How to prevent a dust explosion in your dust collector

A dust collection system is vital to operating a clean, safe bulk solids plant. Ironically, however, the inside of a dust collector provides a near-perfect environment for the very type of hazard the dust collection system is designed to prevent. In this article, dust explosion experts first discuss the hazards associated with handling combustible dust in dust collectors, then cover dust explosion ignition sources and methods for preventing or limiting dust explosions in dust collectors.

A recent insurance industry study showed that about 40 percent of dust explosions from 1983 to 2006 occurred in dust collectors. Preventing this type of explosion requires understanding the conditions necessary for a dust explosion and how your dust collector creates those conditions even while it keeps the air in your plant clean and dust-free.

Why dust explodes

Dust composed of combustible material, and even some dust composed of material not normally considered combustible, including some metals, presents a fire or explosion hazard when it accumulates or becomes suspended in air. When airborne, dust particles provide the maximum exposed surface area relative to mass, so they ignite much more easily and burn much faster than larger particles. In the right concentration, burning dust particles quickly heat and ignite nearby particles in a chain reaction, creating a deflagration or explosion.

The dust concentration necessary to create a hazard varies based on the dust’s characteristics and can be determined by testing. This value is referred to as the minimum explosive concentration (MEC). [Editor’s note: You can contract any of several independent dust explosion testing labs around the US to test your dust’s combustibility.] Surface accumulations that create a hazard vary as well, but, in general, a layer of dust as thin as 1/32 inch over just 5 percent of the surface area will present a risk. The National Fire Protection Association (NFPA) provides methods for determining acceptable dust accumulation in its NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particle Solids.

As a result of several combustible dust explosions in various industries, OSHA issued a National Emphasis Program (NEP) directive in 2007 and reissued it in 2008. The NEP’s purpose is to increase OSHA’s enforcement activities and intensify its focus on combustible dust hazards.

Why dust explosions occur in dust collectors

To reduce dust accumulation and combustion hazards in bulk solids plants, companies commonly use dust collectors (also called air-material separators). A dust collector draws an airstream containing suspended dust particles through an enclosure, where filters separate the dust from the air. [Editor’s note: For more information about dust collector types and how they operate, see the “For further reading” section later in this article.]

That so many dust explosions occur inside dust collectors should come as no surprise when you consider how a dust collector operates. A dust explosion can’t occur without the
five elements in the dust explosion pentagon: combustible dust, oxygen, a confined area, a suspended dust cloud, and an ignition source, as shown in Figure 1. A typical dust collector operates with four of the five elements nearly always present. The ignition source is the only element that’s not normally present, so avoiding ignition is a key to limiting the risks of handling combustible dust. History has shown, however, that ignition sources seem to find their way into dust collectors, sometimes with devastating results.

**What causes ignition**

Flames, sparks, heat, and static electricity can all ignite a dust collector explosion. Sometimes it’s easy to identify what caused the ignition, but it can also be an unpredictable or random event. Often, the cause is never known. Generally, any mechanism that expends energy handling combustible material can introduce an ignition source to a dust collector. Well-documented ignition causes in dust collector explosions include processing and handling equipment, electrical equipment, human error, and the process material itself.

**Processing and handling equipment.** The ignition source in a dust collector explosion is often introduced by connected processing and handling equipment, such as a mill, shredder, dryer, oven, bucket elevator, or dust pickup hood exhausting hot process material. For example, tramp metal inadvertently introduced into size reduction equipment, such as a mill or grinder, or into a blender can become heated or create a spark that travels to the connected dust collector and trigger ignition. A bucket elevator with bearing failure, belt slippage on the drive drum, or a misaligned bucket rubbing on the housing can cause excessive heat or a spark to be carried into the connected dust collector and ignite the dust.

**Electrical equipment.** Electrical equipment can also introduce an ignition source to a dust collector. An electrical fault, such as a short, arc, insulation breakdown, or water ingress, can create a spark or excessive heat capable of igniting dust. Plant areas where combustible dust is present are categorized as Class II, Division 1 or 2 hazardous locations in the National Electric Code (NEC), and electrical equipment in such areas should be rated accordingly. OSHA also provides information about NEC hazardous location classifications (see www.osha.gov/doc/outreach training/htmlfiles/hazloc.html).

**Human error.** Wherever and whenever people interact with process equipment, unpredictable events can occur. Dropping a tool or other metal object into an open blender or onto an open conveyor can create a spark on impact or produce tramp metal, which can heat up or create a spark in a dust collector. Feeding the wrong material into a process can also cause ignition. For example, if a previously dried or milled material is inadvertently reintroduced to a process, it can be more prone to ignite. Welding without following proper safety procedures (a hot work permit, a fire watch, and adequate cleanout prior to starting the work) can also result in ignition. NFPA provides guidelines for safe hot work procedures in NFPA 51B: Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.

**Process material.** Every material has unique characteristics that affect how susceptible it is to ignition. For example, a material with a low minimum ignition energy (MIE) that holds a static electric charge tenaciously can be susceptible to ignition simply when being transferred into a container. A change in a raw material’s source can also increase the likelihood of ignition: The new material, suitable in every other way, might prove more susceptible to electrostatic ignition than the previous material. The hazards of using such a material can be controlled in part by sequencing its addition to a process with other less susceptible materials, reducing its fill rate, using conductive or static-dissipative hoses and bin liners, or premixing ingredients.

Flammable vapors, such as methane, propane, butane, and various alcohols, are present in many materials, often called hybrid materials. A dust collector handling a hybrid material of flammable vapor and combustible dust may require groundable bag or cartridge filters, which have tiny wire filaments woven into the filter media to dissipate static electricity. However, in a dust collector handling pure combustible dust (that is, with no flammable vapors), the only electrostatic discharge possible is a brush discharge (an electrostatic discharge of about 1.0 millijoule), which has been demonstrated and independently verified as insufficient to ignite pure dust. As a result, groundable filter media shouldn’t be used in a collector handling pure dust, because the cleaning air pulses can damage the media’s conductive filaments during normal operation. A filament that becomes sufficiently damaged can form an isolated
conductor with a sharp point or raised edge capable of releasing a spark strong enough to ignite the pure dust.

An accumulation of a self-heating material can cause ignition when left undisturbed. Such a material breaks down chemically via either aerobic or anaerobic respiration and gives off heat as a by-product. Common self-heating materials include low-rank coal (such as lignite or sub-bituminous coal), wood containing pitch, and organic materials stored in a hopper, bin, or silo.

**How to prevent or limit dust collector explosions**

Limiting dust accumulation and keeping preventable ignition sources out of your dust collector will greatly reduce your risk of a combustible dust explosion. Here are some ways you can avoid completing the dust explosion pentagon in your collector:

**Administrative measures.** First, complete a process hazard analysis (PHA) to identify hazards associated with your dust collector. A PHA uses either lab tests or published data to determine the MEC, MIE, and other values related to your dust’s explosive characteristics so you can determine a potential explosion’s relative severity. For more PHA information, see NFPA 654 or consult a dust explosion expert.

Next, implement a management of change (MOC) program in your plant to avoid introducing potential ignition sources throughout your dust collector’s service life. Your MOC program should include written procedures for evaluating any changes to your process or plant. For example, if a process change introduces a new dust to your dust collector, your MOC should dictate that the new dust must be evaluated before being handled by the collector. If your dust’s explosive characteristics have changed, you may have to implement new prevention, static discharge management, maintenance, or explosion mitigation or isolation procedures. You can also find more MOC information in NFPA 654.

Establish procedures (described in NFPA 51B) in your plant for welding, cutting, and grinding operations, which can generate sparks or open flames. Implement lockout/tagout and confined-space-entry procedures to prevent introducing foreign material or hazards to your dust collector that could cause ignition. OSHA provides information on these procedures in *OSHA 29 CFR 1910.147: The Control of Hazardous Energy (Lockout/Tagout)* (available at www.osha.gov). Also make sure that no open flames or smoking areas are located near the dust collector or associated equipment.

**Preventive maintenance.** Properly maintaining your dust collector’s filter media is critical to the collector’s safe operation. Clean any excessive dust buildup off the filter media and replace the filters according to the dust collector manufacturer’s specifications (or the filter manufacturer’s specifications, if you’re no longer using the original type of filter). Inspect the collector’s clean-air side for dust from filter leaks and tears. Perform required maintenance on your dust collector’s accessories (such as the exhaust fan, auger, valves, and level indicator) and connected processing and handling equipment to ensure that they won’t introduce ignition sources into the dust collector. Find more specific maintenance requirements in NFPA 654.

**Inerting.** An inerting system uses an inert gas, such as nitrogen, argon, or carbon dioxide, to displace the air in a dust collector and connected equipment, and with it, the oxidant that would support combustion. Inerting is a complex subject, however, and a properly designed system has many variables.

You must seal the dust collection system from the surrounding environment to contain the inert gas and protect plant personnel from suffocation or asphyxiation risks. If the system is inadequately sealed, your inert gas usage rate will go up substantially, and the system’s oxygen concentration could increase enough to support an explosion. You can monitor the oxygen concentration continuously or at certain points, depending on the dust collection system’s design.

If your dust collector has a pulse-jet filter-cleaning system, it must use inert gas instead of air for the pulses. Also, if your collector contains a large, homogeneous dust cloud, you’ll need a significant amount of inert gas to stop a combustion reaction and cool down the material heated by that reaction. In such a case, you’ll need to ensure that the system contains a large volume of inert gas and that the gas is continuously replenished.

Inerting can be a good prevention method for a dust collection system handling a self-heating material, which can cause combustion whenever enough oxygen is present for a given time. Inerting removes the oxygen and prevents combustion from taking place. However, some fine-grained dusts, such as flour or cornstarch, decompose exothermically (releasing heat) without oxygen, and inert-
ing provides only limited explosion protection in such an application.

**Process interlocks.** A process interlock can react to a potential ignition source in your dust collection system and trigger an event or events in your process to prevent a deflagration or limit a deflagration’s potential damage. The interlock can trigger an isolation valve, sound an alarm, or even alert an operator to take corrective action. For example, tobacco dust tends to smolder over time, so a hot-particle detection system is a must on any dust collector handling tobacco dust. Interlocking the detection system with an alarm alerts the operator when a hot particle enters the collector, where it can smolder and lead to a dust deflagration.

![Figure 2](image)

**Figure 2**

**Hot-particle detection systems**

*a. System with IR detector and water extinguishers*

*b. System with IR detector, slide-gate valve, and CO₂ injector*
You can also use process interlocks to automatically shut down a dust collector or upstream process equipment to prevent introducing additional fuel or potential ignition sources to the system after a hot particle has been detected. By combining administrative measures and a hot-particle detection system with process interlocks, you can create a very robust ignition control system for your dust collector.

**Why prevention alone isn’t enough**

While these prevention measures can go a long way toward making your dust collector safer, they can’t completely eliminate the risk of a dust explosion. You should always assume that some unknown, unpredictable source could ignite the dust in your dust collector. To limit the effects of such a deflagration, you should also implement explosion mitigation measures, such as explosion venting, chemical suppression, and explosion isolation and containment. [Editor’s note: For information about dust explosion mitigation measures, see the “For further reading” section or contact the authors.]

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**References**

2. NFPA standards are available from 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 combustible dust hazards, dust explosion prevention and mitigation, and dust collection in articles listed under “Safety” and “Dust collection and dust control” in *Powder and Bulk Engineering*’s article index in the December 2013 issue or the Article Archive on PBE’s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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