

Rock Dust and Coal Dust

Metallurgical Coal Producers Association

PE Seminar

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What is Rock Dust

Float Coal Dust Characteristics that affect explosibility

How rock dust stops a propagating coal dust explosion

Rock Dust changes and research over last 10 Years

What is Rock Dust?

Definition of Rock Dust – 30CFR 75.2 (definitions)

- *Rock dust.* Pulverized limestone, dolomite, gypsum, anhydrite, shale, adobe, or other inert material, preferably light colored, 100 percent of which will pass through a sieve having 20 meshes per linear inch and **70 percent or more of which will pass through a sieve having 200 meshes** per linear inch; the particles of which 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**; and which does not contain more than 5 percent combustible matter or more than a total of 4 percent free and combined silica (SiO_2), or, where the Secretary finds that such silica concentrations are not available, which does not contain more than 5 percent of free and combined silica.

What is the Purpose of Rock Dust

Stops the propagation of a coal dust explosion

Does nothing to stop a gas explosion!

Coal Dust Explosion

- Normally starts from a gas ignition
 - Puts coal dust into suspension and is also the ignition source for the coal dust explosion
- Air expansion from the gas ignition creates a pressure wave
- Pressure wave travels in front of the flame front and causes dusts on floor, ribs and roof to go into suspension
 - Typically top 1/8 inch of dust
- Heat from flame front causes volatile matter in the coal to escape from the coal float dust
 - Volatile matter is explosive gases in the coal
- Volatile matter gases ignite and create more heat causing additional expansion of air repeating the process
- Coals with less than 12% volatile matter are considered non-explosive and rock dust is not required. (Anthracite coal)

Factors affecting Explosibility of Coal Dust

- Volatile Ratio of the coal (above 0.12)
 - Volatile Ratio is Volatile Matter/ (Volatile Matter + Fixed Carbon)
- Particle size
 - Below 200 mesh is considered explosive (74 microns or 0.003 inches) (float coal dust)
 - NIOSH considers below 50 microns generally involved in explosion
- Moisture Content
 - Inherent moisture and humidity
 - Inherent moisture above 8% moisture drastically increases the minimum energy required and at 15% moisture it is 15 times more than at 5% moisture content
- Minimum Explosive concentration (MEC)
 - 0.1 ounce per cubic foot or 100 grams per cubic meter for bituminous coal
 - Cannot see a cap lamp at 10 feet distance
- Energy or Heat to ignite dust cloud
 - Minimum of 30 millijoules of energy or temperature of 440°C (dry lignites) 525°C dry Bituminous Coals
 - Increases with particle size and moisture content
 - Decreases with increase in volatile ratio



What is the Purpose of Rock Dust (Stops the propagation of a coal dust explosion)

- Stops a propagating coal dust explosion by acting as a heat sink
 - removes the heat needed to volatilize the coal dust particles (approximately 530° C for Bituminous Coals) and then ignite this volatile matter.
 - Need 80% TIC (Total Incombustible Content) to stop explosion using current float coal dust composition
 - Rock dust is your TIC
- CO₂ production in decomposition of rock dust may also play an important role in suppressing a coal dust explosion (450° C)
 - CO₂ displaces Oxygen and acts as an inerting agent
- Does not stop a gas explosion
 - Only stops propagation of a float dust ignition!
 - If we didn't have float coal dust rock dust would not be needed!!!

Main Characteristics needed in Rock Dust to be effective in stopping an explosion

- Size – sub 50 microns needed to suppress explosion
 - 200 mesh is 74 microns - 70% of rock dust must pass 200 mesh screen, larger sizes have less surface area per weight to act as the heat sink, (also more CO₂ production)
 - The smaller the coal dust particles the smaller the rock dust particles need to be.
- Must be dispersible - by a light blast of air.
 - Explosion pressure wave must lift and distribute rock dust into the air
- To be dispersible, Must not cake when wetted and dried
 - Rock dust may be dispersible when applied but moisture may cause the rock dust to which makes it useless!

Current Laws Pertaining to Rock Dust

30 CFR 75.402 Rock Dusting

- All underground areas of a coal mine, except those areas in which the dust is too wet or too high in incombustible content to propagate an explosion, shall be rock dusted to within 40 feet of all working faces, unless such areas are inaccessible or unsafe to enter or unless the Secretary or his authorized representative permits an exception upon his finding that such exception will not pose a hazard to the miners. All crosscuts that are less than 40 feet from a working face shall also be rock dusted.

30 CFR 75.403 Maintenance of Incombustible Content of Rock Dust

- Where rock dust is required to be applied, it shall be distributed upon the top, floor, and sides of all underground areas of a coal mine and maintained in such quantities that the incombustible content of the combined coal dust, rock dust, and other dust shall be not less than 80 percent. Where methane is present in any ventilating current, the percent of incombustible content of such combined dust shall be increased 0.4 percent for each 0.1 percent of methane.

Why is there a new emphasis on Rock Dust ?

UBB EXPLOSION (April 5, 2010 - 29 miners Died)

- Gas ignition/explosion turned into a propagating coal dust explosion
 - Investigation claimed inadequate rock dusting caused the coal dust explosion
 - Massey cited for inadequate rock dust
- MSHA internal review of UBB explosion recommended MSHA and NIOSH to re-evaluate rock dust and its usage.
 - Possibility of caked rock dust at UBB

Evidence of non-dispersed rock dust following UBB disaster



**UBB Post-Explosion Photo
Massey Internal Review Report - Figure 31**

NIOSH Investigation Into Rock Dust

- May 2010- Recommended 80% incombustible everywhere in coal mines (NIOSH RI 9679)
 - June 2011 - Adopted by MSHA and changed 30 CFR 75.403
 - Previously, requirement was 65% TIC everywhere with 80% TIC required in returns
 - adjustments +.4% TIC adjustment for every .1% CH₄
 - Justification for 80% everywhere was due to smaller float dust in todays coal mining methods

NIOSH investigation into Rock Dust

- Survey of underground Rock Dust that was being used
 - 393 rock dust samples were collected – Mostly collected by MSHA inspectors and Tech Support
 - Found non-conforming rock dust
 - Size of rock dust too large - randomly collected of 393 rock dust samples from 278 underground coal mines, 47 percent were found to contain less than the minimum specification of 70 percent passing through a 200-mesh (75 μ m) sieve. (Rock Dust particles were too large)
 - Caking of rock dust (All of these rock dusts caked when wetted and dried)
- NIOSH Issued hazard alert (HID 16 October 2011) “Non Conforming Rock Dust”
 - Rock Dust being used is not properly sized
 - Rock Dust cakes!

Non-Conforming Rock Dust

Summary: In September 2011 as part of an ongoing investigation, the National Institute for Occupational Safety and Health (NIOSH) determined that rock dust not conforming to the requirements in 30 CFR § 75.2 for particle size and caking properties is being used in U.S. underground coal mines. The use of non-conforming rock dust reduces the protection from potential dust explosions. Mines should ensure through accepted test methods that rock dust they receive from their suppliers meets the regulatory requirements. Rock dust suppliers should assure their customers that their product meets the regulatory requirements for use in underground coal mines.

DESCRIPTION OF HAZARD

Underground coal mining produces finely divided coal dust which deposits throughout an underground coal mine and creates an explosion hazard. Mines use a suite of control strategies to prevent methane and dust explosions. The primary control strategy for preventing dust explosions is to create an inert mixture of dusts throughout the mine by applying incombustible rock dust to the coal dust.

In 2011, the Mine Safety and Health Administration (MSHA) issued new regulations [76 Fed. Reg. 119 (2011)] requiring the percent incombustible content of dusts in all areas of the underground coal mine to be at least 80% by applying rock dust. This requirement is based on NIOSH full-scale explosion test research [NIOSH 2010]. However, to be effective at the 80% incombustible level, rock dust must conform to the specifications in 30 CFR[†] § 75.2 (emphasis added):

Rock dust: Pulverized limestone, dolomite, gypsum, anhydrite, shale, adobe, or other inert material, preferably light colored, 100 percent of which will pass through a sieve having 20 meshes per linear inch and 70 percent or more of which will pass through a sieve having 200 meshes per linear inch; the particles of which 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; and which does not contain more than 5 percent combustible matter or more than a total of 4 percent free and combined silica (SiO₂), or, where the Secretary finds that such silica concentrations are not available, which does not contain more than 5 percent of free and combined silica.

^{*}Federal Register. See Fed. Reg. in references.

[†]Code of Federal Regulations. See CFR in references.

RESULTS

In September 2011, the NIOSH Office of Mine Safety and Health Research investigation of rock dust revealed two significant concerns with the supply of rock dust to U.S. mines:

1. **Insufficient particles <200 mesh (75 µm):** In a population of 393 rock dust samples, which were collected by MSHA personnel from 278 underground coal mines, 47% were found to contain less than the minimum specification of 70% passing through a 200-mesh (75-µm) sieve. Noncompliant rock dust was found at 51% of the mines sampled.
2. **Tendency to form a cake:** Examinations of the tendency of the rock dust samples to cake when wetted and subsequently dried revealed that all ten of the examined samples formed cakes and were not easily dispersed with the subjective requirement of a *light blast of air*. The rock dust samples NIOSH analyzed contained very fine (<10-µm) particles. Fine particles enhance the caking potential of rock dust when wetted.

The low temperature ash test procedure used by MSHA to determine the incombustible content of coal dust samples does not detect oversized particles nor measure the tendency of the particles to form a cake. Although the mine operator may be applying sufficient rock dust to achieve an 80% or greater incombustible content as confirmed by the MSHA test procedure, if the rock dust does not conform to all of the requirements described in 30 CFR § 75.2 the mixture may not reduce the coal dust explosion risk.

RECOMMENDATIONS

1. NIOSH recommends that mine operators test their supply of rock dust upon receipt to assure that it meets the requirements of 30 CFR § 75.2. Rock dust that does not meet the requirements should be returned to the supplier and must not be used in the mine.
2. NIOSH recommends that rock dust manufacturers test their rock dust product and provide documented assurance to their customers that rock dust intended for use in underground coal mines meets the requirements of 30 CFR § 75.2.

A recognized method for testing particle size should be used. The qualitative test for caking is described in 30 CFR § 75.2.

NIOSH will continue to examine the issues associated with the use of rock dust for explosion prevention. Periodic updates will be posted at [www.cdc.gov/NIOSH/mining].

REFERENCES

76 Fed. Reg. 119 [2011]. Maintenance of incombustible content of rock dust in underground coal mines, pp. 35968–35978.

NIOSH [2010]. Report of Investigations 9679: Recommendations for a new rock dusting standard to prevent coal dust explosions in intake airways. DHHS (NIOSH) Publication No. 2010–151, [http://www.cdc.gov/niosh/mining/pubs/pubreference/outputid2825.htm]

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

MSHA issues PIB

NO. P11-50 (Oct 27, 2011)

Action

The NIOSH Hazard ID contains two recommendations that MSHA believes are important to mine operators, miners' representatives and manufacturers. NIOSH recommends that operators:

1. Test their supply of rock dust upon receipt to assure that it meets the requirements of the 30 C.F.R. § 75.2. Rock dust that does not meet the requirements must not be used in the mine.
2. Operators must obtain documented assurance, based on testing from the rock dust manufacturer, that rock dust intended for use in underground coal mines meets the requirements of 30 C.F.R. § 75.2

MSHA inspectors will check whether operators are following these recommendations, and have manufacturers' documentation, to assure compliance with 30 C.F.R. § 75.2. MSHA will continue to work with NIOSH to examine the issues associated with the use of rock dust for explosion prevention.



ISSUE DATE: **OCT 27 2011**

PROGRAM INFORMATION BULLETIN NO. P11-50

FROM:

KEVIN G. STRICKLIN
Administrator for
Coal Mine Safety and Health

A handwritten signature in black ink, appearing to read "Kevin G. Stricklin", is written over the typed name and title.

LINDA F. ZEILER
Director of Technical Support

A handwritten signature in black ink, appearing to read "Linda F. Zeiler", is written over the typed name and title.

SUBJECT:

Rock Dust Composition, 30 C.F.R. § 75.2

Scope

This Program Information Bulletin (PIB) applies to operators of underground bituminous coal mines, miners' representatives, Mine Safety and Health Administration (MSHA) enforcement personnel, and other interested parties including rock dust manufacturers.

Purpose

The purpose of this PIB is to alert coal mine operators and rock dust manufacturers of a possible problem with rock dust meeting the definition in 30 C.F.R. § 75.2 regarding particle size and tendency to form a cake.

Information

MSHA's existing definition of "Rock dust" at 30 C.F.R. § 75.2 states:

Pulverized limestone, dolomite, gypsum, anhydrite, shale, adobe, or other inert material, preferably light colored, 100 percent of which will pass through a sieve having 20 meshes per linear inch and 70 percent or more of which will pass through a sieve having 200 meshes per linear inch; the particles of which 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; and which does not contain more than 5 percent combustible matter or more than a total of 4 percent free and combined silica (SiO₂), or, where the Secretary finds that such silica concentrations are not available, which does not contain more than 5 percent of free and combined silica

Inspector Responsibilities

- MSHA issued PIB Letter NO. P11-50 addressing rock dust quality (Oct 27, 2011).
 - Check that mines have documentation that Rock Dust meets 75.2 definition sizing specifications
 - MSHA has no jurisdiction over suppliers
 - Inspectors should collect a sample of the rock dust used at a representative number of mines in each field office with a minimum number of 5 mines from each field office sampled during each Eo1 inspection. Each Field Office collect at least 5 rock dust samples
 - Caking of rock dust is still not directly addressed although required in the definition of rock dust
 - No non-caking rock dust is available!

NIOSH develops the Coal Dust Explosibility Meter – CDEM
(Aug. 2012) becomes commercially available



CDEM

- Used underground and Gives an **immediate evaluation of TIC** content (lab analysis took average of 3.6 weeks for results)
 - Uses near-infrared radiation reflected from the surface of a homogenous mixture of 2 dusts with two different optical reflectance (dark coal dust and light-colored rock dust)
 - Calibrated using Pittsburgh Pulverized Coal Dust as (dark) reference dust and mine rock dust as the (light) reference dust
 - Moisture must be removed for CDEM analysis while lab analysis include moisture as TIC
 - Green indication means greater than 80% TIC
 - Red indication means less than 80 % TIC
- Still have to collect a rock dust sample in normal method (band sample)
 - Had hoped to have a device that you just pointed at test area and had result

CDEM used only as an Engineering tool

Has numerous limitations

- Still must collect a normal rock dust sample
 - Immediate results instead of weeks
- Moisture not included but TIC definition requires moisture to be part of TIC
 - Moisture in a CDEM sample will give erroneous results (false red readings)
- CDEM must be calibrated for the rock dust being sampled
 - Calibrated at each mine using their rock dust (not the coal dust)
 - Reflectivity of both the rock dust and coal may change throughout the mine
 - Analysis is based on reflectivity of both
- Good Engineering Tool but not enforceable
 - Can be used to abate a citation
- Still a very good reference tool but not enforceable!
 - Encourage operators to use CDEM



MSHA Revises Procedures of Rock Dust Sampling

April, 2013 (Chapter 5 of MSHA Handbook Series Number: PH16-V-1)

Dec. 2019 (Chapter 4 MSHA Handbook Series Number: PH19-IV/V-1)

- Prior to revision inspectors took samples on 500' increments on all working sections to update from last EO1 inspection
- Changes to Quarterly Sampling during regular inspection
 - CM Sections - Collect at least four band samples per air course between 40 feet outby working faces to 1,000 feet outby working faces
 - At least one of these samples per air course should be collected inby the section loading point
 - LW Sections – collect at least two samples per air course within 1,000 feet of the longwall face
 - Collect at least four samples from the LW tailgate within 1,000 feet of the LW face
 - Additional samples required per air course including bleeders
 - Conveyor Belts – Inspectors should collect at least one sample per belt flight

Sampling Procedures Changes

- Target a 1/8 inch sampling depth (Prior to 2013 – 1/2 inch depth permitted)
- Split Samples - Previously (Prior to 2013) Band Samples were required, 2013 version allowed Split Samples permitted – based on inspectors evaluation, samples may be split at any location where coal dust is visible on the roof, ribs, structures or suspended items
 - Sample roof, ribs and floor (typical band sample)
 - Sample only floor
 - Sample only roof and ribs
- 2019 Handbook states – Partial samples may be collected at any location where coal dust is visible on the roof, ribs, structures or suspended items, or conditions prohibit a full band sample from being collected
- If insufficient dust is not obtained, collect a second adjacent sample
- Still must:
 - Cone and Quarter Samples
 - Screen sample with 10 mesh screen
- CDEM may be used to terminate a citation

Lake Lynn Experimental Mine Closes in September 2013

- NIOSH does not have a site for full scale explosion testing!
- NIOSH is still trying to locate a site to replace Lake Lynn!
 - Site has been identified in West Virginia but has zoning problems
 - Will have to be built from ground up!
- NIOSH has requested funding to create a 100 foot long, 16" by 24" explosion test chamber to be installed in the Pittsburgh Research Mine
 - Use this chamber to screen products which may warrant full scale explosion tests

Dispersibility and Caking are still Issues

NIOSH Investigates Issues

- NIOSH initially identifies and tests new hydrophobic rock dusts
 - Rock Dust treated with steric acids which make it hydrophobic – will not cake!!!
 - Extremely effective and will not cake!!!!
 - Hydrophobic rock dust is currently being used in other countries (Poland, Australia)
 - Hydrophobic rock dust is presently used in at least one U.S. coal mine in untraveled areas.
 - Uses regular rock dust in work areas and hydrophobic rock dust untraveled areas
- NIOSH also recommends smaller sized rock dust (more effective)
 - Instead 100 percent rock dust passing 20 mesh and 70% passing 200 mesh sieve, NIOSH proposed a 2600 cm²/g surface area requirement.

2014 NIOSH Proposes Use of Hydrophobic Rock Dust with new 2600cm²/g surface area Size Characteristics

■ MSHA Concerns

- MSHA had just implemented a new Dust Standard and how would this new rock dust Impact respirable dust concentrations?
 - Dust standard was being lowered from 2.0 mg/m³ to 1.5 mg/m³
 - Limestone is about 1.5 times heavier than coal dust
- NIOSH recommended size characteristics will contain significantly larger amount of respirable dust
- Hydrophobic dust on roadways could be a major respirable dust source on sections
 - Applying a rock dust on roadways that cannot be wetted down could cause major respirable source on sections
- MSHA prompted NIOSH to Evaluate “Engineered” Rock Dust
 - Remove respirable range dust - sub 10 micron rock dust (have rock dust in 10 micron to 74 micron size range)
 - Proved to be cost prohibitive and not obtainable
 - Removing smaller size makes rock dust less effective!!!!
 - All explosion tests have used sub 10 micron rock dust!

NIOSH Solution – Conduct a Mine Test

- Conducted testing of this rock dust at the Stockton Mine in 2015
- Both Regular Rock Dust and the New NIOSH Proposed Rock Dust are applied in a test zone 500 feet long
- Results of Test
 - New Proposed Rock dust appears to be very effective, but NIOSH realizes that this new rock dust will cause respirable dust problems.
 - Rock Dust was so fine that the hydrophobic rock dust traveled almost 1 mile out of the mine and contaminated surface areas and outside offices in low air velocities (about 50 - 80 fpm air velocity in a neutral travel entry)
 - Rock Dusted area still in good condition
 - NIOSH could not suppress the entrainment of rock dust generated dust when equipment drove through dust.



Un-treated rock dust in scoop
applied at Stockton Mine



Treated Rock Dust applied at the
Stockton Mine

Deployment of dry treated and untreated rock dust in operating coal mines

Stockton Mine Study to evaluate respirable dust during rock dust application

Untreated Rock Dust



Initial Application



1 Year Later



2 Years Later

Specifications

36.2% < 10 μ m
contained
moisture (12%)

- Poor coverage
- Less dust downwind

Treated Rock Dust



Initial Application



1 Year Later



2 Years Later

- Specifications**
- 43.1% < 10 μm
 - Light and fluffy
 - Good coverage
 - More dust downwind
 - No caking

Foam Rock Dust

- Emerald Mine applied Foam Rock Dust in an outby test area.
 - Everyone thought this was the rock dust solution
- In 2015, NIOSH Personnel, Joe Main, Myself, Mine Officials, Mike Sapko of NIOSH, MSHA and Union officials had a mine visit to look at this foam rock dust application
 - Everyone looked at this rock dust and thought it was fantastic!!!
- Mike Sapko (NIOSH) and myself looked at this rock dust and explained that it was useless!
 - No dispersability – not effective, essentially caked rock dust
 - Would not and Could not stop a propagating coal dust explosion!!!

NIOSH Looks at Foam Rock Dusts

- MSHA Policy on wet rock dusting
 - Foam rock dusts are currently considered wet rock dusting per MSHA policy
 - Apply dry rock dust once dried
 - This policy defeats the purpose intended purpose of developing a dispersible foam rock dust
 - Policy can be changed if NIOSH can prove the foam dust by itself can stop an explosion
- Can NIOSH create a Foam Rock Dust that is Dispersible?
 - Is it dispersible?
 - If dispersible, does it disperse in proper size and quantities to suppress a propagating explosion
 - Must pass full scale explosion testing before it would get MSHA approval
 - NIOSH currently does not have a site to conduct full scale explosion testing
 - Lake Lynn Research Facility is no longer available!
 - NIOSH is currently doing full scale testing in Poland

7/6/2015 Updated Program Policy Manual regarding Wet Rock Dusting which Foam Rock Dust would be considered

75.403 Maintenance of Incombustible Content of Rock Dust

Section updated July 2015\ Release V-51

Provided the percentages of incombustible content specified in this Section are maintained, **rock dust may be applied wet (including foam rock dust)**. Wet rock dust shall be limited to rib and roof surfaces in the face areas and shall not be used for redusting mine surfaces. In such applications, only limestone or marble dust which meets the specification contained in Section 75.2(d) shall be used.

The application shall be at the rate of not less than 3 ounces of dust per square foot of surface, and shall be by a mixture of not more than 6 to 8 gallons of water with 100 pounds of dust, whether by premixed slurry or by mixing at the nozzle of a hose to assure that the mixture is not too fluid and that sufficient dust adheres to the surfaces.

After the wet rock dust dries, additional dry rock dust shall be applied to all surfaces to meet applicable standards.

Wet rock-dusting of ribs and roof does not eliminate the necessity for dry rock-dusting the floor.

NIOSH Develops Tests to Evaluate Rock Dust (Foam Rock Dust)

- Caking Test
 - Will it cake when wetted and dried
- Dispersibility Test
 - Will the foam rock disperse with a light blast of air?
 - What is a light blast of air?
 - NIOSH determined that it is the pressure pulse created by a weak coal dust explosion
 - Used past explosion testing to determine pressure and time of this pressure pulse
- Papers written to justify and quantify both tests.

Basic Caking Test Conducted by NIOSH

Not wetted

Wetted

Wetted
then dried

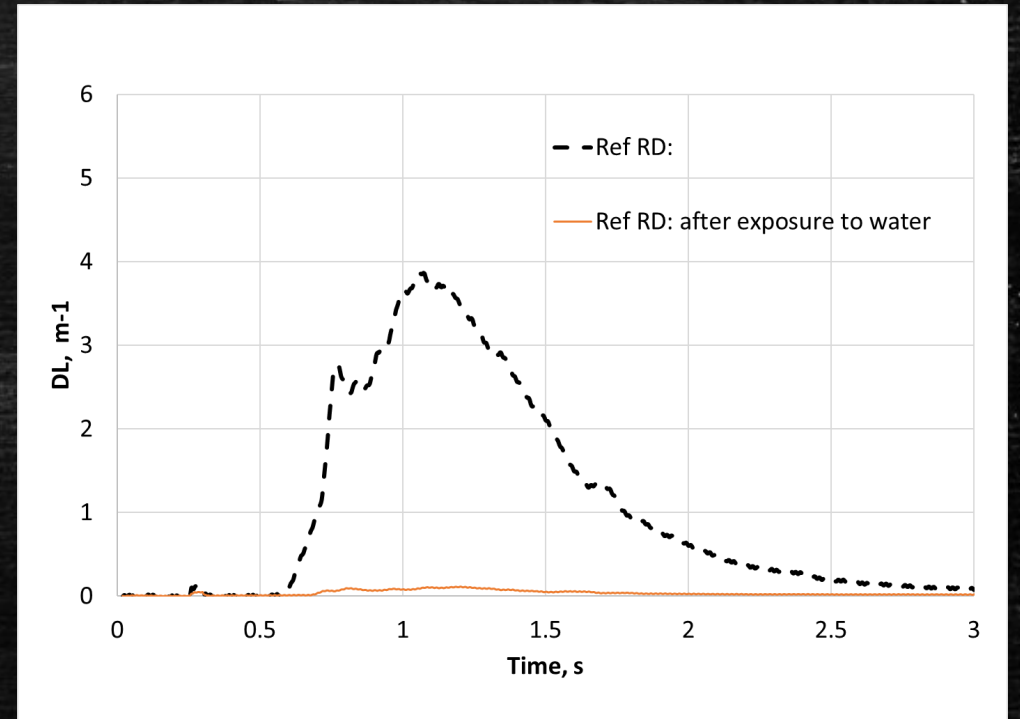
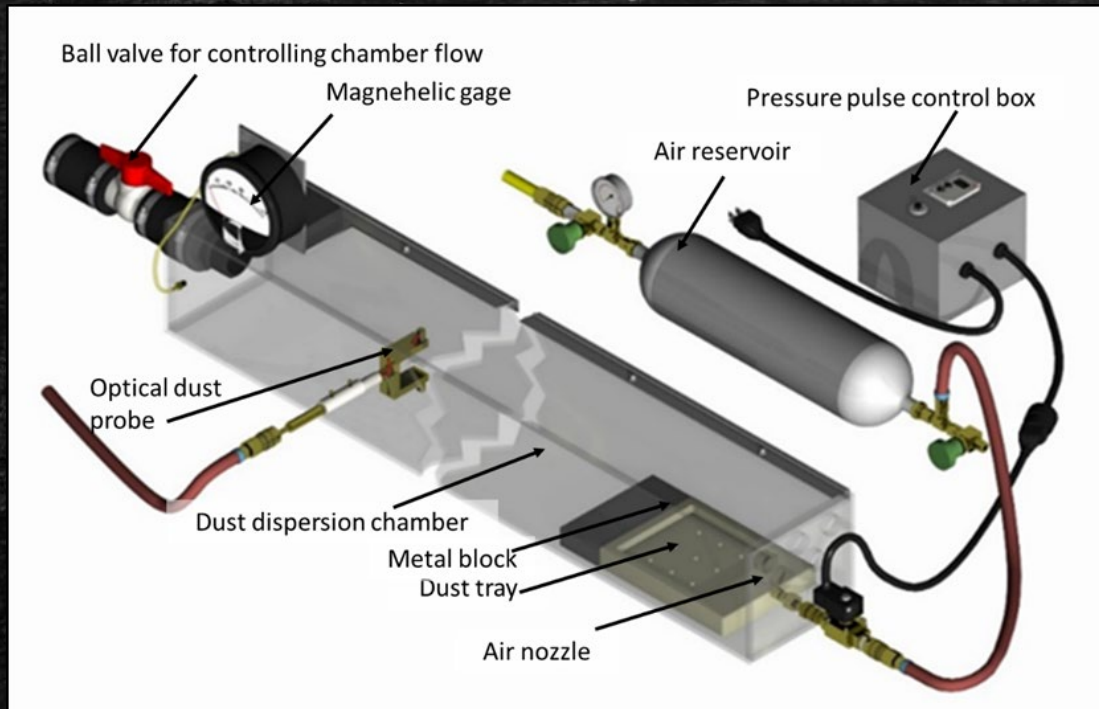
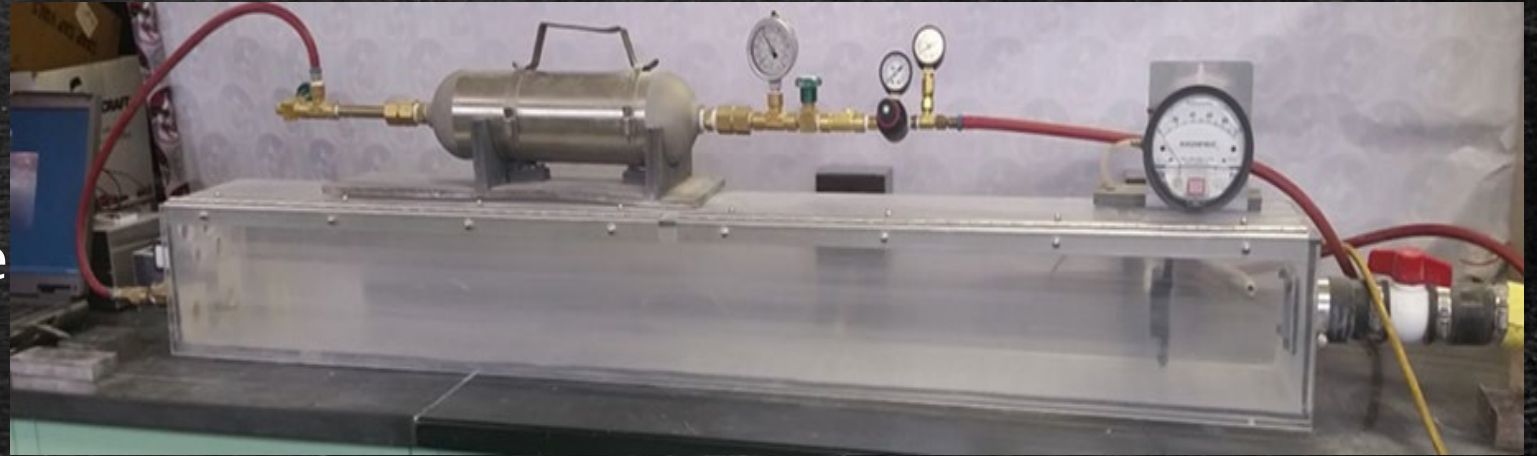


Dust Dispersion Chamber

Based on LLEM coal dust explosion data

Generates a reproducible air pulse

4.2 psi for 0.3 sec



Examples of Dispersion Test Results

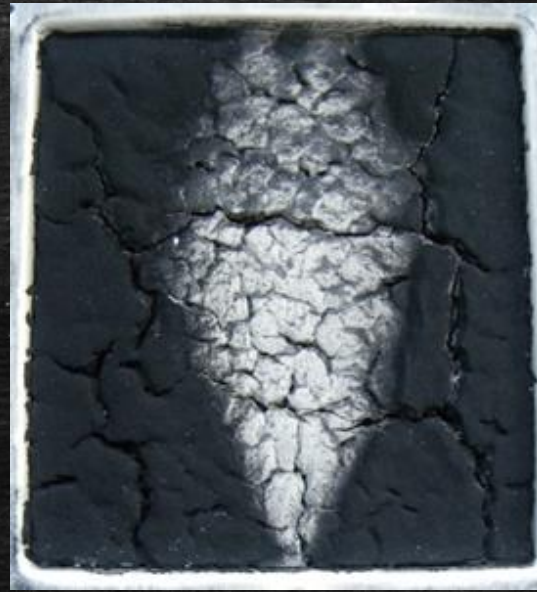
Rock dust is effective if sufficient quantities of properly-sized particles are dispersed

Solution

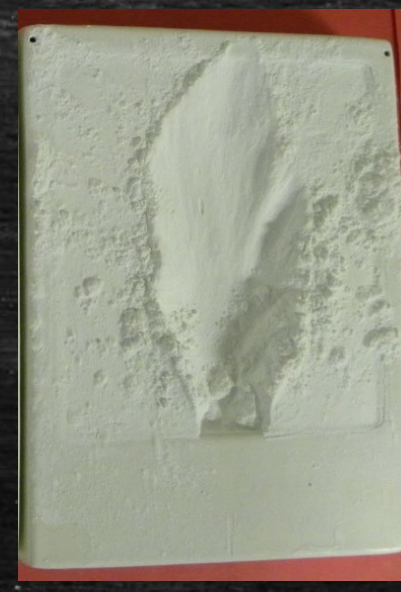


Dry untreated rock dust

Untreated rock dust (After moisture exposure)



Coal dust on top of untreated rock dust (Exposed to water and dried)



Treated rock dust (After moisture exposure)



Coal dust on top of treated rock dust (Exposed to water and dried)

Where do we currently stand on Rock Dust?

- Numerous improvements have been made in both the quality of rock dust and its application in mines
- MSHA has changed regulation and polices concerning rock dust
- NIOSH is currently evaluating numerous foam rock dusts
 - More Testing Needed on Foam Rock Dusting
 - Foam looks promising but currently not as effective as regular rock dust
- Some Foam rock dusts look promising, but still need full scale explosion tests to assure effectiveness
 - Site needed for full scale explosion tests!
 - Lake Lynn is gone!!
 - Use 100 foot long 16 inch by 24 inch test chamber in experimental mine to simulate tests until test mine is established

Questions?

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