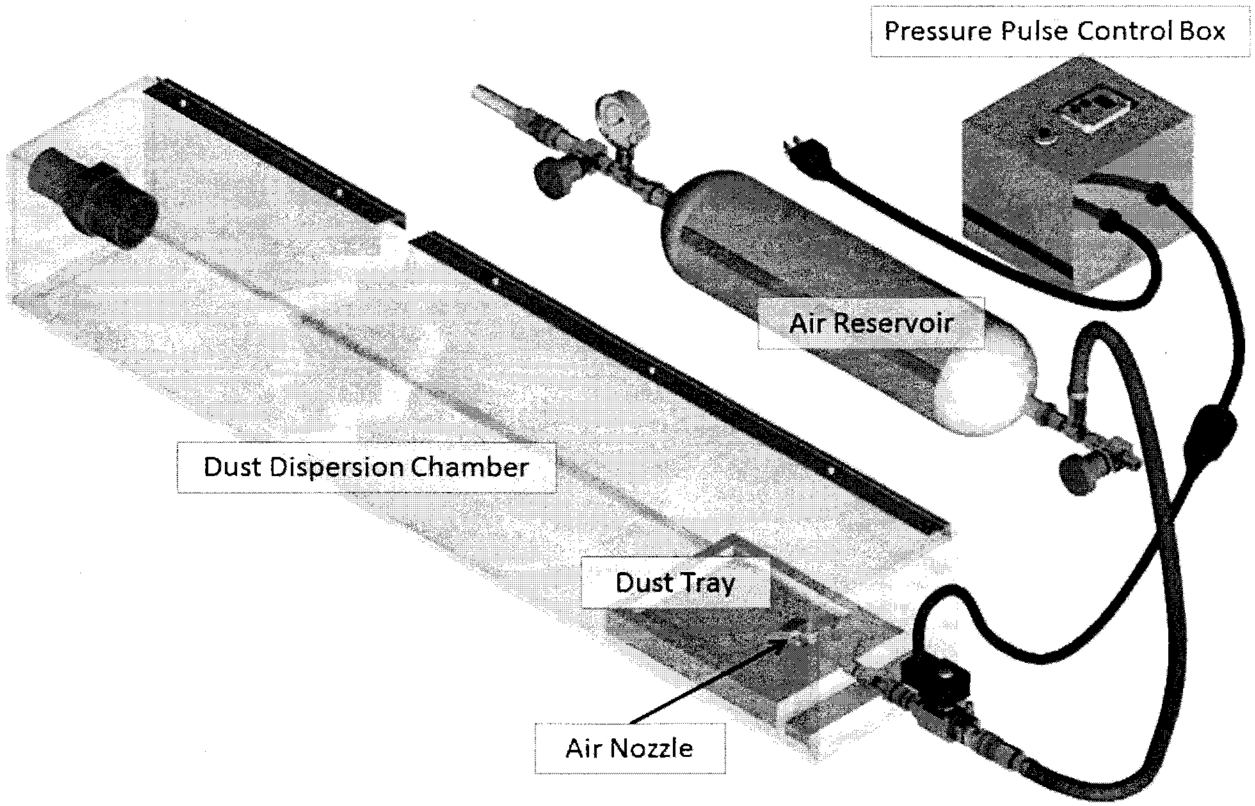
Untreated rock dust

Treated rock dust

Wicking

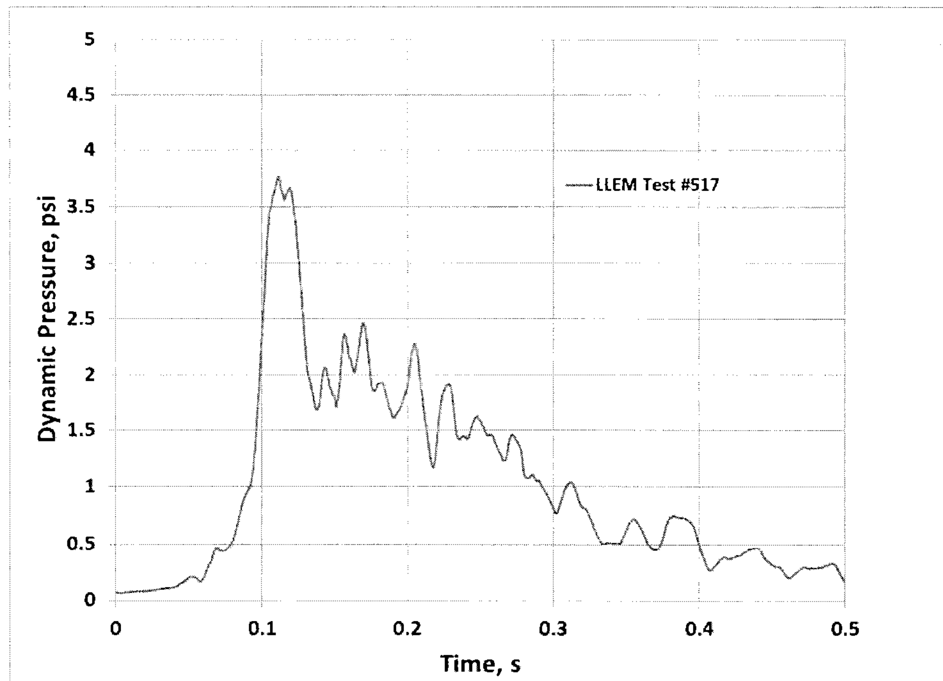
- From the bottom
- Exposure to long-term high humidity
- No degradation in dispersibility after moisture exposure

Controlled Dispersion

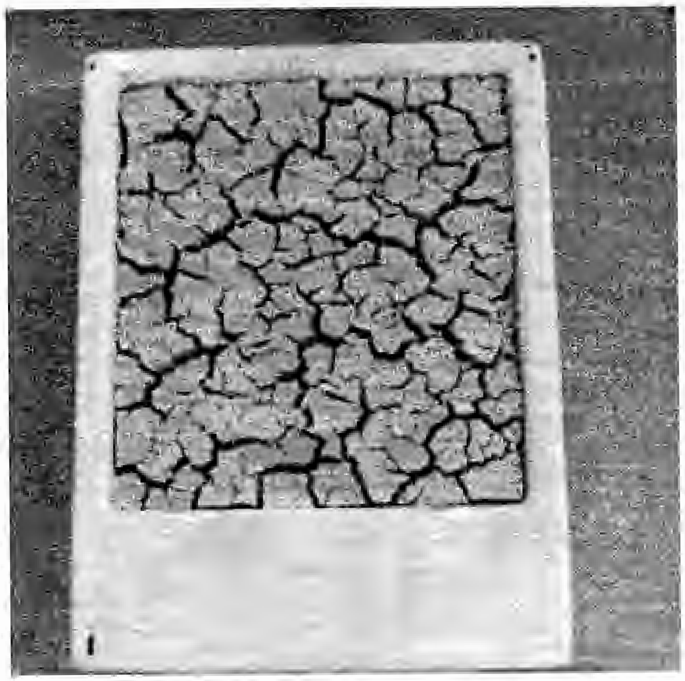


Controlled Dispersion

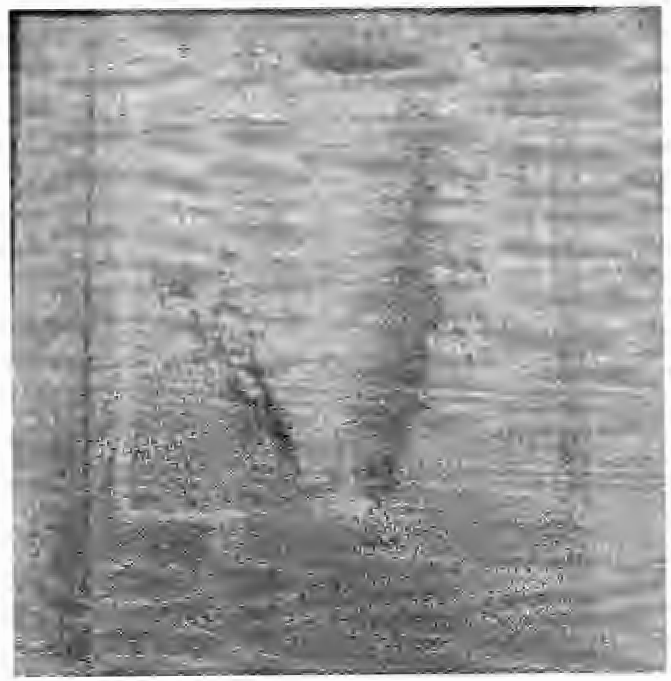
- Define *"light blast of air"*
- Based on LLEM coal dust explosion data
- 4.2 psi for 0.3 sec



Comparison of Controlled Air Pulses



Untreated rock dust exposed to water



Treated rock dust exposed to water

Additive Effects on Explosibility

- Verify the anti-caking additive does not hinder the inerting properties of the rock dust
- Verify that the treated rock dust inerts as well or better than the untreated rock dust

Health Effects of Additive

- Calcium and magnesium stearate
  - Considered nontoxic
  - Applications in consumed products
- Stearates have TLVs of 10 mg/m^3
  - Stearate additives at levels of 0.125% in rock dust supply
  - Potential exposure to stearates is on the order of $\mu g/m^3$

Combustible Material

- Does not contain more than 1% combustible matter
  - Combustible matter within the deposit
  - Anti-caking additives

Combustible Matter of Rock Dust

20-L Chamber		
(400 g/m^3 coal dust loading)		
Rock Dust	Combustible Content of Rock Dust, %	75% Rock Dust in Rock Dust/Coal Dust Mixture
Rock Dust A	0	non-Explosible
Rock Dust A	1	non-Explosible
Rock Dust A	2	non-Explosible
Rock Dust A	5	Explosible
Rock Dust B	0	non-Explosible
Rock Dust B	1	non-Explosible
Rock Dust B	2	Explosible
Rock Dust B	5	Explosible

Determination of Combustible Content

- Existing MSHA Low Temperature Ashing method

Application of Treated Rock Dust

- Treated rock dust would be applied within the mine in the same manner as MSHA recommendations for untreated rock dust including applying the dust to damp strata

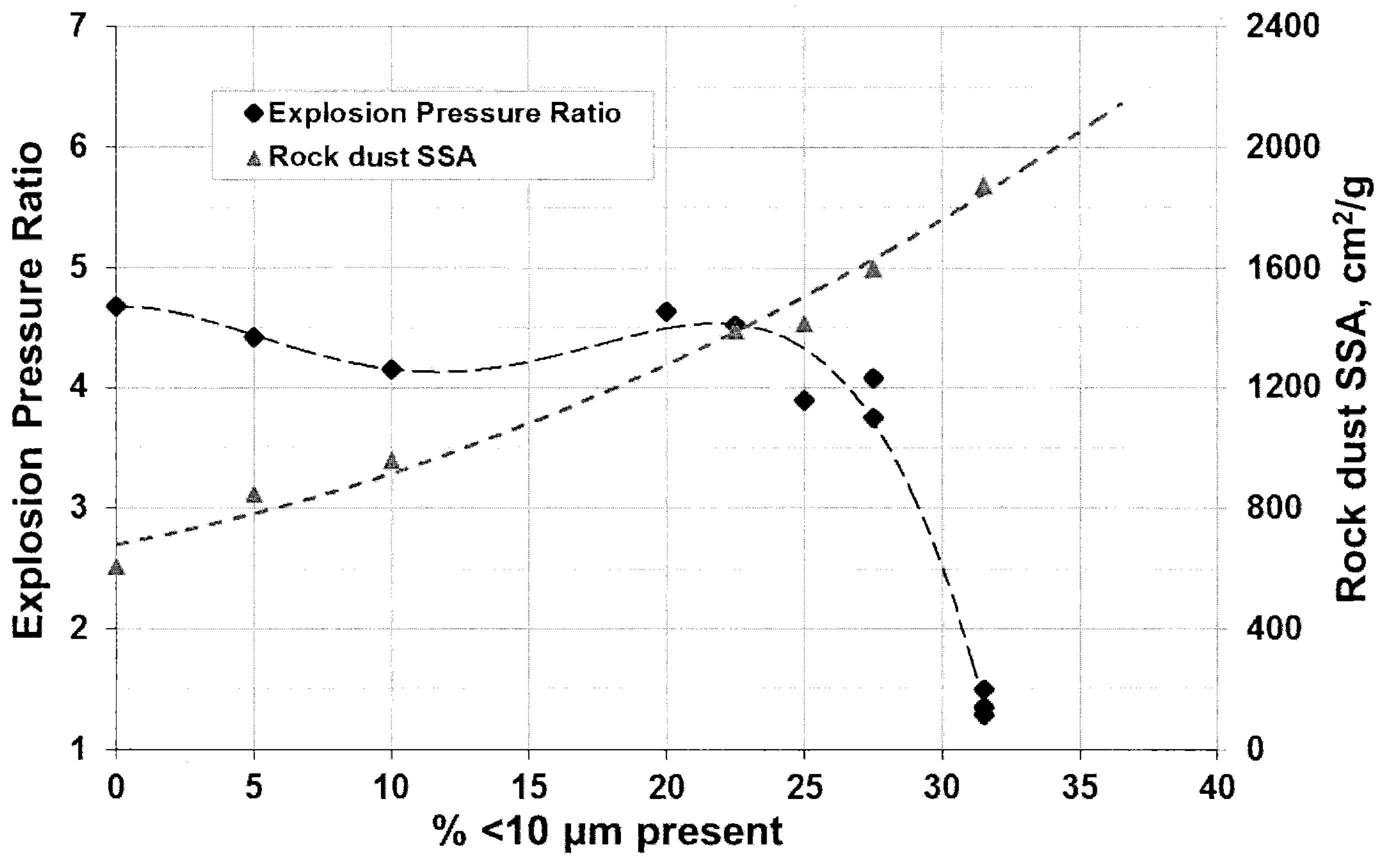
Attributes Proposed

- Pulverized limestone, dolomite, or other inert material, preferably light colored,
- 95 percent or more of which will pass through a sieve having 200 meshes per linear inch as determined by a dry air jet sieving method, and have a minimum specific surface area of 2,600 cm^2/g as determined by B-C method or acceptable equivalent method,
- the particles of which when wetted and dried will not cohere to form a cake and will disperse when exposed to a reproducible blast of air characterized by a dynamic pressure pulse of 4.2 psi applied parallel across the dust bed surface for a minimum of 0.3 seconds,
- and which does not contain more than 1 percent combustible matter as determined by a modified low temperature ashing method.

Comments and Discussion

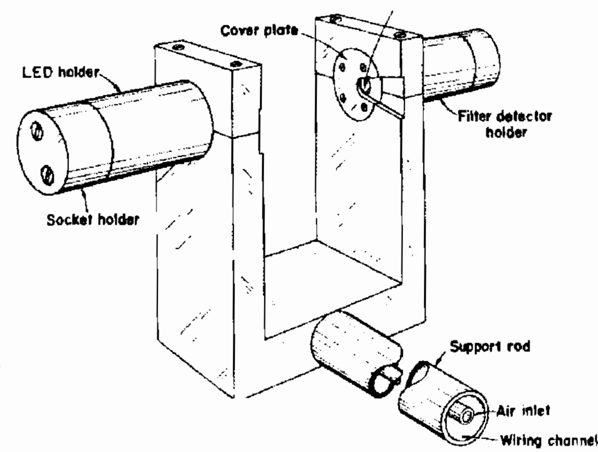
- Discussion of proposed rock dust attributes
- Partnership experiences with improved rock dusts
- Implementation issues
  - Influence of particles ≤ 10μm
  - Dispersibility
  - Reentrainment of respirable dust
- Economics of improved rock dusts
- Next steps/action items?

Effect of < 10 µm Particles on Inerting



Dust Probe

- Dust probe operation based on Bouguer-Beer-Lambert theory.
- $\frac{I}{I_0} = e^{-3QC_mL/2\rho d}$
  - I = transmitted light
  - I_0 = incident light
  - Q = dimensionless extinction coefficient
  - C_m = Mass concentration of dust cloud
  - ρ = Particle density
  - L = light path length
  - d = surface weighted mean diameter

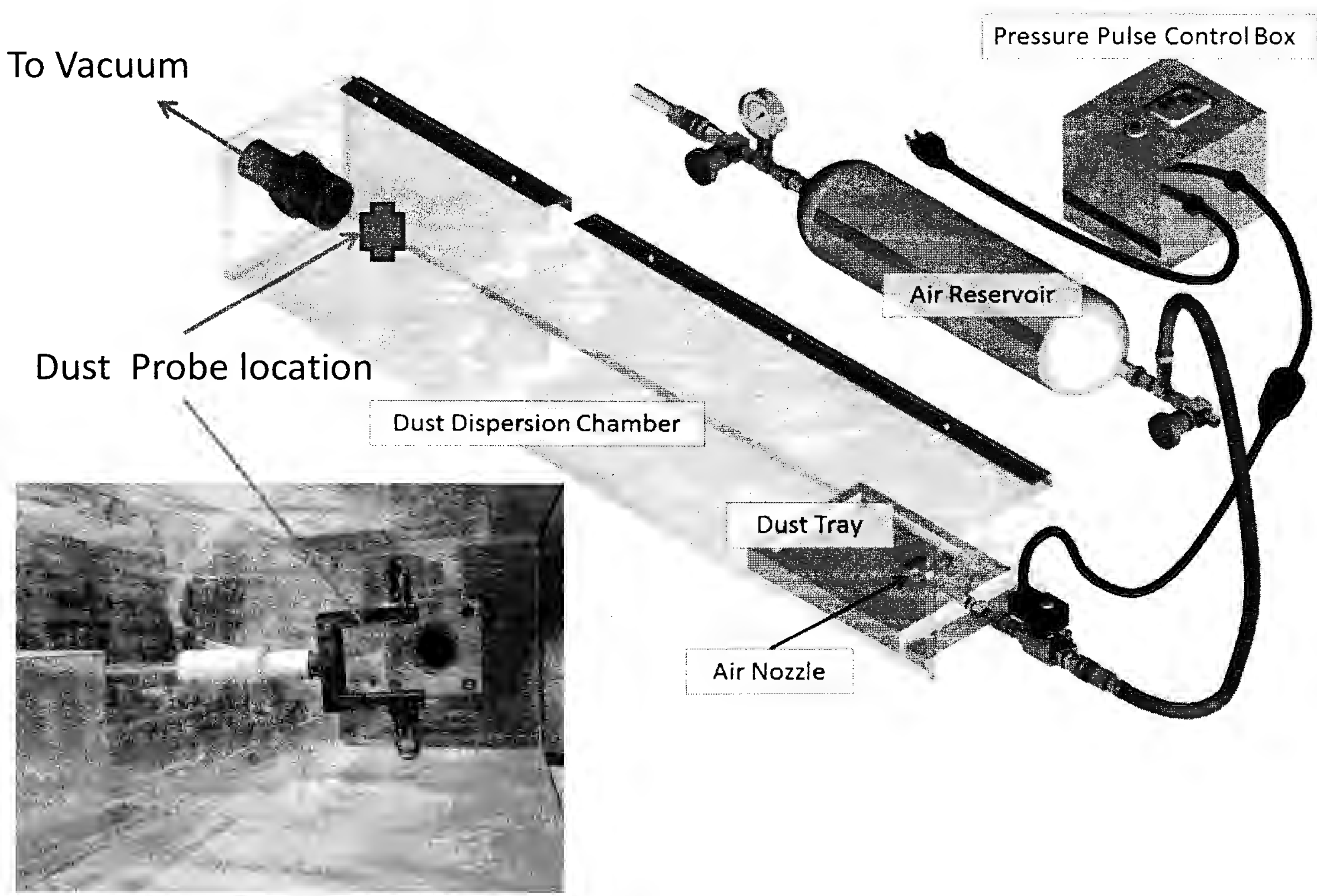


Optical Density D/L , (1/m)

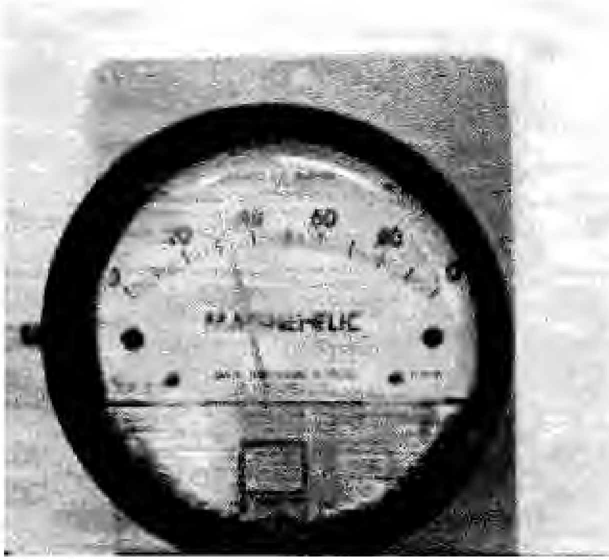
- Optical Density D per unit path length L is proportional to the mass concentration and inversely proportional to mean dust particle size over path length L

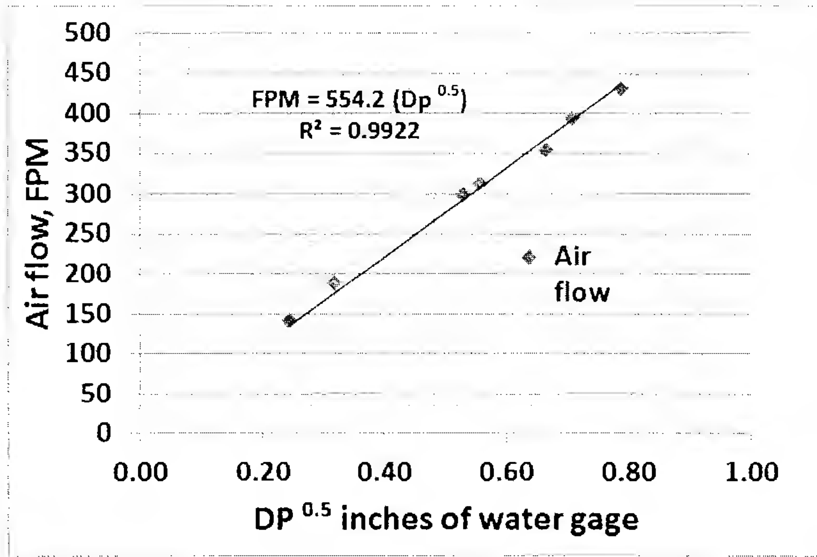
$$D/L = -LN(\frac{I}{I_0})/L$$

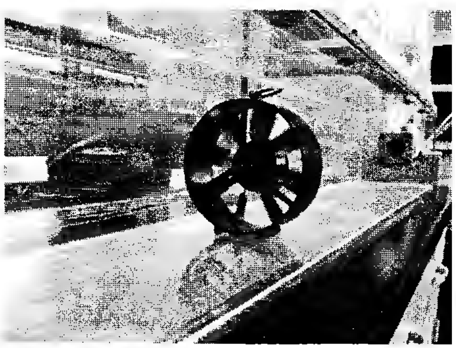
Dust Dispersion Chamber With Dust Probe



Dust Chamber Air Flow Control



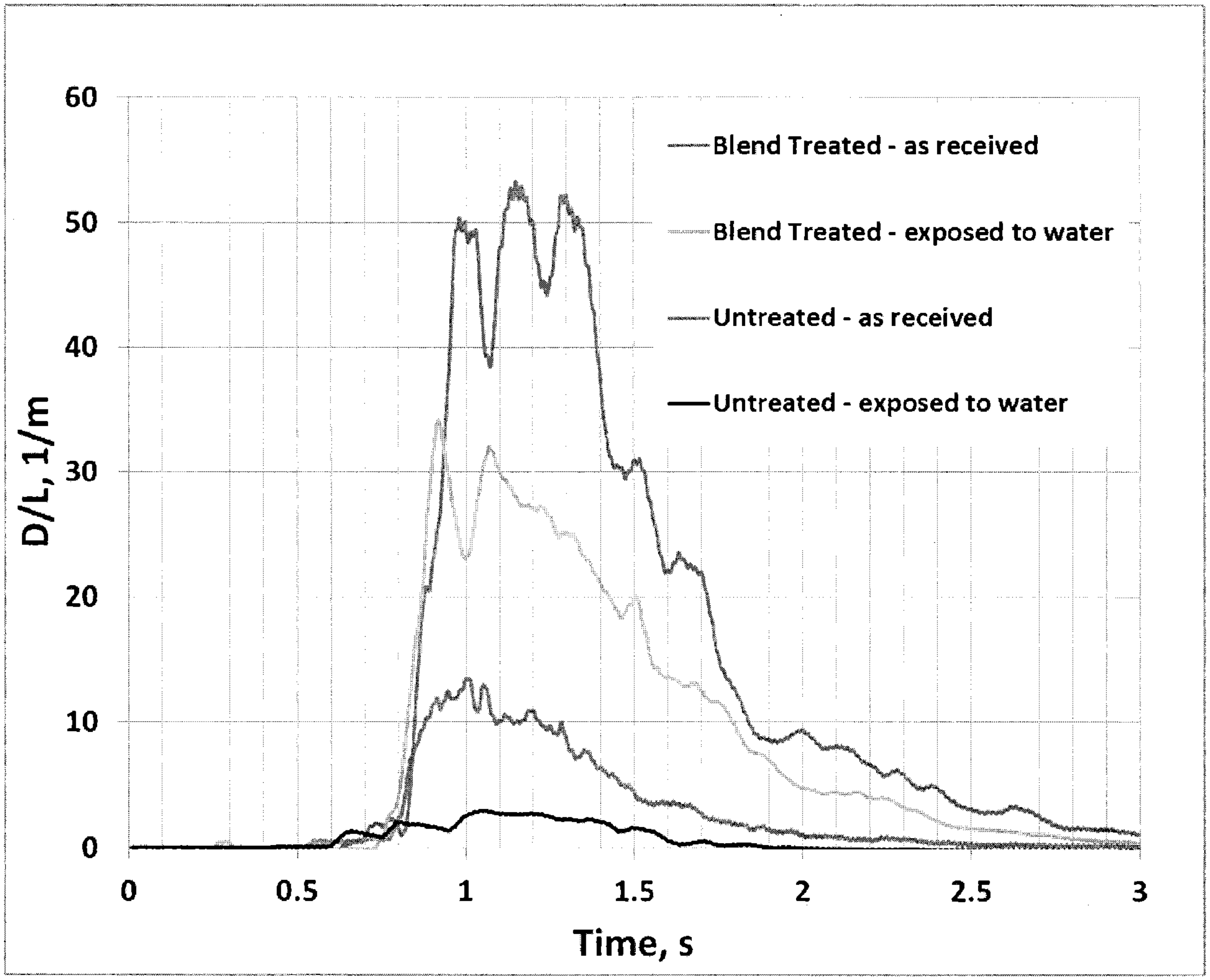




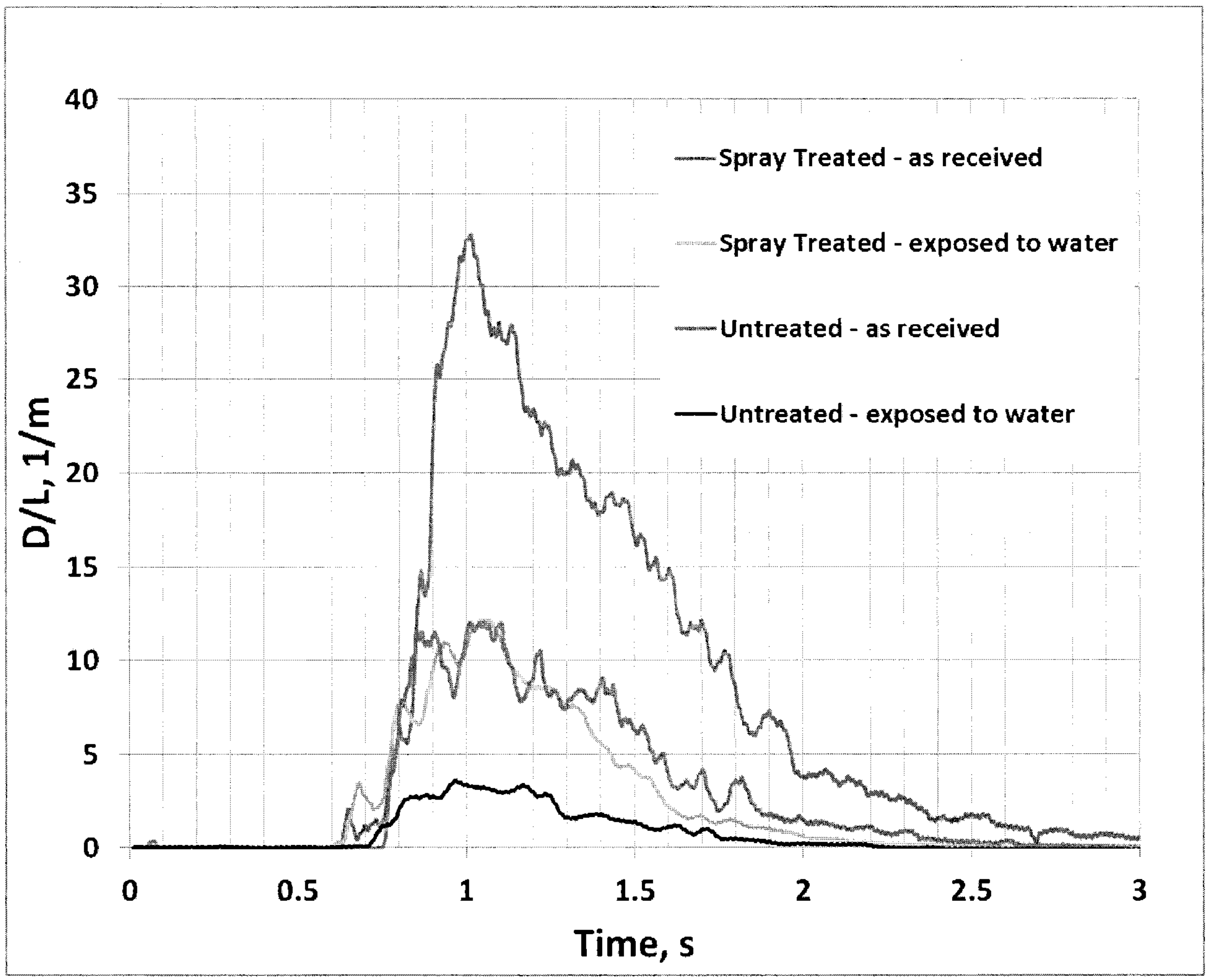
Air velocity in FPM in center of chamber

DP	FPM	FPS	$Dp^{0.5}$
0.62	431	7.2	0.79
0.5	393	6.6	0.71
0.44	354	5.9	0.66
0.31	314	5.2	0.56
0.28	300	5.0	0.53
0.1	189	3.2	0.32
0.06	142	2.4	0.24

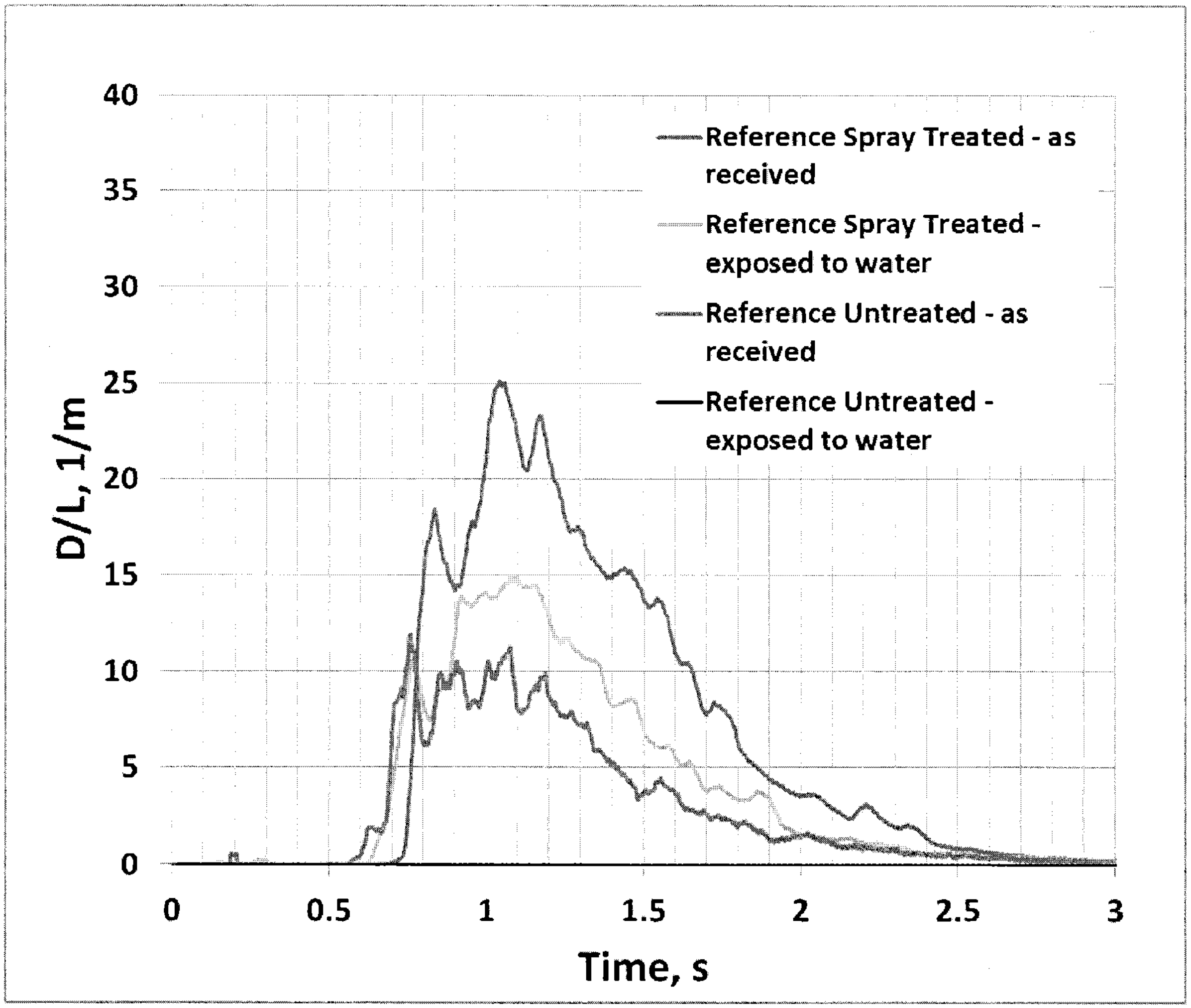
Relative Dispersion of Blended Treatment



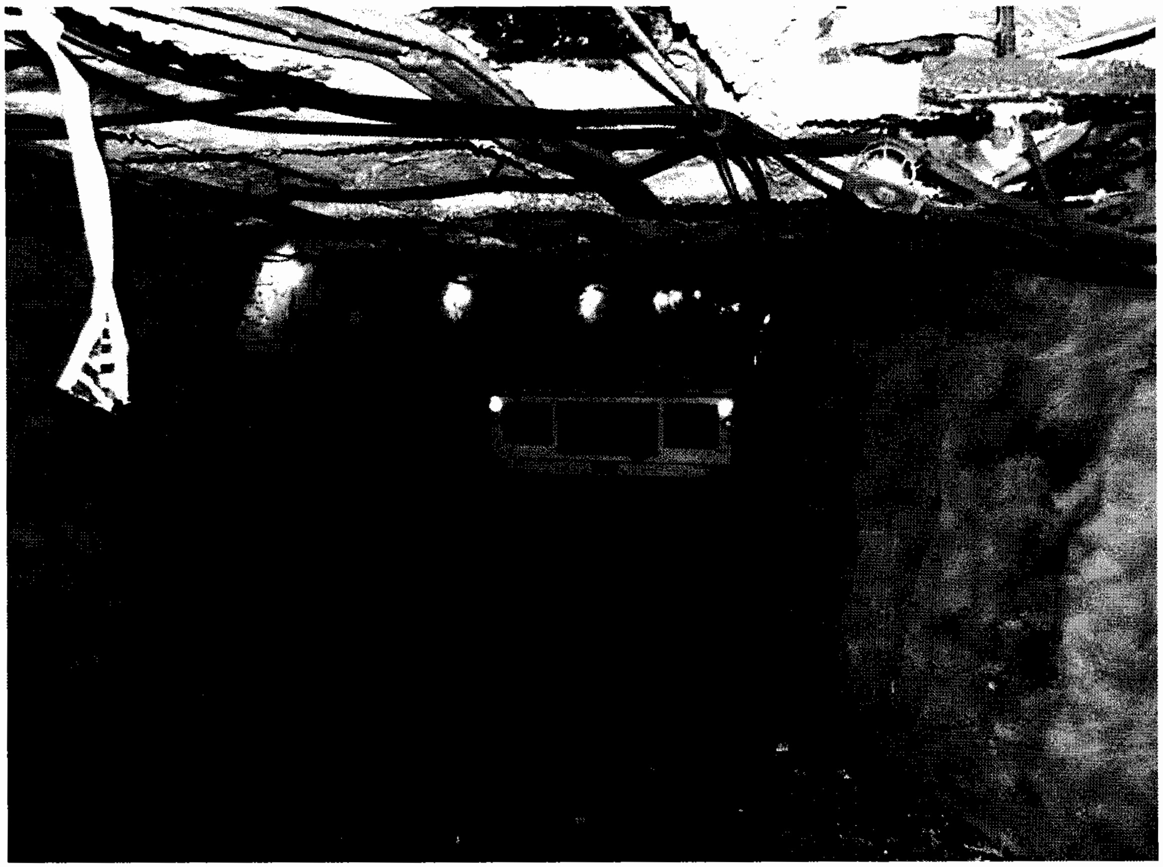
Relative Dispersion of Spray Treatment



Relative Dispersion of Reference Rock Dust and Spray Treatment



Re-entrainment Experiments SRCM

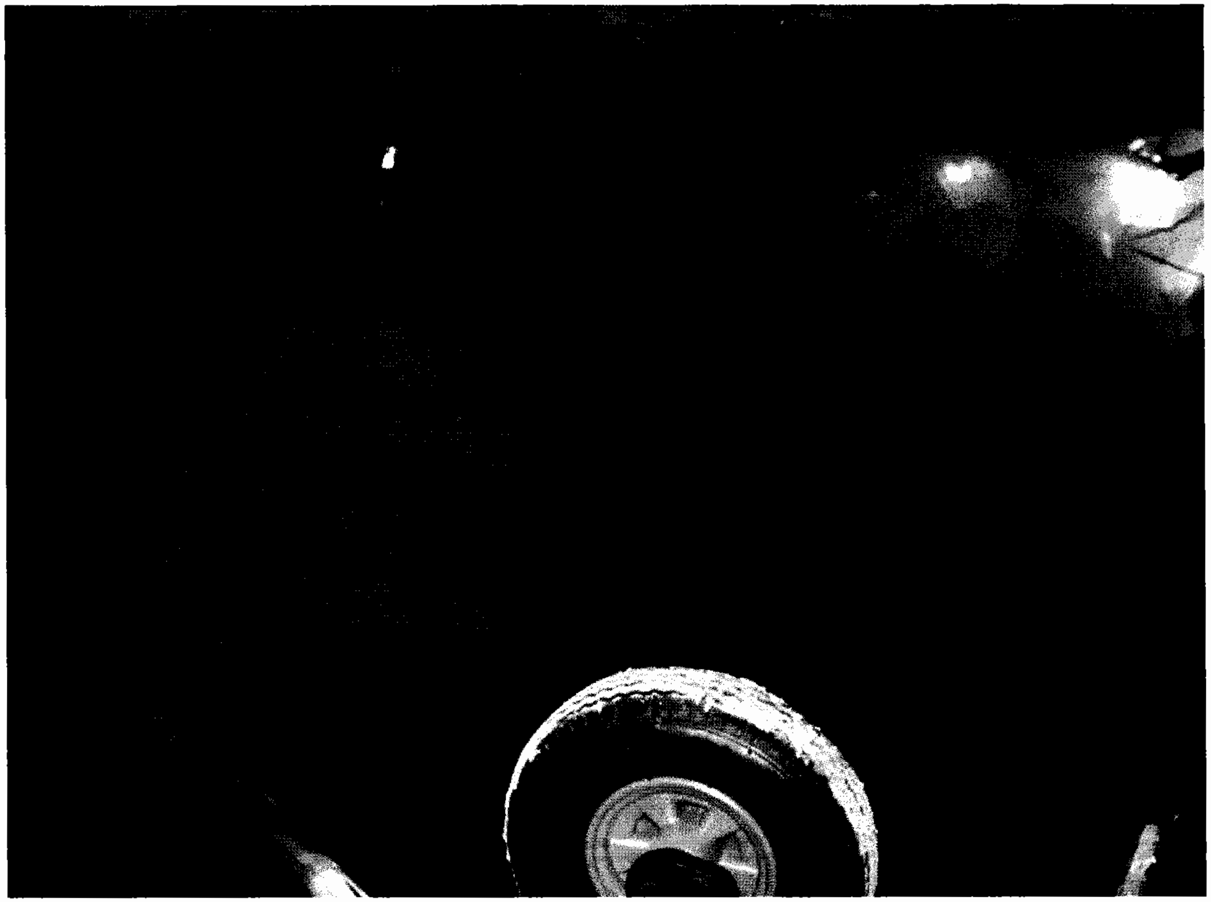


Assessing Respirable Dust Concern

Effects on current practices?

- Working Areas
  - Low ventilation velocity (~100 fpm)
  - Areas wetted by continuous miner sprays
  - Use of water to wet floor/roadways
  - Use of surfactant
- Outby Haulageways
  - Higher ventilation velocity (~200 fpm)
  - Thicker layer of rock dust (¼ – ½ in)
  - Use of calcium chloride to absorb ambient moisture

Dispersing Dust with Rock Duster



Reentrainment Experiments-SRCM

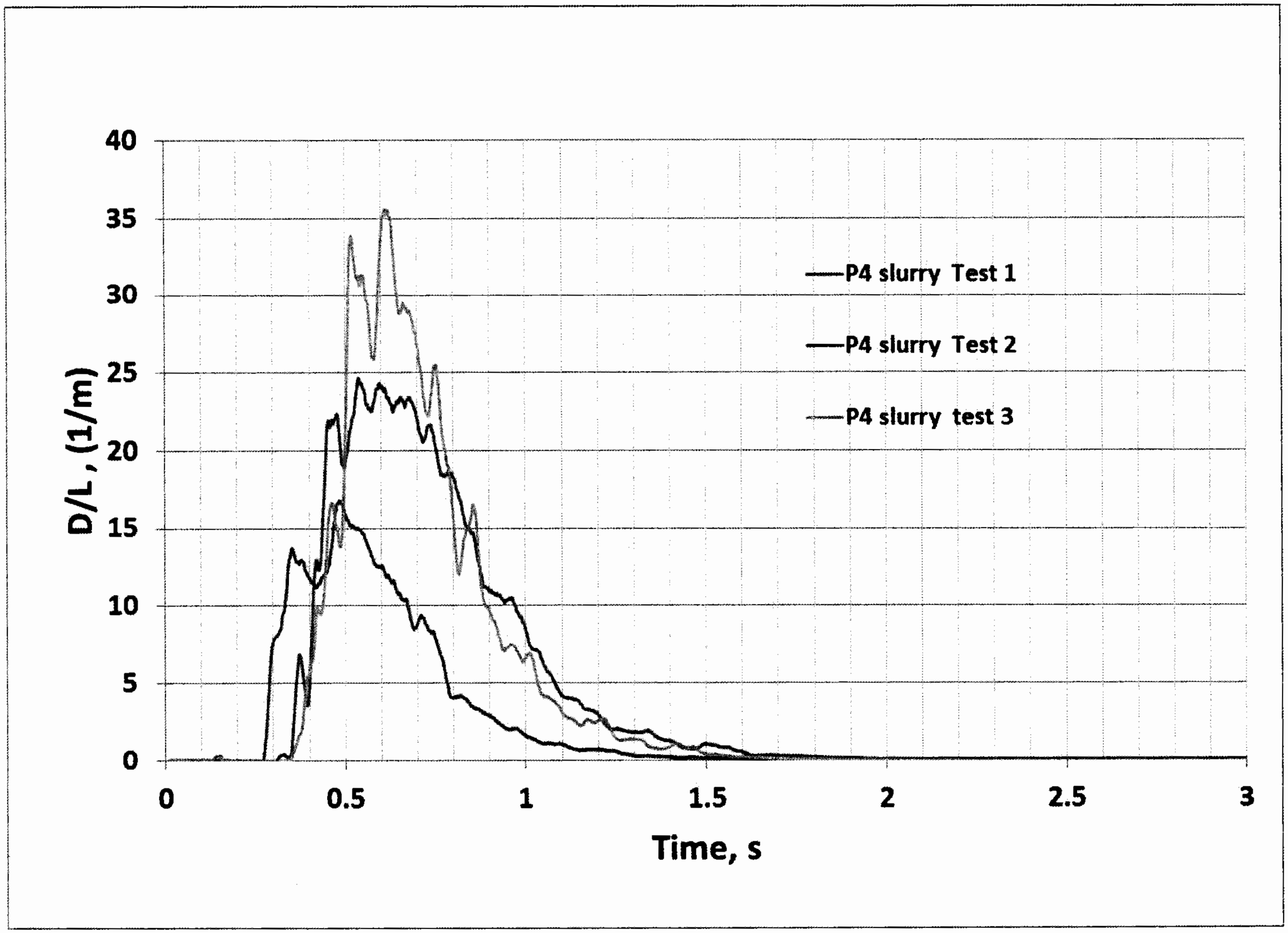
Preliminary Results

- Working Areas
  - Low ventilation (100 - 115 fpm average range)
  - Use of water to wet floor/roadways effective on both treated and untreated dust
  - Surfactant performed as well as the water
- Outby Haulageways
  - Higher ventilation (~206 fpm average)
  - Thicker layer of rock dust (¼ – ½ in)
  - When calcium chloride used on treated rock dust, mud bottom resulted
- According to PDM results
  - Wetting the floors appears to work with treated rock dust
  - Low operator levels

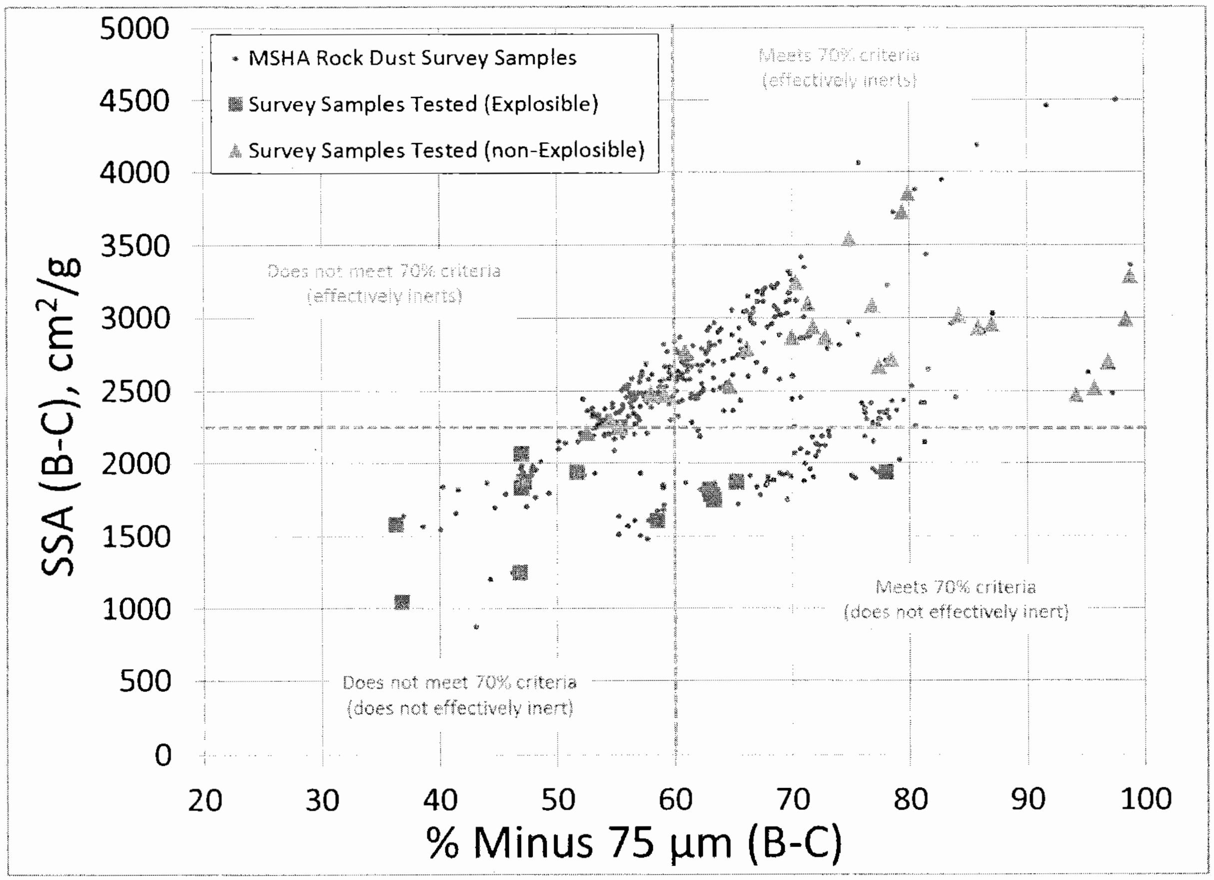
Proposed Efforts to Address Respirable Dust Issue

- Formulation
  - Other hydrophobic mixtures
  - Maximum SSA
- Application
  - Surfactants to form rock dust slurry and dusting with dry hydrophobic dust
  - Dry collection

Relative Dispersion of Dried Slurry OF MW 100 + P4 + Water+ Surfactant



Maximum SSA



MSHA Rock Dust Survey Samples
Survey Samples Tested (Explosible)
Survey Samples Tested (non-Explosible)
Meets 70% criteria
(effectively inerts)
Does not meet 70% criteria
(effectively inerts)
Meets 70% criteria
(does not effectively inert)
Does not meet 70% criteria
(does not effectively inert)
SSA (B-C), cm²/g
% Minus 75 μm (B-C)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
20
30
40
50
60
70
80
90
100

Comments and discussion

- Economics of improved rock dusts
- Next steps/action items?
  - Partnership commitment to underground testing
  - Pursue surfactant research
  - Pursue limitation of SSA

Thank you