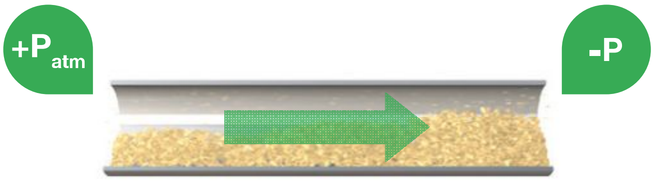
Piab Vacuum Academy

1. Piab vacuum academy emphasizes the basics

In industry today there is an accelerating trend toward ever more customized solutions that can be made available at short notice. Product development times and production runs are both becoming shorter. Changes are becoming more sudden and harder to predict. Competence and willingness to change are being challenged by a never-ending parade of new situations. Training that sharpens skills and broadens perspectives enables your personnel – and your company – to handle more sophisticated assignments while accepting highly qualified responsibilities. This makes it easier for you to develop new functions and work procedures while advancing into new markets.

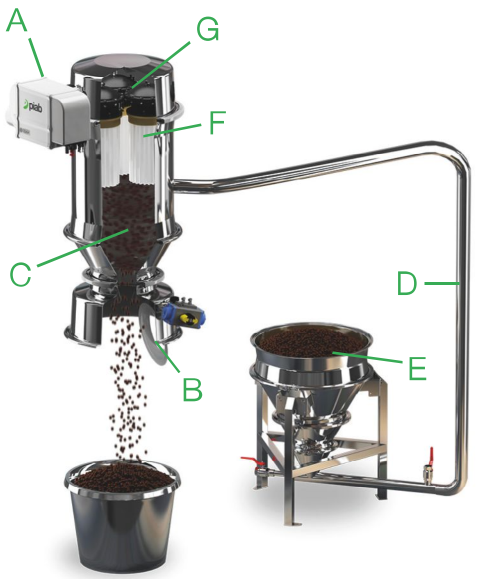
1.1 Principles of conveying



In the field of vacuum conveying technology we speak of vacuum conveyors being used for "sucking" material. What actually happens is that the air is evacuated from the suction pipe and the pressure of the atmosphere pushes the material into the suction pipeline. It is the atmospheric pressure that indirectly performs the work. The stream of air that is formed upon pressure equalization pulls the solid particles into the pipeline.

All vacuum conveyors work according to the same main principle. The material is conveyed from a suction point through a pipeline to a container, where the air and the material are separated. The filter cleans the air before it passes through the vacuum source. A control unit regulates the operating sequence.

2. A typical vacuum conveying system



Vacuum is generated by a compressed air-driven vacuum pump (A). The pump can easily be automatically controlled. Since it has few moving parts, the pump is virtually maintenance-free.

1. The bottom valve (B) is closed, and vacuum is raised in the container (C) and the conveying pipeline (D).
2. From the feed station (E) the material is drawn into the conveying pipeline and then on to the container.
3. The filter (F) prevents dust and fine particles from being drawn into the pump and escaping into the surroundings.
4. During the suction period, the filter cleaning device (G) is filled with compressed air.
5. When the material container is full, the vacuum pump is stopped. The bottom valve opens and the material in the container is discharged. At the same time, the compressed air in the filter cleaning device is released and cleans the filter.
6. When the pump is restarted, the process is repeated and a new cycle begins. The suction and discharge times are normally controlled by pneumatic or electrical control systems.

3. Material handling

3.1 Material flow

The material flow is determined by the:

- Diameter of the conveying pipeline
- The vacuum flow
- Conveying distance
- Characteristics of the material

Dense phase means that the material is conveyed in separate plugs in the conveying pipeline. Some materials can be conveyed in dense phase.

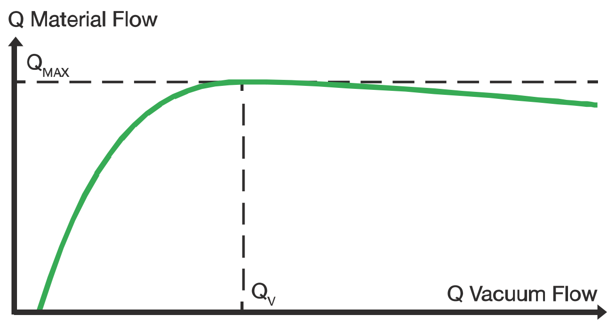
Another conveying phase is “dilute phase”. Conveying speed in dilute phase is usually >10 m/s.

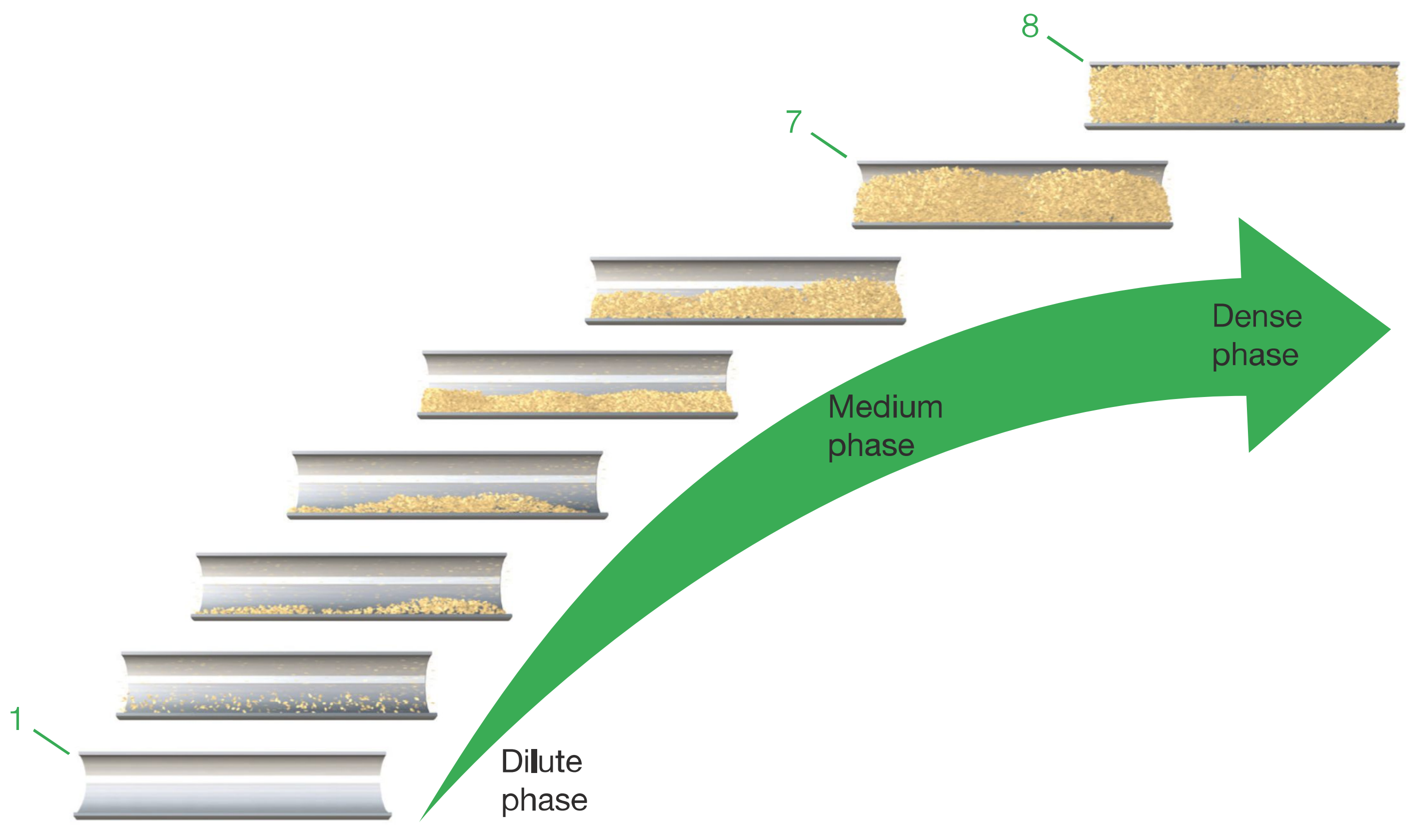
The following figure shows conveying phases with different phase densities. From very dilute phase (1), over dense phase (7) to blocked pipeline (8).

$$* \text{ Phase density} = \frac{\text{Material flow (kg/h)}}{\text{Vacuum flow (kg/h)}}$$

It is generally the case that in dense phase, because the material moves in the form of plugs, the vacuum level is usually 30–65%, while in dilute phase it is 10–30%.

When sizing a conveying installation, it is important to find the optimum conveying phase for a specific material. A common misapprehension is that the greater the vacuum flow, the higher the material flow. The relation between material flow and vacuum flow may, for example, be as shown in the figure. The diagram shows that the maximum material flow Q_{max} is equivalent to the vacuum flow Q_v. When the vacuum flow increases, the material flow will decrease.





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3.2 Material classification

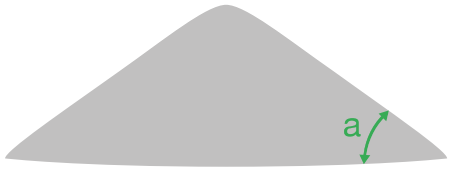
When sizing a conveyor, it is important to determine the fluidity of the material that is to be conveyed.

To sum up, the following points should be included in the material classification:

- Fluidity/angle of repose
- Bulk density
- Abrasion factor
- Particle
  - size
  - distribution
  - form
  - density
  - hardness
- Moisture sensitivity (hygroscopicity)
- Explosion hazard
- Harmfulness/poisonousness

3.2.1 Fluidity

The fluidity is one of the most important qualities when the conveying possibilities of a material shall be decided. One way of making a rough assessment of the fluidity is to determine the material's angle of repose by pouring out the material from a height and measuring the angle (a).
A small angle of repose means good fluidity and a large angle of repose, poor fluidity. The factors that determine the fluidity of the material are particle size, geometric shape, tendency to pick up static electricity and degree of moisture sensitivity. Plastic granules generally have good fluidity while corn flour has poor fluidity and is also sensitive to moisture.



Material with poor fluidity can often be fluidized. For fluidization to work, the material must be reasonably fine so that it is lifted by the fluidizing air. If the material consists of coarse particles, fluidization will not be so effective.

3.2.2 Bulk density

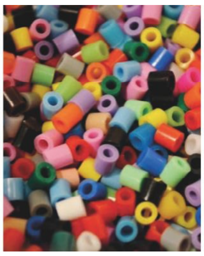
The term "bulk density" refers to the weight/volume of a material, in other words, how much one litre of the material weighs. As one litre of powder contains both material and air, the bulk density will vary considerably depending on how closely a particular material is packed. In other words, the same material will have different bulk density values if you weigh a litre of material that has been poured into a beaker and a litre of material that has been shaken and packed. It is therefore important to measure bulk density under conditions that are as similar as possible to the actual conveying conditions.

3.2.3 Particles

Individual particle weight, size, distribution, form and hardness are all parameters that determine a material's flow ability and thus its conveying characteristics.

The weight (density and size) of the individual particles determines the vacuum flow that is required to lift the material into the conveyor pipe and move it forward in the pipeline.

The term "particle distribution" refers to how much of various-sized particles, from the smallest to the largest, make up the material's composition.


3.2.4 Moisture sensitivity

Different materials are more or less hygroscopic. If test running is carried out on a particular material, it is important that the conditions are kept as similar as possible to those that will apply on installation. A moisture-sensitive material may form lumps that catch in the material intake, stick in the pipeline or block up the filter.

3.2.5 Explosion risk

In connection with handling of finely ground material, there may be a risk of dust explosion. Dust explosions can occur when certain types of particles are mixed with air at a certain ratio and a source of ignition is present. Rapid expansion and pressure increase are characteristics of dust explosions. Dust explosions that occur during conveying of materials are commonly caused by sparks from static electric discharge.

In a vacuum conveyor, the ratio of the air-to-material mixture (phase density) varies and the risk of a dangerous mix cannot be eliminated entirely. The risk of ignition can, on the other hand, be minimized by preventing electrostatic discharge and thus the generation of sparks. This can be achieved by connecting the various parts of the conveyor system to the same earth point (equipotential connection).

Many common materials have a tendency to cause dust explosions. Examples of such materials are given below but of course there are many more.

- Aluminium
- Aspirin
- Carbon
- Coffee
- Cork
- Cotton
- Flour
- Grain
- Iron
- Nylon
- Sugar
- Tea

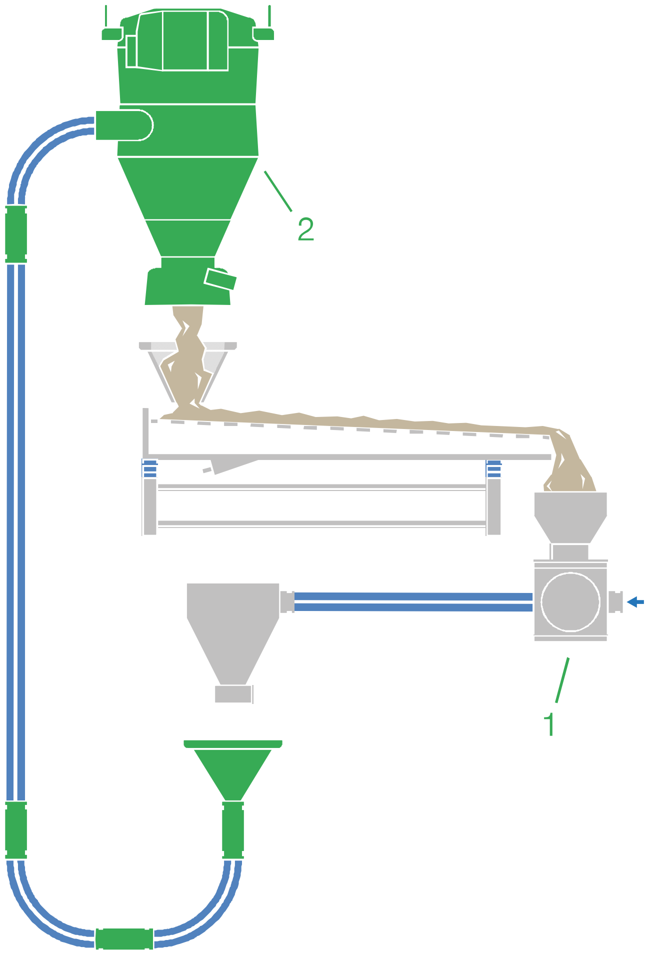
4. Pneumatic Conveying system

4.1 General

From a technical point of view, pneumatic conveying is based on conveying of solid particles mixed with a gas, usually air.
By means of pneumatic conveying, solid particles of varying sizes can be conveyed between points, for example, from a storage to a processing machine.

4.2 Pneumatic conveying systems are divided into two categories:

1. Positive-pressure systems, where the material is blown through the conveying pipeline by compressed air.
2. Negative-pressure systems where the material is "sucked" through the conveying pipeline.



5. Components of a vacuum conveying system

A vacuum conveying system always consists of a number of components. The components are suction point, conveying pipeline, collecting container, filter, vacuum pump and control equipment. Support components may be fluidization, pipeline valves, various sack dischargers, weighing equipment, etc.

5.1 Feeding point

For automatic or semi-automatic systems a feed station or different types of feeding adapters can be used. A feed station is a special feeding adapter that can mix air with the material and, if necessary, be provided with fluidization.

The suction point can also consist of an aspirated feed nozzle, which entrains extra air to the conveying.

A feeding adapter with adjustable intake for air and material, that can be mounted on, for example, a silo.

5.2 Conveyor pipeline

One of the many advantages of pneumatic conveying systems is that they are simple to install. Friction in pipes and hoses can reduce the material flow considerably. For permanent installation, rigid pipes should always be used. Pipes have lower friction than hoses. A good pipe installation may mean an increase in the material flow so that pump capacity can be reduced and thus lower running costs achieved.

5.3 Conveyor body

The collection container is the vessel or volume that is placed under vacuum in connection with the suction cycle and in which the material is collected. At the bottom of the container there is a discharge device that opens when the suction cycle is complete and the material flows out and then closes again in preparation for the next suction cycle.

If necessary, the discharge device may be fitted with fluidization for better discharge.

5.4 Filter

The filter separates the conveyed material from the carrier air. If some particles should follow the air up to the filter, they will be filtered away, and the clean air will continue out through the vacuum pump. Most filters are fitted with some kind of cleaning device.

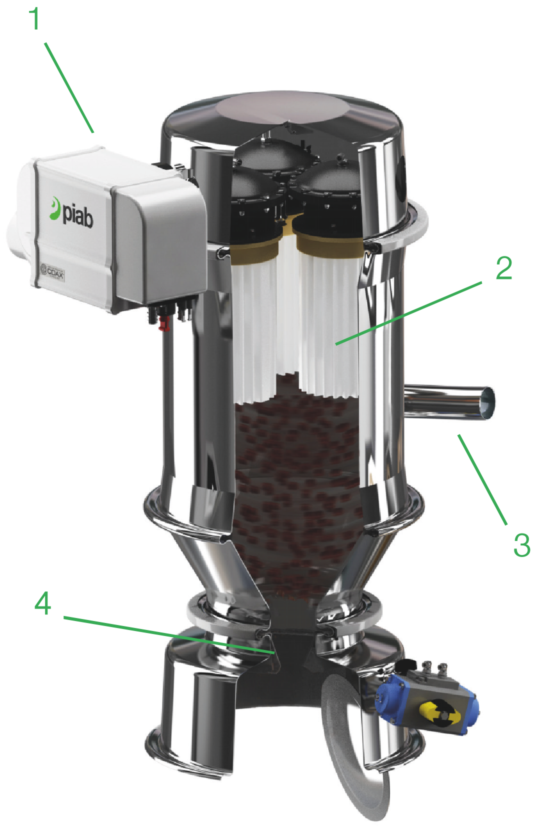
5.5 Vacuum pump

The heart of the system is the vacuum pump that creates the reduction of pressure or suction that moves the material.

By using a compressed air-driven vacuum pump, a complete explosion-proof unit is achieved, which is important in order to avoid dust explosions. Vacuum pumps driven by compressed air also have the advantage of being virtually maintenance-free, silent and not emitting any heat. They are also easy to control as they react very quickly. The pump can be controlled by means of the compressed air supply, which means that the pump runs only during the suction period and is at rest, saving energy, at other times.

5.6 Control equipment

As a vacuum conveyor works intermittently, some form of control equipment that regulates running time, standstill time, discharge, fluidization, etc., is required.



1. Pump unit
2. Filter unit
3. Connection unit
4. Bottom valve unit
5. Control unit (not in picture)
6. Nylon tubing kit (not in picture)

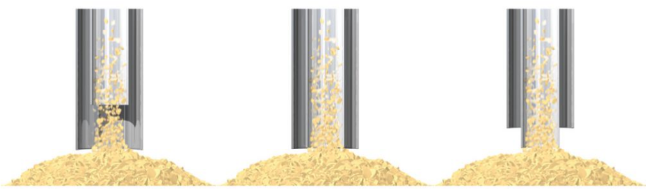
6. System design

As mentioned previously, there are many parameters that affect a vacuum conveying system. Naturally, the system design itself is also extremely important. However, as most vacuum conveying systems are unique it is hard to give direct instructions. Certain general basic principles do of course apply and the most important of these are described below.

6.1 General

Some general rules to bear in mind when planning a vacuum conveying system are:

- Short conveying distance reduces system and running costs.
- Keep number of pipe bends to a minimum to reduce system and running costs.
- Avoid running the conveying pipeline on an inclined plane.
- Use rigid pipes where possible.

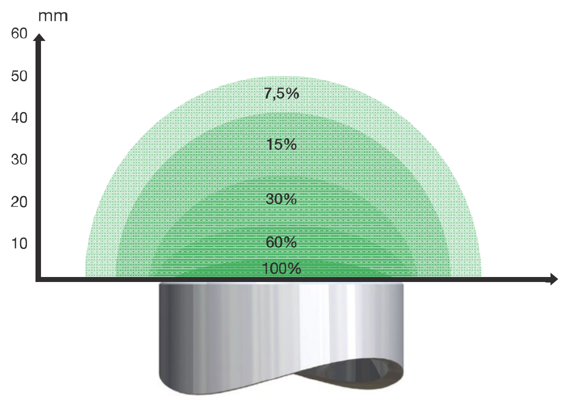


6.2 Suction point design

Most materials need additional air in order to be set in motion. If a system is to function satisfactorily, the feed, i.e., the suction point, must be designed correctly. It is important that the material is placed close to the intake on the conveying pipeline as the suction capacity decreases by the square of the distance.

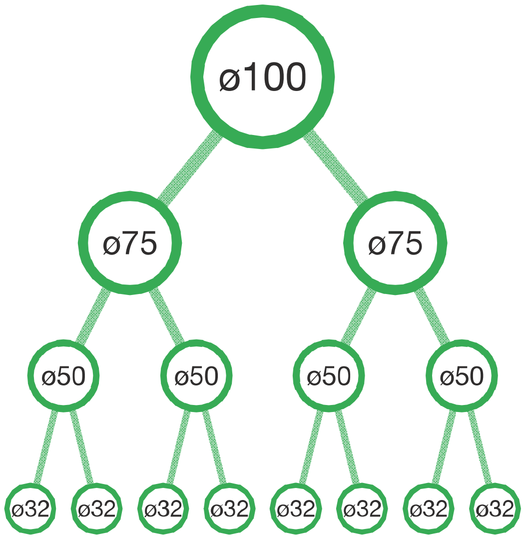
When the suction point is designed as a feed station, there are normally two valves, one for air and one for the material, which can be controlled to give the right proportions of material and air in the pipeline. Another way of supplying air, particularly with material that is hard to convey, is to fit the feed funnel with fluidization.

If a suction nozzle is used, the simplest way of supplying additional air is by using a double-mantled feed nozzle, where the input air is regulated by means of a valve on the handle. The inner tube can also be regulated upwards and downwards in relation to the outer one, and this setting also has an effect on conveying.



6.3 Pipe dimensions

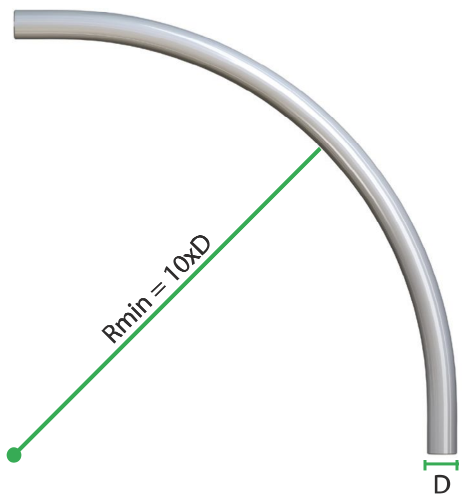
Pipe diameter is of vital importance for the capacity of a conveying system. In principle, the greater the diameter of the pipe, the greater the capacity of the system, provided the speed is kept constant. In practice this means that if you want to increase the capacity, you usually have to overhaul the entire system, including vacuum pump and containers as well as tube dimensions. In certain cases, however, a capacity increase may be made possible with smaller pipes and the same pump. This is due to the fact that it may be possible to move the material in another phase (dense phase). The ratio of the various pipe diameters is shown by the adjacent figure. For example, a pipe with a diameter of 75 mm is equivalent to two pipes with a diameter of 50 mm.



The speed of the material is directly related to the speed of the air in the pipeline. As the pressure in the pipeline falls the closer you get to the conveyor, the speed of the air and the material increases correspondingly. That is why in certain cases stepped pipelines (pipes of increasing diameter) have to be used to keep down the speed of the material so that it is not broken to pieces.

6.4 Pipe bends

A large bending radius is one way of avoiding unnecessary wear and pipeline resistance. Hoses are often used in bends so that they can be simply and cheaply replaced when they wear out.



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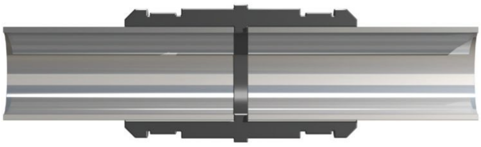
6.5 Pipe joints

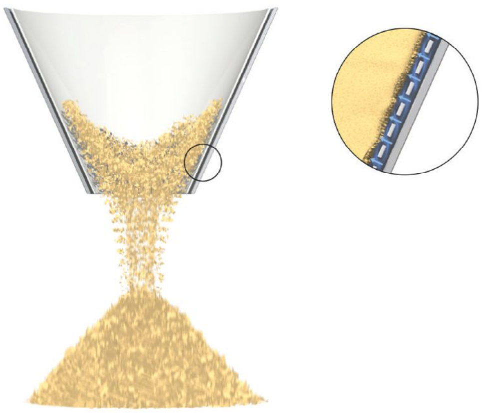
Pipe joints must be constructed correctly so that material does not build up around the joints. Rounded edges and a good seal are important points to remember.



6.6 Fluidization

In cases where the material to be conveyed has poor flow capacity, fluidization may be an option. Fluidization may take place both at the feed station, to ensure supply of material to the conveyor, and in the conveyor container to improve discharge.

Fluidization means that compressed air passes through a porous filter material where it is finely distributed. The finely distributed air creates a cushion or film that reduces the friction quite considerably between material and base. What is more, the air is mixed with the material in such a way that friction is also reduced between the particles in the material, which means that the material “flows like water”. Not all materials can be fluidized.



6.7 Weighing

Checking or weighing how much material has been conveyed may take place according to three main principles. The feed station can measure how much has been taken away, the conveyor container can be weighed to measure how much has reached it, and the receiving container may be weighed to ascertain how much has been discharged. Usually, the last weighing option provides the greatest accuracy. The degree of accuracy that can be achieved with the various systems is entirely dependent on the properties of the material conveyed and the construction of the system. In cases where the aim is to meter out a certain quantity of material it is best to place special metering equipment between the conveyor and the receiving container. There are many different types of equipment in the market and the properties of the material determine type and make.

6.8 Several different materials

It is simple to connect a vacuum conveyor to different feed stations and thus it can convey different materials to one and the same container, but only one material at a time. If you want to mix different material to a recipe, the system can be fitted with load cells for weighing.