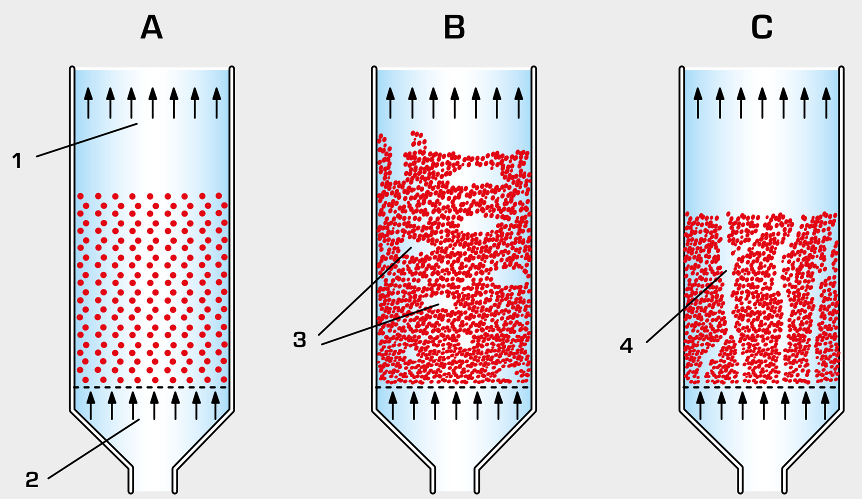
Basic knowledge
Fluidised beds

A fluidised bed involves two phases: a solid and a fluid (gas or liquid). If a fluid flows through a resting layer of bulk solid at an adequate velocity (fluidisation velocity), the layer is loosened so that individual solid particles enter a suspended state. This state is termed fluidisation. The fluidised bed created in this way behaves similarly to a liquid in terms of flow and thermodynamics.

If the velocity is excessive, particles are discharged from the fluidised bed. Hydraulic or pneumatic transport begins.

Owing to the large contact surfaces between the solid and fluid, heat and material transport processes between the particles and the fluid, and among the particles themselves, are encouraged.

One application of this is in fluidised bed combustion, where combustion takes place in a fluidised bed made of comminuted fuel and hot combustion air. The fluidised bed principle permits low combustion temperatures. As a result, very low nitrogen oxide emission limits can be achieved.



Fluidised bed forms:
A homogeneous fluidised bed,
B bubbling fluidised bed,
C channeling;
1 fluid outlet,
2 fluid inlet,
3 bubbles,
4 channel

The following forms of fluidised bed may occur:

- **Homogeneous fluidised bed**

As the flow velocity of the fluid increases, a uniform volumetric dilation of the fluidised bed occurs. The solid particles are evenly distributed across the entire layer. In reality, behaviour of this kind is to be observed only in liquids when using particles of equal size.

- **Inhomogeneous fluidised bed**

Classification or sorting processes take place in the fluidised bed. Specifically heavier particles are enriched in the lower zone. When using gases as the fluid, bubbling almost always occurs in the fluidised bed. The bubbles are free of solids. Smaller bubbles merge on their way to the surface to form larger bubbles. At the surface they burst. The surface of the fluidised bed looks like a boiling liquid.

- **Channeling**

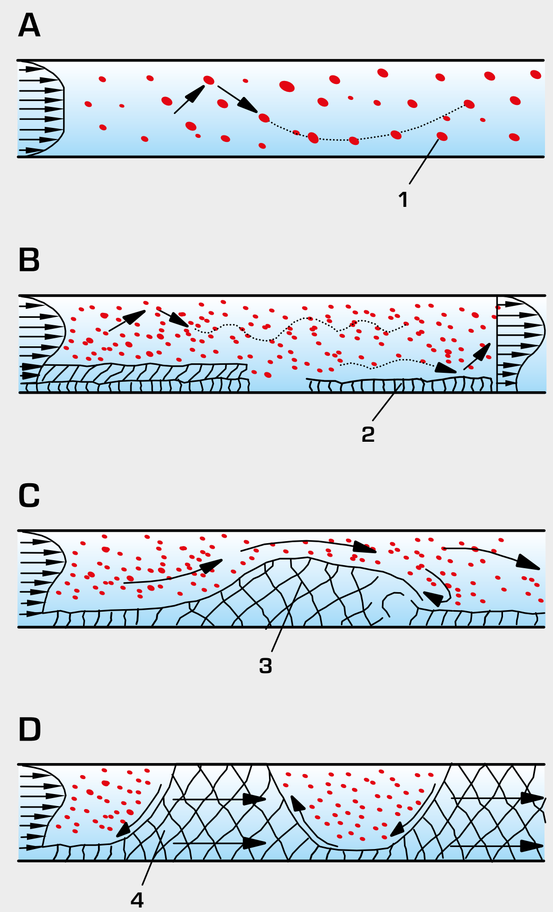
If a fine-grained bulk solid is used as the solid, and if the individual particles adhere to each other, formation of a fluidised bed may not occur. Instead, flow channels are created. There is no flow through the surrounding zones. With such solids, a fluidised bed can only be created by additional stirring.

Basic knowledge
Pneumatic transport

Pneumatic conveyor systems transport powderous and granular bulk solids by means of a gas flow (mostly air) in pipelines. The bulk solids may be foodstuffs such as grain or pulses for example.

Pneumatic conveyor systems essentially consist of an air compressor, a conveying line and a dust separator (e. g. gas cyclone). Transport may be effected horizontally, vertically, or occasionally inclined.

Typically the conveyor line may be connected to the intake (suction or vacuum) or delivery (positive pressure) side of the air compressor. Combination suction/positive pressure systems also exist. Vacuum conveying systems have a beneficial feature in that the vacuum in the system does not permit any dusty air to leak out. Positive pressure conveying systems enable transport over greater distances and differences in height than vacuum conveyors.



Transport states with velocity profiles in horizontal pipelines:
A suspension flow or dilute phase transport,
B intermediate flow or strand transport;
C dense phase dune transport, D dense phase plug transport;
1 solid particles, **2** strands, **3** plug or slug formation from a dune,
4 moving plug

Depending on the velocity and solid content of the airflow, different transport states may occur in **horizontal** pipelines:

- **Suspension flow or dilute phase transport**
  At high velocities the solid particles move through the line distributed uniformly across the cross-section. Particles impact against each other or against the pipe wall.
- **Intermediate flow or strand transport**
  If the velocity is reduced while the solid content remains constant, the energy of the flow is no longer sufficient to hold the entire solid mass suspended. Some of the solid particles slide along the bottom of the pipe in the form of strands. The rest are transported in suspension above the strands.
- **Dense phase dune transport**
  If the velocity is reduced further, the solid particles move like a dune. Particles are moved over the summit of the dune and are deposited on its sheltered side. If the velocity is reduced further, incipient plugs may be formed from the dunes which occupy a major part of the cross-section of the pipe.
- **Dense phase plug transport**
  At very low velocities the material occupies the entire cross-section of the pipe and plugs are formed. Plugs advance slowly. If the air compressor does not have sufficient pressure reserves, plug transport may quickly lead to blockage of the pipeline.

In **vertical** pipes the same transport states occur in principle, though gravity is more of an influencing factor.

Not all materials are capable of being transported in dense phase. The detailed behaviour observed in the conveying line is highly dependent upon the particular material's characteristics.