Five ways new explosion venting requirements for dust collectors affect you

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This article sums up what you need to know about the new NFPA 68 standard on explosion venting for combustible dusts. The information here can help you better understand what's changed in this revised standard and how it will affect your dust collection choices today and in the future.

The topic of combustible dust hazards in bulk solids processing plants has never been more — pardon the expression — *explosive*. In February this year, a dust cloud explosion triggered a fatal blast and fire in the Imperial Sugar Company's Wentworth, Georgia, plant, generating a storm of media attention, public outcry, and governmental scrutiny. The blast, while more severe than most, was reportedly not a freak incident but the latest in a 25-year string of similar incidents at manufacturing facilities around the US.

Since February, OSHA has contacted 30,000 companies that deal with combustible dusts, warning them of the danger of a deadly explosion if airborne dust particles contact an ignition source. On May 1, Congress passed legislation granting OSHA immediate authority to enforce National Fire Protection Association (NFPA) standards as law and gave OSHA 1 year to make its own laws relating to explosive dust in factories.

Explosions are a risk in many areas of a bulk solids processing plant, including the plant's dust collection system. The current industry focus on dust explosion hazards makes it a good time to examine the newly revised NFPA standard focusing on this topic, *NFPA 68: Standard on Explosion Protection by Deflagration Venting,* and discover how it will affect your dust collection system. This standard, completely revised in 2007, is in effect now. You can purchase a copy of the full standard from the NFPA Web site.[1]

This article's intent is to help you better understand what's changed in this revised standard and how it will affect your current and future dust collection choices. The following information reflects our best efforts at this time to comprehend and interpret NFPA 68 as it relates to dust collection systems that use closed-vessel (cartridge and baghouse) dust collectors. This interpretation — and eventually, the standard itself — will likely continue to evolve as industry experience with explosion protection grows over time.

The revised NFPA 68 affects how you handle your plant's combustible dust in five key ways:

1. NFPA 68 has changed from a "guideline" to a "standard."
2. You need to determine whether your dust is explosive.
3. You need to commission a hazard analysis of your dust collection system.
4. You need to maintain extensive documentation.
5. You need to schedule an annual inspection of the dust collection system's explosion venting equipment.

Let's examine each of these topics in detail. As you read the following information, it may be helpful to refer to the related sidebar, "NFPA 68: A glossary of selected terms," which defines the NFPA 68 terms used in this article.

1 NFPA 68 has changed from a "guideline" to a "standard."

NFPA 68 now includes mandatory requirements for dust collection applications with combustible dusts. This change from a "guideline" to a "standard," which incorporates much more stringent requirements than past editions, is echoed by OSHA's recent launch of its National Emphasis Program (NEP) on safely handling combustible dusts. Simply stated, it's NFPA's role to set the standard and the role of OSHA and local authorities to enforce it.

Most insurance agencies and local fire codes state that NFPA standards shall be followed as code, so in nearly every US town and county, NFPA 68 is to be treated as legal code. The only exceptions are where the authority having jurisdiction (AHJ) specifies another safety approach, such as Factory Mutual.

OSHA defines combustible dusts as *"organic or metal dusts that are finely ground into very small particles, fibers, chips, and/or flakes. These dusts can come from metal, wood, plastic and organic materials such as grain, flour, sugar, paper, soap and dried blood. Dusts can also come from textile materials. Some of the industries in which combustible dusts are particularly prevalent include agriculture, chemical, textile, forest [and] furniture...."* The OSHA NEP directive on safely handling combustible dusts is available on the organization's Web site.[2]

What does all this mean to you and other bulk solids plant managers and engineers? In many cases, you will now have to install updated dust collection and explosion venting equipment to ensure that your plant complies with the new requirements.

2 You need to determine whether your dust is explosive.

In a closed vessel such as a dust collector, an explosion usually begins when a suspended cloud of combustible dust is present in high concentration inside the collector. As the fan draws in large volumes of air, an outside spark or ember can be sucked into the collector and collide with the dust cloud under pressure, triggering an explosion. The spark's source may be a production process, a cigarette butt thrown into a dust capture hood (believe it or not, this really happens), or a static electricity discharge from improperly grounded nearby equipment.

In describing the standard's scope in Chapter 1, NFPA 68 says that it *"applies to the design, location, installation, maintenance, and use of devices and systems that vent the combustion gases and pressures resulting from a deflagration within an enclosure so that structural and mechanical damage is minimized"* (1.1) and *"the standard applies where the need for deflagration venting has been established"* (1.3).

The important point here is to determine whether your application requires deflagration venting. And that, in turn, requires you to determine whether your dust is considered explosive. A dust's explosive power is the dust cloud's deflagration index (that is, the rate of pressure rise), denoted as "K_{St}." Both NFPA and Factory Mutual use this value in formulas to calculate the amount of explosion vent area required for a dust collector.

NFPA classifies dusts according to their explosibility — that is, their K_{St} values. Class 1 dusts are rated below 200 K_{St}, Class 2 dusts range from 200 to 300 K_{St}, and Class 3 dusts are rated above 300 K_{St}. As a rule of thumb, when dusts approach 600 K_{St}, they're so explosive that wet collection methods are recommended. In addition to K_{St}, other important measurements that factor into the standard include "P_{max}," the maximum pressure developed in a contained explosion (or in a contained deflagration of an optimum mixture), and "P_{red}," the maximum pressure developed in a vented enclosure during a vented deflagration.

The need for explosion venting can be dismissed *only* when a dust is known to be inert (that is, it has a 0 K_{St} value). Limestone, fume silica, and rock dust are examples. Even Class 1 dusts with relatively low K_{St} values (such as 50) are considered explosive. *Therefore, if your dust's K_{St} value is greater than zero, you must follow NFPA 68 requirements and use explosion venting in your dust collector.*

The K_{St} values of several common dusts are listed in Table I. For a much more comprehensive compendium, go to http://www.hvbg.de/e/bia/gestis/expl/index.html. This Web site contains a European database known as *GESTIS-DUST-EX* that lists the combustion and explosion characteristics of more than 4,000 dusts from virtually all industry sectors.

As you prepare to update existing or install new dust collection equipment, your equipment supplier may ask you to do one of two things: 1) supply in writing the K_{St} value you know your dust doesn't exceed, or 2) supply a report of the dust's K_{St} value based on your dust tests.

Pharmaceutical applications are an example of the first option. Pharmaceutical manufacturers sometimes can't determine the K_{St} of a new product because it hasn't been manufactured yet, so they'll go with a conservative estimate of 300 K_{St} or even higher to be on the safe side. On the other hand, if you have a dust sample but aren't completely certain of its K_{St}, you should go with the second option and test the dust. In fact, NFPA 68 advises that *all* dusts be tested, and the standard clearly dictates that you, the end user, and not the equipment supplier, is responsible for establishing the dust's K_{St} value. Your dust collector supplier can provide a list of dust testing facilities for this purpose.

A standard explosion vent that has been sized for 200 K_{St} dust and manufactured according to NFPA standards is shown on a cartridge dust collector in Figure 1. For highly combustible dusts, vent sizing and vent discharge ducting requirements become more complex and may require special calculations and equipment modifications to achieve compliance. (For more information, see the later section "How NFPA 68 will affect your explosion venting design.")

NFPA 68:

A glossary of selected terms

Here are definitions from NFPA 68 for terms used in this article.

Authority having jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

Combustible dust. A combustible particulate solid that presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentration, regardless of particle size or shape.

Deflagration. Propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium.

Dust. Any finely divided solid, 420 microns or 0.017 inch or less in diameter (that is, material capable of passing through a U.S. No. 40 Standard sieve).

Enclosure. A confined or partially confined volume.

Explosion. The bursting or rupturing of an enclosure or a container due to the development of internal pressure from a deflagration.

K_{St}. The deflagration index of a dust cloud.

Maximum pressure (P_{max}). The maximum pressure developed in a contained deflagration of an optimum mixture.

Reduced pressure (P_{red}). The maximum pressure developed in a vented enclosure during a vented deflagration.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Non-mandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Vent. An opening in an enclosure to relieve the developing pressure from a deflagration.

Vent closure. A pressure-relieving cover that is placed over a vent.

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3 You need to commission a hazard analysis of your dust collection system.

Chapter 4 in NFPA 68 introduces a new hazard analysis requirement that states *"the design basis deflagration hazard scenario shall be identified and documented"* (4.2.3.1) and *"a documented risk evaluation acceptable to the AHJ shall be permitted to be conducted to determine the level of protection to be provided"* (4.2.3.2).

This means that you'll have to commission a hazard analysis (also called *risk evaluation*) of your plant's dust collection system and keep the report on file to show to the local fire marshal or other AHJ at a moment's notice. It's possible that some equipment suppliers or independent sales reps may start to offer these analyses. Given how time-intensive a hazard analysis is, however, we anticipate that a whole cottage industry of consultants will spring up to meet the newly created demand.

4 You need to maintain extensive documentation.

A hazard analysis isn't the only documentation required by NPFA 68. In Chapter 11, the standard lists 19 documents that you must now maintain on file to satisfy the local fire marshal or other AHJ. Some of these — such as suppliers' equipment data sheets and drawings, instruction

Table I

K_{St} values for common dusts

Dust	Size (in microns)	K_{St} value
Activated carbon	18	44
Aluminum grit	41	100
Aluminum powder	22	400
Asphalt	29	117
Barley grain dust	51	240
Brown coal	41	123
Charcoal	29	117
Cotton	44	24
Magnesium	28	508
Methyl cellulose	37	209
Milk powder	165	90
Paper tissue dust	54	52
Pectin	59	162
Polyurethane	3	156
Rice starch	18	190
Silicon	10	126
Soap	65	111
Soy bean flour	20	110
Sulfur	20	151
Tobacco	49	12
Toner	23	145
Wood dust	43	102

manuals, and specifications — are readily obtained. Obtaining others — including a combustible material (dust) properties test report, user documentation of conformity with applicable standards, and employee training requirements — will present a more substantial challenge to you or the plant or safety engineer in charge.

5 You need to schedule an annual inspection of your dust collection system's explosion venting equipment.

Chapter 11 also stipulates that your explosion venting equipment must be inspected at least annually and possibly more often, based on your documented operating experience. This inspection's objective is simply to determine that all of the system's components are operating correctly. The chapter outlines a 16-point vent inspection with this objective in mind (11.4.4). Your plant owner or operator must also verify in writing that your process material hasn't changed since the last inspection (11.4.5). You must file the inspection reports with your other required documentation (11.2).

For inspections and documentation, responsibility again rests with you, the end user. Although the new requirements are challenging for everyone, they will be especially taxing for smaller bulk solids plants that don't have a dedicated safety engineer.

How NFPA 68 will affect your explosion venting design

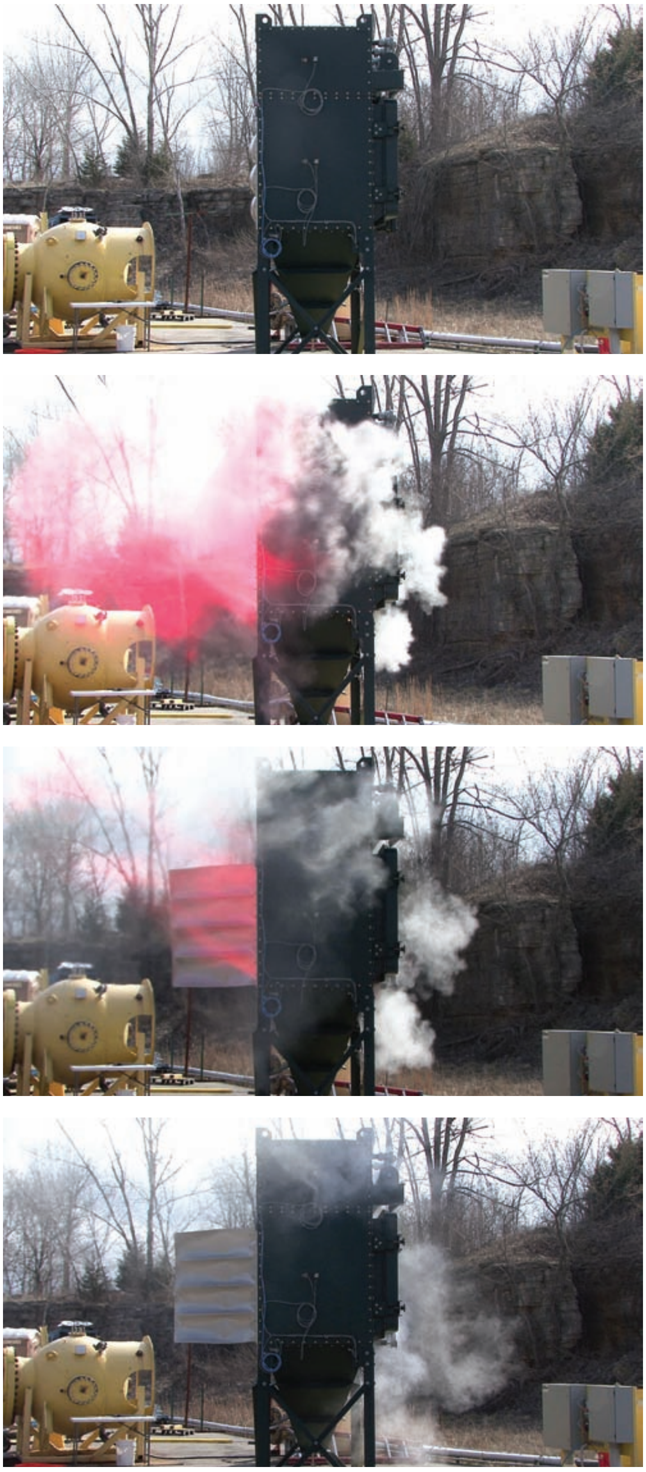
When a dust collector is designed with explosion venting, the primary purpose is to save lives, not property. A well-designed explosion vent functions as a weak element in the equipment's pressure envelope, relieving internal combustion pressure (back pressure) to keep the collector from blowing up into pieces. The vent's function is illustrated in Figure 2, a series of photos showing a staged deflagration in a cartridge dust collector equipped with an explosion vent. Typically, the collector is located outside and de-

Figure 1

Explosion vent designed according to NFPA 68

Figure 2

Staged deflagration in cartridge dust collector with explosion venting



signed to vent away from buildings and populated locations, as shown in Figure 3.

While explosion venting will usually save the dust collector from being a total loss, the collector can still sustain major internal damage. Nonetheless, if personnel remain safe, the explosion venting equipment has done its job.

NFPA 68 includes several chapters with detailed information on design requirements for explosion venting equipment. In the following subsections, rather than attempt to summarize all of these requirements we'll instead focus on the most important areas that have changed or are of most concern to bulk solids processors.

Performance-based design option. Chapter 5 in NFPA 68 describes a performance-based design option, which specifies that if another method for protecting your dust collector from explosions is acceptable to the AHJ, you can use that method instead of one specified in NFPA 68. You must document and maintain this optional design method and its data sources over the collector's service life.

An example of a performance-based design option is conducting actual explosion tests of your dust collector to show that it will stand up to certain pressure conditions, instead of using the back-pressure calculations for collectors in NFPA 68. Some dust collector suppliers can provide this testing using a combination of field tests and full-scale dust collector laboratory tests. This approach can sometimes yield more accurate real-world performance data than the calculations provided in NFPA 68.

Sizing vents and vent discharge ducts. For many years, explosion vents were sized using simple ratios — that is, for a given dust collector volume, 1 square foot of explosion vent area was needed. The agricultural and wood products industries were among those that commonly used these ratios. However, these old formulas no longer apply; instead, you must use the new design criteria in NFPA 68.

Chapters 7 through 9 provide the calculations you now must use for properly sizing explosion vents, vent discharge ducts (also called *vent ducts*), and other components. A reputable dust collector supplier will follow the vent sizing equations in Chapter 8 and be able to supply a calculations sheet that becomes part of the documentation you keep on file to prove your plant's compliance.

Regarding vent discharge ducts, Chapter 6 stipulates that *"vent ducts and nozzles with total lengths of less than one hydraulic diameter shall not require a correction to increase the vent area"* (6.8.4). (*Hydraulic diameter* expresses a noncircular opening's area.) This means, for example, that if you have an explosion vent with a hydraulic diameter of 40 inches, you can use a 40-inch-long vent discharge duct without risking damage to the collector from increased back pressure. However, for a duct more than 40 inches long (or whatever length is equivalent to the vent's hydraulic diameter), you must follow much more stringent calculations for vent size to compensate for the estimated increase in back pressure to the collector.

Therefore, when you require longer vent discharge ducts — such as when the collector will be located inside — and the standard calculations no longer apply, you'll have to work with your supplier to verify your dust's K_{St} value, vent discharge duct length, and strengthening requirements. When designing a collector for such an application, the performance-based design option may come into play.

Chapter 6 also notes that *"to prevent snow and ice accumulation, where the potential exists, and to prevent entry of rainwater and debris, the vent or vent duct shall not be installed in the horizontal position, unless any of the alternative methods in 6.5.2.3.1 are followed"* (6.5.2.3). This means that if your dust collector has horizontally mounted filter cartridges and horizontally mounted explosion vents, you may need to take extra steps to achieve compliance.

The accepted *"alternative methods"* for protecting horizontal vents are fixed rain hats, weather covers mounted at an angle to shed snow, and deicing devices such as heated vent closures (pressure-relieving covers). If you use one of these methods, your vent may require additional safety components and testing. For example, if you use a weather cover, the standard says that you must use restraints and design and test the cover to prevent it from becoming a free projectile in an explosion. The other option is to eliminate horizontal explosion vents altogether by using a dust collector with vertically installed cartridge filters and vertically mounted explosion vents.

Figure 3

Cartridge dust collector with explosion venting to vent explosion away from building

Also new in NFPA 68 are sections allowing flameless venting inside buildings (6.9, 10.6). Flameless venting devices allow you to vent an explosion safely indoors without allowing any flame (or pressure front) to escape from the collector. Devices that meet this standard are commercially available in various configurations. A flameless device for quenching explosions, as shown in Figure 4, is a viable option to ducted explosion vents, but it's not recommended for toxic applications such as potent pharmaceutical dusts because of the risk that dust can be released into the room where venting occurs.

Given the many NFPA 68 changes and new requirements for explosion venting, here are some useful questions to ask when dealing with dust collector suppliers and installing contractors:

- Is the explosion venting equipment manufactured by a company specializing in such equipment, or is it "homemade" by the dust collector supplier? Either way, ask for documentation proving that the equipment has been manufactured in accordance with NFPA 68.

- Will the supplier provide a calculations sheet on vent sizing and vent discharge ducting?

- Does the supplier have the engineering and testing capabilities to use the performance-based design option where needed?

- Can the supplier perform a hazard analysis or recommend a qualified consultant for this task?

- Does the supplier have access to, and familiarity with, alternative protection technologies such as flameless venting and explosion suppression (see the next subsection)?

- Is the installing contractor familiar with the new NFPA 68? There's no formal supplier certification for this, so you'll have to inquire about the supplier's specific experience and capabilities.

Figure 4

Flame-quenching device

Courtesy of Fike Corp., Blue Springs, Mo. (www.fike.com).

Explosion suppression and other protection methods. If it's not feasible to duct an explosion to the outside through a wall or ceiling in your dust collection application, you'll need an explosion suppression or suppression-isolation system. A system like this may cost more than the dust collector itself.

Suppression methods are covered in a separate document, *NFPA 69: Standard on Explosion Prevention Systems,*[1] which has also just undergone a complete revision. Like NFPA 68, it has evolved from a guideline to a standard. NFPA 69 extends beyond explosion venting to address the whole dust collection system — that is, inlet and outlet ducting, spark-extinguishing systems, and methods for preventing an explosion from traveling back into the building.

Both now and in the future, these two related standards will have a significant impact on the design and cost of dust collection systems handling combustible dusts. By taking the time today to learn about and comply with these standards, you can keep your plant's dust collection system operating safely. **PBE**

References

1. National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471; 800-244-3555, fax 617-770-0700 (www.nfpa.org).
2. 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.

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