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DUST COLLECTORS: DO WE NEED TO PROTECT AGAINST EXPLOSIONS AND WHAT ARE THE BEST METHODS?

Steven J Luzik PE, CFEI, Senior Process Safety Specialist

Introduction
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 exploitable 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.
NLPA Requirements for Explosion Protection and Isolation of Dust Collectors

There are no new 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 measures. 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 equipment work areas. Explosion isolation systems are designed to prevent propagation of a deflagration, primary 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

A list of 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 explosion if suspended or 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 explosive dust cloud atmosphere in the dust collector. However, as the dust collectors, the dust 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 psi) 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 exist, 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 shows common protection methods based on the type of dust being collected. Table 2 shows the advantages and disadvantages of the various types of explosion protection/prevention strategies.

<table>
<thead>
<tr>
<th>Type of Collector</th>
<th>Method</th>
<th>Location</th>
<th>Design Consideration</th>
<th>Material Properties</th>
<th>Explosion</th>
<th>Ignition</th>
<th>Flameless Vents</th>
<th>Chemical Suppression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclones</td>
<td>Flameless Vents</td>
<td>Vent directly to a safe area. (If the distance from the vent to the roof or wall exceeds 2 meters, a vent duct is not recommended)</td>
<td>Not suitable for toxic material,</td>
<td>Low cost, simple to install (usually)</td>
<td>Not suitable for toxic material - must keep clean</td>
<td>May not be suitable for high K&lt;sub&gt;d&lt;/sub&gt; dusts</td>
<td>Can install indoors</td>
<td>High initial cost</td>
</tr>
<tr>
<td>Cyclones</td>
<td>Deflagration</td>
<td>Vents directly to a safe area. (If the distance from the vent to the roof or wall exceeds 2 meters, a vent duct is not recommended)</td>
<td>Not suitable for toxic material,</td>
<td>Low cost, simple to install (usually)</td>
<td>Not suitable for toxic material - must keep clean</td>
<td>May not be suitable for high K&lt;sub&gt;d&lt;/sub&gt; dusts</td>
<td>Can install indoors</td>
<td>High initial cost</td>
</tr>
<tr>
<td>Cyclones</td>
<td>Flap Vents</td>
<td>Located in areas of potential explosion hazard</td>
<td>Not suitable for toxic material,</td>
<td>Low cost, simple to install (usually)</td>
<td>Not suitable for toxic material - must keep clean</td>
<td>May not be suitable for high K&lt;sub&gt;d&lt;/sub&gt; dusts</td>
<td>Can install indoors</td>
<td>High initial cost</td>
</tr>
<tr>
<td>Cyclones</td>
<td>High Efficiency Filters</td>
<td>Location in areas of potential explosion hazard</td>
<td>Not suitable for toxic material,</td>
<td>Low cost, simple to install (usually)</td>
<td>Not suitable for toxic material - must keep clean</td>
<td>May not be suitable for high K&lt;sub&gt;d&lt;/sub&gt; dusts</td>
<td>Can install indoors</td>
<td>High initial cost</td>
</tr>
<tr>
<td>Cyclones</td>
<td>Pre-Filtering</td>
<td>Location in areas of potential explosion hazard</td>
<td>Not suitable for toxic material,</td>
<td>Low cost, simple to install (usually)</td>
<td>Not suitable for toxic material - must keep clean</td>
<td>May not be suitable for high K&lt;sub&gt;d&lt;/sub&gt; dusts</td>
<td>Can install indoors</td>
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</tr>
</tbody>
</table>

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. Where bins and silos are receiving product. This article has described the 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 described. This article should provide those responsible for design and management of dust collection systems with guidance with regard to the selection of the appropriate systems, based on the logistics involved.

References:

1. NFPA 61 (2013) “Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities”

* 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 returns. (See appropriate NFPA 61 or 664).
1. If the K<sub>e</sub> is less than 150 bar meters/sec, filter media is conductive and bonded (if the MIE is less than 1000 mJ).
2. 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 exothermic reactions is also required.
3. With permission restricted (See NFPA 664 Section 8.2.2.6).
4. 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.
5. 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) P<sub>L</sub> less than 8 bar, (2) K<sub>e</sub> less than 150 bar meters/sec, (3) MIE greater than 1000 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 ft<sup>3</sup> or an airflow greater than 1500 CFM.
6. 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.
**Table 2 - Types of Explosion Protection/Prevention Systems with Advantages and Disadvantages**

<table>
<thead>
<tr>
<th>System</th>
<th>Limitations</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxidant Reduction (Inerting)</td>
<td>None</td>
<td>Prevents deflagration from occurring</td>
<td>Expensive to install and maintain</td>
</tr>
<tr>
<td>Fuel Dilution (Particulate Inerting)</td>
<td>Dust must be non-agglomerating</td>
<td>Prevents deflagration</td>
<td>Difficult to install as a practical matter</td>
</tr>
<tr>
<td>Deflagration Containment</td>
<td>None</td>
<td>Low maintenance / passive</td>
<td>High initial cost, heavy and difficult to install, connected duct/piping must also be designed for containment, or isolated</td>
</tr>
<tr>
<td>Deflagration Venting</td>
<td>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)</td>
<td>Low cost, simple to install (usually)</td>
<td>Need to vent to a safe area. May be problematical in some cases</td>
</tr>
<tr>
<td>Flameless Vents with particle retention</td>
<td>Not suitable for toxic material - must keep clean</td>
<td>Can install indoors</td>
<td>High initial cost. Requires four annual inspections</td>
</tr>
<tr>
<td>Chemical Suppression</td>
<td>May not be suitable for high Kp dusts</td>
<td>Can install indoors</td>
<td></td>
</tr>
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