Dust and fume collection is a necessity in most powder and bulk handling facilities to ensure environmental safety and process cleanliness. However, a hasty or uninformed dust collector purchase, or one based on lowest initial price, can result in high operating costs and performance headaches.

Installing a dust collection system can be a complicated and costly process. However, by testing your dust, performing a hazard evaluation, calculating the filters’ total cost of ownership, recirculating the dust collector airstream, and looking for other cost-efficient features upfront, you can reduce operating costs and ensure that your system is optimized for your application. This article presents five strategies you can use to ensure that your new dust collection system is efficient and effective.

1. Test your dust.

Testing samples of your dust can help you make informed dust collection decisions. There are two types of dust testing: bench testing, which pinpoints the dust’s physical properties, and explosibility testing, which determines whether a dust is combustible.

**Bench testing.** Bench testing is offered by some dust collection equipment manufacturers (often free of charge) and is also available from independent labs. Bench testing incorporates a series of tests that provide valuable data for filter media selection and proper design and sizing of dust collector components. A particle size analysis reveals the dust’s particle size distribution down to the submicron range to calculate the required filtration efficiency to meet emissions regulations. This test pinpoints both the number of particles of any given size and the dust’s volume, or mass spread of the dust, which are both important to know because many dusts are mixed. For example, the exhaust dust from a plasma cutter includes submicron carbon particles mixed with much larger steel particles. Bench testing is the only way to identify the tiny carbon dust particles.

A video microscope provides visual analysis of the dust’s particle shape and other characteristics, such as whether the dust contains oil. A moisture analysis measures a dust’s moisture percentage by weight, providing information that can prevent problems related to moisture incursion.

**Bench testing identifies physical properties of the dust, providing valuable data for filter media selection and the design and sizing of a dust collection system.**
humidity chamber measures how quickly a dust will absorb moisture. A hygroscopic (or moisture-absorbent) dust requires widely pleated cartridge filters to avoid plugging.

While bench testing isn’t always necessary, if you or your supplier suspect there’s anything unusual about your process or dust, bench testing is a good idea and will help your supplier choose the optimal dust collection equipment for your application.

**Explosibility testing.** To determine whether your dust is combustible, you should have your supplier or an independent lab conduct explosibility testing as stated in NFPA Standard 68.1 If a dust sample isn’t available, it’s permissible to use an equivalent dust (with the same particle size, etc.) from an equivalent application to determine combustibility. Once your dust becomes available, however, you should go back and test it using either the 20-liter test method described in ASTM E1226-12a1 or the similar method described in ISO 6184/1.3

First, a screening test will determine whether the dust is combustible. If the dust isn’t combustible, testing will stop there. If the dust is combustible, further tests will pinpoint the $K_D$ (the deflagration index or rate of pressure rise of a dust cloud) and $P_{max}$ (the maximum pressure during a contained explosion).

These values will help your supplier determine what explosion prevention or protection equipment is needed for your dust collection system. Explosibility testing is an essential part of a hazard evaluation, which is discussed in the following section.

A heavy-duty dust collector with a high pressure rating will stand up better in the event of a combustible dust event.

**2 Conduct a hazard evaluation.**

A hazard evaluation, also called a process hazard analysis, risk assessment, or hazard review, can identify your dust collection system’s potential hazards, such as the risk of combustible dust explosions. The evaluation should start at the system’s design phase and continue through the system’s lifespan with periodic reviews and updates.

The hazard evaluation will determine the type of explosion protection and duct isolation devices required for your application. Given the importance and complexity of combustible dust issues, an independent professional engineer should determine your system’s requirements with support from your supplier. The engineer can specify the best explosion protection approach for your application and ensure compliance with applicable standards and the requirements of your insurance carriers.

A hazard evaluation will first determine if the dust is combustible. If it is, you then look for hazardous levels of dust accumulation on floors, elevated surfaces, hidden surfaces, and inside equipment. If accumulation is present, you have a potential flash fire or explosion hazard. You must then identify a way to disperse the dust to clear the accumulation.

Though a hazard evaluation is performed for safety reasons rather than cost control, it can contribute to cost efficiency by ensuring that safety requirements are met without over-engineering the system. In the absence of such an evaluation, the dust collection equipment supplier must default to a worst-case scenario and incorporate a very high level of explosion protection that may be unnecessarily costly.

The NFPA is currently putting the finishing touches on a new combustible dust standard called NFPA 652: Standard on the Fundamentals of Combustible Dust.4 This standard will provide a detailed guide for a hazard evaluation on a dust collection system. The standard also will introduce the term “Dust Hazard Analysis” in order to avoid confusion with OSHA regulations requiring a much more complex Process Hazard Analysis for industries such as oil refining and chemical manufacturing. NFPA 652 should be a useful tool for processors because it will identify the general requirements for managing combustible dust fire and explosion hazards.

**3 Calculate your filters’ total cost of operation.**

Similar in concept to life-cycle costing, a total cost of operation (TCO) calculation is very useful for deciding which filters to select for your dust collector. A TCO is a step-
by-step evaluation process encompassing three categories: energy, consumables, and maintenance and disposal.

**Energy.** A dust collector’s electrical energy consumption is primarily influenced by the type of fan (or blower) the system uses. When running a dust collector with a constant-speed fan, the amount of air moving through the collector will vary during the filters’ service life.

When filters are clean and pressure drop across the filters is at its lowest, the fan blows more air through the system than is required, essentially wasting energy. As the filters become loaded with dust, the static pressure increases and the fan blows less air. The fan uses more energy in the early stages of the filters’ service life and less energy in the later stages.

A mechanical damper at the fan outlet will provide some energy savings, but a far more effective approach is to use a variable frequency drive (VFD) to electrically control the fan speed. With a VFD, when the filters are new, the fan speed decreases to maintain the desired airflow. When filters become loaded, the fan speeds up to maintain that airflow. The VFD is highly efficient at maintaining the optimal airflow. When the system is new, the filters are clean and will operate below the designed maximum pressures. Using a VFD, the system can adjust pressure based on the buildup on the filters throughout the filters’ lifespan. The added capital cost of installing a VFD on a dust collector varies, but the return on investment is often less than a year.

The efficiency of the motor you use to power the dust collector fan and the amount of compressed air required to pulse-clean the filters also affect the dust collection system’s energy use.

**Consumables.** It’s important to look at the cost of the replacement filters when putting together a TCO. Additionally, you must also factor in the money required to have replacement filters delivered to the operation site. Because you never want to be without spares, money required to carry inventory of replacement filters must also be added.

**Maintenance and disposal.** The TCO needs to include the labor costs required for maintenance personnel to change filters, the cost of disposing of filters laden with process dust, and the cost for the amount of time in lost production due to shutting down the dust collector for a filter change.

These factors are largely dependent on the filters’ anticipated service life. The changeout schedule will determine how many filters you can expect to buy, transport, store, and dispose of, as well as the labor and downtime costs associated with filter service. A premium filter designed for extended service life and low pressure-drop performance can result in dramatic savings compared to a commodity filter with low initial cost, but it may take a TCO analysis to learn this. A data collection work sheet, as shown in Figure 1, provides a tool for recording and calculating TCO.

![Figure 1](image_url)

**Dust collector filter total cost of ownership sample data collection worksheet**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many days will the system operate per year?</td>
<td></td>
</tr>
<tr>
<td>How many hours will the system operate per day?</td>
<td></td>
</tr>
<tr>
<td>What is the volume of air required to operate the system?</td>
<td></td>
</tr>
<tr>
<td>How much does a kilowatt-hour cost?</td>
<td></td>
</tr>
<tr>
<td>What is the cost of no production for one hour?</td>
<td></td>
</tr>
<tr>
<td>What is the cost of a filter cartridge?</td>
<td></td>
</tr>
<tr>
<td>How many filter cartridges are in the dust collector?</td>
<td></td>
</tr>
<tr>
<td>What is the shipping cost per filter?</td>
<td></td>
</tr>
<tr>
<td>What is the labor and overhead rate for one hour?</td>
<td></td>
</tr>
<tr>
<td>How much does it cost to dispose of a filter?</td>
<td></td>
</tr>
<tr>
<td>How much does a variable frequency drive (VFD) cost?</td>
<td></td>
</tr>
<tr>
<td>What is the current interest rate?</td>
<td></td>
</tr>
<tr>
<td>How many minutes does it take to change a filter?</td>
<td></td>
</tr>
<tr>
<td>Will there be a VFD operating the system?</td>
<td></td>
</tr>
</tbody>
</table>
Recirculate the dust collector airstream.

Air recirculation is the single best way to save energy and maximize a dust collector’s return on investment. The plant air captured by the dust collection system’s hoods has often been heated or cooled, depending on the outside air temperature. Recirculating that air back through the plant instead of venting it outdoors eliminates the cost to replace that conditioned air. Facilities in all geographic regions report five- to six-figure annual energy savings from air recirculation, with the greatest savings seen in northern climates, which experience longer, colder winters. In addition, the US Department of Energy offers public-utility-sponsored rebates and incentives to facilities that recycle heated or conditioned air. Most dust collection equipment suppliers have cost-calculation software to help predict the savings based on system airflow, climate, local utility costs, and other factors.

When recirculating the dust collection airstream, you should use a HEPA after-filter (sometimes called a safety monitoring filter), especially if you’re filtering hazardous or toxic dusts. These high-efficiency filters provide backup protection and a final scrub of the air before it returns to the workspace.

Look for cost-efficient features and functions.

There are a number of additional choices you can make to enhance your dust collector’s cost efficiency:

Nanofiber filter media. A layer of nanofibers applied to the base filter media promotes surface loading of fine dust, preventing the dust from penetrating deeply into the filter’s base media. This translates into better dust release during cleaning cycles and lower pressure drop readings throughout the filter’s service life. Some regard nanofiber media as a high-end choice for exotic or demanding dust capture applications, but its use is actually becoming much more widespread. Compared to standard filter media, nanofiber filters offer higher filtration efficiency, better energy performance, superior pulse-cleaning characteristics, and greater resistance to wear and tear from pulse-cleaning.

Efficient pulse-cleaning technology. Dust collector filters are automatically pulse-cleaned using very brief bursts of compressed air that blow the dirt off the filter surfaces. You should try to pulse clean your dust collector filters as little as possible. This will maintain a controlled dust cake on the filters, which actually improves filtering efficiency. It also saves on compressed air, reducing operation costs.

The most common method to reduce pulse cleaning is on-demand pulsing, which only activates the cleaning system when the dust collector’s pressure-drop reading goes above a preset high setpoint and then pulses until the reading reaches a preset low point. Another option is to use downtime pulsing, which only performs pulse cleaning while the dust collector fan is off.

These methods conserve compressed air compared to continuous pulsing, in which the cleaning system is pulsed at a set time period, such as every 10 or 15 seconds. Sometimes continuous pulsing is absolutely required, but it uses much more compressed air over the life of the dust collector and is very costly compared to other methods.

Heavy-duty vessel strength. Vessel strength is an important factor when sizing explosion protection equipment for a dust collection system. A heavy-duty dust collector, constructed of thick-gauge metal will have a higher pressure rating and stand up better in the event of a combustible dust explosion. A heavy-duty vessel may also require a simpler and less costly explosion protection system to comply with NFPA combustible dust standards.

Ask your supplier whether your application requires HEPA filtration, or if less costly ASHRAE-grade high-efficiency filters can be used instead. Also ask whether separate ductwork and transition sections will be needed to connect the after-filter module to the dust collection system. In some applications, an integral after-filter module can be mounted on top of the collector to save on floor space and eliminate the need for transitional ductwork, reducing installation costs.

References

For further reading

Find more information on this topic in articles listed under “Dust collection and dust control” in Powder and Bulk Engineering’s article index in the December 2014 issue or the Article Archive on PBE’s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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