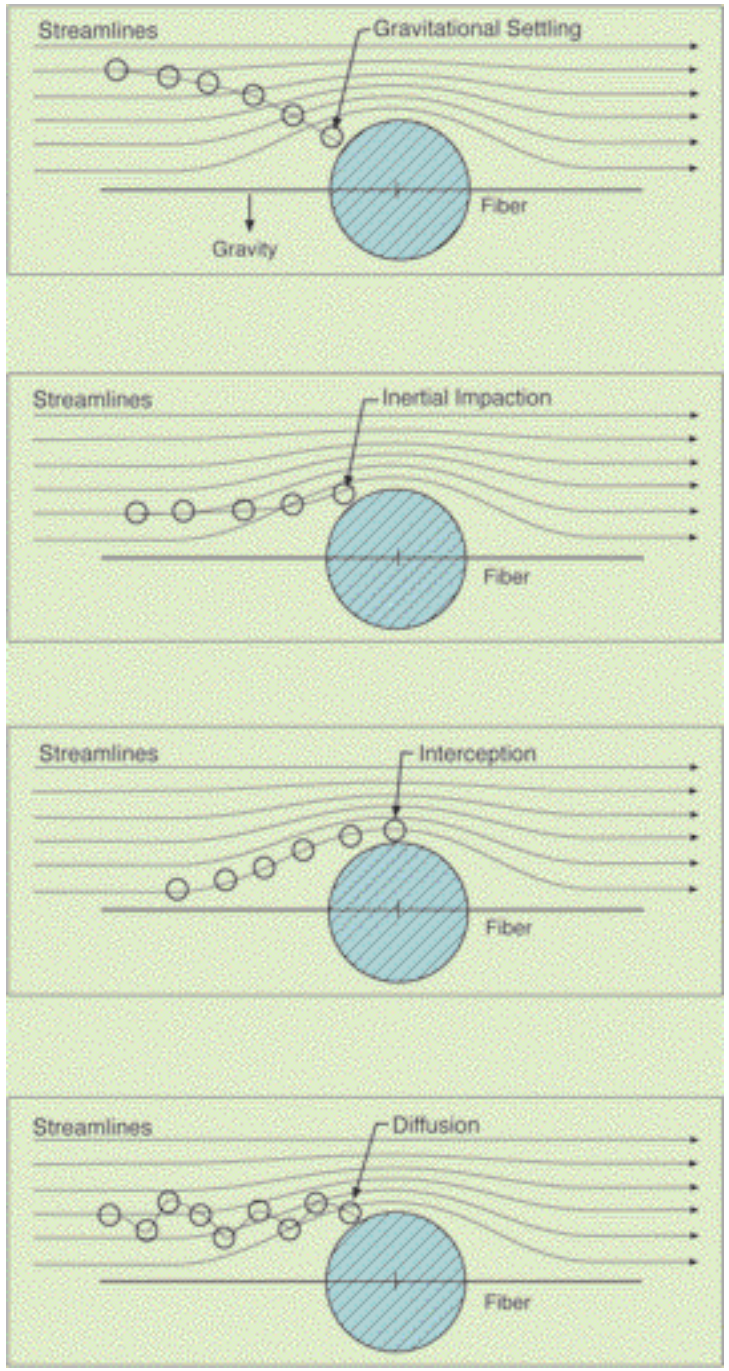
Air Pollution Control

Mechanisms for filtration



Feature	Cyclone Separator	Electrostatic Precipitator (ESP)	Bag Filter
Working Principle	Utilizes centrifugal force to separate particulate matter from the gas stream based on particle density and size.	Uses high-voltage electrostatic charge to ionize and capture dust particles on plates.	Captures particulate matter by passing gas through filter bags made of fabric.
Particle Removal Efficiency	Moderate (80-90% for large particles); lower for fine particles.	High efficiency (up to 99%) for both large and fine particles.	Very high efficiency (up to 99.9%) for both fine and large particles.
Suitable Particle Size	Large particles (>5 µm).	Can handle both fine and large particles.	Can handle both fine and large particles effectively.
Pressure Drop	Low to moderate.	Low pressure drop due to open spaces between plates.	High pressure drop due to the dense nature of filter bags.
Maintenance	Low; no moving parts, but efficiency may reduce over time as wear occurs.	Medium; requires periodic cleaning of plates (manual or automated).	High; regular replacement or cleaning of filter bags needed.
Cost	Low initial cost	High initial cost due to complex system and electrical components.	Medium initial cost
Applications	Pre-cleaner for high-density particles, typically in industries like cement, sawmills.	Used in power plants, cement industries, and steel plants for capturing fine particles.	Widely used in industries with strict emission standards, such as pharmaceuticals and food processing.
Operating Temperature	High (up to 400°C or more).	Moderate (up to 300°C, depending on design).	Lower temperature range (generally up to 250°C, depending on fabric material).
Space Requirement	Requires relatively more space compared to ESP and bag filters.	Requires more space compared to bag filters but less than cyclone separators.	Compact design, requires less space compared to ESP and cyclone separators.
Energy Consumption	Low to moderate (depends on particle size being separated).	High due to the need for high-voltage equipment.	Moderate due to the fan power needed to overcome pressure drop.

Removal of SO_2: Flue Gas Desulfurization (FGD)

Limestone

- $CaCO_3(s) + SO_2 \rightarrow CaSO_3(s) + CO_2$

Lime

- $Ca(OH)_2(s) + SO_2 \rightarrow CaSO_3(s) + H_2O\ (l)$
- $CaSO_3(s) + \frac{1}{2}O_2 + 2H_2O(l) \rightarrow \mathrm{CaSO_4}.2H_2O(s)$