Choosing a pneumatic conveying system: Pressure or vacuum, dense or dilute phase?

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A pneumatic conveying system is efficient and inherently dust-tight, making it the most practical equipment for moving large quantities of many dry powders, granules, and pellets. The system uses an airstream to push or pull material through a fully enclosed horizontal or vertical conveying line (pipe or tubing). This article provides basic information to help you determine what kind of pneumatic conveying system will work best for your application.

A pressure pneumatic conveying system introduces compressed air at the system inlet to push the material through the conveying line. A vacuum system applies a vacuum at the delivery end to pull the material through the conveying line. Both pressure and vacuum systems can be used for dense-phase (high-pressure, low-velocity) or dilute-phase (low-pressure, high-velocity) operation.

A *dense-phase* system has a low air-to-material ratio. The conveying velocity is below the *saltation level,* the critical velocity at which particles fall from suspension in the airstream. The dense-phase system moves the material through the conveying line in batches, with discrete material waves or plugs separated by air pockets. Adjusting the system's valves to add less material increases the air pocket size; adding more material reduces the air pocket size.

A *dilute-phase* system has a high air-to-material ratio. In this system, the material is most often fluidized, or suspended in the airstream, and moves at a relatively high velocity, depending on the particle size and density. The dilute-phase system constantly supplies the material at the pickup point and conveys it to the system's discharge end without interruption, with no waves or plugs of material and no air pockets.

Pressure systems

A pressure system's basic components are a lower-pressure positive-displacement blower or fan (for dense phase) or a high-pressure air compressor system (for dilute phase) to serve as the air mover, rotary airlock feeder, pressure vessel, conveying line, and receiver. A system using a lower-pressure blower or fan supplies an initial pressure below 15 psig and a terminal pressure near atmospheric pressure. A system using a high-pressure air compressor operates with pressures above 15 psig, usually with an initial pressure of about 45 psig and a terminal pressure near atmospheric pressure.

In the pressure system, the rotary airlock feeder charges the material into the pressure vessel. Once the pressure vessel is full, the vessel's inlet valve closes and seals, and compressed air is gradually introduced into the vessel. The high-pressure air discharges the material into the conveying line and conveys it to the receiver, where a filter or other system separates the material from the air. Valves and sensors control the system air pressure and velocity. When the predetermined low-pressure setting is reached at the conveying cycle's end, the air mover is turned off and the residual air volume purges material from the pressure vessel and conveying line.

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The pressure conveying system is generally preferred for transporting a heavier material over a longer distance. However, the system can be fairly costly since it requires special equipment, such as a rotary airlock feeder to introduce material into the airstream at the inlet and extra components such as a bin vent or dust collector to remove the air at the discharge end.

Vacuum systems

A vacuum system's basic components are a vacuum generator (the air mover), pickup nozzle, conveying line, and receiver. The vacuum generator creates the required negative pressure (typically 1 to 10 inches Hg) to pull the material through the conveying line and into the receiver and can be any of several devices: a regenerative blower, a compressed-air-driven eductor (venturi) unit, the plant's central vacuum system (using liquid-ring vacuum pumps or low-pressure blowers), or a positive-displacement vacuum pump. The type of vacuum generator determines the maximum negative pressure generated and the conveying system's overall capability, as well as the system's efficiency and general operating characteristics.

In the vacuum conveying system, the vacuum creates suction that allows the pickup nozzle to pick up the material from a hopper, railcar, or other source; the vacuum pulls the material through the conveying line and into the receiver. There, the material drops into the receiver's hopper by gravity. A filter, either internal to the receiver or in a secondary filtration device, filters the conveying air to remove any dust and protect the vacuum generator. Depending on the application, a counterweighted flapper valve, slide-gate valve, pneumatically operated dump gate, or rotary airlock valve can deliver the material from the receiver's hopper to its final destination (a process vessel or packaging line).

The vacuum system is usually preferred for transporting free-flowing, nonabrasive materials. It's also a good choice for an application with limited space at the inlet. For example, the vacuum system may be more practical when there's not enough space below a railcar hopper to attach a pressure system's rotary airlock feeder. However, the vacuum system isn't a good option for material that must be transported over a long distance. Because it operates with pressures at or below atmospheric pressure (14.7 psig), the vacuum system is generally limited to a vertical distance of about 60 feet and a horizontal distance of about 200 feet. The effective horizontal distance is reduced by vertical distances and conveying line bends. [***Editor's***

Table I

Pneumatic conveying system specifications and applications

	System types: Pressure		System types: Vacuum	
	Dense phase	**Dilute phase**	**Dense phase**	**Dilute phase**
Conveying velocities (fpm)	Initial: 50 Terminal: 500	Initial: 2,000 Terminal: 4,500	Initial: 0 to 50 Terminal: 50 to 1,000	Initial: 1,000 to 4,000 Terminal: 4,000 to 9,000
Conveying distance	High; around 1,600 feet	Medium; around 650 feet	Low; optimal performance is generally limited to about 100 feet	Low; optimal performance is generally limited to about 200 feet
Operating pressures (psig)	Initial: 45 Terminal: near atmospheric pressure	Initial: <15 Terminal: near atmospheric pressure	At or below atmospheric pressure; pressure drop through the system	At or below atmospheric pressure; pressure drop through the system
Air-to-material ratio	Low	High	Low	High
Degradation	Use where material degradation or conveying line erosion is a major concern	Use for all dry bulk materials	Use where material degradation must be limited	Use where material degradation isn't a concern
Best for these material types	Abrasive or nonabrasive Fluidizable Free-flowing Granular Noncohesive Noncompressible Pelletized Uniformly sized	Adhesive Cohesive Hard to fluidize Nonpermeable Sticky Very fine	Abrasive Coarse Cohesive Fine Sticky Very fragile	Coarse, lightweight particles Fibrous Fine Granular Low or high bulk density Lightweight Nonabrasive

note: For more detailed information about pneumatic conveying dense- and dilute-phase pressure and vacuum systems, see the later section "For further reading."]

Which system best suits your needs?

You'll want to consult with one (or more) pneumatic conveying specialist (a consultant, engineering firm, or equipment supplier) before making your system choice. Prepare for your discussion by answering the following questions:

- *Why am I considering a new conveying system?* Do you simply want to move material? Do you want to transfer more material than your current conveying system can handle? Are you more concerned with reliability, efficiency, or gentle handling? Your answers to these questions will help your pneumatic conveying specialist recommend the most suitable system for your plant.

- *What kind of material am I going to transport?* Consider your material's handling characteristics, including cohesiveness, flowability, friability, and others, and the material's optimum air-to-material ratio.

- *Is material degradation or conveying line erosion a concern?* Your answer can be the key to choosing a dense-phase system (which provides gentler handling for both your material and system components) or a dilute-phase system.

Table I sums up some basic guidelines to help you choose a dense- or dilute-phase pressure or vacuum system for your material based on some key specifications, such as conveying velocities, conveying distance, operating pressures, and material characteristics. For example, if you need to convey carbon black several hundred feet, you can look at the "Conveying distance" and "Best for these material types" rows and see that a dilute-phase pressure system is likely to be your best bet.

Please note that this table provides only guidelines. You'll want to work closely with an experienced pneumatic conveying specialist who can help you consider every important factor before making your final choice. **PBE**

For further reading

Find more information on vacuum and pressure dense- and dilute-phase pneumatic conveying systems in articles listed under "Pneumatic conveying" in *Powder and Bulk Engineering*'s comprehensive "Article Index" at www.powderbulk.com and in the December 2004 issue.

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