DESIGN GUIDELINE FOR MATERIAL HANDLING SYSTEMS

Part 1

Florida Board of Professional Engineers
Approved Course No. 0010329

4 PDH Hour

A test is provided to assess your comprehension of the course material – 24 questions have been chosen from each of the above sections. You will need to answer at least 17 out of 24 questions correctly (>70%) in order to pass the overall course. You can review the course material and re-take the test if needed.

You are required to review each section of the course in its entirety. Because this course information is part of your Professional Licensure requirements it is important that your knowledge of the course contents and your ability to pass the test is based on your individual efforts.

Course Description:

This course is a basic design guideline that can be used in the development of a basic engineering design package. This document provides guidelines to aid in the selection of equipment for systems used in unloading, loading, transfer, packaging and collection of bulk materials including: granular materials, powders, pellets, ores, flakes etc. This guide also provides information that can be used in the selection of material handling equipment and the preparation of equipment data sheets.

This is Part 1 (4 PDH) of a two course series and covers:

1. Pneumatic Conveying Systems
2. Mechanical Conveyors
3. Bucket Elevators

In Part 2 (4 PDH) of the series the following systems are covered:

1. Bulk Loading Systems
2. Packaging Systems
3. Product Sampling
4. Feeders (Weigh Belt Feeders, Screw Feeders, Rotary Feeders)
5. Storage Bins and Silos
6. Dust Collection Systems

How to reach Us …

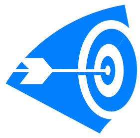
If you have any questions regarding this course or any of the content contained herein you are encouraged to contact us at Easy-PDH.com. Our normal business hours are Monday through Friday, 10:00 AM to 4:00 PM; any inquiries will be answered within 2 days or less. Contact us by:

EMAIL: bajohnstonpe@aol.com
Phone: 888-418-2844 (toll free)
FAX: 813-909-8643

Refer to Course No. 0010329,

DESIGN GUIDELINE FOR MATERIAL HANDLING SYSTEMS (Part 1)

Here's How the Course Works…

What do you want To do?	LOOK For This!
 **Search for Test Questions and the relevant review section**	 **Q1** **Search the PDF for: Q1 for Question 1, Q2 for Question 2, Q3 for Question 3, Etc…** **(Look for the icon on the left to keep you ON Target!)**

Easy-PDH.com (FBPE Approved Provider 442)
Britian Arthur Johnston PE (50603)
Johnston Service Corp
CA No. 30074
11909 Riverhills Drive, Tampa FL 33617
Email: bajohnstonpe@aol.com
Toll Free: 888-418-2844 FAX: 813-909-8643

24 TEST QUESTIONS

Q1: [Refer to Section 3.0 - Principles of Operation]

A well designed material handling system will meet the following Criteria:

(A) Provide consistent performance and maximize operating availability
(B) Meet Governmental and Environmental standards and regulations
(C) Allow for maintenance without unscheduled interruption
(D) All of the above

Q2: [Refer to Refer to Section 4.1.3 - General Design Criteria]

You are considering installing a Pneumatic Conveying system. As a General Rule of Thumb, as the Bulk Density of the material to be conveyed INCREASES, what would you expect the required Gas Velocity to do in relation:

(A) DECREASE
(B) STAY THE SAME
(C) INCREASE
(D) NA, Bulk Density has no correlation with Gas Velocity

Q3: [Refer to Section 4.1.4 - Types of Pneumatic Conveying Systems]

There are two TYPES of Pneumatic Conveying Systems, Dilute Phase Conveying and Dense Phase Conveying. What are the characteristics of a DENSE Phase Conveying System:

(A) A Low Pressure motive fluid is used (i.e. air) to convey the material at Low Velocities
(B) A Low Pressure motive fluid is used (i.e. air) to convey the material at High Velocities
(C) A High Pressure motive fluid is used (i.e. air) to convey the material at High Velocities
(D) A High Pressure motive fluid is used (i.e. air) to convey the material at Low Velocities

Q4: [Refer to Section 4.1.4 - Types of Pneumatic Conveying Systems]

There are two TYPES of Pneumatic Conveying Systems, Dilute Phase Conveying and Dense Phase Conveying. What are the characteristics of a DILUTE Phase Conveying System:

(A) A Low Pressure motive fluid is used (i.e. air) to convey the material at Low Velocities
(B) A Low Pressure motive fluid is used (i.e. air) to convey the material at High Velocities
(C) A High Pressure motive fluid is used (i.e. air) to convey the material at High Velocities
(D) A High Pressure motive fluid is used (i.e. air) to convey the material at Low Velocities

Q5: [Refer to Section 4.1.5 Pneumatic Conveying System Equipment]

What type of conveying equipment is typically used in lower pressure Pneumatic Coveying Systems (35 kPa or less):

(A) Centrifugal fans
(B) Centrifugal blowers
(C) Rotary Screw Compressor
(D) A or B

Q6: [Refer to Section 4.1.6 Safety and Fire Consideration]

Given the risk of explosion with pneumatic conveyance of some types of solids, which of the following common methods of explosion protection uses a gas such as Nitrogen or Carbon Dioxide to lower the oxygen concentration below the level required for combustion:

(A) Containment
(B) Inerting
(C) Deflagration Venting
(D) Deflagration Suppression

Q7: [Refer to Section 4.1.6 - Safety and Fire Considerations]

Dust explosions and fires are the principal hazards associated with pneumatic conveying systems. And while material testing is recommended, a general rule of thumb is that an explosive dust would have an ignition temperature:

(A) < 410 °C
(B) < 100 °C
(C) between 100 °C and 410 °C
(D) between 410 °C and 600 °C

Q8: [Refer to Section 4.1.6 Dust Characteristics Relative to Fire and Explosion]

For an explosion to occur which of the following components must be present:

(A) fuel
(B) an oxidizer (oxygen in air)
(C) an ignition source
(D) All of the Above

Q9: [Refer to Section 4.2.1 – Belt Conveyors]

Which type of pulley is installed at the loading end of a belt conveyor:

(A) Tail pulley
(B) Head pulley
(C) Snub Pulley
(D) Bend Pulley

Q10: [Refer to Section 4.2.1 – Belt Conveyors (Special Types of Belt Conveyors)]

Steel and Stainless Steel belt conveyors are typically used for which application(s):

(A) operation at high temps up to 350 degrees C
(B) operation at low temps below -20 degrees C
(C) processing and handling of foods
(D) All of the above

Q11: [Refer to Section 4.2.2 – Screw Conveyors]

Screw Conveyors are one of the simplest methods for moving bulk materials because they:

(A) are compact
(B) can be mounted in almost any configuration (horizontal, vertical, or inclined)
(C) they consist primarily of a conveyor screw rotating in a stationary trough
(D) All of the above

Q12: [Refer to Section 4.2.2 – Screw Conveyors]

In its simplest form, a screw conveyor consists of two parts: a stationary part and a rotating part. What is the common name of the STATIONARY part of a screw conveyor:

(A) Trough
(B) Coupling
(C) Conveyor Screw
(D) Flight

Q13: [Refer to Section 4.2.2 Flight and Pitch Arrangements for Special Applications (Screw Conveyors)]

Stepped diameter conveyor screws consist of flights of different diameters and are typically used to:

(A) moderately mix granular or flake materials
(B) regulate the flow of material (as a feeder screw)
(C) promote agitation and aeration
(D) mixing, blending or stirring dry or fluid materials

Q14: [Refer to Section 4.2.2 Screw Conveyor Design (Screw Conveyors)]

As a PE you have been asked to design a Screw Conveyor that will move a No. 80 Sieve material. This material would be considered what SIZE:

(A) very fine
(B) fine
(C) granular
(D) lumpy

Q15: [Refer to Section 4.2.2 Screw Conveyor Design (Screw Conveyors)]

Which Conveyor Equipment Manufacturers Association (CEMA) Standard pertains to the dimensional standards for Screw Conveyors:

(A) CEMA Standard No. 300
(B) CEMA Standard No. 350
(C) CEMA Standard No. 400
(D) CEMA Standard No. 450

Q16: [Refer to Section 4.2.2 Screw Conveyor Design (Screw Conveyors)]

Minimum trough loading for design of Screw Conveyors is:

(A) 10%
(B) 15%
(C) 17%
(D) 20%

Q17: [Refer to Section 4.2.2 Screw Conveyor Design (Screw Conveyors)]

Screw conveyors that convey hot materials will increase in length as the temperature of the trough and screw increases.   Special Design considerations in this case include:

(A) provide supports for the trough to allow movement of the trough end feet
(B) provide expansion type troughs
(C) provide expansion hangars for the screw
(D) All of the Above

Q18: [Refer to Section 4.2.3 – Roller Conveyors]

In the design of Roller Conveyors manufacturers' consider Total Live Load. Which definition below best describes Total Live Load:

(A) weight of conveyor and total load resting on the conveyor at one time
(B) total load resting on the conveyor at one time
(C) (weight of conveyor and total load resting on the conveyor at one time) X 1.5
(D) expected total load passing on a conveyor measured over a one minute time period

Q19: [Refer to Section 4.2.3 – Roller Conveyors]

Roller conveyors are used to feed or convey products (cartons, boxes, drums, bags, etc.) from one point in a process to another. How would you determine the minimum Roller Capacity of a Roller Conveyor:

(A) Multiply the total number of Rollers x the Design Capacity of each Roller
(B) Divide the weight of the heaviest load by the total number of Rollers on the conveyor
(C) Divide the weight of the lightest load by the total number of Rollers that will support the carrying surface of the load
(D) Divide the weight of the heaviest load by the total number of Rollers that will support the carrying surface of the load

Q20: [Refer to Section 4.2.3 – Roller Conveyors]

When conveying loads around a turn what is the BEST type of roller conveyor that can be used to keep the load centered without skewing:

(A) Tapered Roller curve
(B) Double Roller-Differential curve
(C) flat single straight roller curve
(D) inclined single straight roller curve

Q21: [Refer to Section 4.3 – Bucket Elevators]

Of the main categories of bucket conveyors which employs pivoting buckets that are side-mounted between two chains:

(A) Pivoting Bucket Elevator
(B) Centrifugal Bucket Elevators
(C) Positive Discharge Elevator
(D) Continuous Discharge Elevator

Q22: [Refer to Section 4.3.2 - Components of a Bucket Elevator]

A bucket elevator can be divided into how many major assembles:

(A) 3
(B) 4
(C) 5
(D) 6

Q23: [Refer to Section 4.3.3 - Elevator Details]

Typically the maximum speed for Chain equipped conveyors is:

(A) 90 meters per minute
(B) 90 meters per hour
(C) 120 meters per minute
(D) 240 meters per minute

Q24: [Refer to Section 4.3.3 - Elevator Details]

Typically the maximum speed for Belt equipped conveyors is:

(A) 90 meters per minute
(B) 90 meters per hour
(C) 120 meters per minute
(D) 240 meters per minute

END OF TEST QUESTIONS

MATERIAL HANDLING
TABLE OF CONTENTS

1.0 SCOPE

This design guideline is presented to assist in the development of a basic engineering design package. This document provides guidelines to aid in the selection of equipment for systems used in unloading, loading, transfer, packaging and collection of bulk materials including: granular materials, powders, pellets, ores, flakes etc.

This guide also provides information that can be used in the selection of material handling equipment and the preparation of equipment data sheets.

2.0 INTRODUCTION

Bulk material handling requires that individual conveying units be arranged to operate within a system or be used to tie a process together. In a material handling system bulk feeders, conveyors, elevators, pneumatic conveying systems etc. efficiently and safely interact with bins, hoppers, silos, screens, dryers, blenders, packaging machines and other types of process equipment as well as with the structures that support them. Chutes, spouts, skirt boards and gates are necessary to transfer bulk material from one unit to another. Dust collection equipment is installed to prevent particulate matter from entering the environment or is required to minimize the chance for fires or explosions that can be caused by a sufficient accumulation of dust.

This guide cannot begin to address every type of feeder, conveyor, dust collector, processor, packaging equipment available in the market place, but a thorough understanding of the information presented in this guide should prepare the engineer to understand other equipment or equipment variations available. This is a mechanical equipment guide and discusses the more common and most frequently applied equipment. Material handling systems are not covered in detail because it is the process that dictates the system.

The preliminary selection of equipment for a material handling system requires:

- A detailed description of the requirements of the system.
- Complete physical and chemical properties of the material(s) to be handled.
- A material flow diagram.
- A preliminary layout drawing.
- Coordination between process, project, mechanical and control specialists.
- Early consultations with potential equipment suppliers.

After the preliminary selections are made, equipment data sheets can be prepared, quotes can be obtained and final equipment items can be selected.

3.0 PRINCIPLES OF OPERATION

Q1

Basic principals of operation require that a material handling system and the individual equipment within that system are efficient and safe. A well designed system will maximize operating availability, provide consistent performance, optimize staff and operating control, meet governmental and environmental standards, allow effective maintenance without unscheduled interruption and ensure a safe working environment.

Operation of specific equipment is provided in the individual equipment sections that follow.

4.0 MATERIAL HANDLING TYPES/MAJOR COMPONENTS

4.1 Pneumatic Conveying Systems

4.1.1 Introduction

Pneumatic conveying is a method of transferring bulk materials from one storage vessel to another. The material may be transported both horizontally and vertically. A pneumatic conveying system can be used in place of other mechanical methods of transfer such as conveyors, bucket elevators, screw conveyors and other mechanical equipment which have high maintenance costs and are prone to contamination problems.

Typical applications for pneumatic conveying systems are: transfer of bulk materials from trucks or railroad hopper cars to large bulk storage vessels; subsequent transfer of material from large bulk storage vessels to smaller day hoppers or batch type vessels that feed into a process; transfer of final bulk products to hoppers feeding bags, super sacks, totes or other shipping containers, transfer to shipping silos mounted over railcar or truck loading stations or transfer directly back into trucks or railcars.

4.1.2 Codes, Standards and References

a. Standards

NFPA 650: Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids, 1998 Edition (This standard is no longer current, but it is still available from the National Fire Protection Association and is a useful reference. Much of NFPA 650 has been incorporated in the current Edition of NFPA 654.)

NFPA 654: Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids, Current Edition

b. References

The American Society of Mechanical Engineers (ASME) Publishes a book entitled “Successful Pneumatic Conveying” (96 pages). This volume looks at more innovative systems and applications to pneumatic conveying. Some of the operational topics considered are: problem solving in pneumatic conveying systems; aspects of conveying fragile materials; understanding and controlling wear and product attrition; vacuum versus positive pressure; and ensuring reliability of position. Successful Pneumatic Conveying combines experience from users and manufacturers of pneumatic conveying components and equipment and is complimented by industrially relevant views from the academic field.

Q2

4.1.3 General Design Criteria

Selecting a suitable pneumatic conveying system depends on the process requirements and the properties of the material being conveyed. A review of the following criteria will help guide the design and selection of a suitable system. For specific details of each type of conveying system, refer to Section 4.1.4.

- Do the material characteristics allow the material to be pneumatically conveyed?

  Particle size, distribution, and shape significantly affect pneumatic conveying capabilities. For example, uniformly sized particles or round and smooth particles are generally easier to convey than angular, rough particles with a large size distribution. And unless the material being conveyed has a mono-size distribution, use of a mean diameter particle size may or may not provide suitable data for a suitable design. A general rule of thumb is that when conveying large particles, the pipe diameter should be 3 to 5 times the maximum particle diameter.

  Cohesive or sticky materials are often difficult to convey and if the material is generally moist enough to stick to the walls of the pipeline, pneumatic conveying is not a suitable method of material handling.

  Generally, larger particles of higher densities will require a higher gas velocity to become entrained in the air stream, will require higher pressure drops, and will consume more power. Typically, for particle sizes of about 12 –19 mm, by simply increasing the air velocity, heavier particles can be conveyed. In addition, a typical particle size upper limit of about 50 mm is most practical for pneumatic conveying systems. On the other hand, at higher velocities and higher solids loading rates, saltation may become a factor (the velocity below which entrained solids will fall out of suspension in the gas stream and settle at the bottom of horizontal lines). Refer to the table below for a list of typical bulk densities and minimum gas velocities required.

  In summation, unless specific operational experience and data are available, the material to be conveyed should be tested.

Typical Gas Velocities

Bulk Density, kg/m^3	Gas Velocity, m/min
10	884
20	1256
30	4539
40	1780
50	1981
60	2179
70	2347
80	2515
90	2652
100	2804
110	2957
120	3200

- What is the layout?

  For design of effective pneumatic conveying systems it should be desired to limit the number of bends and avoid placing them close together. If the layout requires a large number of turns, the conveying line will be susceptible to plugging due to loss of solids velocity. In addition, increasing the number of elbows leads to increased system pressures.

- What is the maximum transfer rate required?

  Positive pressure systems can provide higher transfer rates than vacuum systems because of higher available pressure drop. In general the length of a positive pressure pneumatic system should not extend greater than 300 m for each pneumatic unit. However, bulk materials can be conveyed over longer distances by connecting the systems in series with a practical limit of up to 1000 m. Positive pressure systems are generally limited to up to 270,000 kg/hr. Vacuum systems generally do not have an upper transfer rate limit but the conveying distance becomes much shorter.

- How many feed and discharge points are required?

  Vacuum systems are better suited for systems that have multiple feed points since the gas mover is located at the discharge end. Example systems include feeding from multiple silos or bins to a single day bin or hopper. If the system requires product delivery to multiple locations (ex. a single silo feeding several bins), a positive pressure system may be the better choice as the air mover is located upstream of the delivery point.

Both pressure and vacuum systems can be used to unload received material from trucks, rails cars, or ships. In this situation, vacuum systems require little or no component systems to be built into the transportation vehicle. However, vacuum systems are limited to moving free flowing materials over short distances that can be easily fed into the conveying line. To transfer longer distances a combination “pull/push” or “push/pull” system can be employed.

- Is a conveying gas other than air required?

  If the material being conveyed reacts with oxygen, air would not be a suitable conveying gas but rather nitrogen may be used. Installation of a closed loop system will reduce overall operating costs by recirculating the conveying gas. Note: a supply of make-up gas will be required as some gas is inevitably lost. If an inerting environment is needed, a pressure system may be preferred to keep oxygen from entering the system.

- Is the conveyed material hazardous?

  If an exposure or release to the atmosphere is undesirable, a vacuum system may be more suitable as any leaks will occur INTO the conveying line.

- Is the material friable or is particle attrition a concern?

  Since attrition is a strong function of velocity, if particle attrition is a concern then a low velocity system may be appropriate. Experience with the material or product testing will provide insight of the level of attrition expected.

- Is the material abrasive?

  Again, similar to attrition, wear is a strong function of velocity. Therefore, if the material to be conveyed is very abrasive, use of a low velocity system may be appropriate. As a general rule of thumb, if the material is greater than 5 on the Moh’s hardness scale, significant wear is likely expected in high velocity dilute-phase systems.

- Is the material hygroscopic?

  If the material to be conveyed is hygroscopic, exposure to humid air may lead to build-up in the line and flow problems in downstream solids handling equipment. In these cases, dry air may be needed and product testing should be completed to determine the amount of moisture that can be expected to be absorbed by the material during transit and storage.

- Is the material temperature sensitive?

  Heat is generally generated when the conveying gas is compressed. If the material is temperature sensitive, additional heat generation could lead to line build-up and downstream solids handling problems. In these cases, installation of a heat exchanger in the conveying line may be required.

Q3 Q4

4.1.4 Types of Pneumatic Conveying Systems

a. Dilute Phase Conveying (Low Pressure / High Velocity)

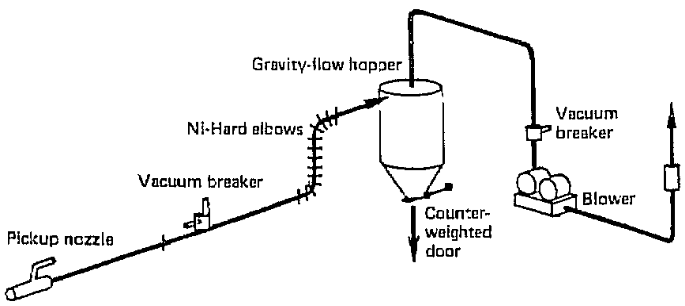
Low pressure systems, sometimes referred to as dilute phase pneumatic conveying systems utilize air pressure under 100 kPa and use either positive or negative pressure to push or pull materials through the conveying line at relatively high velocities. They are described as low pressure/high velocity systems and have a high air to material ratio.

If you look at a typical low pressure system using a rotary air lock feeder, you will notice a high pickup velocity of around 125 m/sec at the beginning of the system, and about 300 m/sec at the end. The conveying line pressure is under 100 kPa at the beginning versus near atmospheric pressure at the end.

Low pressure systems generally use a low pressure positive displacement blower or a fan as the pressure source.

- Vacuum Operation - When conveying from several locations to one discharge point, a vacuum system is usually the best choice (Fig. 1). A pickup manifold and cutoff valve may be all that is needed to introduce material into the system, instead of a rotary valve and manifold at each pickup point, as with pressure systems. Dust control-needed for pressure methods to allow for blowback air is not required either. If heat of compression causes product fusion, special measures are not needed because the blower is isolated from the conveying circuit. These considerations and the ones that follow usually make a vacuum system less expensive than a pressure one.

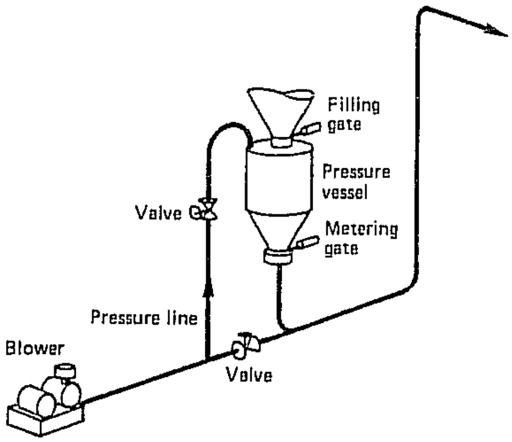
Figure 1



- Cleanliness – Because all leaks are inward, housekeeping or complications that might arise from escape of product are eliminated, particularly when handling toxic or corrosive substances. And if bags or drums are dumped into the system, the conveying air controls the dust, thus eliminating a separate dust-collection system.

- Pressure Operation - A positive-pressure system normally conveys best from one pickup location to several discharge points (Fig. 2), with cost being the deciding factor. One reason for such cost savings is that a rotary valve is needed at the inlet but not necessarily at the discharge. Often, the discharge can be a cyclone collector with an atmospheric exhaust vent on top and a simple spout connection at the bottom. This is especially true when handling granular or dustfree material. When conveying to a number of hoppers, a simple bag-type cloth can serve as the filter.

Figure 2



The cost advantage of these systems over the vacuum ones is obvious when conveying from one location to numerous discharge points. A negative system requires a vacuum vessel at each outlet, plus a rotary valve to form an air seal at the product discharge. Also, pressure systems do the same conveying job with smaller pipelines because they operate with about 1½ times the differential pressure (Δp) of a vacuum system.

Maximum operating pressures are normally 70 to 80 kPa when rotary air-lock seals are placed at the inlet. Most rotary valves cannot tolerate a much higher because of deflections in shaft and bearings, and the increased blowback air encountered. A negative system, on the other hand, normally operates at a maximum vacuum of 380 to 410 mm Hg with large blowers and filters.

In dilute-phase pressure systems, about 20 kg of material per kg of air can be conveyed, which is roughly about 24 kg of material/standard (std.) mt^3 of air. Vacuum systems generally run at about one-half of these figures.

However, power needed for the two systems is about the same (except for small differences between the efficiencies of the two blowers) because the same amount of product is moved and the distance is identical. Rotary valves would also be the same, since equal volumes of material must pass through them.

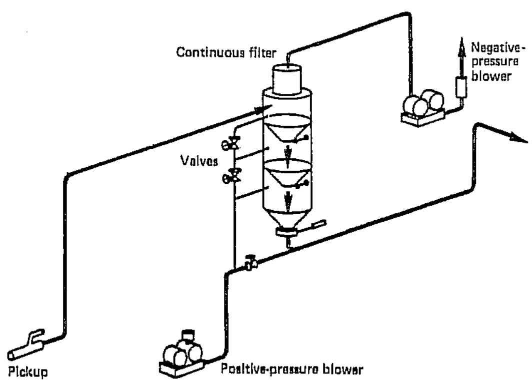
If a separate venting system is needed to care for blowback air or dust generated at a dump hopper, then the pressure system becomes more expensive than the negative one, because the vacuum can control dusting at the pickup location due to lack of blowback air.

- <u>Product Degradation</u> – Due to higher pressures and smaller pipes in pressure systems than in vacuum ones, the product-to-air ratio is much higher. Experience has shown that the more crowded the conveying line is, the less damage results to the product while being transported, because the product bounces less inside the pipe.

  A pressure system is normally preferred for closed-loop, inert-gas systems to prevent oxygen infiltration. To do this, the zero point is set at the lower inlet at a pressure about 7 to 14 kPa above atmospheric. The system is thus open at the zero point to an inert atmosphere instead of to ambient air.

- <u>Combined Pressure-Vacuum Operation</u> - Having the advantages of both the vacuum and pressure systems, combination systems are suited for conveying from several pickup locations to various discharge points (Fig. 3). They are ideally suited for unloading all types of railroad cars above the rail, although they can also unload under the rail if vacuum is desired at the car for sanitary reasons.

Figure 3



These systems are also well suited for conveying light and dusty materials because the suction at the inlet aids the product to enter the conveying line. Feeding such products into pressure systems can be difficult and, at best, present a severe dust-collection problem at the pickup location, due to blowback or leakage air through the rotary valve.

Usually, the rotary-displacement blowers – together with filter receivers – are combined in these systems to keep line sizes to a minimum. A single blower can be satisfactory if the conveying distances arc relatively short, so that line sizes are small. While a single blower can serve both the pressure and the vacuum sides of the combination system, this generally creates such problems that good design dictates a separate blower for each side.

If the velocities are analyzed with a single-blower arrangement, the velocity on the vacuum leg will be quite higher than the velocity on the pressure leg, because of the compression ratios involved. A single blower is limited to a 2:1 compression ratio across the blower. Separate blowers provide 380 to 410 mm Hg for vacuum, and 70 to 80 kPa pressure. Ordinarily, a pull/push system is installed so that the vacuum leg is much shorter than the pressure leg; it is more convenient to locate the equipment in this manner.

With a single-blower installation, the low velocities on the pressure side tend to cause plugs. Speeding up the blower to increase the velocity on the pressure side causes the velocity on the vacuum side to get out of hand very quickly. This can generate product degradation or abrasion. The load on the filter-receiver then also exceeds recommended air-to-cloth ratios.

<u>Portable Conveyors</u> - Pull/push systems are especially suitable for portable conveyors because of the simple pickup arrangement with nozzles and/or manifolds; they can also discharge directly into bins or hoppers. A single power source is often used because of space and weight limitations. Generally, these systems perform well because conveying distances are limited.

b. <u>Dense Phase Conveying (High Pressure / Low Velocity)</u>

High pressure systems, generally known as dense phase systems utilize air pressures above 100 kPa and use positive pressure to push materials through the conveying line at relatively low velocities, much like extruding. They are generally described as high pressure/low velocity systems and have a low air to material ratio.

A typical high pressure system using a high pressure vessel to maintain conveying pressure will have a low pickup or starting velocity at about 0.25 m/sec and a higher conveying velocity at the end of the system at about 2.5 m/sec. The conveying line pressure at the beginning of the system is typically at about 300 kPa and atmospheric pressure at the end of the system.

High pressure systems generally use a high pressure air compressor as the power source.

- Basic Design - The basic design is the lowest cost of the four options described in the following paragraphs. This design is a batch type system. It is generally suitable for shorter conveying line distances and for granular, free-flowing, abrasive and non-abrasive materials, such as silica sand or plastic pellets. This design consists of a pressure vessel, which is referred to as a transporter, and a conveying line.

  During the filling cycle, material is charged into the transporter through an inlet valve. Displaced air is vented up through a vent valve to allow easier filling and to prevent any back pressure that would retard material flow.

  Once the transporter is filled, as signaled by a level control or weighing device, the inlet and vent valves close and seal. Then, all the high pressure air required to convey a given product, regardless of distance, is gradually introduced through the top of the transporter during the conveying cycle.

  The compressed air introduced into the transporter mixes with material and is forced through the conveying line. The material then conveys in discrete slugs until the transporter and conveying line are empty.

  When the conveying line becomes nearly empty, the pressure in the transporter falls to zero and the air supply turns off allowing the residual air volume to purge the transporter and conveying line. Characteristics of this system are high air flow at the beginning and end of the transport cycle and higher conveying line pressures. A characteristic “whoosh” signals completion of the cycle. Diagrams of both the filling cycle and the conveying cycle are shown below (Figures 4 and 5).

Figure 4
Basic Design – Filling Cycle

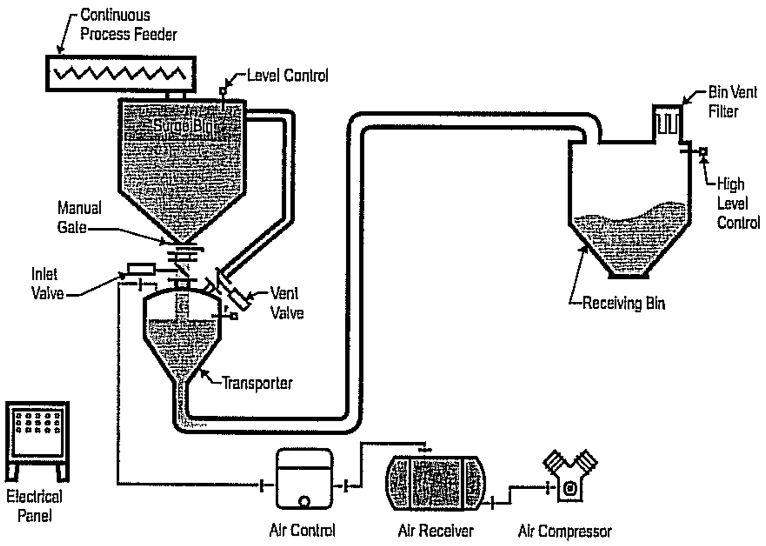
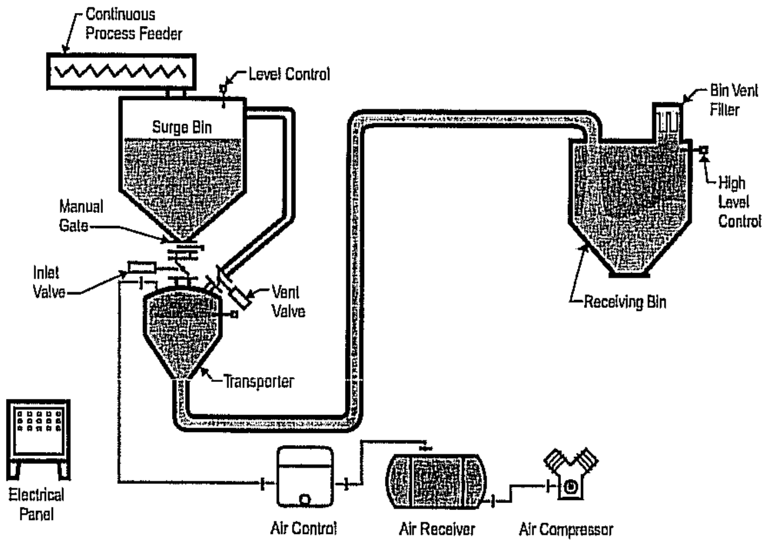


Figure 5
Basic Design – Conveying Cycle



- Basic Design Plus Fluidizing Air - This option is generally suitable for shorter conveying line distances and very fine and non-abrasive powdery materials, such as talc or flour. This system is also a batch type system that consists of a fluidizing transporter and conveying line.

  The fluidizing pressure vessel employs fluidizing nozzles or membrane to “fluidize” the material during the conveying cycle, eliminating packing in the transporter vessel and promoting flow. This action is so effective it makes most powdery material flow much like a liquid.

The filling cycle is identical to that of the basic design.

Once the transporter is filled, as signaled by a level control or weighing device, the inlet valve and vent valve close and seal. High pressure air is then introduced gradually through the top of the transporter and the fluidizing nozz1es or membrane. Then, all air required for conveying is introduced into the transporter during the complete conveying cycle.

The material is transferred as it was in the basic system. Characteristics of this system are high air flow throughout the transport cycle and lower conveying pressures. Diagrams for the filling cycle and the conveying cycle are shown below (Figures 6 and 7). Note that during the filling cycle, the air flow is shut-off so this cycle is identical to the basic design cycle.

Figure 6
Basic Design with Fluidizing Air – Filling Cycle

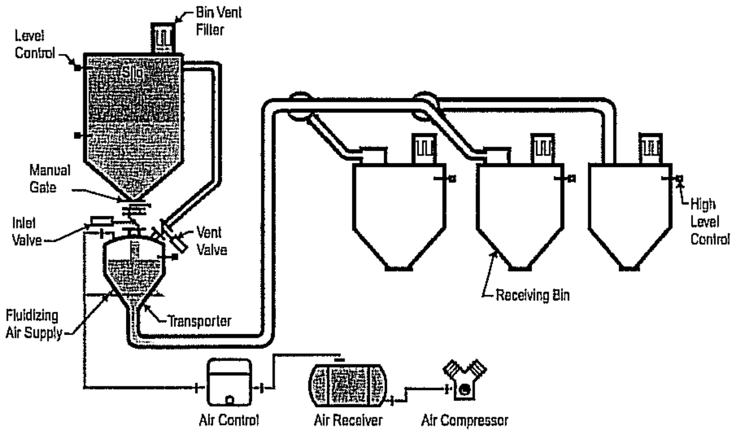
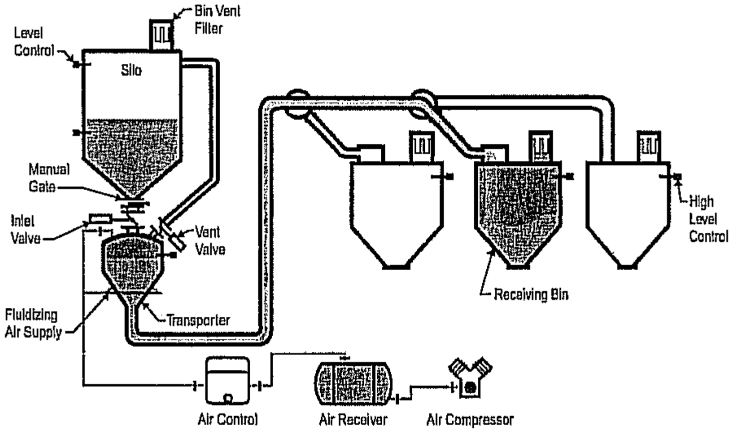


Figure 7
Basic Design with Fluidizing Air – Conveying Cycle



- <u>Basic Design Plus Booster Assist</u> - For longer conveying line distances and fine, granular, abrasive, non-abrasive and difficult-to-handle materials, such as silica sand, a batch type conveying system that consists of a transporter, conveying line and booster fittings should be considered.

  Once the transporter is filled, as signaled by a level control or weighing device, the inlet valve and vent valve close and seal. The only compressed air that enters the transport vessel is the air that is used for material displacement. All other air required for conveying is added through booster fittings that are strategically located along the length of the conveying line.

  Different types of booster fittings are available. Fitting must be able to modulate to add air to the conveying line as it is required. It must be designed to allow compressed air to enter into the conveying line while preventing material from back-feeding into the air supply lines. This is crucial to the reliability of the booster fitting and to overall system performance.

  The spacing of the booster fittings is completely dependent on the complexity of the material being conveyed. A very difficult material may have booster fittings very close together, whereas a very easy-to-handle material may have them spaced much further apart.

  By spacing the booster fittings along the conveying line, the length of the conveying line, in effect, is reduced to the distance between the booster fittings, adding to system reliability and performance. When the conveying line becomes nearly empty, the pressure in the transporter falls to zero and the air supply turns off allowing the residual air volume to purge the transporter and conveying line, as it does in the other systems.

Characteristics of this system are high air flow at the beginning and end of the transport cycle and a low air flow in between, with lower conveying line pressures. Diagrams for the filling cycle and the conveying cycle are shown in Figures 8 and 9.

Figure 8
Basic Design plus Booster Assist – Filling Cycle

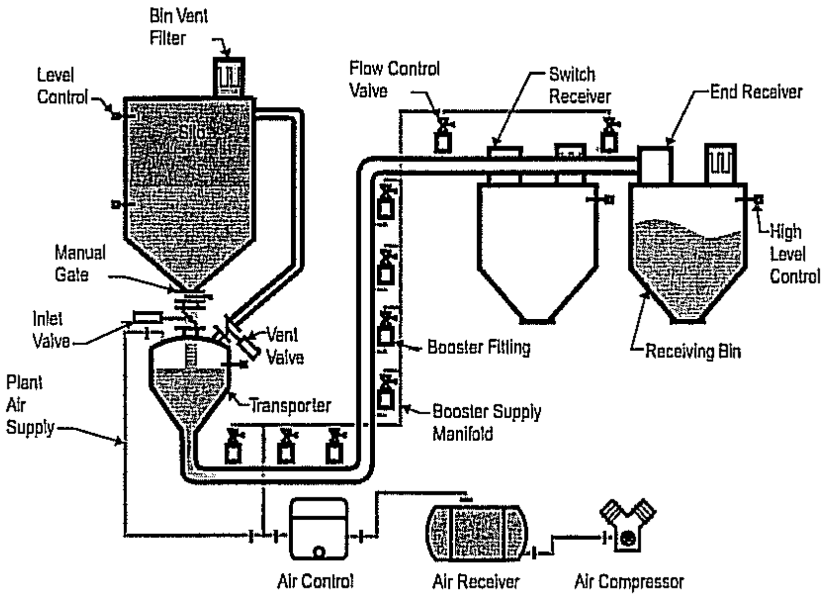
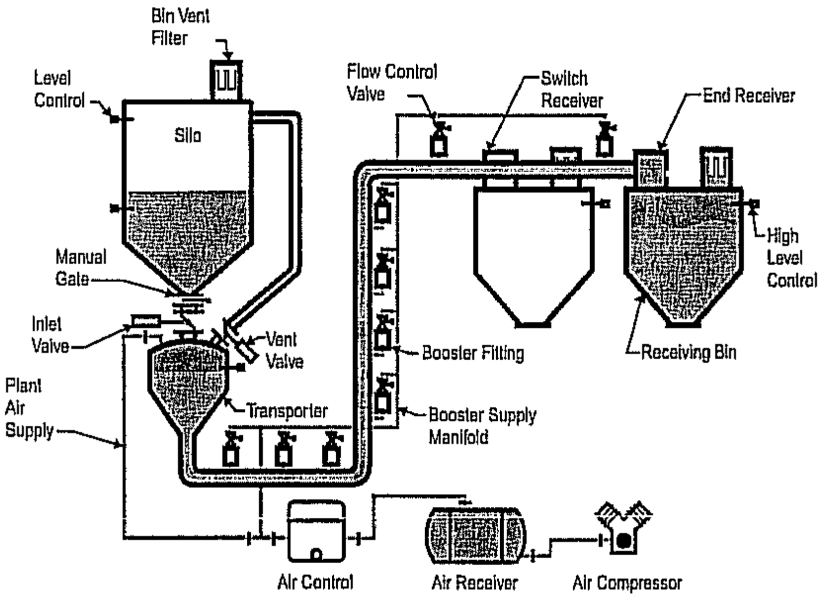


Figure 9
Basic Design plus Booster Assist – Conveying Cycle



- Full Line Variation - Another available option is the full line variation. This concept is generally suitable for longer conveying line distances and very fine granular, abrasive, non-abrasive, fragile and difficult-to-handle materials such as carbon black, silicon carbide, plastic pellets or silica sand. The full line variation can be either a batch type or continuous system that consists of single or multiple transporters and a conveying line with booster fittings.

  From an operating viewpoint, the main difference between this option and the three previous designs is that the full line variation never allows the conveying line to become empty. The conveying line always remains full at the start and end of a conveying cycle.

  The batch feeding cycle is identical to that of the basic design.

  Once the transporter is filled, as signaled by a level control or weighing device, the inlet and vent valves close and seal. The outlet valve then opens and compressed air is introduced into the transporter to displace the conveyed material.

  All other compressed air used for conveying is added through the booster fittings spaced along the conveying line.

  When the transporter is completely empty, as signaled by a low level control, the compressed air is turned off and material stops in the conveying line. Prior to refilling of the transporter, the air pressure inside is vented through a special vent valve that remains open during the filing cycle. Because the conveying line does not purge itself, the high velocity normally seen with the other three concepts during the purge cycle is eliminated, making this option ideal for abrasive and/or fragile materials.

Since the line always remains full, no time is lost in emptying and filling the conveying line. In addition, air consumption is drastically reduced, making this option ideal for long conveying line distances and where a single material is being conveyed.

Characteristics of the full line variation are very low air flows throughout the conveying cycle and high conveying line pressures. Diagrams for the filling cycle and the conveying cycle are shown in Figures 10 and 11.

Figure 10
Full Line Variation – Filling Cycle

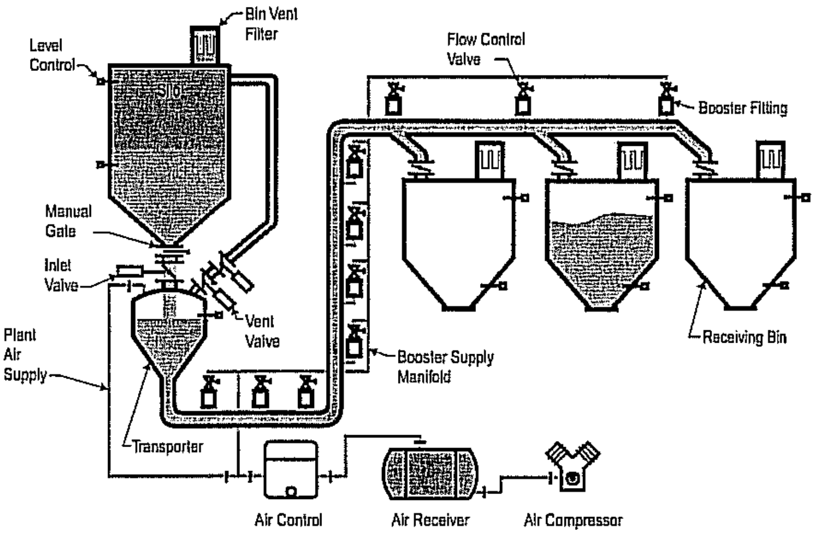
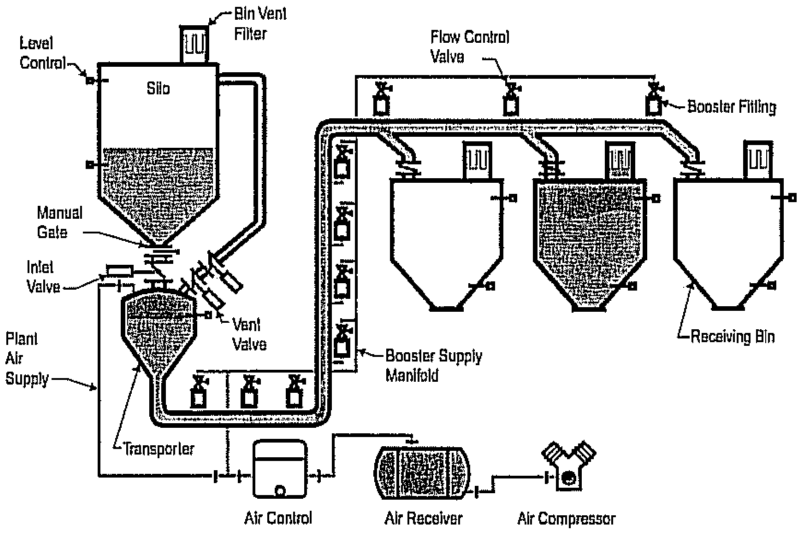


Figure 11
Full Line Variation – Conveying Cycle



- <u>Continuous Full Line System</u> - This system is ideal for conveying over longer distances or at high conveying rates. The continuous full line system consists of two transporters, a conveying line and booster fittings.

  The components are very similar to those of the previous system except for the use of multiple vessels which operate alternately with respect to filling and conveying. When one transporter is filling, the other is conveying, providing a continuous flow of material from the transporters and eliminating any time normally lost during filling. This offers the ultimate in conveying line utilization and efficiency.

Characteristics of this system are extremely low air flows throughout the conveying cycle and high conveying line pressures.

Q5

4.1.5 Pneumatic Conveying System Equipment

a. Fans, Blowers and Compressors

The type of fan, blower or compressor required for a pneumatic conveying system is dictated by the following parameters:

- the specific material to be conveyed
- the distance the material is conveyed
- the elevation the material must be raised
- the size and configuration of the pipeline
- the air (gas) flow and the pressure required to satisfy the above conditions

Low pressure systems requiring 35 kPa or less may be pressured by centrifugal fans or blowers. Fans are used in low pressure systems where the fan is located in the product pipe line with material being conveyed through the fan. Positive displacement blowers and compressors of all types are not suited for this type of service.

For systems with pressures less than 100 kPa, positive displacement blowers are normally employed. The most common of these is the rotary lobe type blower that can be used for both pressure and vacuum service. In the past, noise has been a concern with these blowers, but most manufacturers (Roots and Aerzen for example) now have new quieter designs. In addition, silencers can be located on the suction and discharge connections of the blower. If noise is still a problem, standard, though expensive, noise enclosures are available as an option. Two-stage blowers are sometimes employed to obtain pressures up to 150 kPa.

For systems requiring pressures greater than 100 kPa, air compressors are normally used along with air receivers, air coolers and air filters. Although reciprocating compressors were considered standard, the current trend is towards the use of rotary screw compressors, which are much quieter and require less maintenance.

b. Rotary Valves

Rotary valves are used in several locations in pneumatic conveying systems. They are used as feeders and/or air locks between storage silos, bins and hoppers and the conveying line pick-up point. They are also used after dust filters and cyclones that are emptying into process bins, product bins and product silos. For more information about rotary valves see Section 4.8.3 of this guide.

c. Dust Collectors

Cyclones are sometimes used in pneumatic conveying systems to separate the material being transferred and the conveying air or gas and discharging it to a bin or vessel. Entrained fine dust that could not be separated by the cyclone would be subsequently removed by a bag filter and returned to the process, mixed with the product or disposed of by other means.

Bag filters and bin vents are used in pneumatic conveying systems to prevent fine dust from entering the atmosphere.

For more information concerning dust collectors see Section 4.10 of this guide.

d. Hoppers, Bins and Silos

Hoppers, bins and silos are used for storing raw materials, for feeding process equipment, for storing intermediate and finished products, and for shipping. Their size, shape and details are a function of their location and function in the process. For a detailed discussion of Storage Vessels see Section 6.9 of this guide.

e. Piping Systems

The layout of the piping in a pneumatic conveying system has a major impact on the conveying rate. Anything that adds friction or resistance to flow should be minimized. Some factors that influence the friction losses and thereby the conveying rate are: the length of the piping, the number of elbows or bends in the piping, the relative roughness of the interior of the pipe material (smoother is better), sloped conveying lines (These should be avoided if at all possible. Conveying lines should only be horizontal and vertical.), reductions or restrictions of any kind in the piping.

The velocity in pneumatic conveying system piping is also of vital importance. Every material has an optimum velocity at which it is conveyed the best. For this reason, we find pipe diameters in use in pneumatic conveying systems that are not commonly used in other process and utility piping (5 inch for example).

Materials used for piping include: aluminum tubing or pipe, which is generally used for conveying plastic materials, stainless steel, which is used for conveying abrasive materials, carbon steel, which can be used where abrasion resistance is important and rust in the material being conveyed can be tolerated. Some manufacturers furnish special hard (550 Brinell) spun-cast chrome-iron abrasion-resistant alloy pipe and fittings that are specifically designed for pneumatic conveying systems. These materials are very expensive but can prove to be economically feasible when used in high wear areas of the piping system. Special elbows are available that are designed such that material being conveyed fills a pocket formed in the elbow and becomes the wearing surface. Cement and ceramic lined elbows are also available.

f. Other Equipment

Transporter Vessels (Pressure Pots): Vessels that have a design pressure of over 100 kPa should be designed and built to the ASME Code for unfired pressure vessels

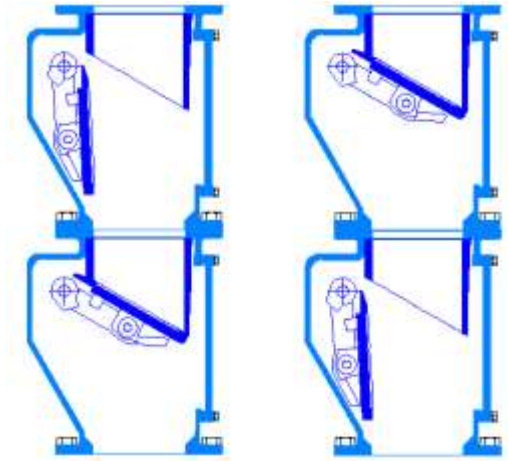
g. Solids Feeders and Pressure Seal Devices

In order to properly operate a pneumatic conveying system the solids fed into the conveying line must be properly controlled to ensure uniform feed. And specifically in positive pressure systems, the feed system must be properly sealed against the pressure in the conveying line. Typical devices used as solids feeders and pressure seal devices include: (1) rotary valves, double-dump valves, specially designed screws, and eductors. While all of these devices provide a pressure seal, only some control the flow of solids and are considered feeding devices. A discussion of each is below.

Refer to Section 4.8.3 of this guide for more details on Rotary valves.

Double dump valves typically embody two valves, an upper and lower valve, in series inside a common body. In operation, the upper valve of a double dump valve opens to allow material to fill the upper part of the valve body. After the upper valve is closed the lower valve opens allowing the solid material to flow into the conveying line while maintaining a seal with the closed upper valve. Refer to Figure 12 for an operational illustration.

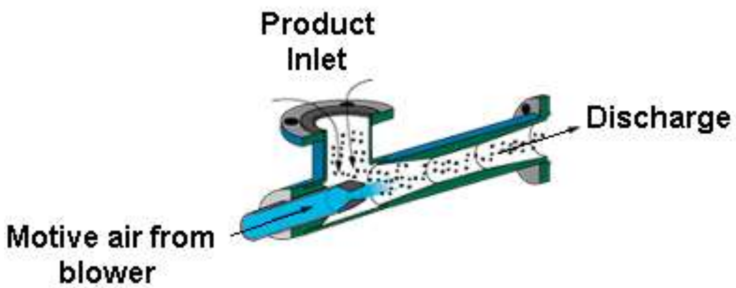
Figure 12
Typical Double Dump Valve Operation



Screw feeders are used in pneumatic conveying systems to seal and accurately measure the rate of feed flow into the conveying line. Typical types of these feeders include gravimetric and volumetric feeders. Gravimetric feeders measure the weight of flowing material and then adjust the feeder output to achieve and maintain the desired flow rate. Conversely, volumetric feeders do not weigh the flowing material but operate by delivering a certain volume of material per unit time from which a weight-based flow rate is inferred by the process of calibration.

Eductors use low pressure air (typically below 100 kPa) to convey powders, pellets, and bulk solids with no moving parts. By converting the air output of a blower into suction, eductors act to compress the air/solids feed mixture to a pressure adequate to overcome losses in the downstream convey line. Typically used in positive, dilute-phase conveying systems, eductors can be found in applications where fine, abrasive, or irregularly-shaped products are conveyed and where rotary valves do not perform adequately. While providing a constant pressure seal, eductors do not actually control or meter the amount of solids flow into the conveying stream.

Figure 13



h. Solids Separators

Solids separators are used in pneumatic conveying systems to separate the solids from the gas in ways ranging from inertial separation, where the solids settle by gravity, to pulse-jet cleaned fabric filters. However, for most systems, a combination of inertial separators and high efficiency fabric filters are employed prior to gas discharge in order to meet environmental regulations.

Inertial collectors, in general, are comprised of any dry type collection device that utilizes the inertia of moving particles to remove them from a gas stream. Efficient in removing larger particles, inertial collection devices are typically installed at the inlet of receiving vessels. Examples of inertial collectors include cyclonic and impingement separators.

Fabric filters use woven fabrics, typically in the form of woven bags, to remove small particle solids and are generally more efficient at removing smaller particles than inertial collectors. With tighter weaves, smaller particles are collected with higher pressure drops across the filter. Two typical types of fabric filters are the shaker-type and reverse-jet. With shaker-type fabric filters, a series of woven bags are mounted on a tube sheet. As the gas / solids are disengaged in a hopper, the remaining solid material collects on the bags and a suspension spring system and motor is activated to shake and clean the bags. With reverse-jet fabric filters, the operation is similar except that a series of solenoid valves open and feed compressed air through a manifold pipe to clean the dust collector bags.

Refer to the following table for a listing of common solids separators used and their relative efficiency / cost.

Solids Separating Devices					
Equipment	Collection efficiency (%) at following sizes:				
	50 µm	5 µm	1 µm	High Temperature	Relative Cost*
Inertial collector	95	16	3	Yes	1
Medium efficiency cyclone	94	27	8	Yes	3
High-efficiency cyclone	96	73	27	Yes	4
Shaker type fabric filter	>99	>99	99	No	12
Reverse jet fabric filter	100	>99	99	No	17

* relative cost per 100 m^3 of gas treated – the lower value the better

i. Diverter valves

Generally, a diverter valve is designed to change the path of flow material from one pipe source to a number of other destinations.

The most common type of diverter is the "two-way" diverter which has one source and two destinations. However, a variation of the two-way diverter is the "converger" where material is conveyed from two sources to a single destination. If more than two destinations are required, multi-port diverters (3-way, 4-way or greater) may be required dependent on the number of destinations.

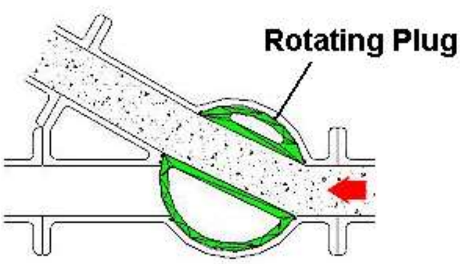
Depending on the system requirements and power availability, diverters may be selected with choice of actuators; manual, air actuated, electric motor actuators with choice of electrical enclosures and hydraulic actuators. Air control solenoids, if required, and position indicating switches may also need to be considered.

There are several styles of two-way diverters as listed below:

Rotary plug (tunnel) diverters typically have a cast housing (aluminum, stainless steel or cast iron) that is precision machined to allow a rotating internal plug to divert material flow. The internal plug rotates to align the inlet and outlet. To divert material to the opposite port, the plug is rotated causing what was the outlet port of the plug to align with the inlet of the housing and the plug inlet port to align with the outlet port of the housing. This style of diverter is typically designed for up to 100 kPa conveying line pressure and has minimal conveying line pressure drop across the valve. Rotary plug diverters are well suited for handling non-dusty granular or pelletized materials, are typically more expensive than other diverter valves, and mainly used in high pressure, abrasive material dense phase applications.

Use of this type of diverter is not recommended for systems that convey powders as there is the potential of packing material between the rotating plug and external housing. Caution areas include: seal abrasion is common resulting in the loss of conveying air pressure and continuous material conveying while shifting the valve is not recommended (system blowers and fans must be constantly started and stopped to allow the diverter to shift).

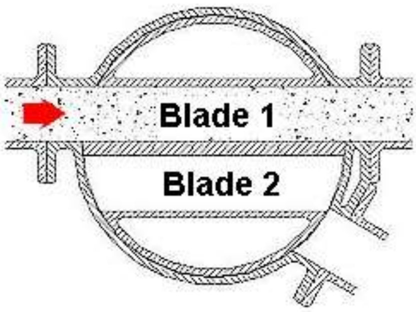
Figure 14



Rotating Blade diverters are usually recommended when handling granular and powdered materials. This diverter avoids the material packing problems associated with the plug style diverter. Like the rotary plug diverter, the rotating blade diverter is constructed from a cast housing and uses a rotating blade to divert the conveyed material.

The same type of cautions apply with the rotating blade as the rotating plug diverter.

Figure 15



Flapper style diverters are generally available in a choice of cast aluminum, carbon steel or stainless steel housings. They are lighter in weight than the plug style diverters and are available for in-line connection with either pipe flanges, or stub ends for compression coupling connections.

The standard flapper diverter uses a metal flapper that shifts to block one port and divert material and air to the open port. In some models, the flapper seals against a replaceable polyurethane liner; in others, polyurethane is sandwiched between two metal plates to create a better seal. These diverters are primarily used in pressure conveying systems where materials are being conveyed from a single source to two destinations, or from two sources to a single destination.

Inherent in design, the flapper diverter seals are in the material stream and exposed to material abrasion leading to rapid wear when handling even mildly abrasive materials. As the result of seal wear, conveying line air and fine material leak past the seal to the closed conveying line causing system pressure drop, possible cross-contamination, and potential line plugs may result.

If a flapper diverter is selected, choose a design that can be maintained without removing the diverter from service. Caution should be taken when placing a flapper diverter into vacuum conveying applications as most flapper diverters are limited to low vacuum service. (In higher vacuum service, the flapper loses its seal as the flap is "lifted" from the internal sealing surface).

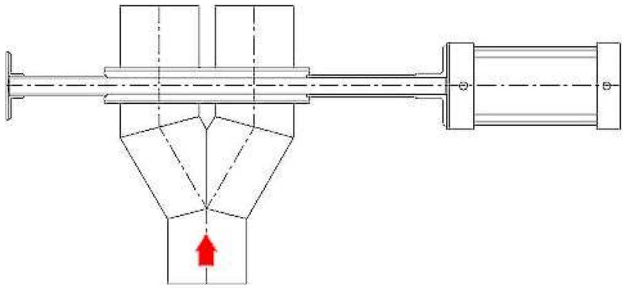
Figure 16

Sliding blade diverters are precision fabricated valves with a structural frame and fabricated tube or pipe inlets and outlets called weldments. The inlets and outlets are typically available in carbon steel, aluminum or stainless steel. Weldments can be easily replaced if abrasive materials wear through the tube or pipe. The sliding blade diverter is light-weight and easy to install.

This type of diverter may be placed in-line using compression couplings or the diverter can be fabricated with flanges, ferrule-type or Victaulic mounts. The inlet and outlet weldments are designed to shield the seal plates from material blast abrasion. The stainless steel blade has an orifice machined into it the size of the conveying line I.D. and is shifted from port-to-port.

With this design wear compensating seals are compressed against the stainless steel blade eliminating clearances where materials lodge and remain trapped or promote accelerated wear. The sliding orifice blade isolates the closed port to eliminate conveying air loss and material leakage across the closed port. With the sliding orifice, the material stream can be shifted without the need to shut down system blowers or fans. In addition, the diverter is bi-directional, being used in a one-to-two or a two-to-one configuration and can be used in pressure or vacuum applications. However, note that this type of valve requires more system pressure drop.

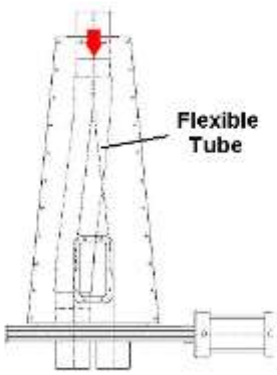
Figure 17



Flexible tube or hose style diverters utilize the basic sliding orifice blade design. A tube stub is welded to an orifice style blade, and a flexible hose is then attached to the tube stub. As the diverter blade is shifted, the conveying line, a flexible hose, moves from one port to the other. The hoses are typically constructed of an abrasion resistant rubber or flexible steel. These diverters can be used to convey material from one source to two destinations or from two sources to a single destination. Flexible tube diverters are capable of handling either pressure or vacuum and have very little pressure drop across the diverter.

Note: severely abrasive applications are generally not suited for a flexible tube style diverter, due to hose wear. Overall stack up height and hose support may also be a concern. Some vendors may offer a hose support frame to minimize torsional loads on the sliding blade.

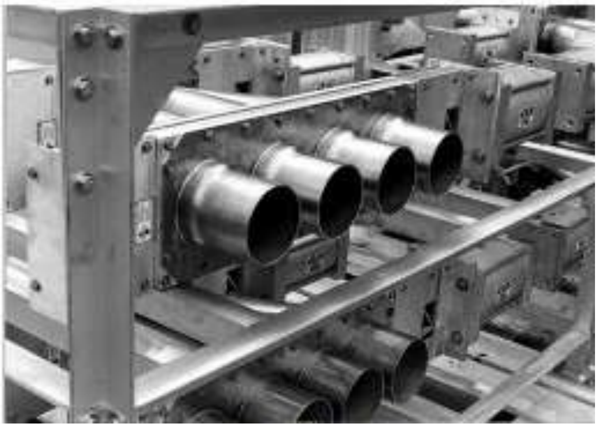
Figure 18



Multi-port diverters are used when there is a need to convey material from multiple sources to multiple destinations. Typically, multiport diverters are custom built to fulfill specific needs utilizing the sliding gate design. Generally, multi-port diverters are independently mounted to a stand-alone frame, ready for transport and installation as a single unit. In addition, single connections for compressed air, electrical and controller connections are included in the assembly.

However, multi-port diverters can be much more expensive than combining and stacking 2-way diverters.

Figure 19



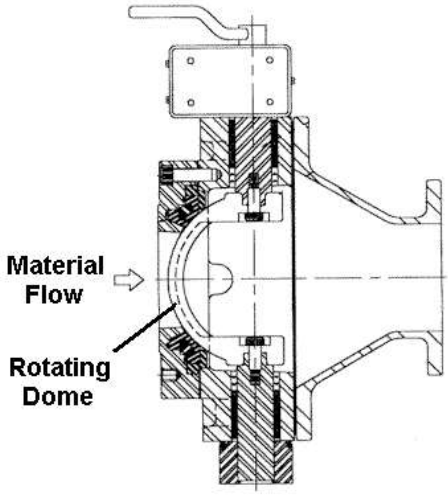
j. <u>Cutoff Valves</u>

Cutoff valves, commonly referred to as "dome valves", are used in pneumatic conveying systems to positively stop the flow of bulk conveyed material and provide a pressure tight seal. Designed to withstand the flow of abrasive bulk materials and slurry mixtures, a rotating dome inside the body of the valve, similar to the ball in a ball valve, closes against seats at the sides of the valve to provide the pressure seal. Some models of the dome valve employ inflatable seats that are inflated (at closing) or deflated (at opening) to prevent abrasive particles from being entrapped against the dome surface and the seal.

When the rotating dome is in the open position, unrestricted full bore material flow is allowed minimizing the possibility of material build-up within the valve body.

Dome valves can be pneumatically actuated or manually operated with a lever.

Figure 20



Q6

4.1.6 Safety and Fire Considerations

Dust explosions and fires are the principal hazards associated with pneumatic conveying systems. Other hazards are:

- The development of static electrical charges on the conveyed material or system components which might ignite vapors or dusts in associated processes.
- Unexpected electrical shocks from static charges on ungrounded components, causing involuntary reaction.
- In the case of toxic dusts, health hazards associated with even small leaks or with maintenance work on the system.

Pneumatic conveying systems should possess the following general characteristics:

- Air tightness, to prevent the escape of dust from the system where it might present a fire, explosion, or health hazard, or, if operating under a negative pressure, to prevent pulling in air or other contaminants.
- Physical strength, to remain intact and tight under normal operating conditions, including vibration; and, in some cases, to withstand or contain explosive pressures.
- Electrical conductivity and grounding, including bonding across joints where necessary to drain off static electrical charges that are generated by the flow of materials. Electrically isolated metallic objects within the system may accumulate dangerous static charges. Wire braid within rubber-covered transfer hose may act as a static accumulator. Nonconductive bags and bags without ground wires are recommended, but electrically conductive bags may be used in bag filters handling extremely static-sensitive materials. Care must be taken to ensure that the conductive bags do not become ungrounded and that the grounding strands do not break. Wire cages used to support the bags must be grounded, regardless of whether the bags are conductive or nonconductive.
- An electrical installation meeting the electrical classification imposed by the conveyed materials as well as the surrounding environment.
- Materials of construction compatible with the materials handled and the surrounding environment.

- Facilities such as screens, magnets, and metal detectors, for the detection or removal of any foreign material which might create hazards in the system.

- Appropriate use of special materials, such as nonferrous metals, to minimize mechanical sparking in the event of misalignment or failure of moving parts within the process stream.

- An adequate program of maintenance and inspection to assure proper alignment of drives, proper clearances, dust tightness, electrical bonding and grounding and control of ignition sources.

- Suitably located joints and access openings to facilitate cleaning or unplugging. High velocities (15 to 20 mm/sec) will minimize settling and therefore reduce frequency of cleaning.

Many organic dust suspensions, when ignited at essentially atmospheric pressure, are capable of peak explosion pressures of 500 to 700 kPa. It often is possible to design conveying systems to contain explosive pressures of this magnitude thereby reducing exposure to personnel and equipment and minimizing the possibility of secondary explosions in the surrounding area. Minimizing bends, elbows, and dead ends, and the installation of rupture disks directed to discharge to a safe location may he helpful.

For economic reasons, collectors, separators, filters, and similar large-volume components usually are not designed to contain explosions. In these cases, substantial vent areas in the form of blowout panels, diaphragms, or lightweight doors are needed to reduce peak pressures. For many large, lightly constructed components, required vent areas may be prohibitively large. These components should be barricaded or located on roofs or other open, normally unoccupied areas. Alternatively, if the problem of prohibitively large vent areas is recognized early in the design process, a higher design pressure may be specified, not to contain the explosion but to allow more reasonable vent areas.

With closed-cycle systems, where the fluidizing medium is recycled, it may be practical to use an inert gas to reduce oxygen content below the minimum oxygen concentration required for combustion, thus eliminating the internal dust explosion hazard. Moreover, inerting often is practical for bins which are isolated from the pneumatic stream by choke or star feeders. Where inerting is employed, a reliable means of monitoring the inert atmosphere must be provided.

Observation or sampling of equipment under all conditions of operation may demonstrate that explosive dust concentrations cannot occur.

Explosive concentrations of dusts in the air external to conveying systems may be generated by:

- Failure of a system component, allowing fluidized dusts to spill or he blown into the surrounding area. Design features described earlier are employed to control this hazard.

- Shaking dust accumulations from overhead horizontal surfaces, such as ducts or roof beams, as by an initial internal explosion.

These hazards may be minimized by maintaining systems as dust tight as possible using spot exhausters where dusts may be released and frequent cleaning. Horizontal surfaces such as ledges and beams should be minimized or boxed in where dusts may be present to reduce cleaning requirements.

Q7

Dust Characteristics Relative to Fire and Explosion Hazards

Fire and explosion hazard testing should be the first step in identifying and eliminating fire and explosion hazards. Next, the results of the tests can be used to assess the risk and consequences of an explosion including safe operating parameters. Finally, the results can be used to define or establish specific safety measures such as installing an explosion protection system. A general guideline for characteristics of explosive dusts is as follows; however, testing is always recommended.

Critical Parameter	Value
Particle Size	< 0.1 mm
Dust Concentration	40 g/m^2 to 4000 g/m^2
Moisture Content	< 11%
Oxygen	> 12%
Ignition Energy	> 100 mJ to 100 mJ
Ignition Temperature	410 to 600 °C

To determine if the dust or powder material being conveyed is at risk for explosion or fire the following characteristics should be identified through sample testing at a suitable lab or testing facility:

- Explosion Classification: This should be the first test performed. Typically called an A/B screening, this test will determine whether a dust cloud will explode when exposed to an ignition source. The results of this test will determine if the material is either combustible or non-combustible. Group A powders, when suspended, will ignite and propagate flames. Group B powders do not ignite when suspended. Note: the test should be conducted at the process temperature rather than at ambient temperatures as some Group B powders can be combustible at high temperatures. If the material tested is classified as Group B, typically no additional testing is required. For Group A materials, the following additional tests should be considered.

- Minimum Ignition Energy (MIE): This test will determine the lowest electrostatic spark energy that is capable of igniting a dust cloud at its optimal concentration for ignition. This test is primarily used to assess the potential susceptibility of dust clouds to electrostatic discharges. For example, the test results could be used to determine if a material can be safely pneumatically conveyed into non-conducting plastic packages or containers without the danger of an electrostatic discharge igniting the material.

- Minimum Explosible Concentration (MEC): This test will determine the lowest concentration of the dust cloud in air that can give rise to flame propagation upon ignition.

- Minimum Ignition Temperature (MIT): This test will determine the lowest temperature at which dust, that is dispersed in the form of a cloud, can ignite. The results of this test are useful in evaluating the ignition sensitivity to hot environments, heated surfaces, and electrical apparatus.

- Electrostatic Chargeability: This test will determine the propensity of powder particles to become charged when flowing through conveying tubes or when handled in containers. This test is normally conducted at ambient temperatures and low-relative humidity conditions.

- Electrostatic Volume Resistivity: This test will measure the electrical resistance for a unit volume of material and is the primary criteria for classifying powders as low, moderate, or highly insulating. Typically, highly insulating powders or dusts will have a propensity to retain an electrostatic static charge and can produce electrostatic discharges when exposed to a ground. This test is normally conducted at ambient temperatures and low-relative humidity conditions.

- Limiting Oxidant Concentration (LOC): This test will determine the minimum amount of oxygen required to support combustion of the material being tested. The results of this test will determine if the use of inert gases is suitable to reduce the severity of explosions or prevent explosions altogether. For processes with oxygen atmospheres below the LOC, there is not enough oxygen to support combustion and thus a dust explosion can not be supported as well. Determination of the LOC is also useful to set oxygen concentration alarms or interlocks for use in systems. This test should be conducted to closely match the process conditions and be performed using an inert gas that is representative of the inert gas used in practice.

- Maximum Explosion Pressure and Explosion Severity: This test will determine the maximum explosion pressure, P_{max}, and the rate of pressure rise of a dust cloud, the results of which will be used to calculate the Explosion Severity, K_{st}. These tests are repeated with varying sample sizes until an optimal dust cloud concentration is determined. Based on the K_{st} values, dusts can be classified into three hazard classes, ranking from lowest to highest, as shown in the following table.

Explosive Dust Classes

Dust Hazard Class	K_{st} (bar-m/sec)	P_{max} (bar)	Explosion Strength
St-1	200	10	Weak
St-2	201-300	10	Strong
St-3	>300	12	Very Strong

Q8

Explosion Control

For an explosion to occur three components must be present: (1) a fuel, (2) an oxidizer (typically the oxygen in air), and (3) an ignition source. If any one of these components is removed or diminished, the risk of an explosion is reduced. With respect to pneumatic conveying systems, an explosion, known as a deflagration, may occur as dust provides the fuel for a flame front that propagates at rates that are slower than the speed of sound. Given this risk, the most common methods of explosion protection are: (1) Containment, (2) Inerting, (3) Deflagration Venting, (4) Deflagration Suppression, and (5) Deflagration Isolation. A discussion of each method is below.

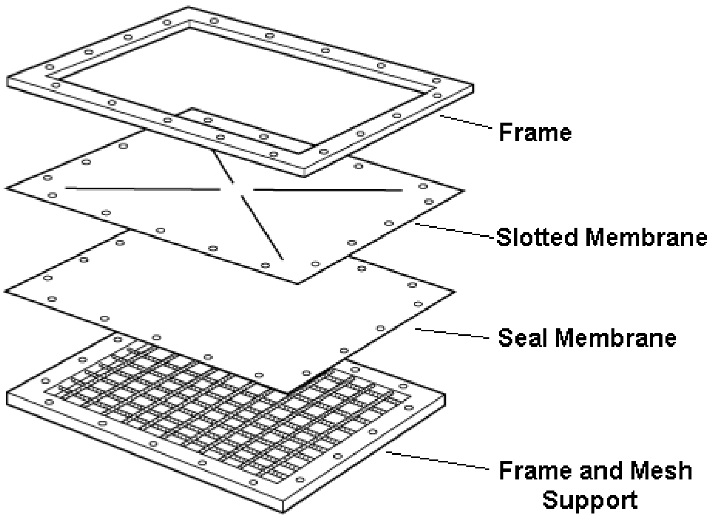
- Containment - The basis for containment explosion protection is to withstand the maximum deflagration pressure of the material being handled (up to 12 bar). In this method of protection, the equipment would be designed in accordance with ASME Section VIII, Division 1 and the final deformation pressure would depend on the maximum initial pressure in the vessel prior to a deflagration. The advantage to this type of explosion control method is of low maintenance as the design of the vessel is the control. The biggest disadvantages are high initial costs of high pressure equipment and the weight loading associated with this type of equipment.

- Interting – Inerting is a method of explosion protection where an inert gas such as nitrogen or carbon dioxide is introduced into a system to lower the oxygen concentration within the system to below the minimum oxygen level required for combustion. The major advantage to inerting is prevention of combustion and product loss. The major disadvantages include: (1) the ongoing cost of the inert gas, (2) possible asphyxiation hazards to personnel, and (3) high maintenance.

- Deflagration Venting – Deflagration venting provides explosion protection by allowing the expanding hot gases of an explosion to be vented through a panel or door. Typically, deflagration vents are designed to open at a predetermined pressure thus allowing the pressure gases produced by an explosion to be discharged to the atmosphere – either directly or through an attached duct. Note: if the material or the high pressure gases are toxic, venting is not recommended.

  Specific equipment that can be used for deflagration venting typically include vent panels or vent doors. Deflagration vent panels can be either rectangular or circular and are typically flat or slightly domed panels that attach to the process equipment being protected. Refer to Figure 21. The panel can be made from any material and construction that will allow the panel to rupture, detach, or swing open. Materials that could fragment or act as shrapnel should not be used in the construction of a vent panel. A deflagration vent door is a hinged door that is designed to open at a predetermined pressure governed by a special latch arrangement. Generally vent doors have a greater opening inertia than vent panels, therefore reducing its efficiency.

Figure 21
Typical Deflagration Vent Panel

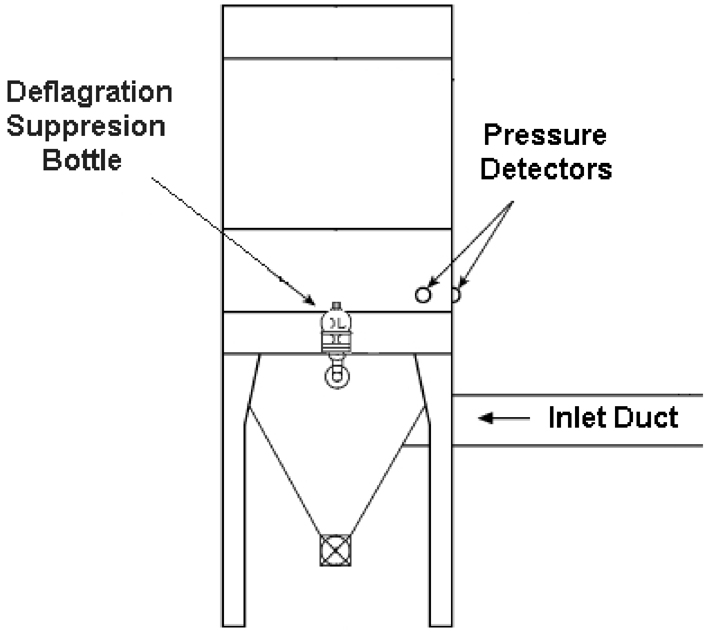


The advantages of deflagration venting include low cost (if the equipment is located outside) and low maintenance. The disadvantages include: (1) the potential for a post-venting fire, (2) the recommendation that the equipment be near an outside wall or located outside, (3) an exiting fireball from the vent that would be a severe fire hazard to personnel and equipment near the vent opening, and (4) atmospheric release of toxic or corrosive material.

- Deflagration Suppression – Deflagration Suppression involves a high speed extinguishing system that detects and extinguishes a deflagration before destructive pressures are created. A deflagration system works by sensing the increased pressure of an explosion by a pressure detector or the growing fireball by a flame detector. Then, once either the pressure increase or fireball are detected, a control unit actuates one or more high-rate discharge extinguishers. The extinguishers, mounted directly to the process equipment to be protected, quickly suppress the fireball and prevent over pressurization of the equipment. Refer to Figure 22.

  The advantages of deflagration suppression systems include: (1) elimination of the flame and reduced chance of a secondary fire, (2) reduced risk of ejecting toxic or corrosive materials, (3) flexibility in locating process components. Disadvantages include: (1) generally higher costs compared to venting, (2) regular maintenance is required, and (3) not effective in systems with certain metal dusts, acetylene, and hydrogen.

Figure 22
Typical Deflagration Suppression System



- Deflagration Isolation – Isolation, in the form of mechanical or chemical means, is used to protect interconnected process equipment from damage by halting the propagation of a deflagration to other pieces of equipment. Mechanical isolation can be found in either the installation of rotary airlock valves of suitable construction or the installation of high-speed knife gate valves. Refer to Figure 23. In a typical installation, a detector, either a pressure switch or an optical detector, senses a deflagration pressure or flame front. This trigger, then initiates the rapid closure of the isolation valves to prevent propagation downstream of the valve. Chemical isolation is achieved by the rapid discharge of a chemical extinguishing agent in the interconnecting piping or duct. Refer to Figure 24. Chemical isolation is used to stop a deflagration that has already started. Chemical isolation systems should not be confused with ignition source suppression systems (covered below in the section on Fire Protection) that are used to detect and extinguish burning particles traveling in a duct.

  For specific details on explosion control systems refer to the following NFPA Standards – NFPA 68 – Standard on Explosion Protection by Deflagration Venting, NFPA 69 Standard on Explosion Prevention Systems, and NFPA 654 – Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids.

Figure 23
Typical Mechanical Isolation

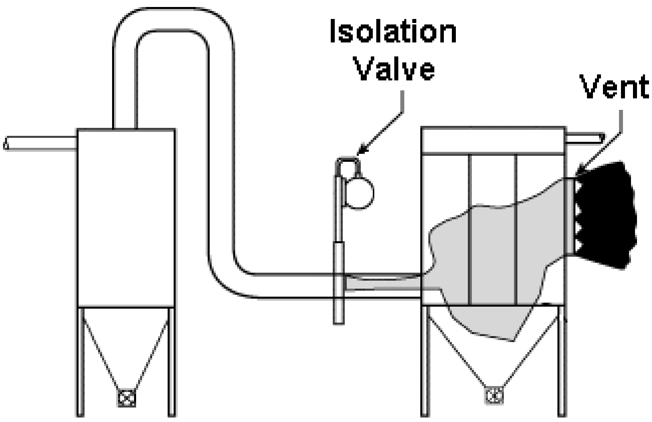
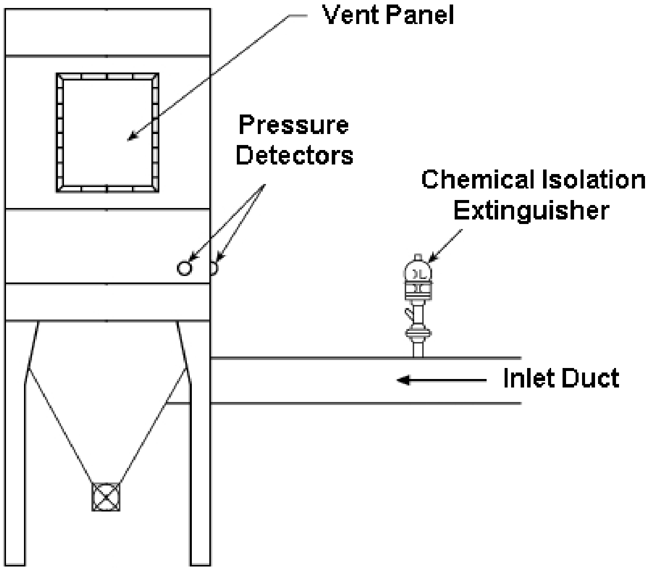


Figure 24
Typical Chemical Isolation



Fire Protection

In addition to explosion control, there is the potential for fires in pneumatic conveying systems. Therefore, the typical concepts used for fire protection in pneumatic conveying systems are spark detection and extinguishing systems.

For effective fire protection, first, detectors must be installed to reliably detect a spark, ember, or flame and then process an alarm signal quickly. The detectors are radiant energy-sensing devices that sense the potential fire and then quickly take action to stop propagation of the spark. In addition, since spark detectors have limited fields of view, most systems will require two detectors to cover a round duct.

For minimum protection, a spark detector may be mounted upstream of an abort gate and used to actuate the gate. As the detector senses a spark, a signal from the detector is sent to and processed by a control panel to alarm and energize the abort gate. In this instance, the abort gate diverts the air stream to the atmosphere to prevent the flames and combustion gases of a fire to be returned to the conveying system. Refer to Figure 25. If sparks are not more than a rare occurrence, this approach may be suitable. However, if sparks are a common occurrence, the lost production time associated with shutting down the pneumatic conveying system and resetting the abort gate would suggest installation of a spark extinguishing system instead.

Spark extinguishing systems utilize a spark detector upstream of an intermittent extinguishing spray to detect and quench a spark prior to entering a piece of downstream equipment. Refer to Figure 26. For secondary protection, an additional spark detector and abort gate could be installed to ensure that a detected spark is properly extinguished. Refer to Figure 27. The spark extinguishing systems provide two advantages for fire protection: (1) the spark is extinguished before a larger fire is allowed to start or propagate and (2) the system can continue operating without a shutdown.

The choice of the appropriate extinguishing medium depends on the materials begin conveyed but typically falls into the following categories: (1) water-compatible, (2) water-incompatible, and (3) water-reactive.

Water as an extinguishing medium is most widely used, most available, and the most economical. However, water should only be used in systems where the conveyed combustibles will not react with, or form mixtures with, the water. Typical examples of water-compatible materials include: many plastic powders and pellets or wood dusts, fibers, and chips.

In water-incompatible systems, water could be used to extinguish the spark/flame but the introduction of water will produce unacceptable damage to the product or the equipment. Examples of agents to be used in these systems include: carbon dioxide, sodium bicarbonate, nitrogen, and clean agents. Typical examples of water-incompatible combustibles include: many foodstuffs, many pharmaceuticals, and many chemicals.

In water-reactive systems, the combustibles being conveyed could chemically react with water to produce some other materials that may present a different set of fire protection problems. The most notable water-reactive materials are powdered metals.

Figure 25
Typical Abort Gate Fire Protection System

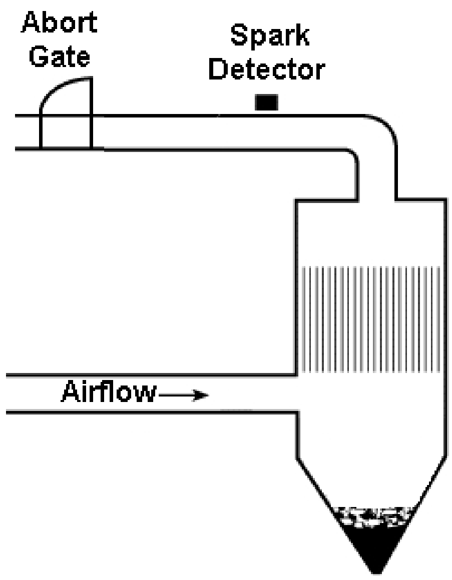


Figure 26
Typical Spark Detection / Extinguishing System

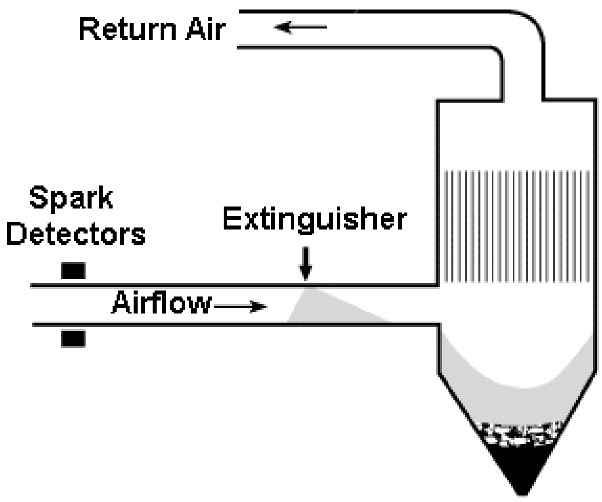
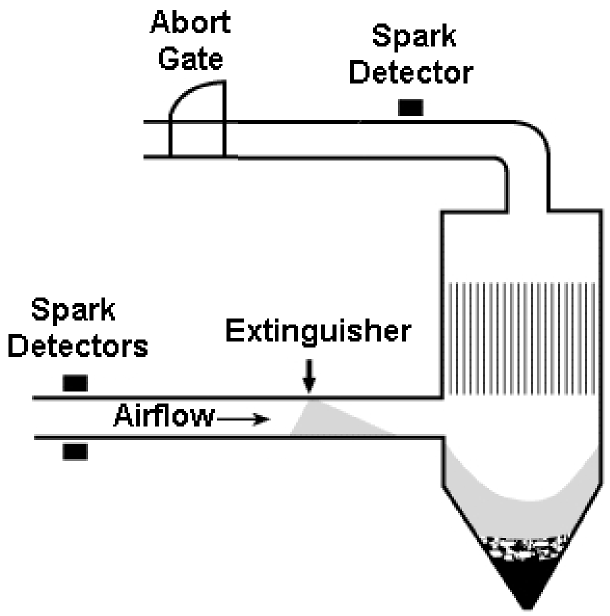


Figure 27
Typical Spark Detection / Extinguishing System with Abort Gate



4.2 Mechanical Conveyors

4.2.1 Belt Conveyors

Q9

a. Introduction

The conventional belt conveyor consists of one continuous belt that can economically transport most bulk materials horizontally and at inclines. The rate of incline possible is based on the physical properties of the bulk material. Recommended inclination angles range from 7° for soda ash briquettes to almost 30° for cinder concrete and ground phosphate fertilizer. Special belt type conveyors can lift material at angles approaching 90°.

b. Components of a Belt Conveyor System

Idlers

Idlers are classified by the Conveyor Equipment Manufacturers Association (CEMA) as Series B, C, D, E or F. Series B idlers are for light duty, Series C for medium duty, Series D for medium to heavy duty, Series E for heavy duty and the new Series F for severe duty.

Roll diameters for each classification have been established by CEMA. Series B idlers are available with 4 inch and 5 inch diameter rolls; Series C with 4, 5 and 6 inch diameter rolls; Series D with 5 and 6 inch rolls, Series E with 6 and 7 inch rolls.

In the impact area (belt loading area) troughing idlers with rolls of cushioning rubber discs are often employed to minimize belt damage due to impact from materials being loaded onto the belt. Idler spacing in the loading area is also shortened to better distribute the impact loading.

Sealed ball bearings are standard. Regreaseable bearings are available. Pillow blocks are used to provide an increased loading capacity when required.

The most common types of idlers are listed as follows:

Troughing idlers carry the load on a moving belt. The idler rolls shape the belt in a trough to prevent spillage of the material and to increase the load carrying capacity of the belt. Standard troughing angles are 20°, 35°, and 45°.

Flat carrying idlers are designed to handle dry materials, packages, etc. and also for applications where plows are used to achieve intermediate discharge.

Return idlers support the belt and limit the sag as the empty belt moves along the underside of the conveyor. Steel tube rollers are used where materials are not sticky, corrosive or abrasive. Rubber disc type idlers are used where sticky, corrosive, or abrasive materials are present. Urethane coated rolls are used where very sticky or abrasive materials are present.

Training idlers (self-aligning idlers) are idlers equipped with guide rolls on both sides of the belt that cause the idler to swivel on the cross-member when the belt comes in contact with either guide roll, thereby directing the belt to its normal position.

Impact idlers are special idlers designed to absorb the shock of feed material dropping onto the belt.

PVC & Sleeve Idlers can be formed from standard steel idlers fitted with a PVC sleeve or of all PVC construction. These idlers are typically used in corrosive and abrasive plant environments to resist corrosion from the atmosphere and the material being conveyed (i.e. fertilizer plants). In addition, PVC & Sleeve idlers offer an advantage in noise reduction.

Replacement Idlers are designed to fit into sliding frames on a stationary base to allow for easy replacement of the idlers.

Pulleys

Although some cast-iron pulleys are still in use, most modern pulleys are constructed of welded steel.

A covering, called "lagging", is often applied to pulley rims to improve conveyor performance and to increase the life of the pulley and the belting. It is used on drive pulleys to increase the coefficient of friction between the pulley face and the belt and thereby prevent slippage. Certain types of radial grooved lagging are used to improve severe belt tracking problems. Lagging materials range in thickness from a few millimeters for sprayed on types used in light duty applications to thicknesses of several centimeters for vulcanized rubber lagging used for heavy duty service.

Head pulleys are pulleys located at the discharge end of a belt conveyor. On a simple belt conveyor they are the drive pulley that imparts the driving force to the belt. Drive pulleys are sometimes located at the tail end of the conveyor.

Tail pulleys are pulleys located at the loading end of a belt conveyor. On a simple conveyor the tail pulley can also be used as the take-up pulley.

Take-up pulleys are used to provide the belt tension required for maintaining the proper drive contact between the drive pulley and the belt and to compensate for changes in belt length that may be caused by temperature changes or stretching of the belt over time.

Snub pulleys are sometimes installed near the drive pulley to provide more arc of contact between the belt and pulley to create maximum adhesion for driving the belt.

Bend pulleys are installed simply to redirect belt travel when large diameter tail pulleys are used and before and after vertical take-up pulleys.

Conveyor Belts

A wide range of belt materials are available in varying widths and thicknesses. Some of the more common materials are: Aramid, cotton canvas, EPDM, Kevlar, Neoprene, Nitrile, Nylon, Polyester, PVC, rubber and some silicones.

Two types of belt splicing are commonly used to join the ends of the belts: mechanical splicing with metal staples or other clamping devices or the preferred method of joining the two ends of the belt with an adhesive in a vulcanizing process. For conveyors that are short enough that they can be shipped as a unit, the belt splice should be done in the fabrication shop and should always use the vulcanizing method. Belt splicing in the field should be done by the vulcanizing method when available.

Belt Skirts

Skirts are side panels that are located in the area where material is being fed onto the conveyor for the purpose of preventing spillage.

Plows

Tail protection plows or return belt scrapers are employed to protect the tail pulley from damage from large objects and tramp iron that may have accumulated on the top side of the return belt.

V-plows discharge tramp material to either side of the conveyor.

Diagonal plows discharge material to only one side of the conveyor.

Belt Cleaners

Belt cleaners are not required on all belt conveyors. If the conveyed material is a dry, non-sticking, free falling material, belt cleaners are not applied. However, if the material is of a sort that will stick to the return belt, belt cleaning systems are strongly advised. To insure proper cleaning two, and even three, devices should be applied in a series arrangement. The first device, commonly called a pre-cleaner or primary cleaner, should be capable of removing most of the carryback from the belt, leaving behind only a thin skim of fines. It is installed on the face of the head pulley, just below the trajectory of the material being discharged from the belt. In this position material removed falls into the other product leaving the belt. Secondary cleaners are designed to remove the remainder of the sticky fine material that remains on the belt. Some type of blade or scraper design is normally applied for belt cleaning; however specialized cleaning systems are available for certain applications. Food grade cleaning systems must be engineered to satisfy the hygienic requirements. Belts with ribs, cleats or chevrons are usually cleaned with blades that are designed to walk over those obstacles. Rotary brush cleaners are sometimes employed on dry materials, but caution should be used as material can readily build up in the bristles. Pneumatic air-knife cleaners can be effectively used but require a constant source of air and can create a dusting problem.

Belt Take-ups

A take-up is a necessary component of all belt conveyors:

- To maintain proper Slack Side Tension or pressure of the belt on the driving pulleys to transmit the horsepower required for driving or retarding the belt.
- To maintain proper tension in the belt at loading points or other places along the belt to prevent excessive sagging of the belt.
- To compensate for belt stretch or shrinkage.

Screw type take-ups are located in the tail section of the conveyor. Screw take-ups are used for light, short centers, portable and underground conveyors or for conveyors not requiring long take-up travel or frequent adjustment. They should be used only when, due to space limitations or other conditions, it would be impossible or impractical to use the gravity type.

To reduce frequency of adjustments and to insure sufficient pressure of the belt against the driving pulley at all times, a greater amount of tension is usually put into the belt with screw take-ups than would otherwise be required. This unknown and varying amount of excess tension increases the loads and wear on shafts and bearings and, if properly considered, may, sometimes require a stronger or more expensive belt.

Screw take-ups should not be used when temperature or other climatic conditions change rapidly or change sufficiently to cause wide variations in the length of the belt.

Gravity take-ups meet all the requirements for which take-ups are needed in a belt conveyor, having such advantages as:

- Maintaining constant selected belt tensions without adjustments.
- Requiring no more belt tension than is necessary to provide proper pressure of belt on driving pulleys and to prevent excessive sag in the belt.
- Minimizing power requirement of and wear on shafts, bearings and driving equipment.
- Saving manual adjustments.
- Reducing the number of times belt must be shortened and respliced because of permanent stretch.

Location of take-up is sometimes determined by convenience in locating supports and access for maintenance. If take-up is located where the tension in the belt is least, the minimum amount of pull or counterweight will be required.

When a foot end or head end pulley is used as the take-up pulley, fewer pulleys are required and the number of times the belt must bend over a pulley is decreased which tends toward increasing the life of the belt.

The greater the distance between the driving pulley and the take-up pulley on horizontal conveyors, the more sluggish may be the effect of the take-up while the conveyor is being started, since the take-up must overcome the inertia required to start the return belt and idlers between the two pulleys. To reduce slippage and consequent belt wear, the take-up pulley should be located as near the driving pulley as practical so that any accumulated stretch in the belt, caused by starting, will be absorbed as quickly as possible. On the steeper inclined conveyors, the weight of a return run of belt descending from the drive pulley may be sufficient to prevent starting stretch from accumulating where the belt leaves the pulley.

The horizontal style of gravity take-ups are usually placed at the foot end of conveyors, whereas when the take-up is to be placed at some intermediate point along the conveyor, the vertical style gravity take-up is used.

The length of take-up travel should be sufficient to:

- Compensate for stretch of belt when full driving load is applied.
- Compensate far permanent stretch of belt.
- Compensate for elongation or shrinkage of the belt due to wide variations in temperature and other climatic conditions.
- Provide for stretch which accompanies starting the belt.

The amount of take-up travel to allow depends on a great number of varying conditions.

Sometimes both the screw and the gravity take-ups are used in the same conveyor; the gravity type to take care of the constant operating fluctuation, and the screw type for occasional adjustments and training of belt.

Drives

Selection of equipment for transmitting power from motor to the drive pulley shaft requires careful consideration of conditions of service, so that dependability and life expectancy will be consistent with the other parts of the conveyor.

Where space is adequate, an enclosed gear speed reducer with flexible couplings to drive pulley shaft and motor is simple, dependable and easy to maintain. Where space beside the conveyor is limited, an enclosed chain drive from the head shaft enables the speed reducer and motor to be located above, beneath or in front of conveyor. Also, a chain drive from head shaft provides a convenient means of changing speeds, if desired.

Backstops are required to prevent conveyors from running backward when they are stopped or power is interrupted and when unbalanced gravitational forces in the conveyor belt exceed the frictional forces. This may occur in steeper ascending conveyors and in conveyors having steep ascending portions. The manufacturer should be consulted for recommendations concerning the need and type of backstop to employ for the existing conditions.

<u>Belt Conveyor Controls</u>

Control devices used with belt conveyors include: safety stop switches, which are employed with conveyor length long lanyards to immediately stop the conveyor in an emergency situation. These switches are required in most jurisdictions. Belt alignment switches are used to send an alarm or stop a conveyor if belt misalignment exceeds the recommended limit.

Alignment switches should be provided on both sides of the conveyor belt near the head pulley. It is also a good practice to mount a pair of these switches near the tail pulley. For conveyors longer than 400 meters, it might also be advisable to provide additional switches evenly spaced on either side of both the carrying belt and the return belt. By experience, switches should be located far enough away from the belt to eliminate nuisance trips, but close enough to signal severe misalignment problems and belt run-off.

Damaged belt detectors are also available. This type of detector consists of two switches that are mounted on each side of the conveyor. They are connected to each other with a detachable vinyl coated air-craft cable that passes underneath the belt. A problem is detected when an object or a piece of damaged belt causes disengagement of the cable from one of the switches sounding an alarm.

Switch devices are also available to detect bulk material flow or motion.

All of the above devices are available in both standard and explosion proof designs.

d. Belt Conveyor Design

1. Design, Standards and Guides

The Conveyor Equipment Manufacturers Association (CEMA) has published the following standards pertaining to belt conveyors.

- CEMA STANDARD No. 575, "BULK MATERIAL BELT CONVEYOR IMPACT BED-CRADLE - Selection and Dimensions"

  Dimensional standards and selection guidelines for Impact Beds/Cradles to insure that they are dimensionally compatible with the most current version of CEMA Standard No 502, "Bulk Material Belt Conveyor Troughing and Return Idlers Selection and Dimensions."

- CEMA STANDARD No. 502, "BULK MATERIAL BELT CONVEYOR TROUGHING AND RETURN IDLERS - Selection and Dimensions"

  Dimensional standards and selection guidelines for 20 degree, 35 degree, and 45 degree troughing idlers and return rollers, 10 degree and 15 degree vee returns. New Items include CEMA C, D and E Picking Idlers, Live Shaft Idler Dimensions and Load Capacities for Rubber Disc and Steel Tube Designs, and modified Idler Selection Procedures to include Impact Idler Selection.

- CEMA STANDARD No. B105.1, "SPECIFICATIONS FOR WELDED STEEL CONVEYOR PULLEYS WITH COMPRESSION TYPE HUBS"

  These pulleys have a continuous rim and two end discs, each with a compression-type hub to provide a clamp fit on the shaft. This ANSI/CEMA Standard provides recommended load ratings, dimensional information, and criteria for selection of welded steel conveyor pulleys with compression type hubs.

- CEMA STANDARD No. 501.1, "SPECIFICATIONS FOR WELDED STEEL WING PULLEYS"

  Welded steel wing pulleys have a number of steel wing plates that extend radially from the longitudinal axis of two compression type hub assemblies and are equally spaced about the pulley circumference. This

ANSI/CEMA Standard provides recommended load ratings, dimensional information, and criteria for the selection of welded steel wing pulleys.

Other useful publications that concern belt conveyors include the following:

- "BELT CONVEYORS FOR BULK MATERIALS" (Fifth Edition)

  This highly acclaimed book is considered by many to be the belt conveyor industry basic handbook. It details subject areas critical to selecting bulk hand belt conveyors. Contains photographs of equipment, including line drawings, formulas, and easy-to-use tables.

  This hard-cover manual is written for the experienced engineer, the recent graduate, consultants, professionals, and all who must design or approve projects involving the handling of bulk materials with belt conveyor systems.

- CEMA BOOK No. 550, "CLASSIFICATION AND DEFINITIONS OF BULK MATERIALS"

  Presents materials classifications with physical characteristics of each, hazards that affect conveyability, along with suggested test procedures to aid the establishment of criteria for selection of conveying machinery and ancillary equipment.

- "CONVEYOR INSTALLATION STANDARDS FOR BELT CONVEYORS HANDLING BULK MATERIALS"

  This book outlines minimum installation standards for installation of bulk conveyors and provides suggestions for meeting or exceeding these standards.

- "FOUNDATIONS2 – The Pyramid Approach to Control Dust and Spillage from Belt Conveyors," Martin Engineering, 1998

2. Design Data Requirements

The successful performance of a belt conveyor will depend largely upon an over-all design that meets the requirements of all operating conditions and the selection of components that are suitable for those conditions. For these purposes it is necessary to consider carefully as much of the following basic data as apply to the problems involved in a specific project:

The materials to be handled - The design of a belt conveyor is greatly influenced by the material to be handled. Some material characteristics which limit the use of belt conveyors are covered in the following subsection – Limitations of Belt Conveyors. Therefore, it is necessary to specify such information about the material, as its size consist (percentages of various sizes), weight per cubic foot (maximum and minimum), abrasiveness, moisture content, dustiness, temperatures, stickiness, angle of repose, and chemical action.

Capacity - Peak or surge rate, expressed in tons per hour and cubic feet per hour.

Path of travel - Dimensions should be complete in sketch form, and should be adequate for consideration of possible alternates.

Method of feeding material to the belt

Number and location of loading points

Operating conditions - including hours of operation (daily, weekly and annually), seasonal periods of operation and shutdown, climatic conditions, ambient temperatures (maximum and minimum), reversing or one way. Will conveyor be enclosed, or will it be exposed to weather?

Required life of installation – Permanent or temporary, expressed in years.

3. Limitations of Belt Conveyors

Since materials being transported by a belt conveyor are carried on the conveyor belt, such characteristics as packing, abrasiveness, etc., are of less importance than if the material were dragged or pushed along a stationary trough.

Therefore, belt conveyors will transport almost all kinds of bulk materials. However, belt conveyors do have limitations imposed by a few materials characteristics, some of which are:

Stickiness – Sticky materials vary widely in the amounts that will adhere to the belt or that will build up on idlers, pulleys and chutes. Few materials are so sticky that a high percentage will not discharge from a conveyor belt. Many sticky materials may be handled successfully if chutes, cleaning devices, idlers, pulleys, belts and belt speeds are properly designed or selected to insure dependable operation.

Temperature - When temperature of material carried exceeds 90° C., heat resisting belts are usually required.

Deterioration of a belt is somewhat in proportion to temperature, although a hot, coarse material such as lump coke is apt to be less damaging to a belt than a closely packed material of the same temperature.

Belt conveyors have been used to carry very hot castings or even occasional incandescent lumps when mixed in sand or other fine materials. However, when temperatures reach 120° C - 150° C., the economics of a belt conveyor should be compared with other types of conveyors.

Special consideration should be given the design of the entire installation when hot materials are handled.

Chemical reaction - Some oils, chemicals, fats and acids may be injurious to some belts, idlers and pulleys. Neoprene or other belt covers can be obtained and the idlers and pulleys can be made of or coated with several kinds of substances to resist corrosion or chemical reaction.

Large lumps - The size of the largest lumps, and the percentage of the total volume represented by the largest lumps, are two of the factors that determine the minimum width of the belt. It may be found advantageous to crush the largest lumps if they require a very much greater width of belt than would otherwise be necessary. The rated tension of some belts is determined by size and weight of lumps.

Angle of Inclination - The angle of inclination at which a belt conveyor will convey a specific bulk material depends upon such characteristic as its size, consistancy, shape of lumps, moisture content, angle of repose and flowability. Design factors which affect the behavior of materials on an inclined belt include belt speed, whether material is ascending or descending, how fully the belt is loaded, and whether it is loaded continuously, uniformly and centrally.

When the incline is too steep, some part of the bed of material may slide, flow or roll back, resulting in spillage. Also, when belt is too steep, large lumps or spherical pelletized material may become dislodged from the bed of fines, either near the side of belt or when the bed "tails out" at the end of feed. For large lumps this condition is aggravated when belt is carrying less than about 60% of its normal cross sectional load. Also large, heavy lumps that are thus dislodged, may roll back and bounce, creating a safety hazard.

All of these conditions, except the "tail outs," are improved if belt can be loaded on a horizontal or low angle run before it curves up to a steeper incline.

The angle of decline for descending conveyers may be the same as for ascending conveyers when sluggish materials like damp earth are handled, but the angle should be somewhat less for lumpy materials and those having lower angles of repose. However, the combination of angle of decline and speed of belt may not be as critical when a descending conveyor is to discharge to a stockpile or into a bin where the effects of possible avalanching will not create a cleanup problem.

Belt Width and Speed - The best combination of belt width and speed depends upon capacity, angle of incline, belt tensions, lump size and other characteristics of the material to be handled. Due to the number and variations of these conditions, it is sometimes necessary to consider several tentative combinations of width and speed before establishing the final design.

The increasing need for handling higher capacities over longer distances has resulted in a trend toward higher belt speeds for conveyor systems. First cost is usually lower for a narrow, high-speed conveyor, but high speeds may create problems at loading points, at transfers, and on inclined portions. Often, lower over-all operating costs may be obtained with wider belts at lower speeds.

The conditions which influence selection of best width and speed are described below:

In conveying some materials, particularly mildly abrasive materials, it is usually found that the narrowest permissible belt at the highest permissible speed will be the most economical. However, with some materials and under certain conditions, slower speeds may prove more profitable. Some of the material characteristics and conditions which influence the speed of the belt are:

Light, fine, fluffy materials, such as soda ash and soap chips, should be carried at a speed slow enough to prevent them from being blown from the belt or their flow from being retarded due to windage or air resistance.

Fine, dry, dusty materials, such as pulverized coal, should be carried at a speed slow enough to minimize dusting.

Fragile materials should be carried slowly enough so that degradation harmful to the use or salability of the material will be minimized at the loading and unloading points.

Sluggish, damp materials, such as fine wet coal or wet sand that may have a tendency to stick or cling to the belt, should be carried at speeds high enough to provide a good discharge from the belt.

Hard, coarse, heavy, sharp and jogged materials, such as lumpy ore and stone, should travel at a moderate speed to minimize damage to the belt at the loading chutes.

Abrasive materials having relatively small size lumps may limit the speed of the belt by their degree of abrasiveness.

Granular, smooth surface materials, such as whole grains and beans and materials similar to wood chips and undelinted cotton seed, usually are carried at higher speeds than most other materials.

Width of belt, since higher speeds ordinarily are used for the wider belts.

Belt tensions sometimes determine speed of belt within the range limited by other factors. A higher speed with reduced cross sectional load may permit a more economical belt.

Type of chutes, loading and unloading devices are affected by both extremely high and low speeds.

Trajectory, which may not throw material far enough beyond head pulley or may throw it too far beyond.

Kind of carrying idlers, if other than ball or roller bearing, which may limit speed by type of bearings or diameter of rolls.

A characteristic of the material that greatly influences belt conveyor capacity is its angle of repose or, as it is being conveyed on the belt, its angle of surcharge. Some fine materials, such as ore, sand and coal, may retain a high surcharge angle on the belt when they contain certain proportions of moisture and clay, but may slump to a lower angle when they are clean and dry. Fibrous materials usually have a high angle of surcharge.

The minimum width of belt to carry the required volume of material depends upon the speed at which the belt will travel and the permissible cross sectional area of the load on the belt.

The volume of material to be handled is usually expressed in terms of tons per hour, cubic feet per hour, cubic yards per hour, or bushels per hour. So that the conveyor will never be overloaded, the volume per hour must be the maximum rate or peak rate at which material will be handled at any moment and not the average per hour or the average as determined by hourly or daily requirements.

To insure that the volume will never be greater than planned, use surge bins with feeders unless the flow of material to the belt is regulated by some other method, such as by other conveyors, or by processing equipment.

The size of lumps to be handled may determine the minimum belt width, particularly for low capacity conveyors or for inclines that approach the maximums.

When a small percentage of large lumps requires a substantially wider belt, special loading methods sometimes may be used to accommodate them. Also, under certain conditions, narrower belts may be used if occasional large lumps are confined by skirts, guards or safety covers.

Belts of ample width usually justify their first cost by subsequent savings in cleanup expense and improved safety, particularly on conveyors of moderate lengths. On very long conveyors or conveyor systems, it may be advisable to crush extremely large lumps or to screen them out and handle them separately.

Usually, it is most economical to operate the narrowest permissible belt at maximum allowable speed. However, when it is calculated that the permissible cross sectional loading at the maximum permissible speed will handle more than the required volume, it is usually best to maintain the cross sectional loading and select a speed sufficient to convey the required volume. The width and speed thus determined should be considered as tentative until belt tensions are established, as it may be necessary to increase the width to provide sufficient operating strength; or, it may be advantageous to operate the belt at a higher speed with reduced cross sectional loading to decrease the required tension. Another consideration which may be found later to influence the width and speed of the belt is the troughability of belt, as determined by its thickness to provide adequate strength.

Belt idler spacing - The spacing of idlers along the conveyor belt is a very important factor in the over-all economy of the conveyor since the spacing greatly influences the life of both the belt and the idlers. Also, idler spacing may influence the required horsepower as well as the tension rating and cost of the belt.

If the distance between troughed belt idlers is too great, the belt will tend to sag excessively, causing spillage of material, decreased belt life, and increased power to drive the conveyor.

Idler spacing under skirt plates should be reduced to avoid wedging of material. Heavy, sharp lumps will cause more damage to high speed belts due to greater impact at the idlers when there is too much sag in the belt. The amount of belt tension required to prevent excessive sag is reduced by closer spacing of idlers.

Occasional large pieces imbedded in fines and centrally loaded on a belt traveling at slow speed are less severe on the idlers than the same size or smaller lumps without the cushioning effect of fines. Lumps not loaded centrally or traveling at high speed have a more destructive effect.

Belt training idlers - It is important that the conveyor belt operates practically centrally with respect to its idlers to avoid damage to belt edges from rubbing against adjacent chutes or structures. To insure central operation the belt must be installed properly and the idlers, terminal pulleys and structures must be correctly aligned. Also, the material handled should be loaded centrally on the belt.

In addition to careful installation, it is necessary to provide means of training the belt in anticipation of subsequent variations in alignment and loading conditions. Some self-aligning effect of the carrying run may be obtained by installing the carrying idlers with a forward tilt in the direction of belt travel of not more than 2°. Tilted idlers should not be used on reversible conveyors. Also, tilted idlers may result in increased wear of belt cover and idler rolls when handling abrasive materials.

The best method of training the belt when misalignment is not excessive is with belt training idlers, which correct this condition automatically by training the belt to a central position. Belt training idlers are made for both carrying and return belts, and for those that travel in one direction or for reversible conveyors.

Q10

d. Special Types of Belt Conveyors

High angle sandwich belt conveyors (HAC's) have two belts that squeeze the material between them and are capable of lifts at high angles, approaching 90° for some applications. The product is sealed by the outer flats of the belts.

Aerobelt conveyors, an air-cushion belt, where the belt is carried on a film of air. Advantages over conventional belt conveyors include: lower power consumption, less wear, lower maintenance, higher belt speeds and steeper angles of inclination.

Steel and stainless steel belted conveyors can handle higher temperatures than other conveyors using other more traditional belting materials. It is common to see steel belted conveyors operating at temperatures up to 350°C. The steel belt conveyor is also good for continuous operation in low temperatures. Below -20°C an austenitic stainless steel is preferred. Stainless steel belted conveyors have applications requiring hygienic properties. This is very important for the processing and handling of foods.

The “Serpentix®” conveyor is a special, flexible, continuous transportation system which can make complete turn, climb at angles up to 90°, side discharge loads without slowing and make load-bearing return runs. These unique capabilities can eliminate the need for multiple conveyors, numerous and expensive drive trains and troublesome load transfer points. It is capable of operation at temperatures up to 260°C.

The Con-Vey conveyor is totally enclosed belt conveyor that runs in a tube. The tube not only forms the enclosure but also serves as the structural support. The concept of this conveyor is simply that an endless belt, pulled by a power driven pulley at the discharge end, slides along the tube which supports it. The material is given a smooth and gentle ride. The belt can be loaded at any point, or at several points, in its travel. Sizes range from 200 to 750 mm in diameter with capacities up to 1000 m^3/hour.

Conveyor Loading

The method and equipment for loading the belt contribute much toward prolonging the life of belt, reducing spillage to a minimum, and in keeping the belt trained during its operation. Since little can be done to attain these objectives after the material has come to rest on the belt, the means of loading the belt is a very important consideration of belt conveyor design.

The design of chutes and other loading equipment is influenced by such conditions as the capacity, size and characteristics of material handled, speed and inclination of belt, and whether it is loaded at one or several places. Most of these design considerations are illustrated schematically in the two figures that follow. These requirements include:

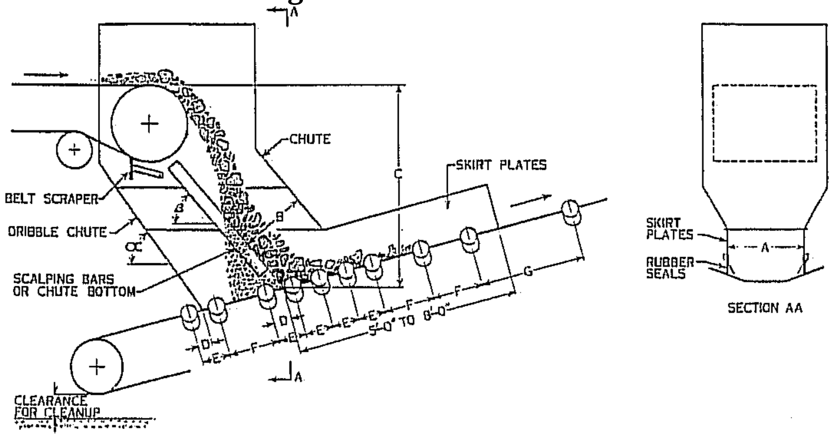
- To load the material on belt at a uniform rate.
- To load it on the belt centrally.
- To reduce impact of material falling on belt.
- To deliver material in the direction of belt travel.
- To deliver material to belt at a velocity as near the speed of the belt as possible.
- To maintain a minimum angle of inclination of belt at loading point.

Loading material at a uniform rate usually requires the use of a feeder. The feeder should be interlocked with the belt conveyor so it will stop operating when the conveyor is purposely or accidentally stopped.

Sometimes it is possible to feed a belt conveyor directly from a gate-controlled chute if the material is small and free flowing, but the gate should be arranged so the belt will not be flooded or over-loaded when it is stopped or is operating at reduced speed.

In addition to a uniform flow to the loading chute, the chute itself must be designed to prevent momentary surges or possible plugging. The slope of chute bottom should be adequate and clearance B, indicated in Figure 28, should be about twice the maximum dimension of the largest lump. Valley angles should be eliminated if possible, or made steep enough to prevent a buildup of material that tends to pack or stick in them.

Figure 28
Arrangement of Transfer Chute



Loading material centrally on the belt is accomplished by directing the flow of material centrally and by confining it between skirt plates until the turbulence of flow has subsided. This requires careful consideration of the design of chutes and their skirt plates. The skirt plates should extend 2 to 3 meters beyond the point where the main stream of material flows on the belt. Their length depends upon the material handled and the speed and inclination of the receiving belt. The distance A between skirts should be about 2/3 of belt width for belts up to 760 mm and about ¾ of belt width for belts wider than 760 mm.

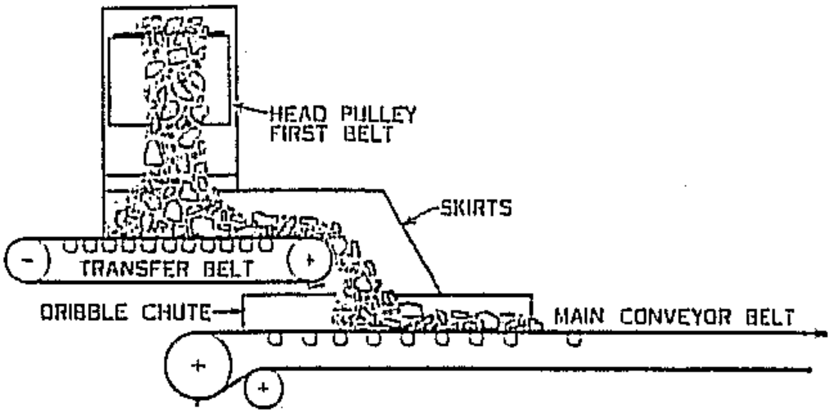
The space between lower edges of the steel skirts and the belt should increase in the direction of belt travel to allow pieces of material to work free without damaging the belt or forcing it off its central position on the idler. The lower edges of skirt plates should be fitted full length with rubber strips to provide a seal and to protect the belt.

Proper contact between the rubber sealing strips and the belt is maintained by spacing the idlers closely. Dimension D on Figure 28 is usually 150 mm and dimensions E, F and G depend upon the size and weight of material handled, belt tension and sag.

In cases where material is received at right angles to the belt, the design of chutes must be considered more carefully than for in-line transfers. Chutes should be arranged to deflect the flow centrally and not allow material to surge higher against one skirt than the other. Also, the angle of chute plates and valley angles must be adequate to prevent buildup of material.

The special transfer belt conveyor shown in Figure 29 provides a positive means for changing the direction of flow of unusually large quantities of material. It is also dependable for transferring sticky materials that might tend to build up in the valley angles of conventional sloping chutes.

Figure 29
Arrangement of Transfer Belt Conveyor



Impact of material falling on the belt is reduced by keeping height C in Figure 28 to a minimum consistent with other requirements of the chute design. The chute bottom plate should be located to receive the impact from the flow of all materials except those that stick to and build up on chutes, where discharge directly on the belt may be necessary. For materials containing large, heavy lumps, scalping bars should be used instead of a chute bottom, permitting the fines to pass through and form a cushion on the belt for the lumps.

When scalping bars are used, the fines are confined and directed to the belt by a dribble chute. Also, dribble chutes are often used to catch material removed by the belt cleaner. Generally, the angle α of the dribble chute should be considerably steeper than the angle β of scalping bars or main chute bottom.

Stone boxes are sometimes used for highly abrasive materials instead of sloped chutes in order to reduce wear of chute liners. They have vertical sides with ledges or partial bottoms, on which material builds up to form its own slope. Skirts are attached to the bottom of the stone boxes.

Rubber cushion impact idlers, closely spaced under the loading point, provide a high degree of protection for the belt when lumpy or heavy materials are handled.

Transfer conveyors, as shown in Figure 29 are used to reduce impact on large expensive main belts when handling large quantities of material which contains large, heavy lumps. The drop from head pulley is held to a minimum.

Delivery of material in direction of belt travel is usually accomplished by sloping the chute bottom or scalping bars in the direction of belt travel to deflect the flow properly. Right angle transfers require particular attention to the design of chute sides and valleys to be sure that, as the direction of flow is changed, it will be delivered centrally to belt without buildup or plugging.

When large capacities are transferred at right angles to high speed belts, the transfer belt conveyor shown in Figure 29 provides a dependable means of delivering materials in the direction of travel of the receiving belt.

Delivery of material at a velocity near the belt speed reduces turbulence and stuffing of belt as the material flows to the belt. This is particularly important for high speed belts.

The chute bottom should be sloped and sometimes curved to impart a forward velocity to free flowing materials. For materials that have a tendency to pack or stick in chutes, a transfer conveyor may prove economical, provided the capacity and cost of replacing the main belt warrants such an expense.

The angle of inclination of belt at loading point should be kept at a minimum to allow the material to come to rest while it is confined between the skirts. Coarse, granular or lumpy materials require a longer time to settle on a steeply inclined belt than fine, moist materials - particularly at high belt speeds. When the belt is too steep, large lumps or spherical pelletized material may become dislodged and roll back along the sides of the bed of fines after leaving the loading chute skids. Similarly, lumps may become dislodged and roll back from the end of bed as it "tails out" after feed has been shut off.

Improved loading of steeply inclined belts may be obtained by designing the conveyor with a loading run at or near horizontal before it curves up to the steeper incline. Longer skirts are usually necessary for high speed belts, and in some cases, they may be desirable the full length of conveyor to prevent occasional large lumps from falling off. Covers over skirts, with ample clearance for bed of material, may be advisable as a protection to personnel.

Descending conveyors, having steep declined portions require similar consideration of loading conditions.

<u>Discharging Material from a Belt Conveyor</u>

Materials may be discharged from belt conveyers to meet a wide variety of requirements. The discharge locations may be confined to one or more specific points, or the material may be distributed along as much of the length of conveyor as desired. With auxiliary stackers and shuttles, material may be stockpiled over wide areas.

The following methods may be used to discharge material from belt conveyors:

1. Discharging over an end pulley.
2. Discharging over one or more fixed trippers.
3. Discharging over movable trippers.
4. Plowing material from one or both sides of belt by fixed or traveling plows.

Discharge over an end pulley can be into a spout or chute or directly onto a pile. Location of discharge is therefore limited to one end of a nonreversible conveyor and to each end of a reversible conveyor.

Even though normal operation of the conveyor may not require discharge over end pulley, provision should be made for discharge over the end of any material which may not be cleanly discharged by intermediate discharging means.

The range of discharge over end pulleys may be extended by a belt slinger, or a shuttle conveyor, which is a horizontal belt conveyor, mounted on wheels with tracks parallel with the belt. Shuttle conveyors are usually reversible.

Discharge over fixed trippers is effected when material is to be spouted into one or more fixed points along the path of the conveyor.

Tripper chutes can be provided to discharge to one side or both sides of the conveyor or back onto the belt to by-pass the side discharge.

Any number of fixed trippers can be installed along the conveyor but in order to prolong the life of the belt, it may be advisable to use a shuttle conveyor or a movable tripper to reduce the number of transfers of material and bends in the belt. Some conditions may dictate a series of individual conveyors, one discharging onto the other or into bins at the transfer points.

Discharge over movable trippers is used when material is to be distributed continuously or intermittently along one or both sides of a conveyor.

When a movable tripper is equipped with a shuttle conveyor at right angles to the main conveyor, material can be distributed along the main conveyor in a wider pile than by chutes.

Movable trippers can be held stationary for intermittent or fixed points of discharge and may be provided with a chute to by-pass material back onto the conveyor belt.

Discharge by plows or scrapers is generally used for removing light, free-flowing, granular bulk materials at predetermined points along the conveyor. Also, some fine, heavy materials, such as foundry sand, may be plowed off.

Plows can be made to discharge variable quantities of material from either edge or both edges of the belt and to be put into or taken out of operating position from remote points. Although they are usually used with flat belts, they can be used with thinly loaded troughed belts by flattening the troughed belt under the plow. While usually installed in a fixed position, they are sometimes made so they can be moved along the conveyor.

Plows are comparatively inexpensive and require little space but should be used with caution to prevent damage to the belt. When plows are used, the speed of the belt should normally not exceed 1 m/sec and the belt should be joined by a vulcanized splice.

Discharge chutes should always be made large enough and steep enough to prevent clogging and should be so located that lumps of material will not become caught or wedged between the conveyor belt and any edge of the chute.

When belt cleaners or scrapers are used, the bottom of the chute should be placed low enough to catch the dribble unless separate dribble chutes are used.

Unusual Conveyor Belt Arrangements

The broad application of belt conveyors has resulted in the development of many special design features to provide for a wide range of variations in materials handled, and conveying requirements.

As an example, a special arrangement of the return run of the belt can be applied so that the clean side of the belt rides on the return idlers. This is particularly advantageous on a conveyor handling wet or sticky material that would tend to cause an undesirable amount of buildup of material on the return pulleys and idlers. With this feature the return run of the belt is turned over after leaving the head pulley of the conveyor; the clean side rides the intermediate idlers; and the belt is again turned back to normal carrying position at the foot end. The necessity for cleanup of dribble from the belt, between its terminals, is practically eliminated. Such an arrangement is particularly advantageous on a long centered belt.

Unusual arrangements can be developed so that the belt conveyor can handle materials in either or both directions simultaneously, making use of the usual return run for conveying. The two runs of the conveyor may be in their normal relationship, one above the other, or by means of appropriately applied guide pulleys, be horizontally separated.

With proper engineering of a belt conveyor and its loading and discharging facilities, it can be advantageously applied to convey other than the usual bulk materials. As an example, belt conveyors have become popularly applied for handling of pulp wood logs.

Safety Devices

A wide selection of safety devices is available to be applied for varying arrangements of conveyors and conditions surrounding their operation. Safety pull cords can be strung the length of the belt conveyors. Pulling on the safety cord at any point immediately shuts off the power.

Terminals and drive machinery can be protected by guards to any degree necessary, depending upon exposure to Personnel. For the highest degree of protection, expanded metal guards can completely enclose all moving parts. Generally, guarding of high speed rotating parts and pulleys is adequate.

Backstops can play an important part in safety to personnel as well as protection of the conveyor equipment.

Automatic take-up machinery should be completely enclosed with expanded metal guards or the like. In addition, a counterweighted take-up can be supplied with a means to avert its free fall in the case of accidental parting of the belt.

Weighing

When it is necessary to weigh materials in transit on belt conveyors and record the amount delivered to certain points of a processing system, automatic recording scales are used. These scales can be either mechanical, electronic or air operated. Impulses from electronic type scales can be used to control the feeders delivering materials to the belt.

The scales can be furnished for standard width conveyors. These units are accurate, compact, and do not disrupt the continuous flow of material on the belt.

There are also available batch feeders that consist of belt feeders, weighing or measuring hoppers.

Magnetic Separation

Tramp iron can be removed from materials carried on belt conveyors by either permanent or electro-magnetic pulleys.

The pieces of tramp iron are drawn to the belt surface as they pass over the magnetic pulley. The pieces then fall free as the belt leaves the pulley, falling into a chute or bin.

Other types of separators and metal detectors are available that are suspended over the stream of material on the conveyor. The metal detectors indicate the presence of magnetic or non-magnetic metals.

Sampling

There are sampling systems available that take a representative sample of the material as it passes over the conveyor discharge. Samples may be taken for various reasons and can be collected on a continuous or intermittent basis. The sampling system crushes, sizes and prepares the sample for laboratory analysis. See Section 4.7 of this guide for additional information on sampling.

Dust Control

Dust control and protection of personnel can be accomplished by enclosures. Where required, the entire belt conveyor and its terminals can be totally enclosed and the dust exhausted to dust collecting systems. Many applications require no more than enclosures at transfer points, with or without dust collecting systems.

Supports and Galleries

Belt conveyor supports are simple and are easily designed. These illustrations will serve to suggest other possibilities to suit particular applications.

Galleries and housings are used to enclose belt conveyors where the conveyors are carried across open spaces. They can be incorporated in a bridge structure and can be designed for convenient access to the conveyor. A wide selection of modern materials such as roofing and siding, and window and door framing, often make it possible to design conveyor galleries uniformly blending with the architecture of adjoining buildings and structures.

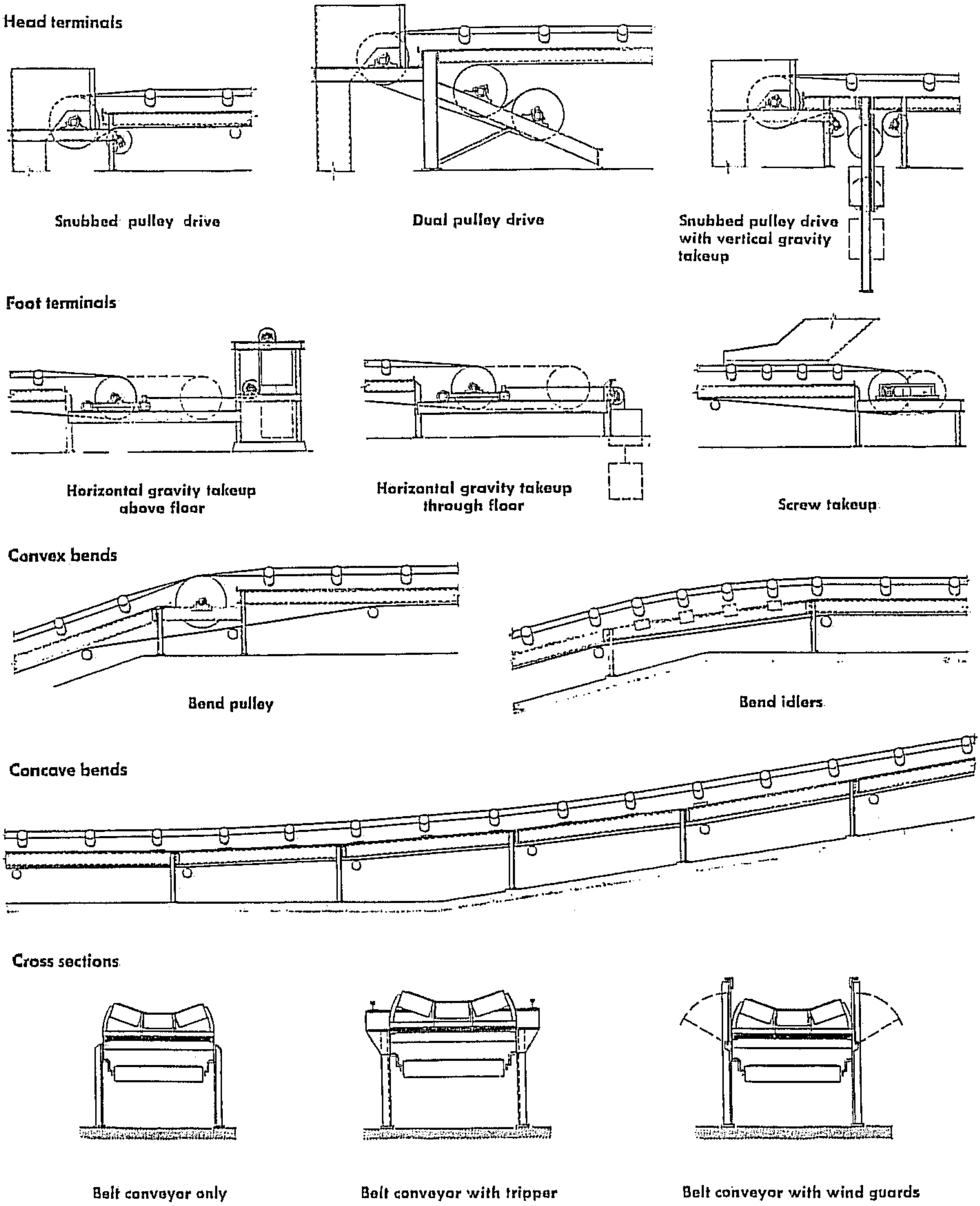
Housings prevent ice and wind from causing a belt to run off-center and an empty belt from being blown off the idlers. They also decrease deterioration of the belt by protecting it from the sun.

Typical structural steel supports, galleries and housings are illustrated on the following pages.

Typical Structural Steel Supports

Belt conveyors have the advantage of requiring only simple and easily designed structures. This applies to terminals and bends as well as to straight runs. The drawings in Figure 30 illustrate this in typical designs of structures. Other designs to suit other conditions can be readily adapted.

Figure 30

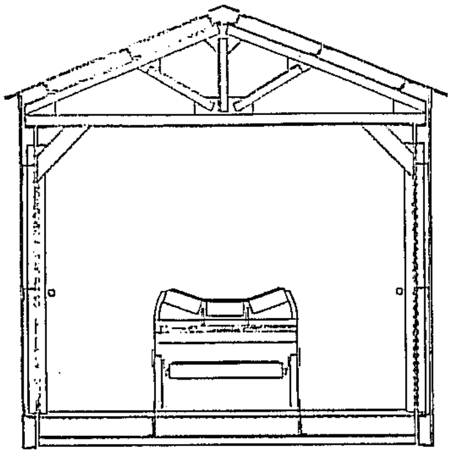

Head terminals
Snubbed pulley drive
Dual pulley drive
Snubbed pulley drive with vertical gravity takeup
Foot terminals
Horizontal gravity takeup above floor
Horizontal gravity takeup through floor
Screw takeup
Convex bends
Bend pulley
Bend idlers
Concave bends
Cross sections
Belt conveyor only
Belt conveyor with tripper
Belt conveyor with wind guards

Typical Galleries and Housings

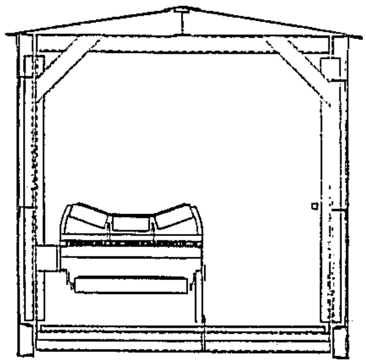
Galleries and housings are used to enclose belt conveyors and provide accessibility where the conveyor is carried on a bridge, as when it is required to span open spaces. Many forms of galleries and housings are possible, depending upon the conditions encountered.

Typical galleries and housings are illustrated in Figure 31.

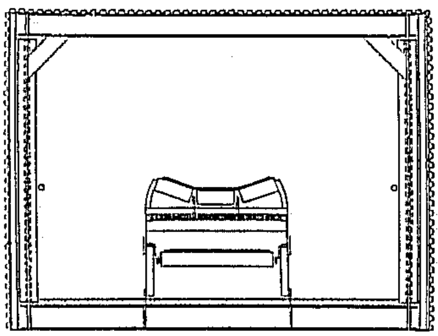
Figure 31



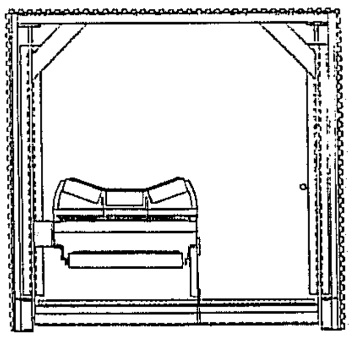
Horizontal closed gallery with walkway both sides



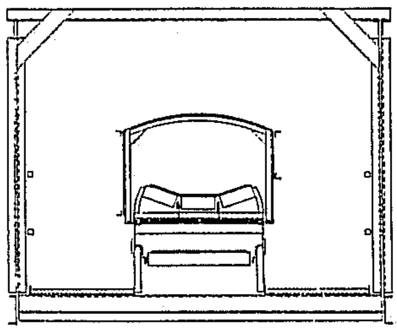
Horizontal closed gallery with walkway one side



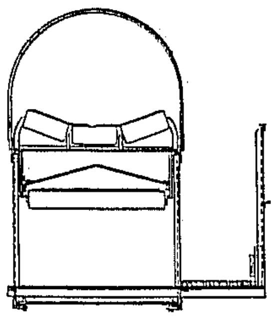
Inclined closed gallery with walkway both sides



Inclined closed gallery with walkway one side



Horizontal or inclined open gallery with walkway both sides, and cover over conveyor only



Pre-Bilt, standardized structures are available for belts up to 36″

Q11 Q12

4.2.2 Screw Conveyors

a. Introduction

Screw conveyors are one of the simplest methods for moving bulk materials. They consist primarily of a conveyor screw rotating in a stationary trough. Material placed in the trough is moved along its length by rotation of the screw which is supported by hanger bearings. Inlets, outlets, gates and other accessories control the material and its disposition.

Screw conveyors are compact, easily adapted to congested locations and can be mounted horizontal, vertical, and in inclined configurations. Their supports are simple and easily installed.

The screw conveyors can be used to control the flow of material in processing operations which depend upon accurate batching . . . or as a mixer, agitator or stirrer to mix and blend dry or fluid ingredients, provide crystallization or coagulant action, or maintain solutions in suspension.

Gasketing with the proper cover and screw conveyors can be effectively sealed to prevent dust or fumes from escaping or dirt or moisture from entering. They can be jacketed to serve as a dryer or cooler, or furnished in a wide variety of materials to resist corrosion, abrasion or heat.

Screw conveyors fit in cramped quarters, are simple to support and easy to install . . . and they cost less than most other types of conveyors.

b. Components of a Screw Conveyor System

The conveyor screw is the rotating portion of a screw conveyor which imparts smooth and positive motion to the bulk material being conveyed. It consists of spiral flighting mounted on a pipe and is made either right or left hand to suit the screw rotation and the desired direction of material travel.

Couplings and shafts connect components of the conveyor system and transmit motion. **The conveyor drive shaft, end shaft and coupling** support the conveyor screw sections and keep them in alignment.

The conveyor drive shaft connects the conveyor screw to the driving unit and transmits rotary motion to the screw. Coupling bolts secure the drive shaft in the conveyor screw.

The end shaft is located at the end opposite the drive shaft. **Couplings** are used to connect successive conveyor screw sections when more than one section is necessary to make up the total length of conveyor. The shafts and coupling are secured in the conveyor screws by coupling bolts.

Quick Change Sections allow an individual conveyor section to be lifted out without dismantling adjacent parts or components.

Hangers provide support, maintain alignment and serve as hearing surfaces.

Trough Ends support the conveyor drive and end shafts, maintain trough alignment. They can be furnished with several choices of bearings or thrust bearings.

Troughs and Covers completely enclose the material being conveyed and the rotating parts. Covers are available in various types and are secured to the trough by Springs, Screws, quick-acting Clamps or special seals depending on the trough cover combination used.

Inlet and Discharge Openings may be located wherever needed, discharge spouts may be without slides or fitted with either flat or curved slides. These slides may be operated by hand, rack and pinion gears, or by power.

Standard **End Bearings** are of the three (3) or four (4) bolt flange type using either bronze bushings or ball bearings. Four bolt ball bearings are generally preferred. Ball or roller bearing pillow blocks mounted on pedestal type trough ends should be used for heavy duty or critical applications.

Shaft Seal options include the following: compression type packing gland seals, split compression type packing gland seals, flanged product drop-out seals, waste pack seals and plate seals.

The Complete Screw Conveyor Unit is supported by the trough end and by either Feet or Saddles at intermediate locations.

c. Conveyor Details – Conveyor Screws

1. Helicoid Flight Conveyor Screws

The helicoid flight conveyor screw is made of a helix, formed from a flat steel bar or coil strip and mounted on a pipe or shaft. The helix, formed by special rolling equipment to the required diameter, pitch and thickness, is a smooth, continuous one-piece flight.

By virtue of its one-piece construction, it possesses superior strength. The absence of laps, rivets or welds on the carrying face of the flight promotes and maintains cleanliness and reduces wear. The rolling process effects a hardening and smoothing of the flight surface which increases resistance to wear and reduces friction and power consumption.

The flight is fastened to the pipe, or shaft, by intermittent or continuous welds and with or without formed steel end lugs. The pipe, of a size carefully selected for adequate torsional strength and resistance to excessive deflection, has internal collars at each end. These collars are permanently inserted and have appropriate inside diameters to accept coupling or end shafts.

The assembled helicoid flight conveyor screw is solidly constructed and exceptionally sturdy, and its inherent balance permits operation at high speeds. Its distinctive characteristics contribute to maximum efficiency, durability and economy.

Helicoid flight conveyor screws are interchangeable with sectional flight conveyor screws of the same diameter and shaft size.

Helicoid flighting is made with regular pitch approximately equal to the diameter. It can also be furnished with other than regular pitch and in a wide range of diameters, thicknesses and lengths to meet the most exacting requirements.

For extremely heavy duty the flighting may be continuously welded to the pipe or shaft on one or both sides.

2. Sectional Flight Conveyor Screws

Sectional flight conveyor screws are made of individual flights each blanked from a flat steel plate and formed into a helix. The flights are butt welded together and fastened to the pipe or shaft by intermittent or continuous welds and with or without formed steel end lugs. Sectional flights are formed with regular pitch approximately equal to the diameter.

Sectional flight conveyor screws are interchangeable with helicoid flight conveyor screws of the same diameter and shaft size.

Sectional flights afford flexibility in choice of diameters, pitches and thicknesses. The sectional flight conveyor screw is a sturdy constructed assembly, carefully designed to render efficient, economical and lasting service.

When desired, sectional flights may be lap welded together, or flights may be continuously welded to the pipe on one or both sides, thus providing exceptionally rugged construction for the most severe conveying applications.

Many variations of sectional flight conveyor screws can be furnished to meet specific needs. Some of these are listed on the following pages.

3. Quick Change Conveyor Screws

The Quick Change conveyor screw is designed for easy removal from the conveyor trough. Each section of screw is provided with a Quick Change key located at one end of the pipe. By removing this key, a conveyor screw section and coupling with hanger can be quickly and conveniently disassembled without disturbing other components. Quick Change conveyor screws are available in both the helicoid flight and sectional flight construction.

4. Ribbon Flight Conveyor Screws consist of sectional flights, butt welded together to form a continuous helix. Flights are secured to the pipe by supporting lugs.

Variations of diameter, pitch, flight width or thickness can be furnished. Also, these screws can be furnished with either continuous or sectional flights, lap or butt welded together.

Ribbon flight conveyor screws are the solution to most conveying problems encountered in the handling of sticky, gummy or viscous materials. The tendency of materials of this nature to adhere and build up at the juncture of solid flight with the pipe is overcome by the open construction of the ribbon flight. Raw sugar, molasses, asphalt, hot tar, sticky feed mixes, and similar products are typical of the many materials successfully handled by ribbon flight conveyor screws.

Providing the periphery of ribbon flights with a beveled edge improves operation and reduces power consumption when handling materials which tend to pack or trowel between flights and trough. Consequently, beveled edge ribbon flight conveyor screws are usually subjected to extremely heavy loads, and construction is accordingly heavy and rugged. The ribbon flights are supported on the pipe or shaft by steel lugs, generously proportioned to resist bending.

Where the material handled moves virtually en masse, there is but very slight difference in capacity between ribbon and solid flight conveyor screws of the same size. Mixing action without supplementary means of agitation is negligible.

5. Ribbon Flight Conveyor Screw with Paddles

To provide moderate mixing or stirring of materials being conveyed, paddles can be furnished, spaced at intervals and set to partially oppose the forward flow. Paddles are adjustable and may be set at any angle to produce the desired degree of agitation. They are used for light or medium weight, fine, granular or flaky materials.

6. Multiple Ribbon Flight Conveyor Screws

This type of screw consists of two or more ribbon flights of different diameters and opposite hand, mounted one within the other on the same pipe or shaft by rigid supporting lugs. Material is moved forward by one flight and backward by the other, thereby including positive and thorough mixing.

7. Abrasion-Resistant Conveyor Screws

The particularly severe service encountered when conveying abrasive materials has prompted many attempts to overcome excessive wear on flights. Several successful methods have been developed.

Hard surfacing by application of a special compound, by arc or torch, to the flight periphery or face, or both, provides an exceptionally hard surface at the points of greatest wear.

For severe applications, conveyors with high alumina ceramic tile bonded to the flight periphery or face are also available.

8. Corrosion-Resistant Conveyor Screws

Corrosion is manifested in so many different ways that no one choice of material will suit all requirements. To withstand the effects of corrosion encountered in many fields of industry, conveyor screws are fabricated of stainless steel, Monel metal, aluminum, and other materials.

Galvanizing and other coating methods have proved effective under mildly corrosive conditions. Vulcanized or bonded rubber covering of the entire conveyor is frequently satisfactory for resistance to extremely corrosive action.

9. Heat-Resistant Conveyor Screws

Conveyor screws for high temperature applications are made of many of the available heat-resistant alloys. Several of the stainless steels and other high-chrome alloys are particularly suitable for this service.

Q13

10. Flight and Pitch Arrangements for Special Applications

Cut flight conveyor screws have notches cut in the periphery of either helicoid or sectional flights. These notches supplement the conveying action with a moderate mixing action. They are used for light, fine, granular or flaky materials.

Conveyor screws with paddles have paddles spaced at intervals and set to partially oppose the forward flow, to provide a moderate mixing or stirring of materials being conveyed. Paddles are adjustable and may be set at any angle to produce the desired degree of agitation. They are used for light or medium weight, fine, granular or flaky materials.

Cut and folded flight conveyor screws provide folded segments which act as lifting vanes to produce a cascading effect. This promotes agitation and aeration, resulting in better mixing. They are used for light or medium weight, fine, granular or flaky materials.

Short pitch conveyor screws are of regular construction except that the pitch of the flights is reduced. They are recommended for use in inclined conveyors of 20 degrees slope and over, including vertical conveyors and are extensively used as feeder screws. They retard flushing of materials of a fluid nature.

Cut flight conveyor screws with paddles have paddles mounted at intervals and set to counteract the flow of materials, considerably increases the agitation and mixing action produced by the cutflights.

Paddle conveyor screws have formed steel blades mounted on rod shanks inserted through the pipe. Conveying action can be controlled by adjusting the angle of the paddles. They are used for mixing, blending or stirring dry or fluid materials.

Tapering flight conveyor screws are frequently used as feeder screws for handling friable lumpy material from bins or hoppers and also to draw the material uniformly from the entire length of the feed opening.

Stepped diameter conveyor screws consist of flights of different diameters, each with its regular pitch, mounted in tandem on one pipe or shaft. They are frequently used as feeder screws, with the smaller diameter located under bins or hoppers to regulate the flow of material.

Stepped pitch conveyor screws are screws with succeeding single or groups of sectional flights increasing in pitch and are used as feeder screws to draw fine free-flowing materials uniformly from the entire length of the feed opening.

Long pitch conveyor screws are occasionally used as agitators for liquids or rapid conveying of very free-flowing materials.

Double flight conveyor screws of regular pitch promote a smooth gentle flow and discharge of certain materials.

Double flight short pitch conveyor screws assure more accurate regulation of feed and flow in screw feeders and effectively deter flushing action of fluid materials.

d. Conveyor Details – Drive Shafts, End Shafts and Couplings

1. **The conveyor drive shaft** delivers the driving power, and is therefore carefully designed of quality steel of the proper characteristics to provide adequate torque, bending and shear strength, and with closely controlled tolerances for correct bearing clearances.

   For conveyors of unusual length or for severely heavy loads alloy steels, heat-treated high carbon steels or 3-bolt connections, are used.

   Jig-drilled coupling bolt holes and accurately cut keyways contribute to ease of assembly.

2. **The conveyor end shaft** supports the last section of conveyor screw and is furnished with close tolerances for proper operation in end bearing. Coupling bolt holes are jig drilled for interchangeability and ease of assembly.

3. **Conveyor couplings** connect and space adjoining sections of conveyor screw and transmit rotation.

   Carefully selected steels, with accurate heat-treating or hard surfacing when required, insure ample strength and resistance to wear for the kind of service specified.

For conveyors of unusual length or for severely heavy loads, alloy steels, heat-treated high carbon steels or 3-bolt connections are used.

Close tolerances on diameters and jig-drilled coupling bolt holes assure interchangeability and ease of assembly.

4. **Quick change conveyor screws** provide an easy means for the quick removal of a conveyor screw section and coupling with hanger without disturbing other components. Regular couplings are used with these screws.

5. **Split flight couplings** permit installing or removing individual conveyor screws without disturbing adjoining sections. With split flight couplings installed on both sides of each hanger, conveyor screws can be removed without disturbing the hangers.

e. <u>Conveyor Details – Hangers</u>

The screw conveyor industry has standardized the nomenclature for the many hanger options available. Some of the most common are listed as follows:

1. **No. 216 hangers** have formed steel box frames of superior strength and rigidity and are excellent for heavy service. They are mounted within the conveyor trough. Mounting holes are slotted parallel with the conveyor to permit adjustment and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings.

2. **No. 216F hangers** are similar in construction to No. 216 hangers except they are designed to mount in a flared trough.

3. **No. 220 hangers** are similar in construction to No.226 hangers, except they are mounted on top of the trough flanges. Mounting holes are slotted parallel with the conveyor to provide adjustment and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings.

4. **No. 226 hangers** have a rigid, formed-steel box frame with clearance for passage of material in large volume. They are mounted within the conveyor trough. Mounting holes are slotted parallel with the conveyor to permit adjustment and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded

fabric bearings, but can also be furnished with special bearings.

5. **No. 270 ball bearing hangers** have self-aligning ball bearings. The frame is a box-member top-bar with a pipe stem support for the bearing. The bearing is factory adjusted for the proper length from the top-bar and locked with a sealant and a lock nut. The frame is designed for mounting inside the trough and slotted mounting holes parallel to the conveyor permit adjustment and alignment.

6. **No. 316 hangers** have formed steel frames of superior strength and rigidity and are excellent for heavy service. They are mounted within the conveyor trough, are self-adjusting and will accommodate operating variations which may exist between the conveyor screw and trough. Mounting holes are slotted parallel with the conveyor to permit adjustment and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings.

7. **No. 326 hangers** have a rigid, formed steel frame with clearance for passage of material in large volume. They are mounted within the conveyor trough, are self-adjusting and will accommodate operating variations which may exist between the conveyor screw and the trough. Mounting holes are slotted parallel with the conveyor to permit adjustment and alignment. These hangers are normally furnished with hard iron, babbitted, bronze, oil impregnated wood or molded fabric bearings, but can also be furnished with special bearings.

8. **Air purged hangers** are recommended when handling dusty and abrasive materials which contribute to shut-downs and hanger bearing failures. They should not be used when handling hot materials (over 120°C) or wet sticky materials or when handling nonabrasive materials when an inexpensive hanger will do the job satisfactorily. Maximum trough loading should not exceed 15%. The air, at approximately 10 kPa, enters the housing at the top, passes over and around the bearing, and is dissipated around the coupling shaft on both sides of the housing. Only 5 to 12 m^3/hour is required to keep each hanger bearing clean.

f. Conveyor Details – Trough End Plates

Trough end plates for either U-trough or flared trough are made of heavy gauge steel plate with the top flanged to support the trough cover. They are furnished with or without supporting feet.

Trough end plates can be made of stainless steel or nonferrous metals for corrosive or high temperature applications. They can also be furnished with protective coatings such as galvanizing.

They may be equipped with either sleeve, bolt, or roller bearing flange blocks, or with the addition of a mounting shelf, pillow block bearings.

1. **Drive Shaft Trough Ends** are of the double ball bearing and double roller bearing types. Each consists of a rigid shaft, operating in double bearings and designed to accommodate both radial and thrust loads. The radial or overhung load is usually a chain drive connected to a power source. Since the bearings will also accept thrust loads in either direction, the need for auxiliary thrusts is eliminated.

2. **Drive shaft trough ends with double ball bearings** consist of double ball bearing flanged blocks rigidly attached to heavy steel plate trough ends for either U-troughs or flared troughs. The gray iron housings are of one-piece construction and are precision machined for accurate alignment. Effective seals are provided in the flanged blocks to exclude dirt and moisture and retain lubricant.

3. **Drive shaft trough ends with double roller bearings** consist of heavy duty double roller bearing flanged blocks mounted by means of machined surfaces into extra heavy steel plate trough ends for either U-troughs or flared troughs. The gray iron housings are accurately machined and fitted with roller bearings of high radial and thrust capacity. The blocks have effective seals and are arranged for easy lubrication.

4. **Countershaft trough ends** are used on screw conveyors where application of right angle drives is necessary due to space limitations, interference of adjoining equipment or for better service and maintenance accessibility.

   Application of countershaft trough ends permits drive installations alongside, above or below the conveyor and permits using horizontal drives for inclined conveyors. A common drive for two conveyors intersecting at right angles, or a battery of parallel conveyors driven from a common source, can be readily arranged.

g. Conveyor Details – Troughs

The trough is the enclosure in which the material is confined and guided in its movement. Trough end flanges preserve the contour of the trough, facilitate assembly of adjoining sections, and insure accurate alignment. Supporting feet at the trough joints or saddles located between the joints, support the intermediate trough sections.

Discharge spouts provide outlets for the material and direct its flow to bins or succeeding equipment: With more than one discharge point in a conveyor, selective control may be exercised by means of slide gates, made integral with the discharge spouts.

Trough covers with fasteners complete the conveyor enclosure. Material is fed into the conveyor through inlet openings in the cover.

The trough not only confines and guides the flow of material, but also serves as the housing in which all operating components are supported and held together in their proper functional relationship.

1. **Flanged trough** - By forming the top flanges integrally with the trough sides from a single steel sheet, adequate strength and rigidity is obtained without superfluous bulk or weight. Steel connecting flanges, securely welded at each end in special welding fixtures to assure square, true ends, facilitate assembly, insure proper alignment and preserve the contour of the trough.

2. **Angle Flanged trough** - This trough is identical in construction to the flanged trough, except that top flanges are obtained by securely welding structural steel angles to the trough.

3. **Flared trough** - This trough is of conventional construction except that trough sides are flared outward to afford a wider top opening. This results in improved feed and conveying action with sticky materials or materials which are not entirely free flowing. It is customarily used with ribbon flight conveyor screws.

4. **Drop bottom troughs** are equipped with a drop bottom usually hinged, held in place by spring clamps of various types for ready access to trough interior, conveyor screws and hangers.

   This design facilitates quick, thorough, and frequent cleaning of the trough, screw and other parts and is particularly useful to combat infestation and promote sanitation.

5. **Channel side troughs** are made with separate detachable trough bottoms, bolted or clamped to formed or rolled steel channels. The channels may be of any reasonable length to span widely spaced supports.

   This trough is occasionally selected for ease of replacement of trough bottoms subject to unusually severe abrasive or corrosive wear.

6. Corrosive or high temperature applications may require the specific qualities that make stainless steel and non-ferrous metals well adapted to these services. In general, any type of trough that can be fabricated of mild steel can also be made of stainless steel or aluminum, brass, bronze, copper, Monel metal, nickel, etc. For resistance to corrosion there are numerous protective coatings that are applied to steel troughs and covers. Galvanizing, tinning, chrome plating, etc., all effective for certain applications. Vulcanized or bonded rubber coatings resist abrasion and corrosion.

h. <u>Conveyor Details – Trough Covers</u>

Covers are used for protection of operating personnel, dust control or protection for or against the material being handled. When required, protective seals can be furnished between the covers and troughs. Covers are made in three general types: plain, semiflanged and flanged.

1. **Plain** covers consist of flat steel sheets and can be furnished with spring clamps, clamps or bolts.

2. **Semiflanged** covers are flanged 30 degrees along the sides and provided with spring clamps attached to the top side of the cover. These covers can also be furnished with screw clamps or bolts.

3. **Flanged** covers have right angle flanges along the sides to provide a stiffer cover for more convenient handling. They are normally attached to the trough with screw clamps or bolts.

4. **Hip Roof** covers are peaked to form a longitudinal ridge. They are normally furnished for use in outdoor applications because of their ability to shed water.

5. **Shrouds** are used in U-trough sections of screw feeders to decrease the clearance between the cover and feeder screw to obtain proper feed regulation.

i. Conveyor Details – Trough Discharge Spouts and Gates

Discharge spouts and gates afford the means for discharging material from the trough and for connection to succeeding equipment to which material is delivered. Gates provide for selective control of multiple spouts.

All spouts and gates are of welded steel construction with connecting flanges punched with accurately space holes for interchangeability and ease of assembly.

Spouts and gates can be fabricated of stainless steel and nonferrous metals. Spouts of special design can be furnished to accommodate unusual conditions.

Slide gates, either hand or rack and pinion operated, may be installed in practically all applications for operation either parallel or at right angles to the conveyor axis. Rack and pinion operated gates may be furnished with chain wheels and chains for remote control. Pinion shafts may be extended to accommodate various operating arrangements.

1. **Plain** discharge openings are cut in the bottom of the trough at the desired location to provide free discharge of material. They are used for delivering to open or closed storage or similar applications.

2. **Discharge** Spouts are welded in place when furnished with a complete conveyor. They are furnished in thicknesses proportioned for the size and thickness of trough.

3. **Flush end** discharge spouts are furnished welded in place on flanged or angle flanged trough. They are furnished in thicknesses proportioned for the size and thickness of the trough.

4. **Hand Slide** Gates are made to attach to discharge spouts and can be operated from any one of the four sides, provided there is sufficient clearance for the gate in its open position.

5. **Rack and Pinion** slide gates have cut tooth racks welded to the slide plates and actuated by cut tooth pinions mounted on pinion shafts operated by hand wheels or chain wheels. These are available with either flat slide plates or curved slide plates.

6. **Air Operated** gates are high quality units designed for low-friction performance in applications requiring frequent gate operation. These gates are built to accept a flange-faced air cylinder and have a roller-mounted slide plate operating in a formed steel housing. The cylinder can be furnished with the

gate or supplied by the user for field installation. No air piping or controls are provided with these gates.

Q14 Q15

k. Screw Conveyor Design

1. Design Standards and Guides

The Conveyor Equipment Manufacturers Association (CEMA) has published the following standards pertaining to screw conveyors.

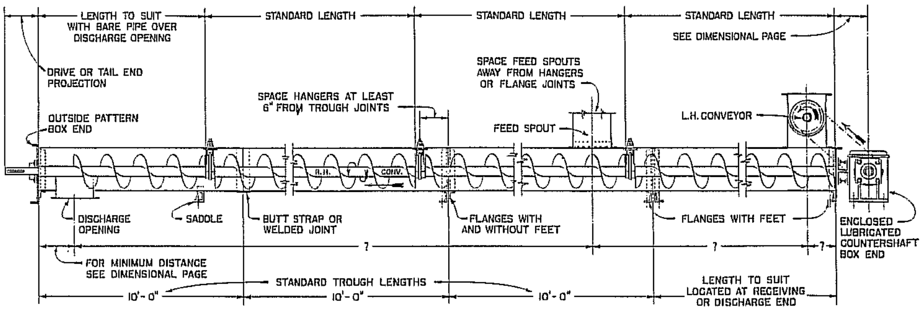
- CEMA Standard No. 300, "Screw Conveyor Dimensional Standards"
- CEMA Standard No. 350, "Screw Conveyors"

2. Layout

Screw conveyors are made with either helicoid or sectional flighting of various thicknesses in a wide range of sizes in both right-hand and left-hand assemblies. The conveyor screws and troughs are made in regular lengths, but can also be furnished in odd lengths to suit requirements.

A typical screw conveyor system is shown below. Note that a left hand screw conveyor is discharging into a right hand screw conveyor.

Figure 32

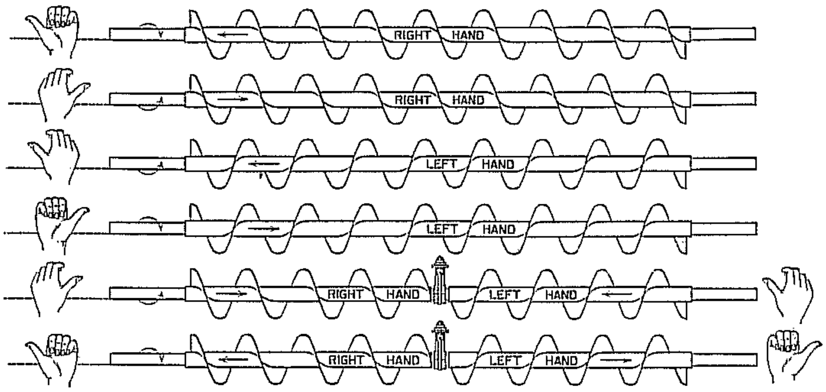


Standard trough lengths are in 3m and 1.5m sections, unless otherwise specified. Where supports permit, always use standard trough ends with feet. If this is not practical, use flanges with feet. Locate drive and thrust bearings at discharge end whenever possible, as the conveyor operates better in tension than compression, and will tend to hold its alignment better.

The "Rule of Thumb" for determining the proper "hand" of conveyor required is demonstrated in the following diagrams.

A simple method of selecting the "hand" of a conveyor is to extend the thumb of your hand to indicate the direction of the flow of material, with the extended fingers in the direction of rotation. The "hand" of the conveyor will be opposite that used; that is, you use your left hand to analyze a right-hand conveyor. The above may seem complicated, but by checking with it a few times you will soon appreciate its value.

Figure 33



3. Design Data

To enable the manufacturer to furnish a screw conveyor that will give complete satisfaction, it is important that the following information be provided by the purchaser:

- Type of material to be conveyed.
- Maximum size of hard lumps.
- Percentage of hard lumps by volume.
- Capacity required, in cubic meters.
- Capacity required, in kg.
- Distance material to be conveyed.
- Any additional factors that may affect conveyor or operations.

The conveying industry has standardized a classification of material properties. See the following table.

Major Class	Material Characteristics Included		Code Designation
Density	Bulk Density, Loose		Actual kg/m^3
Size	Very Fine	No. 200 Sieve (0.074 mm) And Under No. 100 Sieve (0.15 mm) And Under No. 40 Sieve (0.4 mm) And Under	A_{200} A_{100} A_{40}
	Fine	No. 6 Sieve (3.35 mm) And Under	B_6
	Granular	12.7 mm And Under (6 Sieve to 12.7 mm) 76.2 mm And Under (12.7 m to 76.2 mm) 178 mm And Under (76.2mm to 178 mm)	$C_{½}$ D_3 D_7
	Lumpy	400 mm And Under (0 mm to 400 mm) Over 400 mm To Be Specified X = Actual Maximum Size	D_{16} D_x
	Irregular	Stringy, Fibrous, Cylindrical, Slabs, Etc.	E
Flowability	Very Free Flowing Free Flowing Average Flowability Sluggish		1 2 3 4
Abrasiveness	Mildly Abrasive Moderately Abrasive Extremely Abrasive		5 6 7
Miscellaneous Properties or Hazards	Builds Up and Hardens Generates Static Electricity Decomposes – Deteriorates in Storage Flammability Becomes Plastic or Tends to Soften Very Dusty Aerates and Becomes a Fluid Explosiveness Stickiness – Adhesion Contaminable, Affecting Use Degradable, Affecting Use Gives Off Harmful or Toxic Gas or Fumes Highly Corrosive Mildly Corrosive Hygroscopic Interlocks, Mats or Agglomerates Oils Present Packs Under Pressure Very Light and Fluffy – May Be Windswept Elevated Temperature		F G H J K L M N O P Q R S T U V W X Y Z

An example of material code could be as follows:

D3 3 6 NQT

Size = (½ “ to 3”)

Flowability = Average

Other Characteristics = Explosiveness (N)
Degradable,
Affecting Use (Q)
Mildly Corrosive (T)

Abrasiveness = Moderately

Q16

Material characteristics for many materials are available in the table form from CEMA or conveyor manufacturers. These tables generally include the loose bulk density, material code, type of conveyor to be used, trough loading classification, and horsepower factor.

Although the CEMA Standards and most conveyor manufacturers publish criteria and methods for the calculation and design of screw conveyors, this is best left up to the experts. It may be of interest for the end user to require the manufacturer to submit calculations with the quotation for comparison purposes in the evaluation of the bids.

Design considerations and calculations to be performed by the manufacturer include:

- Determine the design capacity.
- Determine the screw diameter and speed. (Note: Depending on the trough loading classification, screw conveyors will be designed on the basis of 15%, 30% or 45% trough loading. Screw conveyors are rarely operated above a 45% loading.)
- Check the minimum screw diameter for lump size limitations.
- Determine type of bearings.
  (Note: Manufacturers standard bearings are of the flange type. Purchaser may want to consider pillow blocks, especially for critical applications.)
- Determine horsepower.
- Check torsional and/or horsepower ratings of conveyor components.
- Select components.
- Detailed layout drawing of conveyor.

Special Design Considerations

Q17

a. Expansion of Screw Conveyors Handling Hot Materials

Screw conveyors often are employed to convey hot materials. It is therefore necessary to recognize that the conveyor will increase in length as the temperature of the trough and screw increases when the hot material begins to be conveyed.

The recommended general practice is to provide supports for the trough which will allow movement of the trough end feet during the trough expansion, and during the subsequent contraction when handling of the hot material ceases. The drive end of the conveyor usually is fixed, allowing the remainder of the trough to expand or contract. In the event there are intermediate inlets or discharge spouts that cannot move, the expansion type troughs are required.

Furthermore, the conveyor screw may expand or contract in length at different rates than the trough. Therefore, expansion hangers are generally recommended. The trough end opposite the drive should incorporate an expansion type ball or roller bearing or sleeve bearing which will safely provide sufficient movement.

The change in screw conveyor length may be determined from the following formula:

$$\Delta L = L (t_1 - t_2) C$$

Where:

- ΔL = increment of change in length, meters
- L = overall conveyor length in meters
- t_1 = upper limit of temperature, degrees Kelvin
- t_2 = limit of temperature, degrees Kelvin, (or lowest ambient temperature expected)
- C = coefficient of linear expansion, meters per meter per degree Kelvin. This coefficient has the following values for various metals:
  - (a) Hot rolled carbon steel, 2.0E – 5/°C
  - (b) Aluminum, 22.2×10^{-6}

b. Conveyor Screw Deflection

When using conveyor screws of standard length, deflection is seldom a problem. However, if longer than standard sections of screw are to be used, without intermediate hanger bearings, care should be taken to prevent the screw flights from contacting the trough because of excessive deflection. The deflection at mid span must be verified by the manufacturer.

Other Types of Screw Conveyors

a. Inclined Screw Conveyors

Inclined screw conveyors have a greater horsepower requirement and a lower capacity rating than horizontal conveyors. The amounts of horsepower increase and capacity loss depend upon the angle of incline and the characteristics of the material conveyed.

Inclined conveyors operate most efficiently when they are of tubular or shrouded cover design, and a minimum number of intermediate hanger bearings. Where possible, they should be operated at relatively high speeds to help prevent fallback of the conveyed material.

b. Vertical Screw Conveyors

Vertical screw conveyors provide an efficient method of elevating most materials that can be conveyed in horizontal screw conveyors. Since vertical conveyors must be uniformly loaded in order to prevent choking, they are usually designed with integral feeders.

As with horizontal conveyors, vertical screw conveyors are available with many special features and accessories, including components of stainless steel or other alloys.

c. Multiple Screw Conveyors

Multiple screw conveyors/feeders are made up of several horizontal screws arranged closely side by side to completely cover the area of flat bottom bins. They discharge materials which have a tendency to pack or bridge under pressure into a collecting conveyor which runs at right angles to the bin conveyors.

d. Flexible Screw Conveyors

These conveyors which are essentially a flexible rotating helix inside a flexible tube can be used to convey some materials vertically, horizontally and at any angle in between. In addition, they can bend around, over and under obstructions and through openings in walls or ceilings.

Q18

4.2.3 Roller Conveyors

Roller conveyors are used to feed or convey products (cartons, boxes, drums, bags, etc.) from one point in a process to another.

Roller conveyors can be furnished to operate by gravity or be powered by motor driven belt or chain drives.

To ensure that equipment provided is satisfactory for the application, it is important to furnish the following information to the manufacturer.

- What will be conveyed?

Cartons	Tote Pans	Baskets	Drums	Bundles
Boxes	Crates	Pallets	Bags	Other

  If "Other", describe the load.

- What are the dimensions of your conveyed item?

  Units of measure: Millimeters
  Units of weight: Kilograms

	Length	Width	Height	Weight
Minimum:				
Average:				
Maximum:				

- What is the "total live load"? (This is the maximum total load that will rest on the conveyor at any one time.)

- Will there be shock loading? If there will be shock loading, from what height will the product be dropped?

- How will the conveyor be loaded (By hand, by lift trucks, by machine, from another conveyor)? Be specific.

- What is the throughput required? (How many items need to traverse the conveyor from one end of the conveyor to the other in an hour?)

- Will the conveyor be started or stopped under full load?

- How many times per minute/hour will the conveyor start/stop?

- How many hours per day will the conveyor be in operation?

- Is the application for a powered or by gravity conveyor? If powered, what power characteristics are available (Voltage / Phase / Hertz)?

- What is the desired conveyor height (Floor to top of roller/belt)?

- What is the desired conveyor speed?

- Does the conveyor need to be reversible?

- Are there any local conditions that might affect the design of the conveyor (Excessive or abrasive dust, heat, moisture or humidity, oil, other conditions)?

- Furnish a layout (plan and elevation of the conveying system)

a. <u>Non-Powered Conveyors</u>

Non-powered conveyor is the most basic type conveyor. Applications can consist of a single unit or a complete system comprised of many units.

Gravity, or non-powered, conveyor consists of either wheel or roller conveyors. A wheel conveyor is constructed of a series of wheels mounted on a common axle supported in a channel frame. A roller conveyor is constructed of metal tubing with bearings pressed in each end with the roller mounted on a hex axle supported in either a channel or angle frame. The product is transported directly on either wheels or rollers.

Gravity, or non-powered, wheel and roller conveyors are ideal for moving most unit loads which have a firm, flat bottom surface.

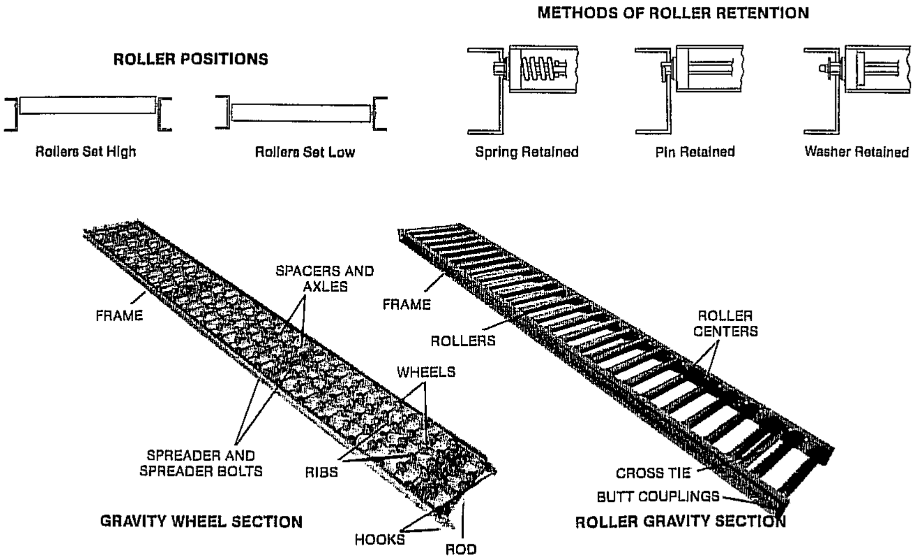
These conveyors are used to transport items either on a level push line or gravity pitched line. The level push line requires manual assistance to move the items on the conveyor some examples are assembly, staging and sorting operations. The most common use of non-powered conveyor is a gravity pitched line. The pitch of conveyor is adjusted so that no manual assistance is required to move items. Some examples are loading and unloading trucks and storage accumulation.

Non-powered conveyors are less expensive than other type conveyors. Normally wheel conveyor will cost less than roller conveyor.

Conveyors are available in a variety of sizes including many stock models. They can be used in either permanent or portable applications. Installation is not complicated and can be accomplished without experienced conveyor installers.

The simplicity of design and cost advantages offered by non-powered conveyors should be given consideration for all floor conveyor applications.

Figure 34



Selection of the proper bearing based upon the conveyor operating conditions is an important factor of roller conveyor life. This is normally done by the manufacturer.

Plain bearings provide excellent service for normal clean and dry indoor applications free of dust and abrasives. This bearing is manufactured with light oil lubricant, turns very easy and is most frequently used for gravity roller conveyors.

Dust-tight bearings have a steel labyrinth shield to inhibit dirt from gathering on the internal components of the bearings. It is designed to operate in a dry dusty atmosphere without being lubricated. This bearing is free turning and often used in gravity roller conveyor.

The dust-tight grease packed bearing is packed with grease during manufacturing. It is ideal for high humidity environment. This bearing is commonly used in powered conveyors and not often used in gravity roller conveyors.

The greaseable bearing is designed for use indoors, outdoors, and under dusty or wet conditions. Grease fittings permit periodic pressure lubrication. New grease is forced into the bearing while dirt and moisture-containing old grease is forced from the bearing. This bearing is normally manufactured without grease and allows the selection of grease to be made depending on the customers application. This bearing is recommended for high speed powered conveyors and applications with excessive moisture or dust. This bearing is not frequently used for gravity roller conveyors.

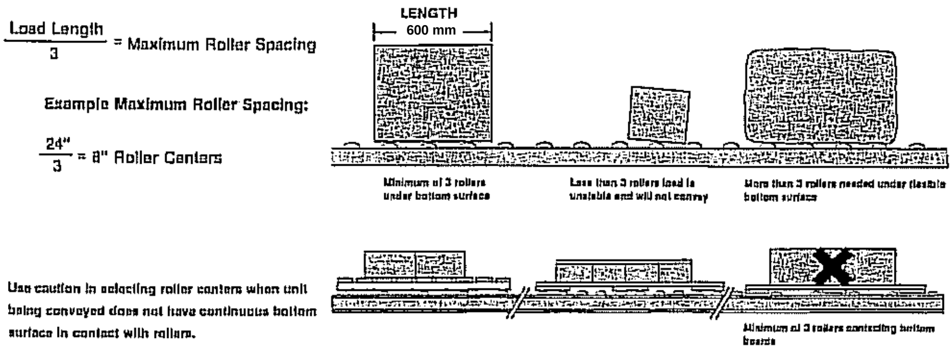
Based on the data provided by the purchaser, the manufacturer will select the rollers and the roller spacing.

A minimum of three rollers must support the smallest unit load.

To determine maximum roller centers divide the shortest load length by three.

Care must be taken so that the weight of the load does not exceed the combined capacity of the rollers under the load nor the rated load per meter capacity of the conveyor.

Figure 35

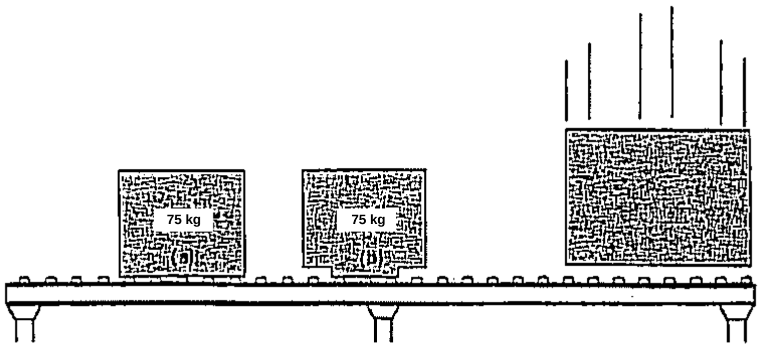


Q19

To determine minimum roller capacity divide the weight of the heaviest load by the minimum number of rollers that will be under the carrying surface of the load.

If unusual circumstances exist, such as drop or shock loading or unloading from the side, a roller with a higher-than-calculated load rating will be required.

Figure 36



For shock loads the manufacturer should consider higher capacity bearing, heavier gauge roller wall or closer roller centers.

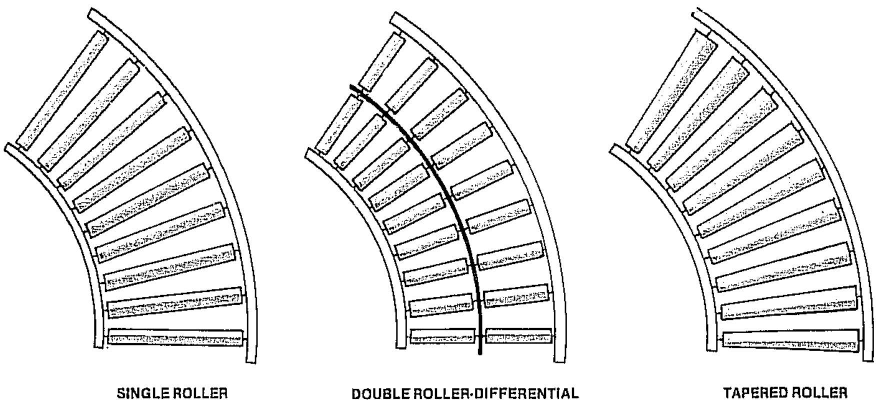
Q20

Single Straight Roller curves provide a good means for conveying loads around turns. Loads do not track perfectly on straight roller curves and will be skewed at the exit of the curve.

Double Roller-Differential curves provide a better means for conveying loads around curves. The double roller has a differential action to reduce skewing of loads.

Tapered Roller curves are the best means of conveying loads around curves. Loads will remain in the same position as they travel around the curve. This curve should be used for all widths of conveyor if keeping the product oriented is important.

Figure 37



The wheeled conveyor has a distinct advantage over the straight roller conveyor in that the load being conveyed tends to maintain its original lateral position during travel. This is especially advantageous on curved sections. As the load negotiates the curve, the individual wheels provide a turning action which enables the load to maintain its original orientation as does a taper and roller conveyor.

The selection of the conveyor width and the design of the conveyor frame and supports are better left up to the conveyor manufacturing using the basic data provided by the purchaser.

Conveyor pitch must be determined by the conveyor manufacturer using the basic data provided by the purchaser. However, the following information is approximate and for general guidance only.

The roller centers and the type or size of rollers must also be taken into consideration. If cases or cartons have strapping or cording the below pitches will have to be increased to facilitate the flow. Most of the pitches were taken from conveyors having rollers at 4" centers. The more rollers or wheels under a load the more it takes to get the conveyor to "turn over".

Containers with flanged or recessed bottoms can be handled only on tubular type GRAVITY ROLLER CONVEYOR. Burlap or cotton sacks of feed, seeds, etc., are in most cases too flexible to be carried on any type of gravity roller or wheel conveyor.

Suggested Pitch For Gravity Conveyors

Container Being Conveyed	Approx. Cont. Weight	Gravity Roller Conv.			Gravity Roller Conv.			Gravity Wheel Conv. Or Live Rail Conv.		
		Pitch Per Ft. – Pitch Per 10'-0" Sec. And Per 90° Curve								
		1"/Ft.	10'-0"	90°	1"/Ft.	10'-0"	90°	1"/Ft.	10'-0"	90°
Cartons (Fiber Smooth Bottom)	10#	5/8	6¼	5	-	-	-	3/8	3¾	4
Cartons (Fiber Smooth Bottom)	20#	½	5	5	-	-	-	¼	2½	3½
Cartons (Fiber Smooth Bottom)	45#	3/8	3¾	3½	¾	7½	6	3/16	1-7/8	3
Cartons (Fiber Smooth Bottom)	100#	¼	2½	3	5/8	6¼	5	¼ - 3/16	-	3
Fiber Beverage Carton Empty	5#	-	-	-	-	-	-	1½	15	10
Fiber Beverage Carton Empty Bottles	35#	½	5	4 – 5	¾	7½	6	3/8	3¾	4
Fiber Beverage Carton Filled Bottles	45#	3/8	3¾	3½	5/8	6¼	5	¼	2½	3½
Wood Cases or Boxes	5#	5/8	6¼	5	-	-	-	3/8	3¾	5
Wood Cases or Boxes	10#	3/8	3¾	4	¾	7½	6	¼	2½	5
Wood Cases or Boxes	25#	¼	2½	4	5/8	6¼	5	¼	2½	4
Wood Cases or Boxes	50#	3/16	1-7/8	3	½	5	4	¼	2½	3½
Wood Cases or Boxes	100#	3/16	1-7/8	3	3/8	3¾	3½	1/8	1¼	2½
Steel Drums	20#	5/8	6¼	5½	¾	7½	6	-	-	-
Steel Drums	55#	7/16 – ½	4¼ - 5	5	5/8	6¼	5	-	-	-
Steel Drums	120#	3/8	3¾	4	½	6	4½	-	-	-
Steel Drums	250#	¼	2½	3	3/8	3¾	3½	-	-	-
Steel Drums	550#	¼ - 3/16	2½ - 1-7/8	3	¼	2½	3	-	-	-
Wood Barrels	100#	½	5	5	5/8	6¼	6	-	-	-
Wood Barrels	400#	3/8	3¾	4	½	5	5	-	-	-
Metal & Fiber Glass Tote Boxes	10#	½	5	5	-	-	-	3/8	3¾	4
Metal & Fiber Glass Tote Boxes	25#	3/8	3¾	4	¾	7½	6	¼	2½	3½
Metal & Fiber Glass Tote Boxes	50#	¼	2½	3	5/8	6¼	5	3/16	7-7/8	3
Wood Pallets Smooth Runner †	350#	3/8	3¾	-	7/16	4¼	-	-	-	-
Wood Pallets Smooth Runner †	750#	5/16	3-1/8	-	3/8	3¾	-	-	-	-
Wood Pallets Formica Base	350#	¼	2½	-	5/16	3½	-	-	-	-
Wood Pallets Formica Base †	750#	1/8	1¼	-	3/16	2½	-	-	-	-
Wood Pallets Fine Plywood †	350#	3/8	3¾	-	7/16	4¼	-	-	-	-
Wood Pallets Fine Plywood †	750#	5/16	3-1/8	-	3/8	3¾	-	-	-	-
Wood Beverage Case Empty	6#	13/16	8-3/8	6¾	-	-	-	¼	2½	3½
Wood Beverage Case Empty Bottles	30#	½	5	5	¾	7½	6	1/8	1¼	2½
Wood Beverage Case Full Bottles	40#	7/18	4¼	4	5	5	5	1/8	1¼	2½
Multi-Wall Bags-Firm	50#	-	-	-	-	-	-	5/8	6¼	6
Multi-Wall Bags-Firm	100#	-	-	-	-	-	-	½	5	5

* Varies with new or reconditioned drums

† Depends on the way it is nailed and if banded or not – bad nailing or banding will considerable increase the pitch and make a planned slope impractical.

b. Powered Roller Conveyors

Powered roller conveyors are powered by a belt, o-rings or chains depending on the capacity and severity of the service. The product should have a flat and firm conveyable surface. Loads may easily be diverted, merged, conveyed or transferred from a live roller conveyor. The path is limited, however, since most live roller conveyors are level and should not exceed a 5° pitch. Live roller conveyors should be used for heavy loads with riding surfaces that might damage belting.

Uses of live roller conveyors include: transportation, accumulation, diverting and merging. Pop-up stops, both manual and automatic, are used in conjunction with roller conveyors to stop or control the feed of the product.

Both fixed speed and variable speed drives are used to power roller conveyors. Variable speed drives are particularly interesting when products of different dimensions are conveyed by the same conveyor system. Right-angle gear motors are common.

Q21

4.3 Bucket Elevators

4.3.1 Introduction

Bucket elevators have long been, along with pneumatic conveying systems, the industry standard for any bulk material elevating application.

A bucket elevator can transfer bulk materials as high as several hundred feet. The equipment consists of a series of uniformly fed buckets attached to an endless spliced loop of belt or chain inside a fabricated housing.

Bucket elevators can handle light to heavy materials that range from dry dusty powders to wet sticky material.

The three main categories of bucket elevators are the centrifugal style, the continuous style and the positive discharge style.

a. Centrifugal Bucket Elevators

The Centrifugal Discharge design has spaced buckets that travel at a relatively high speed. It is a medium capacity unit, capable of handling materials with small-to-medium size lumps. The buckets dig the material from the casing boot section and discharge it by centrifugal force.

Foot Shaft Take-up – Elevators of this type meet the service requirements of the majority of installations using centrifugal discharge elevators. The head shafts are fixed, with the foot shaft take-up being internal gravity type or external screw type take-up. Buckets are designed for use on either chain or belt.

For most applications, chain is recommended, however, belting is used when handling materials that must not be contaminated or for materials that are extremely abrasive and corrosive.

As an alternate to the standard foot shaft take-up design, an alternate design is available. The head shaft is adjustable and the boot shaft is fixed to maintain the relationship of buckets to the inlet spout and curved bottom plate. This type is recommended when handling food products; for materials that tend to pack or build-up, or when handling materials having a large percentage of lumps.

b. Continuous Discharge Elevator

The Continuous Discharge Design has overlapping buckets mounted continuously that travel at a much slower speed. The continuous discharge design elevator handles a variety of materials from fines to large lumps. Materials that are difficult to pick up in the casing boot section or friable are normally handled in this type elevator. The buckets are fed directly from a loading leg or chute and are emptied by gravity at the discharge point. Standard operating speed is 40 m/min. When handling light or fluffy-type material, operating speeds of 50 to 55 m/min are common. When bulk material is abrasive, operating speeds are normally reduced for longer component life.

A gravity take-up is most frequently used with the continuous discharge design. The head shafts are fixed, with foot shaft take-ups being internal gravity type. Buckets are steel and spaced continuously on a strand of chain.

As an alternate to the standard continuous discharge design, an alternate design is available. The head shaft is adjustable and the foot shaft is fixed. This type of elevator is used for the handling of fine or crushed materials with lumps not exceeding 10 to 12 mm. With the addition of a loading leg and a correspondingly higher inlet spout, this type elevator can also be used for handling lumps up to 115 mm.

c. Positive Discharge Elevator

The positive discharge bucket elevator is a specialty unit built to move materials at very low speed (typically about 40 m/min.) in an L, C, T, or Z configuration to fit the plant layout. The elevator gently handles materials that must be conveyed without breakage or spillage, such as cereal flakes, nuts, and dried fruits. The elevator has pivoting buckets that are side-mounted between two chains; thus the unit can't use a belt. A positive discharge bucket moves material through all planes and remains level until it reaches the discharge point, providing the gentlest handling of any bucket elevator.

Q22

4.3.2 Components of a Bucket Elevator

A bucket elevator can be divided into four major assembles. They are listed below and indicated on Figure 38.

a. Boot Section (13)

The boot section is the fabricated steel assembly at the base of the elevator. It includes a flanged inlet opening (19), a take-up device (18), cleanout and access panels (14), access doors (15), the lower shaft assembly (17), take-up removal beam (20) for servicing internal gravity take-up, flanged bottom (16) for complete bearing on the foundation.

b. Intermediate Casing Section(s) (9)

The intermediate casing section(s) which house the chain and buckets and provide support for the head section. Hinged inspection doors (12) can be provided in intermediate casing sections.

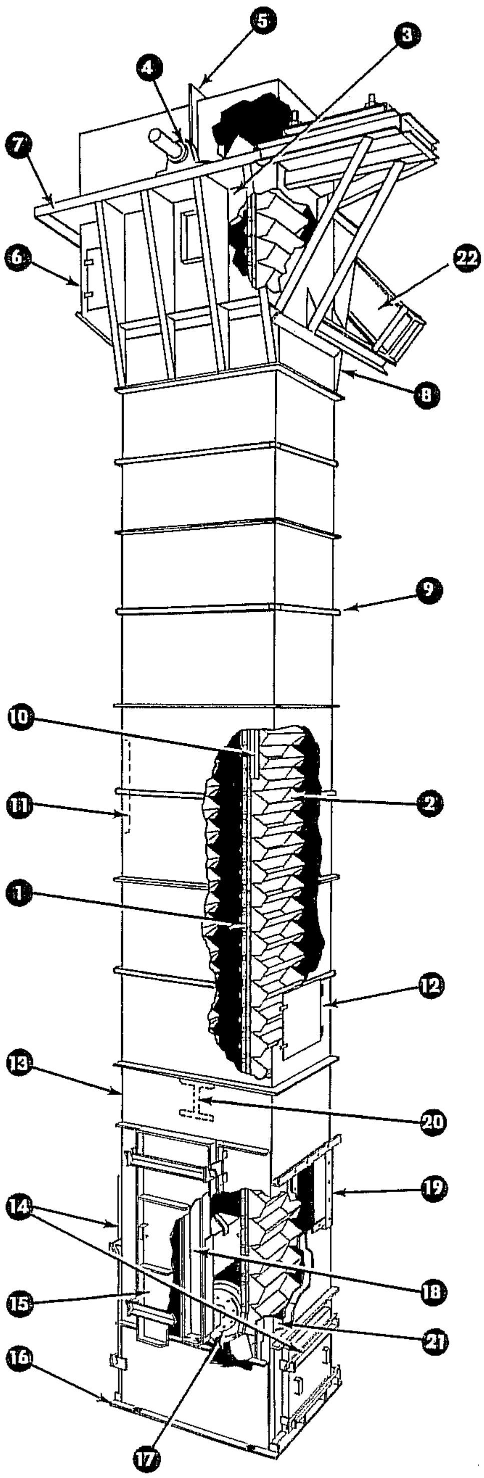
c. Head Section (5 & 8)

The head section is the fabricated assembly at the top of the elevator. It includes a flanged discharge spout (6), a split upper hood (5), the conveyor drive assembly (Not Shown), the head shaft assembly (4), holdback assembly (22), head shaft bearing supports (7).

d. Buckets (2) Mounted on Continuous Chains (1) or Belts

Change guides (10) are required for elevators with greater than 60 foot centers and optional for shorter elevators.

Figure 38



Q23 Q24

4.3.3 Elevator Details

a. <u>Buckets</u>

Bucket size, materials of construction, and configuration are determined from materials handled, capacity required, conveyor type, and manufacturer's availability. Manufacturers' data should be consulted for the full range of possibilities.

b. Chain vs Belt

Chain equipped conveyors have a wide range of application, but good practice dictates that chain speeds be kept within reasonable inertia limits, usually a maximum of 90 meters per minute. Chain is used for "Z" type conveyors or those carrying heavy loads of materials which would tend to pack between buckets and the belt, or between the belt and pulley. Chain conveyors usually are used where ambient temperatures would exceed 100°C.

Belt conveyors are used where the materials to be handled are extremely abrasive, but usually should be limited to dry and free-flowing types. Belt conveyors can be operated at much higher speeds. With proper choice of head pulley and bucket type, speeds up to 240 meters per minute are attainable. Belts are more susceptible to damage than chains, and the pulleys must be aligned more accurately than chain sprockets.

c. Casing

1. Size

Casing cross-section dimensions are determined by bucket and drive pulley or sprocket size. Sufficient casing clearance for chain or belt sway should be provided to prevent internal rubbing. Particular attention is necessary for taller conveyors.

2. Construction

Casings normally are not specified lighter than 12 gage. "Z" type conveyors, and those for light duty, generally will be 16 gage. Casing corner angle size is a function of conveyor height, and the sheet gage does not enter, into this consideration. Good practice is to make boot and head sections heavier than the intermediate section. Extremely wide casings should incorporate stiffener angles to prevent sheet buckling.

3. Loading Leg

On continuous conveyors, a 7 mm plate loading leg, with a minimum length of three bucket spaces, should be bolted in place to aid in feeding directly to each bucket. Bucket to casing clearance should be held to a maximum of 10 to 12 mm around the bucket to inhibit flow of materials into the conveyor boot.

4. Access Doors

Accessible inspection and maintenance openings should be located near foot sprocket or pulley, and on both sides of the casing, if possible. Conveyor boots should be equipped with removable panels for easy boot pulley or sprocket removal. Panels should be of sufficient size to allow bucket replacement. Head section should be split-removable type for access to internal drive components.

Cleanout doors should he placed at the bottom of the casing to provide for easy cleaning of the boot section.

5. Ladders

Ladders with safety cages are optional and should be provided to access the head platform when elevator is free-standing or extends above a building roof. Ladders should be provided to meet local safety regulations. Rest platforms should be provided at 9 meter (maximum) intervals.

6. Head Platforms

Head platforms should be provided with the elevator, for access to the drive and head terminals, when the elevator is free-standing or extends above the roof of a building. Platforms should include hand rail, toe plates and non-skid grating that satisfy local safety regulations. The platforms should be supported by and form an integral part of the elevator.

c. Drives

Sprockets or traction wheels may be used for driving chain conveyors. Traction wheels are not required for chain conveyors under 15 meters high, for units handling wet materials, or for materials which have a natural lubricating tendency, regardless of height.

Crowned drive pulleys are used with belt-type conveyors. Drive pulleys should be provided with some form of lagging, usually rubber, where there is a need for increased traction, such as when handling abrasive or natural lubricating materials.

Backstops or brake systems must be added on all types of bucket conveyors to prevent runaway travel in reverse when unit is shut down, or in case of drive failure.

Differential hand brake can be used for most applications. Dust covers are advisable; however, for use in extremely dusty atmospheres this type of brake is not recommended.

Wedging roller type normally is used for heavy-duty or corrosive conditions.

Rachet and pawl (rapid, positive action). This type tends to be noisy but can be obtained in noiseless design.

e. Take-ups

Take-ups can be either external gravity, internal gravity, or screw type. Gravity-type take-ups are recommended for all hot service. Wing-type take-up pulleys for belts are useful in abrasive or lumpy material service in that they are self-cleaning.

f. Shafts

Provide adequate strength for starting and stopping under full bucket load conditions.

g. Belt Splices

Vulcanized splices are stronger and longer lived than mechanical splices. They are economical where a large number of splices are, needed. Belt scrapers and brushers are more effective for cleaning a vulcanized spliced belt because of its uniform smoothness. Belt clearance in the form of brushes can be used with mechanical splices.

Mechanical belt splices are used for general service and require less skill and equipment for joining. They can he made to give a strong, tight butt joint without appreciably decreasing belt strength.

h. Bucket Attachments

The K2 type 4-bolt hole bucket attachment is the type most frequently used. This attachment allows minimum overhung bucket load due to the short distance between bolting face and longitudinal centerline of chain.

i. Guides

Conveyors over 15 meters high using a single strand chain should be equipped with “slap plates,” three bucket spaces long, installed in alternate 3 meters casing sections to prevent contact of upgoing and downcoming chains.

5.0 GLOSSARY FOR MATERIAL HANDLING TERMS

Absorption - Process where one material consumes another as a homogeneous mixture in solution form.

Accumulating Conveyor - Any conveyor designed to allow collection (accumulation) of material. May be roller, live roller, belt and gravity conveyors.

Acid Dewpoint - The temperature at which liquid droplets which are acidic condense from the vapor phase.

Acrylic - Synthetic polymer fiber that goes by trade names Orion, Draylon, and is composed of at least 86% acrylonitrile. There are two groups; Modacrylics and Homopolymers.

Activated Carbon - Carbon that has a highly porous structure to provide filtration of odors and extremely fine particulates.

Adsorption - A weak surface bonding of molecules in a fluid phase (gas) through physical or weak chemical attraction. A good adsorbents is characterized by a high surface-to-volume ratio (e.g. activated carbon).

Agglomeration - The action where small particles group together to form larger particles or nodes of a scale anywhere from pea to golf ball size usually due to moisture or surface tension.

Air, Standard - A specific value of dry air at 15°C and 101.325 kPa (abs) pressure (Density 13.595 gm/cm3).

Air Rotary Actuator - Industrial air cylinder. When operating properly, it should respond immediately upon activation of four-way air valve. Possible problems that could arise are bound probe assembly or worn seals, which are replaceable by the cylinder repair kit.

Air-to-cloth Ratio - The ratio of the amount of air entering the baghouse to the amount of surface area available for filtration. Optimal air to cloth ratios vary for different industry segments and types of dust collectors.

Alligator Lacing - Lacing attached to the belt with a hammer for the purposes of joining the ends of the belt together to form a continuous loop.

Auger - A motor driven auger designed to completely clean out sample from sample tube. If it becomes inoperable, remove sampler from line and check for obstructions between it and the sample tube.

Axle - A non-rotating shaft on which wheels or rollers are mounted.

BACT - Acronym for Best Available Control Technology. A standard for permitting of baghouse and dust collectors that takes into account the impact of energy and equipment costs in balance with environmental needs in new or retrofit applications.

Baffle - A plate, grating, or refractory wall used especially to block, hinder, or divert a flow. The baghouse inlet typically has the highest velocity. Particulate will sandblast the lower portion of the bags in the baghouse in the absence of a baffle.

Bag Flattener - A mounting assembly used to hold one conveyor upside down over another conveyor in order to squeeze or flatten the product.

Ball Table - A group of ball transfers over which flat surface objects may be moved in any direction.

Ball Transfer - A device in which a larger ball is mounted and retained on a hemispherical face of small balls.

Bare Pulley - A pulley which does not have the surface of its face covered (or lagged).

Batch Cleaning - As a textile term refers to the process used in heat-cleaning glass filter cloth prior to converting into a filter by exposing it to 250-300°C temperatures for prolonged periods to burn off the starches and other lubricants used to assist in the weaving process.

Bearing - A machine part in or on which a shaft, axle, pin or other part rotates.

Bed - That part of a conveyor upon which the load rests or slides while being conveyed.

Belt Feeder - Belt design performing similar function to a screw feeder. Belts are used commonly for large outlets, cohesive materials, or coarse materials.

Bed Length - Length of bed sections only required to make up conveyor excluding pulleys, etc., that may be assembled at ends.

Bed Width - Refers to the overall width of the bed section.

Belt - A flexible band placed around two or more pulleys for the purpose of transmitting motion, power or materials from one point to another.

Belt Scraper - A blade or brush caused to bear against the moving conveyor belt for the purpose of removing material sticking to the conveyor belt.

Belt Speed - The length of belt, which passes a fixed point within a given time. It is usually expressed in terms of “meters per second”.

Between Rail Width - (BR) referred to as the distance between the conveyor frame rails on a roller bed, live roller or gravity type conveyor. Also referred to as (BF) Between Frame.

Bin Vent Filters - commonly mounted on the bin deck. Size and weight of the filter must be considered to provide adequate reinforcing in the deck.

Bleed - When particulates are so fine that they pass through the cross-section of the filter media and exit the baghouse. If the dust cake is poorly managed or there is little dust loading bleeding is likely to occur.

Bleed-through - Particulate migrates through the filter media and is discharged up the stack.

Blinding - Particulate accumulates within and/or on surface of the media such that the flow passages for the gas are blocked restricting the flow and resulting in high pressure drop.

Booster Conveyor - Any type of powered conveyor used to regain elevation lost in gravity roller or wheel conveyor lines.

Brake Motor - A device usually mounted on a motor shaft between motor and reducer with means to engage automatically when the electric current is cut off or fails.

Brake Rollers - Air or mechanically operated brakes used underneath roller conveyor to slow down or stop packages being conveyed.

Butt Coupling - Angles or plates designed to join conveyor sections together.

Can Velocity - Velocity of the baghouse process air as it flows upward though the rows of bags. Excessive Can Velocity can cause premature bag wear due to abrasion and can cause more dust to be carried upward to the bags overloading the bags and the cleaning system. Conversely a Low Can Velocity can cause segregation of the incoming dust carrying only the finest of particles which can prevent the formation of a good Dust Cake.

Capture Velocity - The air velocity at any point in front of the hood or at the hood opening necessary to prevent particulate material and contaminant gases from escaping to the working area.

Casters - Wheels mounted in a fork (either rigid or swivel) used to support and make conveyors portable. See our caster section for information on industrial applications.

Ceiling Hangers - Lengths of steel rod, attached to the ceiling, from which conveyors may be supported to provide maximum utilization of floor space or when required height exceeds floor support capability.

CEM - Acronym for Continuous Emissions Monitoring. The measurement and reporting of specific pollutant levels at a facility.

Center Drive - A drive assembly mounted underneath normally near the center of the conveyor, but may be placed anywhere in the conveyor length. Normally used in reversing or incline application.

Chain - A series of links pivotally joined together to form a medium for conveying or transmitting motion or power.

Chain Conveyor - Any type of conveyor in which one or more chains act as the conveying element.

Chain Drive - A power transmission device employing a drive chain and sprockets.

Chain Guard - A covering or protection for drive or conveyor chains for safety purposes.

Chain Roller Conveyor - A conveyor in which the tread rollers have attached sprockets which are driven by a chain.

Chute - A trough through which objects are lowered by gravity. Can either be a slider bed or roller/wheel bed.

Cleat - An attachment fastened to the conveying surface to act as a pusher, support, check or trip, etc. to help propel material, parts or packages along the normal path of conveyor travel.

Cleated Belt - A belt having raised sections spaced uniformly to stabilize flow of material on belts operating on inclines. Cleats may be a part of the belt or fastened on.

Clipper Lacing - Lacing attached to the belt with a clipper lacing machine.

Clutch Drive - Drive used to disengage motor from reducer without stopping the motor or cutting the power.

Clutch-Brake Drive - Drive used to disengage motor from reducer and stop conveyor immediately without stopping the motor or cutting the power.

Concentration - Amount of dust in the gas. Usually expressed in terms of ppm or mg/cu mt.

Constant Speed Drive - A drive with no provisions for variable speed or a drive with the characteristics necessary to maintain a constant speed.

Converging - A section of roller or wheel conveyor where two conveyors meet and merge into one conveyor.

Conveying Surface - Normal working surface of the conveyor.

Criteria Pollutant - An air pollutant for which a national ambient air quality standard has been promulgated.

Cross Bracing - Rods and turnbuckles placed diagonally across roller bed or live roller type conveyors to aid in squaring frames, necessary for tracking purposes.

Crossover - A short section of conveyor placed in a conveyor when drive is switched to opposite side of conveyor.

Crowned Pulley - A pulley which tapers equally from both ends toward the center, the diameter being the greatest at the center.

Curve Conveyor - Any skatewheel, roller, or belt conveyor which is produced with a degree of bend so as to convey products away from the straight flow.

Cycle Timer - This timer controls the interval between samples. If operating correctly, digits will change either up or down.

Cyclone - A conical-shaped vessel for separating mixed sized particulates from the gas stream. The vessel has a tangential entry at the largest diameter allowing the larger particles to drop out and be removed from the bottom of the cone while smaller particulate exits overhead with the majority of the gas stream.

Damper - An adjustable gate installed in a duct for the purpose of regulating airflow or introducing outside air to the ducting system.

Decline Conveyor - A conveyor transporting down a slope.

Degree of Incline - Angle of slope (in degrees that a conveyor is installed.

Denier - The weight, in grams, of 9000 meters of a single fiber strand.

Dew Point - The temperature at which water molecules in a gas will begin to condense and form a liquid.

Diaphragm Valve - A compressed air operated valve that is used to deliver air in short bursts to pulse clean bags.

Differential Curve - A curved section of roller conveyor having a conveying surface of two or more concentric rows of rollers. Also referred to as a Split Roller Design.

Differential Pressure - In a Dust Collection System usually refers to the difference in pressure (typically measured in mm or Hg) between the dirty side of the baghouse and the clean side of the baghouse. Essentially this yields the pressure drop or resistance to the air-flow through the filter bag.

Discharge End - Location at which objects are removed from the conveyor.

Dispersion Model - A computerized set of mathematical equations that use emissions and meteorological information to simulate the behavior and movement of air pollutants in the atmosphere. The results of a dispersion model are estimated outdoor concentrations of individual air pollutants at specified locations.

Diverging - A section of roller or wheel conveying which makes a connection for diverting articles from a main line to a branch.

Drive - An assembly of the necessary structural, mechanical and electrical parts which provide the motive power for a conveyor. Usually consisting of motor/reducer, chain, sprockets, guards, mounting base and hardware.

Drive Pulley - A pulley mounted on the drive shaft that transmits power to the belt with which it is in contact. Pulley is normally positive crowned and lagged.

Dry Scrubber - A chemical reaction chamber that neutralizes acids in a gas stream. Two system types are common: the spray dryer system injects a slurry, whereas dry sorbent injection systems use a dry powder.

Dust Cake - Essential buildup of porous dust layer on the surface of a filter, which significantly increases the efficiency of the filter. Proper management of the dust cake also effects useful life of the filter.

Dust Loading - The amount of particulate (by weight) that is suspended in a gas stream at the baghouse inlet. See also Grain Loading.

Dutchman - A short section of belt, provided with lacing, in a conveyor belt which can be removed when take-up provision has been exceeded.

Emergency Pull Cord - Vinyl coated cord that runs along the side of the conveyor that can be pulled at any time to stop the conveyor. Used with an Emergency Stop Switch.

Emergency Stop Switch - Electrical device used to stop the conveyor in an emergency. Used with an Emergency Pull Cord.

EPA - Acronym for Environmental Protection Agency. The federal agency responsible for developing and enforcing environmental policy in the United States and its territories.

Epitropic Fiber - Fiber whose surface contains embedded particles to modify one or more properties of the fiber, typically electrical conductivity.

ESP - Acronym for Electrostatic Precipitator. A device that collects particulates by placing an electrical charge on them and attracting them onto a collecting electrode.

Extendible Conveyor - Roller or wheel conveyor that may be lengthened or shortened within limits to suit operating needs.

Feeder - A conveyor adapted to control the rate of delivery of packages or objects.

Felled Seam - Vertical seam in a filter bag, typically a nonwoven, which requires an overlap of the material. See also French seam.

Felt - Fabric structures constructed by the interlocking action of the fibers themselves, without spinning, weaving, or knitting.

Filter Cake - The accumulation of dust on a bag. Often assists in the filtration process. Also see Cake.

Filter Media - The permeable barrier employed in the filtration process to separate the particles from the fluid stream.

Filter-Regulator - The filter-regulator is designed to supply a constant pressure to the four-way valve. It functions as an air filter for the line. The pressure range is from 0 to 1000 kPa and set at the factory. Maximum temperature range is 5 degrees Centigrade. If filter is clogged, filled with water, or frozen, you will decrease air supply to the sampler. Check weekly and drain if needed. If the regulator valve becomes inoperable, you will experience a decrease in pressure to the four-way valve. If this happens, check regulator gasket on inside of regulator for excess wear or dirt. Replace gasket if necessary.

Flapper Gate - A hinged or pivoted plate used for selectively directing material handled.

Flat Face Pulley - A pulley on which the face is a straight cylindrical drum, i.e. uncrowned.

Floor Supports - Supporting members with vertical adjustments for leveling the conveyor.

Flow - The direction of travel of the product on the conveyor.

Flue Gas - The gases emitted to atmosphere from a production or combustion process through the flue or “smoke stack”.

Fly Ash - Gas-borne particulate resulting from the combustion of fuels, typically fossil fuels such as coal and lignite. The ash is composed of a variety of oxides and silicates depending on the fuel and efficiency of the combustion process.

Frame - The structure which supports the machinery components of a conveyor.

Frame Spacer - Cross members to maintain frame rail spacing. Also referred to as Bed Spacer.

French Seam - Vertical seam in a filter bag, typically a woven, which requires a doubling over of the material. See also felled seam.

Fugitive Dust - Emissions from a process or control that occur at points other than stacks or vents.

Gate - A section of conveyor equipped with a hinge mechanism to provide an opening for a walkway, etc. (Manual or Spring Loaded)

Glazing - High pressure pressing of the filter medium at elevated temperatures; fuses surface fibers to the body of the filter medium.

Grain - Weight unit of measure where one pound equals 7000 grains.

Grain Loading - The amount of particulate (by weight) that is suspended in a gas stream at the baghouse inlet. See also Dust Loading.

Gravity Bracket - Brackets designed to permit gravity conveyors to be attached to the ends of a powered conveyor.

Gravity Conveyor - Roller or wheel conveyor over which objects are advanced manually by gravity.

Ground Wire - Braided metal strip, usually copper or stainless steel, placed on or in the seam and grounded to the collector to assist in dissipating static build-up caused by the gas flow.

Guard Rail - Members paralleling the path of a conveyor and limiting the objects or carriers to movement in a defined path.

HAP - Acronym for Hazardous Air Pollutant. A list of nearly 200 pollutants has been classified under this heading by the Clean Air Act Amendments of 1990. Standards were to have been adopted no later than November 15, 2000.

Hog Rings - Rings used to hold the shaft in a roller.

Horizontal Floor Space - Floor space required for a conveyor.

Horsepower - (HP) A measure of the time rate of doing work defined as the equivalent of raising 33,000 pounds one foot in one minute. Electrically, one horsepower is 746 watts.

Hydrocarbon - A chemical compound containing only molecules of carbon and hydrogen.

Hydrolysis - A chemical reaction in which water reacts with another substance, either dust or the filter media, breaking the chemical links and creating two or more substances. The presence of water in a baghouse is a significant detriment to the filter media. See also Dew point.

Hydrophilic Fiber - Fiber that readily absorbs water.

Hydrophobic Fiber - Fiber that does not readily absorb water.

HZ - HERTZ - Electrical terminology, a unit of frequency equal to one cycle per second. Most common cycle times are 50 and 60 Hertz.

Incline Conveyor Length - Determined by the elevation change from infeed to discharge versus the degree of incline.

Incline Conveyor Length - Determined by the elevation change from infeed to discharge versus the degree of incline.

Inclined Conveyor - A conveyor transporting up a slope. More information: Inclined Conveyors.

Infeed End - The end of a conveyor nearest the loading point.

Intermediate Bed - A middle section of conveyor not containing the drive or tail assemblies.

Interpolate - To compute intermediate values.

Inversion - The occurrence of a layer of cool air trapped beneath a warmer layer and the cooler layer not warming and dispersing upward. The emissions at ground level are trapped and remain concentrated creating high concentrations of pollutants.

Knee Braces - A structural brace at an angular position to another structural component for the purpose of providing vertical support.

Knurl Thumb Adj. Nut - A nut used on accumulating conveyors to adjust the pressure required to drive the product, may be turned with- out the use of tools.

Lacing - Means used to attach the ends of a belt segment together.

LAER - Acronym for Lowest Achievable Emission Rate.

Lagged Pulley - A pulley having the surface of its face crowned with a material to provide for greater friction with the belt.

Lime - Common name for calcium carbonate as it is found in the ground. When heated in a kiln, it yields “burnt” or “quick” lime (calcium oxide). When lime is hydrated or "slacked" it becomes calcium hydroxide.

Limit Switch - Electrical device used to sense product location.

Live Roller Conveyor - A series of rollers over which objects are moved by the application of power to all or some of the rollers. The power transmitting medium is usually belting or chain.

Machine Crowned Pulley - A pulley in which the crown or vertex has been produced by an automatic, usually computer driven, machine.

MACT - Acronym for Maximum Achievable Control Technology.

Magnehelic Gauge - Instrument to measure the differential pressure between the dirty (inlet) and clean (outlet) sides of a baghouse. As a general rule differential pressures greater than 2 kPa indicate serious performance problems with the unit and require investigation.

Magnetic Starter - An electrical device which controls the motor and also provides overload protection to the motor.

Main Power Supply - Check the terminal block inside the control panel to determine the proper power supply. If proper power is not available, a transformer must be used to supply correct power.

Major source - As defined by The Clean Air Act Amendment of 1990: “any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants."

Manometer - An instrument for measuring pressure; a U-tube partially filled with liquid, usually water, mercury or a light oil, so constructed that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Manual Start Switch - A simple one direction switch used to turn the conveyor on or off.

Micron - A unit of measure equal to 1/1,000,000 of a meter.

Minimum Pressure Accumulating Conveyor - A type of conveyor designed to minimize build-up of pressure between adjacent packages or cartons.

Mullen Burst Test - Standardized ASTM test method to measure the strength of a filter material under multidirectional pressure expressed in pounds per square inch.

NAAQS - Acronym for National Ambient Air Quality Standards.

Negative Crowned Pulley - A pulley with raised areas set equally in from each end. This crown is used on tail pulleys 600 mm OAW and wider and aids in belt tracking.

NESHAPS - Acronym for National Emissions Standards for Hazardous Air Pollutants. A federal requirement setting standards and limitations for monitoring and reporting of carcinogenic discharges into the atmosphere.

Net Lift - The net vertical distance through which material is moved against gravity by a conveyor.

Nip Point Guard - A guard placed to eliminate points or areas on the conveyor where injuries might occur.

Non-Attainment - When pollution criteria that is being monitored exceeds the national or regional level set for that particular pollutant.

Nose Roller - A small roller, used on power belt curve conveyors, to reduce the gap at the transfer points.

Noseover - A section of conveyor with transition rollers placed in conveyor to provide transition from incline to horizontal or horizontal to incline.

NSPS - Acronym for New Source Performance Standards.

Opacity - A measurement of the density of emissions in the plume of a stack.

O-Ring - Polyurethane bands polyurethane used to transmit drive power from roller to roller or spool to roller.

Osmosis - The diffusion of a solvent through a semi-permeable membrane into a more concentrated solution.

Overall Length - (OAL) The dimension outside of pulley to outside of pulley including belting or lagging, of any conveyor lengthwise.

Overall Width - (OAW) The dimension outside to outside of frame rails.

Overhead Drive - A drive assembly mounted over a conveyor which allows clearance for the product.

Package Stop - Any of various devices, either manual or mechanical, used to stop flow on a conveyor

Parts Conveyor - A conveyor used to catch and transport small parts, Stampings, or scrap away from production machinery to hoppers, drums, or other operations.

PC Board - Solid state printed circuit board.

PEL - Acronym for Permissible Exposure Limit. The allowable exposure level in the workplace for a particular pollutant over an 8-hour shift. See also TWA.

Permeability - A measurement of the ability of air to flow through a filter at a given differential pressure. The value is expressed as liter/mm at 20mm water gauge differential.

pH - The measure in units from 0-14 of the acidity or alkalinity of a stream of gas or liquid. A pH of 7 is neutral. Values below 7 tend towards acidic; values above 7 tend toward alkaline.

Photo Cell - Electrical device used to sense product location.

Pitot tube - A sensing unit inserted into the gas stream to measure gas velocity based on a differential between the total pressure and the static pressure.

Pivot Plate - The gusset which attaches the conveyor to the support leg.

Plastisol Coating - Poly-vinyl chloride (PVC) covering for roller tubes to prevent product damage or marking. Usually (#70 durometer) green or (#90 durometer) red in color.

Plenum Chamber - An air compartment maintained under pressure, and connected to one or more ducts. A pressure-equalizing chamber.

Plow - A device positioned across the path of a conveyor at the correct angle to discharge or deflect objects.

PM10 - A USEPA standard that includes additional controls on particulates sized 10 micron and smaller.

PM2.5 - A USEPA standard that includes additional controls on particulates sized 2.5 micron and smaller.

Poly-Tier Support - Supporting members capable of supporting more than one level of conveyor at a time. Each tier has vertical adjustment for leveling the conveyor.

Pop-Out Roller - A roller, normally placed on the ends of a belt conveyor, used to aid in transfer, and set in a wide groove to allow it to eject if an object comes between it and the belt.

Portable Conveyor - Any type of transportable conveyor, usually having supports which provide mobility.

Portable Support - Supporting members which provides conveyor mobility by use of casters or wheels.

Positive Crowned Pulley - A pulley which tapers equally from both ends toward the center, the diameter being the greatest at the center. The crown aids in belt tracking.

Power Belt Curve - A curve conveyor which utilizes a belt, driven by tapered pulleys.

Power Conveyor - Any type of conveyor which requires power to move its load.

Power Light - This light indicates that the main power is on to the controller. When power light is on, timer should be functioning.

Powered Feeder - A driven length of belt conveyor, normally used to move product horizontally onto an incline conveyor.

Pre-coat - Material added to air stream in initial process startup to aid in establishing filter cake on bags. Pre-coat is good insurance for operations that may introduce.

Pressure Drop - Resistance to gas flow; may refer to pressure differential across the cloth, the baghouse, or across the entire system. Units are usually inches of water.

Pressure Roller - A roller used for holding the driving belt in contact with the load carrying rollers in a belt driven live roller conveyor.

Product Footprint - The surface of the product that comes in contact with the belt, rollers, or wheels of the conveyor.

Pulley - A wheel, usually cylindrical, but polygonal in cross section with its center bored for mounting on a shaft.

Pulse-jet - Type of baghouse design where dust is collected on the exterior of a filter tube, supported by a cage, and clean with a rapid pulse of compressed air driven down the interior of the filter tube.

Push Button Station - An electrical device which operates a magnetic starter.

Pusher - A device, normally air powered, for diverting product 90 degrees from one conveyor line to another line, chute, etc.

Return Idler - A roller which supports the return run of the belt.

Reverse-air - Type of baghouse design where cleaning is accomplished by reversing the flow to a portion of filters and dislodging the dust.

Reversible - A conveyor which is designed to move product in either direction.

Roller - A round part free to revolve about its outer surface. The face may be straight, tapered or crowned. Rollers may also serve as the rolling support for the load being conveyed.

Roller Bed - A series of rollers used to support a conveying medium.

Roller Centers - The distance measured along the carrying run of a conveyor from the center of one roller to the center of the next roller.

Roller Conveyor - A series of rollers supported in a frame over which objects are advanced manually, by gravity or by power. Links: see Gravity Roller Conveyor or Power Roller Conveyor.

Rotary Valve - Commonly used in pneumatic handling systems and consists of a housing and turning rotor with paddles that meter the stored material into the conveying equipment.

Sample Tube - This tube rotates to collect a sample. If the tube fails to rotate, it could be caused by poor alignment or obstruction.

Screw feeder - Auguring device designed to remove stored material at a specified rate which must be compatible with outlet size and downstream processing. Commonly used for applications where feeders must be enclosed due to dust. Improper design can cause adverse flow conditions such as eccentric flow channel, bridging, and ratholing.

Scrim - A very loosely woven fabric onto which felt is needled to add dimensional stability and strength. Use of scrims is declining as high performance textile equipment is allowing for creation of 100% fiber media with the same or superior strength characteristics.

Self-supported - A nonwoven fabric that has been processed to interlock the fibers such that a scrim is not required. Self-supported filter materials have established themselves as the most popular choice for low temperature applications. However, high temperature applications of self supported fabrics, especially in long bag configurations, should be approached with caution and on a case by case basis.

Set High - Vertical spacing which allows the rollers to be mounted above the frame rails.

Set Low - Vertical spacing which allows the roller to be mounted below the top of the frame rails.

Shaft - A bar usually of steel, to support rotating parts or to transmit power.

Shaker - Type of baghouse design where the filter bag is agitated by mechanical means to dislodge the dust.

Sheave - A grooved pulley wheel for carrying a v-belt.

Side Channels - Members which support the rollers on the side of the conveyor.

Side Mounted Drive - A drive assembly mounted to the side of the conveyor, normally used when minimum elevations are required.

Side Tables - Steel tables attached to either side of conveyor bed to provide working surface close to conveyor.

Singeing - Passing of the filter medium over an open flame, thereby removing the protruding surface fibers. Singing the collection side of the filter allows for easier dust cake removal.

Singulation Mode - Mode where packages are- automatically separated while traveling down the conveyor.

Slide gate - A cut-off valve either manually or automatically controlled to open or shut positions. Generally withdrawal is through a center outlet slide gate. Intermediate gates may be used in flat bottom bins for removal of stored material between

Skatewheel Conveyor - A type of wheel conveyor making use of series of skatewheels mounted on common shafts or axles, or mounted on parallel spaced bars on individual axles. Link: see skatewheel conveyors for more details.

Slat Conveyor - A conveyor which uses steel or wooden slats mounted on roller chain to transport the product.

Slave Drive - A conveyor drive powered from another conveyor instead of having its own prime power source.

Slider Bed - A stationary surface on which the carrying run of a belt conveyor slides.

Slug Mode - Allows all packages to be released simultaneously.

Snub Idler - Any rollers used to increase the arc of contact between a belt and drive pulley.

Solenoid - 110/50, 120/60 or 220/50, 240/60 volt single phase coil which operates the four-way valve. When operating properly, valve will open if air is being supplied by filter-regulator. If the solenoid is working properly, a clicking sound can be heard. If the solenoid is not functioning the four-way valve will not operate the air cylinder.

Sonic Cleaning - Sonic energy from air-powered horns produces shock waves, which enhance dust removal from fabrics. Sonic cleaning is typically used in reverse-air application involving fiberglass bag.

Sortation Conveyor - A conveyor which is able to sort different packages or products to specific take-away lines. Link: see Sortation Conveyors.

Specific Gravity - The ratio of a mass of a unit volume of a substance to the mass of the same volume of a standard substance at a standard temperature. For gases, dry air at the same temperature and pressure as the gas is often taken as the standard substance.

Speed Reducer - A power transmission mechanism designed to provide a speed for the driven equipment less than that of the prime mover. They are generally totally enclosed to retain lubricant and prevent the entry of foreign material.

Spool Conveyor - A conveyor where power to the rollers is accomplished by o-rings driven by spools on a rotating shaft.

Spunbonded - A non-woven fabric formed by producing, laying and self-bonding a web of filament material in one continuous set of processing steps. Usually made of polyester, polyamides or olefins.

Spur - A conveyor section to switch unit loads to and from the mainline.

Staple Fiber - Short fiber cut to specific length in synthetics to either form yarns or nonwoven felts. The size, distribution and type of fibers used in filtration vary to suite process needs. Selecting the right combination is essential for maximum performance.

Support - Arrangement of members used to maintain the elevation or alignment of the conveyors. Supports can take the form of hangers, floor supports, or brackets and can be either stationary or portable.

Switch - (1) Any device for connecting two or more contiguous package conveyor lines; (2) An electrical control device.

Tail End - Usually the end of a conveyor nearest loading point.

Tail Pulley - A pulley mounted at the tail end of a conveyor, its purpose is to return the belt.

Take-Up - The assembly of the necessary structural and mechanical parts which provide the means to adjust the length of belt and chain to compensate for stretch, shrinkage or wear and to maintain proper tension.

Tangent - Straight portion after a curve conveyor.

Tapered Roller - A conical conveyor roller for use in a curve with end and intermediate diameter proportional to their distance from center of curve.

Tapered Roller Curve - A curved section of roller conveyor having tapered rollers.

Tensile Strength - A measure of the ability of yarn or fabric to resist breaking by direct tension.

Teratogen - Substances that affects the genetic coding of an organism such that birth defects occur in subsequent offspring.

Terminal Block - Electrical junction between sampler components and controller. Check for loose connection which could make sampler inoperable. Terminal block can be used as a testing point to determine whether proper signals from controller components are being received.

Thread count - The number of warp and filling yarns in a fabric.

Throughput - The quantity or amount of product moved on a conveyor at a given time.

Total Load - Amount of weight distributed over the entire length of a conveyor.

Tracking - Steering the belt to hold or maintain a desired path.

Traffic Cop - A mechanical or electrical mechanism to prevent collision of objects as they merge from two conveyor lines into a single line.

Transfer - A device or series of devices, usual- ly mounted inside a conveyor section, which uses belts, chains, o-rings, rollers, or skate- wheels, to move products at right angles to adjacent or parallel conveyor lines.

Trash Conveyor - A conveyor, normally a belt conveyor, equipped with high side guards, used in transporting empty cardboard boxes and paper trash away from working areas.

Tread Plates - Diamond top steel filler plates used to fill the gap between rollers on roller conveyor.

Tripod Support - Three legged stand for small roller and skatewheel conveyor. Usually easily moved or aligned to maintain elevation of the conveyor.

Troughed Bed - A conveyor designed with a deep trough used for carrying broken glass, cans, wood chips, stampings, etc. Also used in recycling operations. (TR, CRB)

Troughing Attachments - Angles used on belt conveyors to cup the edge of the belt.

Tube Sheet - The steel plate that bags are suspended from in a baghouse. Both the diameter and thickness are crucial data to ensure a dust tight seal.

Tubing - Sewing of fabric in the form of a tube when making a filter bag. Standard Filter is a world leader in this technology. View our process equipment here.

Turnbuckle - A link with a screw thread at both ends, used for tightening the rod, normally used in cross-bracing.

Turning Wheel - Wheel mounted on an adjustable bracket to help insure proper package orientation.

Turntable - A horizontal, rotatable conveyor mechanism used for transferring objects between conveyors which are in angular relation to one another. (90 degrees, 180 degrees, 360 degrees)

TWA - Acronym for Time Weighted Average. The allowable exposure level for a pollutant over a given time period (8-hour day or 40-hour workweek, etc.).

Two-Pulley Hitch - A special transition section for moving product from horizontal to incline.

Underside Bed Cover - Sheet metal used to cover the underneath side of a conveyor.

Underside Take-Up - A take-up section located beneath the bed of a belt conveyor.

Undertrussing - Members forming a rigid framework underneath the conveyor, used for supporting the conveyor.

Variable Speed - A drive or power transmission mechanism that includes a speed changing device. Standard mechanical variable speed ratios- 6:1 A.C. electrical variable speed ratio-10:1

V-Belt - A belt with a trapezoidal cross section for operation in grooved sheaves permitting wedging contact between the belt sides and groove sides.

Venturi - An air affect passage that gradually contracts to a smaller opening and expands again at a different rate thus causing acceleration of flow and gradient pressure change. Venturis are typically used in pulse-jet cages to enhance the pulse clean cycle. However they also restrict normal flow as well and add to system delta P.

VOC - Acronym for Volatile Organic Compound.

Warp - The yarn running lengthwise (machine direction) in a woven fabric.

Zero Pressure Accumulating Conveyor - A type of conveyor designed to have zero build-up of pressure between adjacent packages or cartons.