INDUSTRY AND ENVIRONMENT

PROF. MAIE ELGAMMAL

AIR POLLUTION CONTROL

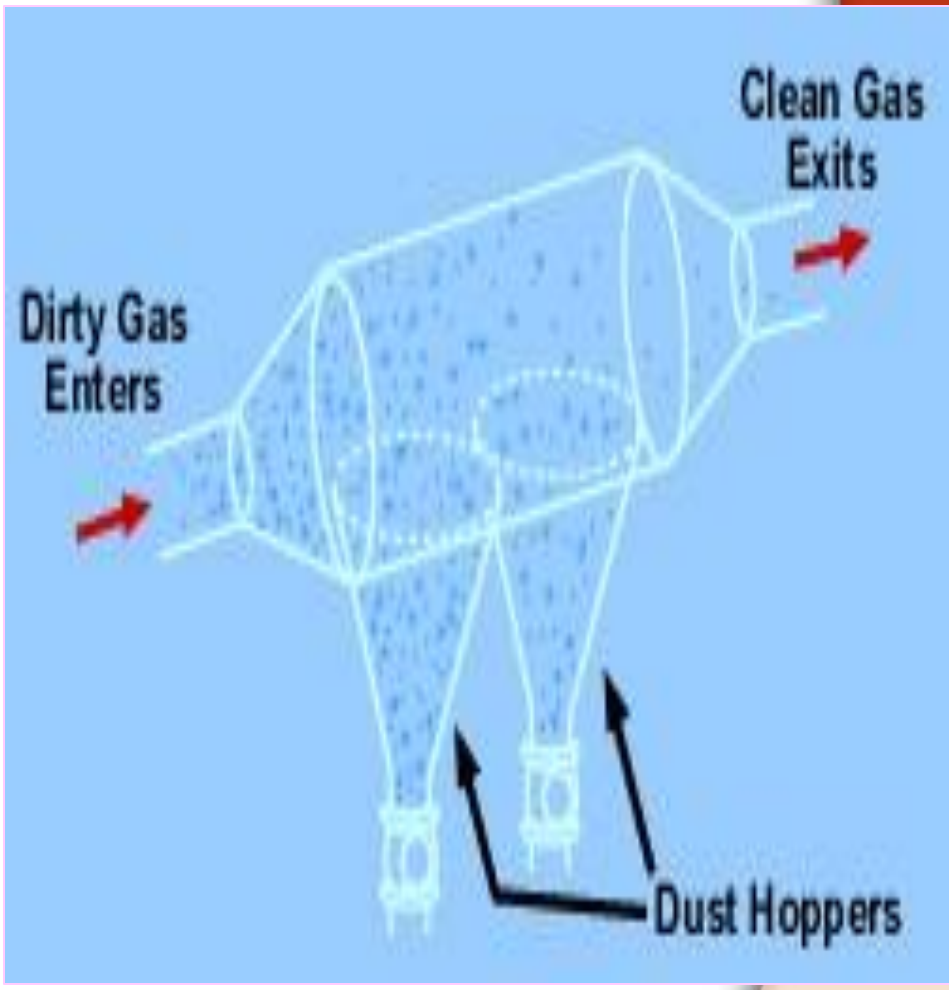
Principles of controls

CONTROL OF PARTICULATE-PHASE POLLUTANTS

Settling Chambers

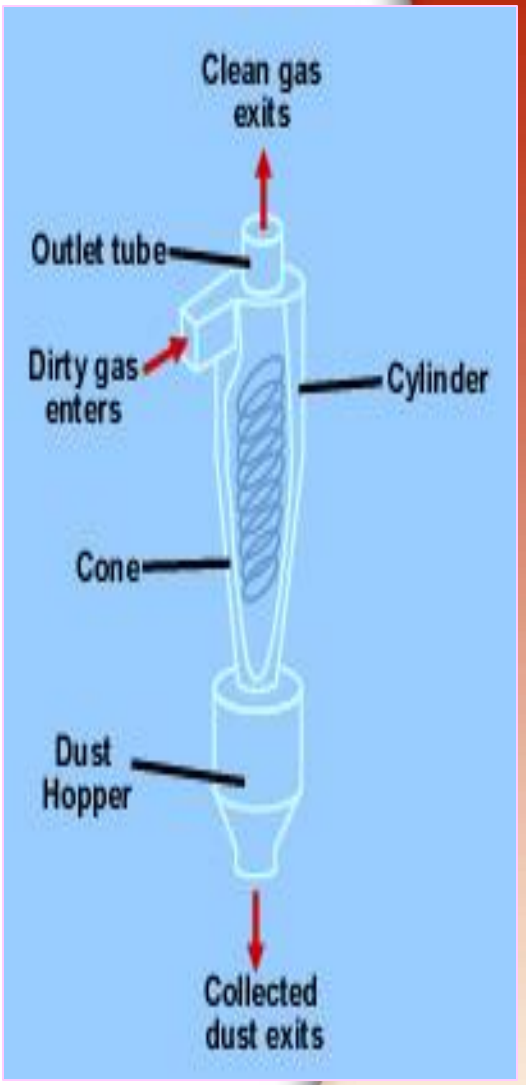
Settling chambers use the force of gravity to **remove solid particles.**

The gas stream enters a chamber where the velocity of the gas is reduced. Large particles drop out of the gas and are recollected in hoppers. Because settling chambers are effective in removing only larger particles, they are used in conjunction with a more efficient control device.



Cyclones

- Cyclonic systems are widely used particle collectors.
- They employ principle of inertial separation to remove particles from waste streams.
- The general principle of inertia separation is that particulate-laden gas is forced to change direction. As gas changes direction, the inertia of the particles causes them to continue in the original direction and be separated from the gas stream.
- The walls of the cyclone narrow toward the bottom of the unit, allowing the particles to be collected in a hopper.



- They consist of **multiple tubular collecting bags** suspended inside housing.
- **Single housing**, called bag house, may contain several hundred to several thousand bag filters.
- **Bags** are made from variety of **fibrous materials**. Fabric choice depends on temperature, moisture, and chemical composition of waste gas, as well as the physical and chemical nature of particles collected
- Filter bags are made of woven and nonwoven materials
- Glass fiber bags are used for high temperature or high-corrosion-potential gas cleaning.

Wet Scrubbers

- Scrubbers use liquid stream to remove solid particles.
- Scrubber designs vary from one manufacturer to another.
- All scrubbers have two basic components: (1) liquid-gas contact occurs (2) wetted particles are removed.
- Particles in scrubbers come in contact with liquid droplets to form particle-liquid agglomerate are removed by inertial
- In venturi scrubber, gas laden with particulate matter passes through short tube with flared ends and constricted middle.

Electrostatic Precipitators (ESPs)

- Widely used as particle collecting systems, where **waste gas streams** have large, steady volumetric flow rates.
- To remove fly ash from high-S-coal-using power plants, (H_2SO_4) mist and metal oxides and metallurgic in ferrous & nonferrous metal processes
- ESP is particle control device that uses electrical forces to move particles out of flowing gas stream and onto collector plates.
- **Electrostatic precipitators** remove solid or liquid particles from waste gases passing through electrical field where negative ions are produced from high voltage wires or plates and imparted to entrained particles.
- Negatively charged particles are then collected on positively charged collection plates.

- Particles are removed from plates by "rapping" and collected in hopper located below unit.
- Removal efficiencies for ESPs are highly variable; however, removal efficiency is about 99% for very small particles alone.
- **Electrostatic precipitators** are used in utility applications and other industries (other exhaust gas particles) such as cement (dust), pulp & paper (salt cake & lime dust), petrochemicals (sulfuric acid mist), and steel (dust & fumes).

CONTROL OF GAS-PHASE POLLUTANTS

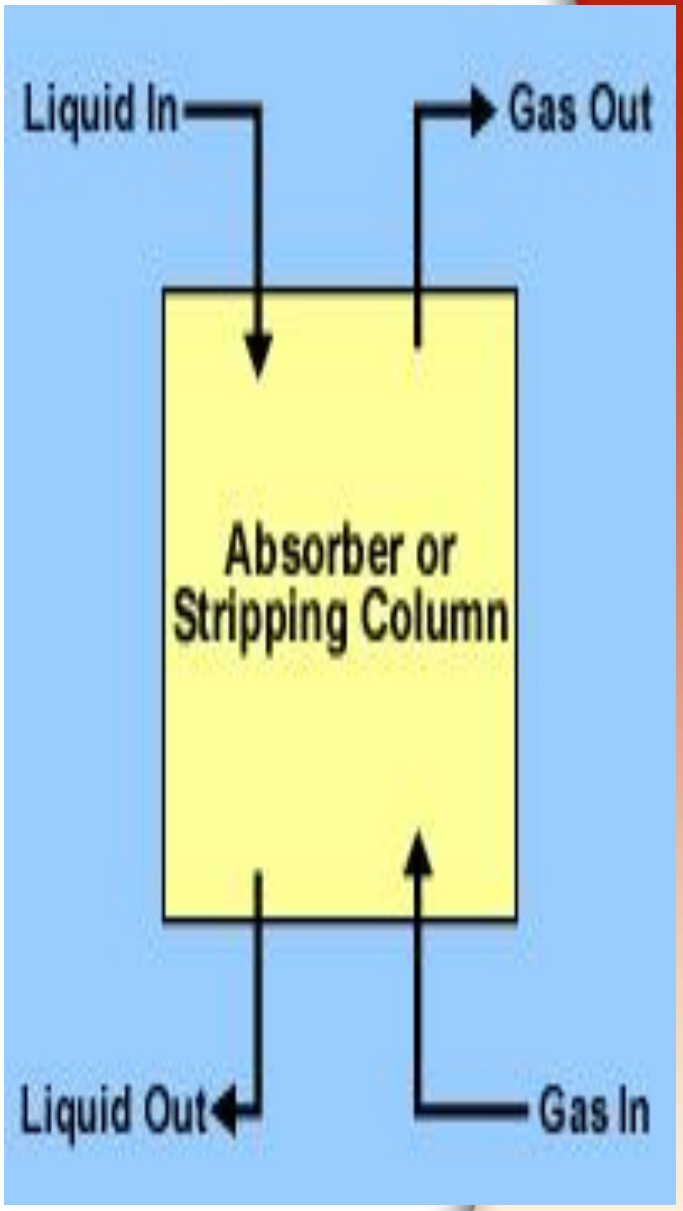
The most common method for controlling gaseous pollutants is the addition of add-on control devices to recover or destroy a pollutant.

There are four commonly used control technologies for gaseous pollutants:

- Absorption,
- Adsorption,
- Condensation
- Incineration (combustion)

Absorption

- The removal of one or more selected components from gas mixture by absorption is probably most important operation in control of gaseous pollutant emissions.
- Absorption is process in which gaseous pollutant is dissolved in liquid.
- Water is commonly used absorbent liquid.
- As gas stream passes through the liquid, liquid absorb gas (in much same way that sugar is absorbed in glass of water when stirred).



Adsorption

- When **a gas** or **vapor** is brought into contact with **solid**, part of it is taken up by the solid.
- **The molecules that disappear** from gas either enter the inside of solid, or remain on outside **attached to surface.**
- Former phenomenon is termed absorption (or dissolution) and latter adsorption.
- Common industrial adsorbents are **activated carbon, silica gel, and alumina**, because they have enormous surface areas per unit weight.
- **Activated carbon** is universal standard for purification and removal of **trace organic contaminants** from liquid and vapor streams.

Condensation

- Condensation is the process of converting a gas or vapor to liquid.

- Any gas can be reduced to a liquid by lowering its temperature and/or increasing its pressure.

- Condensers are typically used as pretreatment devices. They can be used ahead of **absorbers, absorbers, and incinerators** to reduce the **total gas volume** to be treated by more expensive control equipment.
- **Condensers** used for pollution control are contact condensers and surface condensers.

Incineration

- Incineration, known as combustion, is most used to control **emissions of organic compounds** from process industries.
- This control technique refers to **rapid oxidation of a substance through combination of oxygen with a combustible material** in presence of heat.
- When combustion is complete, **gaseous stream** is converted to **carbon dioxide and water vapor**.
- Equipment used to control waste gases by combustion can be divided in three categories:
  - ✓Direct combustion or flaring,
  - ✓Thermal incineration and
  - ✓Catalytic incineration.

Direct combustor

- Direct combustor is a device in which **air and all the combustible waste gases** react at the burner.
- Complete combustion must occur instantaneously since there is no residence chamber.
- Flare can be used to control almost any emission stream containing volatile organic compounds.

Studies conducted by EPA have shown that the destruction efficiency of a flare is about 98%.