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OSHA and Combustible Dust: Standards and Solutions
The risks of combustible dust are not new. But the dangers are still very real. Truth be told, the dangers can be dramatically reduced, if not virtually eliminated.
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Flap Valves: Standards, Applications, and Limitations
Flap valves are relatively new in the North American market and gaining wide acceptance. It is only recently that they have been included in NFPA 69 Standard on Explosion Prevention Systems, 2014 Edition.
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Expect More from a Horizontal Shaft Impactor
The mineral processing industry usually evolves rather than revolutionizes, but the Horizontal Shaft Impactor (HSI) has revolutionized the crushing process in numerous industries.
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Explosion Protection Passive Isolation Valve
Fike Corp. announces the ValvEx passive isolation explosion protection solution for dust aspiration and dilute-phase pneumatic conveying systems. The ValvEx passive explosion isolation valve is designed to prevent flame and pressure propagation through interconnected pipes, ducts, or conveying lines to additional process equipment or operating locations. Fike has defined the dominant explosion parameters that affect flame and pressure propagation in a vented vessel-pipeline system. A correlation between venting parameters and valve performance was found, and the conditions under which valves fail was identified.
Fike Corp., Blue Springs, MO 816-229-3405 www.fike.com

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This new, clear, and lightweight, static dissipative polyurethane hose can replace heavier PVC and polyethylene conductive hoses in many fume and dust collection applications. Flexaust Flx-Thane LD-SD static dissipative polyurethane hose is clear, highly flexible, and compressible, making it ideally suited for a wide range of dust collection and fume extraction applications. Featuring the inherent abrasion resistance and superior tear strength of polyurethane, this lightweight hose is reinforced with a bronze coated spring wire helix. The hose is manufactured from FDA-approved materials.
Flexaust, Warsaw, IN 800-343-0428 www.flexaust.com

Getting the Dust Out: Sizing and Selecting Particulate Control Systems
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Getting the Dust Out: Sizing and Selecting Particulate Control Systems

By Richard Saab, Amece Foster Wheeler

Selecting and sizing an appropriate air filtration system involves more than use of an engineering formula. In choosing between baghouses and cartridge collectors, air filtration system design engineers must take into account the intended application, the volume being treated, the type of dust being collected, moisture content, space limitations, and many other factors.

Collector Types

For a wide variety of industrial processes, pulse jet baghouses and cartridge collectors are the two technologies most commonly selected for air filtration. Pulse-jet baghouses have replaced reverse air and shaker-type bag systems for most large, outdoor installations, while pleated cartridge collectors are widely used for compact indoor installations.

Pulse jet baghouses (Figure 1) have been successfully deployed for controlling emissions in the iron and steel, non-ferrous mineral, coal-fired utility, hazardous waste, and waste-to-energy industries and others. Pre-engineered designs provide cost-effective, reliable performance in removing particulate emissions from industrial processes at flow rates from 500 to 1 million actual cu ft/min (acfm). Filter bags, typically 6 in. in diameter and up to 16 ft in length, are supported by steel cages and mounted to a tubesheet using a “snap ring” sewn into the bag.

Cartridge collector systems (Figure 2) are more compact than baghouse systems, enabling high collection efficiencies for lower flow rate applications, often at lower capital and installation costs. Unlike pulse-jet filter bags, cartridges do not require cages, and the cartridges can be removed externally. Cartridge collectors are most cost effective at flow rates up to 20,000 acfm, and are routinely used for treating ferrous and nonferrous metals, mining and rock products, and chemical and food facility dust streams.

Pulse-Jet Baghouse or Cartridge Collector? How to Choose

When choosing between pulse-jet and cartridge collectors, it’s definitely not one size fits all. While pulse-jet filter bags and cartridge collectors are similar in terms of how they work, selection depends on a number of design parameters, including:

- Application/process
- Type of dust
- Air volume
- Temperature
- Dust loading
- Moisture content
- Gas composition
- Space limitations
- Dust explosivity
- Capital and life cycle costs

For more challenging applications, such as sticky dusts, a baghouse is often selected because bag-style filters are generally more forgiving in releasing difficult dusts than cartridge-style filters. Conversely,
When space or headroom is limited, the compact cartridge collector is often the best choice.

Baghouses are typically selected when ventilating processes (especially hot applications up to 500°F), when used as a product collector, or when handling more difficult dusts (hygroscopic, sticky, etc.). Figure 3 shows a baghouse installed on a metals processing application.

Cartridge collectors are typically selected for ventilating storage silos, transfer points, and general material handling of dusts such as limestone, cement, and rock products. Because of their compact design, cartridge collectors can be mounted directly on silos, transfer points, and other indoor locations where space is limited. Figure 4 shows a cartridge collector mounted in a packaging plant.

For cases where the process requirements could be addressed using either bag or cartridge filters, the choice often comes down to capital costs. Cartridge collectors are typically more economical up to 20,000 acfm, and baghouses are typically more economical at higher flow rates, although there are exceptions. Life-cycle costs also should be considered, such as how often the filters need to be changed and the cost of replacement filters. In general, replacement costs for filter bags with support cages are less than cartridges on a per unit basis without installation. Pressure drop is generally the same across the filters, so there is not much difference in operating costs, depending on the application.

Once a technology is selected, the design process is not finished. Engineers should pay special attention to filter selection, filter cleaning system, inlet configuration, flow distribution, and control flexibility to most effectively match these factors to the intended application. The cost will obviously depend on the design and features selected. For example, a PTFE membrane filter might be selected if required to meet a lower particulate emission standard, but will increase the overall cost. In addition, corrosion-resistant materials may be required for some components of the cleaning system; metal corrosion could eventually degrade the structural integrity of the filtration system, which could lead to undesired release to the surrounding environment.

Right-Sizing for Best Performance

Once the filtration design engineer has decided between a baghouse and a cartridge collector, he/she can turn his/her attention to sizing the system. The main sizing criteria for a baghouse system is the air-to-cloth (A/C) ratio, which is defined as the amount of air being filtered relative to the amount of filtering media (see Equation 1 below).

\[
\text{Air to Cloth Ratio} = \frac{\text{Volume (acfm)}}{\text{Filtration Area (ft}^\text{2})}
\]

The A/C ratio is a feet per minute (fpm) ratio, and is often referred to as face velocity. A lower A/C ratio is generally associated with improved performance. Difficult process applications typically have A/C ratios of 3:1 to 4:1, while easier applications have A/C ratios up to 6:1. If the air filtration system is designed with too high of a ratio, the cost will be less, but a number of operational issues could result, such as blinded filters, decreased filter life, and unit pluggage.

A second sizing factor, the interstitial “can” velocity, also should be considered for baghouse design. The can velocity is defined as the upward velocity in between the filters and will vary by manufacturer depending on the filter diameter, center-to-center filter spacing, and distance from filter to wall. A high can velocity may cause re-entrainment of the dust after cleaning.

While the A/C ratio is a useful design parameter for systems using cloth filters, it is not useful for pleated or cartridge filters. If it were, one could simply add more pleats to an element to increase the surface area, thereby lowering the A/C ratio and improving performance. The low air-to-cloth ratio is deceiving, however, as the tight pleat spacing renders some of the media useless for filtering. One common result is dust bridging between the tighter pleats, which makes it difficult to pulse the dust out.

Certain applications, such as collecting sugar dust, need a wide pleat spacing to prevent dust buildup in between the pleats. This in turn increases the A/C ratio, but can actually improve performance. See variations of pleats shown in Figure 5.

The proper way to size a cartridge collector, independent of pleat spacing, is based on cfm per element (see Equation 2 below).

\[
\text{Element Volume} = \frac{\text{Volume (acfm)}}{\text{Number of Elements}}
\]

For common applications such as nuisance dust collection, silos, and transfer points, cartridge type dust collectors should be sized for 300 to 400 cfm per element; for more difficult applications such as light dusts, a lower value of 200 to 300 cfm per element can be used, for simple applications such as air blast rooms, a higher value of 400 to 500 cfm per element is acceptable.

While pulse-jet filter bags and cartridge collectors are similar in terms of how they work, selection depends on a number of design parameters.

Cartridge collectors typically feature a conventional vertical design. Horizontal cartridge collectors are sometimes specified, but it’s important to recognize that only one-half of the cartridge may be used for filtering. The dust piles up on the top half of the cartridge, while the lower half doesn’t see the dust due to poor air flow distribution. As the dust is pulsed off...
and lands on the filters below, or is blown into the pleats of the lower elements, the impacted pleats are no longer available for filtering. Despite the fact that not all of the filter media is being utilized, some manufacturers may specify a misleadingly low A/C ratio.

For sizing pleated filters, face velocity, in feet per minute (fpm), can also be used, which gives another measure of the volume per element. For a 12.75-in.-diam cartridge, the face velocity is calculated as follows (see Equation 3 and 4 below).

\[
\text{Face Velocity} = \frac{\text{Element Volume}}{\text{Cartridge Face Area}}
\]

\[
= \frac{277 \text{ acfm}}{27.7 \text{ ft}^2}
= 10.0 \text{ fpm}
\]

Proportional to air-to-cloth ratios, cartridge collector face velocities for common applications should be in the following ranges: for difficult applications, 20 to 30 fpm; for normal applications, 30 to 40 fpm; and for easier applications, 40 to 50 fpm.

**Case Studies**

Case studies can help illustrate the various factors involved in successfully selecting and sizing an air filtration system.

**Case Study 1** involves a potash mine ventilating various processes, including drying, screening, compaction, and loading/unloading. Table 1 describes the process conditions for the dryer; in this case study, the air filtration system will be ventilating the dryer directly, handling the product rather than waste.

<table>
<thead>
<tr>
<th>Application</th>
<th>Potash dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>30,000 acfm</td>
</tr>
<tr>
<td>Temperature</td>
<td>50–320 F</td>
</tr>
<tr>
<td>Inlet pressure</td>
<td>–3 inches water gauge</td>
</tr>
<tr>
<td>Inlet loading</td>
<td>5–10 grains/cubic foot</td>
</tr>
<tr>
<td>Moisture</td>
<td>10–12%</td>
</tr>
</tbody>
</table>

In this case, the application engineer selected a filter baghouse over a cartridge collector. The main factors guiding this selection were that the dust was hygroscopic and any moisture present would make it difficult to clean off a pleated filter; the inlet loading was moderate; and the A/C ratio made the baghouse more cost effective.

**Case Study 2** involves indoor dust collection from a potash storage bin, in which the filtration system is not intended to collect product, but to maintain negative pressure in the bin (with exhaust fan), especially during loading operations. Table 2 describes the process conditions for this application.

<table>
<thead>
<tr>
<th>Application</th>
<th>Potash dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>4,000 acfm</td>
</tr>
<tr>
<td>Temperature</td>
<td>Ambient</td>
</tr>
<tr>
<td>Inlet pressure</td>
<td>N/A</td>
</tr>
<tr>
<td>Inlet loading</td>
<td>&lt;1 grains/cubic foot</td>
</tr>
<tr>
<td>Moisture</td>
<td>1–2%</td>
</tr>
</tbody>
</table>

In this case, the application engineer selected a cartridge collector. The main reasons behind this selection were that this was more of a nuisance dust application than a process application; the moisture content was low; the unit was indoors; the inlet loading was light; and the air volume to size ratio made the cartridge collector more cost effective.

Table 3 depicts the type of comparison that an application engineer may make when deciding between a baghouse and a cartridge collector. The table shows the costs over a 10-year period for the bin ventilation application in Case Study 2. Even though the filter replacement cost is higher for the cartridge system, the lower installed cost and lower labor cost for filter replacement makes it the most economic choice over the 10-year period.

**Bottom Line**

In conclusion, baghouses and cartridge collectors are both proven, useful solutions for a variety of applications, including industrial ventilation.
industrial ventilation. But these technologies should be evaluated and sized carefully, considering the many factors associated with a particular application. Air-to-cloth ratio, for example – which is often thought of as the go-to sizing equation for air filtration – is more applicable to baghouse system design than cartridge collection system design. As stated earlier, when choosing between the different particulate collection options, each application is unique. Using the design guidelines described above will help achieve optimal performance and maximum filter life.

Richard Saab is product leader with Aemc Foster Wheeler. Aemc Foster Wheeler purchased the assets of the former Wheelabrator Air Pollution Control Co. from Siemens Environmental Systems and Services in 2014. For more information, Saab can be reached at richard.saab@amecfw.com.

### Table 3: Operating Cost Comparison
*including typical accessories.

<table>
<thead>
<tr>
<th>Filter Device</th>
<th>Flow Rate (ACFM)</th>
<th>Air to Cartridge/ Cloth Ratio (cfm/element)</th>
<th>Filters Installed</th>
<th>Total Installed Cost*</th>
<th>Filter Unit Replacement Cost</th>
<th>Changeout Frequency (years)</th>
<th>Filter Changeout Labor Cost</th>
<th>10-Year Operating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartridge Collector</td>
<td>4,000</td>
<td>333</td>
<td>12</td>
<td>$18,000</td>
<td>$1,800</td>
<td>2</td>
<td>$200</td>
<td>$10,000</td>
</tr>
<tr>
<td>Pulse-Jet Bag Filter</td>
<td>4,000</td>
<td>5:1</td>
<td>49</td>
<td>$24,000</td>
<td>$1,500</td>
<td>2</td>
<td>$800</td>
<td>$11,500</td>
</tr>
</tbody>
</table>

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