

**Control of particulates  
And  
gaseous pollutants**

Can be  
divided  
into four  
major  
groups:

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Gravitational settling  
chambers

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Cyclone separator

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Electrostatic Precipitators

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Fabric Filters



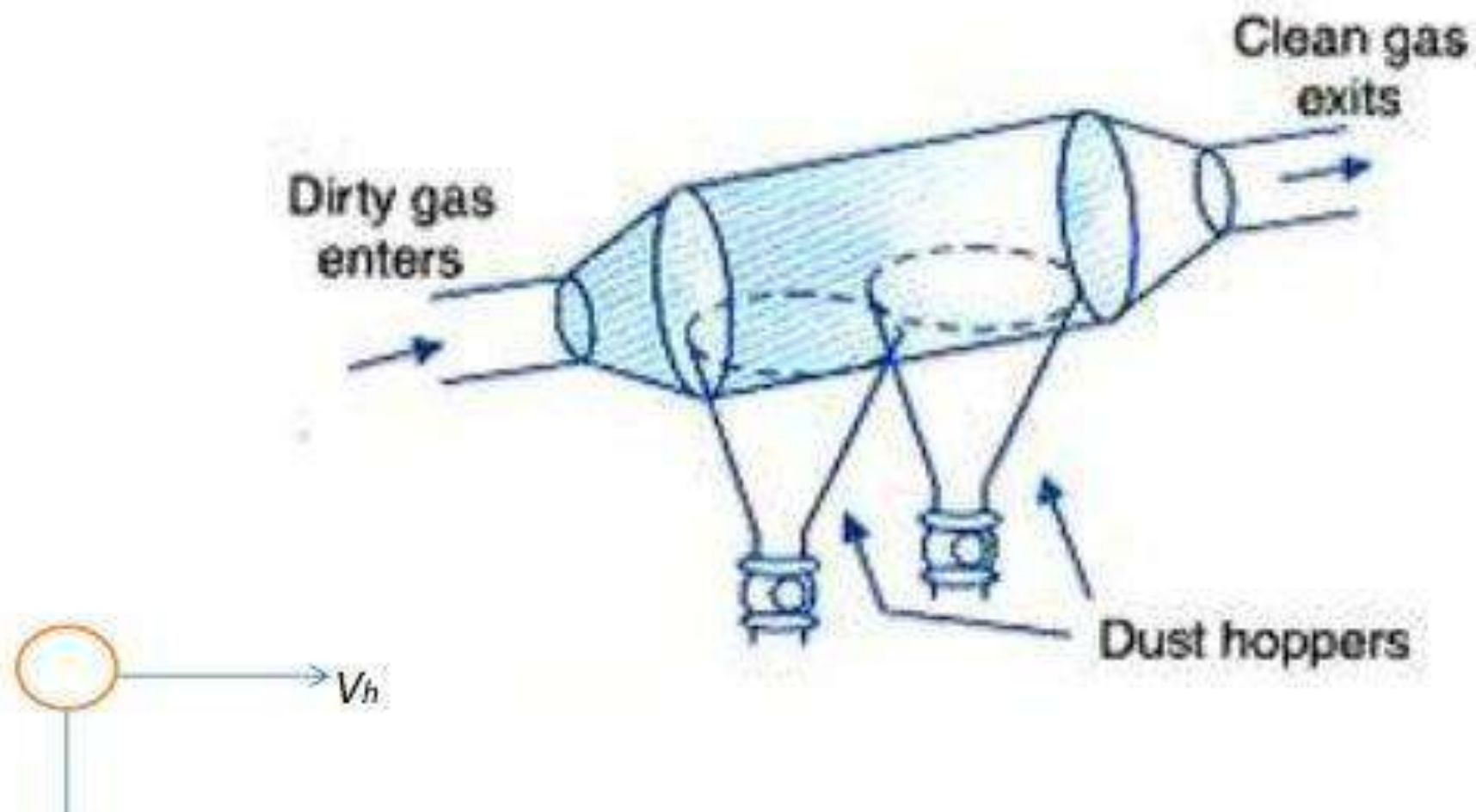
# Gravitational Settling Chambers

- Gravity settling chambers are the oldest and simplest means of removing suspended particles from a gas.
- In principle, pollutants are removed by reducing the velocity of the gas stream sufficiently to allow particles to settle out under the influence of gravity.
- The simplest chamber is merely a horizontal duct in which large particles settle out on the floor.
- High-efficiency settling chambers are often fitted with baffles or deflectors to change the gas flow direction.



# Gravity Settling Chamber

- Generally used as preliminary screening device.





- Provide enlarged areas to minimise horizontal velocities and allow particulates to settle out.
- Usual velocities through settling chambers is between 0.5 to 2.5m/s. for best results gas flow should be uniformly maintained at less than 0.3m/s.
- Usually effective for particles  $> 50$  micrometre.
- Some settling chambers are just enlarged conduits, while others have horizontal shelves and baffles, which shorten the settling path and thus improve removal efficiency.
- Simple in design and operation, but require relatively large space for installation and have relatively low efficiency, especially for removal of smaller particles.

## Advantages

- Low initial cost
- Simple construction
- Low maintenance cost
- Low pressure drop
- Dry and continuous disposal of solid particulates
- Can be constructed of almost any material

## Disadvantages

- Large space requirement
- Only comparatively larger particles can be controlled
- Unable to handle sticky materials

# Cyclone Separator

- Cyclone separators are gas cleaning devices that employ a centrifugal force generated by a spinning gas stream.
- To separate the particulate matter (solid or liquid) from the gas carrier.
- The operation depends upon the tendency (inertia) of particles to move in a straight line when the direction of stream is changed.

# Operating Principle:

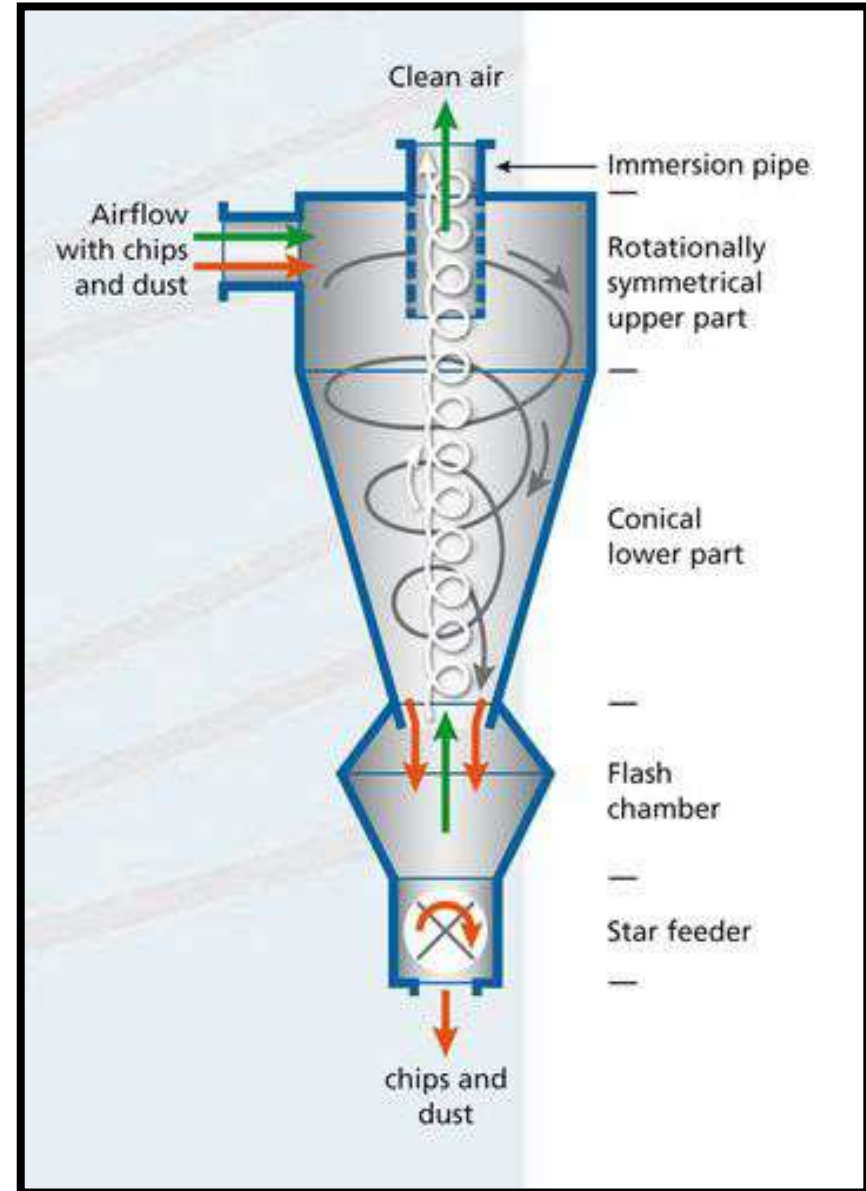
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- A cyclone collector usually consists of a cylindrical shell, conical base, dust hopper and an inlet where the dust laden gas enters tangentially.
- Under the influence of centrifugal force generated by the spinning gas, the solid particles are thrown to the walls of the cyclone.
- The gas spiral upward at the inside of the cone.
- The particles slide down the wall of the cone and into the hopper.
- The operating or separating efficiency of a cyclone depends on the magnitude of the centrifugal force, the greater the centrifugal force, the greater the efficiency.



# Operation

- The gas enters the top chamber tangentially spirals down to the apex of the conical section moves upward in a second, smaller diameter spiral, and exits at the top through a central vertical pipe.
- The solids move radially to the walls, slide down the walls, and are collected at the bottom.



- Two main types of cyclone separators:

**Axial:** The material enters from the top of the cyclone and is forced to move tangentially by a grate at the top.

**Tangential:** The material enters from an inlet on the side which is positioned tangentially to the body.

Cyclone Separator is used:

- For removal of dust particles from emissions from cotton gins, grain elevators, tractors, grain mixers, and other agricultural machinery.
- In the food industry for the separation of agglomerated particles for the separation of starch and protein.
- For cleaning flue gases from power plants.



# Advantages

- Large processing capacity per unit volume.
- The amount and time of slurry retention in the cyclone are small, and it is easy to handle when shutting down.
- Simple structure, light and flexible, no moving parts, and easy maintenance.
- Small footprint
- Low investment cost
- The size of the grit port can be adjusted.

# Disadvantages

- High power consumption
- Wear fast - In particular, the wear around the feed inlet and the sand settling inlet is the fastest and needs to be replaced.
- The fluctuation of feed pressure, feed quality, and feed particle size has a greater impact on the working indicators of the cyclone.

# Electrostatic Precipitator

- ❖ *An electrostatic precipitator (ESP) is a filtration device that removes fine particles, like dust and smoke, from a flowing gas using the force of an induced electrostatic charge.*
- ❖ *It works on the principle of electrical charging of particulate matter(-Ve) and collecting it in a (+Ve) charged surface.*
- ❖ *It can remove particle size range of 0.1mm to 1mm.*
- ❖ *Major components:*
  - A source of high voltage.
  - Discharge electrodes and collecting electrodes.
    - Inlet and outlet for gas.
  - A hopper for disposal of collected material.
    - An electronic cleaning system.



# Types Of Electrostatic Precipitator

- **On the basis of structure and design**
  - Tubular
  - Plate
- **On the basis of method of charging**
  - Single stage
  - Double stage
- **On the basis of removal of particles**
  - Wet
  - Dry

## Tubular

- # It consist of cylindrical collection electrodes with discharge electrodes located in the center of cylinder.
- # Charged particles collected on inside walls of the tube.
- # Collected particles removed by washing the tubes with water sprays.

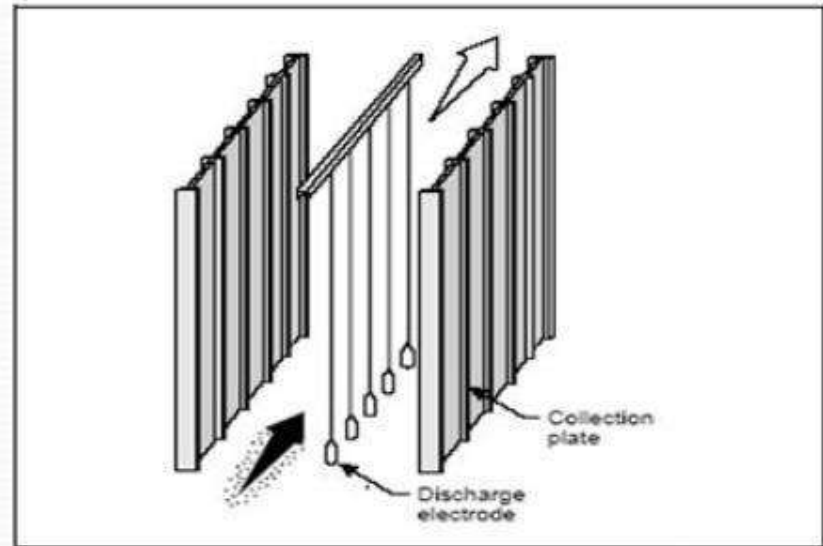
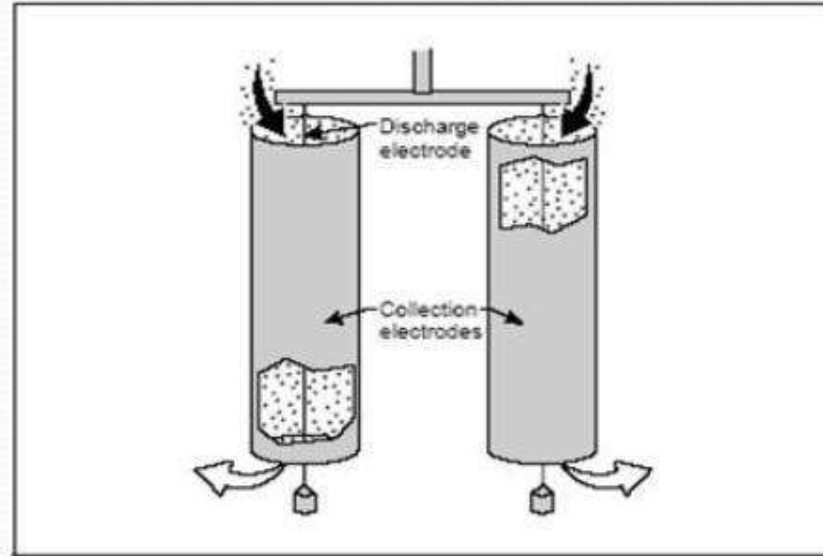
## Plate

- # Plate ESP have rigid frame , or plate discharge electrodes.
- # Dirty gas flows into a chamber consisting of discharge electrode along with collection plates.
- # Charged particles collected on plates as dust , which is removed by rapping and water sprays.



# Tubular precipitators

# Plate precipitators

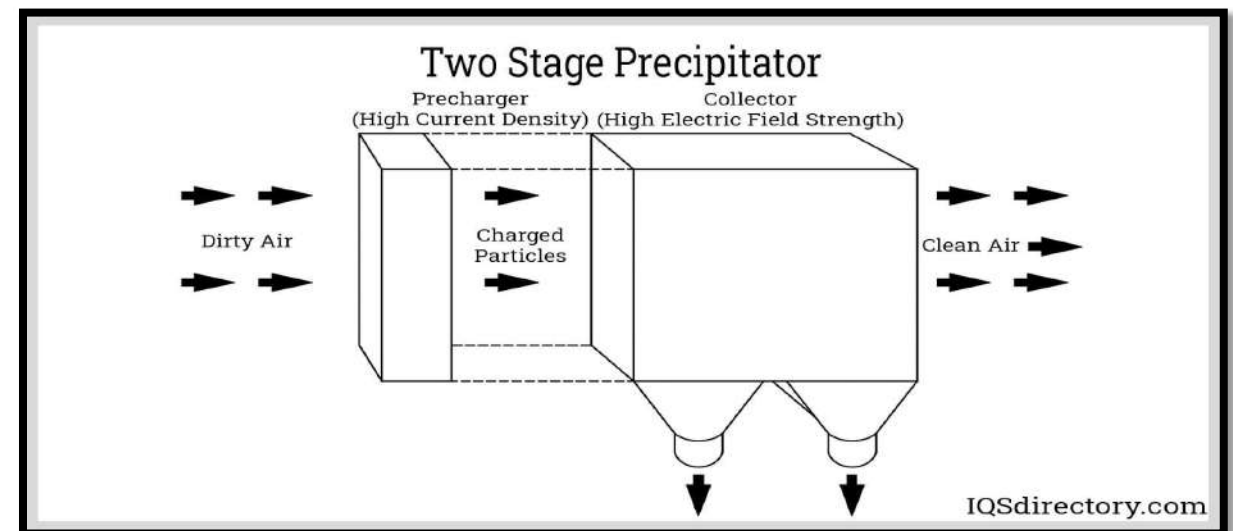


## Single stage precipitators

- Single stage gas ionization and particulate collection in a single stage.
- Single stage for more heavily loaded gas streams.

## Two stage precipitators

- Two stage particles ionized in first chamber and collected in second chamber.
- Two stage used for lightly loaded gases.

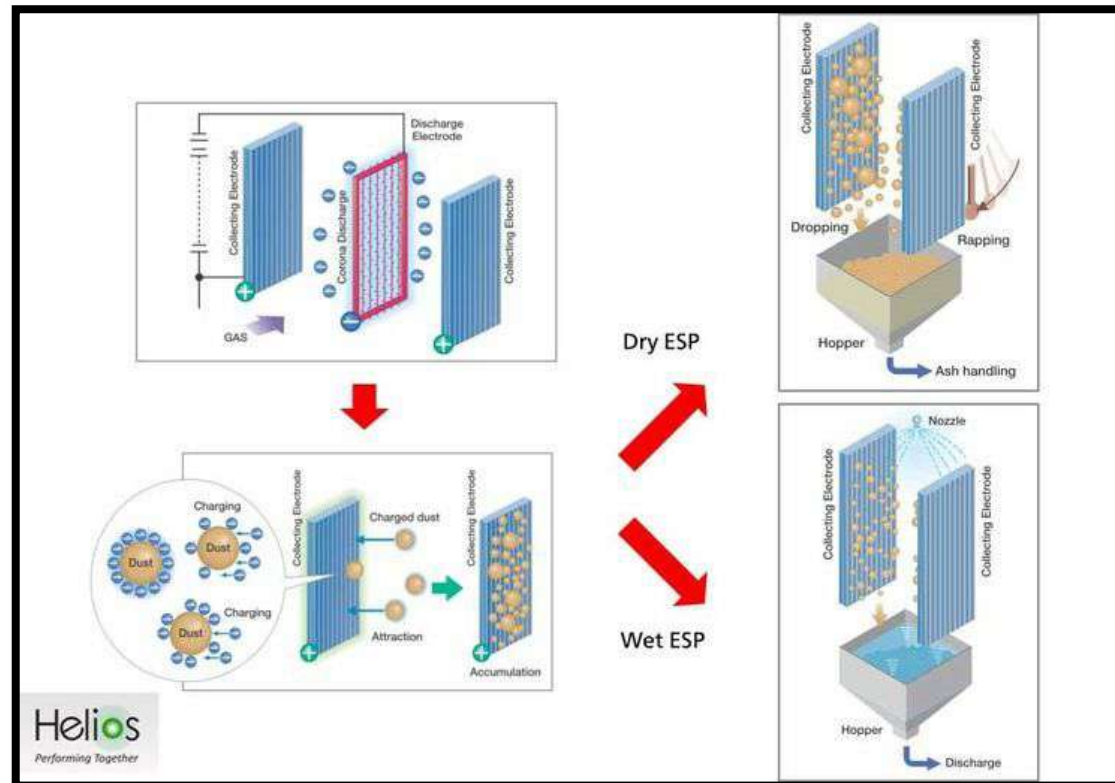


# Wet

- These are used where the potential for explosion is high or when dust is very sticky, or has high resistivity.
- In a circular plate wet ESP, the circular collection plates are sprayed with liquid continuously.

# Dry

- The term dry is used because particles are charged and collected in a dry state and are removed by rapping.

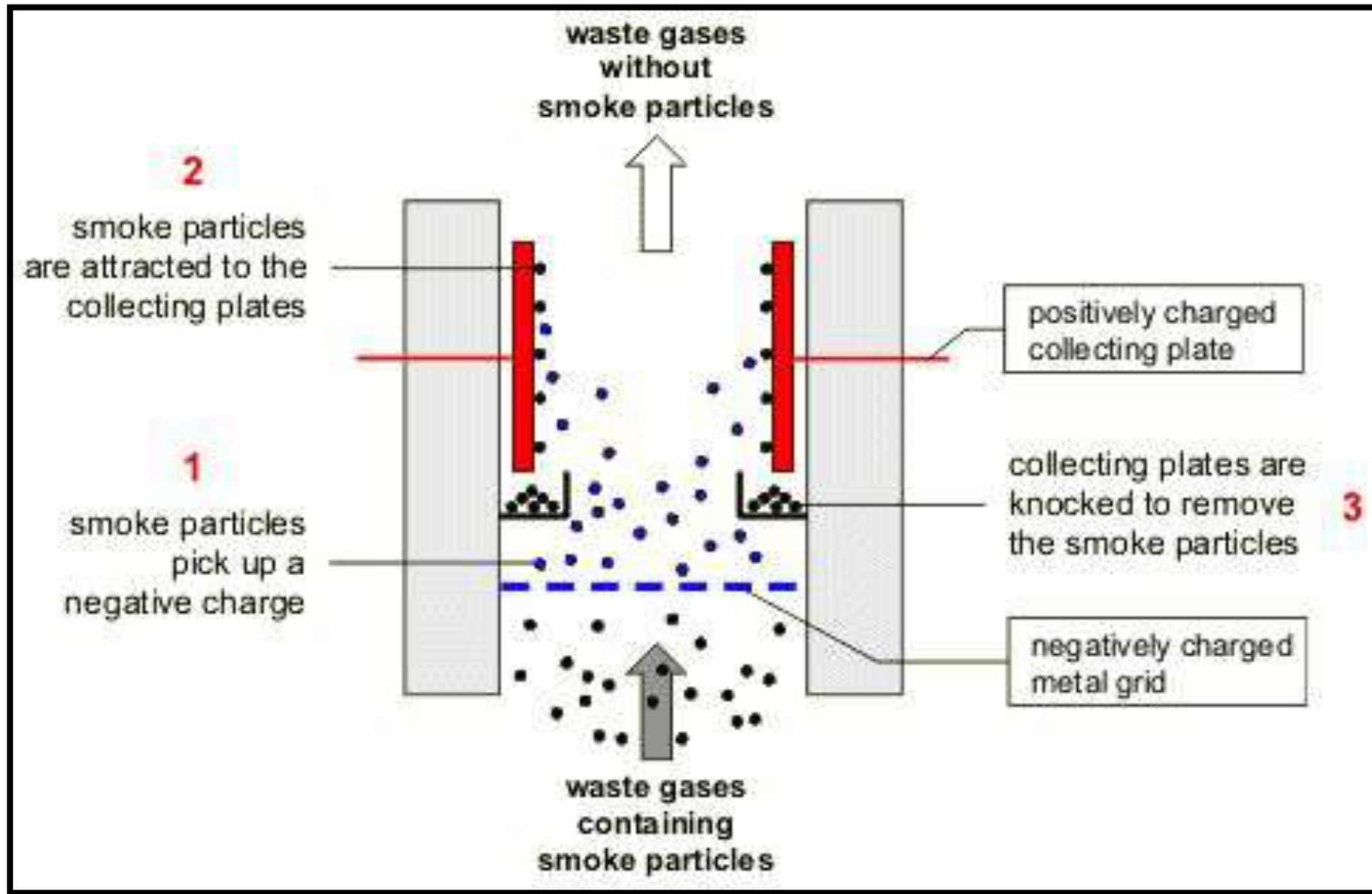


# Working Of Electrostatic precipitator:

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- ✓ Electrostatic smoke precipitators work by forcing dirty flue gas (the gas escaping from a smokestack) past two electrodes, which take the form of metal wires, bars, or plates inside a pipe or smokestack.
- ✓ The first electrode is charged to a very high negative voltage. As the dirt particles move past it, they pick up a negative charge. Higher up the pipe (or further along, if it's a horizontal pipe), there's a second electrode consisting of metal plates charged to a high positive voltage.
- ✓ Since unlike charges attract, the negatively charged soot particles are attracted to the positively charged plates and stick there.
- ✓ From time to time, the collecting plates have to be shaken to empty away the soot; that can be done either manually (by someone brushing them clean) or automatically (by some kind of automated shaking or brushing mechanism in a process called rapping).





**Electrostatic Precipitator**

# Application of ESP:



Cement  
factories



Pulp and paper  
mills



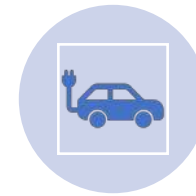
Steel plants



Chemical  
industry



Petroleum  
industry



Electric power  
industry

# Bag Filter

- It is an air pollution control device and dust collector that removes particulates or gas released from industrial processes out of the air.
- Also called bag house filter, bag filter, or fabric filter.
- **Applications:**
  - Steel plants
  - Power plants
  - Chemical producers
  - Pharmaceutical producers
  - Other industrial companies



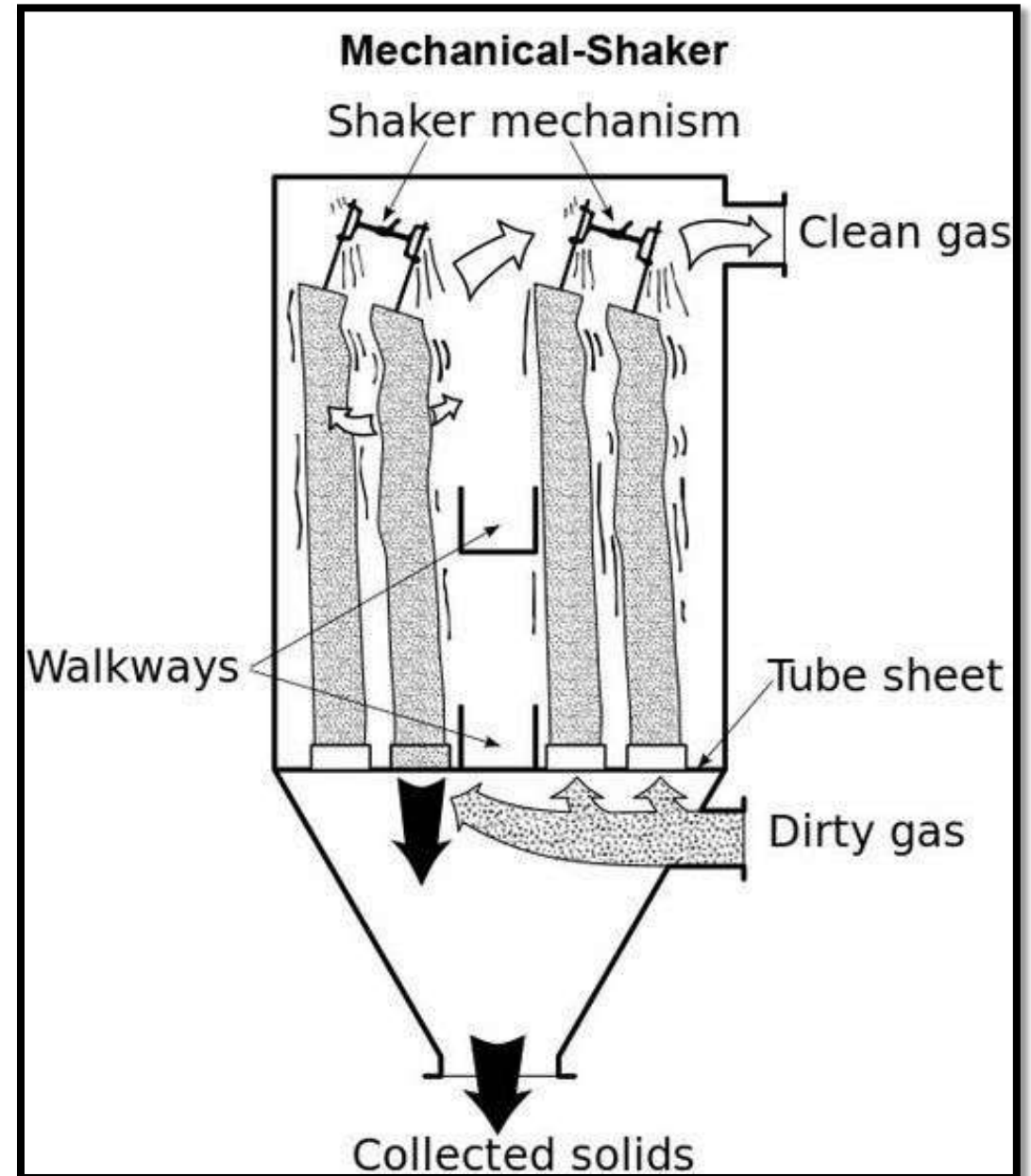
Bag Filter

# Mechanism of bag filter:

- Cleaning mechanism involves:
  - 1) Shaking mechanism
  - 2) Reverse air system

## 1) Shaking Mechanism:

- ~ Cleaning via a shaking mechanism is the oldest method
- ~ involves the filter fabric being shaken back and forth.
- ~ Vibration produced by a motor-driven shaft and creates waves in the bags to shake off the dust cake.

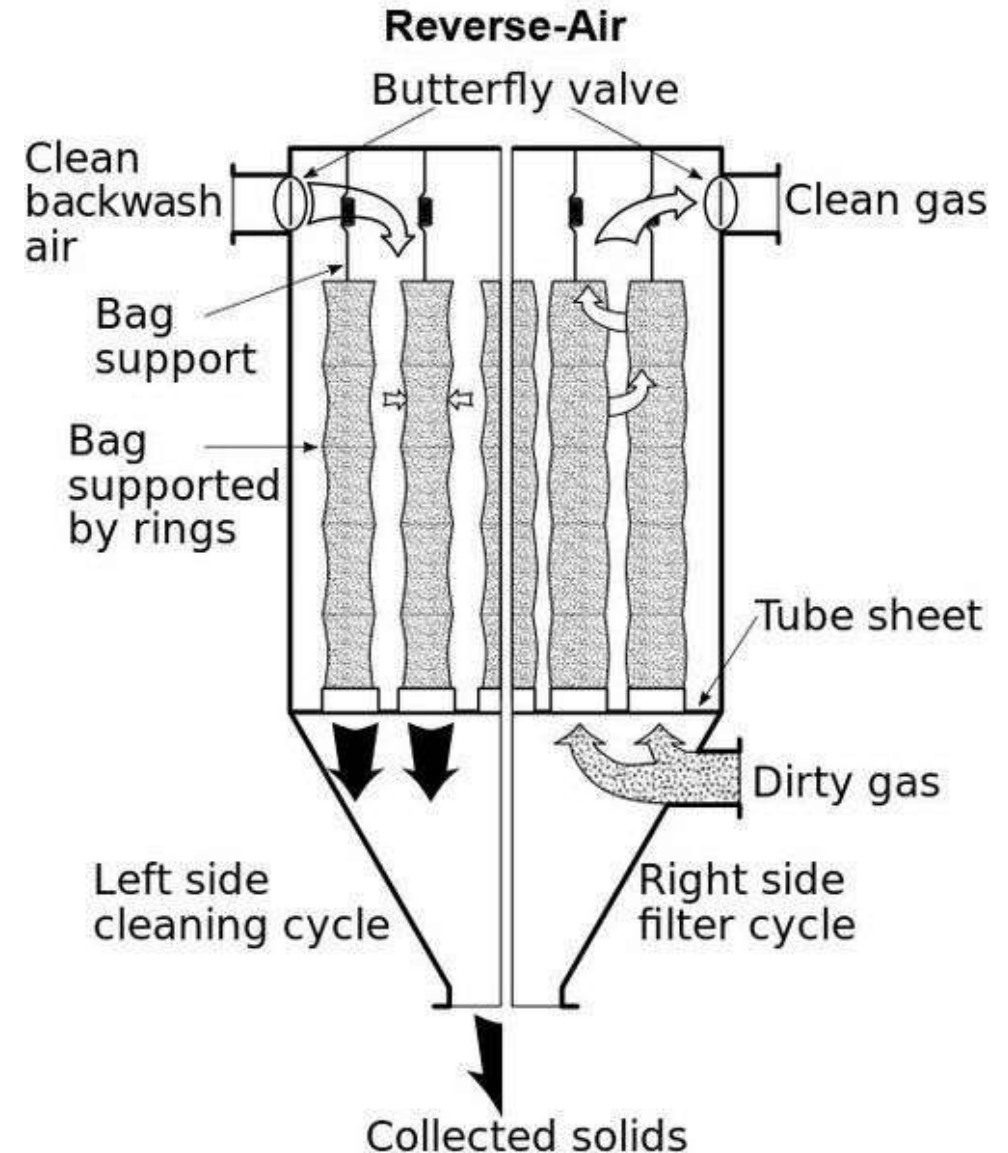




## 2) Reverse air system:

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- In reverse-air bag-houses, the bags are fastened onto a cell plate/tube sheet at the bottom of the baghouse and suspended from an adjustable hanger frame at the top.
- Dirty air flow from inlet & passes through the bags from inside & dust collect on inside of bags.
- Bags are cleaned by injecting clean air into the dust collector in a reverse direction, which pressurized the compartment.. The pressure makes bags collapse partially, causing the dust cake to crack and fall into the hopper below.. At the end of the cleaning cycle, reverse airflow is discontinued, and the compartment is returned to the main stream.



# Advantages of Bag Filter:

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- Fabric filters in general provide high collection efficiencies on both coarse and fine (submicron) particulates
- They are relatively insensitive to fluctuations in gas stream conditions.
- Operation is relatively simple
- Unlike electrostatic precipitators, fabric filter systems do not require the use of high voltage, therefore, maintenance is simplified and flammable dust may be collected with proper care
- Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators
- Fabric filters therefore may be good candidates for collecting fly ash from low sulfur coals or fly ash containing high unburned carbon levels, which respectively have high and low resistivities, and thus are relatively difficult to collect with electrostatic precipitators.

# Disadvantages Of Bag Filter:

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- Fabric life may be shortened in the presence of high acid or alkaline atmospheres, especially at elevated temperatures.
- Maximum operating temperature is limited to 550 degrees Fahrenheit, unless special fabrics are used.
- Condensation of moisture can lead to fabric plugging, loss of cleaning efficiency .
- Fabric bags tend to burn or melt readily at temperature extreme.