If your bulk solids manufacturing plant handles combustible dust, the first steps in reducing the chance of a fire or explosion are to test your dust and assess your processes. Many options are available to help minimize the risk, but each has its own set of considerations. This article outlines the process of evaluating your risk and suggests potential prevention and protection options.

Few manufacturing plant hazards are more urgent than combustible dust. A dust explosion or fire can cause catastrophic loss of life and property, so managing your risks is critical to safety. Also, various authorities having jurisdiction (AHJs) — fire marshals, insurance appraisers, OSHA inspectors, and others — can levy fines, impose insurance barriers, or hamper expansion plans if an inspection determines that combustible dust poses a fire or explosion risk in your plant.

Requirements for handling or processing combustible dust are spelled out in building codes and industry standards, including those published by the National Fire Protection Association (NFPA). Many state, city, and other authorities have adopted these NFPA standards and made them regulatory code. When OSHA levies a fine for an unsafe work environment under the General Duty Clause, the agency often references an NFPA standard as a benchmark.

The NFPA recently published NFPA 652: Standard on the Fundamentals of Combustible Dust. NFPA 652 supplements the previously released NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids. The new standard provides:

- an overview of dust-related hazards along with general requirements;
- references to other related standards for specific industries or commodities; and
- guidance for conducting a dust hazards analysis (DHA).

NFPA standards are clear: manufacturers with potentially combustible dust are required to have a current dust hazards analysis.

Identify your risks

Many manufacturing processes generate combustible dust, especially applications that use dry powders and metals. Working through the NFPA 652 DHA process will help you identify and address your plant’s risks. The first step is to determine the combustibility of the dust produced in your plant. You can use historical or published data to identify your dust’s characteristics, but be sure the data accurately represent your current materials and processes. If you’re uncertain, can’t find a published reference, or if an AHJ requires proof that your determination is accurate, you’ll need to have your dust tested in a lab.

Testing will determine if the dust is combustible (can ignite in a pile or layer), explosible (can ignite in a cloud), or neither. If the dust is explosible, further testing will identify how rapid (the dust’s \( K_e \) value) and severe (the dust’s \( P_{\text{max}} \) value) the explosion will be. Combustible risk tests may also include other dust characteristics, such as minimum explosible concentration (MEC), minimum ignition energy (MIE), and minimum auto-ignition temperature. The more specifics you have, the more able you’ll be to prevent and protect against fire and explosion risks.

The next step is to examine which of your plant’s processes represent a combustion risk. Many processes require mitigation strategies beyond having a functioning dust collection system. Some processes generate significant sparks, for example, and may require spark control. Some applications may use incompatible materials, such as aluminum and metal oxides, which can ignite because of thermite reactions when combined. Chemical or pharmaceutical processes may face toxicity concerns that preclude discharging dust to the outside atmosphere. No two facilities are exactly alike, and every plant owner is responsible for fully reviewing his or her plant’s unique risks and constraints.
Once you’ve analyzed your dust and determined which processes present a hazard, you’re ready to develop a risk mitigation strategy.

**Develop a strategy**

Combustible dust risk mitigation can be roughly divided into two focus areas: prevention and protection. Prevention minimizes the likelihood of a fire or explosion, while protection limits the scope of damage if an event occurs. Because no prevention method is guaranteed to be 100 percent effective, a good strategy should address both.

A few key questions will help you begin:

- When and how could a fire or deflagration (dust cloud ignition) start?
- What would be the consequences of an ignition event?
- If an ignition event occurred, how soon would your process need to be back up and running?
- Is the cost of process downtime greater than the cost of the explosion protection system?

Dust fires and explosions don’t only occur in dust collectors. Under the right conditions, an initial deflagration can trigger a secondary, often much more severe, explosion. When an explosion occurs, the pressure and shock wave produced can disturb accumulated dust on walls, rafters, girders, ducts, lighting, false ceilings, or other surfaces or equipment. This disturbed dust then becomes suspended in the air and is a ready fuel for any other ignition sources to initiate a secondary explosion.

This is why good housekeeping is the first step in fire and explosion risk mitigation. Don’t focus only on floors; look for dust on all surfaces up to the ceiling. OSHA inspectors and other AHJs will collect dust samples from surfaces as high in your facility as is safely accessible, and any accumulated dust layer exceeding 1/32 inch is likely to cause concern.

The next step in risk mitigation is determining whether to locate your dust collector outdoors or indoors. If the collector is outdoors, the system can be designed so that an explosion will affect only the collector; but if the collector is indoors, an explosion potentially puts the entire building at risk. While an outdoor dust collector may simplify mitigation requirements, an outdoor location isn’t always feasible. In some cases, an indoor collector closer to the air that needs filtering may make more sense.

**Prevention options: control ignition**

A fire requires three elements: oxygen, fuel (such as combustible dust), and an ignition source (such as heat or a spark). As shown in Figure 1, a dust explosion requires two additional elements: dispersion of the dust in the air and confinement in an enclosed space. Whether considering the three elements required for a fire, or the five required for a dust explosion, the only element you can typically address is the ignition source. As a result, risk prevention techniques for both fire and explosion generally focus on controlling ignition sources.

Your prevention options will depend on the type of dust you’re collecting, the dust collector location, and your budget. Here’s a summary of common options:

- **Maintain distance between the dust capture hood and the dust collector.** Some plants have been successful at preventing ignition by putting the dust collector several hundred feet from the main dust capture hood, so sparks have more time to die out before reaching the collector.
- **Active spark abatement.** Active spark abatement uses one or more spark detectors mounted on the dust collection system duct to trigger the release of an extinguishing material, which douses the spark before it reaches the collector, preventing ignition. Because the sparks move rapidly in the duct and it takes time for the signal to activate the extinguisher, this type of system may require considerable duct length between the detector and the extinguishing point.
- **Passive spark abatement.** A passive spark abatement device, as shown in Figure 2a, doesn’t require activation by a sensor. The device is mounted inline on the dust collection duct and creates turbulence in the dust collection airstream. This turbulence extinguishes sparks before they reach the dust collector.

**Protection options: limit effects**

Remember, no prevention strategy can guarantee that an ignition event will never occur, so you should also...
use protection methods to help limit the effects of a fire or deflagration if one should happen. Protection equipment typically focuses either on fires or explosions, not both, so the systems are complementary.

**Fire protection.** In most plants, a fire is more likely than an explosion because a fire requires just oxygen, heat, and fuel, as discussed earlier, while an explosion requires the additional factors of dispersion and containment. Fire protection techniques include:

*Sprinkler system.* A sprinkler system integrated with the building fire control system is a tried-and-true fire protection method. When heat builds up in the dust collector, the sprinkler activates and disperses water. While effective, a sprinkler system requires downtime and cleanup after activation and can potentially cause water damage to nearby processes or equipment.

*CO₂.* A CO₂ system, as shown in Figure 2b, smothers a fire by filling the dust collector with carbon dioxide to displace the oxygen. A CO₂ system may have a higher initial cost than a sprinkler system, but CO₂ offers the advantages of fast cleanup and less potential to damage the dust collector when activated. Also, since this fire control option is a stand-alone system, it’s easy to move if you need to restructure your production facility.

Note that water and CO₂ aren’t acceptable extinguishing agents for all materials, including metals, for which argon or nitrogen are the recommended extinguishing agents.

*Dust collector location.* As stated earlier, locating the dust collector outdoors with a designated exclusion zone around it can help limit the consequences of a fire or explosion. In some cases, locating the dust collector safely away from the building and allowing the collector to burn if it catches fire may be a good choice, because the cost of replacing the dust collector is lower than the cost of mitigation equipment.

**Explosion protection.** Separate equipment is available to reduce the damage from a deflagration. These devices are especially important because they also help minimize the chance of a catastrophic secondary dust explosion.

*Explosion vent.* An explosion vent, as shown in Figure 2c, is a weak panel designed to burst or open in the event of a dust explosion. The vent provides a planned pathway through which the explosion’s gas, flames, and pressure can safely escape the dust collector. An
explosion vent is a passive device; when explosion pressure inside the collector reaches a defined level, the vent opens and must direct escaping fire, dust, and debris to a safe location. Vents have a low initial cost but aren’t suitable for applications where the explosion would discharge hazardous dust into the atmosphere. An explosion vent strategy can allow a fire to develop in the dust collector after the explosion occurs.

Chemical suppression system. A chemical suppression system, as shown in Figure 2d, uses sensors to monitor the pressure inside the dust collector and inject a chemical flame suppressant (sodium bicarbonate) within milliseconds of detecting a rapid pressure increase caused by a deflagration. The suppressant absorbs the heat and interferes with flame propagation, snuffing out the fireball before it becomes large enough to threaten the dust collector structure. A suppression system may cost more than other explosion protection methods but is very effective at containing dust within the collector, reducing the risk of a post-deflagration fire and minimizing cleanup, which can shorten your downtime.

Isolation devices. With either a fire or an explosion, containing the damage and avoiding any secondary ignition events is critical. Isolation devices can keep the flames and pressure generated by an ignition in your dust collector from propagating through the system duct or hopper discharge. You should also consider isolation if your application allows returning the filtered air back into the plant rather than discharging it outside. Isolation options include:

Passive isolation equipment. A flow-actuated isolation valve prevents flames and pressure from propagating back through the duct. The valve is activated by the pressure wave flowing countercurrent to the system’s normal airflow and doesn’t require an activating sensor.

Active isolation equipment. Active isolation equipment is available for either fire or explosion applications. Active isolation uses an electronic sensor to detect an event and activate an isolation device. Fire isolation diverts smoke and flames to a safe location, while explosion isolation prevents flames and pressure from flowing back through the duct.

A dynamic approach

Combustible dust risk mitigation is a dynamic practice with no one-size-fits-all strategy. In the absence of a "perfect" answer, follow this approach:

1. Know your dust, your facility, your combustion risks, and the standards that apply to your processes.
2. Understand the likely physical and financial consequences of a fire or explosion.
3. Use prevention and protection strategies to reduce the probability and consequences of a combustion event to an acceptable threshold.

As you complete your DHA, think beyond equipment costs. Consider that you’re protecting your entire facility from harm. An effective mitigation strategy will manage risks to your employees, your facility, and your process. The upfront costs of prevention and protection are typically worth the investment when compared to the costs of a fire or explosion occurring in your plant.

For details about combustible dust risk prevention and protection options, contact an independent combustible dust consultant or a dust collector manufacturer.

References
1. For more information go to www.osha.gov.
2. All NFPA standards are available at www.nfpa.org.

For further reading

Find more information on this topic in articles listed under “Explosion/fire protection” and “Dust collection and dust control” in Powder and Bulk Engineering’s article index in the December 2016 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.)

Karen Wear (karen.wear@donaldson.com) is market manager at Donaldson Company and has more than 20 years of experience in industrial air filtration. She holds a BS in chemical engineering from the University of Minnesota–Duluth and an MBA from the University of St. Thomas–Opus College of Business in Minneapolis, MN.