

Designing your dust collection system to meet NFPA standards — Part I

Gary Q. Johnson | Workplace Exposure Solutions

About 40 percent of combustible dust explosions reported in the US and Europe over the last 25 years have involved dust collectors. Dust collection systems are now a primary focus of inspections required by OSHA's National Emphasis Program on safely handling combustible dusts.¹ OSHA also has the authority to enforce National Fire Protection Association (NFPA) standards for preventing or protecting against dust explosions. This two-part article focuses on how you can design your dust collection system's dust collector, ductwork, and exhaust fan to meet the intent of these NFPA requirements. Part II will appear in January.

The explosion hazards posed by dusts commonly handled in bulk solids plants can be surprising. In fact, most natural or synthetic organic dusts and some metal dusts can explode under the right conditions. You can find a limited list of combustible dusts and their explosion data in the appendix to the NFPA standard focusing on dust explosion hazards, *NFPA 68: Standard on Explosion Protection by Deflagration Venting* (2007),² and in Rolf K. Eckhoff's book *Dust Explosions in the Process Industries*.³

While such published data can give you some idea of your dust's explosion hazards, using this data for designing explosion prevention or protection equipment for your dust isn't recommended. Your processing conditions and your dust's characteristics — such as its particle size distribu-

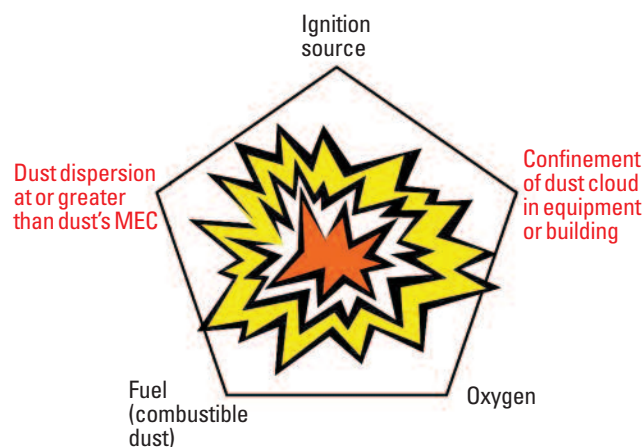
tion — differ from those for the published data for the same material, producing different combustible dust results. The only way to determine your dust's combustibility is to have a qualified laboratory run explosion tests on a representative sample of the dust. Then, to meet NFPA requirements, you'll need to commission a hazard analysis of your dust collection system to document that its design mitigates the explosion risk posed by your dust. (For more information, see reference 4.)

Some dust explosion basics

The five elements required for a dust explosion can be pictured as a pentagon, as shown in Figure 1. The three elements labeled in black are those in the familiar fire triangle: *fuel* (combustible dust), an *ignition source*, and

Figure 1

Dust explosion pentagon



oxygen. For a dust explosion, two more elements (labeled in red) are required: *dust dispersion at or greater than the dust's minimum explosible concentration* (the lowest dust concentration that will propagate a combustible dust deflagration or explosion; MEC) and *confinement of the dust cloud within equipment or a building*.

Put simply, a dust explosion occurs when an ignition source touches a dust cloud with a concentration at or greater than the dust's MEC. A dust cloud with this concentration can result when a layer of dust thicker than ½ inch on equipment, piping, overhead conduit, or similar components is pushed into the air by some event, such as the pressure wave from a relief device's operation. When an ignition source — such as a spark or the flame front from an equipment explosion — touches the cloud, the dust can explode with devastating impact, as evidenced by the fatal results of the sugar refinery explosion in Georgia last February. To mitigate your dust collection system's explosion risk, you need to focus on preventing dust accumulation in the system, preventing ignition, and providing explosion prevention or protection at the collector — all covered by NFPA standards.

Even when a dust collector is equipped with an explosion vent that works properly, the ductwork in the dust collection system can propagate a collector dust explosion throughout a process area. An investigation into one such case revealed that a contributing factor was the ignition and explosion of dust that had accumulated in the ductwork because of the system's inadequate conveying velocity.⁵ Another contributing factor was the lack of flame-front-isolation devices in the collector's dirty-air inlet and the clean-air outlet for recirculating air to the building. Such devices could have prevented the flame front in the collector from entering the inlet duct and re-entering the building through the outlet duct.

In this case as in many others, following the requirements in NFPA standards for mitigating explosion risks in a dust collection system could have prevented the dust explosion from propagating beyond the dust collector. In the following sections, we'll look at how you can design your dust collection system to meet the NFPA standards. Information covers preventing dust accumulation in ductwork, eliminating ignition sources, and using explosion prevention and protection methods at the collector. [**Editor's note:** Capture hood design, another important factor in designing a safe dust collection system, is beyond this article's scope; for more information, see the later section "For further reading" or contact the author.]

Preventing dust accumulation in ductwork

To prevent dust from accumulating in your dust collection system's ductwork and becoming fuel for an explosion, you must design all ducts in the system with two principles in mind, as described in *NFPA 654: Standard for the Pre-*

vention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids (2006).² First, the conveying air velocity must be adequate throughout the duct. Second, at points where two airstreams merge, the duct sections must join in a way that maintains this velocity.

If your plant handles a combustible dust, a visiting OSHA inspector will ask whether the conveying air velocity through your dust collection system is adequate — and will ask you to prove it. Why is this velocity important? Keeping the conveying air velocity in every part of the duct within a reasonable range will prevent two problems: Too low an air velocity will cause the dust to drop out of the air and build up inside the duct, and, depending on the dust's characteristics, too high an air velocity will waste energy, erode the duct, or, if the dust is moist or sticky, cause the dust to smear on the duct wall.

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A conveying air velocity between 3,500 and 4,000 fpm (17.5 and 20 m/s) is a reasonable starting point for designing your system. Then, based on supporting data about your application, you can speed or slow the conveying air to the system's optimal velocity. For instance, if your system handles an extremely fine, lightweight material that won't clump together, like cotton dust, you can slow the velocity to 3,000 fpm; if you handle a very heavy material, like lead dust, you may need to increase the velocity to 4,500 to 5,000 fpm. For guidance in determining the optimal velocity for your application, see Table 5-1 in the American Conference of Governmental Industrial Hygienists' *Industrial Ventilation: A Manual of Recommended Practice for Design* (26th edition, 2007),⁶ which lists minimum duct design air velocities for many dusts.

How duct sections are joined in your system also affects the conveying air velocity. If incorrectly designed, the point where ducts join to merge two airstreams can slow the air velocity, in turn causing the dust to drop out and accumulate in the duct. You can prevent this problem by connecting each branch duct to a 15-degree tapered expansion on the main duct, which enlarges the main duct diameter to a size appropriate for the merged airstreams. A related problem is that dust particles can drop out of the airstream when a branch duct joins the main duct at too great an angle. The momentum of the conveyed dust particles causes them to want to move in a straight line, so when one duct joins another at a sharp angle, the particles have to

change direction and slow down. Avoid this problem by designing the branch duct entry with no more than a 30-degree angle to the main duct.

Failing to practice these duct design principles can lead to any of several problems that produce a slower-than-required conveying air velocity in your ducts. Following are some visual clues that indicate the air velocity in the ducts isn't high enough to prevent dust from dropping out of the air. Under each clue, ways to remedy the problem and get adequate conveying air velocity through the ducts are described.

Clue 1: Main duct diameter doesn't enlarge after branch junctions. In Figure 2a, two 8-inch-diameter branch ducts join an 8-inch-diameter main duct, and the main duct's downstream diameter is the same after each junction. At A, before the first branch junction, the 4,200-fpm air velocity required to convey the dust is reasonable and can be achieved by the system's design airflow of 1,500 cfm. But because the duct diameter doesn't enlarge after the branch junctions, the required air velocity increases exponentially: It's 8,400 fpm at B, after the first branch junction, which would require a 3,000-cfm airflow, and it's 16,800 fpm at C, after the second junction, which would require a 4,500-cfm airflow. However, 5,500 fpm is the practical upper limit for air velocity in system ductwork. To meet the velocity requirements in this duct arrangement, the system would require a major upgrade of the exhaust fan and electric power, which is impractical.

Solution: The more economical solution is to enlarge the downstream duct. This will solve the problem that results from not upgrading the exhaust fan — that is, that C gets most of the airflow, B gets some, and A gets very little. To ensure that the duct's diameter is large enough after a branch duct joins it, follow this rule of thumb: The sum of the areas of the upstream branch ducts should roughly equal the area of the downstream duct. Based on the equation $duct\ area = \pi \times (diameter/2)^2$, this rule can be restated as: the sum of the squares of the upstream branch duct diameters should roughly approximate the square of the downstream main duct diameter. Thus, at B:

$$8^2 + 8^2 = 128 \sim 11^2 \text{ or } 121$$

so the main duct diameter at B should be changed to 11 inches. Then, at C, two solutions are possible:

$$11^2 + 8^2 = 185 \sim 13^2 \text{ or } 169$$

$$11^2 + 8^2 = 185 \sim 14^2 \text{ or } 196$$

so the main duct diameter at C should be changed to 13 or 14 inches, depending on your application's conveying velocity requirements.

Clue 2: Main duct is blanked off. In Figure 2b, an 8-inch-diameter main duct, A, is blanked off. A 4-inch-diameter branch duct, B, joins the main duct at a Y junction that en-

larges from 8 to 9 inches, and the downstream main duct, C, is 9 inches in diameter. Before the blank flange was installed, the system's design airflow met the air velocity requirements at A (4,200 fpm [1,500-cfm airflow]), B (3,900 fpm [350-cfm airflow]), and C (4,100 fpm [1,850-cfm airflow]). But with A blanked off, the required air velocity through the 4-inch-diameter duct (B) is now 3,900 fpm (350-cfm airflow). The exhaust fan might be able to pull an airflow of no more than 600 cfm through B and C, which would drop the air velocity at C from the required 4,100 fpm to 270 fpm.

Solutions: Two solutions are possible: You can replace all the duct between B and the system's dust collector with smaller duct to achieve an adequate conveying velocity. Or, as a much cheaper alternative, you can remove the blank flange and replace it with an orifice plate that delivers 1,500-cfm airflow at the system's available static pressure; the orifice plate has a hole at its center that's sized to meet the system's airflow and pressure drop requirements.

Clue 3: Poor duct junctions don't maintain conveying velocity. Let's look at two examples of this problem. In the first, shown in Figure 2c, an 8-inch-diameter duct section abruptly joins a 20-inch-diameter section. At the system's 1,400-cfm design airflow, the conveying air velocity is 4,000 fpm in the 8-inch section, but it drops abruptly to 650 fpm in the 20-inch section, which will cause the dust to drop out of the air. **Solution:** In this case, the solution is to replace the 20-inch duct section with 8-inch duct. The duct diameter should stay at 8 inches until the next branch junction; after that junction, the duct should be enlarged to maintain the air velocity, following the rule of thumb under Clue 1.

Another poor duct junction is shown in Figure 2d. Here, an 8-inch-diameter branch duct, A, joins an 8-inch-diameter main duct at a 90-degree angle, forming a T junction. The system's 1,400-cfm design airflow can produce the required 4,000-fpm conveying air velocity through A and section B upstream from the junction without a problem. But section C downstream from the junction would require 8,000 fpm (at an airflow of 2,800 cfm) to convey the dust through the duct and past the T junction. Meeting this impossibly high air velocity requirement would demand an unreasonably high fan energy, and the duct at both B and C would probably plug with dust. **Solution:** In this case, replacing the T junction with a 30-degree Y junction that enlarges to a downstream diameter of 11 inches (again following the rule of thumb in Clue 1) will maintain the system's 4,000-fpm conveying air velocity.

Clue 4: Ductwork includes too much flexible hose. In Figure 2e, flexible hose has been used in place of metal duct as a quick way to connect two duct sections. However, dust builds up more easily on the hose's corrugated inside surface than on smooth metal duct. The hose's internal resistance also is more than twice that of smooth metal

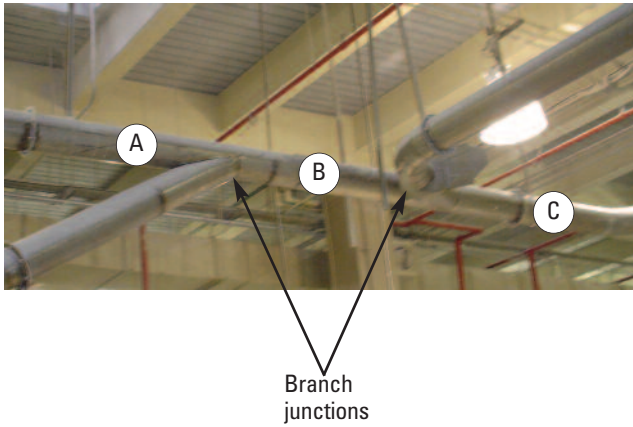
duct, so with the hose bends acting as elbows, the hose's equivalent length is much greater than its actual length. The system's exhaust fan may not be large enough to pro-

vide the speed necessary to overcome this additional air-flow resistance, and the result is low air velocity that causes dust to drop out of the air and plug the ducts.

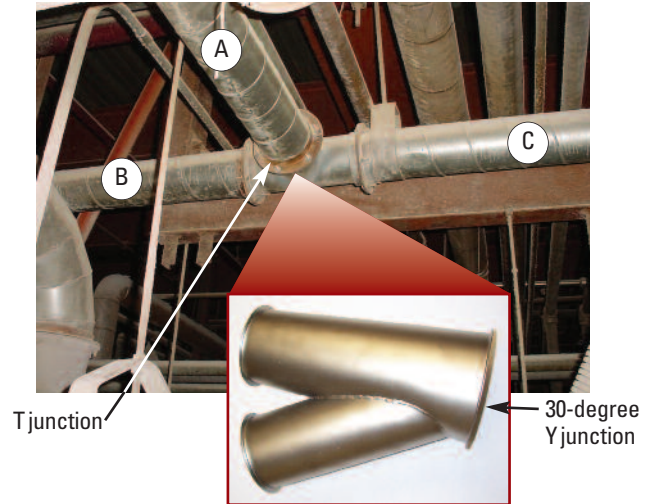
Figure 2

Visual clues to duct problems that cause dust accumulation

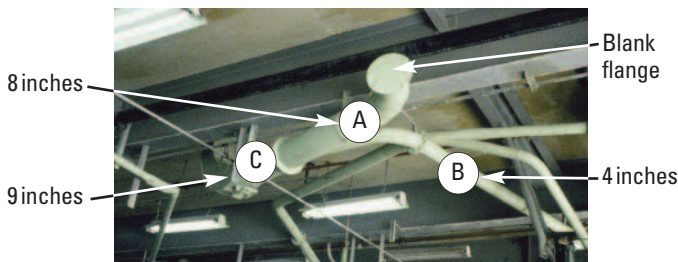
a. Main duct diameter doesn't enlarge after branch junctions



d. Branch duct joins main duct at T junction



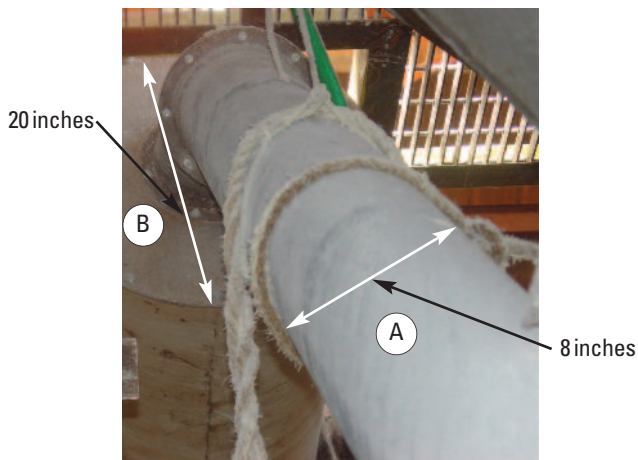
b. Main duct is blanked off



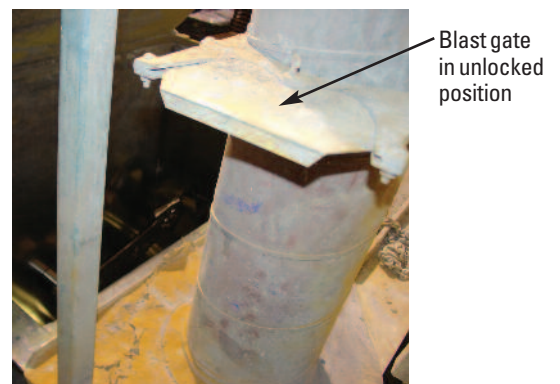
e. Ductwork includes too much flexible hose



c. Smaller-diameter duct abruptly joins larger-diameter duct



f. Duct blast gate isn't locked in position



Solution: Replace the flexible hose with sections of metal duct that are clamped together. You should use flexible hose in the system only with equipment that must move, such as connecting metal duct to the capture hood for a loss-in-weight feeder that rests on load cells; see NFPA 654 for more information.

Clue 5: Duct blast gate isn't locked in position. Blast gates in ducts add artificial airflow resistance to balance the airflow in individual duct branches. For each blast gate, only one position is correct to balance the airflow in all branches. In Figure 2f, the blast gate has been adjusted to send more airflow into this branch, which steals airflow from other branches.

Solution: Set this and other duct blast gates to meet the system's design airflow and then lock the gates in place. You can avoid this problem altogether by designing the dust collection system for the correct airflow balance without using blast gates, which is called *balance by design*.

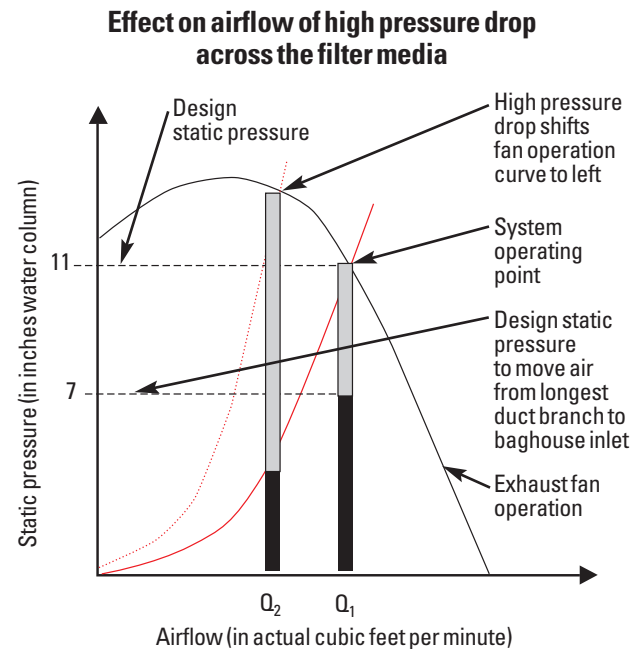
Clue 6: The pressure drop across the filter media is higher than the design pressure drop. Figure 3 shows the airflow resistance increasing in a baghouse dust collection system in which the pressure drop across the bag filter media exceeds the design pressure drop. (Pressure drop, or *differential pressure*, is the difference in the static pressures measured on the clean and dirty sides of the dust collector; the more dust collected on the filters, the higher the pressure drop will be.) In Figure 3, the design pressure drop across the bag filters is the system's design static pressure (11 inches water column) minus the static pressure required to move the air from the longest branch duct to the baghouse inlet (7 inches), which equals 4 inches water column. The line Q_1 represents the design airflow the fan should deliver, with the line's top white portion representing the design pressure drop though the media. But Q_2 represents the airflow the fan actually delivers, which is lower than the design level because the actual pressure drop through the media (shown by the line's white portion) exceeds the design level, increasing airflow resistance.

The system exhaust fan's operating curve shows how much air the fan can move (airflow, represented by the horizontal axis) at different static pressures (on the vertical axis). As you can see, this curve shifts to the left of the system operating point — showing that the fan delivers less airflow than the system requires — because the higher pressure drop has increased the airflow resistance across the system. Because the fan can't deliver the required airflow, the conveying air velocity in the ductwork slows and leads to more dust dropping out in the ducts.

Solutions: The solution to high pressure drop across the media depends on your application. Assuming you've selected the right air-to-cloth ratio (the airflow in cubic feet

per minute divided by the square feet of filter media surface area) for your dust collector, properly starting up the collector when the new filters are installed will provide the best long-term performance. Once the new filters are in-

Figure 3



stalled, you should also condition them (also called *pre-coating* or *seeding*) before your dust collection system goes back online; this will build up an initial dust cake on the media that resists blinding and prevents high pressure drop. (For more information, see reference 7.) With older filters, increasing the cleaning frequency or replacing the filters more often can control the pressure drop across the media. Another solution is to replace your filters with ones that have a larger surface area to better handle your dust-laden airflow.

Clue 7: Dust cloud is first sign of trouble. Figure 4 shows a dust cloud surrounding a vibrating conveyor that delivers powder to a sifter; the cloud has developed because the capture hood over the equipment isn't drawing the dust-laden air into the dust collection system. The dust cloud — a potential explosion hazard — could be the result of duct plugging, filter blinding, or other problems, any of which could reduce airflow through the system. Unfortunately, this dust cloud is the first sign of trouble because the dust collection system pressure, airflow, and other data aren't monitored.

Solution: You need to make routine measurements of static pressure and airflow at appropriate points in the dust collection system, as well as measure each capture hood's face velocity (the air velocity at the inlet opening). Such system monitoring will reveal any changes in pressure, air-

flow, or face velocity from the system's baseline performance data. By helping you spot such changes early, monitoring allows you to catch a small problem before it can create a hazardous dust cloud in your process area.

What is *baseline performance data*? It's documented proof of your dust collection system's performance at startup (or after any significant system modification), which demonstrates that the system can deliver the design airflow at every capture hood or other dust-controlled opening. This is one of the requirements of *NFPA 91: Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids* (2004)², which is incorporated by reference into NFPA 654. In addition to verifying the system design, the baseline data provides a reference point for system monitoring. Baseline data documentation is powerful evidence to show an OSHA inspector that your system has adequate conveying velocities. The design documentation you should keep on file includes the system schematic, a table listing locations and dimensions of air-balancing devices (such as blast gates), the as-built system's static pressure balance calculations for sizing the exhaust fan, and the design bases and specifications for system equipment. (For more information, see reference 8.) Turning the baseline performance data over to the operators once the system is online allows them to use the data to monitor system performance and keep the system working over the long term.

In some cases, comparing this baseline data to current operating data may help you determine that the original system design can no longer handle your application's changed field conditions and requirements. In this case, you'll have to redesign the system to meet the new requirements. Several situations requiring you to test the dust collection system to demonstrate that it works as designed are listed in NFPA 91. **PBE**

Next month: In Part II, sections will cover how to eliminate ignition sources in the system and how to use explosion prevention and protection methods at the collector. A final section will explain how to meet additional NFPA requirements.

References

1. The OSHA National Emphasis Program (NEP) directive on safely handling combustible dusts is available at http://www.osha.gov/OshDoc/Directive_pdf/CPL_03-00-008.pdf.
2. Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471; 800-244-3555, fax 617-770-0700 (www.nfpa.org).
3. Rolf K. Eckhoff, *Dust Explosions in the Process Industries*, Elsevier Publishing, third edition, 2003; available from the PBE Bookstore at www.powderbulk.com.
4. Lee Morgan and Terry Supine, "Five ways the new explosion venting requirements for dust collectors affect you," *Powder and Bulk Engineering*, July 2008, pages 42-49; see "For further reading" for information on purchasing a copy of this article.

Figure 4

Lack of system monitoring makes dust cloud first sign of trouble



5. *Investigation Report: Combustible Dust Hazard Study*, Report 2006-H-1, US Chemical Safety and Hazard Investigation Board, November 2006 (www.chemsafety.gov).
6. Available from American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240; 513-742-6163, fax 513-742-3355 (www.acgih.org, mail@acgih.org).
7. Ed Ravert, "Precoating new filters for better airflow, longer filter life," *Powder and Bulk Engineering*, October 2006, pages 27-33; see "For further reading" for information on purchasing a copy of this article.
8. Gary Q. Johnson, "Dust control system design: Allowing for your range of process conditions and establishing baseline performance values," *Powder and Bulk Engineering*, October 2005, pages 39-48; see "For further reading" for information on purchasing a copy of this article.

For further reading

Find more information on designing dust collection systems and preventing dust explosions in articles listed under "Dust collection and dust control" and "Safety" in *Powder and Bulk Engineering's* comprehensive article index (later in this issue and at PBE's Web site, www.powderbulk.com) and in books available on the Web site at the PBE Bookstore. You can also purchase copies of past PBE articles at www.powderbulk.com.

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Designing your dust collection system to meet NFPA standards — Part II

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About 40 percent of combustible dust explosions reported in the US and Europe over the last 25 years have involved dust collectors. Dust collection systems are now a primary focus of inspections required by OSHA's National Emphasis Program on safely handling combustible dusts.¹ OSHA also has the authority to enforce National Fire Protection Association (NFPA) standards for preventing or protecting against dust explosions. This two-part article focuses on how you can design your dust collection system's dust collector, ductwork, and exhaust fan to meet the intent of these NFPA requirements. Part I (December) covered dust explosion basics and how to prevent dust accumulation in system ductwork; Part II covers how to eliminate ignition sources in the system, how to use explosion prevention and protection methods at the collector, and how to meet additional NFPA requirements.

Eliminating ignition sources

Grounding the system equipment, selecting electrical components for your hazardous area classification, and protecting the exhaust fan are all ways to eliminate ignition sources in your dust collection system.

Grounding equipment. To prevent a static electrical discharge from providing an ignition source for a dust explosion, you must ground the dust collector and its components, the ductwork, the exhaust fan, and other system components to dissipate static electricity. This in-

cludes selecting filters with integral grounding straps that provide a grounding path between the filter and the tubesheet, which also must be grounded. Component materials must be conductive, as well. Don't select duct made of plastic, which is nonconductive. If your ductwork includes flexible hose, the hose should be molded with grounding wires, and you must clamp these wires to the upstream and downstream metal ducts to ground the hose. Examples of how to ground typical system components are shown in Figure 1.

The grounding wires on various components should be visible to operators so they can quickly check that the grounding is in place. Operators should also routinely check the resistance to ground in the wires to ensure that it's less than 10^6 ohms. You can find more information on how to use grounding to minimize these electrostatic hazards in *NFPA 77: Recommended Practice on Static Electricity* (2007).²

Selecting electrical components for your hazardous area classification. You'll also need to choose electrical components for your dust collection system that are certified for use in your hazardous location, as detailed in *NFPA 499: Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas* (2008).² In the US, this certification is provided by Underwriter Laboratories and Factory Mutual. The type of hazardous protection your electrical components must have — such as being dust-ignition-proof or mounted in dust-tight enclosures — depends on the explosion risk in your system's location, and these hazardous locations are rated by classes, divisions, and groups. Hazardous locations with combustible dust are Class II. In Class II, Division I, locations, the dust is present

during normal conditions, and in Class II, Division 2, locations, the dust is present only in abnormal conditions, such as a system breakdown. The additional group subclassification depends on the type of dust in the surrounding environment: for example, Group E is for metal dusts, Group F is

explosion prevention or protection method, including venting, suppression, isolation, and others. Explosion venting is covered in *NFPA 68: Standard on Explosion Protection by Deflagration Venting* (2007), and suppression, isolation, and other methods are covered in *NFPA 69:*

Figure 1

Grounding system components to eliminate ignition sources

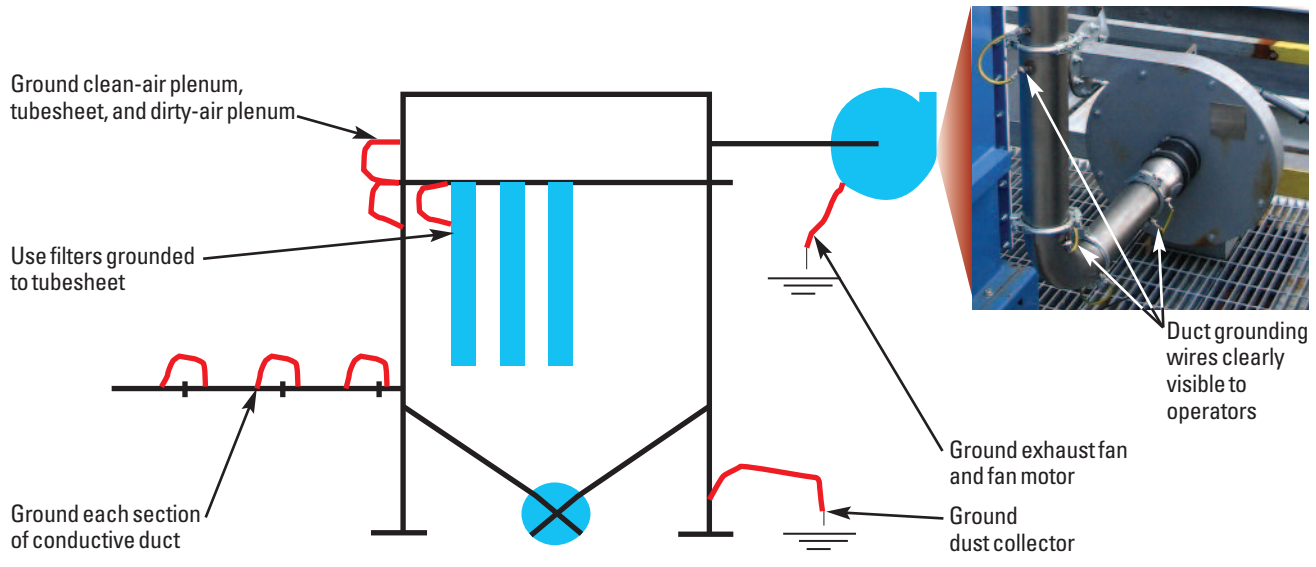


Photo courtesy of J.O.A., North America, Charlotte, N.C.

for carbonaceous dusts, and Group G is for all other dusts. To determine the right hazardous area classification for your system’s electrical components, consider your dust type, dust quantity, whether the system’s dust collector is inside or outside, and related factors.

Protecting the exhaust fan. If your exhaust fan fails mechanically, the fan impeller can shift and rub or hit the housing. A spark from such metal-to-metal contact has enough energy to ignite a combustible dust. To avoid this hazard, you should do two things: First, place the exhaust fan on the dust collector’s clean side, where it can’t contact dust under normal conditions, as detailed in *NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* (2006).² Second, train and equip your operators to practice good dust collector maintenance so they can spot filter leaks early and replace the affected filters before dust can escape the system. One tool available from multiple suppliers for helping the operators spot filter leaks before they cause a problem is a filter-leak detection system; the system uses an inductive or triboelectric probe inserted into the system ductwork to sense particles escaped from a leaking filter.

Using explosion prevention and protection methods at the collector

To meet NFPA requirements for protecting your dust collector from a dust explosion, you must use one (or more)

Standard on Explosion Protection Systems (2008).² You can see a dust collector equipped with various explosion prevention and protection devices in Figure 2.

Of the several ways to meet NFPA 68 requirements for protecting your dust collector from an explosion, explosion venting is the most common. NFPA 68 venting requirements are described in detail in the *PBE* article “Five ways the new explosion venting requirements for dust collectors affect you.”³ As the article states: “The purpose of explosion venting is to save lives, not property. A well-designed explosion vent functions as a weak element in the equipment’s pressure envelope, relieving internal combustion pressure to keep the collector from blowing up into pieces. ...Typically, the collector is located outside and designed to vent away from buildings and populated locations.” Additional venting information in the article highlights NFPA 68 areas that have changed or are of most importance to bulk solids processors, including the performance-based design option and sizing vents and discharge ducts.

If your dust collector is indoors and can’t be vented outside through an exterior wall or ceiling, you must equip it with an explosion prevention method, such as a suppression system, that can prevent a dust explosion from propagating to connected equipment. You can use any of several systems described in NFPA 69. One common example is a chemical suppression system, which senses a developing explosion in the dust collector and rapidly injects a chemi-

cal powder into the developing fireball to stop the flame front; this can be a useful retrofit for a collector located indoors and too far from an outside wall to allow explosion

lates cleaned air to the workplace. Placed on the dust collector's clean-air side between the fan and collector or after the fan, the float valve works like a ball check valve

Figure 2

Dust collector equipped with explosion prevention and protection devices



Photo courtesy of I.O.A., North America, Charlotte, N.C.

venting. Another suppression system injects a hot-water mist into the collector to stop the flame front from traveling to upstream equipment. For a dust collection system that's part of a closed-circuit process, you may consider an explosion prevention method that uses nitrogen to inert the dust collection system; using nitrogen inerting in a closed-circuit application minimizes nitrogen consumption, which otherwise would be prohibitively expensive.

NFPA 69 also describes methods for isolating upstream and downstream equipment from an explosion in the dust collector. One common example is a flame-front diverter, which is an explosion vent in the duct (Figure 2). The diverter is typically placed at the dust collector's dirty-air inlet when the collector is located near the dust collection system's exhaust fan and ductwork. When an explosion occurs in the collector, the flame-front diverter's vent opens and releases the explosion to the atmosphere, thus isolating other equipment from the flame front. Another isolation device is a high-speed isolation valve, which is located in the dirty-air duct and wired to an explosion detector in the collector. The valve's location on the duct is far enough from the explosion detector to allow the detector to respond to an explosion and close the valve before the flame front can reach upstream equipment. A float valve (Figure 2) is another isolation device that protects the exhaust fan or the ventilation equipment that recircu-

— that is, it's pushed shut by the pressure and airflow changes caused by an explosion in the collector.

Meeting additional NFPA requirements

According to our industry's current interpretation of the NFPA standards covering dust collection system design, you don't have to update equipment in your system each time a particular standard is updated unless your location's *authority having jurisdiction* ("an organization, office, or individual responsible for enforcing the requirements of a code or standard" [NFPA 68]) decides otherwise. However, the standards require you to follow certain procedures related to maintenance, housekeeping, explosion protection, and managing system changes, and you must implement the procedures *retroactively*.

Here are some of the key retroactive requirements in NFPA 68, 69, and 654:

- You must provide both initial training and refresher training to employees on the established operating and maintenance procedures for your dust collection system and explosion prevention and protection equipment.
- You must provide housekeeping and cleaning for the dust collection system and surrounding area using procedures (such as vacuum cleaning) that minimize dust-cloud generation and at a frequency that minimizes dust accumula-

tion in your workplace. The portable vacuum cleaners you use must meet Class II hazardous location requirements when operated in a combustible dust hazard area.

- You must ensure that all dust collection system components are conductive, bonded (to protect workers from electric shock), and grounded to a resistance of less than 10^6 ohms.
- You must inspect, test, and maintain the dust collection system and its explosion prevention and protection equipment according to the manufacturer's recommendations. You also must keep records of these inspections and tests and sign off on them.
- You need to establish change management procedures for the dust collection system and its explosion prevention and protection equipment and address related technical issues before making any system changes; after a system change, you must update the system's design documentation to reflect the change.

Also be aware that if equipment in your dust collection system has changed *or* the dust collected by your system has changed since you initially tested the dust for combustible properties and conducted a hazard analysis of your system, you must revisit the hazard analysis to see if you need to change any of the system's explosion risk mitigation strategies, such as explosion vent size and location. Don't forget that NFPA requires that you keep the hazard analysis up to date for the life of the process it protects and that you review and update the analysis at least once every 5 years. **PBE**

References

1. The OSHA National Emphasis Program (NEP) directive on safely handling combustible dusts is available at http://www.osha.gov/OshDoc/Directive_pdf/CPL_03-00-008.pdf.
2. Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471; 800-244-3555, fax 617-770-0700 (www.nfpa.org).
3. Lee Morgan and Terry Supine, "Five ways the new explosion venting requirements for dust collectors affect you," *Powder and Bulk Engineering*, July 2008, pages 42-49; see "For further reading" for information on purchasing a copy of this article.

For further reading

Find more information on designing dust collection systems and preventing dust explosions in articles listed under "Dust collection and dust control" and "Safety" in *Powder and Bulk Engineering's* comprehensive article index (later in this issue and at *PBE's* Web site, www.powderbulk.com) and in books available on the Web site at the *PBE* Bookstore. You can also purchase copies of past *PBE* articles at www.powderbulk.com.

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