Large-Scale Testing of Two-part Foam Rock Dust

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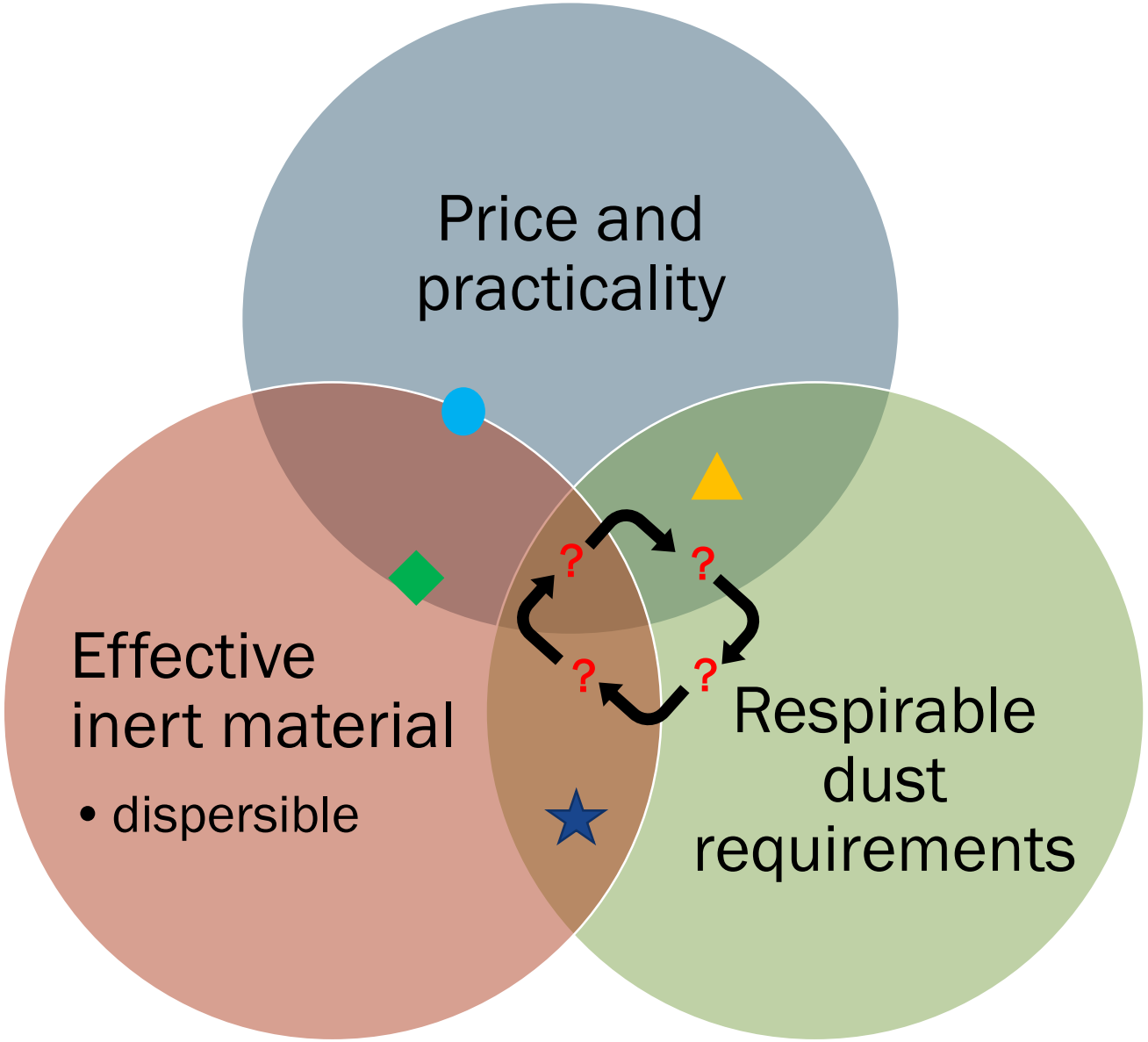
Impetus for testing foamed rock dust

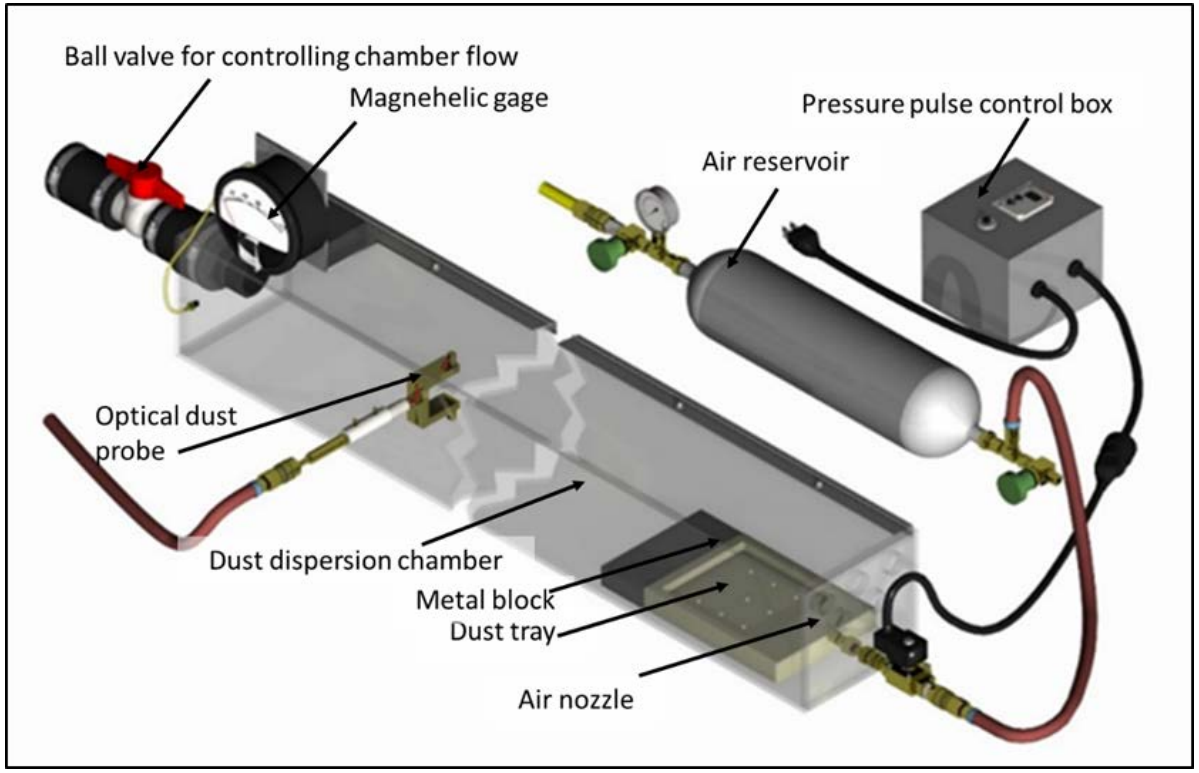
What has been tried?

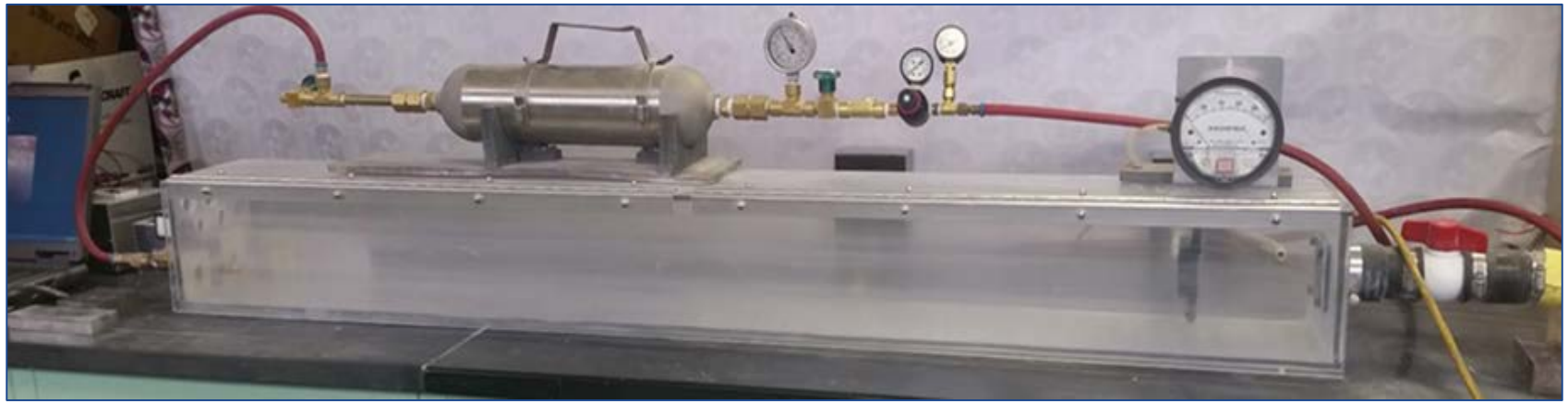
- Traditional rock dust (●)
  - 80% incombustible rule
- Wet Applied rock dust (▲)
- Treated rock dust (◆)
  - Re-entrainment and
  - Respirable dust
- Engineered rock dust (★)
  - Technical success
  - Practical failure
- Foamed rock dust(?)



NIOSH developed dust dispersion chamber

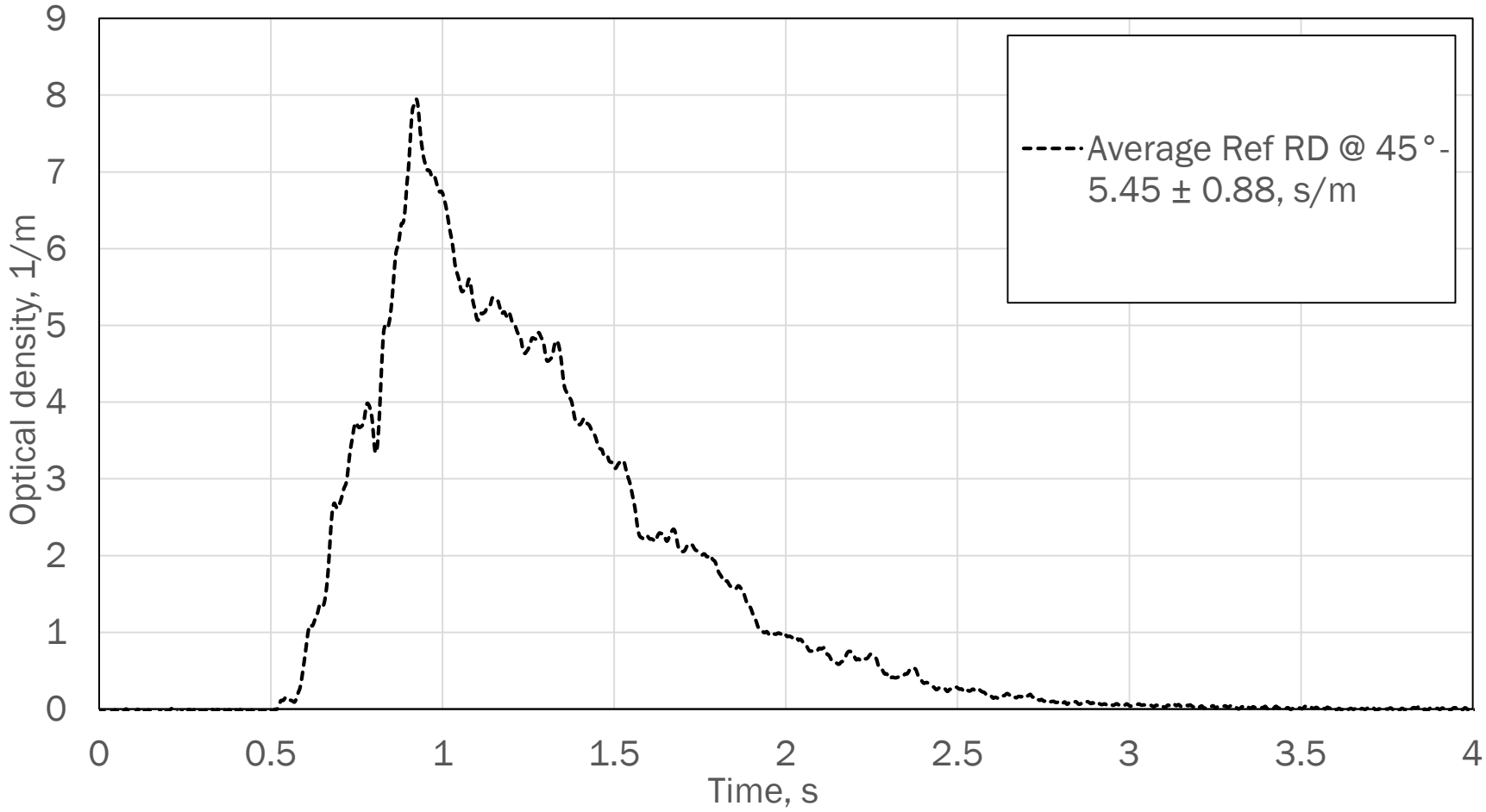
- Based on LLEM coal dust explosion data
- Generates a reproducible air pulse
- 4.2 psi for 0.3 sec
- Dispersion characteristics are compared relative to a standard rock dust





How are the dispersion characteristics measured

- Reference rock dust was used as a qualifying limit.
- Lake Lynn Experimental Mine
  - 80% TIC rule



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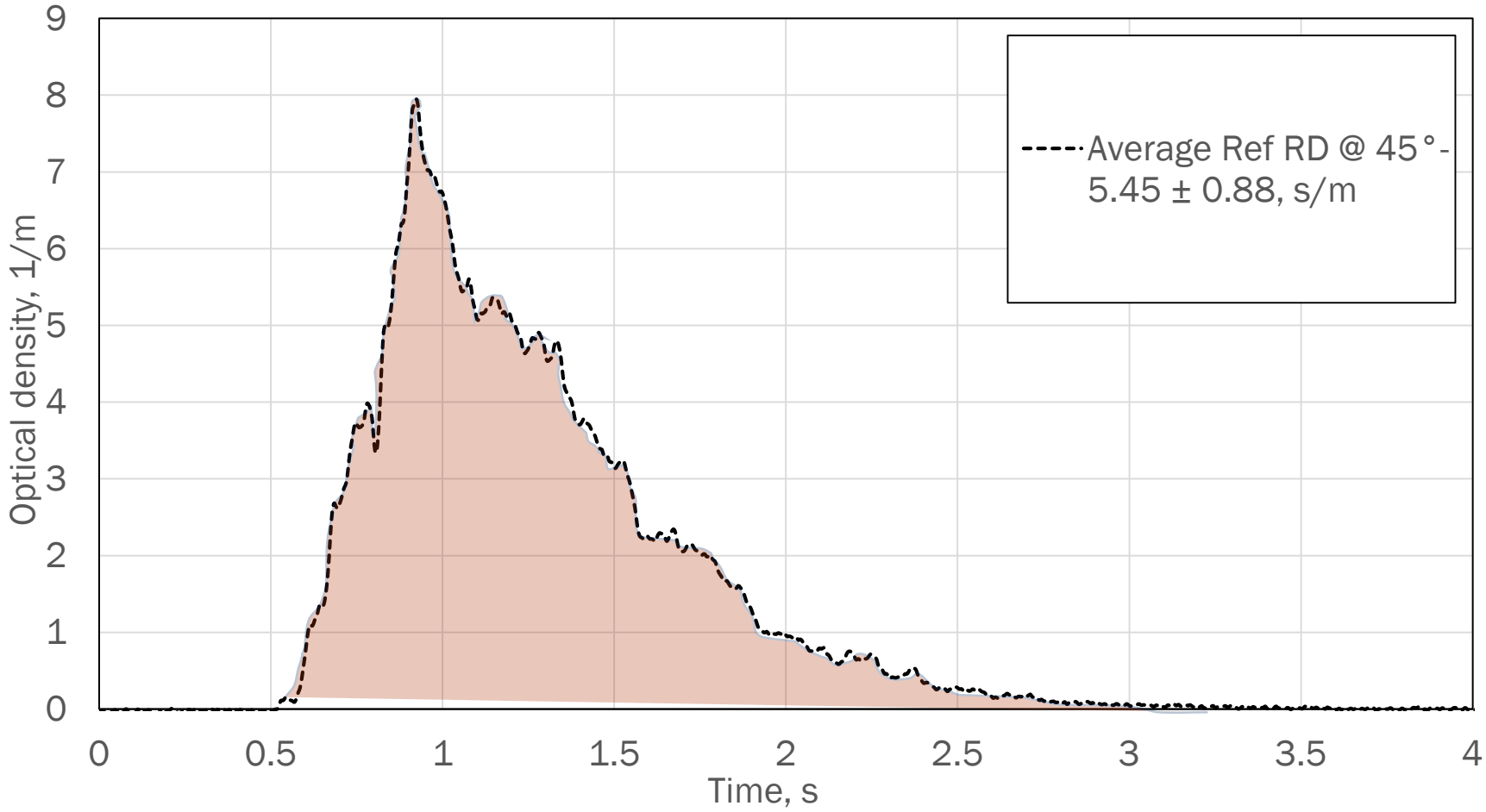
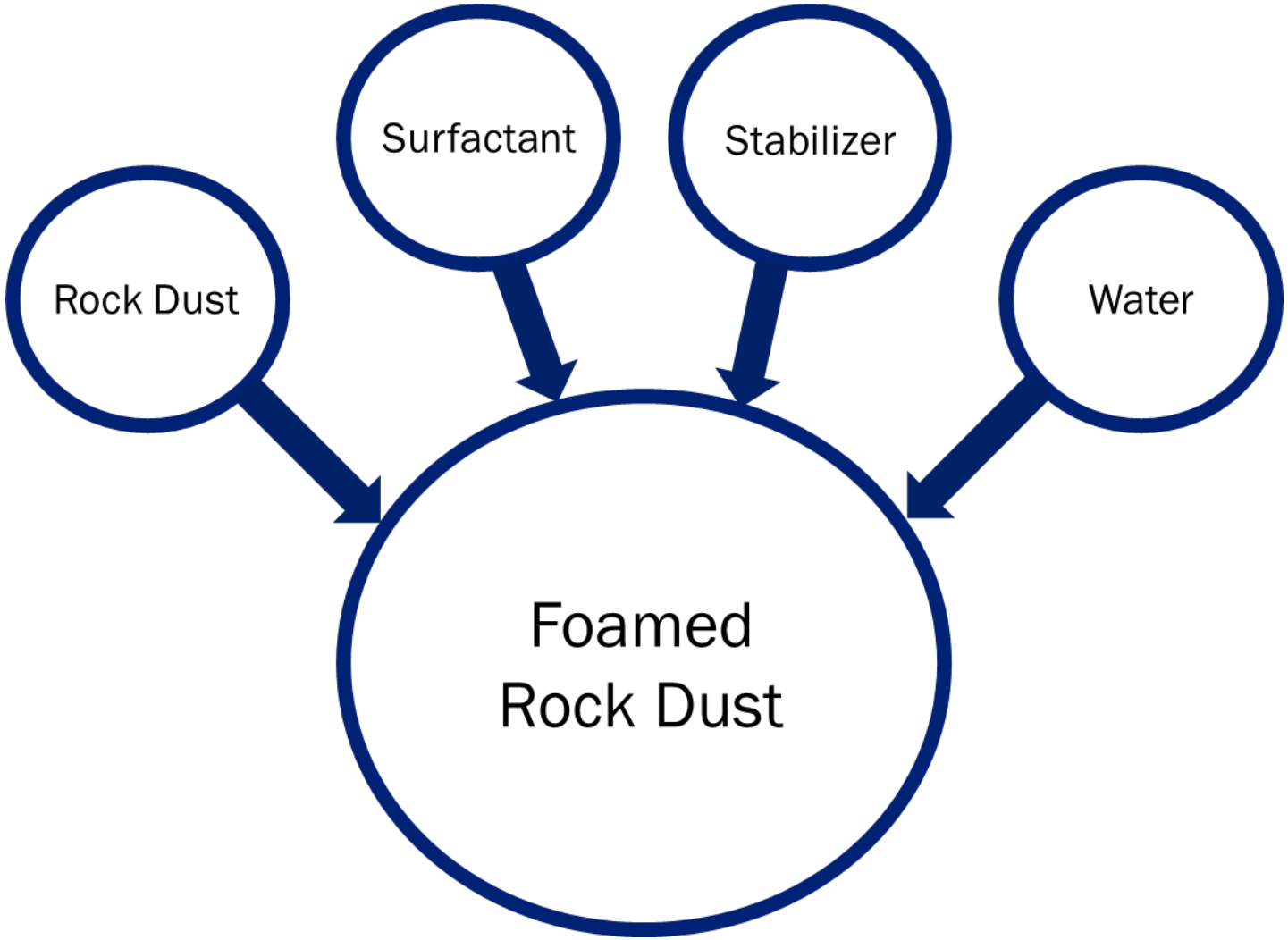
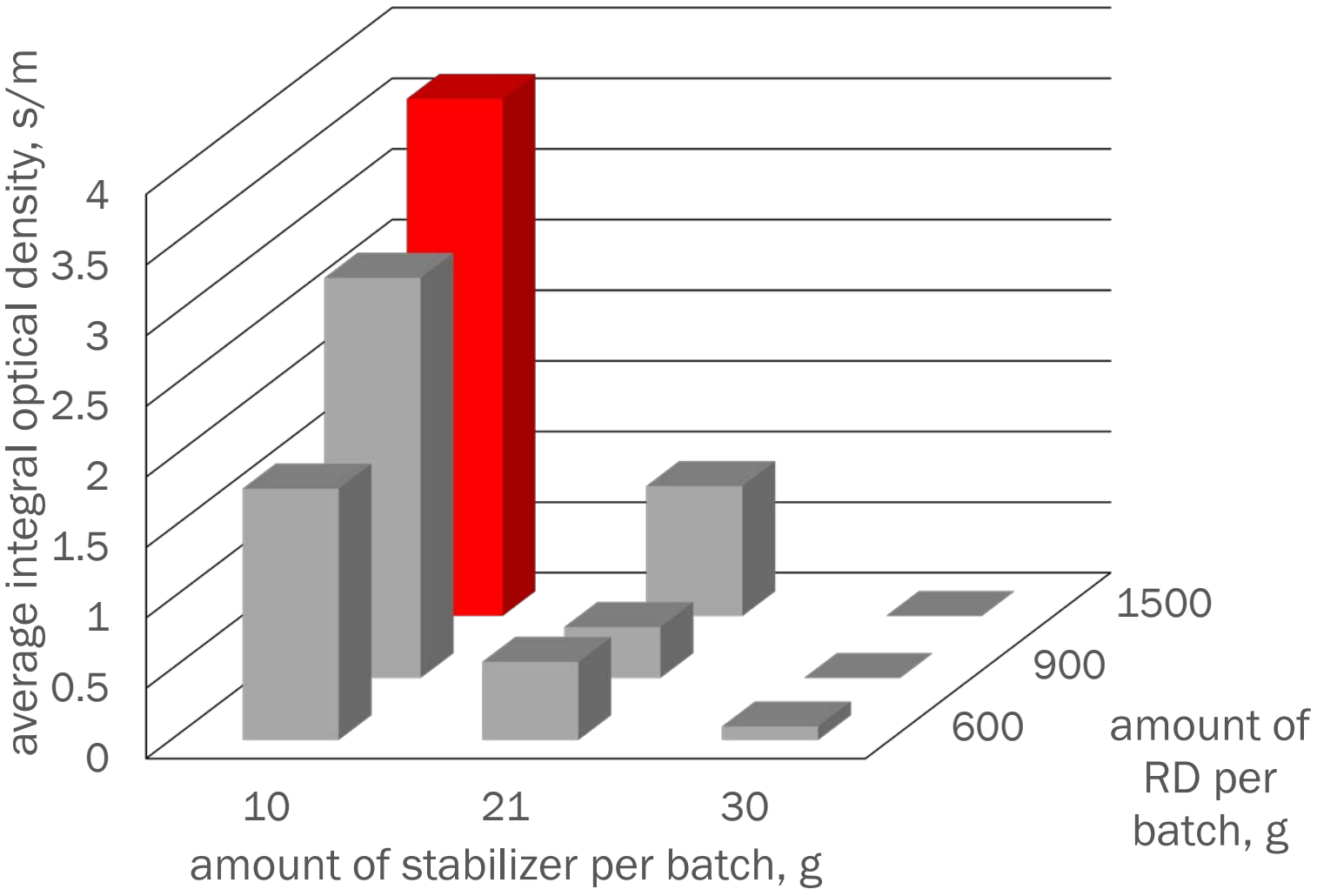


What set this foam apart from the others?

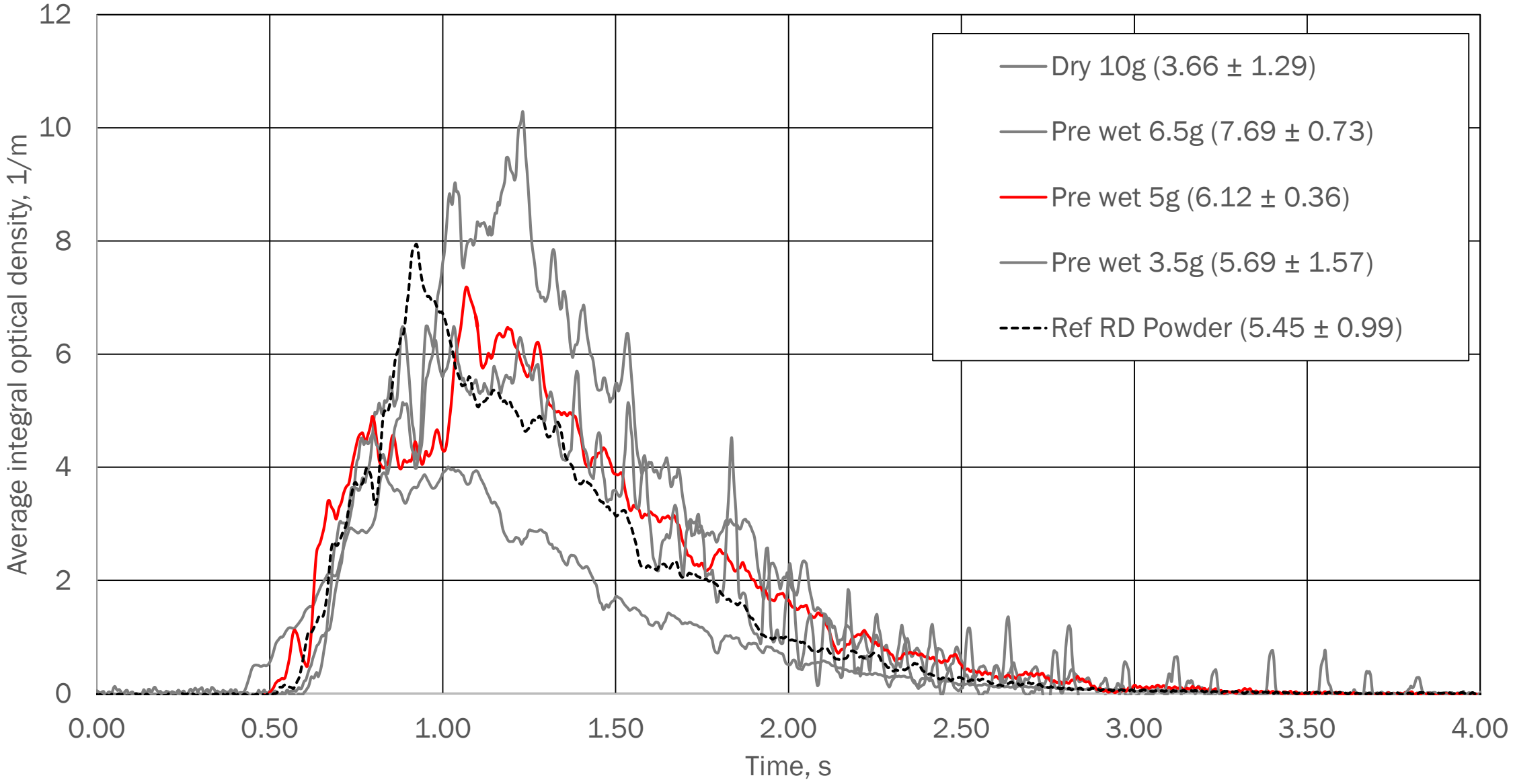
- Most promising foam product
- 2-part foam
- Alterations were made to the original formula in the effort to increase the dispersibility.



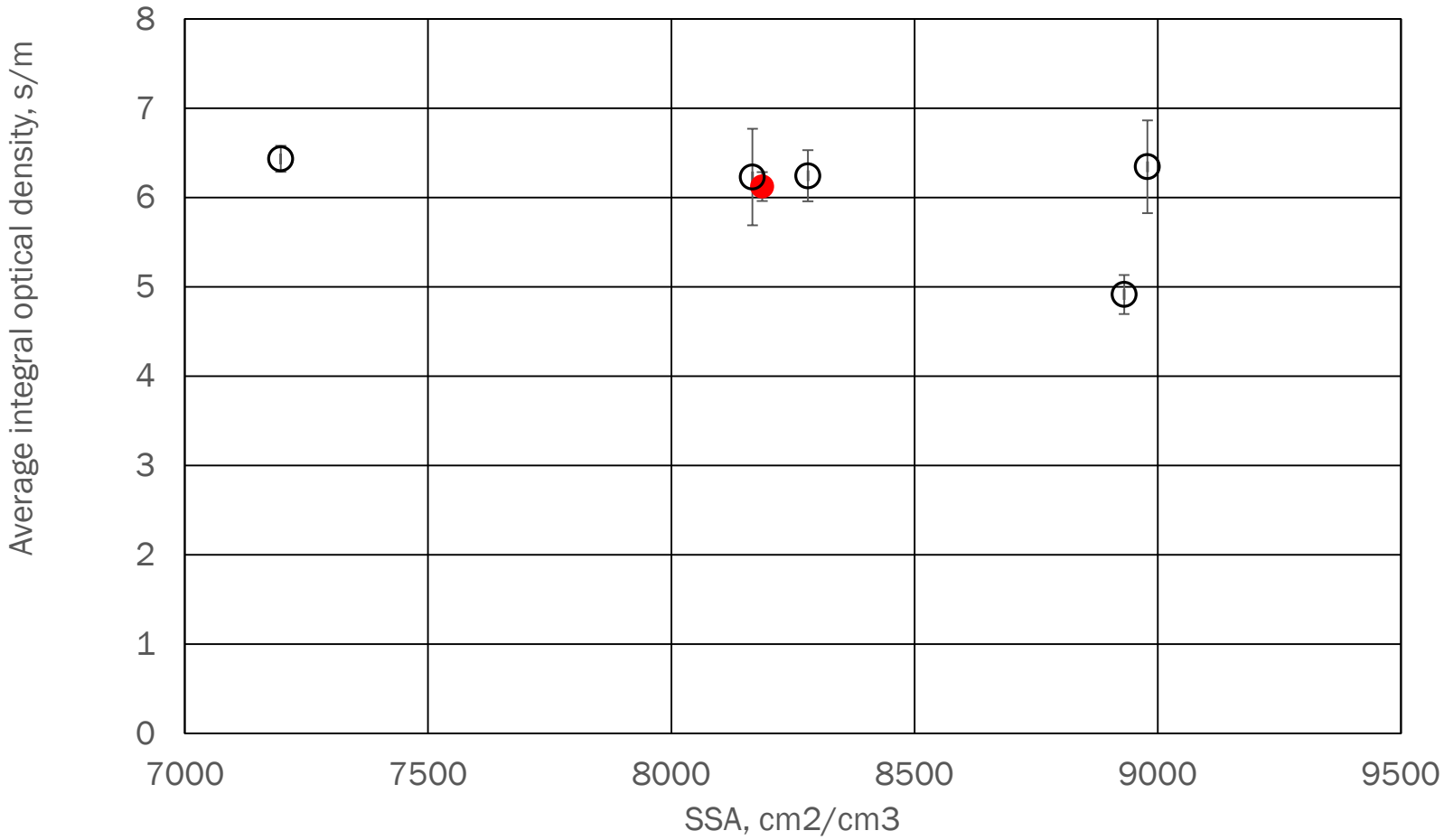
What makes this formulation work?



Can it be improved upon?

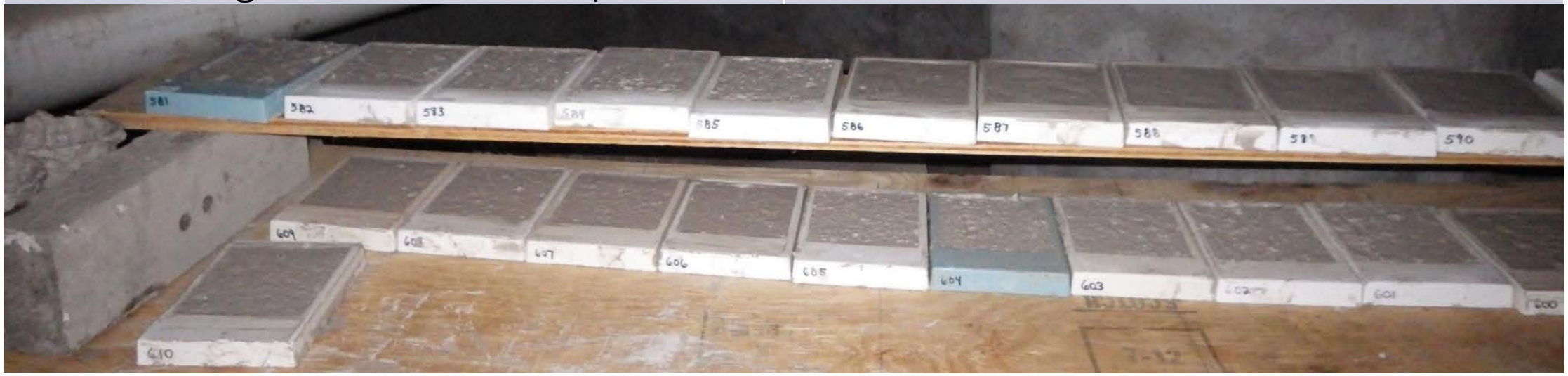


Is the formulation applicable to other rock dusts?

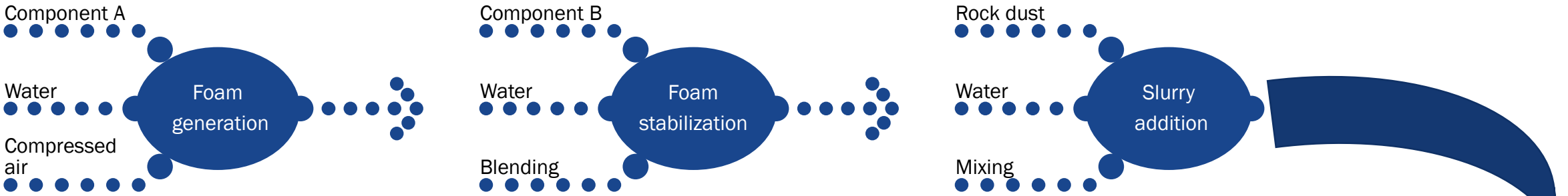


Pilot scale application testing

BEM Testing	SRCM Testing
Test conditions: • 100 lb batches • Auger feed • 15 ft hose Measurements made: • Airborne dust concentration • Triplicate OD for both hopper and nozzle • OD resulting from alterations to inputs	Test conditions • 250 lb batches • Progressive cavity pump “squeeze pump” • 50 ft hose Measurements made: • Triplicate OD for both hopper and nozzle



Two Part Foamed rock dust production



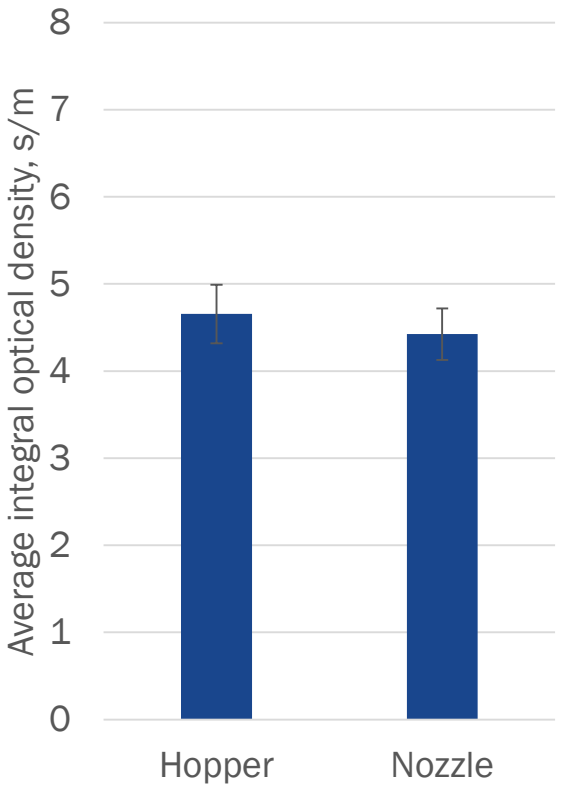
What are the airborne rock dust concentrations during the application?

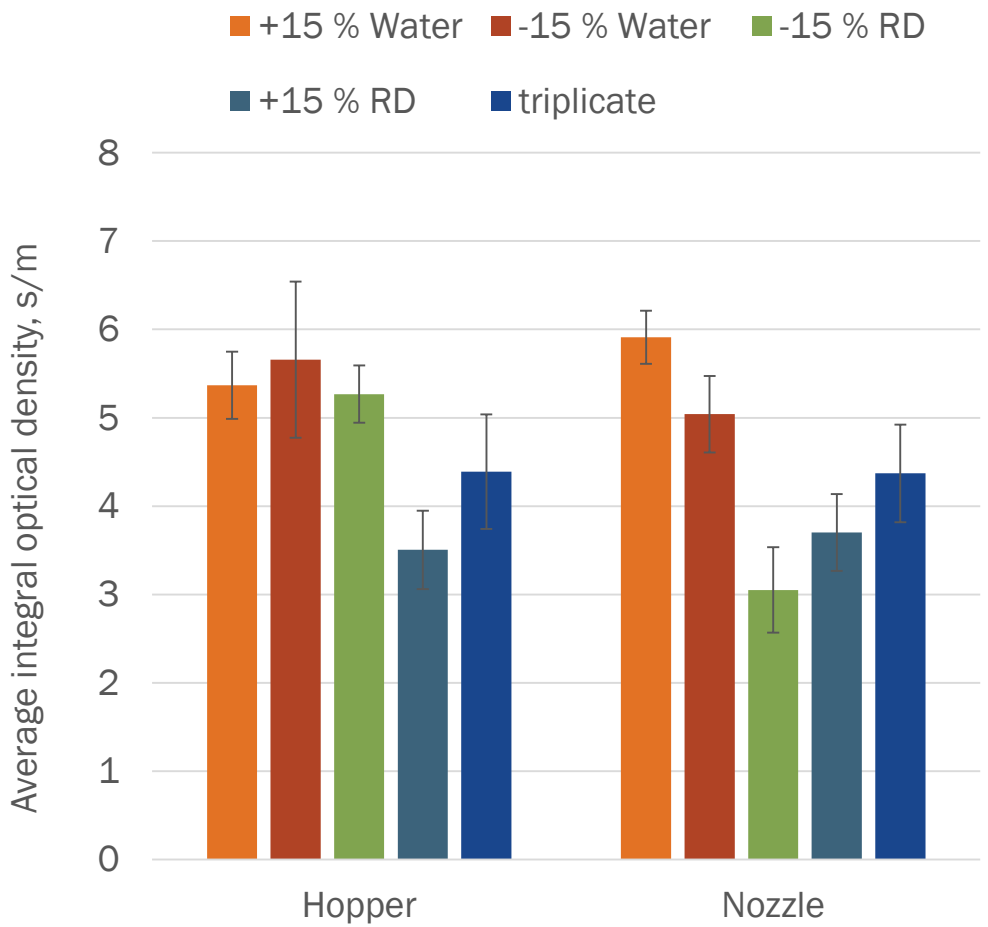
- Samples taken 100 ft from application location using PDMs
- These levels include DPM
- Negligible respirable dust totals for each condition

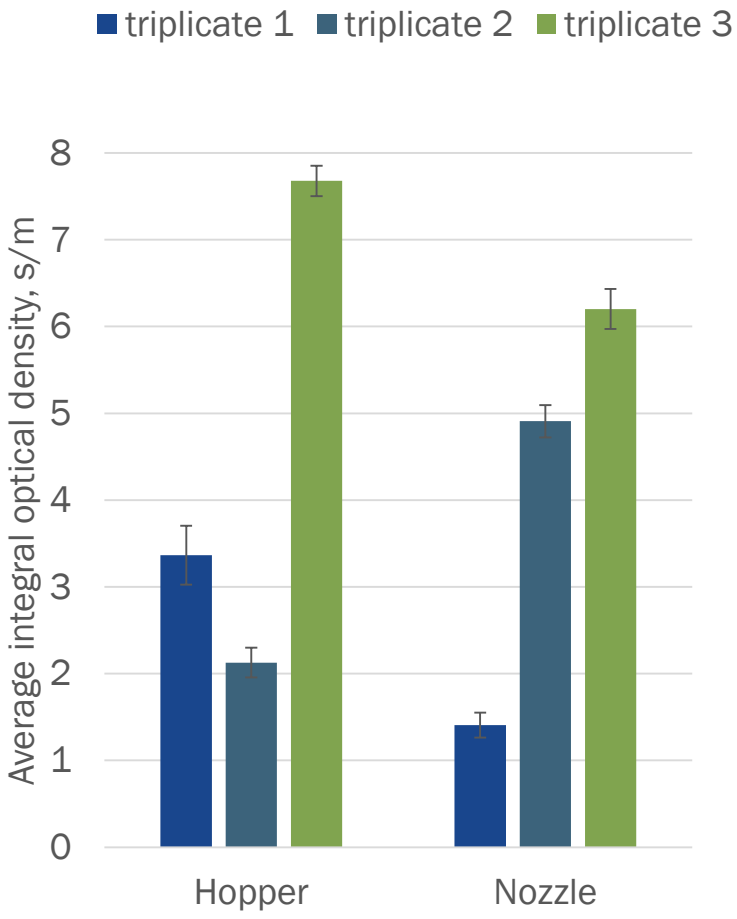
	Dust Conc. Start, mg/m^3	Dust Conc. Stop, mg/m^3	Dust Conc. Total, mg/m^3
triplicate 1	0.167	0.171	0.004
triplicate 2	0.062	0.062	0.001
triplicate 3	0.072	0.075	0.003
+15 % RD	0.079	0.082	0.004
-15 % RD	0.088	0.091	0.003
-15 % Water	0.097	0.100	0.003
+15 % Water	0.109	0.111	0.002

Preliminary Data

BEM dispersion results



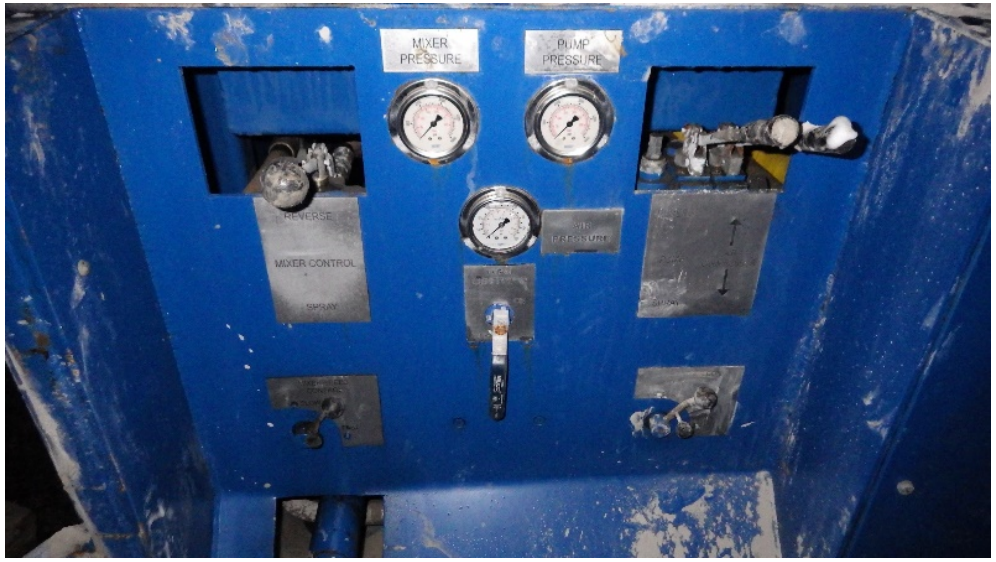




Preliminary Data

SRCM pilot testing

- Three experimental replicates with five technical replicates
- Samples taken from hopper and nozzle
- Looking for reproducibility



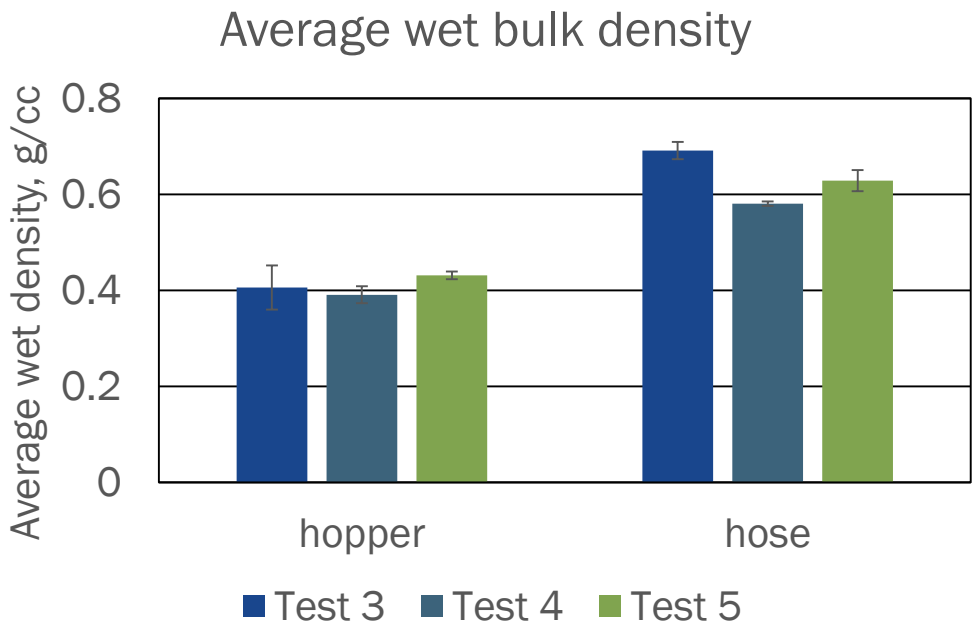
Preliminary Data

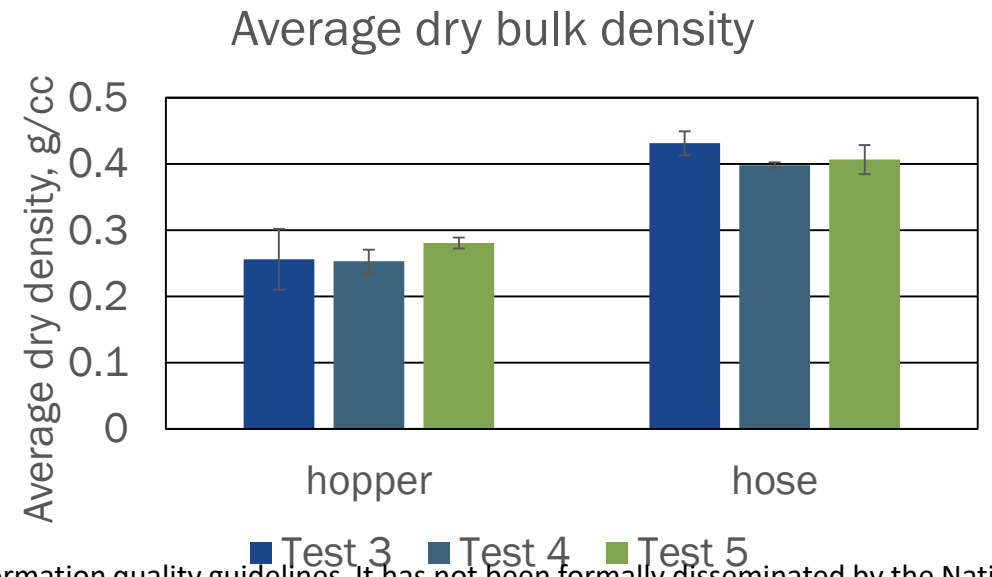
SRCM density results

- Density increases indicate nominal breakdown of the foam at the pump
- Overall product is very reproducible

Test #	Hopper Wet Density, g/cc	Outlet Wet Density, g/cc	Nozzle Wet Density, g/cc
3	0.36	--	0.57
4	0.37	0.52	0.59
5	0.38	0.51	0.57

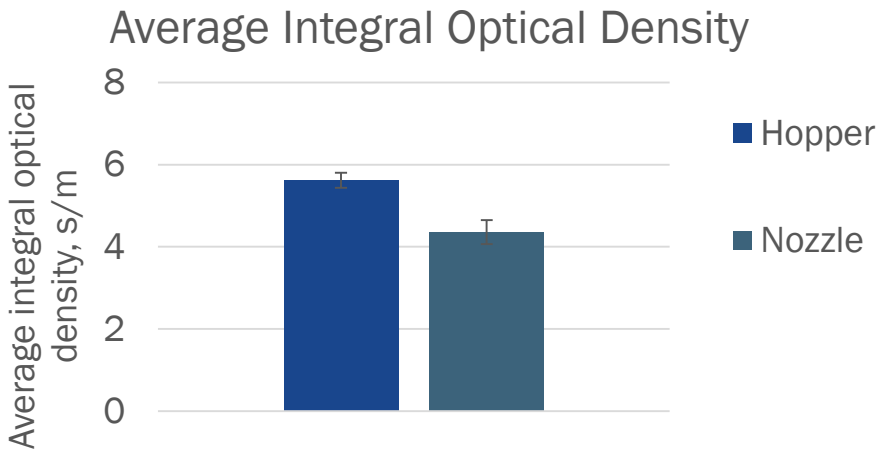
Preliminary Data

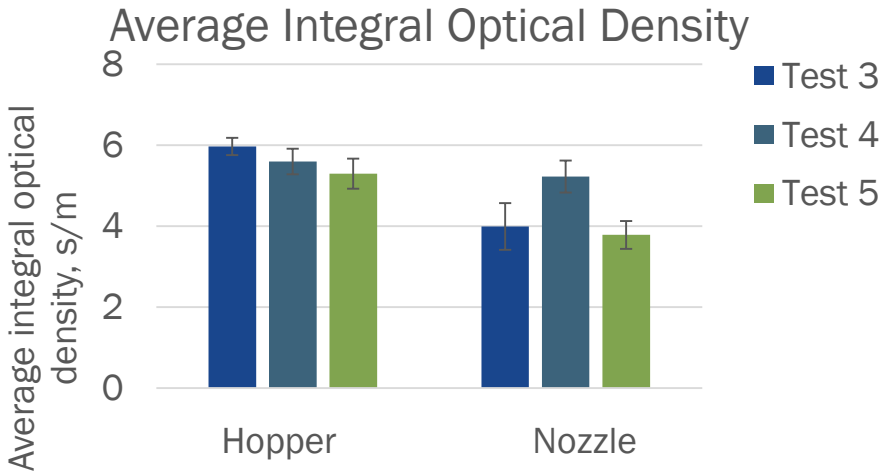




SRCM dispersion results

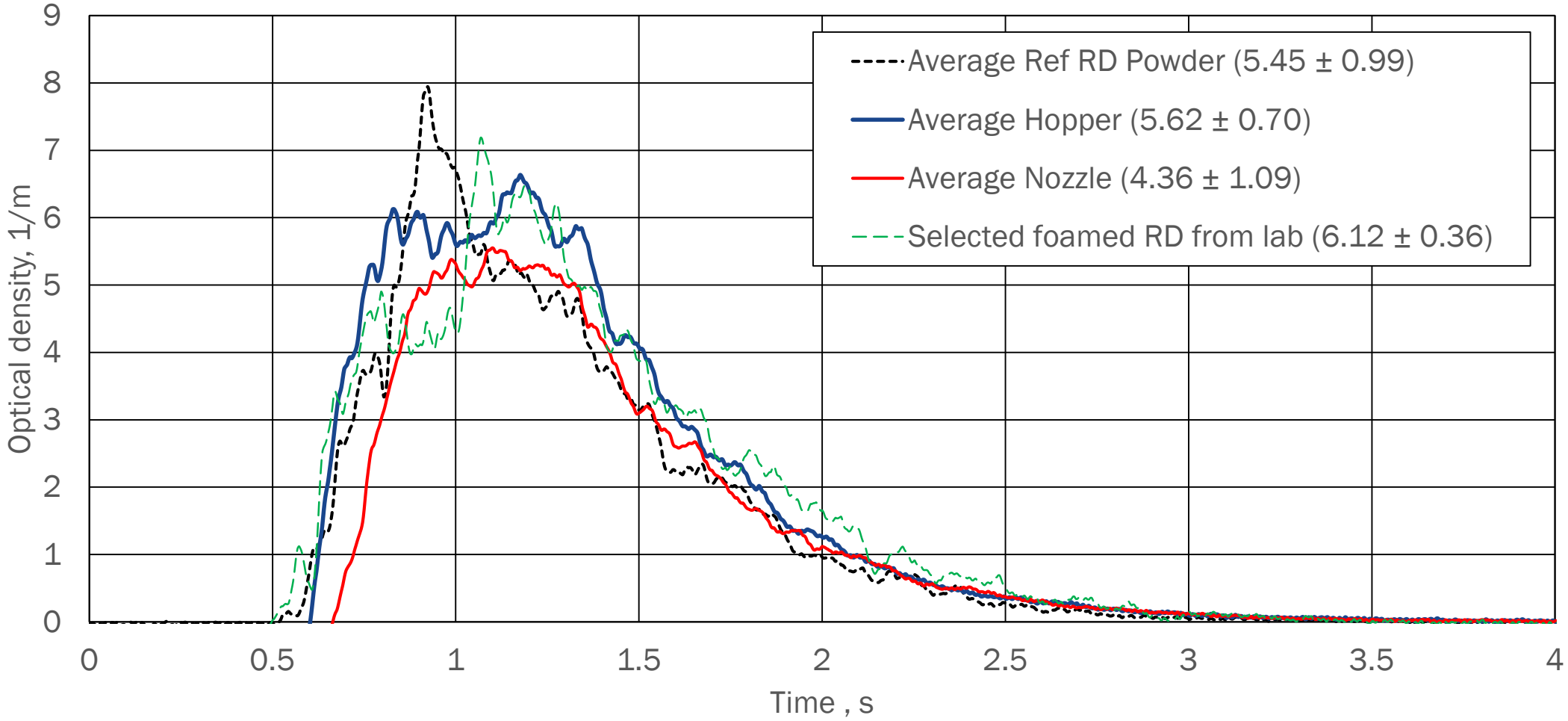
- On average there was a drop in performance after passing though the pump and nozzle
- Significantly decreased the variation between experiments
- Alterations to inputs will be more meaningful in the future





Preliminary Data

Final comparison between dry reference rock dust and two-part foam



Preliminary Data

Large-scale Testing

Central Mining Institute Located in Mikołów, Poland

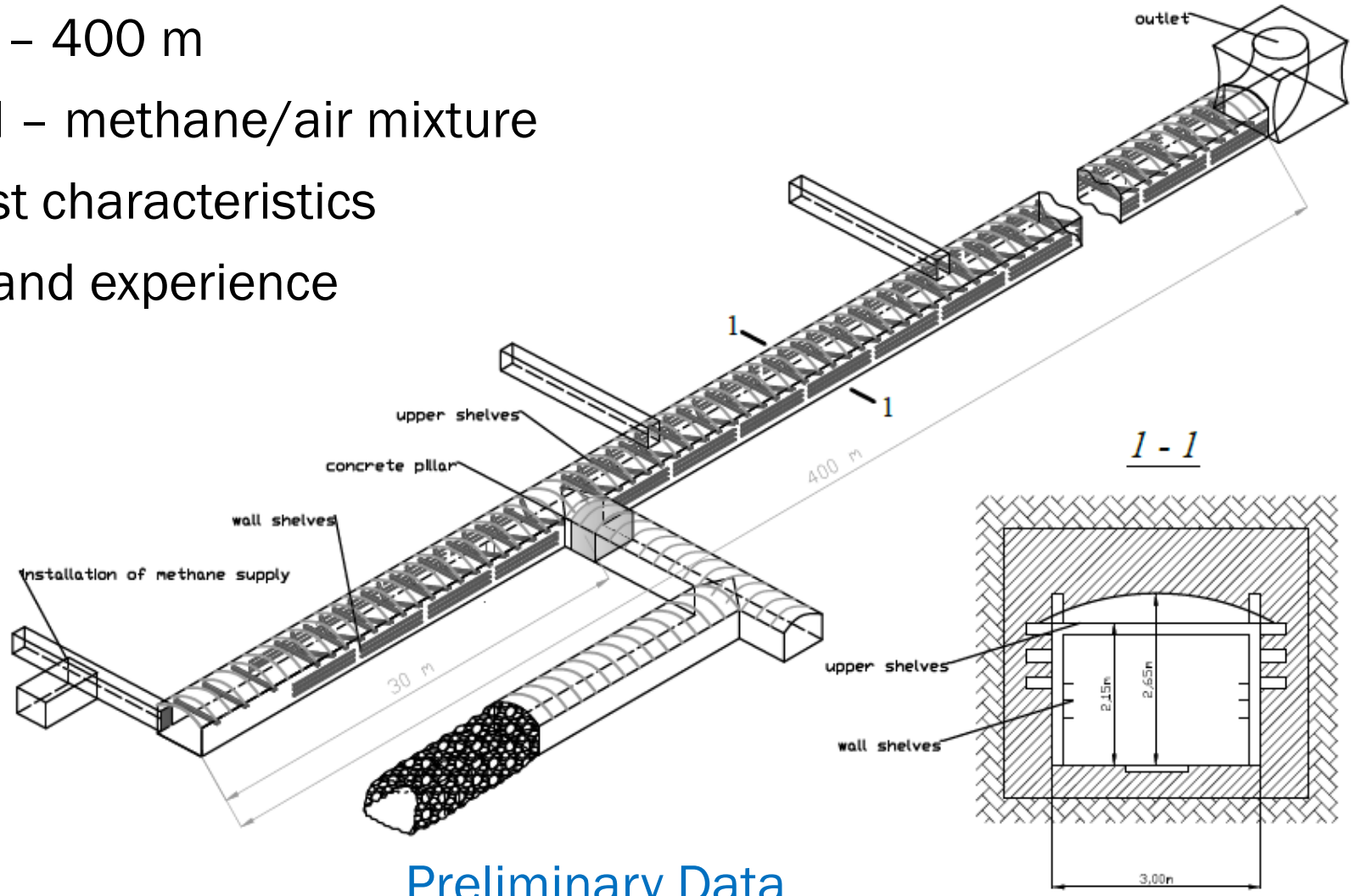
Objective:

- Determine the explosion parameters of methane mixture using two-part foamed rock dust (TPF-RD) placed on the floor as an attenuating medium for coal dust explosions initiated by a weak methane ignition.

Preliminary Data

Large Scale Test Facility

- Length of entry – 400 m
- Ignition method – methane/air mixture
- Similar coal dust characteristics
- Testing history and experience



Preliminary Data

Sample Preparation

- Non-treated rock dust (NTRD) slurry was prepared in a cement mixer
- TPF production was made by the foam generator
- The foam was mixed into the cement mixer with rock dust slurry to obtain a wet density of 0.5-0.55 g/cm^3.
- Samples were carried into the mine and spread in two uniform rows

Preliminary Data

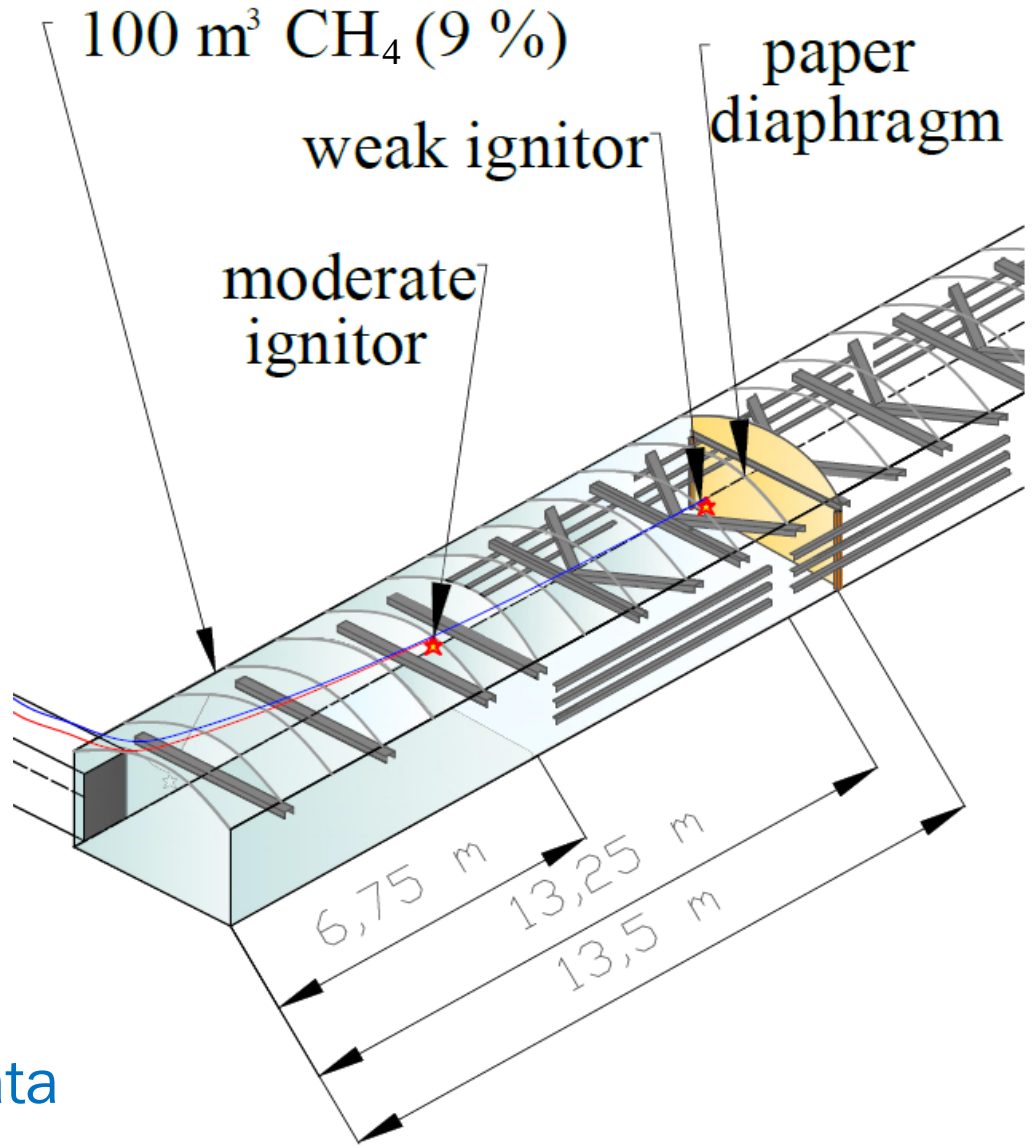
Discussion of experimental setup

- Minimum ignition concentration of 100g/m^3→75 kg of float coal dust
- 80% Total Incombustible Content → 300kg inert material
- All materials were placed on the floor
- A path down the middle was kept clear to place coal dust without breaking the foam matrix

Preliminary Data

Discussion of experimental setup

- Focus on weak ignitions before proceeding to moderate ignitions



Preliminary Data

Tests conducted at EM Barbara

- **TPF-RD** → Two Part Foam – Rock Dust
- **NTRD** → Non-Treated Rock Dust
- **TRD** → Treated Rock Dust
- **CD** → Coal Dust

Type of test	Description	Initiation
Preliminary	Methane / TPF-RD	Weak
	Methane / NTRD	Weak
	Methane / TRD	Weak
	Methane / CD	Weak
	Methane / CD	Moderate
Main group 1	Methane / TPF-RD + CD	Weak
	Methane / TPF-RD + CD	Weak
	Methane / NTRD +CD	Weak
	Methane / NTRD + CD	Weak
	Methane / TPF-RD + CD	Weak
	Methane / NTRD + CD	Weak
	Methane / NTRD slurry +CD	Weak
	Methane / NTRD slurry +CD	Weak
Main group 2	Methane / NTRD + CD	Moderate
	Methane / TPF-RD + CD	Moderate
	Methane / NTRD slurry + CD	Moderate

Preliminary Data

Tests conducted at EM Barbara

- 300 kg of solid inert material was used.
- Inert material was spread over two 1 m wide by 100 m long tracks.

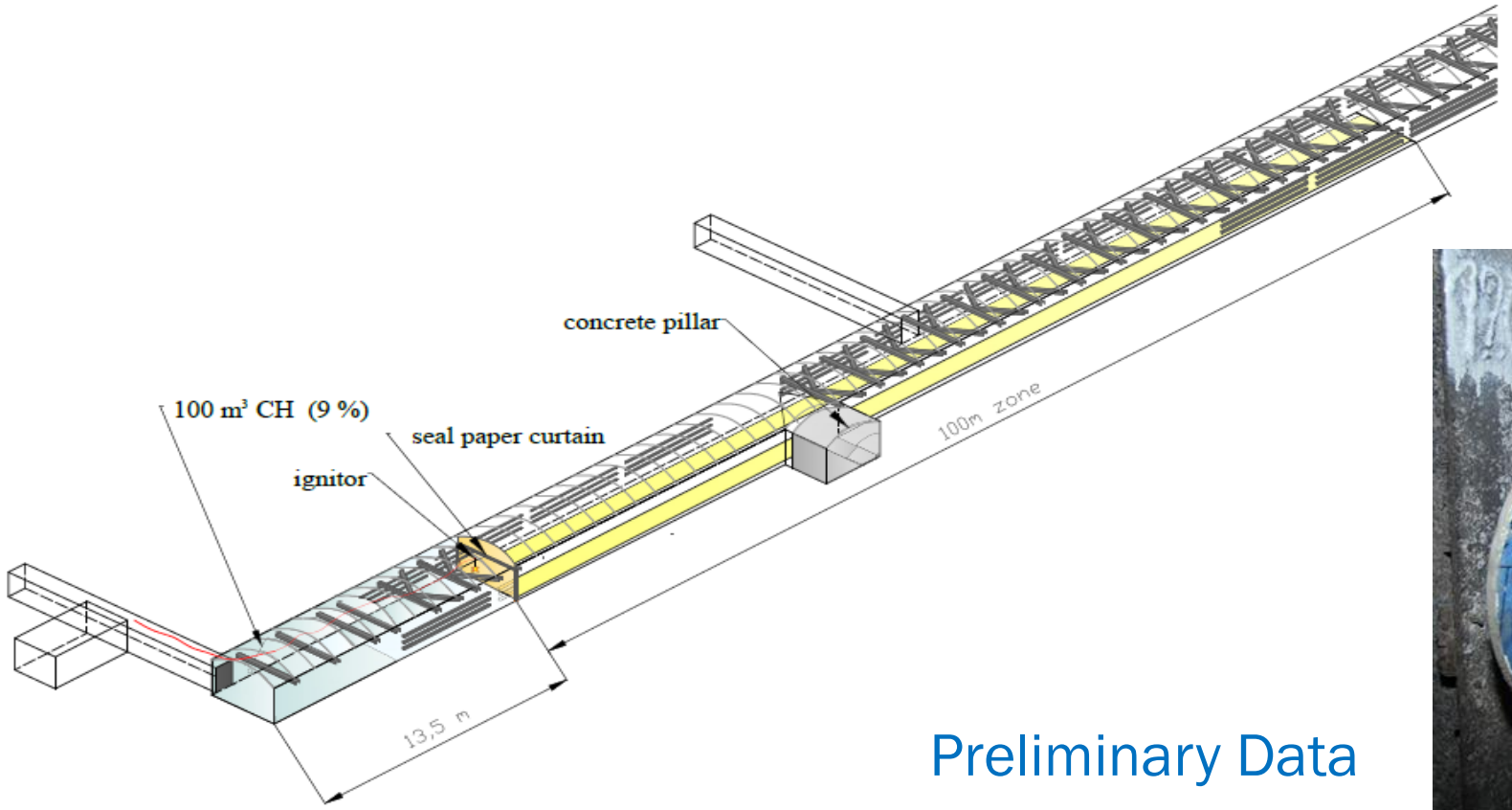
Group	Initiation	Number of Tests	Description
I	weak	3	Methane/TPF-RD/CD
		3	Methane/NTRD/CD
		2	Methane/Slurry/CD
II	moderate	1	Methane/TPF-RD/CD
		1	Methane/NTRD/CD
		1	Methane/Slurry/CD

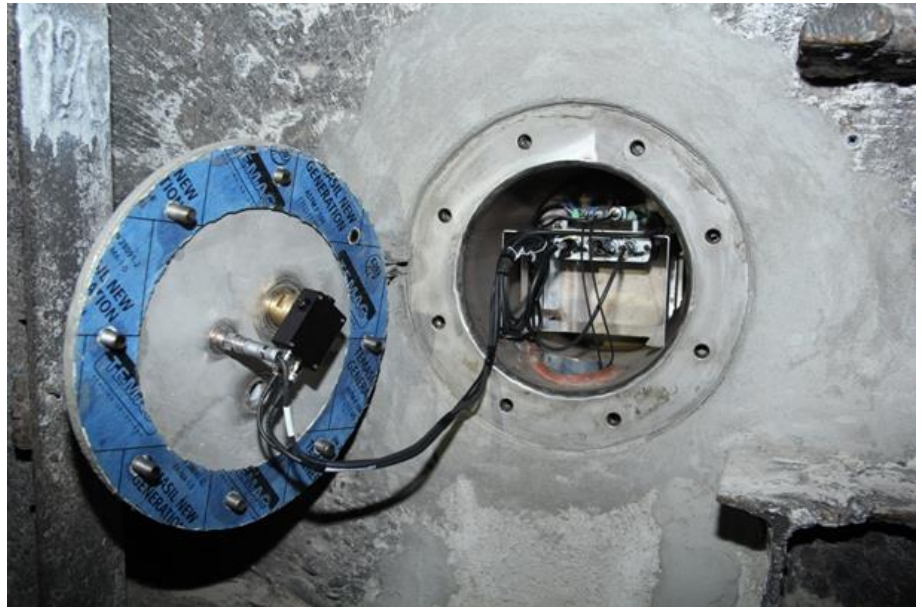
- 75 kg of -200-mesh float coal dust was placed on top.
  - Nominal dispersed incombustible content of approximately 80%
- 100 m^3 of 9% methane/air mixture was set off with a 10 KJ igniter
- Initial explosion strength varied with the position of the ignitor within the methane/air zone.

Preliminary Data

Test Setup

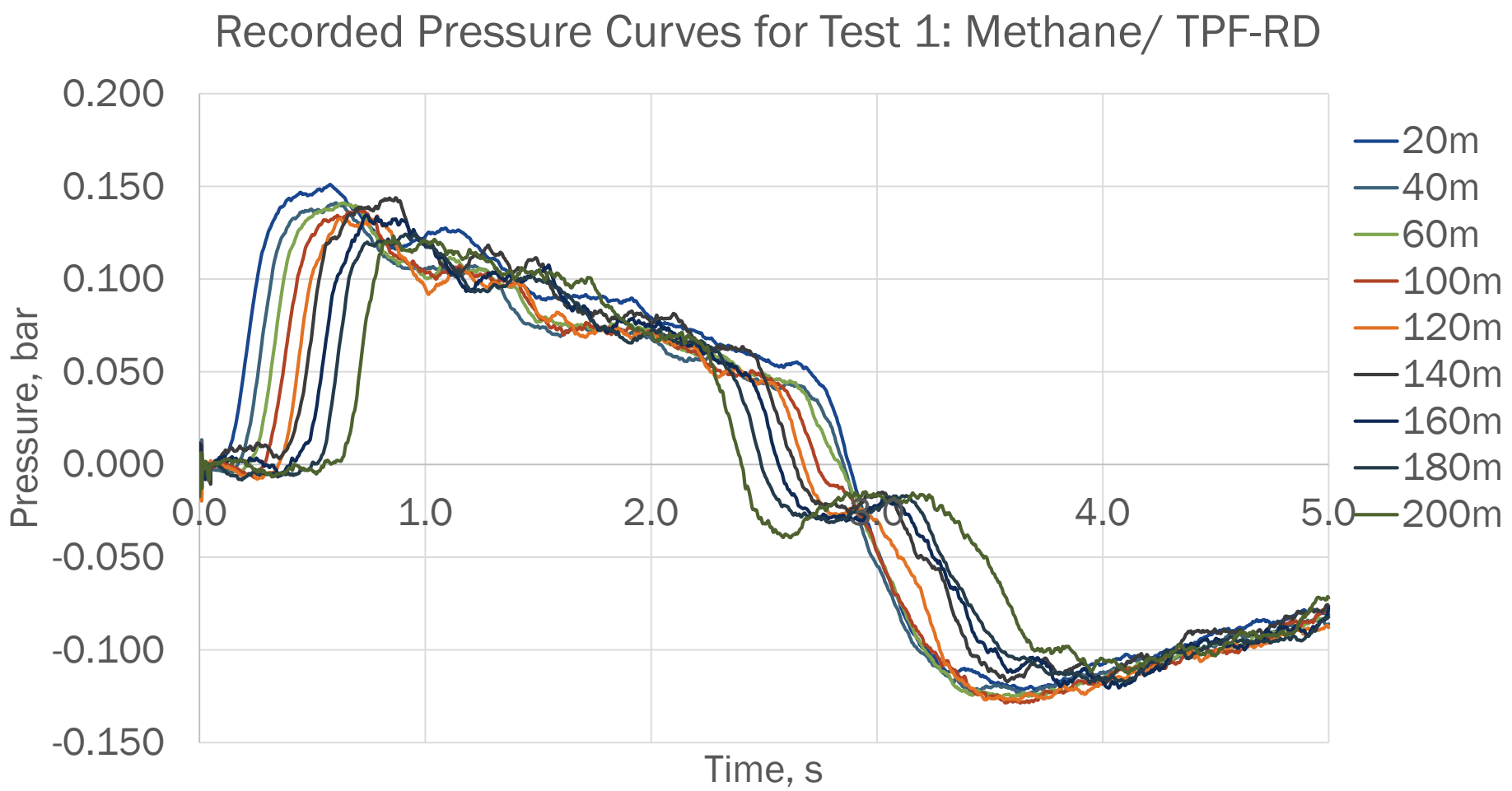
- Pressure sensors and flame sensors are placed along 200m of the gallery
- The initial explosion is initiated at the blind end of the 400m gallery





Preliminary Data

Impulse explanation



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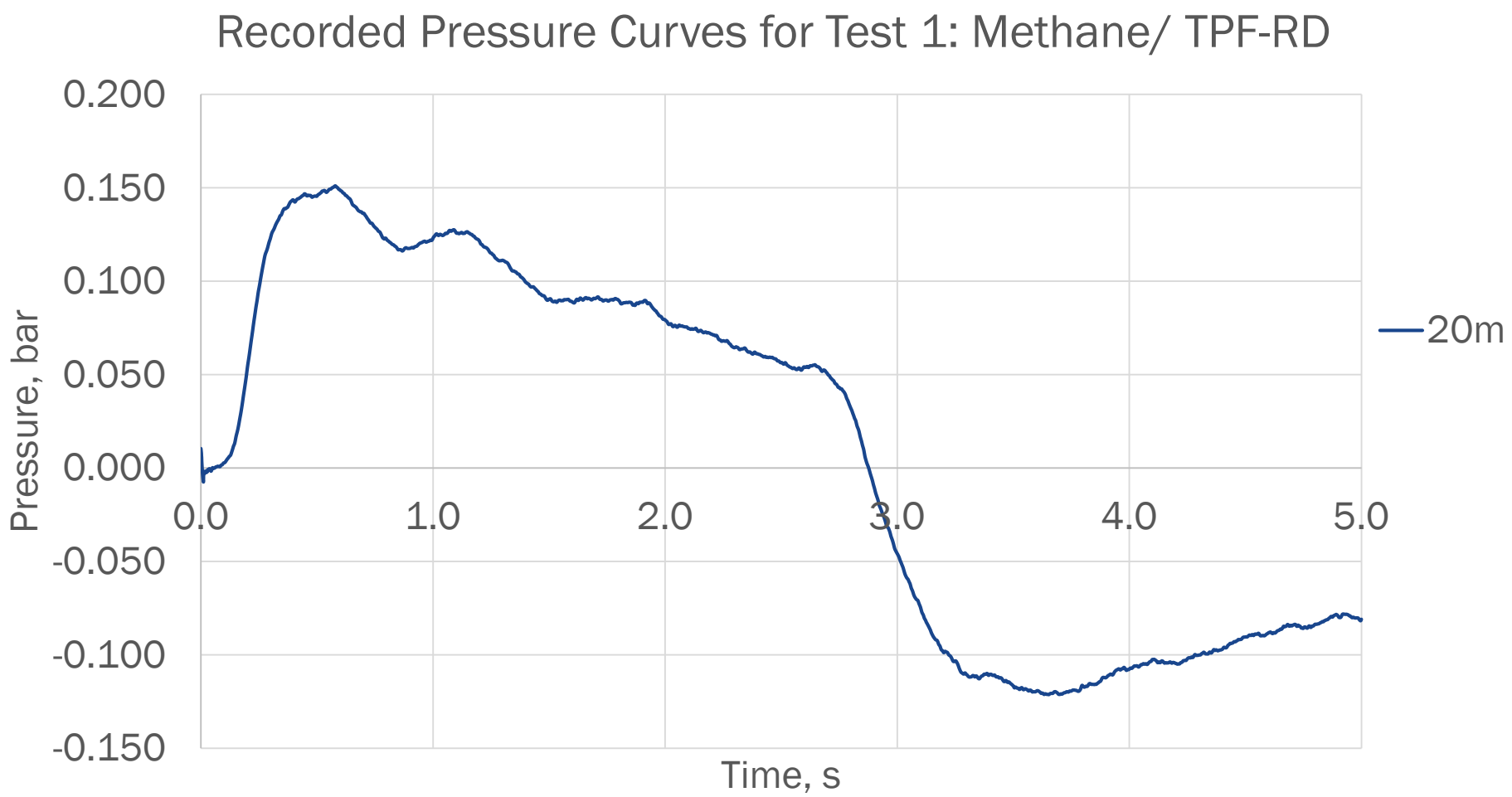

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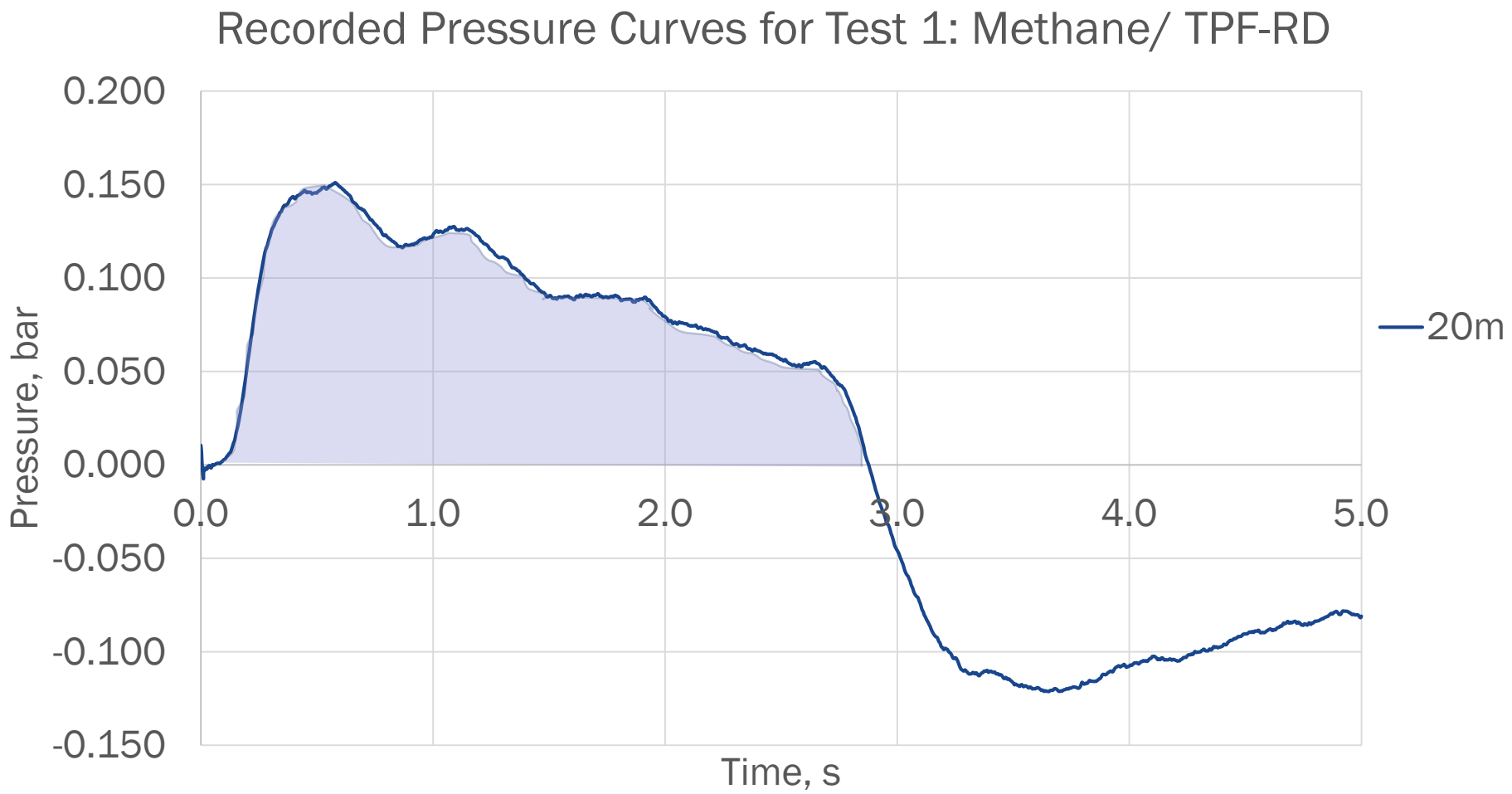
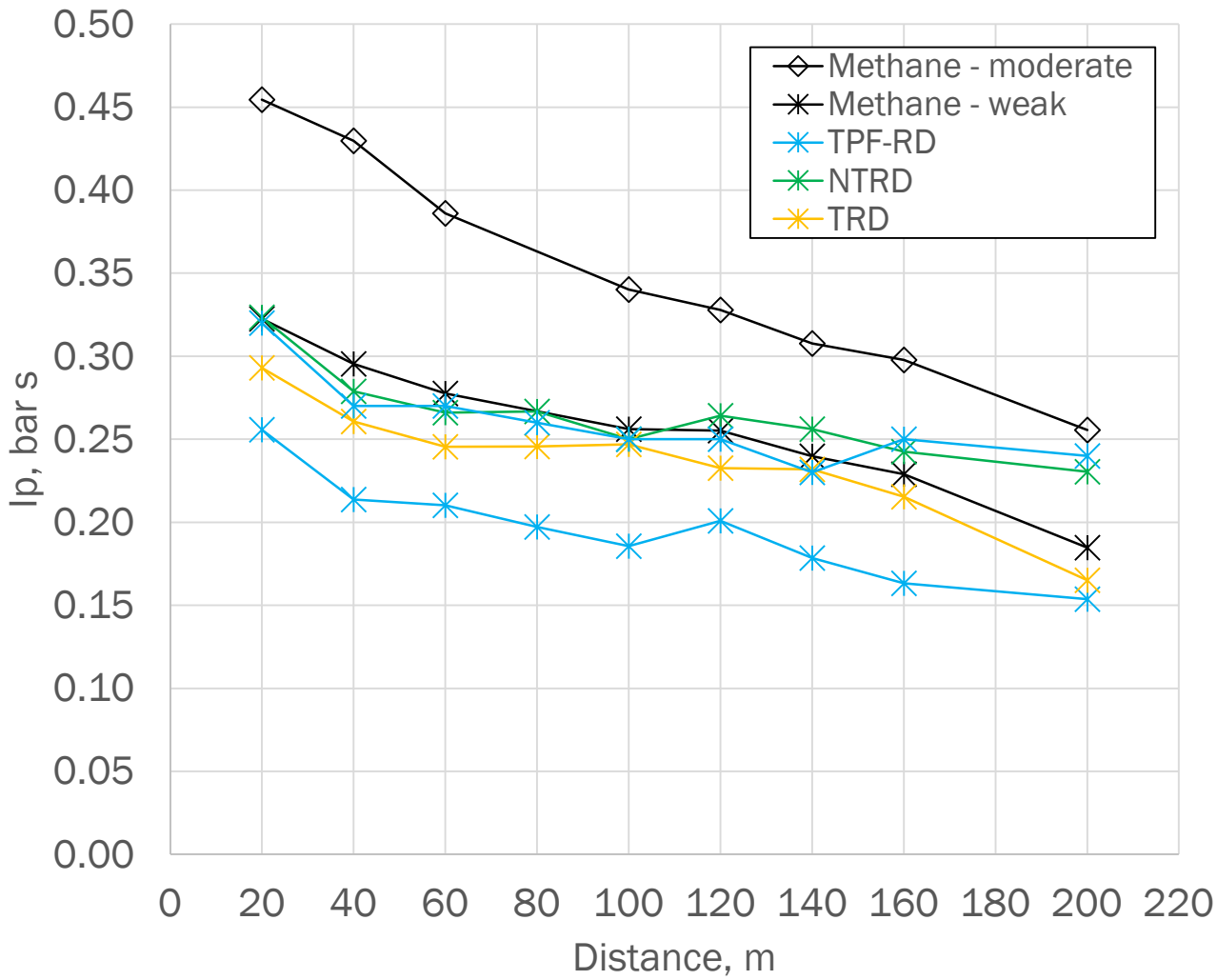


Preliminary Data

Preliminary tests – Methane only

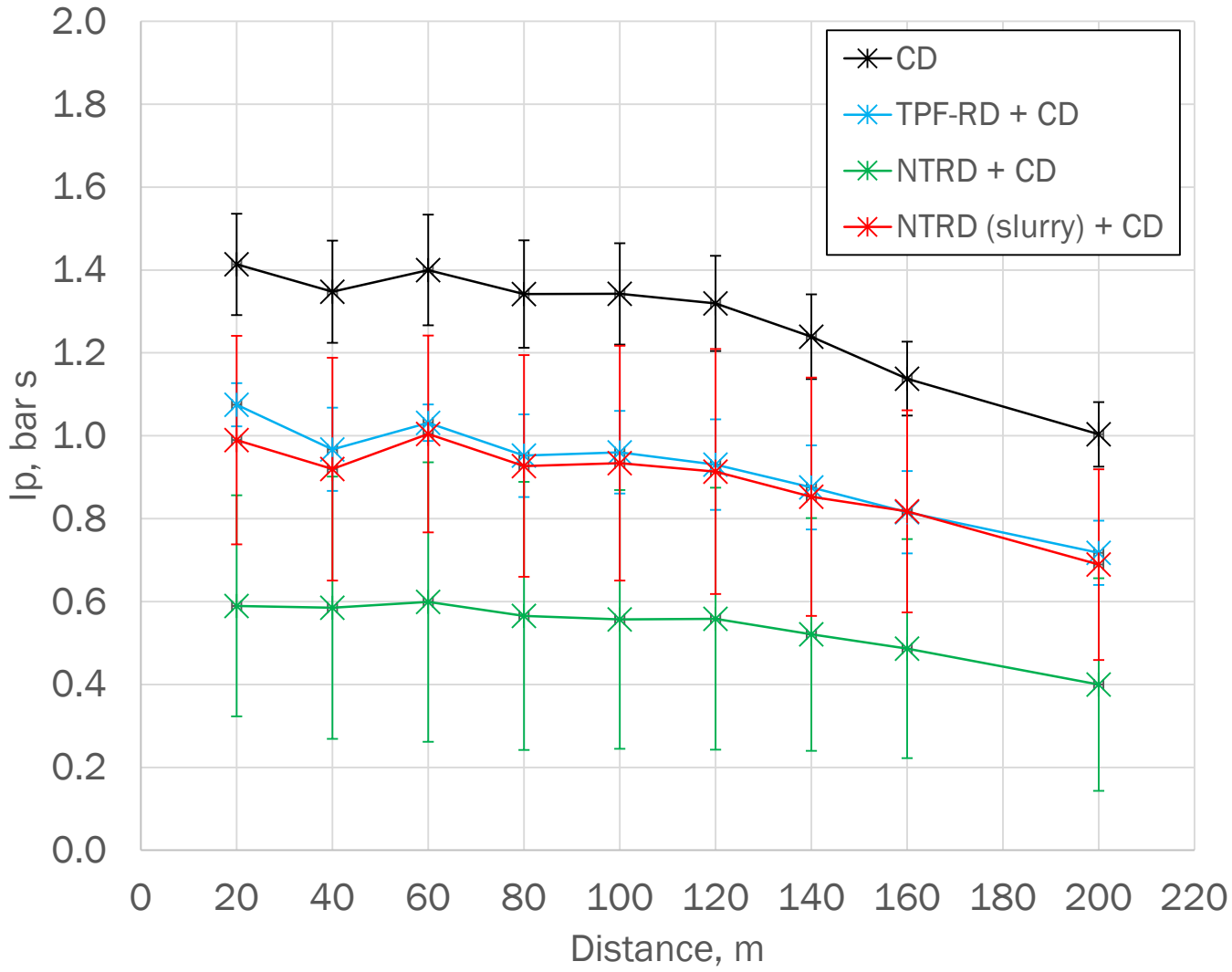
- Pressure impulses for TPF-RD, NTRD and TRD – weak methane ignition
- No substantial impact of the inerting medium on the methane explosion with weak ignition
- A slight drop in the impulse for one of the TPF may be due to residual moisture in the media



Preliminary Data

Main test results with weak ignition and coal dust

- Pressure impulses of explosion tests using float coal dust with TPF-RD, NTRD and slurry
- All pressure impulses are smaller than for the pure float coal dust
- Impulses in TPF-RD tests and NTRD slurry are nearly the same
- Dry NTRD are significantly lower though uncertainties are large.

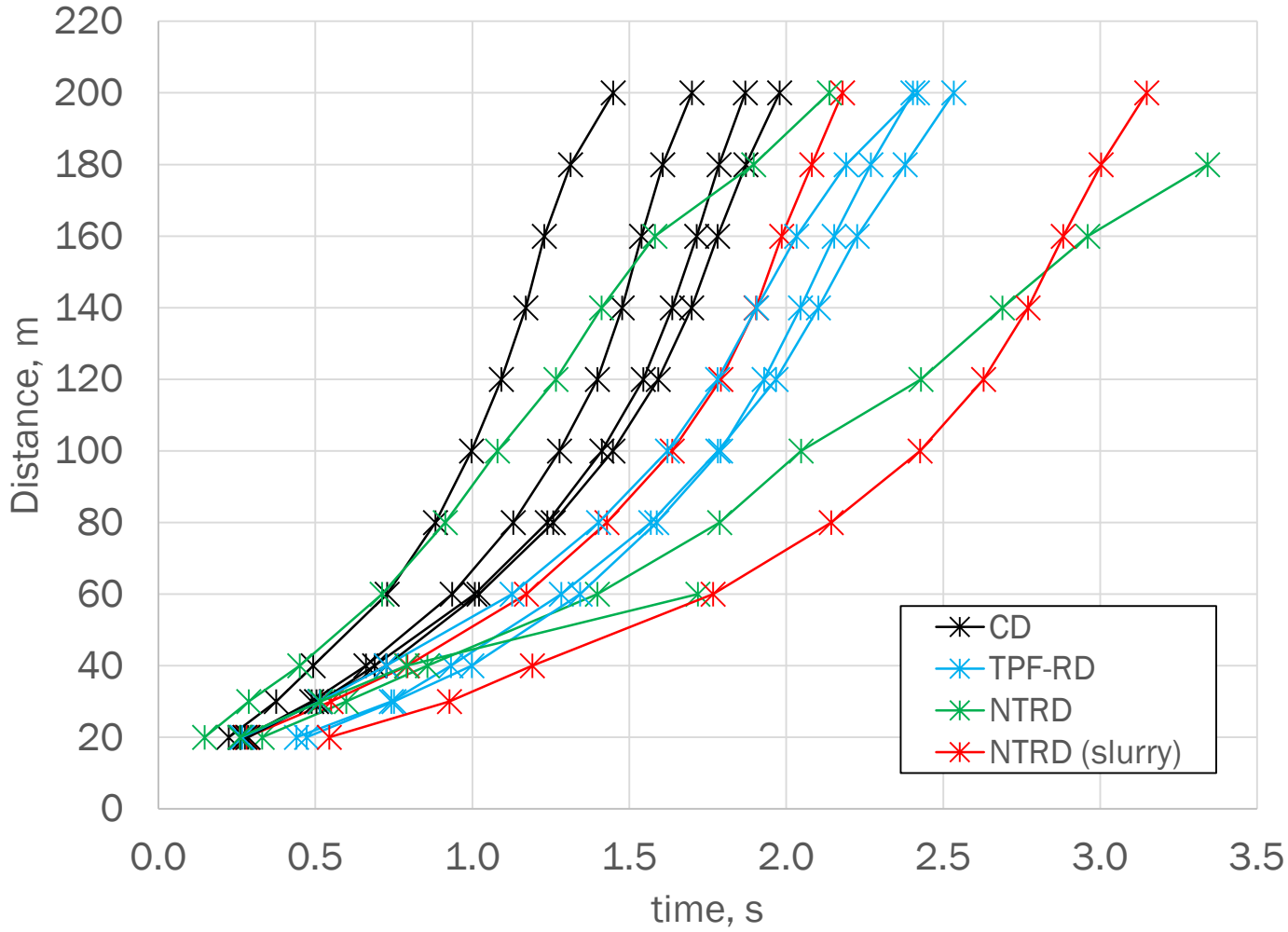


Preliminary Data

Main test results with weak ignition and coal dust

- Flame movement in tests with TPF-RD, NTRD and NTRD (slurry) and a layer of float coal dust on top– weak methane ignition

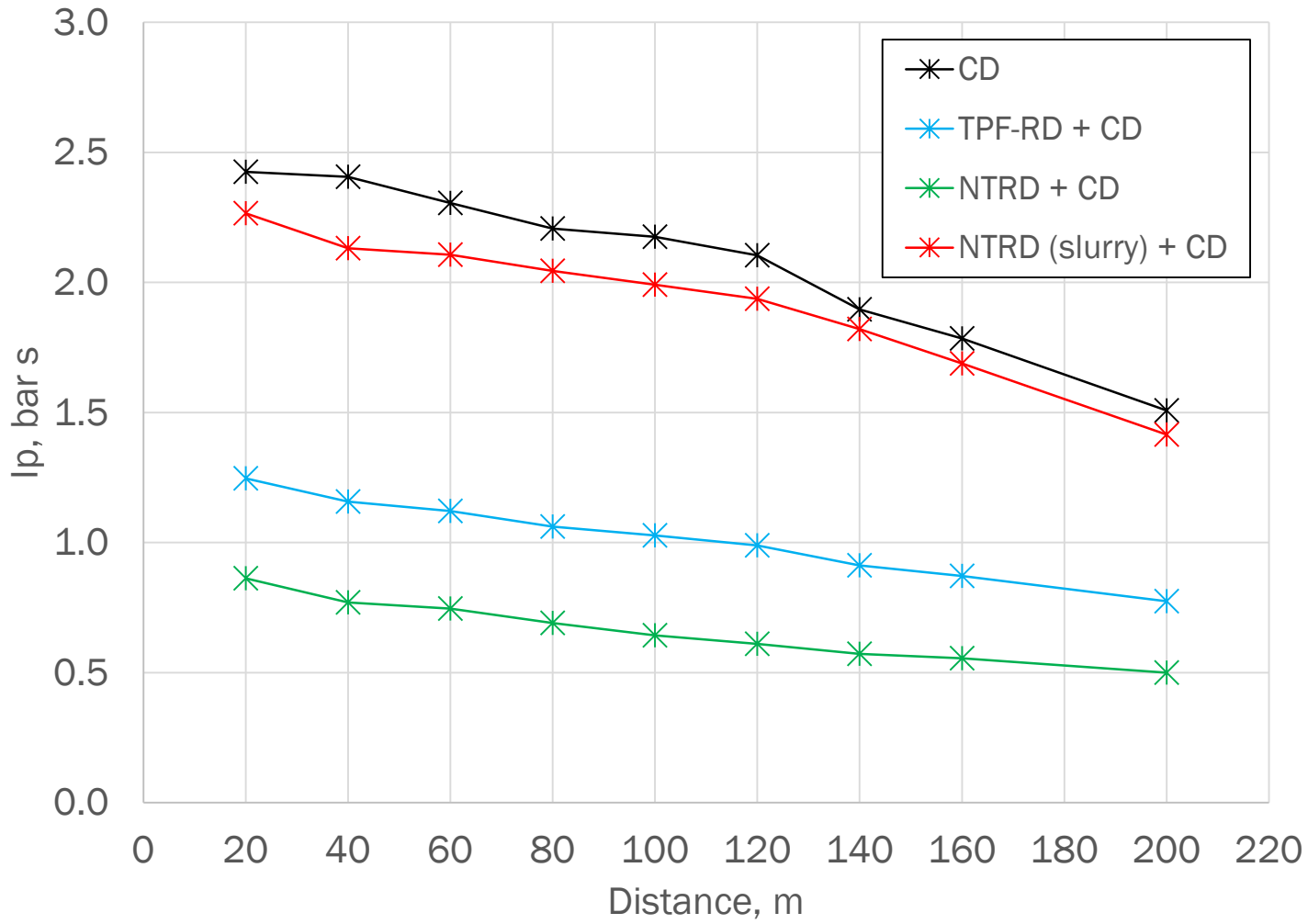
- Dry NTRD outperformed both the TPF and the NTRD slurry in reducing the flames speed



Preliminary Data

Main test results with moderate ignition and coal dust

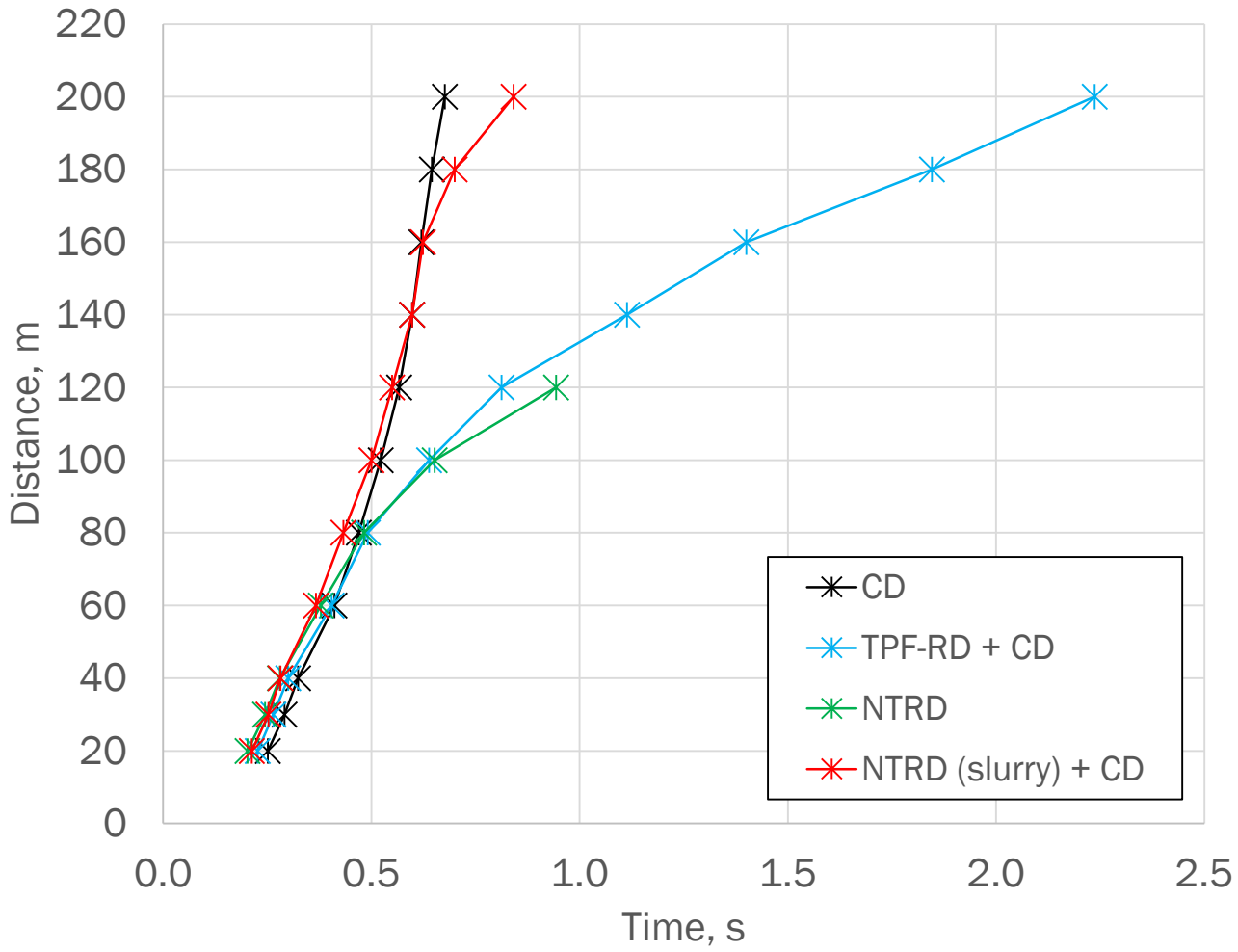
- NTRD slurry shows practically no suppression properties.
- The impulses are almost as large as the impulses obtained from a float coal dust only explosion
- The impulses in the TPF-RD test are about half of those for Barbara coal dust



Preliminary Data

Main test results with moderate ignition and coal dust

- Only in the test with NTRD, the flame range was 120 m
- The flame velocity in the test with slurry was only a little smaller than in the coal dust explosion
- The flame velocities in the tests with TPF-RD and NTRD were very similar, however the flame range in the former was significantly longer



Preliminary Data

Two-part foam summary

- Foam formulations dispersed under lab conditions performed as well as the dry reference rock dust
- The foam formulation was widely applicable to other available rock dusts

- Pilot scale application testing showed repeatable results
- Samples between the pilot application and lab remained consistent

- Under the weak ignition conditions the TPF-RD performed similar to the NTRD-slurry and did not perform as well as the traditional NTRD.
- Under the moderate ignition conditions the TPF-RD appears to significantly outperform the NTRD-slurry, but not to the same extent as the traditional NTRD.

Preliminary Data

Limitations

- Tests conducted using ignition characteristics at the threshold of a possible explosion and increases the variability.

- Testing of the practical application of the foam on the roof and ribs can be challenging to compare directly with traditional dry rock dusting.
    - Adding three more surfaces which can hold and disperse large amounts of dust is one of the largest advantages that foam rock dust has over traditional rock dusting and this was not tested.

Preliminary Data

Thank You

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NIOSH Mining Program
www.cdc.gov/niosh/mining