How to choose a bin vent for your pneumatic conveying system

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Bulk solids processors typically spend a lot of time designing and selecting major components for a pneumatic conveying system. But choosing a bin vent for the receiving bin at the system’s end often gets less attention. This article explains how a bin vent functions in a pneumatic conveying system, what types of bin vents are available, and how to choose a bin vent that will help your system perform to your specifications.

Cómo seleccionar un respiradero de tolva para su sistema de transporte neumático

Por lo general, los procesadores de sólidos volumétricos pasan mucho tiempo diseñando y seleccionando los componentes principales de un sistema de transporte neumático. A la selección de un respiradero de tolva para la tolva de recepción al final del sistema se le presta menos atención. Este artículo explica cómo funciona un respiradero de tolva en un sistema de transporte neumático, qué tipo de respiraderos están disponibles y cómo escoger un respiradero de tolva que le permita a su sistema un rendimiento de acuerdo a sus especificaciones.
The fact that bin vent suppliers often receive rush orders for bin vents is a telltale clue that many plants install a new pneumatic conveying system without thinking much about what kinds of bin vents are available and what type is best suited to their conveying system. Don’t let your system’s bin vent choice be an afterthought. Consider the following information about bin vents with the same level of care you apply to choosing components for the rest of your pneumatic conveying system.

**How a bin vent works in a pneumatic conveying system**

A simple pneumatic conveying system operating under pressure, shown in Figure 1, typically consists of a conveying line and various equipment components, including an air mover (such as a blower), a material feeder (such as a rotary airlock that feeds material from a supply hopper’s outlet), and a receiving bin (or bins) that stores the conveyed material at the system’s end. A bin vent — basically, a specialized dust collector equipped with filter elements for cleaning dust particles from air — is mounted on each receiving bin. (The bin vent can also be applied to a vacuum pneumatic conveying system; in this case, the bin vent — often called a filter-receiver — must withstand the differential pressure between the system’s vacuum and atmospheric pressure.)

In operation, the air mover draws air from the air inlet at the system’s start and pushes it down the conveying line. The material feeder meters material into the line. The air in the line entrains the material and conveys it down the line to the receiving bin. As the coarse particles drop out of the air and fill the bin, the dust-laden conveying air flows upward into the bin vent. In the bin vent, the filters collect the dust particles from the air, then return the particles to the bin when the filters are cleaned. The clean air is exhausted into the atmosphere.

**What bin vent types are available**

Two types of bin vents are common: a shaker bin vent for intermittent operation and a pulse-jet bin vent for continuous operation. Both are specialized versions of standard dust collectors. You can find more detailed information about them in Table I.

**Shaker bin vent.** The shaker bin vent, shown in Figure 2, consists of a housing enclosing multiple bag (round tube or envelope) filters. These filters are made of woven cotton or polyester media. During the pneumatic conveying system’s operation, dust particles from the conveying airflow collect on the bin vent’s filters as the air passes upward through the receiving bin. At intervals, the bin vent shakes the filters to dislodge the dust, but this can only occur when the upward conveying airflow is stopped so the dislodged dust can fall back down into the receiving bin. This makes the shaker bin vent suitable only for a pneumatic conveying system that can be stopped periodically for filter cleaning.

The interval between shaker cleaning cycles is determined by the pressure drop — that is, the resistance — across the filter media, as measured by a pressure sensor. The pressure drop is determined by the dust’s fineness and the thickness of the dust cake on the filter surface: the finer the dust, the denser and more impervious the dust cake, and the thicker the dust cake, the greater the resistance. The dust cake’s thickness is
affected by how much air volume passes through the filter media and the interval since the filter was last cleaned. When the pressure drop across the filter media increases to the point where airflow through the filter is restricted and the receiving bin’s filling rate slows, or dust escapes through the filter media or the receiving bin openings, or the receiving bin’s relief pressure is exceeded, the pneumatic conveying system must be stopped so the bin vent can shake the bag filters clean and the dust can drop into the receiving bin.

**Pulse-jet bin vent.** The pulse-jet bin vent, shown in Figure 3, also consists of a housing enclosing several filters. These can be bag filters, made of felted media, or pleated cartridge filters, which are available in several types of media, generally for finer or difficult-to-handle dusts. But unlike the shaker bin vent, the pulse-jet bin vent can clean the filters while the pneumatic conveying system is operating, thus providing continuous operation. To clean the filters, the bin vent injects a high-pressure jet of compressed air into some of the filters, dislodging the collected dust from the media while the other filters remain online. The pulse-jet cleaning continues in sequence until all filters in the bin vent are cleaned and the dislodged dust has dropped into the receiving bin.

Because the bin vent cleans the filters during pneumatic conveying operation, the dust dislodged from the filters must fall through the conveying airflow that’s moving upward through the receiving bin into the bin vent. The airflow’s upward velocity — called the *can velocity* — is calculated by dividing the airflow rate by the cross-sectional area of the bin vent’s bottom opening. The smaller the bin vent’s bottom opening, the higher the can velocity. The larger and denser the dislodged particle, the more easily it will fall from the filter through the upward airflow and back into the receiving bin. Very small, light particles are re-entrained into the conveying airflow and re-deposited onto the filter media until the particles agglomerate with other particles and become large and dense enough to make the journey back to the receiving bin.

The pulse-jet bin vent’s filter-cleaning effectiveness is thus clearly influenced by the can velocity, which depends on the bin vent’s bottom opening area, the particle density, and the particles’ ability to agglomerate (that is, stick to other particles). Very fine, low-density, nonagglomerating particles, such as fumed silica and activated carbon particles, are the most difficult to clean from the filters. Effectively dislodging such particles can require that the bin vent have a very large

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**Table 1**

<table>
<thead>
<tr>
<th>Bin vent type</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaker</td>
<td>Installs on small opening on receiving bin</td>
<td>Is suitable only for pneumatic conveying systems that operate intermittently</td>
<td>Is available with bag (round tube or envelope) filters made of woven cotton and polyester media</td>
</tr>
<tr>
<td></td>
<td>Has simple filter cleaning</td>
<td>Fine, free-flowing dust can pass through woven filter media</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Requires no compressed air</td>
<td>Must be severely oversized for a bulk unloading system</td>
<td></td>
</tr>
<tr>
<td>Pulse-jet</td>
<td>Is suitable for pneumatic conveying systems that operate continuously</td>
<td>Requires large opening on receiving bin to prevent dust re-entrainment</td>
<td>Is available with bag (round tube or envelope) filters typically made of felted media</td>
</tr>
<tr>
<td>Bag filter</td>
<td>Has no moving parts in airstream</td>
<td>Requires clean, dry compressed air</td>
<td></td>
</tr>
<tr>
<td>Cartridge filter</td>
<td>Handles fine, free-flowing dust</td>
<td>Requires large opening on receiving bin to prevent dust re-entrainment</td>
<td>Is available with cartridge filters of various pleat pitches and depths and in various media types</td>
</tr>
<tr>
<td></td>
<td>Allows workers to change filters from vent’s clean side</td>
<td>Requires clean, dry compressed air</td>
<td></td>
</tr>
<tr>
<td>Insertable</td>
<td>Handles low-density, fine dust as well as all other types</td>
<td>Requires extra receiving bin height for freeboard area</td>
<td>Is available with bag (round tube or envelope) or cartridge filters in various media types</td>
</tr>
<tr>
<td></td>
<td>Requires minimal opening size on receiving bin</td>
<td>Requires clean, dry compressed air</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allows workers to change filters from clean air side</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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A bottom opening and, thus, a low can velocity. Such a large opening requires a correspondingly large opening in the receiving bin’s roof, which not only reduces the bin’s structural strength but leaves less room on the roof for vents, valves, and other components and for workers to access the bin vent.

One way to overcome this limitation is to install a pulse-jet bin vent inside — rather than on top of — the receiving bin. Such a bin vent arrangement, called an **insertable bin vent**, is shown in Figure 4. In this arrangement the filters aren’t enclosed by a housing, so they’re fully exposed to the airflow in the receiving bin. This allows the airflow to contact the filters from all directions, minimizing or eliminating the rising airflow’s can velocity. While this type of bin vent requires short filters — typically 1 meter or under — to minimize the receiving bin’s required **freeboard area** (that is, the space between the bin roof and the stored material’s surface), the large freeboard area also produces a slower airflow velocity. This allows most of the captured particles to fall easily into the receiving bin without being re-entrained. As long as the receiving bin has sufficient freeboard area for this arrangement, the insertable bin vent provides better filtering performance than a roof-mounted pulse-jet bin vent.

**A note about cartridge filters in pulse-jet bin vents.** It’s true that pleated cartridge filters have been used most often in pulse-jet dust collection equipment for light-dust-loading applications that filter fine dusts rather than in bin vents that handle pneumatic conveying airflows with heavy dust loadings. But today’s cartridge filters with wide, shallow pleats
allow pulse-jet equipment to be used for pneumatic conveying bin vents handling heavier dust loadings. A pulse-jet bin vent that uses these cartridge filters also uses fewer filter elements and is easier to maintain than a pulse-jet bin vent with bag filters. The cartridge-style bin vent is more compact, allowing it to be used in applications with limited headroom. The cartridge filter media can also filter extremely fine free-flowing materials, such as alumina and toner dust. These can become permanently embedded in conventional woven or felted fabric media, leading to the filter’s early failure because of uncontrolled pressure drop.

How to size your bin vent

To size a bin vent for your pneumatic conveying system’s receiving bin, you need to know how much filter media surface area your application requires. This depends on your conveying system, the bin vent type, the airflow volume through the bin vent, and your material’s characteristics.
The bin vent manufacturer determines the bin vent’s optimal filtration velocity, commonly called the air-to-cloth ratio, for various materials based on the unit’s design. For example, a 1-to-1 air-to-cloth ratio represents 1 cubic meter per minute of flow per square meter of filter media. Or, with dimensional analysis, the filtration velocity is 1 meter per minute. Thus, a bin vent that must provide a 1-to-1 air-to-media ratio for a specific application—for example, airflow of 900 cubic meters per hour (15 cubic meters per minute)—requires 15 square meters of filter area.

The bin vent manufacturer will base the unit’s air-to-cloth ratio on your material. If you have a fine, light-density, free-flowing material, the manufacturer will use a lower air-to-cloth ratio regardless of the bin vent type. The manufacturer will also use a lower ratio and, thus, more filter media, for materials such as sugar, soda ash, and others that tend to form a hard, crusty dust cake on the media surface over time in humid environments. Such a cake can be almost impervious to airflow, so more filter media surface area is required to compensate for this blockage.

Work with your bin vent manufacturer to size the unit for your application:

- **Shaker bin vent:** Size a shaker bin vent to provide enough filter media surface area to allow the dust cake to build and the pressure drop to increase between cleaning cycles without reaching an excessively high pressure drop—typically, no more than 200 to 250 millimeters water column (2 to 2.5 kilopascals) — before your pneumatic conveying system fills the receiving bin with material. Thus, the longer your system’s filling cycle, the lower the bin vent’s air-to-cloth ratio must be — and the more filter media surface area and the larger the bin vent you’ll need.

- **Pulse-jet bin vent:** Size a pulse-jet bin vent to provide enough filter media surface area to allow a uniform pressure drop of 150 to 200 millimeters water column (1.5 to 2 kilopascals) without excessive pulse-jet cleaning. The bin vent must also accommodate your material’s can velocity restrictions: If you have a light-density material, the can velocity through the bin vent shouldn’t exceed 0.75 meter per second, but if you have a heavier material, the can velocity can be as high as 1.0 meter per second.

**How conveying system type affects your bin vent choice**

Every pneumatic conveying system operates under a unique set of variables. Your pneumatic conveying system type determines how much the system’s operating variables will affect your bin vent selection and sizing. Let’s take a closer look at various pneumatic conveying systems and how their operation varies.

Three pneumatic conveying system types—dilute-phase, two-phase, and dense-phase—are used in general conveying applications in handling and processing plants. The fourth type—bulk unloading—conveys material from a bulk truck to a plant’s storage silo.

**Dilute-phase system.** In a dilute-phase pneumatic conveying system, material is entrained in the conveying air and transferred in dilute phase, or stream flow, through the conveying line. The material travels at a slightly slower velocity than the airflow.

Almost any dry bulk material can be conveyed in dilute phase. Typically, the airflow rate through the system is well-known, and both the airflow rate and material loading are constant. This simplifies your bin vent choice for a dilute-phase system because you don’t need to choose a unit to handle wide variations in airflow rate and material loading.

**Two-phase system.** In a two-phase (also called medium-phase) pneumatic conveying system, the system’s operating pressure is slightly higher and the conveying line diameter is slightly smaller. Material settles on the bottom of the conveying line’s horizontal sections, forming a saltated layer that reduces the line’s cross-sectional area. The airflow rate above the saltated layer increases and causes material to be conveyed in dilute phase above the layer.

Unlike a dilute-phase system, which can handle many types of material, a two-phase system is primarily used to convey fly ash and cement. The system’s airflow rate is lower than that in a dilute-phase system and the material loading is typically higher, but both the airflow rate and material loading are relatively constant, with variations typically less than 20 percent from the average airflow rate and material loading. As a result, choosing a bin vent for this system is also relatively simple.

**Dense-phase system.** In a dense-phase (also called piston-flow) pneumatic conveying system, the conveying line fills with material and air can’t flow through, causing the material to form a piston. Introducing air behind the piston creates a pressure differential across the piston that causes the piston to move. The airflow rate determines the piston’s speed through the line. The system’s operating pressure is often higher than that of other systems.

The system can convey many different materials. A pressure tank (also called a pressure pot or blow pot) feeds material intermittently into the system, which results in large, frequent variations in both the airflow rate and material loading. As a result, the airflow rate and material loading for the system are each given as a time-weighted average. However, these averages don’t accurately identify the burden placed on the bin vent at a given moment: The airflow rate can vary from near zero to twice the average rate, and sometimes the airflow rate can briefly reach three to five times the average rate (called the receiver effect). The bin vent reacts to instantaneous conditions, not average conditions, and so the bin vent you choose must be able to handle this receiver effect and operate effectively during the brief periods of higher airflow rates. If the bin vent can’t handle the receiver effect, the consequences can be severe: Dust will pass through rather than collect on the filters, the bin vent filter cleaning cycles will be less effective, and the receiving bin can be overpressurized, which can cause the pressure relief valve to open and degrade the equipment’s seals and housings, creating dust leaks.
**Bulk unloading system.** In a bulk unloading system, material is pneumatically conveyed from one of the compartments in a bulk truck to a silo (or other storage vessel). In this case, the bin vent is located on the silo. The system, which typically provides dense-phase conveying, warrants special discussion here because of the magnitude of the system’s airflow rate fluctuations and the effect this will have on your bin vent selection and sizing.

During most of the unloading process — generally lasting from 60 to 90 minutes — the airflow rate through the system to the silo is typically between 750 and 800 inlet cubic meters per hour, a unit of measure that accurately reflects the actual airflow rate through a bin vent when it’s exhausting the clean air to the atmosphere. But as the material is nearly emptied from one truck compartment, a magnified receiver effect, called a surge, occurs. The airflow rate during the surge can be four to five times the system’s normal airflow rate and can last 3 to 10 seconds. Although the surge usually occurs only once, just as the entire truck empties, it can occur several times, as each compartment empties.

If you select and size the silo’s bin vent to handle only the average airflow rate through the bulk unloading system, rather than the surge, several consequences are likely:

- **Particles will be forced deep into and through the bin vent’s filter media during the surge, resulting in visible dust emissions from the bin vent.**

- **Conventional filter cleaning won’t be able to remove the particles forced deep into the filter media, and each subsequent surge will further block the media’s pores until the pressure drop in the bin vent reaches an unacceptable level during the unloading system’s normal conveying cycle.**

- **The high pressure drop can overpressurize the silo and cause its pressure relief valve to open, releasing a large amount of dust into the atmosphere.**

- **The overpressurization can damage seals and housings in both the silo and bin vent.**

To prevent these problems, some bin vent manufacturers recommend choosing an oversized bin vent that will compensate for the factors that affect the surge’s magnitude and duration. These factors include the operator’s unloading practices, the truck’s condition, the material being unloaded, and the unloading system’s conveying line length. How much to oversize the bin vent is somewhat subjective but depends largely on the manufacturer’s experience.

A pulse-jet bin vent is best for a bulk unloading system because the bin vent’s continuous pulse-jet cleaning during the system’s 60- to 90-minute normal unloading cycle maintains a low pressure drop across the filters. This allows the bin vent to handle the system’s brief surge without an excessive pressure drop or its consequences.

Nonetheless, many users choose a shaker bin vent for a bulk unloading system because the bin vent is mechanically cleaned and doesn’t require a compressed-air supply, thus avoiding the problems long associated with using compressed air in silos. (These are typically moisture problems, such as moisture contaminating hygroscopic materials, freezing in the air lines, rusting equipment, and so on. Filtering the compressed air can eliminate the problems.) Unfortunately, the shaker bin vent isn’t the best candidate for the bulk unloading system because the bin vent’s filters are cleaned only intermittently and thus are less able to handle the unloading system’s surge. Because the bin vent isn’t cleaned during the system’s normal unloading cycle, a thick dust cake forms on the filters, producing a pressure drop that’s at its highest level at the surge’s onset. To ensure that the shaker bin vent performs adequately for a bulk unloading system, it must be severely oversized, making it an expensive alternative to the pulse-jet bin vent.

**Making your bin vent choice**

Choosing a bin vent shouldn’t be a last-minute step in designing your pneumatic conveying system. To select a bin vent that efficiently cleans the air exhausted from your receiving bin and is correctly sized for your application, work closely with your bin vent manufacturer and consider the factors listed in Table I. Devoting as much care to this process as you do to choosing other major components in your pneumatic conveying system will help ensure that the entire system performs up to your expectations.

**Editor’s notes**

1. Bin vents are also used on receiving bins in mechanical conveying applications. These systems are affected by fewer variables than pneumatic conveying systems and thus it’s typically easier to select a bin vent and size it for a mechanical conveying system. Contact the author for more information.

**For further reading**

Find more information on pneumatic conveying, bin vents, and dust collection equipment in articles listed under “Pneumatic Conveying” and “Dust Collection” in *Powder and Bulk Engineering International*‘s comprehensive “Index to articles” in our November 2001 issue and at our website: www.powderbulkintl.com.

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