FOCUS ARTICLE

Dust Collectors: Do We Need to Protect Against Explosions and What Are the Best Methods?

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Where an explosion hazard exists inside of air-material separators (dust collectors) the NFPA prescriptively requires that such equipment be protected against explosion and that upstream explosion isolation, in the ductwork servicing this equipment, also be provided. This article principally focuses on media-type dry collectors that are typically part of local exhaust ventilation systems designed to remove dust from the atmosphere.

Types of Dust Collectors

There are a number of different types of air-material separators (dust collectors). These include cyclones, wet scrubbers, electrostatic precipitators, drum and media-filter type dust collectors. Media-filter type dust collectors typically employ fabric socks or bags, pleated-cartridges, or envelopes (teabag-type). Electrostatic precipitators impart an electrical charge to particles in a gas stream causing them to adhere to collector plates. These types of collectors are not used where explosible concentrations of dust in air are normally present. Wet scrubbers are normally designed to intimately mix the incoming dust laden airstream with a water bath to trap out combustible particulate. Since the particulate is trapped out as it enters the scrubber, there are no combustible dust explosion hazards associated with the inside of this type of collector.

NFPA Requirements for Explosion Protection and Isolation of Dust Collectors

There are five principal NFPA standards that provide appropriate guidance for the safe management of **combustible dust**, NFPA 61, NFPA 484, NFPA 654, NFPA 655, and NFPA 664. These standards differ, in some cases, with regard to explosion protection and isolation requirements. Explosion protection is generally required for a dust collector where an explosion hazard is judged to exist within the unit. Explosion isolation systems are also required where the dust collector is connected to another piece of equipment that presents an explosion hazard or where the upstream ductwork services work areas. Explosion isolation systems are designed to prevent propagation of a deflagration, initiated in one piece of equipment, upstream or downstream of the connected equipment

or to prevent propagation of deflagrations to locations where personnel may be working.

Defining an Explosion Hazard

Amongst the five combustible dust standards mentioned above, only NFPA 654 provides a definition of what constitutes an **explosion hazard**. An explosion hazard is deemed to exist in enclosed process equipment where both of the following conditions are possible:

1. Combustible dust is present in sufficient quantity to cause enclosure rupture if suspended and ignited.
2. A means of suspending the dust is present. It is interesting to note that this definition does not consider whether or not a credible ignition source is present.

This is consistent with the other NFPA standards which require protection, as part of their prescriptive requirements, based on the presence of fuel loading, and which do not consider avoidance/ control of ignition sources as a potential basis of safety.

Guidelines for Determining if an Explosion Hazard Exists in the Dust Collector

Generally speaking, the quantity of dust first entering a dry media-type dust collector is well below the amount necessary to give rise to an explosible dust cloud atmosphere in the dust collector. However, as the dust enters the collector, it is trapped on the filter media and remains there for a period of time until filter cleaning takes place. Cleaning can be as a result of mechanical shaking of the filter media or, in most cases, high pressure (90- 120 psig) air pulse directly to the inside of the cartridge or sock, causing the accumulated dust to be released from the filter media. It is this dense, localized, dust cloud that typically gives rise to an explosion hazard within the dust collector, as defined by NFPA 654. Calculations can be performed to estimate the density of the dust cloud that is formed when the filter media is cleaned. If the concentrations are less than 25% of the Minimum Explosible Concentration, (MEC), then control of fuel can be used as a Basis of Safety per NFPA 69. In order to consider this option, conditions surrounding the operation of the dust collector must be analyzed. Minimally, there must be no dust accumulation on the side walls or any horizontal sections inside the dust collector and, furthermore, the nature of the dust must be such that there is no tendency to clog or blind the filter media. If any of these conditions exists, an explosion hazard must be judged to be present in the dust collection system and either measures for ensuring safety from dust explosion hazards must be provided or alternatively, a performance based design option can be considered. The performance based design report must be prepared by a person with qualifications acceptable to the owner/operator and, in addition, the authority having jurisdiction (AHJ), usually OSHA, is permitted to obtain independent third-party review of the proposed design. The approach allows for consideration of credible ignition sources as a prerequisite for flash fire or explosion and measures designed to eliminate or control them. The **NFPA standards** that govern combustible dust provide general requirements if this approach is taken.

Dust Collector Explosion Protection Solutions

If an explosion hazard is deemed to exist, the dust collection system must be provided with explosion protection as outlined above, unless a performance based approach is considered. Discussion of the performance based option is beyond the scope of this article. In addition, explosion isolation should also be provided to prevent an explosion initiated inside the dust collector from traveling upstream or downstream to connected equipment or to upstream areas where personnel are working.

Table 1 on page 3 shows common protection methods based on the type of dust being collected. Table 2 on page 4 shows the advantages and disadvantages of the various types of explosion protection/ prevention strategies.

* Cyclones are permitted for all dusts. The explosion protection measures listed in the Table refer to protection of cyclones, where dry media collection is prohibited.

**. With engineering controls in place to prevent transmission of energy from fire or explosion back into the building and also HEPA filters to ensure purity of returned air (See appropriate standard NFPA 61 or 664).

1. Permitted if the Kst is less than 150 bar·meter/sec, filter media is conductive and bonded (If the MIE is less than 1000 mJ), accumulation levels during operations are monitored by pressure drop across the media and periodic inspections and replacement of media are in place. Monitoring of dust for exother-mic reactions is also required.
2. Permitted with restrictions (See NFPA 664 Section 8.2.2.6).
3. For dust collectors that are located outside of buildings, a risk evaluation is permitted to be conducted to determine the level of explosion protection to be provided.

Dust	NFPA stand.	Type of Collector Permitted		Location		Design For Contain-ment	Oxidant Reduction	Solid Particulate Inerting	Chemical Suppres-sion	Deflagra-tion Venting	Flameless Vents	Return exhaust air
		Dry Media	Wet	Out-door	Indoor	✓	✓	✓	✓	✓	✓	**✓
Agriculture	61	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**✓
Food	61	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	x
Aluminum	484	1.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Magnesium	484	1.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Niobium	484	5.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Tantalum	484	5.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Titanium	484	5.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Zirconium	484	5.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Hafnium	484	5.	✓	✓	x	✓	✓	✓	✓	✓	✓	x
Other metals	484	1.	✓	✓	4.	✓	✓	✓	✓	✓	✓	x
Wood/ cellulose	654	✓	✓	3.✓	✓	✓	x	x	✓	✓	Implied	2.
Sulfur	655	✓	✓	3.✓	✓	✓	✓	✓	✓	✓	✓	x
All other dusts	654	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	**✓

Table 1 - Explosion Protection Guidelines, ✓ permitted x not permitted

4. A hazard analysis must be conducted to ensure that the risk to personnel and operations is minimized for both new and existing systems. In addition, the material being collected must meet all the following; (1) Pmax less than 8 barg; (2) Kst less than 150 bar meters/sec: (3) MIE greater than 100 mJ and (4) material is not a Class 4.2 solid as tested using UN 4.2 self heating test methods. Collection of materials other than iron and steel not permitted in collectors with a dirty side volume greater than 20 ft3 or an airflow greater than 1500 CFM.
5. Not recommended unless their use is supported by a risk assessment as acceptable to the AHJ (Authority Having Jurisdiction). Filter media should be of static dissipative materials and grounded in use.

Summary

Dust collectors are used for a wide variety of applications in industry, including removal of dust from manufacturing operations that produce fine particulate and separation of particulate from the airstream where material transfer operations are taking place or where bins and silos are receiving product. This article has described the various NFPA standards that provide guidance for the **safe management** of combustible dusts and their respective prescriptive requirements with regard to explosion protection and isolation for dry dust collection systems. Where explosion protection is deemed to be the only practical method for reducing the risk of a dust cloud explosion to an acceptable level, various options are discussed and the pros and cons of each method are described. This article should provide those responsible for design and management of dust collection systems with guidance with regard to selection of the appropriate systems, based on the logistics involved.

System	Limitations	Advantages	Disadvantages
Oxidant Reduction (Inerting)	None	Prevents deflagration from occurring	Expensive to install and maintain
Fuel Dilution (Particulate Inerting)	Dust must be non-agglomerating	Prevents deflagration	Difficult to install as a practical matter
Deflagration Containment	None	Low maintenance/passive	High initial cost, heavy and difficult to install. Connected duct/piping must also be designed for containment, or isolated
Deflagration Venting	Not suitable for toxic material, venting inside building requires a vent duct to the outside. (If the distance from the DC to the roof or wall exceeds 2 meters, a vent duct is not recommended)	Low cost, simple to install (usually)	Need to vent to a safe area. May be problematical in some cases
Flameless Vents with Particle Retention	Not suitable for toxic material - must keep clean	Can install indoors	High initial cost
Chemical Suppression	May not be suitable for high Kst dusts	Can install indoors	High initial cost. Requires four annual inspections

Table 2 - Explosion Protection Guidelines, ✓ permitted x not permitted

References:

1. NFPA 61 (2013) "Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities"
2. NFPA 68 (2013) "Standard on Explosion Protection by Deflagration Venting"
3. NFPA 69 (2014) "Standard on Explosion Prevention Systems"
4. NFPA 484 (2015) "Standard for Combustible Metals"
5. NFPA 654 (2013) "Standard for the Prevention of Fires and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids"
6. NFPA 655 (2012) "Standard for Prevention of Sulfur Fires and Explosions"
7. NFPA 664 (2012) "Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities"

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Steven J. Luzik, PE, CFEI is a Senior Process Safety Specialist at Chilworth Technology, Inc. with over 30 years experience in the area of fire and explosion hazards including gas/vapor explosions, dust explosions and fire and explosion protection strategies. He graduated from the University of Notre Dame with a BS degree in Chemical Engineering. He is a registered Professional Engineer in the State of Pennsylvania and a Certified Fire and Explosion Investigator (CFEI) with the National Association of Fire Investigators (NAFI). As a former Mine Safety and Health Administration [MSHA] manager and technical specialist, he has investigated a multitude of incidents involving flammable vapors, gases and dusts that have included surface and underground mining facilities and industrial facilities where fires and explosions have occurred. He has conducted dust explosion hazard assessments at several coal-fired power plants.

He also has served as a moderator of a flammability and dust explosibility laboratory, processing requests from MSHA and other Federal agencies for testing to determine the flammability and explosibility properties of solids, liquids, dusts and vapors. In this capacity, he has been called upon to provide expert testimony on the explosibility hazards associated with the manufacturing, processing and handling of these materials. He is a member of the American Society for testing and Materials (ASTM) E-27 Committee on Hazardous Properties of Chemicals, the National Association of Fire Investigators (NAFI) and the National Fire Protection Association (NFPA). He has authored numerous publications in the areas of fire and explosion prevention, protection and investigation.

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