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.”

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.

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**Vacuum cleaning systems: The right tool for removing combustible dust**

**Doan Pendleton**  
Vac-U-Max

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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.

**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

**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-
Identifying your dust’s explosivity

So how much dust is considered a hazard? Most NFPA guidelines 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 $K_o$ 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 $K_o$ 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.

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).


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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Session on combustible dust hazards offered at PBE’s 2013 Midwest Conference & Powder Show™
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