



ADVANCES IN PNEUMATIC CONVEYING

Aptech (Powder Systems) Limited

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PNEUMATIC CONVEYING OVERVIEW

INTRODUCTION

Pneumatic conveying is a system used to transport a wide variety of dry powdered and granular materials in a gas stream. Generally the gas stream will be air but in special cases dried, cooled, heated air or inert gas such as Nitrogen may be used.

In its basic form, the product (solids) is fed into a moving air stream which blows the material down a length of pipe. The pipe is connected to a receiver or cyclone where the air and product are separated

A pneumatic conveying system comprises of four distinct parts:

1. The Prime Mover - a blower, fan, compressor, exhauster or vacuum pump to provide the necessary means to create a flow of gas and the conveying air stream.
2. The Feeder - a rotary valve, venturi, screw, blow vessel or feeder to introduce the solids into the air stream under controlled conditions.
3. The conveying line - pipework comprising straight, horizontal and vertical sections, bends, branches and diverter valves.
4. Separator - a cyclone, receiver, filter receiver or silo/vessel to separate the air from the solids.

A pneumatic conveying system can be classified into two distinct categories:

1. Dilute Phase (also known as lean phase) - where gas volume is high and the solids volume is low and mass flow ratio is approx 0 - 15.
2. Dense Phase - where the gas volume is low and the solids volume is high and the mass flow ratio is greater than 15.

The concentration of solids to gas in the pipeline is an important factor and is known as the phase density or mass flow ratio, which is defined as the ratio of mass of solids to the mass of conveying air.

There are many configurations and factors to consider and selection of components is critical to ensure a correct and efficient transport system is designed.

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PNEUMATIC CONVEYING OVERVIEW

DILUTE PHASE

Gas volume high
Product volume low

Product held in suspension
in the air stream

Pressure or Vacuum

- 0.5 bar to + 1.0 bar

Advantages

- Low pressure
- Low capital cost
- Flexible/versatile

DENSE PHASE

Gas volume low
Product volume high

Moving Bed Flow
Plug Flow

Pressure only

+ 1 to 10 bar

Advantages

- High capacities
- Long distances
- Low velocities

PNEUMATIC CONVEYING OVERVIEW

Advantages of Pneumatic Conveying

Pneumatic conveying offers distinct advantages over other forms of conveying:

1. Low maintenance, low manpower, low costs - the conveying line consists of a smooth bore, enclosed pipe with no mechanical moving parts.
2. Flexibility in routing and distribution - pipe can be routed much easier than mechanical belt/screw/chain conveyors and can be transported vertically, horizontally, round corners and through small spaces. Distribution to many delivery points from one line using branch valves and pick up from several feed points can be simply and easily made. Lines can be easily extended or re-routed at later dates.
3. Versatile use - one system/line can be used to transport a variety of products at different times and virtually all powders and granules can be pneumatically conveyed.
4. Clean enclosed system offers many benefits:
Low cross contamination when different products are conveyed.
Hazardous or high value products can be conveyed in a sealed system.
Hygienic, food quality and pharmaceutical products can be conveyed in a sealed & controlled environment.
Gases can be sealed in and re-circulated for a controlled environment and efficiency by re-cycling.
5. Automation - pneumatic conveying systems can be easily automated and controlled.

Disadvantages of Pneumatic Conveying

Pneumatic conveying systems have some limitations and disadvantages including:

1. Some systems can result in high power consumption when compared to certain forms of mechanical conveying e.g. high capacity systems over long distances.
2. Distances are limited, although it is possible to pneumatically convey more than 1000m, most practical distances range between 5 and 500m.
3. Capacities are limited, although it is possible to pneumatically convey at rates at 400 tonnes per hour, most systems convey between 1 and 60 tonnes per hour.
4. Abrasive products can cause wear and abrasion to pipeline and equipment.
5. High conveying velocities can cause fragile product to break and degrade during transportation.

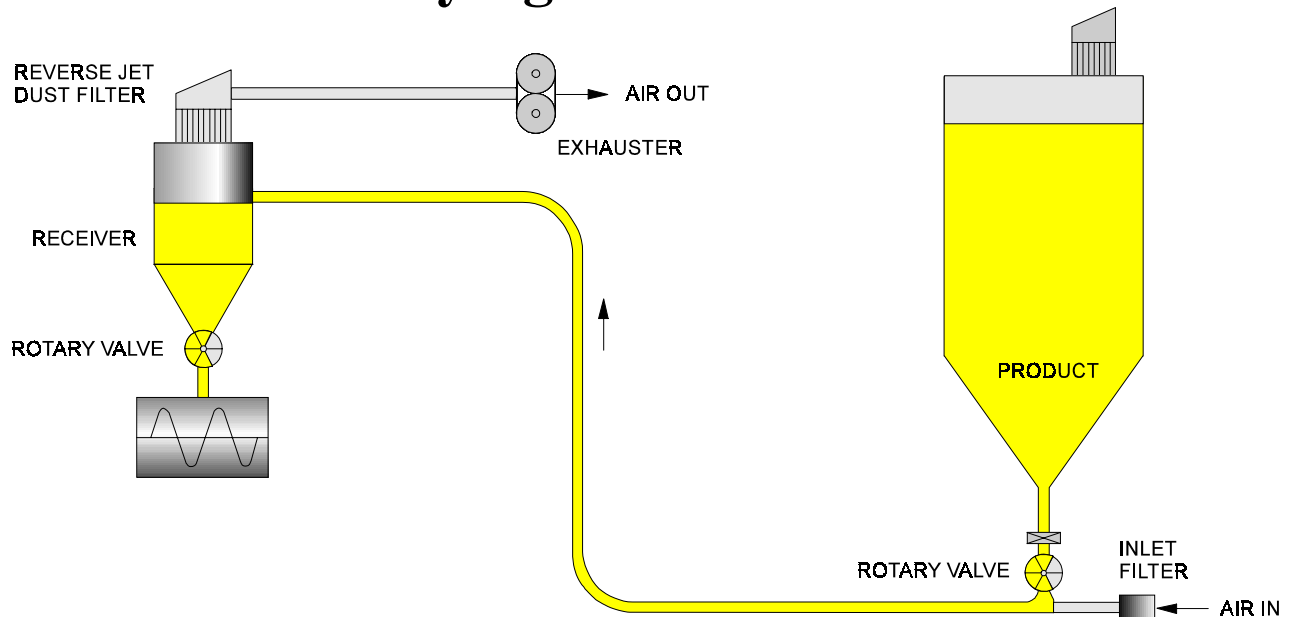
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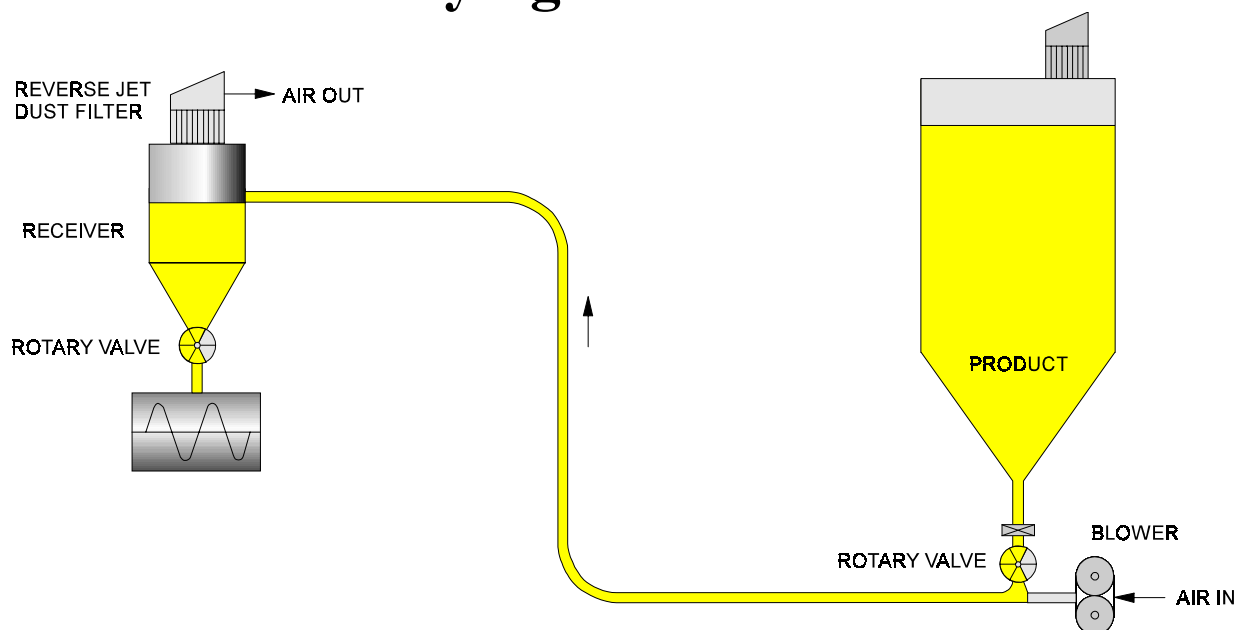
PNEUMATIC CONVEYING

DILUTE PHASE (LEAN PHASE)

1. Vacuum Conveying



2. Pressure Conveying



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PNEUMATIC CONVEYING

ADVANCES IN PNEUMATIC CONVEYING

Advances in pneumatic conveying over the last 20 years has meant that systems have become much more efficient and reliable. Applications and products thought previously unsuitable have now become viable.

The complex flow phenomena of solids and gases means that high levels of skill and experience are required to design efficient and complex systems.

New technology has made available sophisticated, reliable and economical tools to designers to help them achieve better results. Computerised design programmes enabling complex calculations, modelling and scaling can be used to predict performance and specify equipment. Advanced control devices are now available to ensure a system will operate reliably within critical design parameters.

Products can be conveyed at lower and controlled velocities to prevent product damage, reduce wear and abrasion and reduce power consumption.

Monitoring and controlling - the product being conveyed; the conveying system; and the equipment; means blockages, faults and failures can be avoided.

Controlling the conveying medium and environment such as gas flow, humidity, temperature, velocity and pressure means hygroscopic, friable, perishable & hazardous products can be conveyed.

Many products have characteristics which present problems when stored and conveyed.

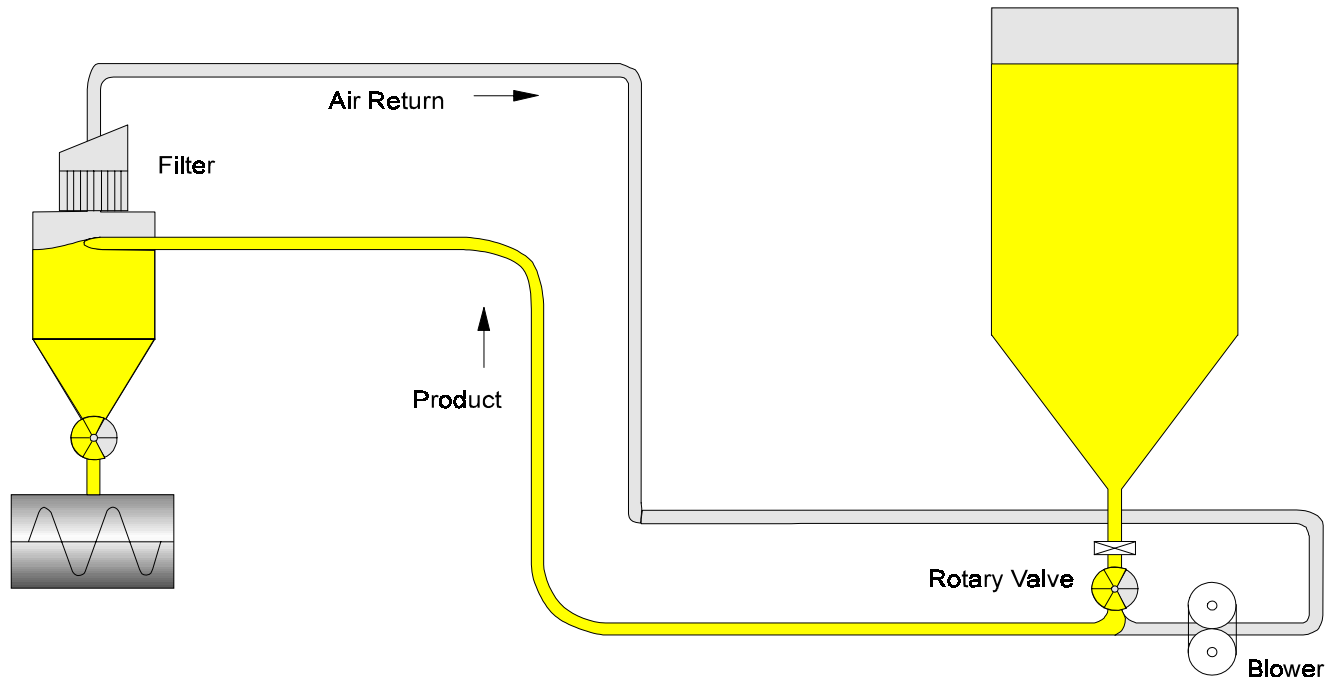
Conditions such as particle degradation, cohesion, caking, agglomeration, static, humidity, micro-biological growth, dust explosion, attrition, abrasion, fluidisation, segregation, mass flow/core flow feeding, are all factors which can effect the performance of a pneumatic conveying system and the products conveyed.

A better understanding of these conditions enables designers to develop advanced solutions to overcome problems associated with these factors.

PNEUMATIC CONVEYING

CLOSED LOOP CONVEYING

The Aptech CLC Closed Loop Conveying System



Sealed System =

- no airborne contaminants
- contained emissions
- clean enclosed method of conveying

Re-circulating gas =

- Economic Dry Air Conveying
- Economic Inert Gas Conveying
- Multiple destinations & single common filter

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PNEUMATIC CONVEYING

CLOSED LOOP DRY AIR CONVEYING

Storage & Transportation of Hygroscopic & Perishable Products in a Dry Sealed System.

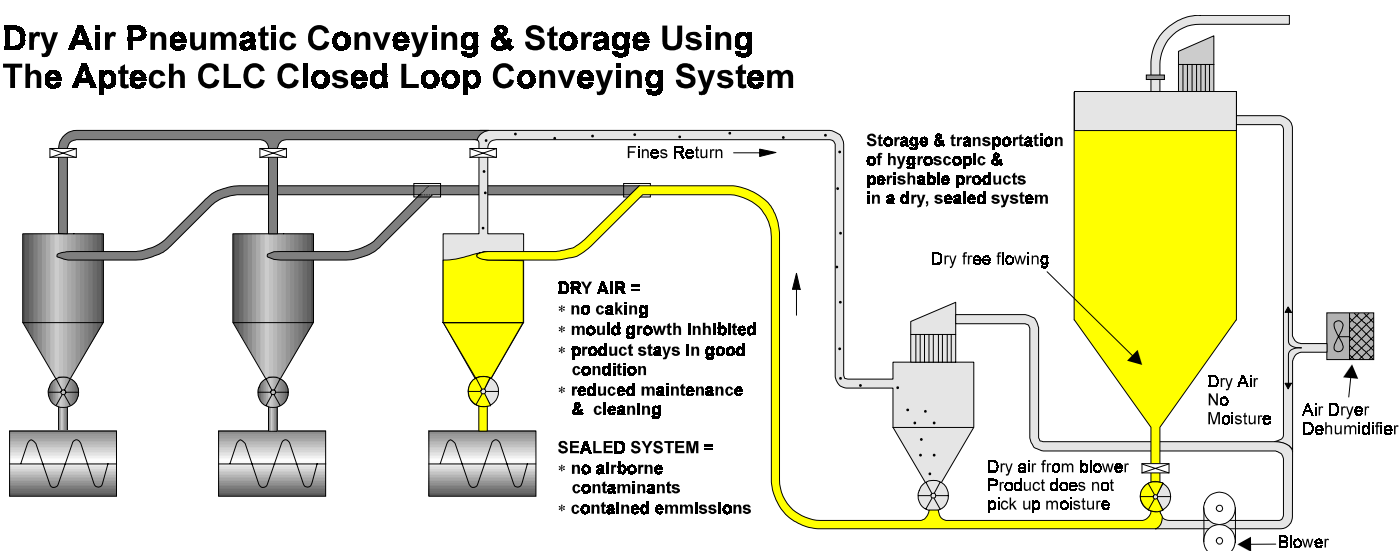
Dry Air =

- no caking/agglomerating
- microbiological growth inhibited
- product stays in good condition dry & free flowing
- reduced maintenance & cleaning
- no condensation or need to lag/insulate pipes
- improved filter performance

Nitrogen conveying =

- Hazardous products transported safely
- Explosion panels and venting eliminated
- Economic conveying by recirculation

Dry Air Pneumatic Conveying & Storage Using The Aptech CLC Closed Loop Conveying System



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PNEUMATIC CONVEYING

APTECH DRY AIR STORAGE & CONVEYING SYSTEMS

Many bulk food ingredients such as sugar, cocoa, milk/whey powder, egg powder, malt, starch and flavourings are Hygroscopic and will readily take on moisture from atmosphere.

Storing these materials in silos and hoppers and conveying to a process often means that the materials are exposed to ambient air conditions. This can lead to caking, agglomerating, build up in hoppers and chutes and mould growth.

Fluctuating temperatures such as day time and night time or outdoor and indoor temperatures causes moisture to condense out of the air on to walls or product.

The European average Relative Humidity (RH) is approximately 80% and a RH of 65% or higher will often cause bacterial/mould growth.

Humid air can enter the system through truck/railcar blowers during unloading, silo vents, pulse jet filters, aeration systems, fans/blowers from pneumatic conveying systems and open process systems.

Controlling the environment in which hygroscopic products are stored, conveyed and handled in will eliminate the problems of blockages, agglomerating and mould growth. Controlling the humidity conditions will ensure the product is kept to a high quality, free flowing and maintain hygienic conditions. Incorporating air driers or de-humidifiers into a system will effectively remove excess moisture from the handling process to give the required conditions.

Drying large volumes of air can be expensive so it is important to minimise losses and re-circulate wherever possible. Sealed Closed Loop Systems are an effective way of providing an economic re-circulating air system. Being a sealed system other benefits include no spillage, dust emissions or losses.

The technical and economic benefits of closed loop conveying and storage have been realised by many diverse companies and to date Aptech have designed and installed more than 200 closed loop conveying systems throughout the UK and Europe. With this wealth of experience Aptech have become market leaders in closed loop storage and conveying technology and are able to offer the most economic and technically advanced solution.

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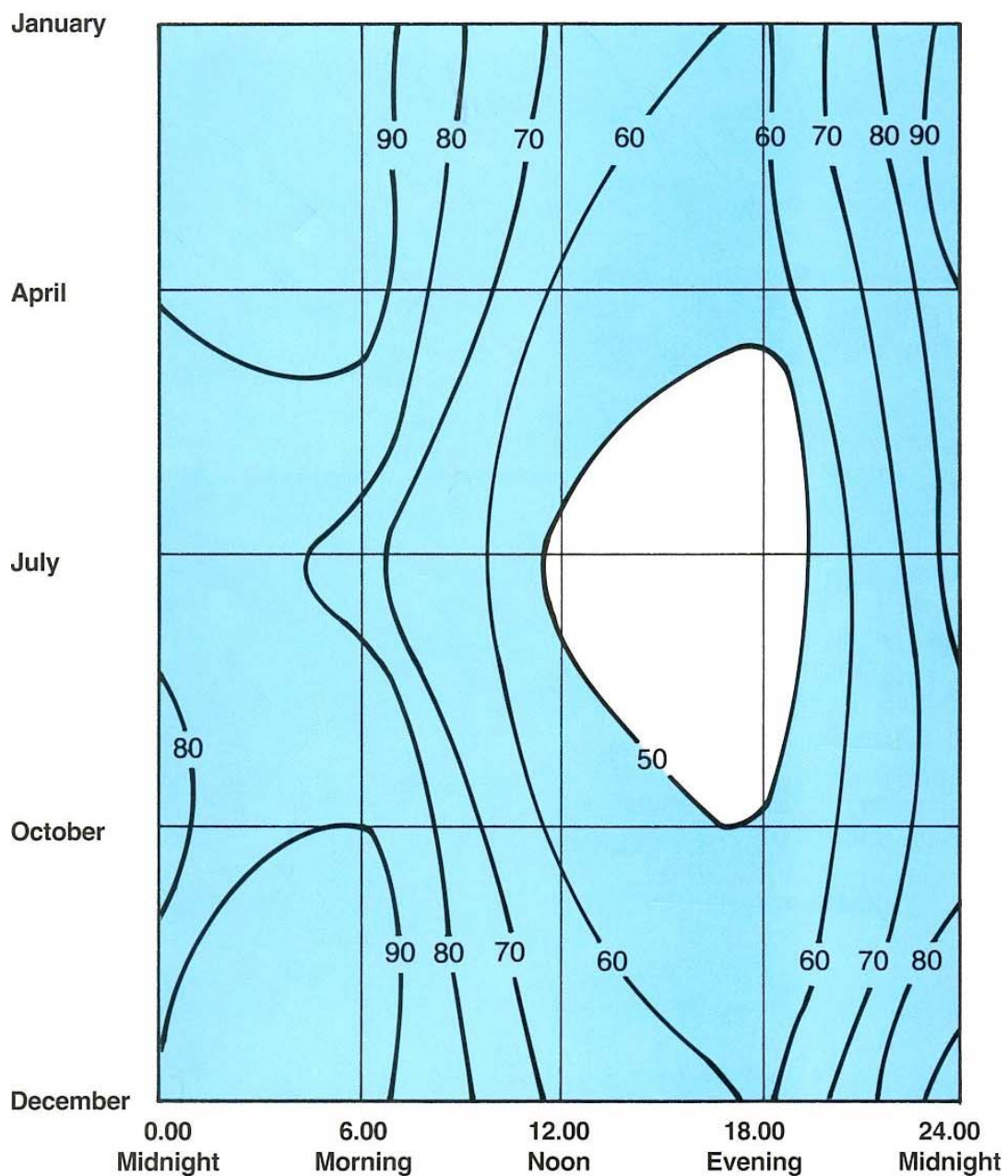
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DRY AIR STORAGE & CONVEYING

EFFECTS OF HUMIDITY & TEMPERATURE ON STORAGE

OUTDOOR AIR HUMIDITY (RELATIVE %)

Typical Annual Conditions (London).



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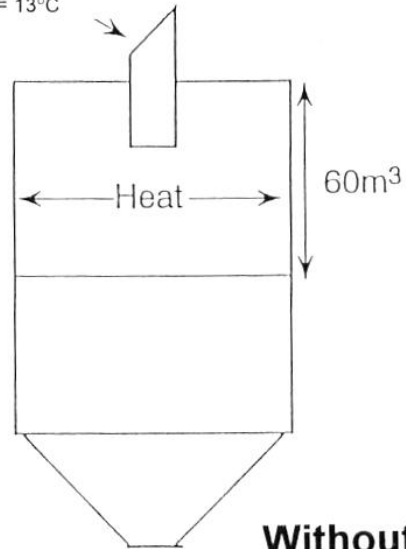
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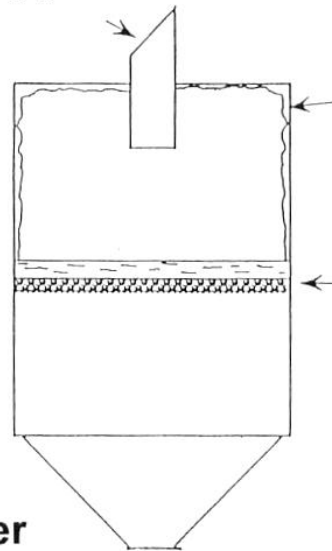
Day/Summertime

21°C @ 60% RH = 9.4g/kg moisture content
Dew point = 13°C



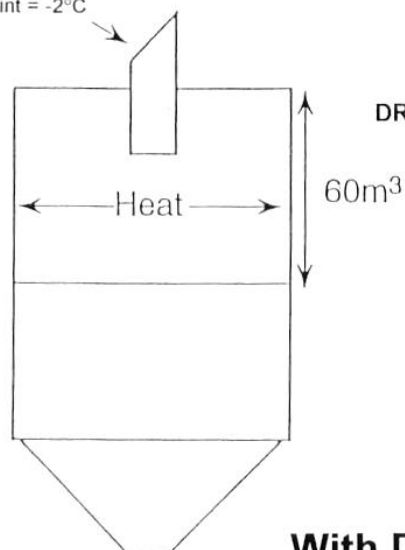
Night Time

Temperature drop to 5°C @ 100%RH = 5.4g/kg
4g/kg moisture will result in condensation



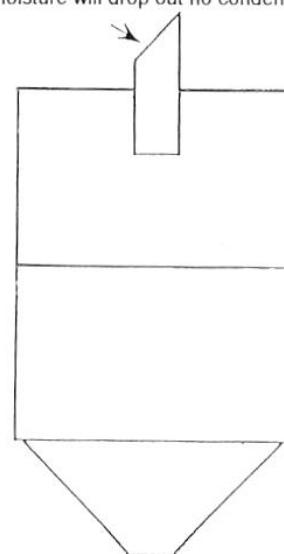
Day/Summertime

Drier removes 5g/kg = 4.4g/kg moisture content
Dew point = -2°C



Night Time

Temperature drop to 5°C
5°C @ 100 RH = 5.4g/kg
No moisture will drop out no condensation



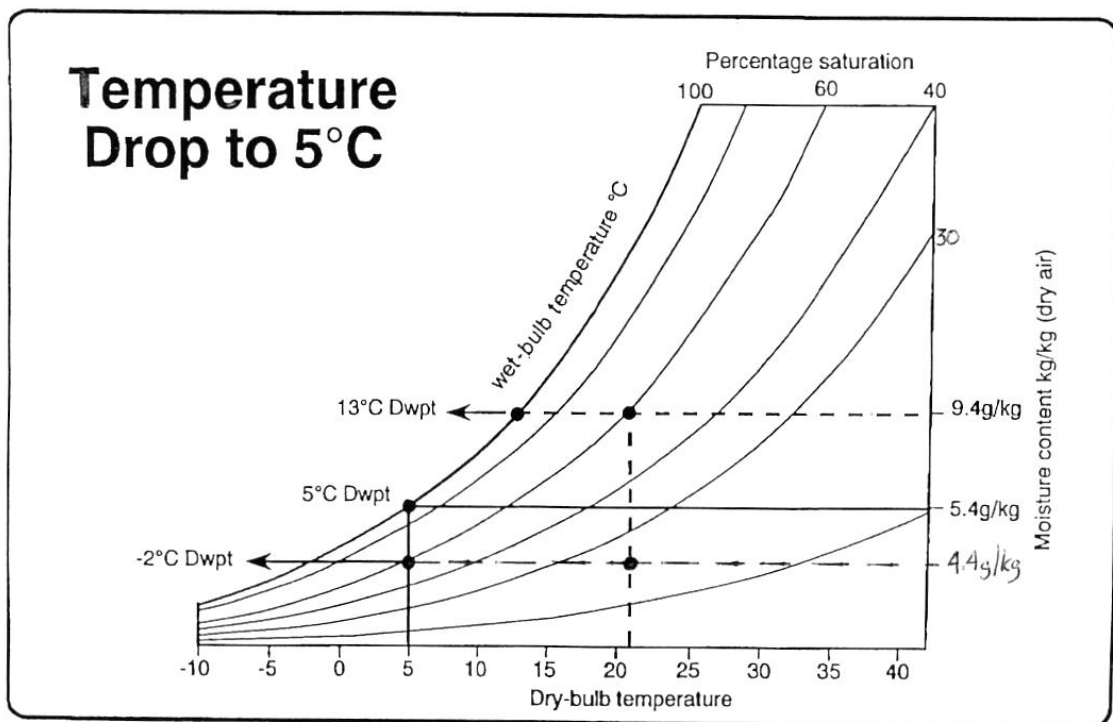
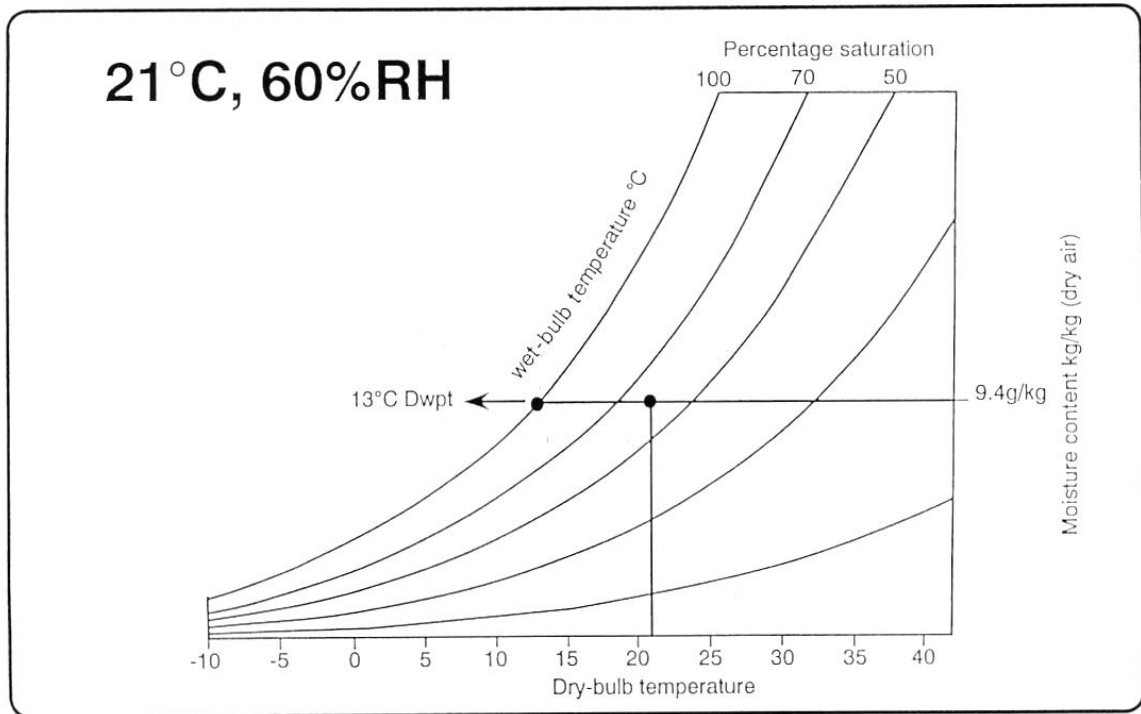
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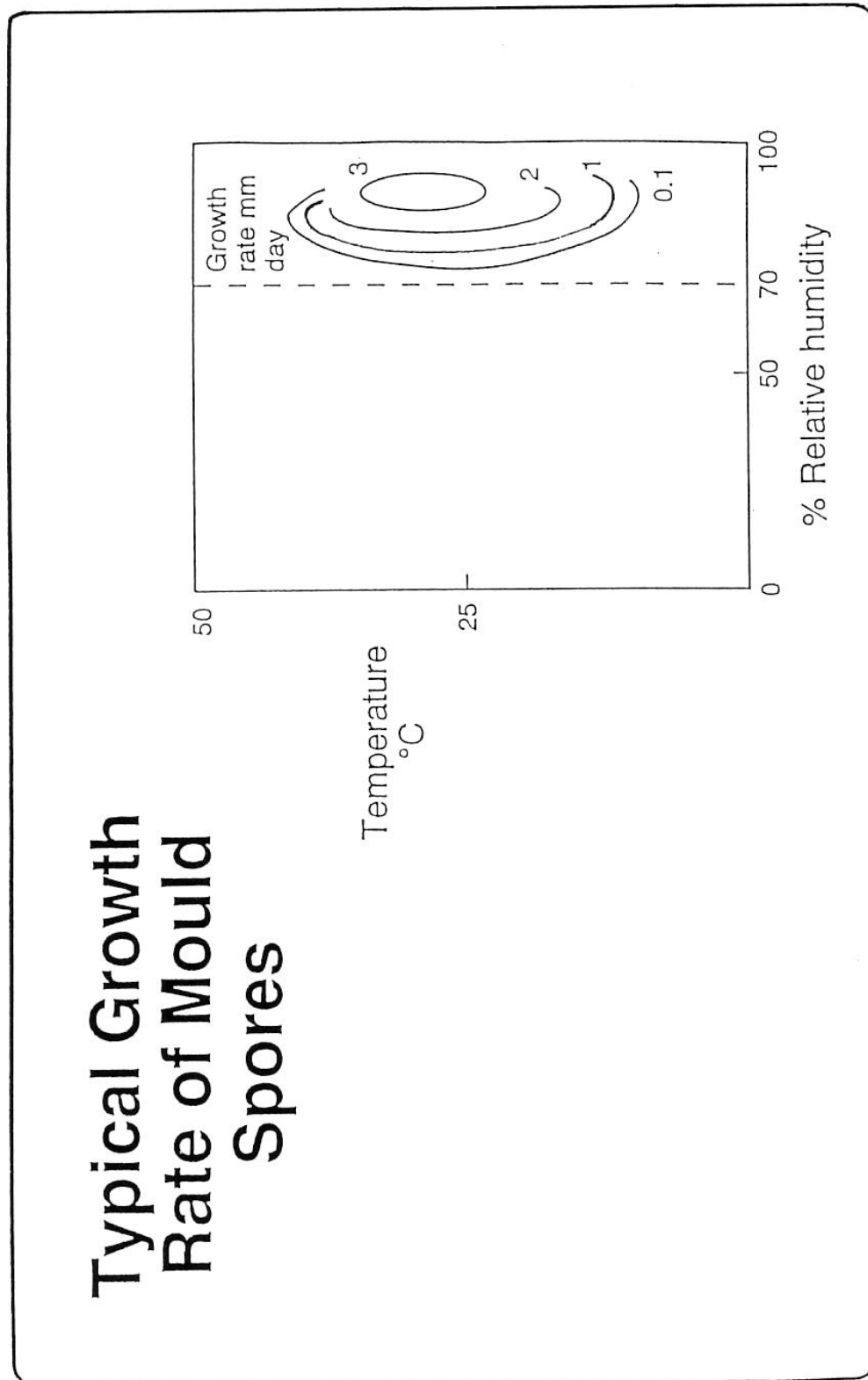
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PNEUMATIC CONVEYING

REDUCING PRODUCT DAMAGE WITH PNEUMATIC CONVEYING

Aptech's air speed control system was originally designed for the controlled and gentle conveying of dried bread crumb for a Dutch food ingredient company. Since then it has been developed further for conveying extruded petfood products, tea leaves, popcorn, navy beans (baked beans), bottle top conveying, maize flakes for horse feed, wheatpro flakes (food ingredient), cereal flakes and various other friable powders, granules and flakes.

The system has been designed to incorporate the following features:-

- The system will constantly monitor the conveying velocities and keep the velocity to a pre set minimum at all times for all distances & any feed rate to avoid product damage.
- Special design offset rotary valves and feeders are used to prevent product damage.
- The receiver/cyclones are specially designed so that product enters the cyclones on a falling velocity and avoids heavy impact. The receiver/cyclone will also draw out dust and light husk, which may have passed the separator. The dust/husk is collected by a central dust collector.

Aptech have an in house test facility which is used to obtain conveying data from trialling product samples. This data is fed into a computer modelling programme which is used to design the system. Aptech use various control systems in lean phase pneumatic conveying to reduce breakage of fragile products and accommodate different product densities.

Air Speed Control is used to convey fragile products at a constant minimum velocity to keep product damage to a minimum. This has been used for breadcrumbs, flakes and extruded petfood.

If the product flow varies or the product is directed to destinations at varying distance, then the back pressure on the blower will vary and the speed of the air, and product, will alter. The purpose of the system is to keep the velocity at a pre-set value. A control device measures and monitors the air speed and automatically adjusts it by altering the speed of the blower if a positive displacement (rootes) machine is used, or by varying the restriction of a valve if a fan is used.

Feed Control is used to maintain a constant feed rate for products of varying density.

A fixed speed rotary valve or feeder delivers a constant volume of product into a pneumatic conveying system. If the bulk density varies the conveying rate (Te/hr) will vary and we have to design for the maximum density. This means for lower density products the conveying rate will be less. Often it is necessary to oversize a system to achieve a minimum conveying rate for all bulk densities.

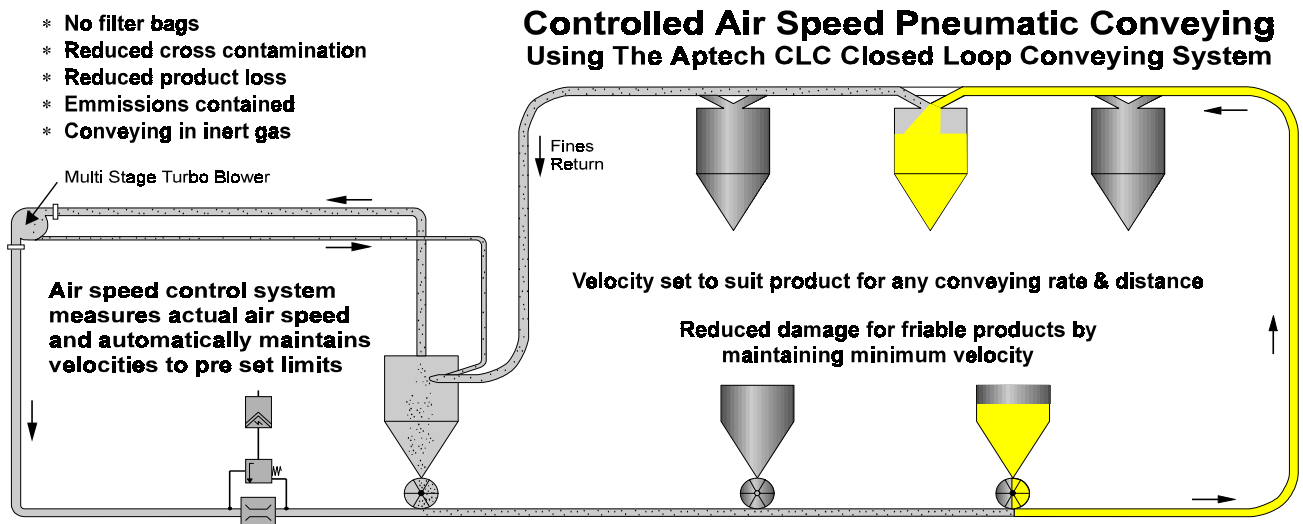
The alternative is to maintain a constant conveying rate (Te/hr) by varying the speed of the rotary valve or feeder (m^3/hr). The rotary valve or feeder runs faster for low product densities and slower for higher product densities. A system will operate at a certain pressure for a set conveying rate (Te/hr). In a CONSTANT FEED system we measure this pressure (Δp) and vary the speed of the rotary valve or feeder. When the product density reduces, the pressure reduces and the rotary valve/feeder will speed up until the set pressure is restored. When the product density increases the rotary valve/feeder will slow down.

PNEUMATIC CONVEYING

AIR SPEED CONTROL SYSTEM

Reduced Damage for Friable Products

- Convey granules and large particulates gently
- Continuous monitoring of conveying air speeds
- Automatically maintain velocities to pre-set limits
- Constant velocity achieved for any conveying distance
- Constant velocity achieved for any feed rate
- Special Design offset rotary valves = reduced damage
- Special Design receiver/cyclones to minimise damage



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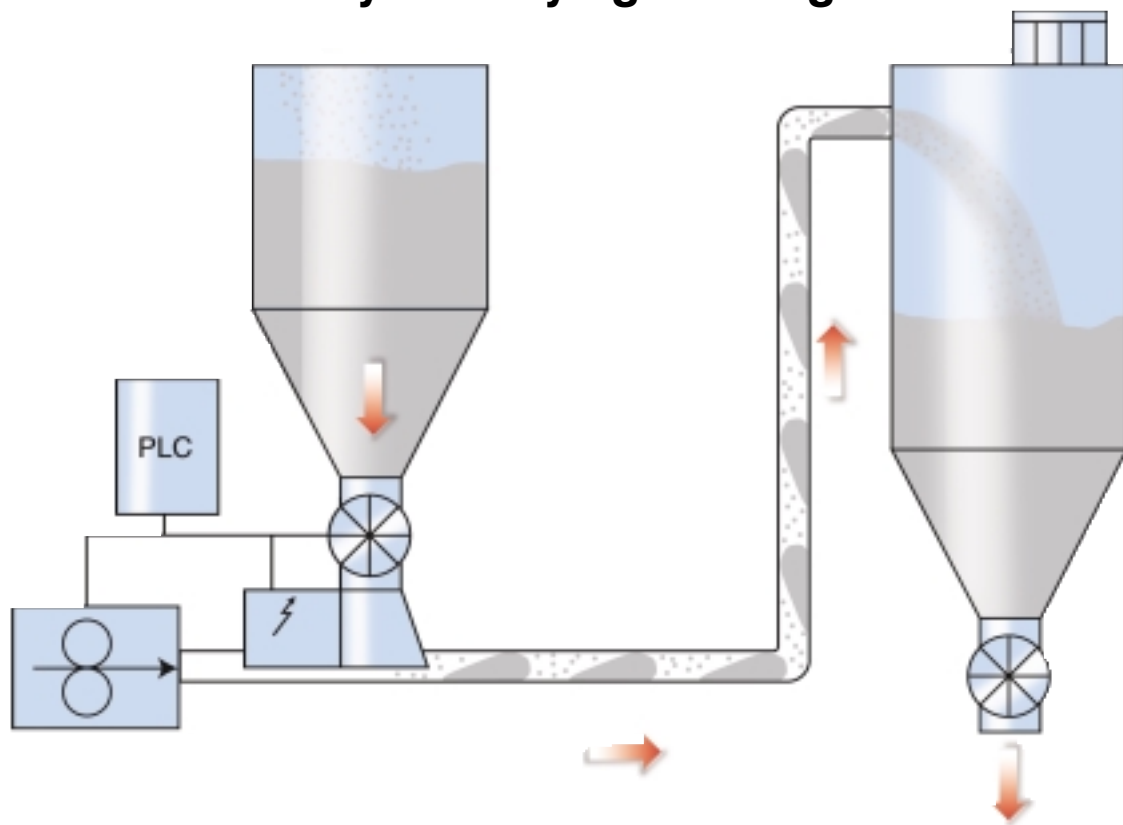
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MAKING A MARK IN 'DUNE FLOW' PNEUMATIC CONVEYING

Low Velocity Conveying for Fragile Products



The Advantages of Aptech's Dune Flow System:

The "Dune Flow" technology has been developed to transfer granular products (in waves) at low velocity and pressure. The system offers a very efficient and economical method of transferring fragile products with minimal damage.

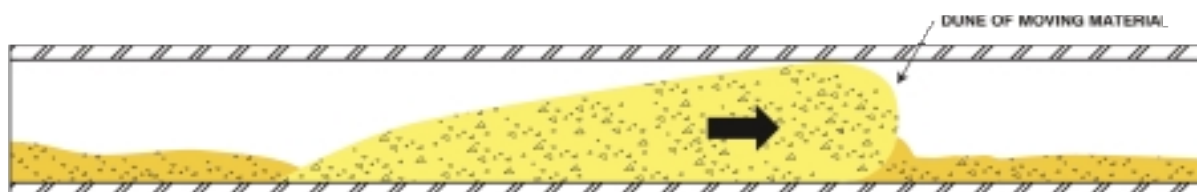
- Reduced degradation of fragile products
- Less dust, less waste, product quality maintained
- For plastic granules – eliminate "angel hair", "snakeskin", "birds' nests"
- Silent conveying lines during transfer
- Auto calibrates to lowest velocity, smaller blowers and filters
- Works at low pressure, low power consumption

- Constant velocity along length of pipe
- Reduced wear on pipe, bends and valves
- Can be fitted to existing pneumatic conveying lines

Products Suited to Dune Flow Conveying

Most granular products are suitable if they allow air to pass through them and do not interlock to form a plug. Typical products are:

- Foods: breadcrumbs, puffed grains, gravy/coffee granules
- Plastic pellets: LDPE, HDPE, nylon etc.
- Grains and pulses: barley, beans, rice etc.
- Extruded foods and petfood
- Minerals and abrasive pellets – glass/limestone beads, sand etc.



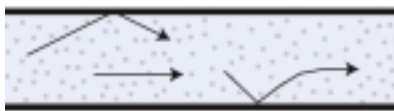


MAKING A MARK IN 'DUNE FLOW' PNEUMATIC CONVEYING

Low Velocity Conveying for Fragile Products

How it Works

When an airflow is sufficiently low, particles first form a “bed” in the pipe, then a moving wave; a “dune”. Once formed, the dune moves on the bed, picking up product at the front and dropping it behind as it travels. During this process air permeates through the “plug” of product. This flow regime results in a reduction of interparticle and wall friction. Instrumentation monitors pressure, air flow and product profile. A PLC analyses the data and makes instant micro-adjustments to the system to maintain the critical dune flow state. The system is self-calibrating and will respond to changes in product, transfer rate and loading conditions; always seeking the lowest velocity. No operator intervention is required.



Dilute Phase Flow (Lean Phase): High air speed and low solids to air ratio. The particles move at a high speed, which can lead to product damage and high wear of pipeline and components. This system works at low pressure.



Dense Phase Flow (plug flow): The particles form a plug, filling the complete cross section of the pipe. The friction and resistance caused by many plugs moving down the pipeline means the system works at high pressure. As the plugs move down the line, the pressure drops, the conveying air expands and the air and product speed increases. Although the particles may start at a low velocity they increase in speed rapidly down the line.



Dune Phase Flow: The particles flow along the conveying line in waves at very low velocities. This flow regime (unlike dense phase plug flow) causes little resistance and hence the system works at low pressure. The speed at the end of the line is similar to the start.

Conveying Mode	Air Flow Speed	Typical Operating Pressure	Degradation	System Cost
Dilute phase flow	12 to 35 m/s	0.1 to 1 bar	High	Low
Dense phase flow	2 to 6 m/s	2 to 6 bar	Medium	High
Dune phase flow	2 to 6 m/s	0.1 to 1 bar	Low	Low

For products not suited to Dune Flow Conveying, Aptech offer AIR SPEED CONTROL.

The benefits of Air Speed Control are similar to Dune Flow Conveying. Air Speed Control maintains the

minimum conveying velocity in a lean phase system for any change in conveying distance or feed rate.

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