

# Sampling of Solids

## Sampling

- **Sampling** is the process of obtaining a representative **sample**  
(We can not analyze the whole thing!)
- A **sample** is the representative of the whole **bulk**. Its composition should closely reflect the composition of the bulk.
- Critical step in analysis as the significance and accuracy depends on sampling
- Sample can be solid, liquid, gas and heterogeneous or homogeneous
- **Homogeneous Sample:** A **grab sample** is often OK. For instance, in clinical lab, gross sample (blood, urine) can be analyzed directly as it is homogeneous.
- **Heterogeneous Sample:** Several individual samples are taken. E.g., analyzing average protein content of shipment of grains, one has to collect little grain from each bag during loading/unloading using a **sampling spear** (sack sampler) and combine to obtain a **gross sample**.

**Gross Sample** consists of several portion of the material to be tested

**Laboratory Sample** consists of a small portion of gross sample made homogenous

**Analysis Sample** is that which is actually analyzed

**Bulk of Material**

**Gross Sample**

(Few g to Kg)

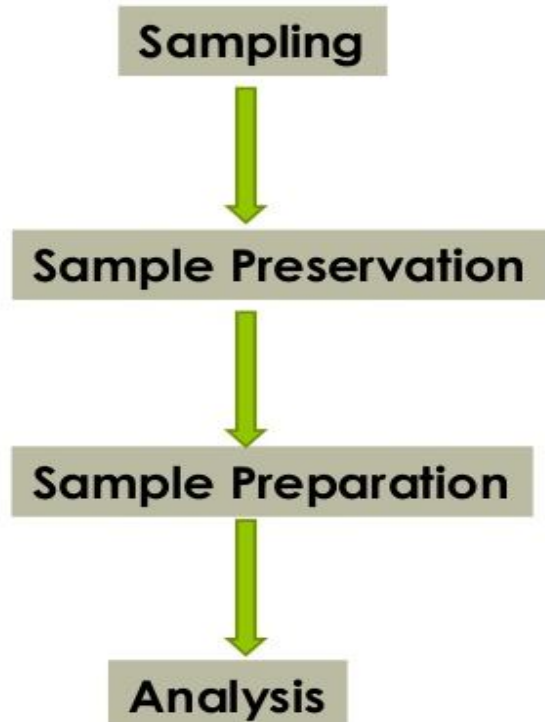
**Laboratory Sample**

(Few g)

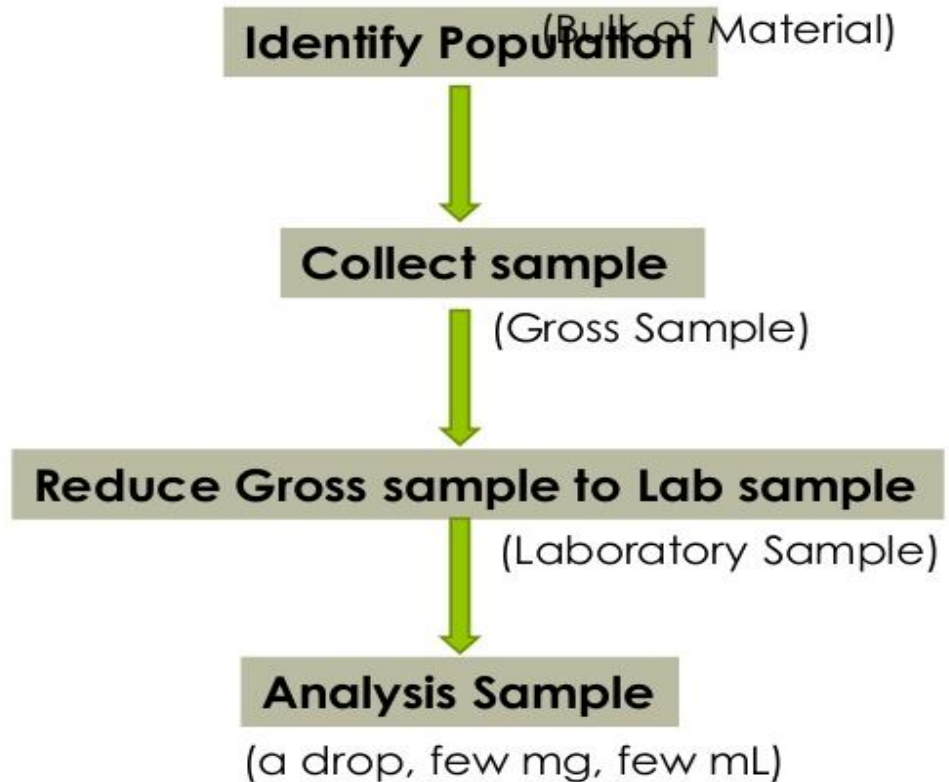
**Analysis Sample**

(a drop, few mg, few mL)

## Steps involved in a measurement process



## Steps involved in Sampling process



# Sampling of solids

- **Solid samples are often the most difficult to sample**  
(Inhomogeneous, variation of particle size, variation within particles)
- Solids are usually heterogeneous and samples must be collected carefully.
- Solids come in variety of forms, each of which is sampled differently.
  - Large particulates such as ores
  - Smaller particulates
  - Sheet material
  - Tissue samples

## Examples

## Grab Sample

- A *grab sample* is a sample taken at random and assumed to be representative.
- 1/50<sup>th</sup> of the total bulk
- Easiest but less reliable
- Satisfactory only for homogenous samples
- Best and easy time for sampling: during transportation





## Powder Thief

The Powder Thief is suitable for sampling free flowing powders and granules.

Operation:

1. Insert the sampler into the product, ensure that the tip is inside the sampler body.

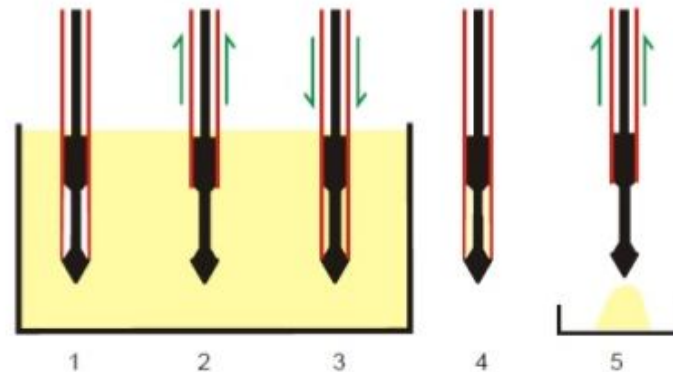
2. At the required depth pull up the body to expose the tip. Powder will flow in around the tip.

3. Push down body of the sampler to trap the sample.

4. Withdraw sampler.

5. Pull up body to release the sample.

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# Sampling of metals and alloys

- Samples of these materials are obtained by sawing , milling or drilling.
- When sampling a metal, it is usually necessary to obtain materials from both the surface and the interior.
- Wire.....cutting off pieces of appropriate length.
- Drilling can also be done.

# Sampling of biological tissues

- It is done by removing the entire organ which is then homogenized before smaller portions are taken for the analysis.
- Alternately small portions may be combined to form a composite sample.
- The composite sample is then homogenized and analyzed.



## REDUCTION OF SAMPLE SIZE

- Reducing particle size
- Sub-sampling of gross sample

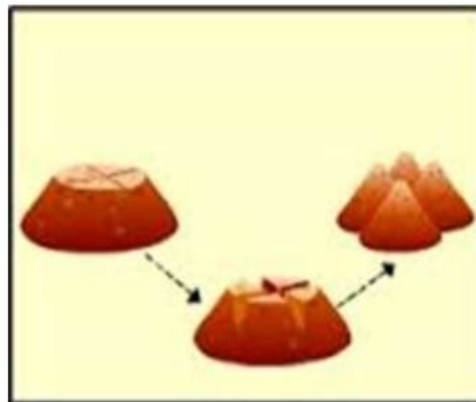


**Coning and quartering**

**Riffling**

### Coning and quartering

- Gross sample is piled as cone
- Flattened
- Divided into quarters
- Separation of quarters
- Discarding opposite quarters
- Process is repeated



### Riffling



**Rifle tank is used**

# Collection of sediment

- Bottom grab sampler is used.
- It has jaws that close when they are in contact with sediments, scooping up sediments in the process.
- Ease of use and ability to collect large samples.
- Disadvantages include tendency to lose fine grained sediments as water flows out of samples.
- Loss of spatial information both laterally and with depth due to mixing of samples.



# Collection of surface soil

- Soil samples collected at depths of upto 30 cm are easily collected with scoops or shovels.
- Even small containers of solid materials may be samples using spatula or scoops.



# Collection of soil at greater depth

- Soil samples collected at greater depth are obtained by digging a trench and collecting samples.
- Drill a hole till the required depth. Remove soil from the drill and analyze.



## Operation

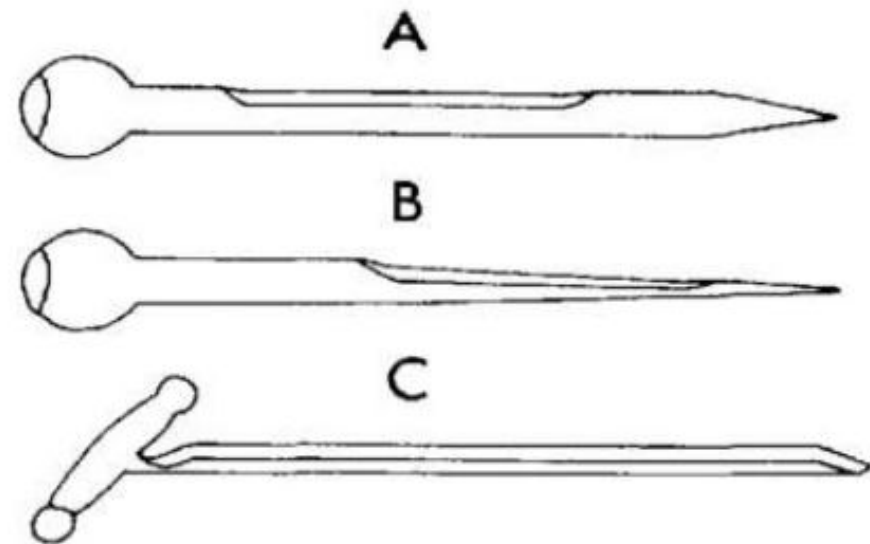
1. Push the sampler into the product
2. Rotate handle
3. Remove sampler
4. Use discharge rod to push sample out





# Sampling from bags

- Simple bag sampling spears (sack samplers) are most commonly used for taking samples from bags because they are relatively cheap and sample quickly.
- To obtain a good cross section of sample, the spear should be 40 to 45 cm in length.
- Tapered type of sampling spears penetrates bags easily.





# Sampling of powder

- Small particulate materials such as powder are best collected with a sample thief.
- Sample thief allow material to be collected simultaneously from several locations.



# Storage of Solids

There are two types of storage

- ▶ Outdoor storage
- ▶ Confined storage

## Outdoor storage:

- ▶ Coarse solid are stored outside in large piles ,when hundred or thousand of ton of material are involved.
- ▶ Out storage can be effected by environmental problem such as dusting or leaching of soluble material from the piles.
- ▶ Dusting is control by covering the piles
- ▶ Leaching can be control by covering or by locating it in a shallow basin .



Coal storage



Gravel storage

## Confined storage.

- Solids that are valuable and can be effected by the environment in out door piles are stored in Bin's, Hopper and Silo's



Silo's



Bin



# Silos

- ▶ Silo is a storage structure for storing bulk materials like storage of grain, coal, cement, food products etc
- ▶ Silo is tall and relatively small in diameter which is used for bin storage.

## TYPES OF SILO

- ▶ Cement storage silos
- ▶ Tower silo
- ▶ Low-oxygen tower silos
- ▶ Bag silos





# Cement storage silos

- ▶ There are different types of cement silos such as the low-level mobile silo and the static upright cement silo.
- ▶ The low-level silos are fully mobile with capacities from 10 to 75 tons.
- ▶ The static upright silos have capacities from 20 to 80 tons.
- ▶ These are considered a low-maintenance option .



Low level mobile  
silo's



Static upright  
cement silo's

## Tower silo

- ▶ Tower silos are cylindrical structures, typically 10 to 90 ft in diameter and 30 to 275 ft in height.
- ▶ Silos can be loaded and unloaded by using rail cars or conveyors.
- ▶ Silos storing grain, cement and woodchips.



## Bag silos

- ▶ Bag silos are heavy plastic tubes, usually around 8 to 12 ft in diameter, and of variable length as required for the amount of material to be stored.
- ▶ They can be used as a temporary measure when growth or harvest conditions require more space



## Low-oxygen tower silos

- ▶ Low-oxygen silos are designed to keep the contents in a low-oxygen atmosphere at all times, to keep the fermented contents in a high quality state, and to prevent mold and decay.
- ▶ Low-oxygen silos are only opened directly to the atmosphere during the loading.





## Storage of solids

- ❑ **Bulk storage**
- ❑ **Bin storage**

Bulk solids are stored in tanks, containers or silos, depending on quantity. The storage facilities must be designed such that they neither impair product quality nor cause disturbances to the removal of the bulk solids. Bulk solids do not behave like Newtonian fluids either when flowing or when at rest in storage.

## BULK STORAGE

- ❑ Coarse solids like coal and gravels ..... Outside in large piles
- ❑ Unprotected from the weather
- ❑ Most economical for large amount of material
- ❑ Solid can be removed from pile by dragline or tractor shovel and delivered to conveyer or process
- ❑ May lead to environmental problems
  - Dusting - avoided by providing protective cover
  - Leaching - avoided by providing protective cover or shallow basin





## BIN STORAGE

- ❑ Valuable or soluble solids
- ❑ cannot exposed in outdoor piles
- ❑ That solids are stored in bins, silos and hoppers.
- ❑ These are cylindrical or rectangular vessels of concrete or metal
- ❑ SILO: tall and relatively small in diameter
- ❑ BIN: not so tall and usually fairly wide
- ❑ HOPPER: small vessel with a sloping bottom for temporary storage before feeding

*All these vessels are loaded from top and discharged  
from bottom*

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## Bin Storage:

- ▶ A bin is typically much shorter than a silo, and is typically used for holding dry matter such as concrete or grain.
- ▶ Bins may be round or square,
- ▶ Round bins tend to empty more easily due to lack of corners,
- ▶ The stored material may be powdered, as seed kernels, or as cob corn.



Square Bins.



Round Bins





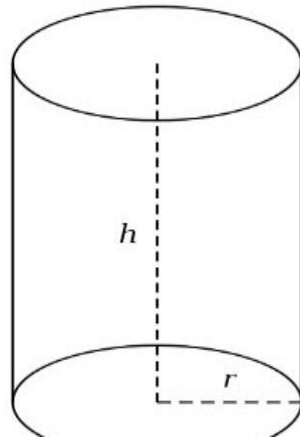
(a) 10 000 tonne steel grain storages, Australia



(b) Corrugated steel storage, Germany



(c) Rectangular concrete silo battery, Austria



(d) Old concrete and corrugated steel



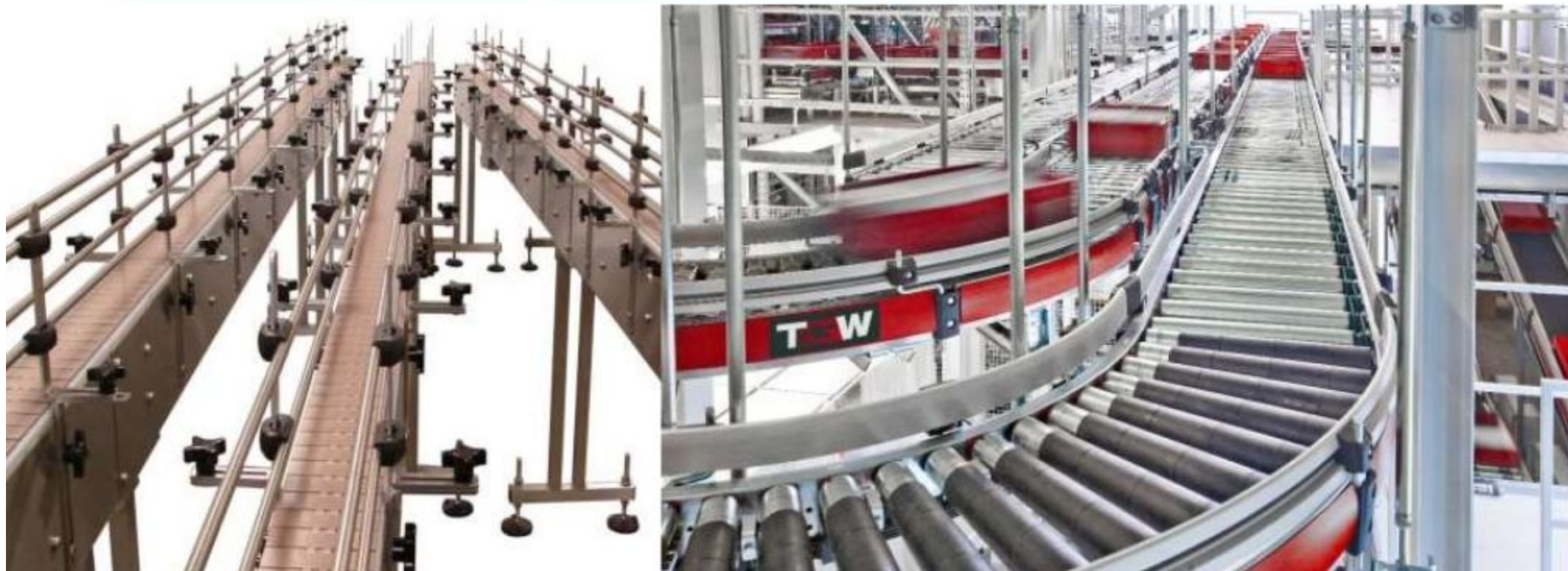
(e) Salt storage with



(f) FRP / concrete / FRP

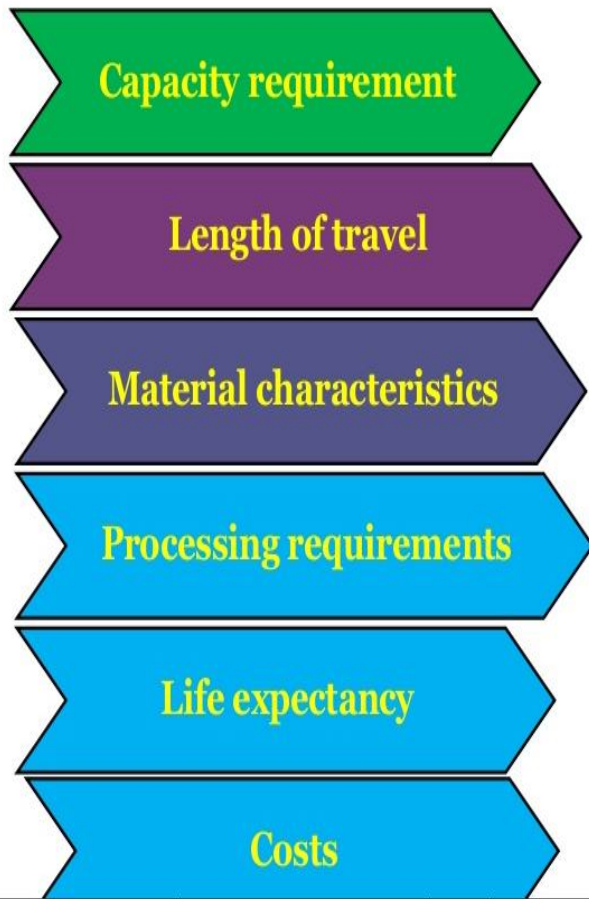
# CONVEYING SYSTEMS

A **conveyor system** is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials.





## Designing a Conveyor System



## MAIN ELEMENTS OF A CONVEYOR

Conveyor drive

Conveyor motor

Auxiliary Equipment

Control of Conveyors

# Types of Conveyors

Chute conveyor

Wheel conveyor

Roller conveyor

- Gravity roller conveyor
- Live (powered) roller

Chain conveyor

Flight chain

Apron chain

Closed belt

Slat conveyor

Continuous flow conveyor

Bucket conveyor

Vibrating conveyor

Screw conveyor

Pneumatic conveyor

Flat belt conveyor

Magnetic belt conveyor

Troughed belt conveyor



**Belt Conveyor**



# BELT CONVEYORS

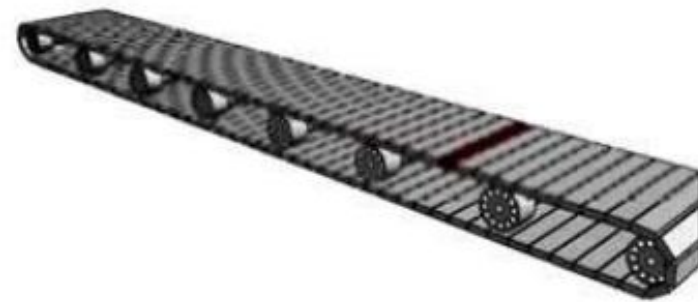
A belt conveyor is an endless belt operating between two pulleys with its load supported on idlers. The belt may be flat for transporting bagged material or V-shaped. The belt conveyor consists of a belt, drive mechanism and end pulleys, idlers and loading and discharge devices. On the belt conveyor baggage/ product lie still on the surface of belt and there is no relative motion between the product and belt. This results in generally no damage to material.



- One of the basic tools in material handling industry,
- Belt conveyors are most commonly used in transportation of bulk materials (grain, salt, coal, ore, sand, etc.).
- Capacity and ability-- It can travel for miles at speeds up to 5.08 m/s (1000 ft/min) and handle up to 4539 metric tons/h (5000 tons/h).

# Working principle

Belt conveyor is composed by two pulleys and a closed conveyor belt. The pulley that drives conveyor belt is called drive pulley ; the other one-only used to change conveyor belt movement direction-is called bend pulley. Drive pulley is driven by the motor ,. The drive pulleys are generally installed at the discharge end. Material is fed on the feed-side and landed on the rotating conveyor belt.



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# TYPES

## **Flat Belt :**

**A type of belt conveyor in which the carrying run of the conveyor belt is supported by flat belt or by a flat surface. They are suitable for low speed and low capacity**

## **Magnetic Belt:**

**A type of conveyor where either a magnetic slider bed or magnetic pulley is used to transport materials.**

## **Troughed Belt:**

**Troughed belt conveyor is that in which the belt forms a trough on the carrying side while running over the rollers which are either in set of 5 rolls, 3 rolls or 2 rolls. They are suitable for bulk quantity materials.**







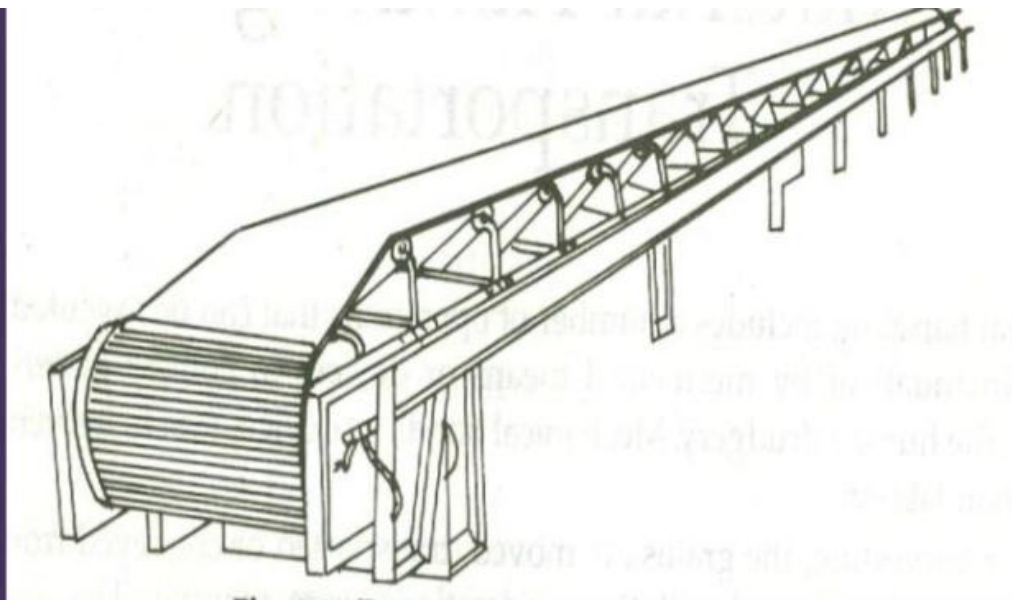


Diagram of a belt conveyor



- ✧ On the belt conveyor baggage/ product lie still on the surface of belt and there is no relative motion between the product and belt. This results in generally no damage to material.
- ✧ Belt can be run at higher speeds, so, large carrying capacities are possible.
- ✧ Horizontally the material can be transported to longer distance.
- ✧ The initial cost of belt conveyor is high for short distances, but for longer distances the initial cost of belt conveying system is low.



- ADVANTAGES OF BELT CONVEYORS

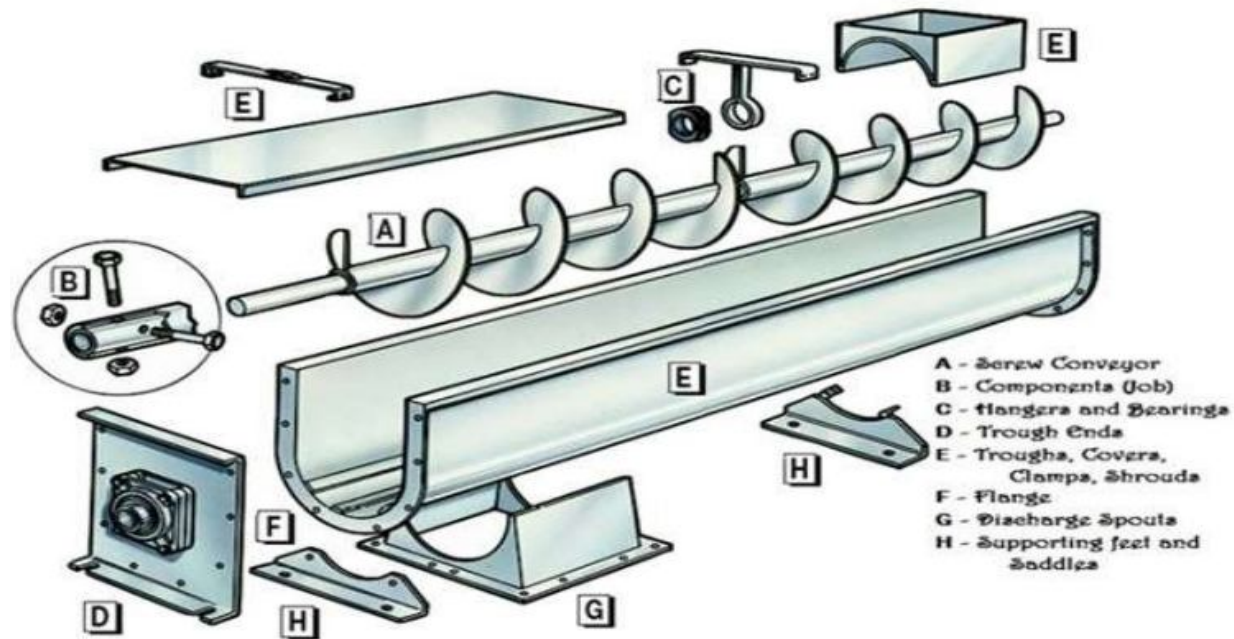
(a) Noiseless operation. (b) Large length of conveying path (c) Lower power consumption. (d) Long life. (e) Adaptability to different types of goods. (j) Ability to carry almost any bulk material (g) High reliability of operation. (h) Can transport material in any direction.

- LIMITATIONS OF BELT CONVEYORS

(a) Accumulation difficult (b) The loss of light weight bulk material carried away as dust (c) Continuous or periodic monitoring of belt is necessary (d) Heat affects the material of belt.

# Screw conveyor

One of the most widely used conveyors in the processing industry.



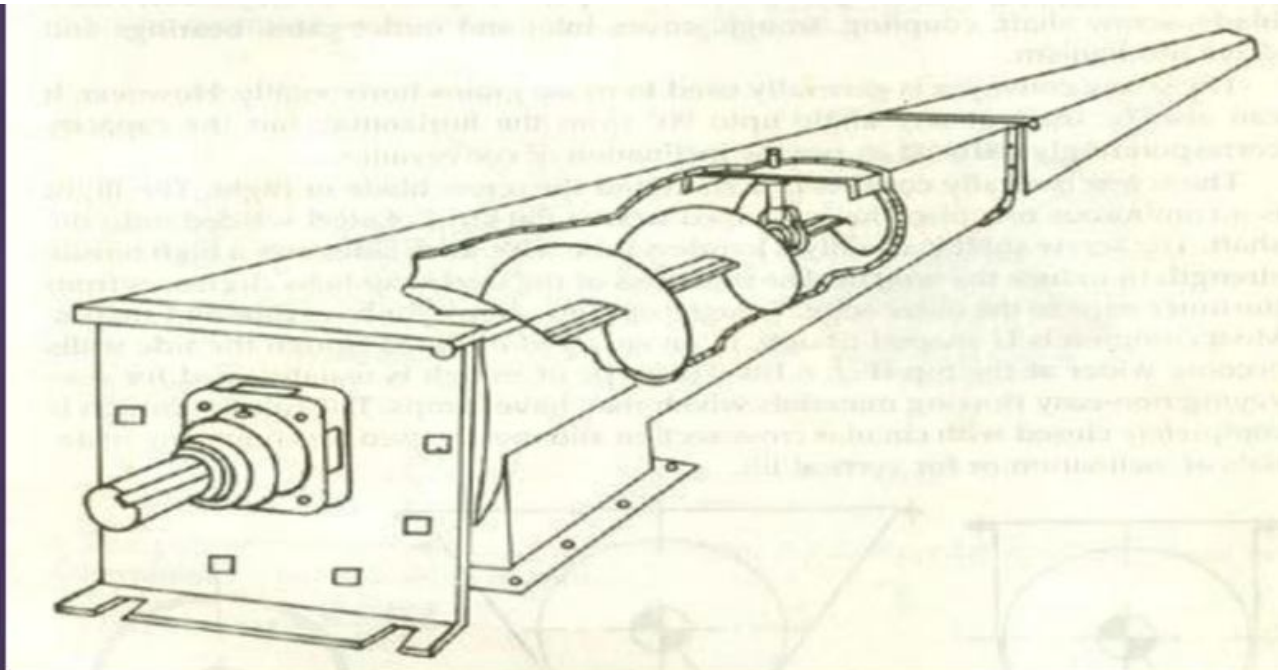




## SCREW CONVEYOR

The screw conveyor consists of a tubular or U-shaped trough in which a shaft with spiral screw revolves. The screw shaft is supported hanger bearings at ends. The rotation of screw pushes the grain along the trough. A typical screw conveyor is shown in the following Figure. The screw conveyor is used in grain handling facilities, animal feed industries and other installations for conveying of products generally for short distances. Screw conveyor requires relatively high power and is more susceptible to wear than other types of conveyors. The pitch of a standard screw which is the distance from the centre of one thread to the centre of the next thread is equal to its diameter. For example a 10 cm diameter screw has a pitch of 10 cm.

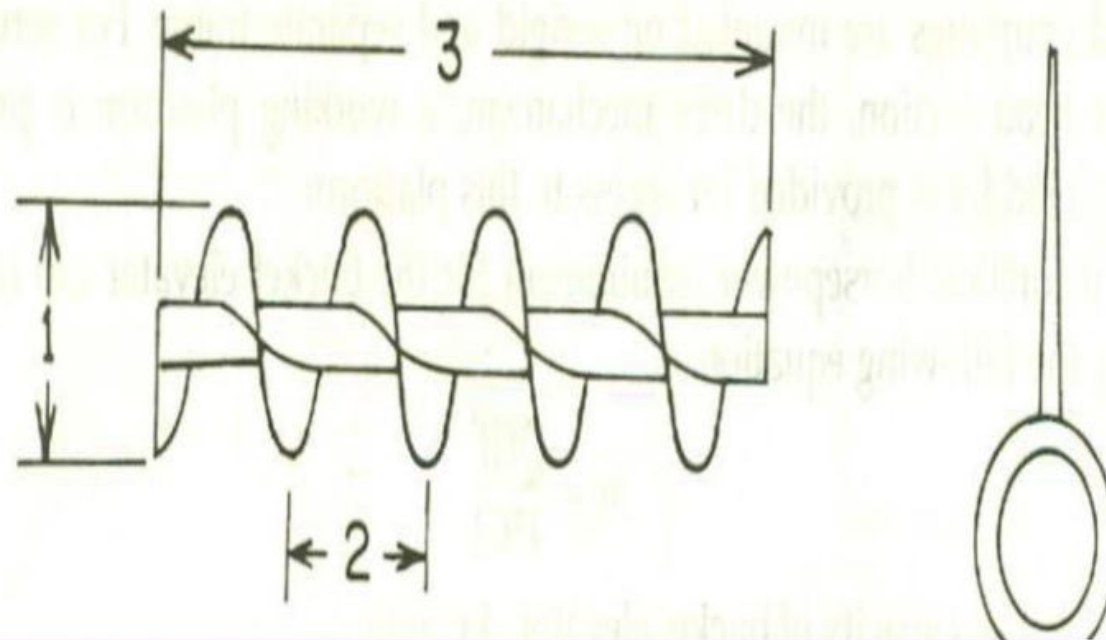




**Screw conveyor**

As the screw conveyor's driving mechanism is simpler, and no tensioning device is required, the initial cost of the conveyor is lower than any other conveyor with the same length and capacity.



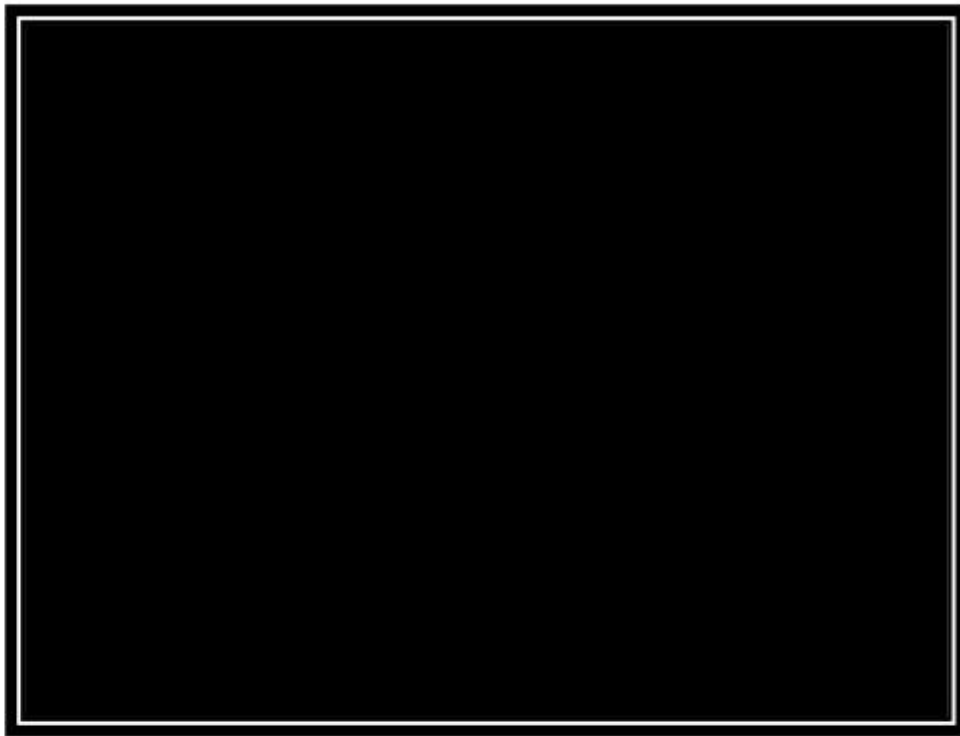


### Screw conveyor details

1. screw diameter 2. pitch of screw 3. screw length



# WORKING PRINCIPLE



- Consists of a tube or U-shaped stationary trough through which a shaft-mounted helix revolves to push loose material forward in a horizontal or inclined direction



# Screw-conveyor abilities

## **CAPACITY**

- generally limited to around 4.72 m<sup>3</sup> /min (10,000 ft<sup>3</sup> /h).

## **PROCESSING OPERATIONS**

- Screw conveyors operate using a continuous shaftless helicoid screw that moves almost any type of solid material through it.
- They typically operate on an incline and can transport up to 80 feet.
- Can convey up to 1,800 cfh.

## **Material design**

- In addition to a wide variety of designs for components, screw conveyors may be fabricated in materials ranging from cast iron to stainless steel.

## **Size**

- Standard sizes range from 2 in. to 8 in. diameter.

# ADVANTAGES

Screw conveyors are capable of handling a great variety of bulk materials from sluggish to free-flowing.

Screw conveyors can have multiple inlet and discharge points. Bulk materials can be conveyed and distributed to various locations as required. Slide gates or valves can be added to control the flow into and out of a screw conveyor.

Screw conveyors are totally enclosed to contain the product and prevent spillage. Screw conveyors can be utilized in the horizontal, vertical or any inclined position depending upon the characteristics of the product being conveyed.

Screw conveyors can be used to cool, heat or dry products in transit. Depending on the heat transfer requirements, a screw conveyor can be jacketed, or a hollow-flight design utilized to provide the necessary heat transfer for the application.

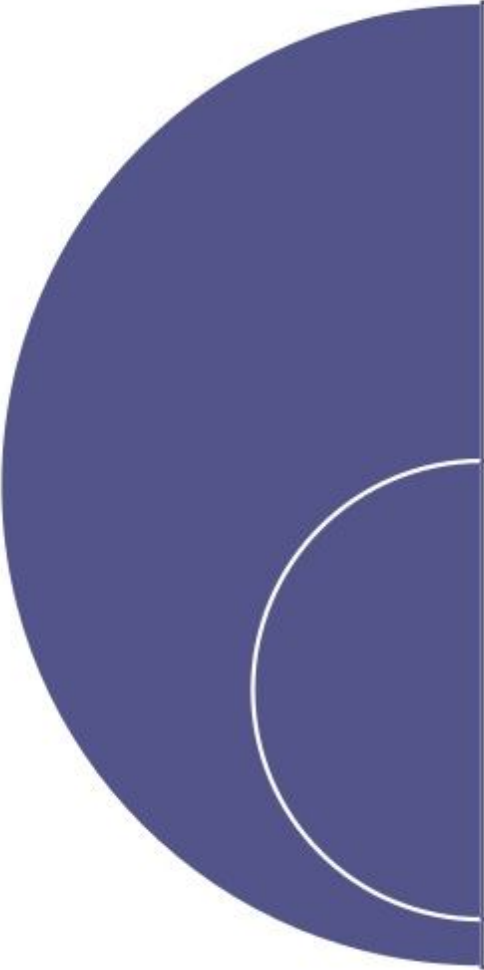
Screw conveyors can be designed to be vapor-tight or hold an internal pressure. This is very important when conveying toxic or hazardous products such as those in the chemical industry.

# Apron conveyor





# Design & Operation



Apron conveyors consist of endless chains with attached overlapping and interlocking plates to provide a continuous-carrying surface that forms a leakproof bed suitable for bulk materials without containers.

Their main application is the feeding of material at controlled rates, with lump sizes that are large enough to minimize dribble.

# Characterestics of apron chain conveyors

Exclusively used for transportation of heavy loads.

Apron conveyor speeds are typically 50-75 ft/min

They have high load-carrying capacity

The number of branches can be selected depending on the nature of the material being moved

Possibility of managing special requirements of the customers, such as the use of a different chain type, chain with carriers, etc.

# BUCKET CONVEYOR



- Bucket elevators are the simplest and most dependable units for making vertical lifts.
- They are available in a wide range of capacities and may operate entirely in the open or be totally enclosed.



# BUCKET ELEVATOR

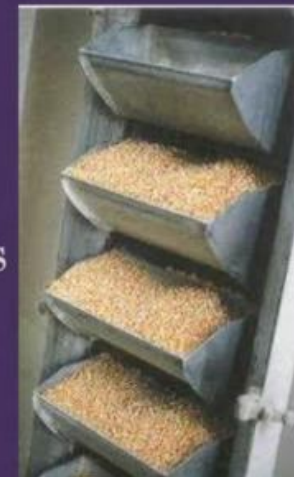
A bucket elevator consists of buckets attached to a chain or belt that revolves around two pulleys one at top and the other at bottom. The vertical lift of the elevator may range between few metres to more than 50 m. Capacities of bucket elevators may vary from 2 to 1000 t/hr. Bucket elevators are broadly classified into two general types, (1) spaced bucket elevators and (2) continuous bucket elevators.

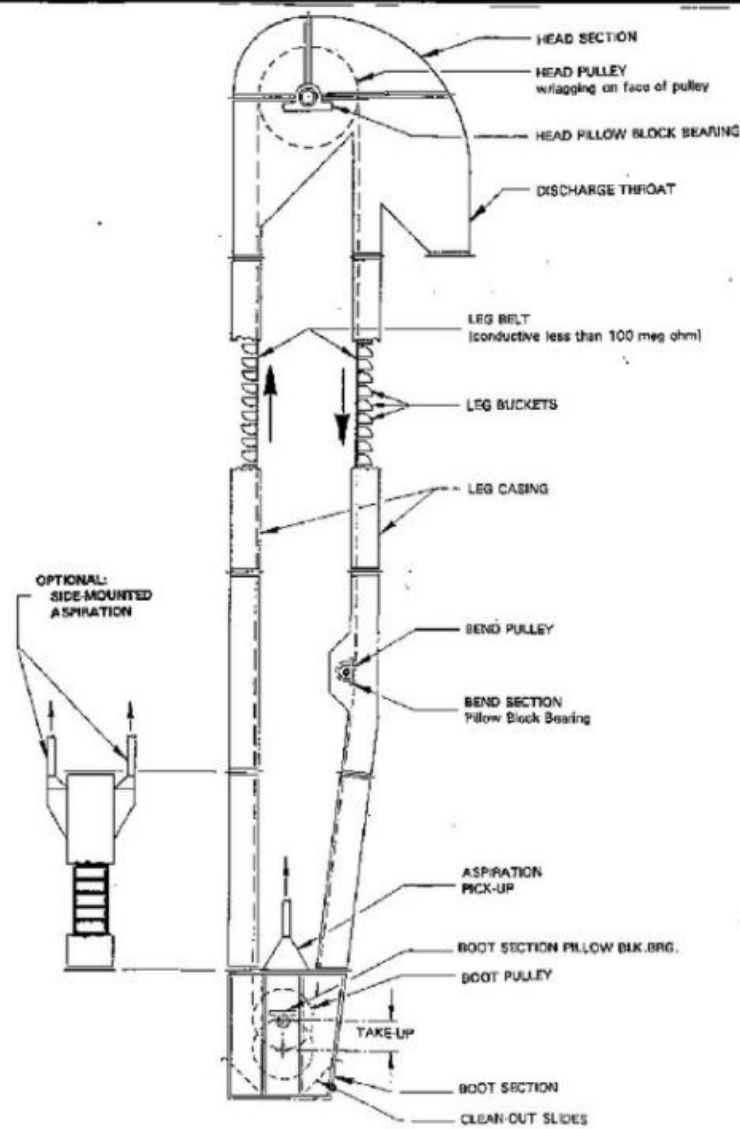
The spaced bucket elevators are further classified as,

- (1) centrifugal discharge elevators,
- (2) positive-discharge elevators,
- (3) marine leg elevators and
- (4) high-speed elevators.

The continuous bucket elevators are classified as

- (1) super capacity bucket elevators and
- (2) internal-discharge bucket elevators.





**Bucket Elevator**

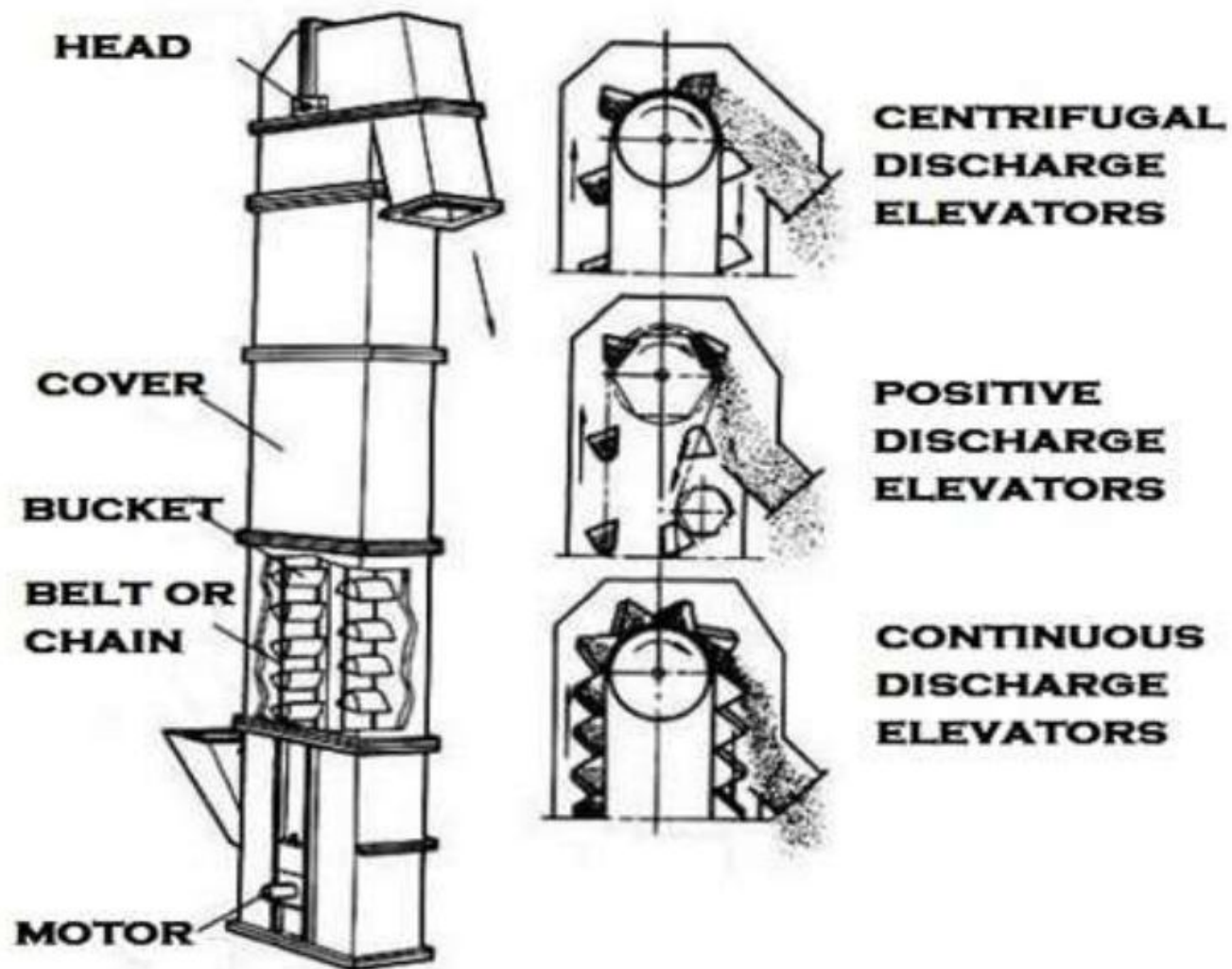
- ❖ The bucket elevator is a very efficient device for the vertical conveyance of bulk grains.
- ❖ Bucket elevators with belts are employed in food industries for vertical conveyance of grains, derivatives and flours.
- ❖ Bucket elevators are usually mounted at a fixed location, but they can also be mounted in a mobile frame.
- ❖ Bucket elevators have high capacities and it is a fairly cheap means of vertical conveyance.
- ❖ It requires limited horizontal space and the operation of conveying is enclosed in housing, thus it is dust free and fairly quite.
- ❖ The bucket elevator has limited wear problem since the product is enclosed in buckets.



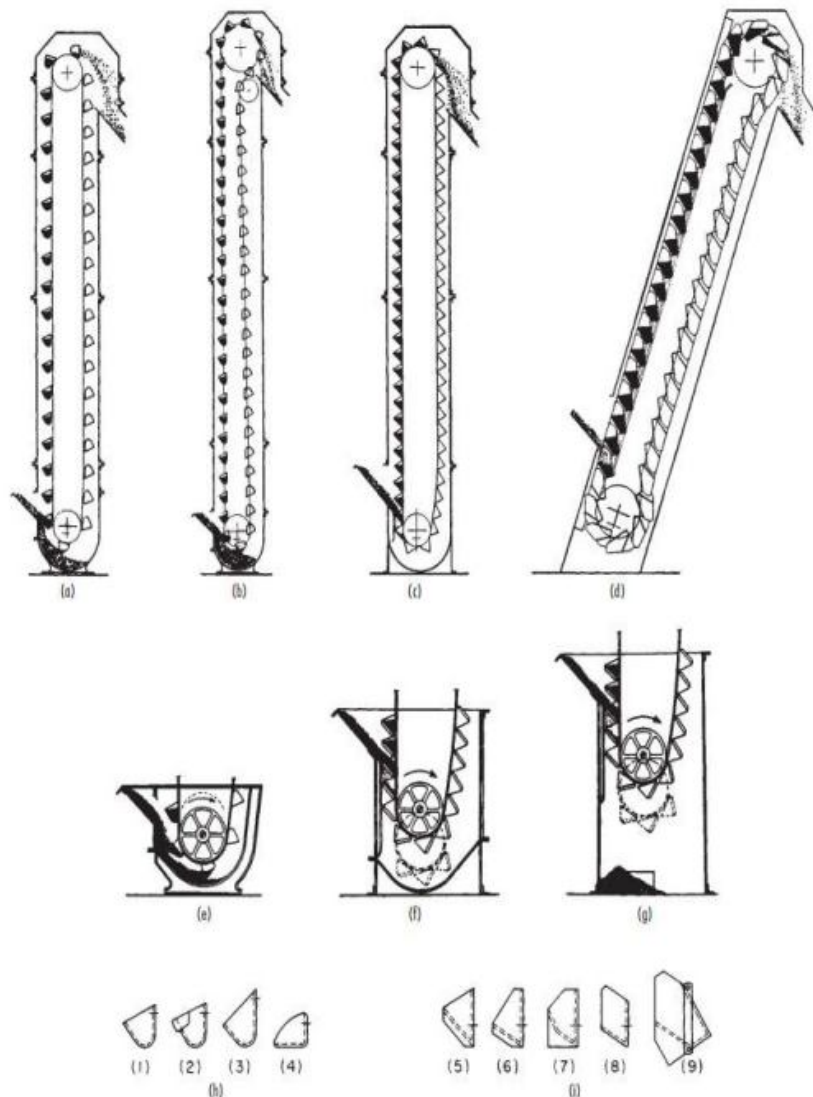


## WORKING

The product is fed into the moving bucket belt at a controlled rate in a similar manner to feeding a normal belt conveyor. At the end of the conveyor, the buckets are emptied by gravity into the discharge section.



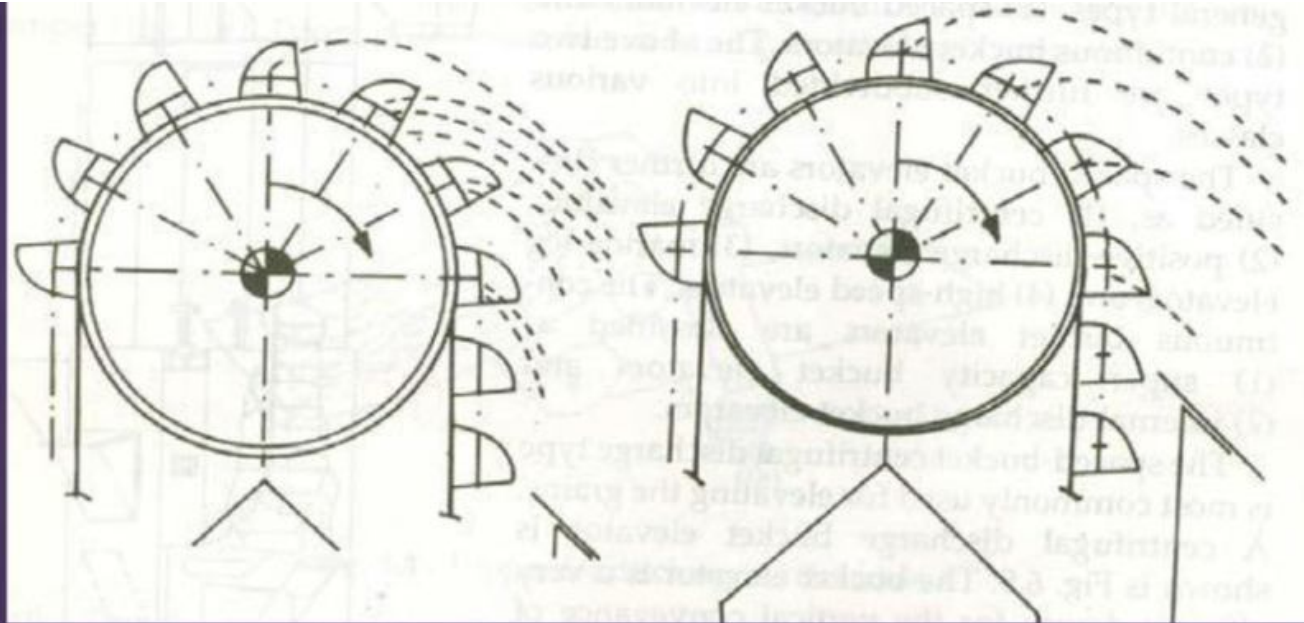
**TYPES OF BUCKET ELEVATORS**



**FIG. 21-5** Bucket-elevator types and bucket details. (a) Centrifugal-discharge spaced buckets. (b) Positive-discharge spaced buckets. (c) Continuous bucket. (d) Supercapacity continuous bucket. (e) Spaced buckets receive part of load direct and part by scooping from bottom. (f) Continuous buckets are filled as they pass through loading leg, with feed spout above tail wheel. (g) Continuous buckets in bottomless boot, with cleanout door. (h) Malleable-iron spaced buckets for centrifugal discharge. (i) Steel buckets for continuous-bucket elevators. (Stephens-Adamson Division, Allis-Chalmers Corporation.)

✧ The main parts of a bucket elevator are,  
 (1) elevator head section,  
 (2) elevator boot section,  
 (3) elevator legs,  
 (4) belts for bucket elevator and  
 (5) buckets.





### Bucket elevator's discharge methods

The bucket elevator's capacity mainly depends on bucket size, conveying speed, bucket design and spacing, the way of loading and unloading, the bucket and the characteristic of bulk material. Belt speed is the first critical factor to consider. Bucket elevators with a belt carrier can be used at fairly high speeds of 2.5 to 4 m/ s.

# ADVANTAGES

- The bucket elevators are used in most of the industries today for a variety of purposes. It has a huge transporting capacity with lower maintenance and better transportation facilities.
- These elevators are durable with low driving power. With the help of elevators, goods and materials can be transported smoothly and easily. Materials can be lifted to a great height with the help of these elevators.
- In addition to reliability, the bucket elevators have a wide range of lifting capabilities.

# CHAIN CONVEYOR

## ✧ Chain Conveyor

A chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission and conveyance systems. The function and uses of chain are similar to a belt. Chains are divided into five types based on material of composition or method of construction.

Cast iron chain

Cast steel chain

Forged chain

Steel chain

Plastic chain

