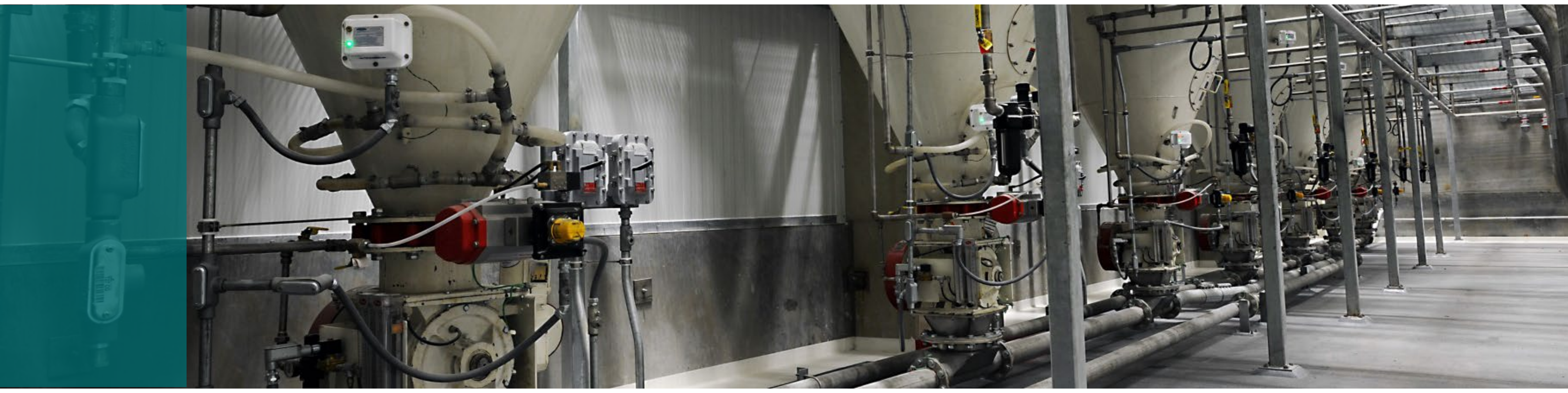
APPLICATION REPORT PNEUMATIC CONVEYING



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Pneumatic conveyance of dry material is a proven method for moving products from place to place in many operations. However, there are multiple types of system configurations possible. Each configuration has strengths and weakness thus, the proper selection depends on the specific process needs. The following article will provide some insight into the different factors to consider when applying a pneumatic conveying solution to a process.

The purpose of a pneumatic conveying system is to move a dry granular or powder material from one unit operation to another in a production or processing facility. The method of transport is airflow through a pipeline moving from an area of high pressure to a relatively lower pressure destination. The success of a pneumatic transport system is greatly influenced by the proper system configuration selection to match the process and specific site needs. The two main variables to consider when making the configuration selection are Pressure vs. Vacuum and Lean Phase vs. Dense Phase. Within these two selections are further configurations based on process needs. For brevity, this article will focus on the technologies that are applicable to sugar production and processing.

Pressure vs. vacuum

A pressure system utilizes an air compressor or blower at the beginning of the system to generate the motive force to move the material from a feed point at an elevated pressure through the pipeline to a receiving vessel at atmospheric pressure. This configuration lends itself to situations where there are few material sources and multiple receiving destinations. A good example would be a storage silo delivering to multiple packaging machines. A pressure system is well suited to high elevations, as well as long distances due to the ability to generate elevated air pressure. This configuration requires a considerable amount of vertical space at the input point to accommodate the equipment required to introduce the material into a positive airstream. Another operational consideration is if the pipe works are not properly installed and supported, leaks may occur leading to housekeeping concerns.

Key aspects of the Pressure System

- Few sources to many destinations
- Considerable clearance required at the source point(s)
- Suitable for high altitudes
- Suitable for long distance conveyance
- Any leaks will result in product escaping into the atmosphere

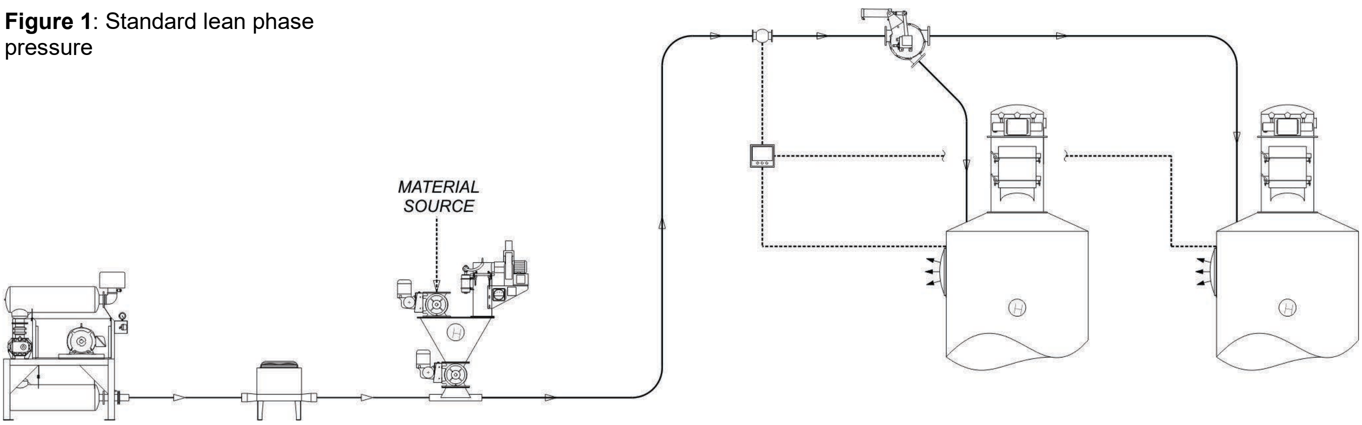
A vacuum system utilizes a pump or blower to generate a vacuum at the destination point, which creates a lower differential pressure relative to the feed point. This configuration lends itself to situations with many feed points going to a single or a few destinations. A common situation would be multiple types of material that need to alternately feed a single destination. A vacuum system is not suitable for long distances or locations with high altitudes. This limitation is imposed by the fact that the potential pressure differential is limited to the total atmospheric pressure. A vacuum system does, however, have two very favourable factors - the height required at the feed point is relatively small compared to a pressure system, and any leaks that the system develops will allow air into the convey pipe, but will not result in material escaping into the plant atmosphere.

Key aspects of the Vacuum System

- Many sources to few destinations
- Limited clearance required at the source point(s) Not suitable for high altitudes
- Not suitable for long distance conveyance
- Leaks result in ambient air being draw into convey system

Lean phase vs. dense phase

Figure 1: Standard lean phase pressure



Lean or dilute phase is the original and simplest pneumatic conveying technology. A lean phase system is identified by an airflow velocity that is high enough to fully entrain the material and suspend it in the airstream. This velocity varies relative to the particle size and geometry, as well as the product's bulk density.

Key aspects of the Dilute Phase System

- Gas flow is not critical
- Compatible with most products
- Convey rates are variable within a given line size Low operating pressure or vacuum
- High velocity
- Degradation is likely
- Simple equipment and operation
- Pipelines are easy to support and route

Dense phase technology was developed to address particle degradation and pipeline abrasion. This is accomplished by moving the material through the pipeline in discrete slugs of material separated by air pockets. In this case, the material is not entrained. The pipeline cross section is fully filled and the velocities are much lower. It is important to note that not every product is a suitable candidate for dense phase conveying.

Key aspects of the Dense Phase System

- Gas flow is critical
- Products must have suitable properties
- Convey rates have limitiable variablity within a given line size
- High operating pressure or vacuum
- Low velocity
- Degradation is reduced or eliminated
- Equipment and operation is more complex
- Pipes must be rigidly supported and routing is critical

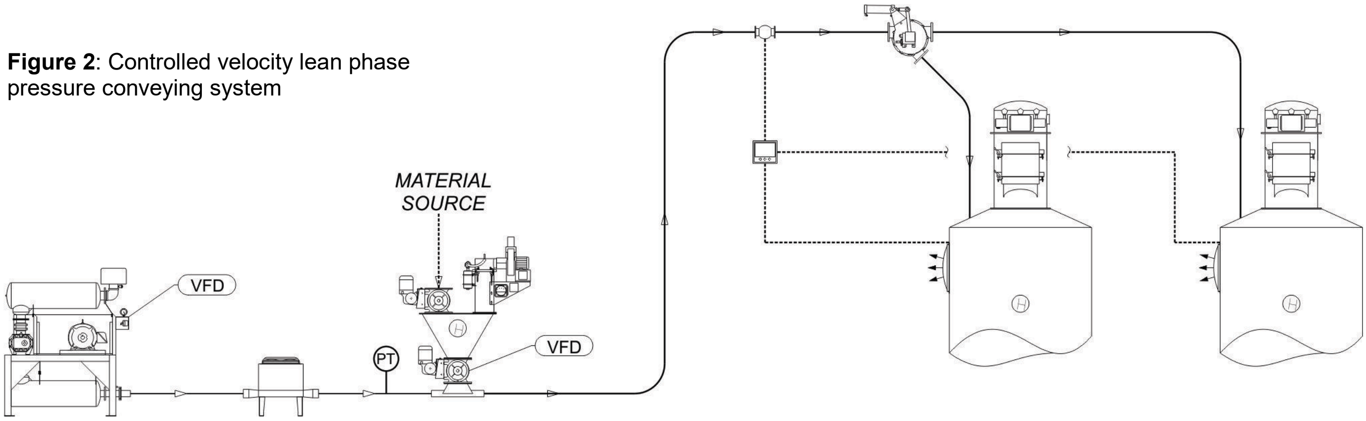
Lean phase system configurations

A standard lean phase pressure system is configured with a pressure blower that is sized for an airflow that allows full entrainment of the particles in the airstream to the furthest destination (Figure 1). Typically, the calculations include a safety factor on the airflow, to allow the system to recover from a momentary upset. These settings are then used to establish a fixed blower speed for all destinations.

Key aspects of the Standard Pressure Lean Phase

- Pressure below 1.03 bar (15 psi)
- Velocities from 21 m/sec to 36 m/sec (4,200 fpm to 7,000 fpm)
- Distance up to 152m (500‘)
- System designed for worst case conditions System operates at single setting
- Most products compatible, but heavier products limit distance and rate
- Utilizes positive displacement blower

Figure 2: Controlled velocity lean phase pressure conveying system



A controlled velocity lean phase pressure system is also configured with a pressure blower that is sized as in a standard system (Figure 2). The difference is a distinct calculation is made for each destination. These calculations are used to control algorithms, along with the pressure transmitter to control the VFD that adjusts the airflow. These airflow adjustments control the velocity to the desired setting for each destination.

Key aspects of the Controlled Velocity Pressure Lean Phase

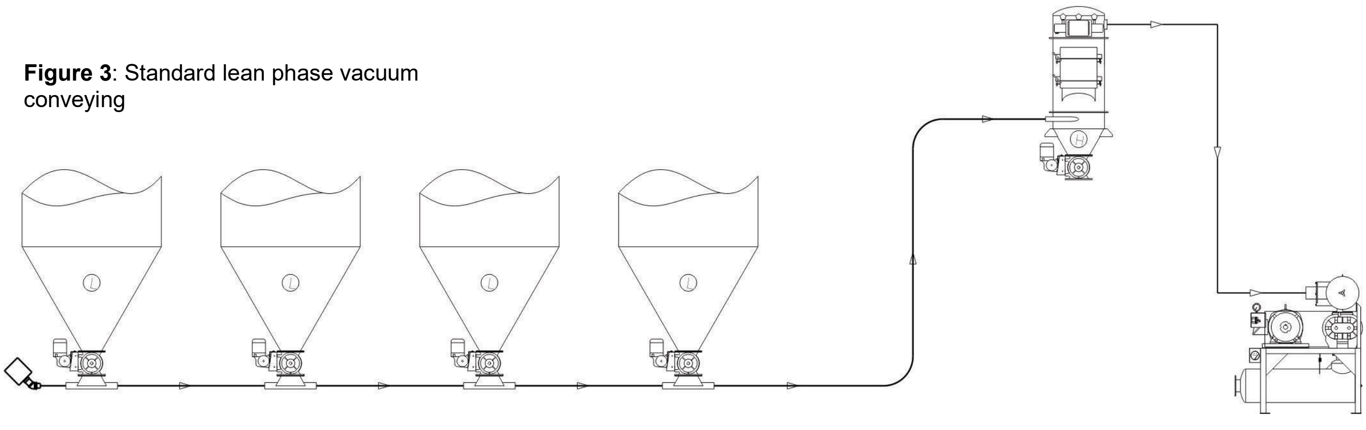
- Pressure below 1.03 bar (15 psi)
- Velocities from 18 m/sec to 28 m/sec (3,500 fpm to 5,500 fpm)
- Distance up to 91m (300‘)
- System designed for worst case conditions Operating parameters vary based on pressure and rate
- Most products are compatible, but heavier products limit distance and rate
- Abrasive products create concern due to elbow and airlock wear
- Utilizes positive displacement blower

A standard lean phase vacuum system is configured with a vacuum blower that is sized to draw airflow through the system from the furthest source at a velocity that ensures full entrainment of the particles in the airstream (Figure 3). As in the standard pressure system, the calculation will include a safety factor to allow for recovery from momentary upsets. These calculations are used to establish a fixed blower speed for all sources.

Key aspects of the Standard Vacuum Lean Phase

- Vacuum depth of 380 torr (15“ HG)
- Velocities from 21 m/sec to 36 m/sec (4,200 fpm to 7,000) fpm)
- Distance up to 91m (300‘)
- System designed for worst case conditions
- System operates at single setting
- Most products are compatible, but heavier products limit distance and rate
- Abrasive products create concern due to elbow and airlock wear
- Utlizes positive displacement blower

Figure 3: Standard lean phase vacuum conveying



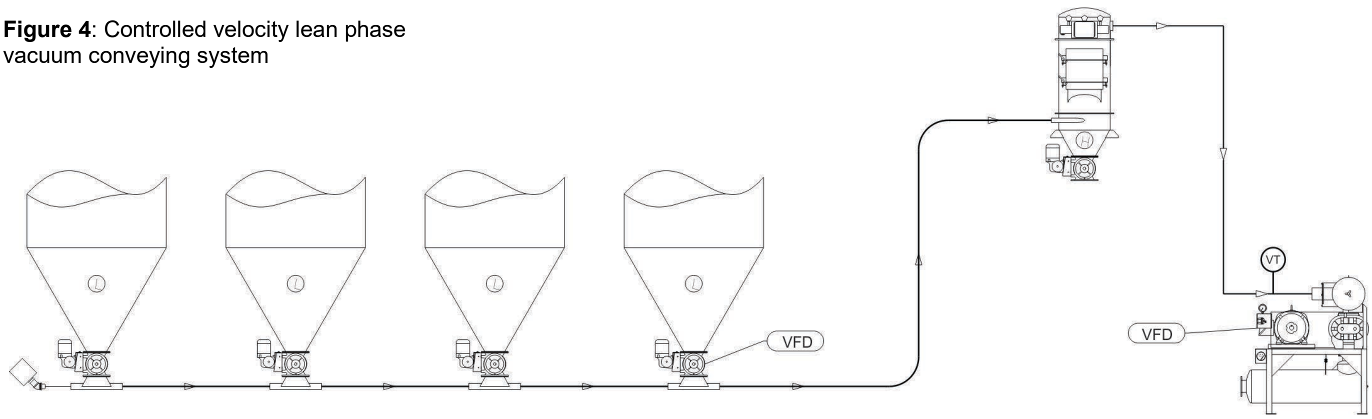
A controlled velocity lean phase vacuum system is configured with a vacuum blower like the standard system (Figure 4). Added features of the controlled velocity configuration are calculations that account for the distance from each source. These calculations are used to control algorithms, along with the vacuum transmitter to control the VFD (variable frequency drive) that adjusts the airflow and the velocity from each material source.

Key aspects of the Controlled Velocity Vacuum Lean Phase

- Vacuum depth of 380 torr (15" HG)
- Velocities from 18 m/sec to 28 m/sec (3,500 fpm to 5,500 fpm)
- Distance up to 61m (200')
- System designed for worst case conditions
- Operating parameters vary based on pressure and rate
- Most products are compatible, but heavier products limit distance and rate
- Abrasive products create concern due to elbow and airlock wear

Dense phase system configurations

Figure 4: Controlled velocity lean phase vacuum conveying system



A pressure vessel dense phase system is configured with a pair of pressure vessels that are alternately filled with material and then discharged at elevated pressure into the pipeline (Figure 5). The motive force comes from compressed air that must be filtered and conditioned for direct product contact. The air management system controls the airflow and pressure to establish the formation of slugs in the pipeline, accomplishing dense phase conveying. A single vessel configuration can be suitable, depending on space available or process considerations.

Key aspects of the Pressure Vessel Dense Phase

- Pressures between 2.06 and 4.12 bar (30 psi and 60 psi)
- Velocities 3 m/sec to 12 m/sec (600 fpm to 2,400 fpm)
- Distances up to 198m (650') depending on product
- Suitable for any product that is permeable and fluidizes well
- Good technology for controlling degradation and reducing abrasive wear
- Suitable for abrasive products
- Fully tested on granular products like EFG (Extra Fine Granulated) sugar
- Requires compressed air

A vacuum dense phase conveying system consists of an inlet hopper that is flood fed with material (Figure 6). A deep vacuum pump draws a vacuum on the system providing the motive force to move the material. A control valve on the pipeline, near the material inlet, modulates to maintain the desired vacuum depth. This valve also meters filtered ambient air into the pipeline to establish the slug formation, accomplishing dense phase conveying.

Key aspects of the Vacuum Dense Phase

- Vacuum depth approaching full vacuum 737 torr (29" HG)
- Velocities from 2 m/sec to 10 m/sec (400 fpm to 2,000 fpm)
- Distance limited to 61m (200')
- Product must fluidize and be permeable
- Good technology for limiting degradation and transporting blended material
- Not suitable for very dense products
- Utilizes a rotary claw or sliding vane vacuum pump

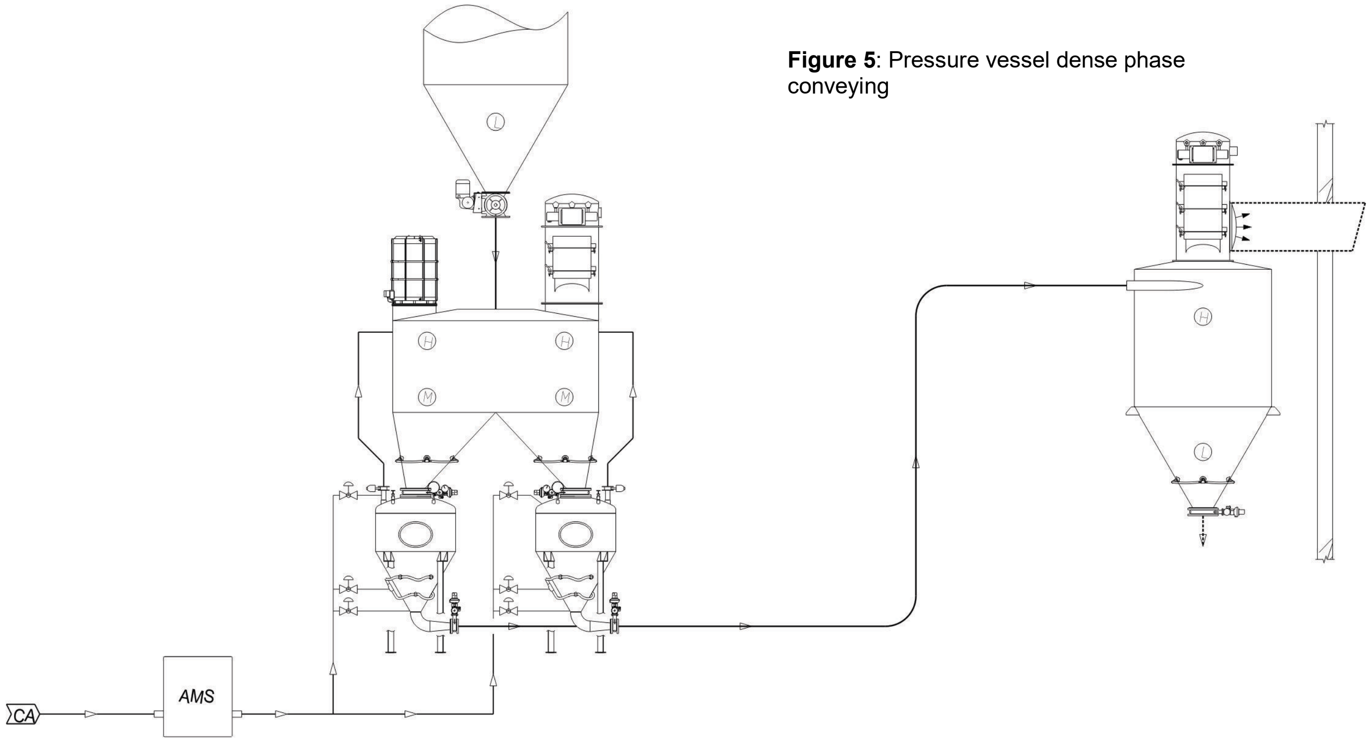


Figure 5: Pressure vessel dense phase conveying

Pneumatic conveying is a viable option to address material handling needs in sugar processing and production facilities, as long as the technology selected matches the process requirements. As with most things, every application must be evaluated on its own merits. There will always be situations where these guidelines need to be overruled by site or process considerations to achieve the best results.