NEW DUST CHARACTERIZATION AND MONITORING TECHNOLOGIES

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Dust control is an important concern in the mining industry. Evaluating dust problems and identifying the most efficient method to control fugitive dust is an emerging science. New monitoring and laboratory testing equipment have been developed to simulate real world situations and to determine the effectiveness and lifespan of various dust suppression methods. Using this new testing equipment, an effective, site-specific dust control program can be developed for a commercial application at a mine site. This article reviews the basic dust control methods and introduces the new monitoring and testing equipment that enables the efficient development of custom dust control methods for mines.

Why Dust Control

The creation of dust is an unavoidable byproduct of a mining operation. The entire mineral extraction process involves liberating individual mineral particles from an ore body. Some of the operations that carry out the job of liberation include blasting, transporting and crushing ores. Each one creates dust. Without proper management of the dust being generated, severe health, environmental and economic concerns can arise.

Respiratory issues caused by dust inhalation are a primary health problem for mine workers. Inhalable dust, dust particles smaller than 100 microns, can get caught in the mucus fluids in the nose and throat. Thoracic dust, dust particles smaller than 10 microns, can enter the lungs. Respirable dust, dust particles smaller than 2.5 microns, can get into the small sacks (alveoli) in the lungs where oxygen transfer to the blood takes place. Respirable dust can settle into the lungs and cause severe scarring of lung tissue, reducing respiratory capacity. Each of these conditions negatively affects the quality of life.

Knowing what elements or compounds compose the dust is just as important as knowing how much dust is in the ambient air. Mining dust can also contain hazardous materials such as mercury, silica and cadmium. Apart from the health concerns, these toxins can be released into the environment over a vast area carried as dust by wind and water.

Mining dust is also abrasive. The dust can get into machinery, creating excessive wear on parts and increase maintenance costs considerably. Visibility concerns due to dust can raise the risk of accidents. The dust can also contain valuable material that when lost can affect a mine’s bottom line. Some types of dust can create explosion and fire risks; under certain conditions, high sulphide concentrate dust and coal dust can self heat and start to burn.

Without even considering the regulatory concerns, the issues identified above suggest that controlling dust and monitoring its characteristics are important issues for mining operations.

Dust Control Methods

Generally, the mining industry uses three types of dust control methods:

1. Mechanical Methods: a combination of venting, high airflow and baghouses
2. Water Spray Methods: use of moisture to keep the dust down on stockpiles, roads, crushers, conveyor drop points, etc.
3. Chemical Methods: wetting agents, binders and foams

A dust control method is selected based on the conditions and the environment where the dust is generated. Mechanical methods are best employed where the dust is generated within an enclosed space. Mechanical methods are usually employed with crusher systems that are enclosed in a building, including any enclosed transport systems.

With today's stringent dust limits, in many cases, a water/chemical spray method is needed in addition to a mechanical method to control dust in crushing and material handling areas. Water sprays are more commonly used throughout a mine site to control dust in open areas such as roadways. Chemical methods are generally used to enhance the water spray in situations where adding water is a concern because water is scarce or the water is detrimental to downstream processes.

Three types of chemical dust control systems exist: wetting agents, binders and foams. Wetting agents and foams significantly reduce the amount of water needed to control dust within acceptable limits. Wetting agents are combined with water to reduce the surface tension between water and the dust particles, thereby causing the wetting action of water to be more effective. This dramatically reduces the amount of water needed for the wetting process. Wetting agents enable the dust to remain moist longer. By itself, water evaporates fairly quickly. However, adding a wetting agent or a surfactant significantly reduces the frequency of reapplication.

Chemical binders work like glue to bond the dust particles together to form a crust. Some binders are added with water while some are applied separately. The lifespan of a binder is even longer than a wetting agent. Binders are used to cap coal cars to reduce coal loss during transportation. They are also used on roads, dry tailings and ore piles.

Foams are applied through a spray nozzle system where air and water are injected with the chemical to create foam to coat the dust. They are used where little to no water is available for dust control and are commonly used in material handling situations.

Dust Characterization and Monitoring Technologies

New technologies have been developed to determine the amount of dust produced along with its size, shape and movement characteristics. They can be used for monitoring as well as for comparative purposes to determine the effectiveness of different dust suppression programs or products or methods.

Ashland uses the **DustTrakTM** system (developed by TSI, an electronics manufacturing company), a portable monitor that measures the amount of dust produced in an area. Using laser photometers, it can measure respirable dust down to less than one micron and is generally used for safety-related issues. This instrument can be placed in a particular area to monitor in real time the amount of dust being generated there, such as on or along roadways, dry tailings areas, conveyor drop points, crushers and stockpiles. The DustTrak system can measure dust levels, monitor dust suppression control programs and the lifespan of a suppressant application. DustTrak collects and stores data for easy retrieval. When monitoring road dust, a camera can be set up and synchronized with the monitoring unit so data can be correlated by type of vehicle. Measurements from the DustTrak can also be used to determine the amount of dust suppression needed to control ambient dust in crushing or material handling areas. Figure 1 shows a DustTrak monitoring unit.

In the laboratory setting, Ashland has a number of dust characterizing techniques. Apart from regular sieves, smaller particles sizes can be determined using focused beam reflectance measurement technology (**FBRM).** Measuring particles down to 0.5 microns, FBRM also corrects for particle shapes and measures an accurate particle size distribution of dust particles.

Particle shape can affect how dust particles become mobile. For instance, needle-shaped particles are streamlined so it takes more airflow to lift them than to lift cube-shaped particles with flat surfaces. This phenomenon can help determine which dust suppressant method and dosages are needed for effective suppression. To determine the actual shapes of the particles, a **Malvern Morphologi G3** instrument can be used. By measuring circularity, convexity, elongation, circle equivalent diameter, solidity, aspect ratio and a few other minor factors, a sample can be characterized in terms of how susceptible it is to becoming mobile at a given airflow.

Dust Suppressant Efficacy
Once the dust sample has been characterized, dust suppression methods are chosen for testing. Ashland uses a number of technologies to determine the effectiveness of a particular dust suppressant method and to determine the dosage requirements.

To assess or determine or measure the absorption of the dust suppressant chemical, laboratory testing techniques measuring permeability and contact angles of suppressants on the dust sample are used. The **Scanning Electron Microscope** is used to determine how suppressants absorb onto particular particle sizes. Micrographs of a treated dust sample are taken and scanned to find how particles absorbed the suppressant and by how much. Figure 2 shows a scanning electron microscope.

Once a dust suppressant chemical shows good absorption characteristics, dust reduction measurements are taken. A **Pera Pulvimeter** is a fairly simple instrument used for this purpose. A dust sample is weighed and then dropped into a cylinder onto a cone shaped structure. As the particles move down the cone and drop to the bottom of the cylinder, dust develops in the cylinder’s interior. The dust is allowed to settle for a set amount of time. A small sample cup located in the center of the cylinder under the cone collects a portion of the dust. The sample cup is then weighed and compared to the total sample weight to determine the amount of the sample that is dust generating. Measurements comparing treated and untreated dust samples give an accurate picture of the effectiveness of the dust suppressant chemical. The data collected can be correlated to determine the amount of ambient dust in material handling areas and the material loss due to erosion by wind. Figure 3 shows a Pera pulvimeter and an illustration of how it works.

Dust suppressant chemicals that are binders create a crust on a surface to inhibit dust generation. The crust must have a particular strength to allow long term stability against environmental conditions such as sun, rain and wind on rail cars, stockpiles, dry tailings and roads. In a road application, vehicle traffic exerts semi-continuous pressure on the crust over time, breaking it down to the original dust particles. To determine the crust strength when treated with a binder, a **Digital Break Force Gauge** (developed by Chatillon) is used. Based on a mechanical tester, the gauge applies a measured force to a crusted dust sample. When the crust breaks, a force measurement is generated. When set up with a **Mechanical Test Stand**, a stroke system is used to apply a set pressure that simulates the pressure applied by a moving vehicle tire on a road. Figure 4 shows a digital break force gauge with a mechanical test stand.

Simulating Real World Conditions

Ashland developed new test equipment and test procedures capable of simulating real world conditions. These allow us to determine the efficacy of new products, to asses or evaluate differences between products, to select products for specific applications, and to identify product limitations. New test equipment and procedures can simulate scenarios such as material handling (crushing, conveyor drops, screening, etc.), materials transport via truck or railcar, and the effects of wind on roads, tailings ponds, and stockpiles. The equipment designed to conduct these scenarios are the DustPro (dust propensity test) kit and the Wind Erosion Tester (WET).

The **DustPro** test is designed to test the propensity of a material to create dust (Figure 5). For this test, a treated or untreated sample of substrate (ore or coal sample) is dropped from a set height into the DustPro chamber where dust is generated. The air from that chamber is then sampled by a DustTrak monitor connected to the chamber. The DustTrak monitor continually samples the air in the chamber and the substrates propensity to dust is measured by magnitude of dust generated and the rate at which the dust settles. Ashland's Mining Research and Development team uses the DustPro to screen developmental products and to compare them against current products. Customer samples are tested in the laboratory or, using a portable monitoring unit, at the customer site. Multiple products can be screened at different dosages and various moisture addition rates to determine which product will work best at a minimum moisture addition rate. The results shown in Figure 6 highlight the difference between an untreated substrate sample and samples that were treated with water alone and with water containing 1000 parts per million of a dust suppression product.

Figure 5. DustPro test equipment attached to the DustTrak monitor.

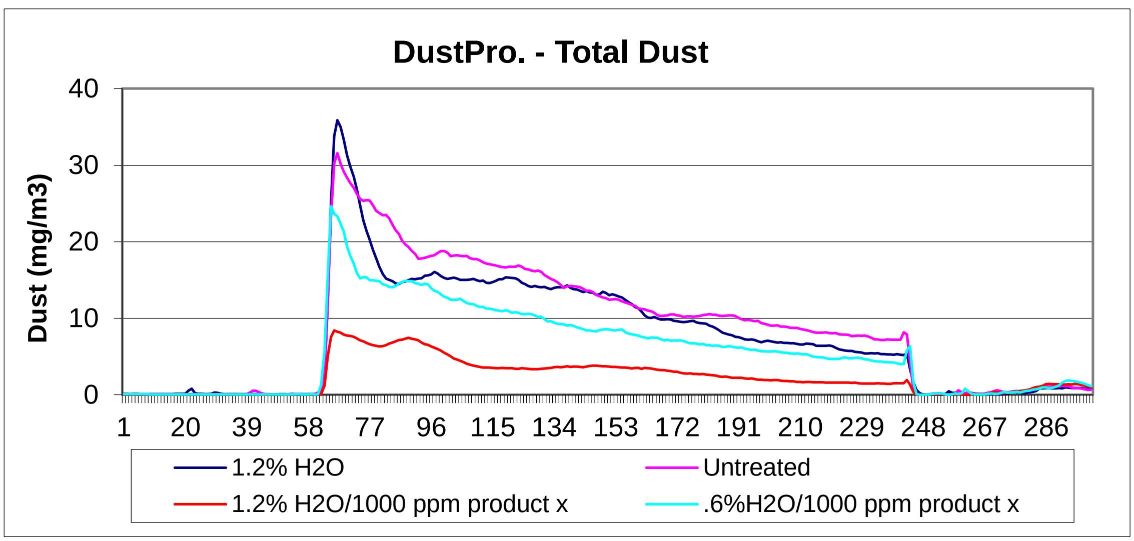

Figure 6. Untreated substrate sample compared to subtrates treated with water alone and with water containing 1000 ppm of a dust suppression product.

To evaluate situations where wind or air movement across a substrate can create dust, the **Wind Erosion Tester (WET)** and procedures were developed. This apparatus tests multiple scenarios where wind can cause small particles to become air-bound and has the capability to test wind velocities from 0 to 60 miles per hour. With this test apparatus, dust suppressants and their effectiveness can be evaluated for almost any substrate. The ability of an encrusting agent to remain intact on a substrate can be evaluated to determine how long it will last at different wind speeds, dosage rates and concentrations. It also measures product loss at various wind velocities to help determine the cost of lost material from stockpiles or from rail cars and trucks during transportation. A shaking mechanism can be placed under a treated or untreated substrate to simulate the vibration or shaking motion of a railcar or truck while it is in motion. Figure 7 is an photo of the Wind Erosion Tester (WET) unit.

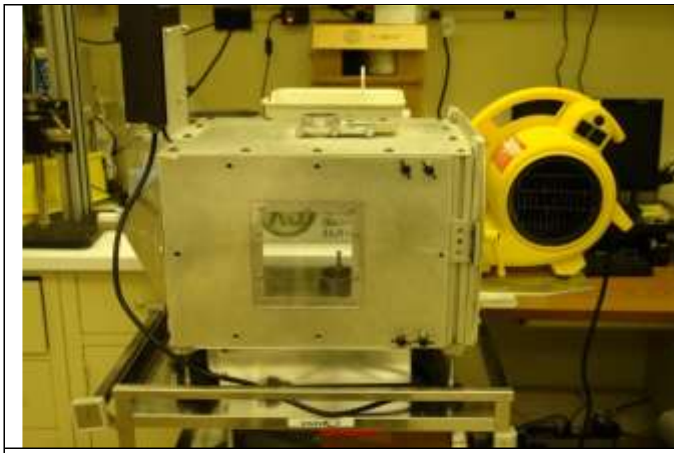

Figure 7. Wind Erosion Test equipment, developed at Ashland Inc.

The interior of the WET unit or apparatus was designed to house different sizes of sample containers. See Figure 8.   Sample substrates can be placed in the sample containers to simulate the various shapes of piles or flat to simulate road surfaces or tailings dams.

Figure 8. The interior components of Wind Erosion Test, developed by Ashland Inc.

WET was conducted on an ore sample that had been sieved at 100 mesh; the ore was then dried for 24 hours. Forty grams of the dried ore was placed in a 2.5 inch diameter by 1.5 inch deep stainless steel cup. A total of 14 cups were prepared: seven were sprayed with only water and the other seven were sprayed with an aqueous solution of Ashland's dust suppression product. The samples were oven dried at 85^{o}C for one hour. WET analysis was conducted on the dried samples (see Figure 9 and 10). During the WET analysis, the pre-weighted sample cups were subjected to wind speeds of 60 miles per hour for 15 minutes. Then the cups were weighed again to measure the percentage of weight loss caused by wind erosion. Figure 9 shows that the average percentage of weight loss for the water treated sample was 4.75% whereas the sample that was treated with the Ashland product experienced an average percentage of weight loss of only 0.03%.

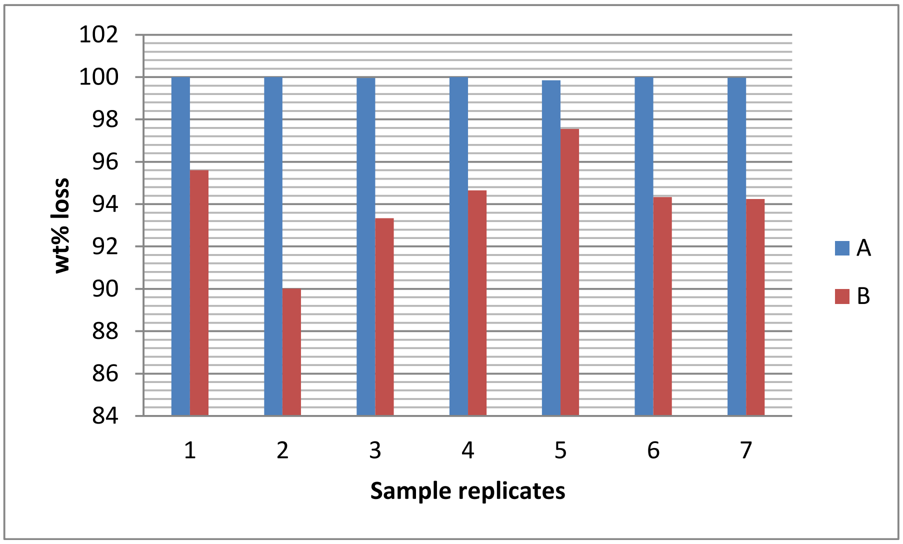

Figure 9. Sample A represents an ore that was treated with Ashland's product; sample B is an ore that was treated with water. Both samples were oven dried for 1 hour at 85°C prior to the Wind Erosion Test; both samples were subject to 60 mile/h wind for 15 min. Sample B showed an average of about 4.75% wt loss

Figure 10 shows photographs of 85°C dried samples that were treated with water (A) and Ashland's product (C); photographs B and D were taken after WET analysis of samples A and C. Figure 10 indicates the occurrence of significant wind erosion when the ore was treated with water only whereas as Ashland's treated sample showed no erosion.

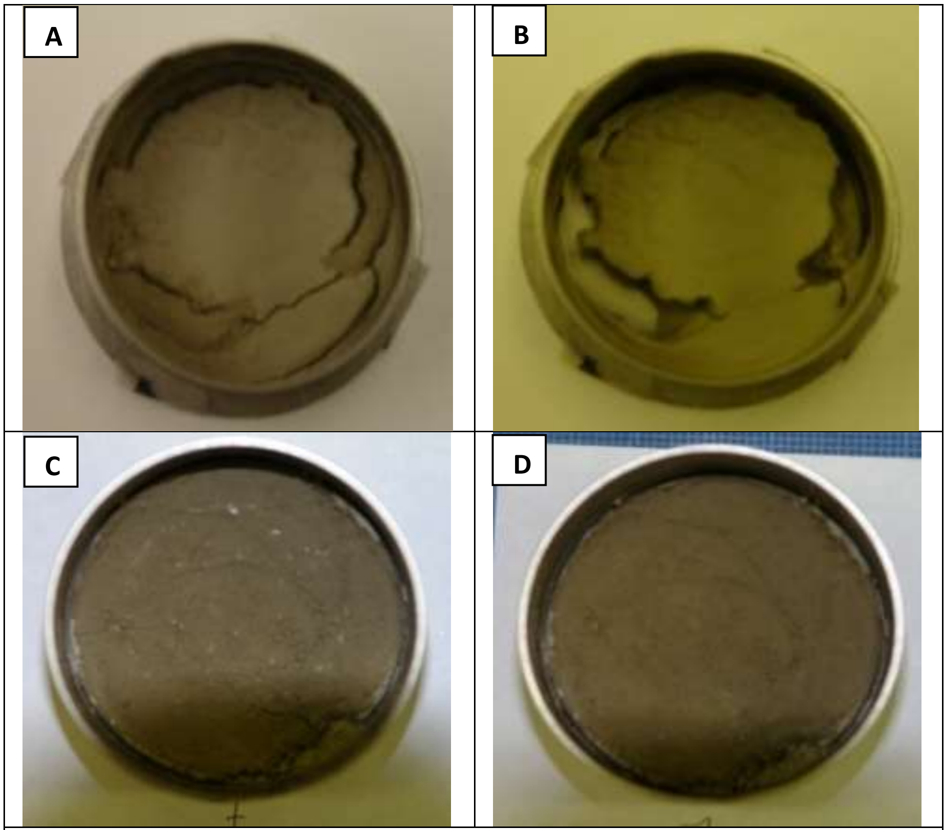

Figure 10. Sample A represents an ore that was treated with water then dried at 85 ^oC for 1h; image B was taken after A was subjected to WET. Sample C represents an ore that was treated with Ashland's product before drying at 85 ^oC for 1h; image D was taken after C was subjected to WET.

Conclusion

Evaluating dust characteristics and dust suppressants is a necessary part of finding the most effective dust control program for real world applications. The new technological advances within this emerging science made this process very exacting and helped to develop very effective dust suppression programs that are applicable to mining operations around the world.

Figure 1. DustTrak* Monitor (Developed by TSI)

Figure 2. Scanning Electron Microscope

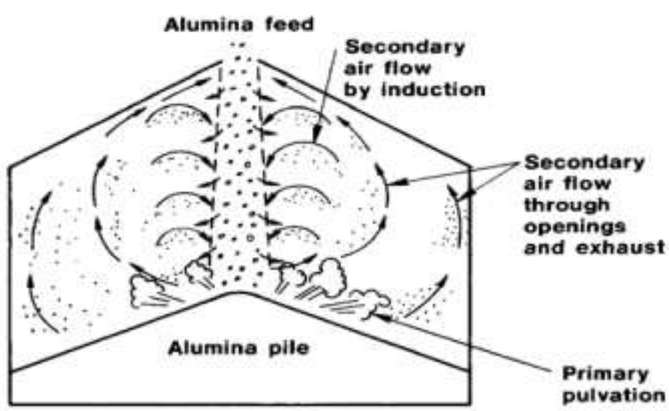

Figure 3. The Pera Pulvimeter

Figure 4. Digital Break Force Gauge with Mechanical Test Stand