Vacuum cleaning systems: The right tool for removing combustible dust

Doan Pendleton Vac-U-Max

Simple as it sounds, effective housekeeping can minimize combustible dust explosion risks in dry bulk solids plants. This article explains how to minimize explosion hazards by using a vacuum cleaning system to safely remove combustible dust from your plant.

Controlling combustible dust hazards in dry bulk solids plants is a hot topic today. Yet concerns about how to clean up dust that can lead to dust explosions are nothing new.

A 1922 National Fire Protection Association (NFPA) book titled *Dust Explosions* cites the need for a vacuum cleaner that can withstand the rigors of an industrial environment. It states that despite every precaution a plant takes to capture dust at the source, small amounts of fugitive dust "will get into the atmosphere...and gather on floors, walls, and ledges." The book's authors knew then — as we know today — that "if there is no accumulation of dust and the plant is perfectly clean, the explosion cannot propagate and the plant will not be destroyed."[1]

Despite the somewhat primitive state of industrial vacuum cleaning technology more than 90 years ago, the book recommends vacuum cleaning to clean up dust and warns against sweeping dust with brooms or using compressed air to blow it off surfaces because these methods often suspend dust in the environment. This warning holds just as true today: The suspended dust could ignite and trigger a primary explosion or settle back onto floors, equipment, and beams, potentially leading to a secondary explosion.

To understand what makes a vacuum cleaning system the right tool for removing combustible dust from your plant, let's look at how dust explosions occur.

This stationary filter-receiver, equipped with an explosion suppression system, is part of a central vacuum cleaning system for safely cleaning up combustible dust.

Some dust explosion mechanics

Primary dust explosion. A primary dust explosion occurs when combustible dust forms a cloud of dust particles in sufficient quantity and concentration in an enclosed environment containing an ignition source and oxygen. Three of these elements — fuel (the combustible dust), the ignition source (heat, such as a spark or flame), and an oxidizer (the oxygen in the air) — form the well-known *fire triangle:* Without all three of these elements, a fire can't occur. Combining these elements with the additional two — a contained environment (a vessel, room, or building) and a sufficient quantity and concentration of dust particles dispersed in a cloud — forms the *explosion pentagon:* Without all five of these elements, an explosion can't occur.

Why containment is necessary: In an open environment, such as outside a building, igniting a dust cloud would just create a big, brief flame flash. But in a contained environment, such as a dust collector vessel, the dust cloud's fast burning creates a rapid pressure rise inside the vessel, producing a primary explosion that could damage or destroy the equipment.

Why a dust cloud is necessary: If you touch a flame to a layer of fugitive dust resting on a table in an enclosed room, the dust will ignite, but won't explode. If you then remove the flame, the dust will only smolder and most likely self-extinguish. But if you throw that same dust into the air — creating a dust cloud — and then touch a flame to it, the dust will explode.

Secondary dust explosion. Throwing dust into the air and touching a flame to it is a good example of what happens in a secondary dust explosion, when the primary dust explosion's force dislodges fugitive dust from plant floors, equipment, and other surfaces, in turn producing more dust clouds and creating a domino effect that can cause further explosions.

A secondary explosion is often termed a *catastrophic secondary explosion* because it has a greater quantity and concentration of dispersed combustible dust and can be far more destructive than a primary explosion. Fatalities and damage to equipment and plant property are often the tragic results of secondary explosions. The plants involved are also subject to OSHA fines for failing to proactively protect their workers.[2]

Safe housekeeping practices

It's difficult to remove fuel (the combustible dust) and the oxidizer (air) from the fire triangle and, hence, from the dust explosion pentagon. So the first rule of both fire prevention and explosion prevention is to eliminate the ignition source.

Even though most bulk solids processing and handling equipment is designed to operate safely, any mechanical equipment can malfunction, heat up, and create an ignition source. Thus, even when your plant takes every precaution to eliminate ignition sources that can cause fires and to design dust collection systems to safely contain most dust generated in the plant, you must go further to prevent dust explosions: Your plant must also use safe housekeeping practices for removing fugitive dust.

What makes a vacuum cleaning system safe compared with using brooms or compressed air to remove dust is that the vacuum cleaning system doesn't suspend fugitive dust in the air during cleaning, thus preventing combustible dust explosions and protecting your workers and plant. [***Editor's note:*** See the sidebar "A review: Vacuum cleaning systems 101" for basic information on portable and central vacuum cleaning systems and their operation.]

Choosing the right vacuum cleaning system

Many plants use standard shop vacs from the local home improvement store for cleaning up work areas. But these aren't designed to handle combustible dust.

Like most nonindustrial vacuum cleaners, a shop vac is vulnerable to ignition, and one of the most common ignition sources with vacuum cleaning is static electricity. Particles flowing in one direction through the plastic vacuum hose can create a significant static electricity charge, and static electricity can also build up on the particles themselves. If a shop vac with a charged, ungrounded hose contacts a grounded object as the operator vacuums up combustible dust, this static electricity buildup can arc, creating a spark that triggers a violent dust explosion. This is why OSHA has cited many plants handling combustible dusts for using standard shop vacs to remove dust.

In contrast to shop vacs, industrial portable and central vacuum cleaning systems for removing combustible dust must be rated for use in Class II Division 2 areas (a National Electrical Code hazardous area designation).[3] A vacuum cleaning system with this rating is not only designed so that no particles can contact any source of ignition in the system, but the system is redundantly grounded to eliminate any possibility of a static-ignited dust explosion. In particular, a vacuum cleaning system powered by plant compressed air is intrinsically safe because it has no motor, and thus, no moving parts or electrical current.

Another shop vac problem that a Class II Division 2 vacuum cleaning system overcomes is that the standard shop vac itself can be a hazard in a plant handling combustible dust. Besides not being grounded or classified for use in Class II Division 2 areas, the shop vac can give the operator electrical shocks and easily become clogged with dust. The operator must also manually remove and clean the unit's cartridge filter, a time-consuming and messy job. As a result, operators don't want to use the shop vac and fugi-

A review:

Vacuum cleaning systems 101

Using a vacuum cleaning system is now the OSHA- and NFPA-preferred housekeeping method for removing dust to reduce dust explosion hazards in dry bulk solids plants. The system not only prevents dust from becoming suspended in air during cleaning, minimizing explosion hazards, but is easy and convenient for operators to use and can handle a variety of dust-removal duties.

Vacuum cleaning systems for use in industrial plants are available in portable and central types. A portable system typically consists of a collection container — often a drum or similar vessel — mounted on wheels that can be moved easily from workstation to workstation in the plant. A flexible plastic hose extends from the container, and its free end can be connected to various vacuum attachments, such as wands, brushes, crevice tools, squeegees, and others for cleaning floors, walls, and other surfaces. The hose's free end can also be fitted with quick-connect couplings to attach to hand tools like grinders and sanders. The system's vacuum is supplied by a blower powered by electricity or plant compressed air.

A central system consists of a vacuum power unit with a collection container and is typically installed at one location in the plant; in some applications, the power unit and container are mounted on wheels so the system can be moved between locations. A tubing network extends from the collection container along the ceiling to multiple workstations or pickup points; at each station or pickup point, a drop-down flexible plastic hose connected to the tubing network extends down to operator level. As with the portable system hose, the central system hose's free end can be fitted with various vacuum attachments or connected to hand tools. The central system typically has a larger blower than a portable system and can be electric or diesel-powered.

With both portable and central systems, permanently positioning a hose's open end directly at the dust source, such as a metal-grinding station, allows the system to provide automatic dust capture at that location. The collection container in both portable and central systems has a filter that can be cleaned by an automatically or manually operated cleaning system. The collection container for both systems can be moved by forklift for dumping.

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tive dust accumulates on surfaces in the plant, creating a dust explosion hazard.

A Class II Division 2 vacuum cleaning system, on the other hand, eliminates operator shocks and has a filter-cleaning mechanism that keeps the filters clean and prevents clogging. This allows the system to continue to collect dust without requiring the operator to manually remove and clean the filter.

Identifying your dust's explosivity

So how much dust is considered a hazard? Most NFPA guidelines[4] for combustible dust state that a layer of dust the thickness of a paper clip is often enough to cause a significant secondary explosion. But this rule of thumb doesn't account for a particular dust's explosivity, called its K_{St} value (determined by measuring the rate of pressure rise in a test vessel after the dust is ignited). Some dusts are more reactive than others. Some are more easily suspended in a cloud. And for some dusts, explosivity test results indicate that a dust layer even half the thickness of a paper clip could cause a secondary explosion.

You can determine your dust's explosivity by having the dust tested by any of several independent dust explosion testing labs around the US. If your plant manufactures several products that each yield a different dust, having all the dusts tested can be prohibitively expensive. In this case, it's best to work with an explosion testing lab consultant or another dust explosion safety expert to select dust samples that are most likely to be explosive. Be aware that if your plant handles a variety of combustible dusts with different K_{St} values, you may be required to select a Class II Division 2 vacuum cleaning system *even* if your plant environment doesn't meet the definition of a Class II Division 2 area.

The current NFPA guidelines leave some room for interpretation when it comes to safely cleaning up combustible dusts. Even if you have a small quantity of combustible dust that could be ignited only by prolonged contact with a very hot ignition source, it's best to be cautious. By using a portable or central vacuum cleaning system designed for combustible dust collection, you can safely and effectively clean up dust in your plant, eliminating the fuel needed for an explosion. In fact, using such a vacuum cleaning system is now the OSHA- and NFPA-preferred housekeeping method for removing dust to reduce dust explosion hazards in dry bulk solids plants. [***Editor's note:*** Find more details on NFPA standards related to combustible dust hazards in Reference 4 and the "For further reading" section later in this article.]

Protecting your workers, equipment, and building from combustible dust hazards is simpler than you think: Just keep your plant clean. **PBE**

References

1. David J. Price and Harold H. Brown, *Dust Explosions,*National Fire Protection Association (NFPA), 1922 (out of print but available in online technical libraries).

2. See the OSHA FactSheet "Hazard alert: Combustible dust hazards" (at www.osha.gov/OshDoc/data_General_Facts/OSHAcombustibledust.pdf) and the OSHA Combustible Dust National Emphasis Program Directive *CPL 03-00-008* (effective March 11, 2008), available at www.osha.gov/OshDoc/Directive_pdf/CPL_03-00-008.pdf.

3. Find more information at www.osha.gov/doc/outreachtraining/htmlfiles/hazloc.html.

4. The NFPA standards applicable to dry bulk solids plants include *NFPA 61: Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities* (2008), *NFPA 68: Standard on Explosion Protection by Deflagration Venting* (2007), *NFPA 69: Standard on Explosion Prevention Systems* (2008), *NFPA 484: Standard for Combustible Metals* (2012), *NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* (2013), and *NFPA 664: Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities* (2012). For more information about these standards, contact National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471; 800-244-3555, fax 617-770-0700 (www.nfpa.org).

For further reading

Find more information on this topic in articles listed under "Vacuum cleaning," "Safety," and "Dust collection and dust control" in *Powder and Bulk Engineering*'s article index (in the December 2012 issue and at *PBE*'s website, www.powderbulk.com) and in books available on the website at the *PBE* Bookstore. You can also purchase copies of past *PBE* articles at www.powderbulk.com.

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