Knowing which way the wind blows…

Pneumatic Conveying

Sugar Industry Focus

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What is Pneumatic Conveying?

A process by which solids, of almost any type are transferred along a pipeline…

- **Using a gas flow as the conveying medium (usually air)**

Transfer of material is achieved by creating a pressure differential along a pipeline and moving a bulk material along with the gas as the gas moves towards the area of lower pressure.

Motive force can be created by:-

- **Compressed air injected into one end of, and/or along the pipeline**
- **Vacuum inducer**

Brief History of Pneumatic Conveying

50 AD	• Greek mathematician & engineer - Hero (Heron) of Alexandria - *Pneumatica*
1700	• Daniel Bernoulli (fluid dynamics) & Giovanni Venturi (Venturi effect)
1800	• Pneumatic capsule transportation invented by William Murdoch, Scotland
1856	• Cyclone separator invented by Knickerbocker Co. for grain cleaning, USA
1860	• Positive displacement blower invented by Philander and Francis Roots, USA
1930	• Pneumatic conveying installed across Europe and USA handling grain & cement
1950	• Flour mills modernised worldwide – pneumatic conveying replaces mechanical
1956	• Pulse Jet dust filter collector invented by MikroPul, USA
1970	• Dense phase conveying innovation becomes popular - lower velocity & power

Transfer of Solids

In contrast to fluids which are transferred almost exclusively through pipelines with pumps or blowers a greater variety of equipment is employed for transporting dry bulk solids and powders to and from storage and between process equipment.

Most commonly, solids are carried or moved by some kind of conveying medium.

- Mechanical
- Hydraulic
- Pneumatic

In this presentation we will look at the use of a pressurised gas flow to transport solids

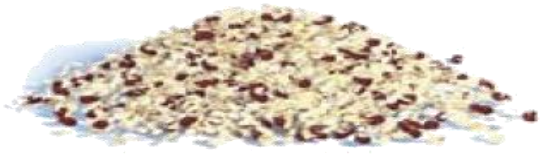
Pneumatic

Pneumatic Conveying of Solids

This form of conveying is used to transport the following material groups…

- **Powder**
- **Granular**
- **Flaky**
- **Pellet**

Bulk densities of 30 to > 2,000 kg/m³ (2 to > 32,000 lbs/cu.ft)



Material Characteristics

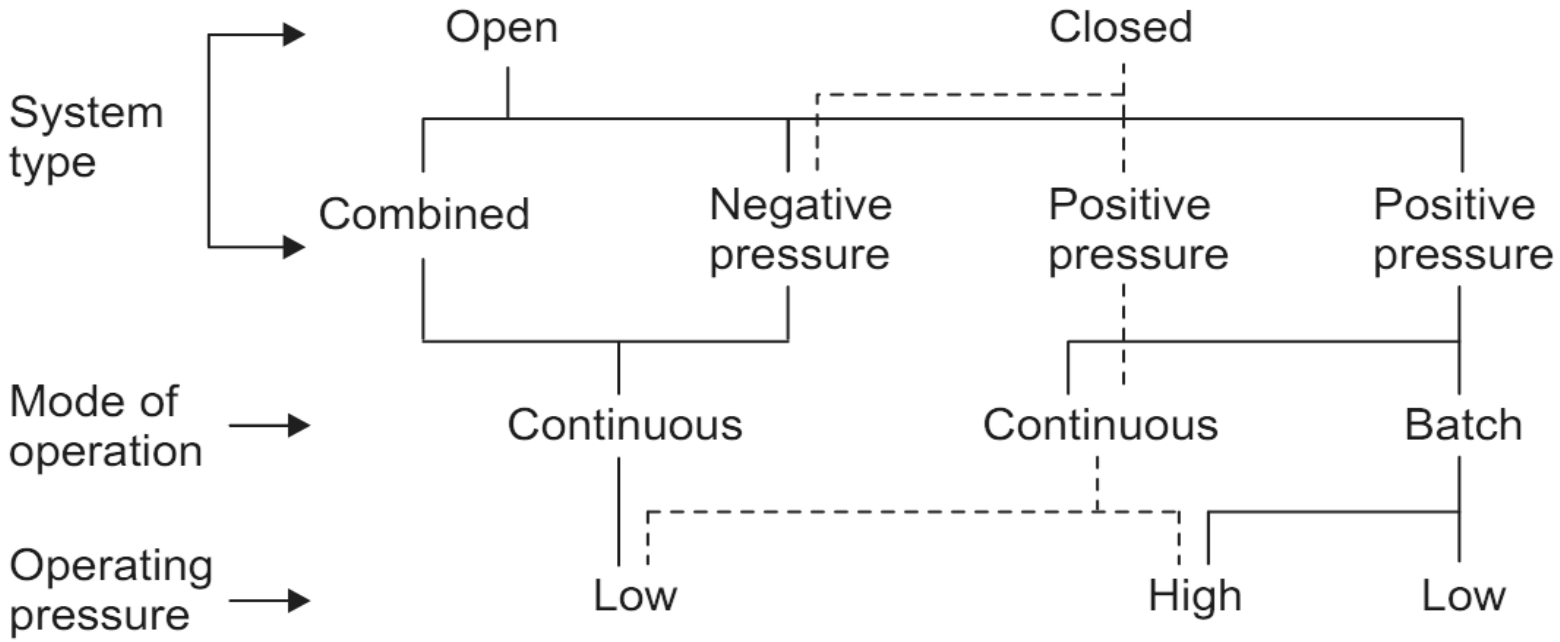
When sizing a pneumatic conveying system, it is important to determine the characteristics of the material that is to be transported, including:-

- **Abrasiveness**
- **Bulk density**
- **Fluidity (angle of repose)**
- **Friability**
- **Explosion risk**
- **Moisture (Hygroscopy)**
- **Oil / Fat content**
- **Particle (size & distribution)**
- **Temperature**
- **Toxicity**

Pneumatic Conveying System Groups

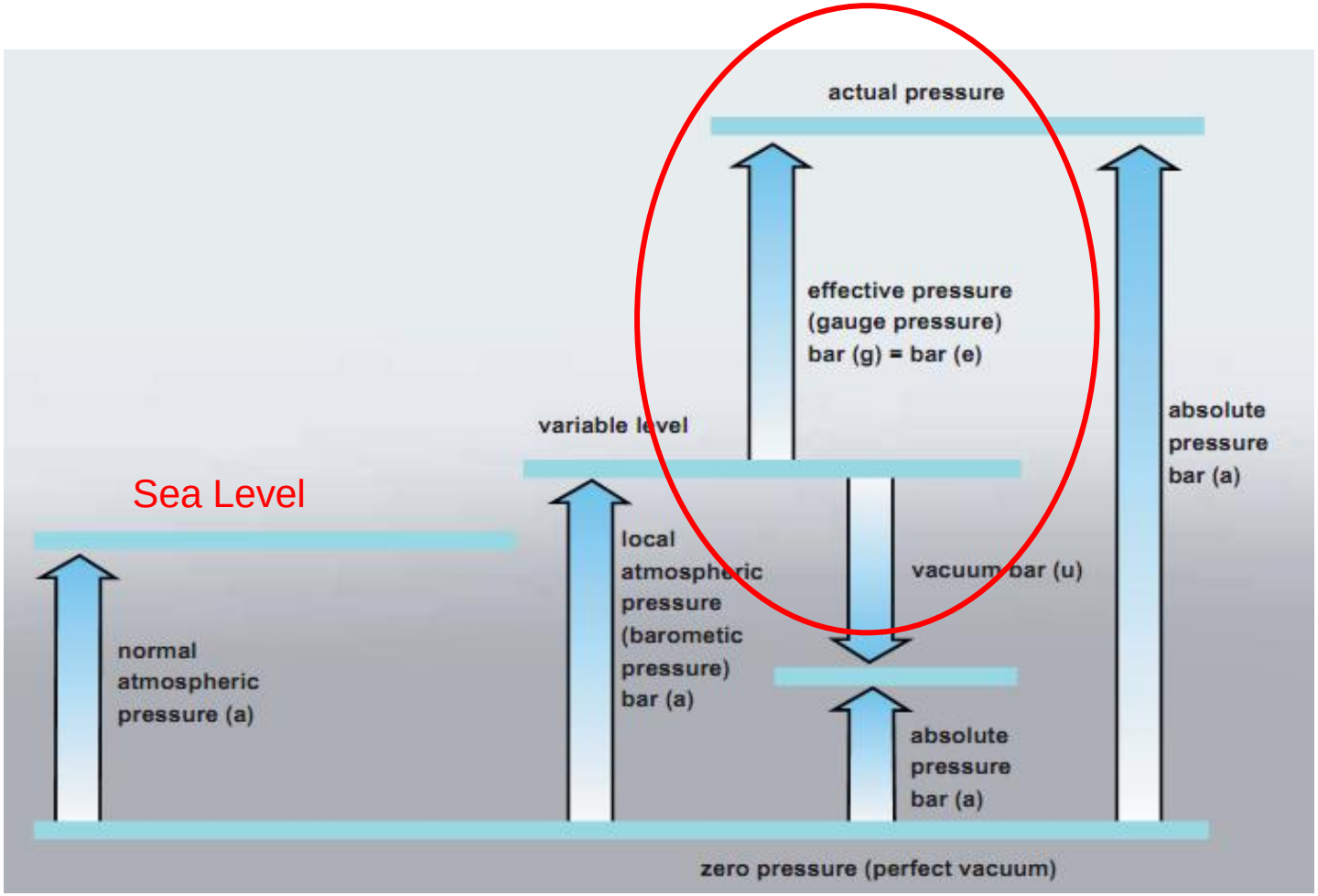
Systems can be either blow or suck material from one point to another, or be a combination of the two.

- **Positive pressure**
- **Negative pressure (vacuum)**



Pressure Guide

1 atm =
101 kPa
1 bar
14.7 psia
29.9 “Hg



Pneumatic Conveying - Operating Modes

The two most distinct categories of pneumatic conveying are:-

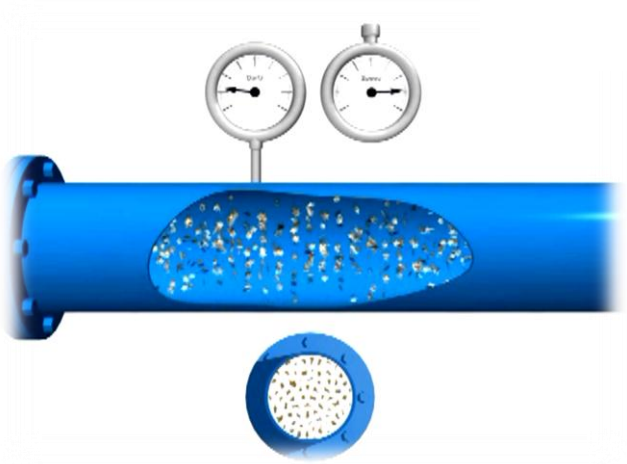
- **Low pressure - dilute (lean) phase**
- **High pressure - dense phase**

To dense phase convey a material, the material should ideally be fluidisable or permeable.

All bulk solids can be conveyed in a dilute phase system.

Dilute (Lean) phase conveying concept is the most commonly used method of transporting materials pneumatically across all industries.

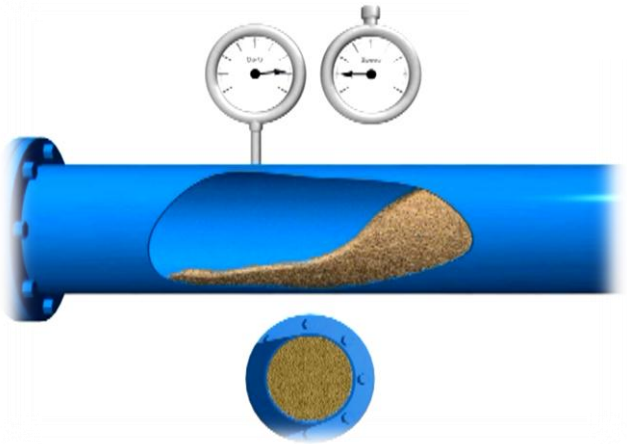
Operating Modes



Dilute (Lean) phase conveying is the process of blowing or sucking air-suspended materials from one location to another by maintaining a sufficient airstream velocity.

Continuous process, characterised by:-

- **high** velocity (15 - 30 m/s = 3000 - 6000 fpm)
- **low** pressure (< 1 barg = < 15 psig)
- **low** solids to air ratio (< 15:1)

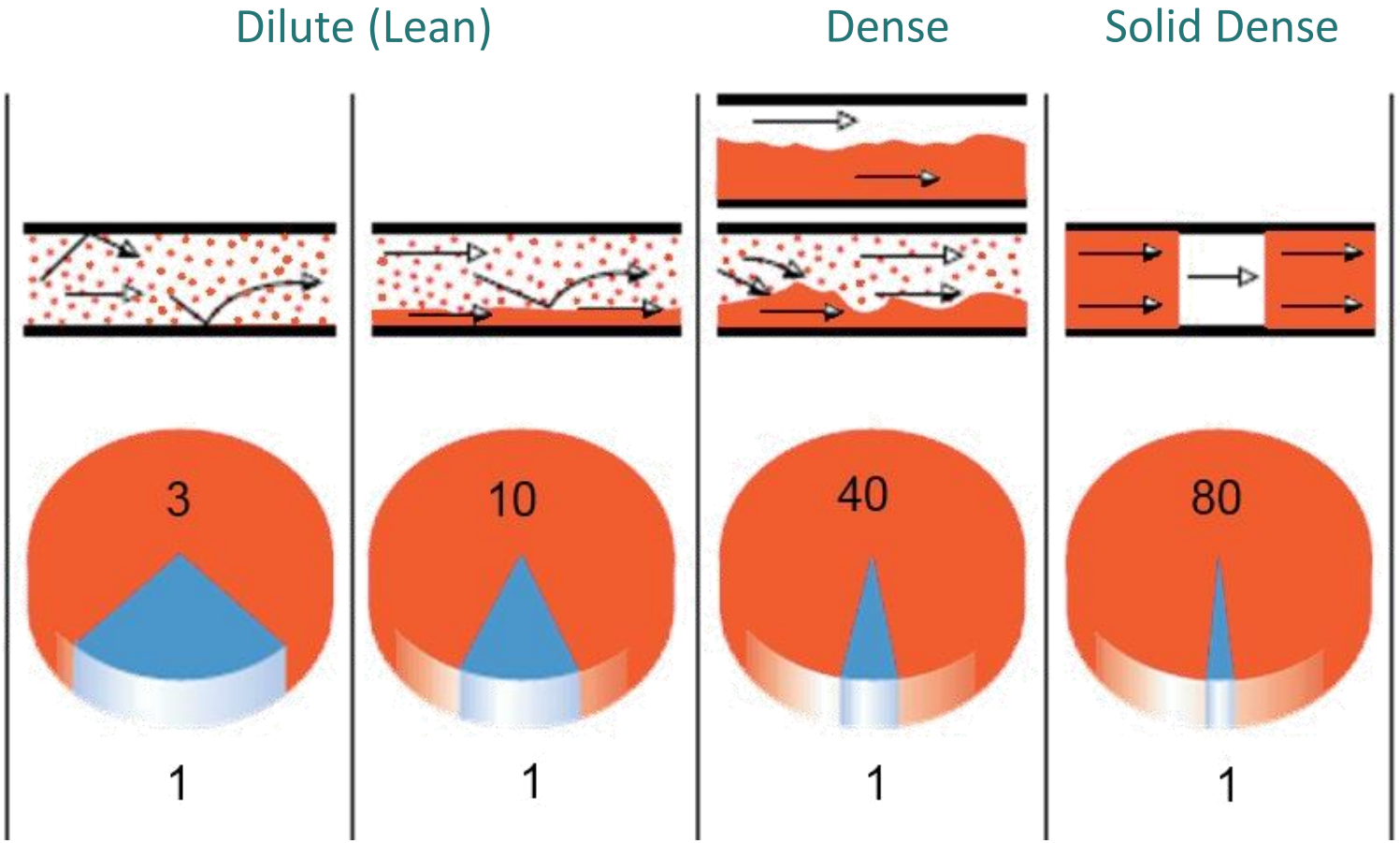


Dense phase conveying relies on a pulse of air to force a slug of material from one location to another.

Essentially a batch process, characterised by:-

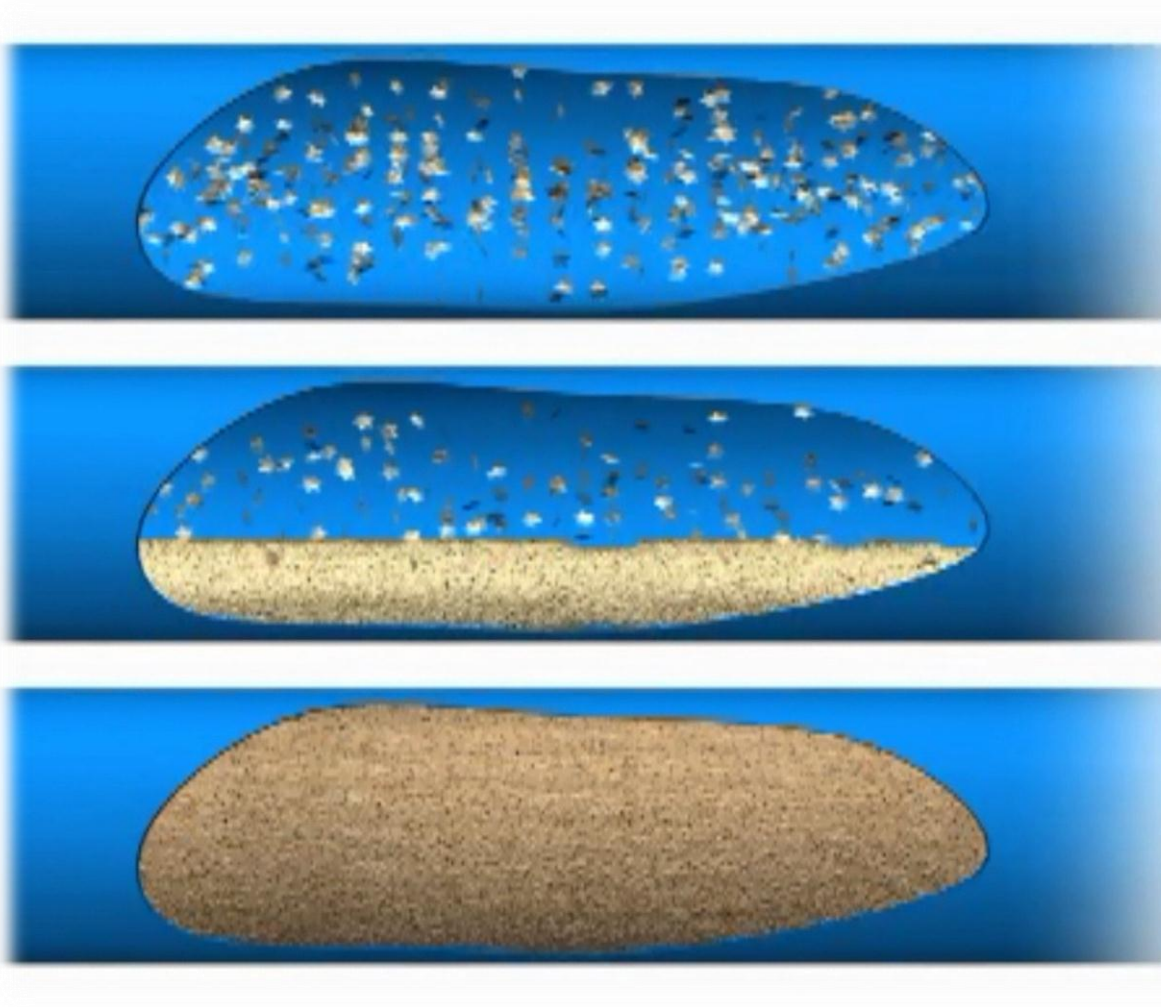
- **low** velocity (2 - 10 m/s = 400 - 2000 fpm)
- **high** pressure (> 1 barg = > 15 psig)
- **high** solids to air ratio (> 15:1)

Solids Loading Ratio



Solid Loading Ratio (air:solids) = kg conveyed solids / kg conveying air

Material Flow - Phases



Dilute (Suspension Flow)
Velocity = 15-30 m/s

Dense (Moving Bed)
Velocity = 10-20 m/s

Dense (Plug Flow)
Velocity = 2-10 m/s

Positive Pressure Conveying - Block Diagram

Compressor

- Roots blower < 1 barg
- Screw compressor > 1 barg

Plant Compressed Air

- Venturi (Eductors)

Material Feeder (Continuous)

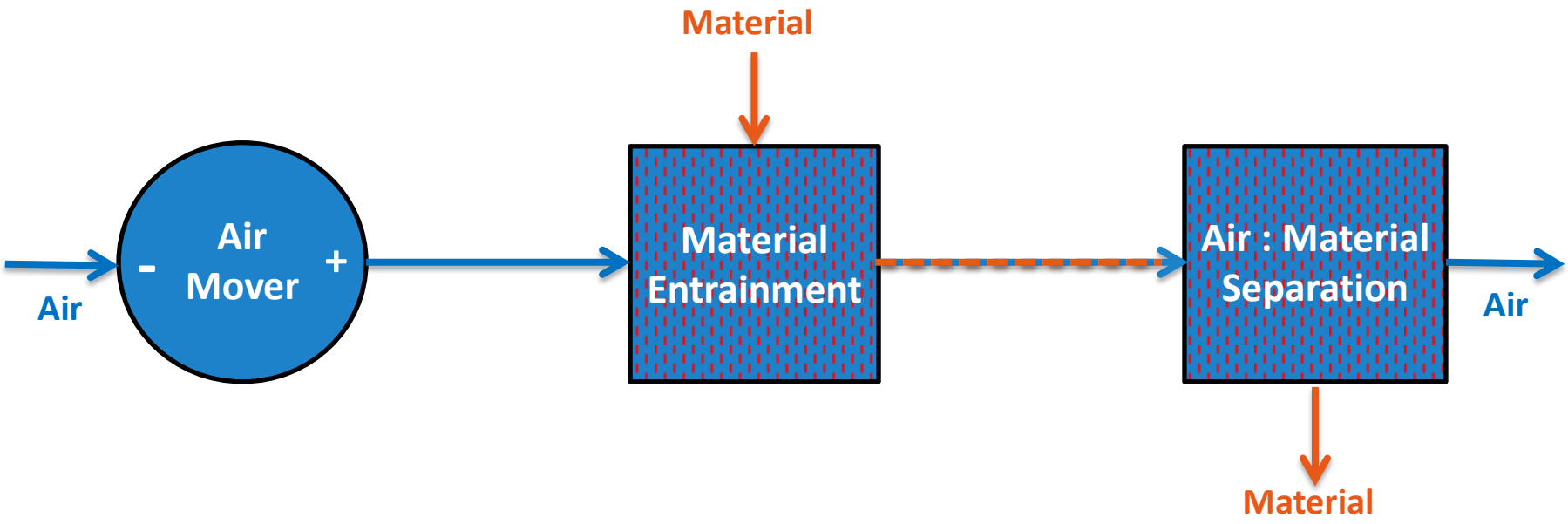
- Rotary
- Venturi
- Screw

Material Feeder (Discontinuous)

- Blow tank & sealing valve(s)

Receiver

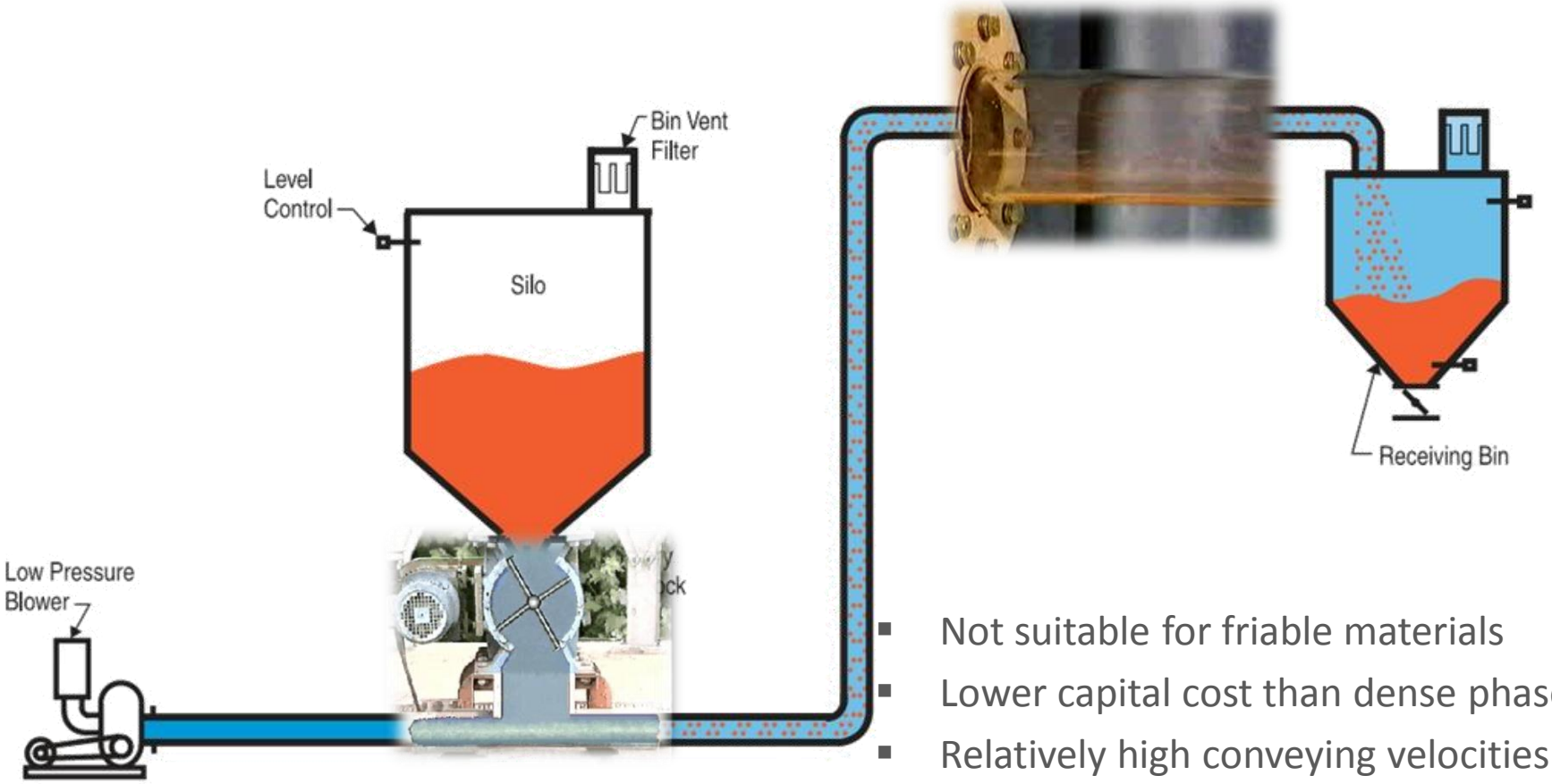
- Cyclone
- Filter separator
- Silo
- Drop-out device



Dilute Phase - Continuous

Low pressure: up to 1 barg (14.5 psig)

Using continuous feeder then average convey rate = instantaneous convey rate

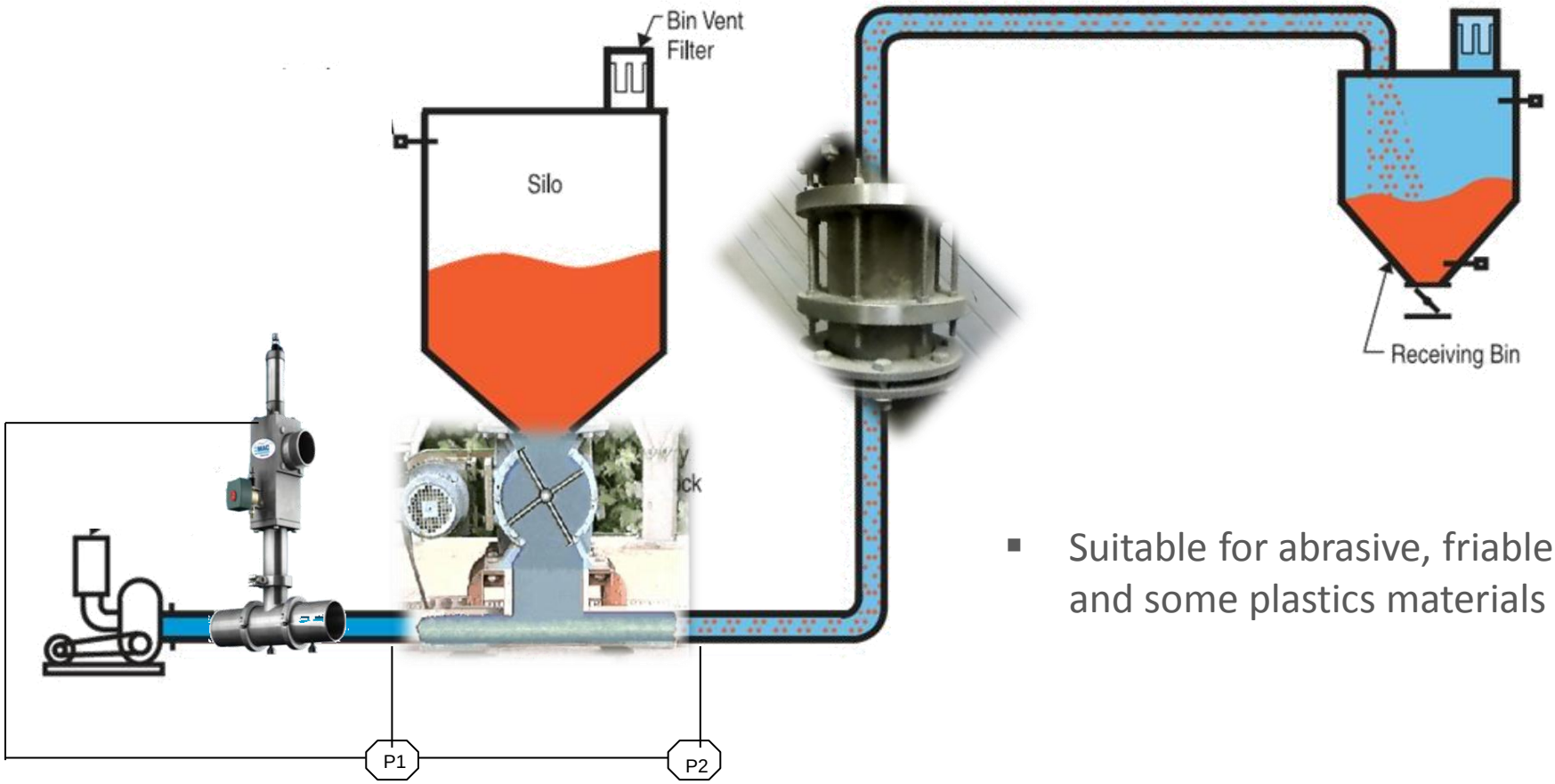


- Not suitable for friable materials
- Lower capital cost than dense phase
- Relatively high conveying velocities

Dense Phase - Continuous

Low pressure: up to 1 barg (15 psig)

High pressure: 1 to 2.5 barg (≤ 36 psig)



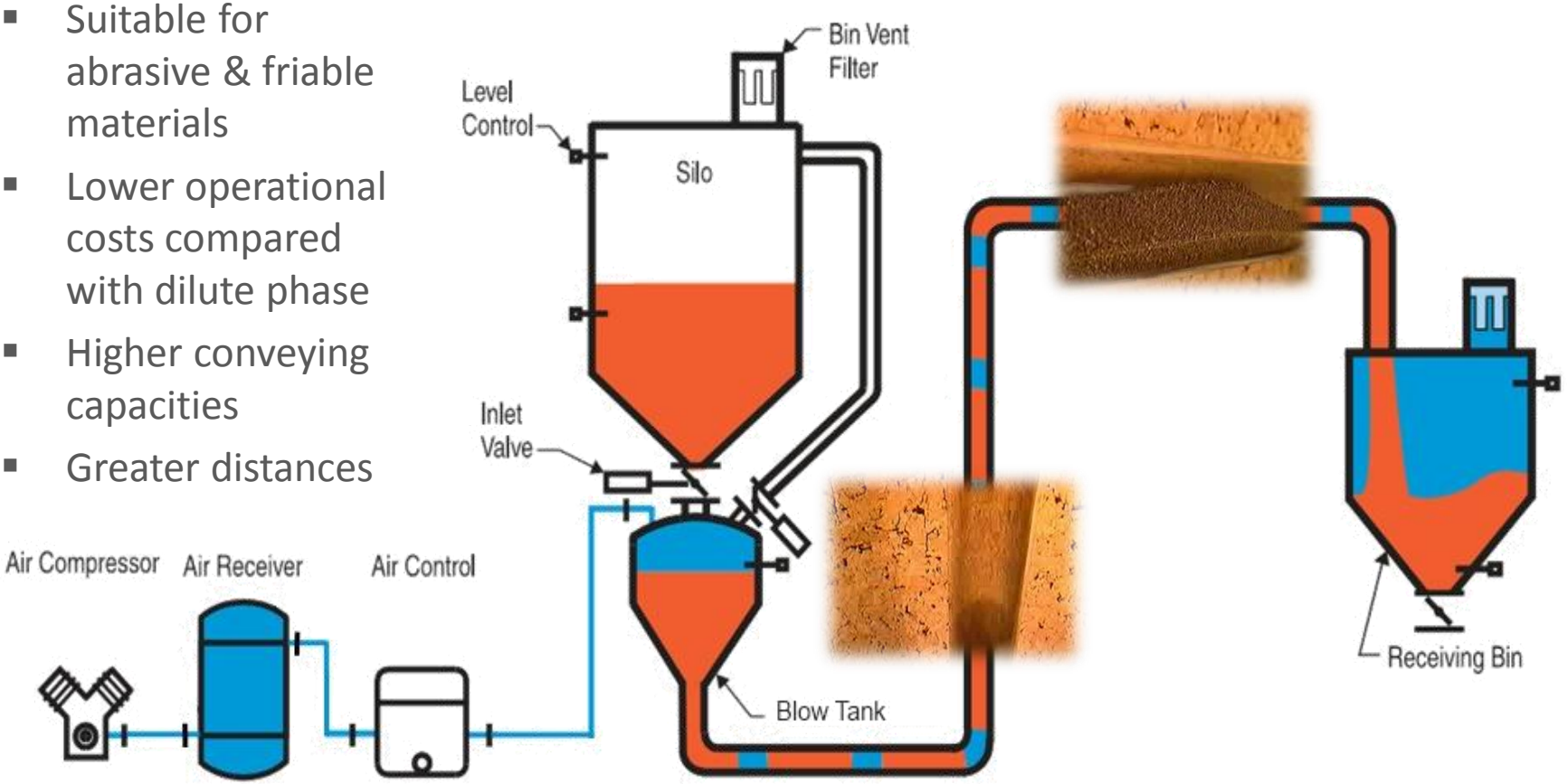
- Suitable for abrasive, friable and some plastics materials

Dense Phase - Discontinuous

High pressure: 1 to 5 barg (14.5 to 73 psig)

Average convey rate = approximately half instantaneous convey rate (single vessel)

- Suitable for abrasive & friable materials
- Lower operational costs compared with dilute phase
- Higher conveying capacities
- Greater distances



Negative Pressure Conveying - Block Diagram

Material Pick-Up

- Suction Point (open)
- Rotary Feeder (controlled feed)
- Screw Feeder (controlled feed)

Receiver

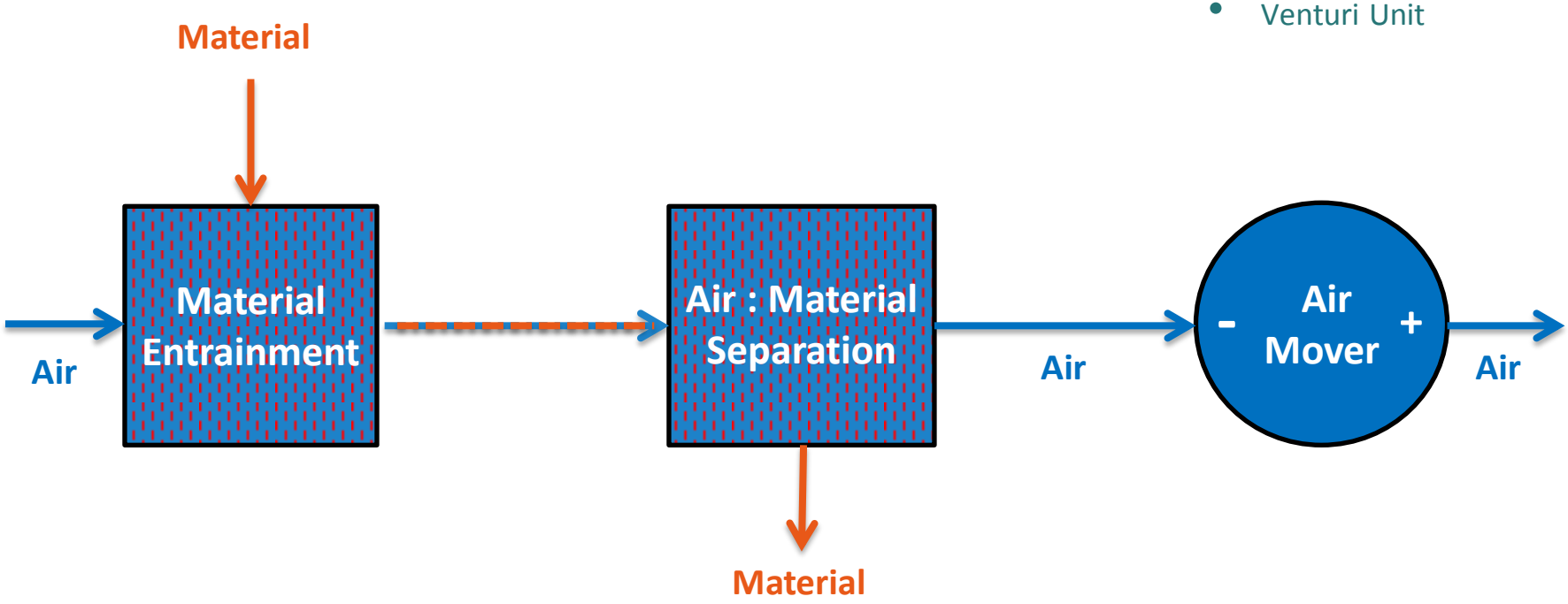
- Cyclone
- Filter Separator

Compressor

- Centrifugal Fan
- Roots Blower

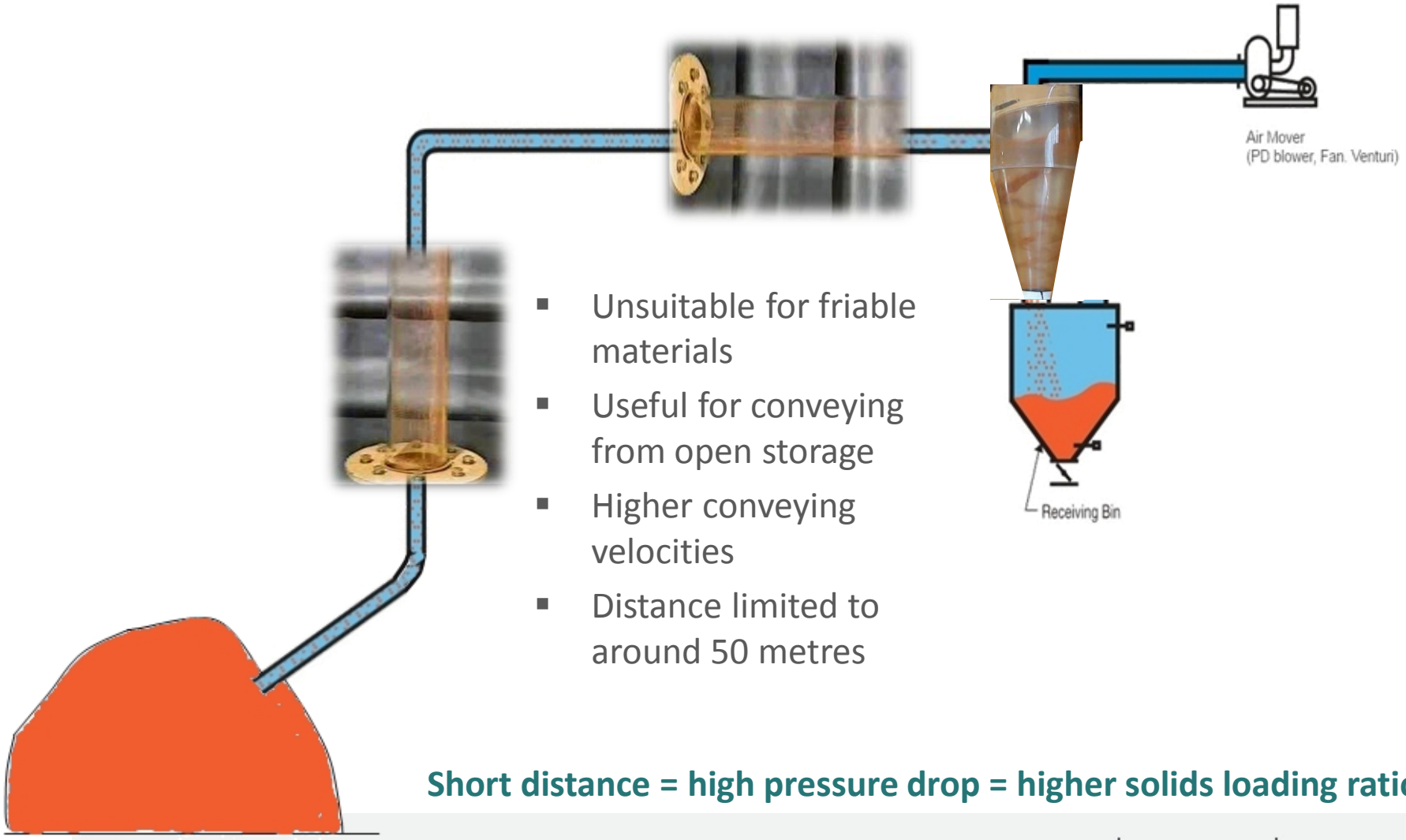
Plant Compressed Air

- Venturi Unit



Dilute Phase – Continuous or Discontinuos

High pressure: up to 0.6 bar (18”Hg) vacuum



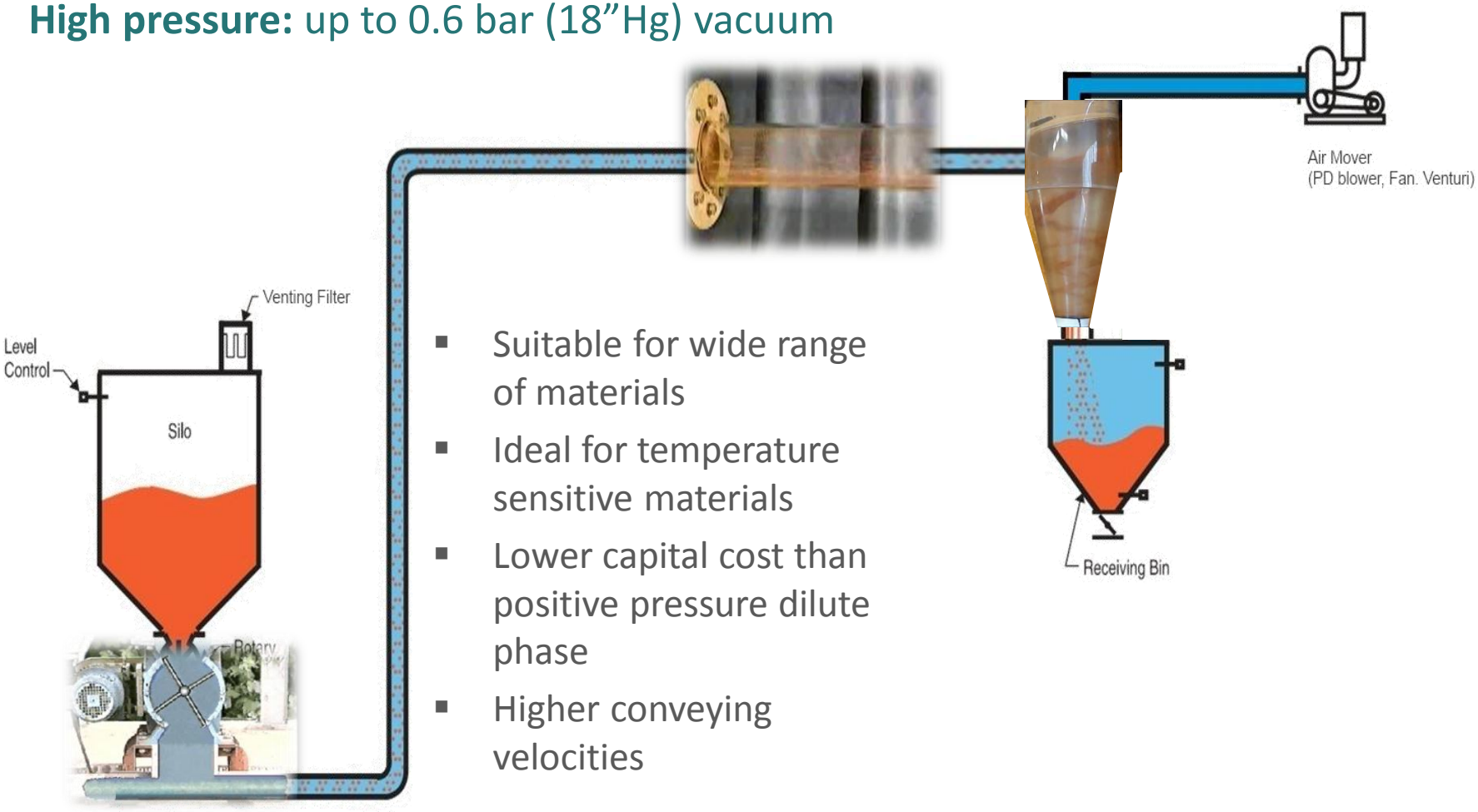
- Unsuitable for friable materials
- Useful for conveying from open storage
- Higher conveying velocities
- Distance limited to around 50 metres

Short distance = high pressure drop = higher solids loading ratio

Dilute Phase - Continuous

Low pressure: up to 0.15 bar (3”Hg) vacuum

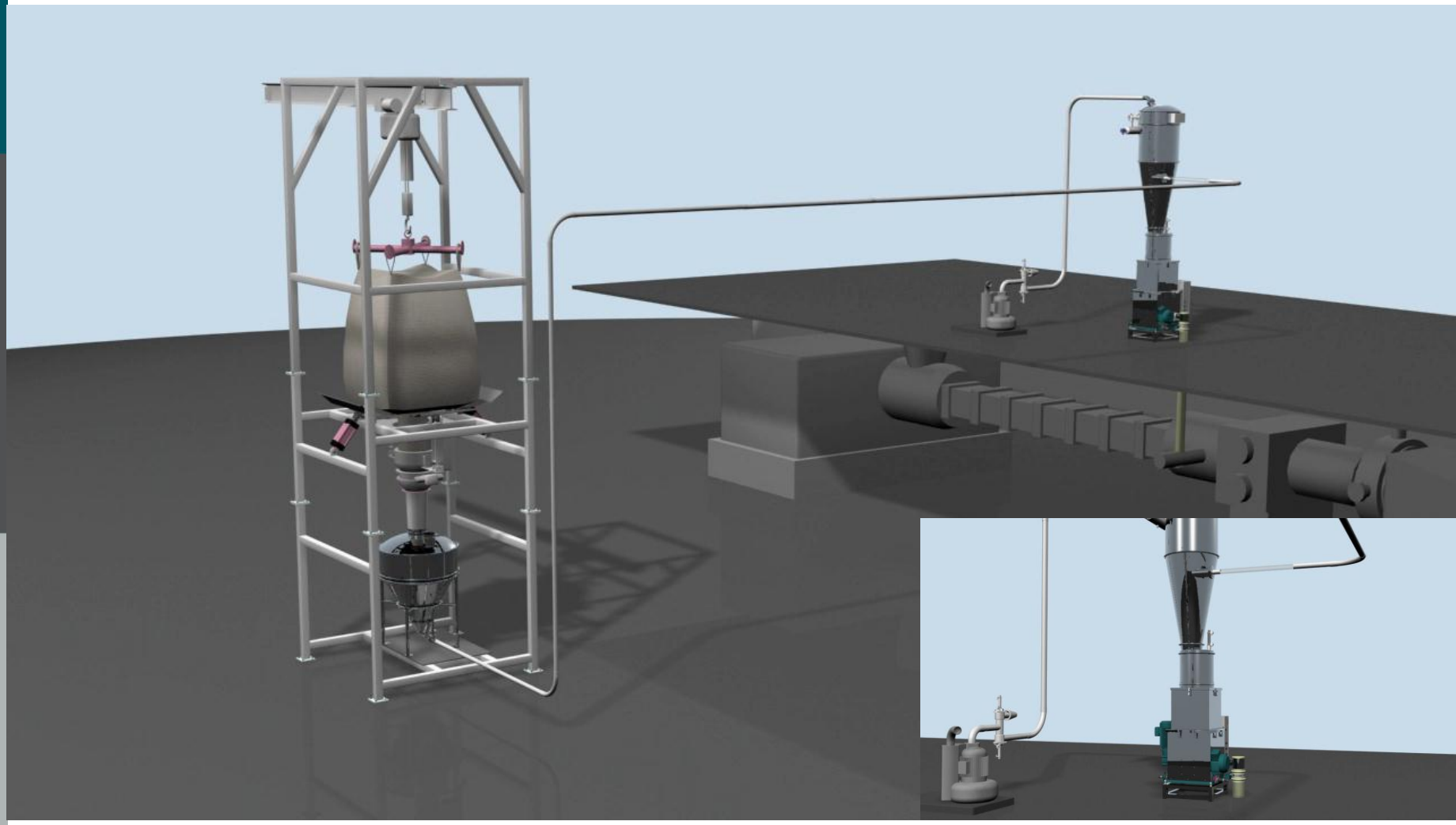
High pressure: up to 0.6 bar (18”Hg) vacuum



- Suitable for wide range of materials
- Ideal for temperature sensitive materials
- Lower capital cost than positive pressure dilute phase
- Higher conveying velocities

Referred to as suspension flow because the particles are carried in a gas stream

Vacuum Conveying with Filter Receiver



Disadvantages of Pneumatic Conveying

Compared to Mechanical Conveying

- Creating the required air pressure at sufficient volume to achieve the conveying mode is a more costly method of providing a motive force

  For applications requiring the same transfer rate over the same conveying distance then a pneumatic conveying system will require more power than a mechanical conveying system.

- A pneumatic conveying system requires a larger dust aspiration/collection system than a mechanical conveying system.

  This is because the pneumatic system has to separate the conveyed material from the conveying air at the system's end point.

- Some materials have characteristics that make them difficult to convey in a pneumatic system

  Examples are materials that are extremely sticky, such as very high fat cocoa powders, these tend to build a coating on the material contact surfaces. In a pneumatic conveying system, such build up often leads to total pipeline blockage.

Advantages of Pneumatic Conveying

Compared to Mechanical Conveying

A well designed pneumatic conveying system is often the preferred and a more practical & economical method of transporting materials from one point to another, than when compared with alternative mechanical systems (belt conveyors, drag chain conveyors, screw conveyors, vibrating conveyors etc.)

This is because of the following key points:-

1. **Relatively economical to install**
2. **Extremely simple and economical to maintain**
3. **Totally enclosed so clean & more environmentally acceptable**
4. **More hygienic**
5. **Satisfy highest ATEX/NFPA dust zone requirements**
6. **Can operate entirely without moving parts in contact with the material**
7. **Extremely flexible in terms of re routing and expansion**
8. **Safer to operate and maintain**
9. **Quieter (air mover can be located remotely)**

Pneumatic Conveying
in
Sugar Refineries & Factories

Applications – Sugar factories & refineries

Application / Type/Mode	Negative pressure	Positive pressure	Dilute phase	Dense phase
Conditioning silos to packing silos to packing		●		●
Conditioning silos to grinding to packing	●	●	●	○
Conditioning silos to bulk out loading silo		●		●
Bulk bags/Silos to Speciality Packing (Sticks/Sachets)	○	●	○	●
Dust collection systems - filter residue returns	●	●	●	○

Hullet Refineries Durban 1980's

Proceedings of The South African Sugar Technologists' Association — June 1992

DENSE PHASE PNEUMATIC HANDLING OF SUGAR AND COAL

By R. E. GELLING
Hulett Refineries Limited, Durban

Abstract

Hulett Refineries has had many years experience in the blowing of brown and white sugars using the dilute phase method. In 1985 the refinery started looking into the feasibility of blowing sugar using the dense phase system of transportation. The reason for this investigation was a project involving the packing of hygienic brown sugar from mill road tankers and the difficulty, due to plant layout, of using conventional conveyors to convey the sugar from the unloading point to the packing station. The paper describes some of the difficulties and solutions found during the commissioning of the systems installed at the refinery.

Introduction

To determine the feasibility of using dense phase pneumatic conveying of sugar and coal the Materials Handling Division of the University of the Witwatersrand (Wits) was sent samples of both products, which they successfully blew over a distance of more than 122 metres. The 100 mm diameter conveying line was made up of 116 m of horizontal and 6 m of vertical pipe and 9 X 90 deg bends as shown in Figure 1. This showed that routes could be followed where normal conveyors could not be used. Although the brown sugar project was dropped for other reasons, the Wits tests proved the feasibility of this type of conveying as there was very little crystal damage (see Tables 1 and 2).

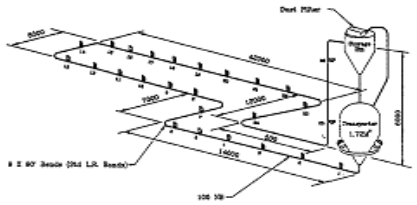


FIGURE 1 Experimental dense phase sugar blowing system at Wits University

Table 1

Screen analysis of the sugar before blowing

Screen	1	2	3	Average
355 micron	73,33	74,76	72,42	73,50
250 micron	16,49	15,41	15,98	15,96
106 micron	9,70	9,25	11,01	9,99
Pan	0,48	0,58	0,58	0,55

Table 2

Screen analysis of the sugar after blowing

Screen	1	2	3	Average
355 micron	69,73	70,03	72,08	70,61
250 micron	18,55	18,17	17,34	18,02
106 micron	10,74	10,82	9,76	10,44
Pan	0,98	0,98	0,82	0,93

Operation

The main difference between dilute and dense phase conveying is that dense phase is a batch process, using far less air at a higher pressure. During dense phase conveying the product is fed from a storage bin into the transporter vessel as shown in Figure 2. The vessel is then pressurised and the product is blown into the conveying line. When the low level probe has been cleared, the pressure in the vessel is released through the vent valves and the cycle is repeated. The conveying line is never emptied. When the booster line is pressurised air passes through the needle valve into the booster (see Figure 3). If the booster pressure is higher than the conveyor line pressure air is injected into the product fluidising and moving it along the conveying line (see Figure 4).

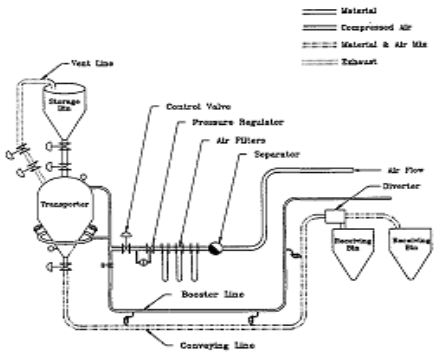
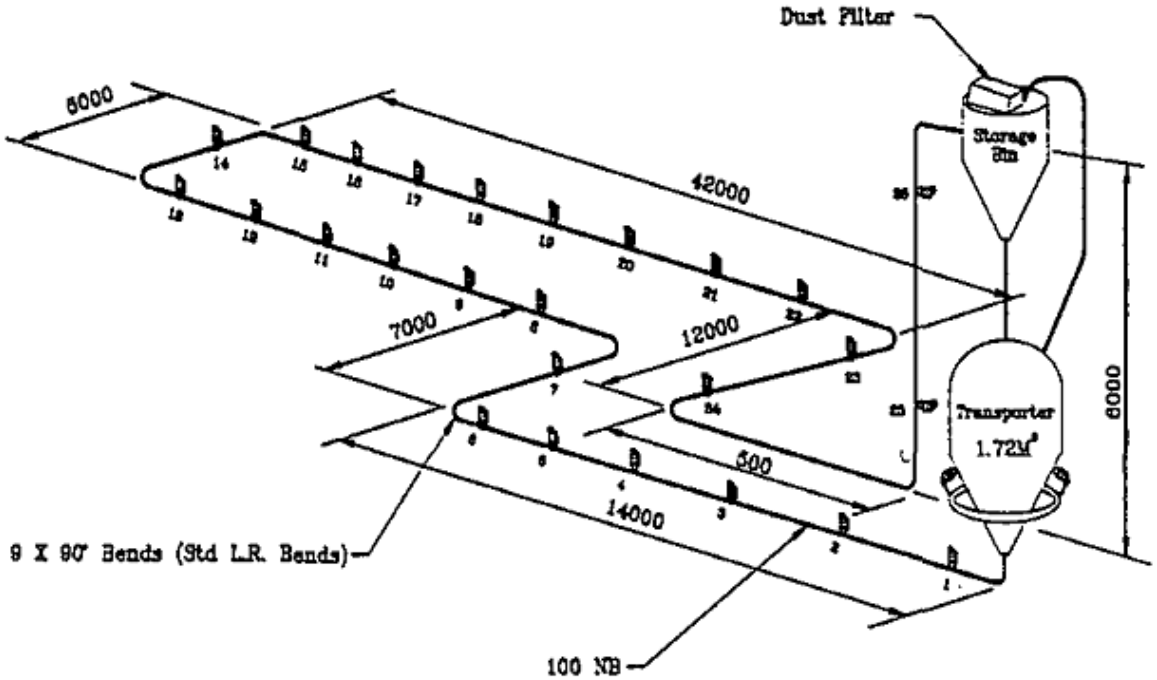


FIGURE 2 Typical dense phase pneumatic conveying system

Paper given by R.E. Gelling at *The South African Sugar Technologists' Association gathering in 1992.*

Hullet Refineries

Fine sugar before & after dense phase conveying



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Dense Phase Pneumatic Handlling of Sugar & Coal
R.E. Gelling - Hulett Refineries Limited, Durban. 1992

Hullet Refineries Durban – Fine Sugar

Conclusions

Advantages of dense phase blowing

(a) Clean – no scrapers and only two transfer points.
(b) Flexibility of conveying system.
(c) Space saving.
(d) Low maintenance – few moving parts.
(e) No chance of outside contamination.
(f) Safe – no moving belts or buckets.
(g) Quiet operation.
(h) Cost effective over difficult routes.

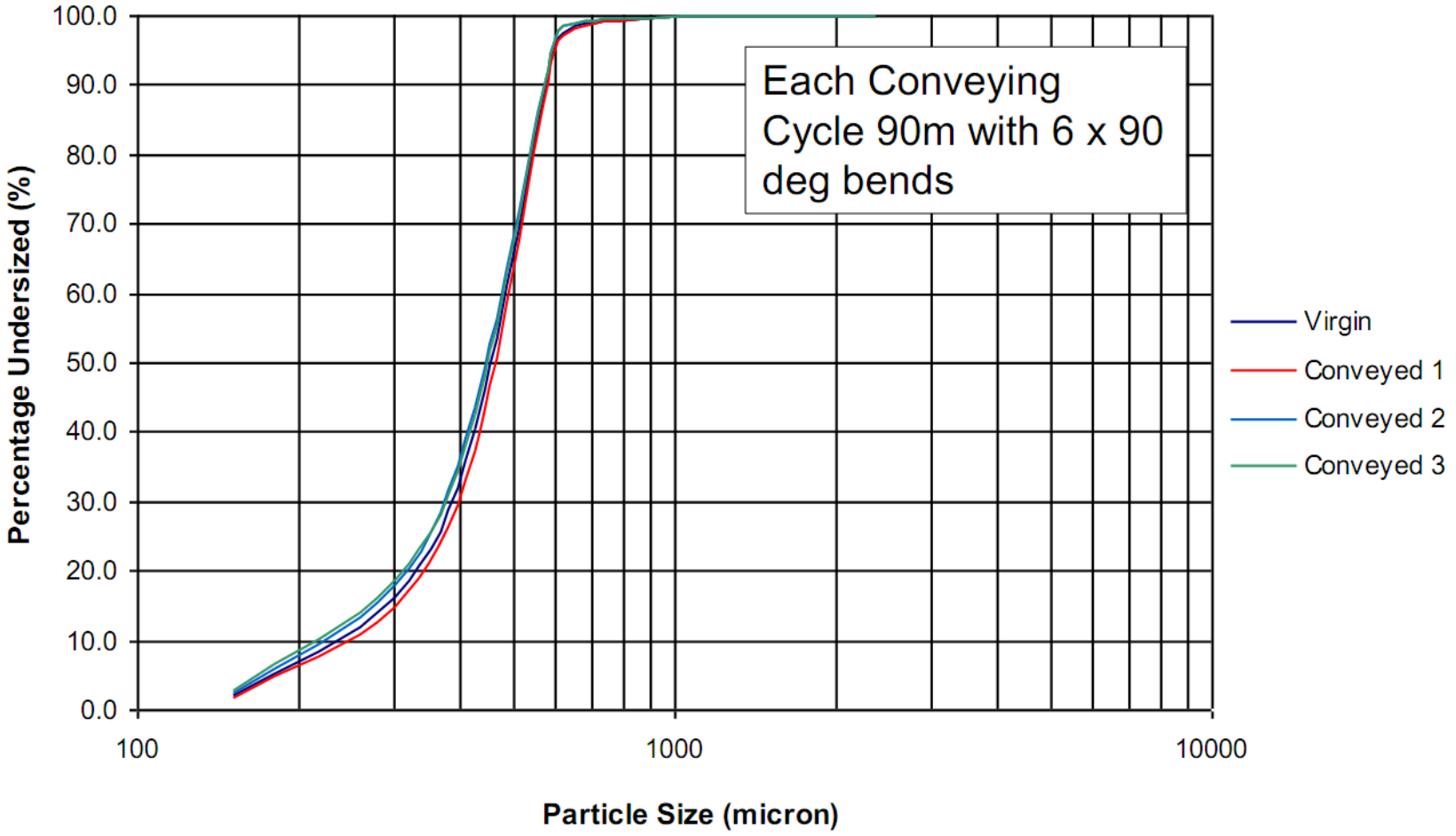
Disadvantages of dense phase blowing

(a) The need for clean dry air.
(b) Chokes can be difficult to clear.
(c) High cost over short distances.
(d) Dust collection at end of pipe.

Dense Phase Pneumatic Handlling of Sugar & Coal
R.E. Gelling - Hulett Refineries Limited, Durban. 1992

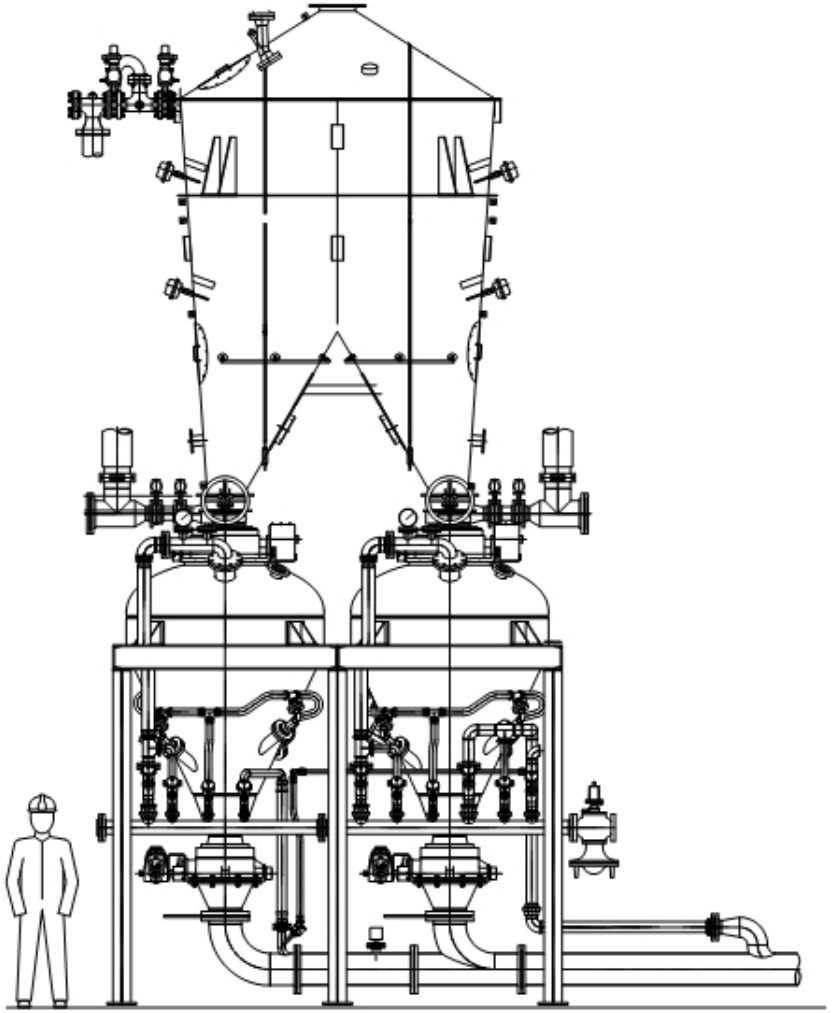
Test Plant Trials – Granulated Sugar

Granulated sugar before & after dense phase conveying



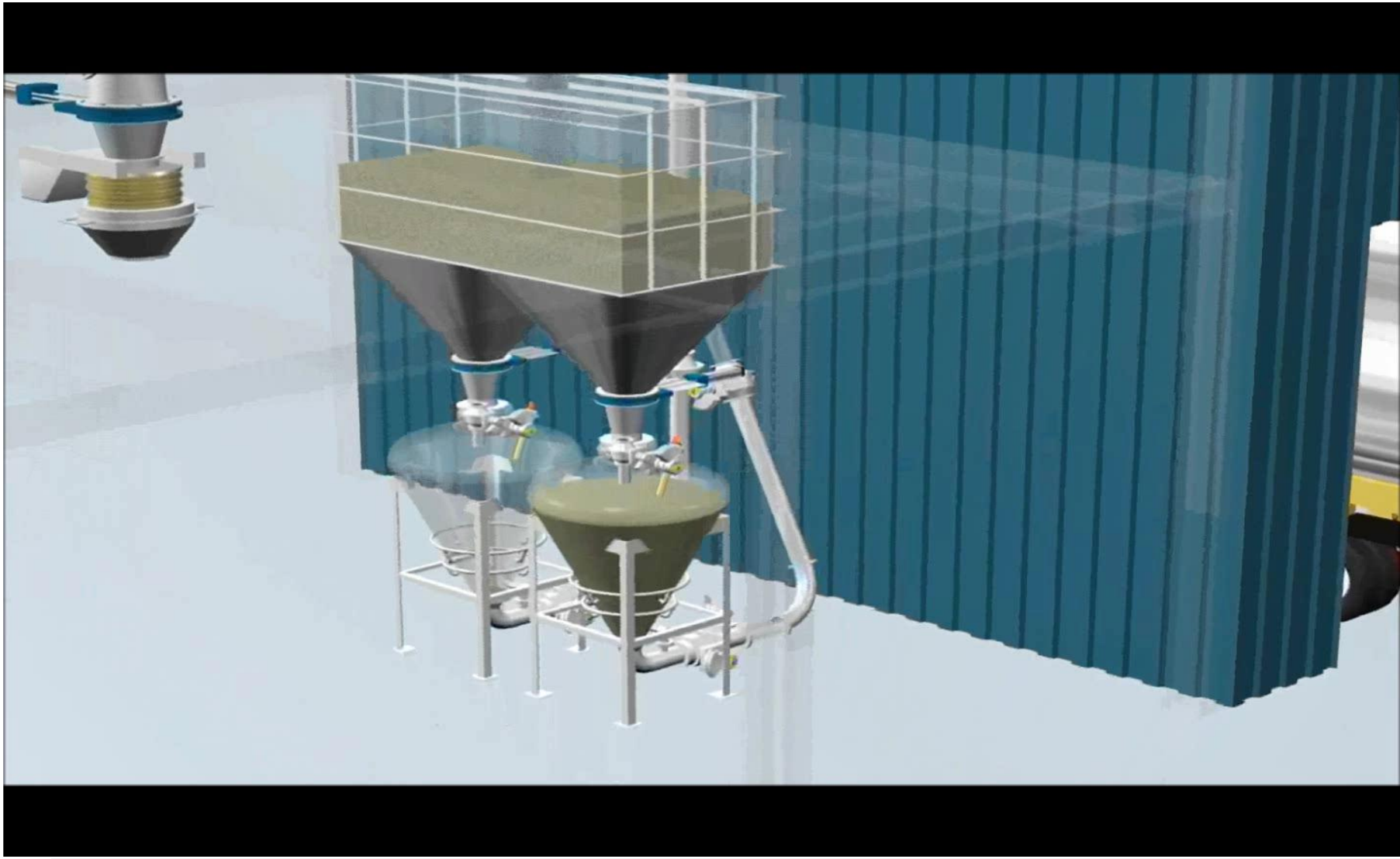
Success Story - Imperial Sugar 2010

Port Wentworth & Gramercy Refineries, USA



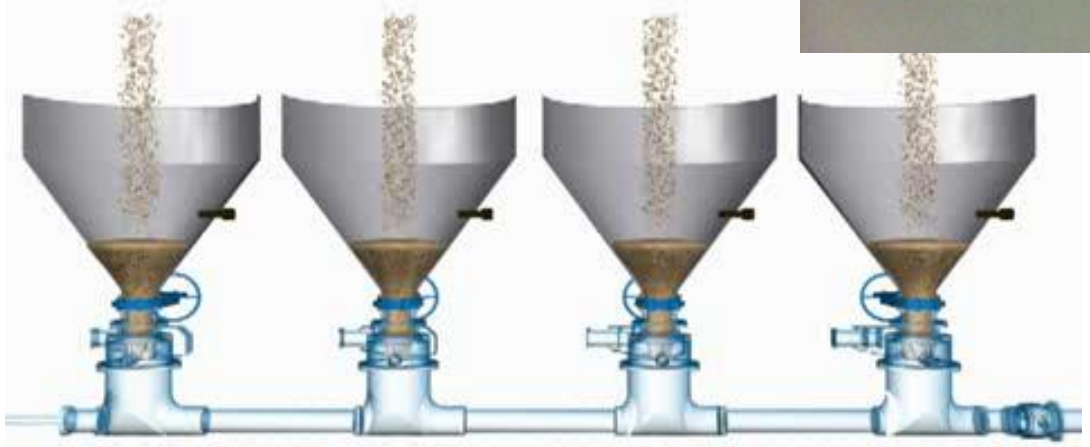
Dense Phase Conveying

Twin vessels allow high capacity near continuous conveying



Dense Phase Conveying
Filter Residue

Dense phase conveying vessels are an efficient method of discharging multiple hopper filter bag houses enabling return of filter residue dusts back into the process plant



Thank you

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