An Aid to Fugitive Material Control in Coal Ash Applications

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Dust is a generic term for minute solid particles, typically less than 500 microns in diameter. Larger, heavier particles tend to settle to the ground, while smaller, lighter solids may hang in the air indefinitely. For occupational health purposes, airborne solids are categorized by size as either *respirable* or *inhalable*.

Respirable dust is small enough to penetrate deep into the lungs, and is usually identified as particles under 10 microns in size. These tiny solids migrate far into the respiratory system, beyond the body's natural cleaning mechanisms such as cilia and mucous membranes, and are likely to be retained.[1] In contrast, the larger inhalable dust particles are typically trapped in the nose, throat or upper respiratory tract, where they have a greater chance of being expelled.

Controlling fugitive fly ash particles is a daunting task, largely because of two physical properties. The first is the inherently water repellent nature (hydrophobicity) of the material. With little natural affinity for moisture, fly ash tends to shed water droplets rather than absorb them, so the particles remain dry and problematic. The second is the size of the particles themselves: usually just 5-12 microns, which is roughly the same as talcum powder. To put that in perspective, a human hair typically ranges from 50-100 microns in diameter, so unfortunately, the most hazardous dust particles in most situations are the ones too small to see.

HAZARDS

The makeup of fly ash dust can vary widely, depending on the coal being burned, but all fly ash contains significant amounts of silica, in both crystalline and amorphous form. "Silica" refers to the mineral compound silicon dioxide (SiO_2). Amorphous silica tends to be spherical and smooth in shape, while the crystalline form is pointed and far more hazardous. Crystalline silica has been cited as a cause of the disabling and irreversible lung condition known as *silicosis*. It has also been classified as a Group I carcinogen (Carcinogenic to Humans) by the International Agency for Research on Cancer (IARC, 1997).[2]

Chronic silicosis can remain undetected for years or even decades. It is a cumulative and often fatal condition, and as it progresses, symptoms typically include shortness of breath, cough and weakness. Over time, the body's ability to fight infection is

compromised and victims become susceptible to other illnesses, such as tuberculosis. Affected individuals frequently experience fever, weight loss, chest pains and eventually respiratory failure. Exposure to crystalline silica has also been linked to lung cancer, kidney disease, reduced lung function and other disorders.

Despite such recognition as a significant health hazard, it's been estimated that 15,000 people have died from the effects of silicosis over the last two decades in the U.S. alone, and hundreds more continue to be afflicted each year. At least 1.7 million workers are thought to be potentially exposed to respirable crystalline silica, many in concentrations that exceed limits defined by current regulations and standards.[3]

In addition, inhaled dust can irritate airways and exacerbate conditions such as asthma and emphysema. Fly ash also contains trace amounts of a number of toxins and heavy metals, including arsenic, lead and mercury. From a purely financial perspective, when equipment air intake includes significant amounts of dust, it can also lead to more frequent maintenance and greater engine wear, causing operating costs to rise.

Unfortunately, fly ash dust is so fine and lightweight that it easily becomes airborne from even minor air turbulence. Unless acted upon by some outside force, the particles can hang in the air for extended periods, resisting settling and potentially migrating off-site.

MITIGATION

The most common methods for controlling dust are *surface wetting* and *airborne capture*. With surface suppression, the goal is to prevent dust problems by wetting the source before particles can become airborne. Airborne capture is more difficult, requiring some form of technology that can force the particles to the ground and keep them there.

Airborne dust capture techniques usually fall into one of two groups: *electrostatically charged fog* or *atomized spray*. With a fog system, the approach is to produce extremely small water droplets with an opposite electrical charge from the airborne dust, resulting in greater attraction and agglomeration. Unfortunately, the method is far better suited to permanent indoor locations than constantly changing outdoor job sites. Fog systems generally do not perform well in windy or turbulent conditions and typically achieve very little surface wetting.

One innovative manufacturer has designed specialized atomized misting equipment that is proving to be a significant advantage in fly ash control. Atomized spray techniques also rely on the principle of creating very small water droplets, but in contrast to fogging systems, they are launched from a powerful fan at moderate to high velocity, facilitating a collision with airborne dust particles to drive them to the ground. The method is one of the few technologies capable of delivering dust control by surface wetting AND airborne particle capture.

Figure 1: Atomized spray is one of the few suppression technologies capable of delivering dust control by surface wetting AND airborne capture.

EQUIPMENT DESIGN

Bulk handling equipment for coal ash frequently has some form of particle suppression built in, typically a water-based system, often with surfactants or tackifiers metered in to improve wetting. Once the damp material exits the conveyor, however, few practical options exist to maintain the moisture content of stored ash and help prevent dust formation. Sprinklers are largely ineffective, and shifting pile sizes and work environments complicate the use of conventional spray systems such as those on stackers or other equipment.

Most atomized mist designs are based around an electric motor, with smaller units running on standard single-phase power and a garden hose water supply. Larger models require 3-phase service and are fed by a fire hose. Some suppliers are offering modifications that increase utility even further, such as an optional metering pump that allows users to introduce surfactants, odor controls and other additives at very precise levels. Larger designs will sometimes have booster pumps that can increase just 10 psi (0.7 kg/sq. cm) of water pressure to 150 psi (10.55 kg/sq. cm) or more, which has a direct impact on performance.

To conserve water and energy, a solenoid-activated valve can be installed in the water line, allowing users to activate suppression equipment at specific times. For example, the solenoid can be activated by control lever or other flow sensor to operate only when conveyor belts are loaded and running. The latest equipment designs can be automated even further to operate via programmable logic control, which allows a user to automatically start or stop machines when specific airborne particulate levels are reached.

Achieving effective dust suppression with an atomized spray requires that each component of the machine be engineered to work in concert with all the others, so it can deliver the right combination of droplet size, water pressure, air flow and velocity. As airborne dust particles and water droplets approach each other, the greatest attraction is created when the particles and droplets are roughly the same size, avoiding a slipstream effect that allows droplets and particles to drift past each other without

contact. (See Figure 2.) But there is a tradeoff: larger droplets will travel farther before losing their momentum, while smaller droplets are more effective at trapping airborne dust.

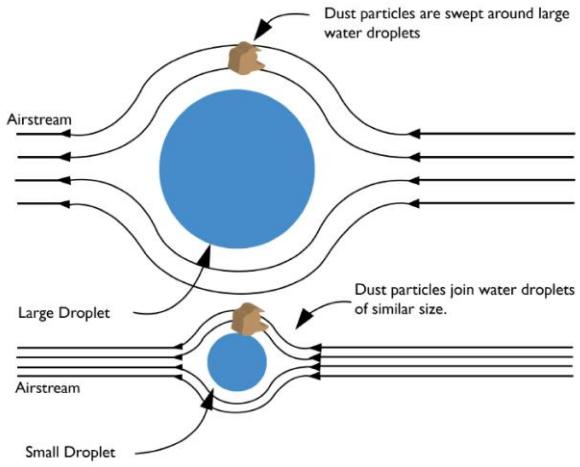

Figure 2: When atomized spray control systems produce droplets approximately the same size as airborne particles, they deliver a greater attraction between droplets and dust.

Testing and experience have shown that in the majority of dust control applications, the most efficient droplet size range is 50-200 microns, considering the conflicting goals of maximizing both particle capture and coverage area. Though ideal in most applications, the 50-200 micron droplet range has been found to be somewhat less effective in fly ash operations.

To address the situation, DustBoss® equipment employs a technology that allows modifications to tailor a machine's output to specific conditions. By using a technique known as Variable Particle Sizing™, additional nozzles can be incorporated into the misting ring to increase droplet production, and changes can be made to the nozzle sizes or configuration. These modifications can produce a wider range of droplet sizes, in greater numbers, allowing a larger volume of water to be used and translating to improved overall suppression efficiency. The technique can also be used to produce droplets in a specific size range, to improve the effectiveness in fly ash applications.

Particularly effective in fly ash applications has been the introduction of tower mounts that elevate the misting units and allow them to spray downward on stored ash. More effective than spraying over the top of the dust cloud from ground level, elevated mounting allows the powerful mist to capture dust particles before they disperse into the air. (See Figure 3.) The tower-mounted dust suppressor uses remote control for convenient operation or automation via sensors, while retaining full oscillation capabilities over a wide coverage area.

Figure 3: Recent developments in dust suppression include a tower mount design that delivers precise targeting while freeing up ground space for vehicles and other equipment.

One of the keys to the equipment's success has been the ability to automate operation, allowing plant personnel to control on/off cycles, direction, oscillation arc and other features from a remote location or even via hand-held wireless control. Fully-integrated systems can be operated entirely by remote control whenever an ash dump is underway, allowing a single staff member to selectively adjust as many as a hundred of the high-output misting units without having to physically visit any of them.

Figure 4: Automated dust suppression units

The most impressive results have been demonstrated through the use of multiple units, mounted at heights that improve performance and aiming. By triangulating the oscillation arcs of several machines, users can create a blanket of mist that effectively targets ash piles and concentrates suppression where it's needed most. These dust management networks deliver a solution that's specifically engineered to function in each individual application, one that's easily implemented by staff members to achieve consistent performance.

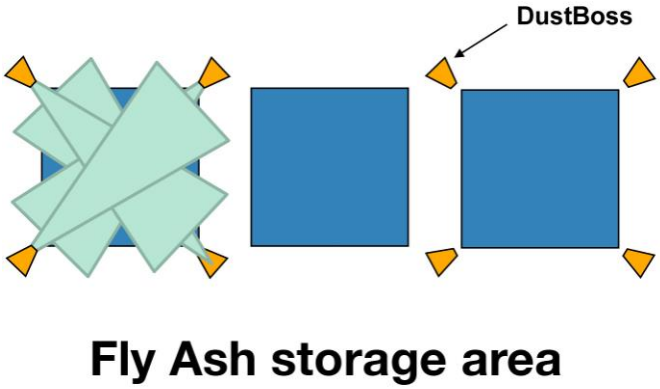

Figure 5: Triangulation of misting units

Although simple to operate and adjust, the new customizable automation packages now available for DustBoss equipment allow the development of sophisticated systems that can be tailored for operation by remote control, central computer, weather data, motion detectors or even airborne particle monitors or other sensors. The latest generation of automation software integrates all components into a user-friendly interface that has been developed and refined over a decade of use to provide a versatile, menu-driven control method to optimize dust suppression activities and minimize energy consumption. Users can monitor and track local weather patterns, adjusting the units as needed throughout their shift, and the software can even be programmed to monitor and control video security systems, lighting, HVAC and other inputs.

Figure 6: Automation software

The effectiveness and versatility of atomized spray systems appear to be gaining popularity in fly ash applications, representing a truly portable dust control option that delivers greater suppression efficiency than much larger fixed systems or manual spraying techniques, at a fraction of the cost. As public awareness and industry regulations become more focused on reducing the risks associated with fly ash, coal-

fired power plants and other facilities are likely to find that effective suppression is no longer a luxury, but a critical element of everyday operations.

REFERENCES

[1] Peterson, Edwin; Shaurette, Mark; Clark, David: Demolition Dust: Hazards and Control, IDE Conference Paper, 2008.

[2] OSHA Instruction (Directive CPL 03-00-007): National Emphasis Program – Crystalline Silica, effective January 24th, 2008.

[3] NIOSH Hazard Review: Health effects of occupational exposure to respirable crystalline silica; Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHSS Publication No. 2002-129.