Cyclone Definition

- Cyclone separators are separation devices that use the principle of inertia and centrifugal force to remove particulate matter from gas streams.
- Cyclone separators are one of many air pollution control devices available.
- Often used as precleaners to remove larger pieces of particulate matter prior to another control device. (This prevents finer filtration methods from having to deal with larger, more abrasive particles, and reduces the dust loading on downstream equipment.)
- Operation in parallel or series configurations depending on the application.
- Multi-cyclone Arrangements – many cyclones in parallel.
- Cyclones can vary drastically in their size depending on gas volume being handled and removal efficiency required.

Example Industries and Processes

Industries

- Food & Beverage
- Paper & Pulp
- Chemical
- Petrochemical
- Automotive
- Oil & Gas
- Metals & Mining
- Wood Processing
- Building Products

Processes

- Dryers
- Kilns
- Roasters
- Nuisance Dust Collection
- Shredders
- Wood Planers / Saws
- Fluid Bed Dryers
- Spray Dryers

Particulate

- The typical unit for particle size is the micron (µm) which is 1.0×10^{-6} meters or 1 millionth of a meter.
- Solid particles between 1 and 100 µm (microns) in diameter are called dust particles (mechanical generation) while solid particles less than 1 µm in diameter are called fumes, or smoke (chemical or thermal generation).
- Particles less than 10 µm (microns) in diameter are of biggest concern to human and animal health as they can be easily inhaled and get trapped in the respiratory system.

Wet or Dry Collections? Why? When?

Consider Wet Collection when:

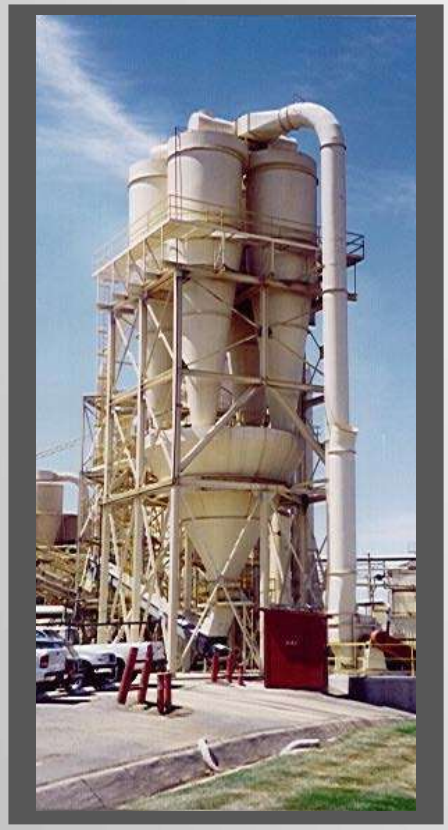
- Sticky particulate or humid gas stream
- Explosive/Combustible dust
- Slurry can be reprocessed
- Fumes or acid gases are to be removed
- Water is readily available and liquid discharge is not a problem

Consider Dry Collection when:

- Water availability/disposal is an issue
- Collected dust must remain dry
- Contaminant has low moisture
- Plenty of space available
- Simplify system controls

Selecting the Correct Solution

Cyclone

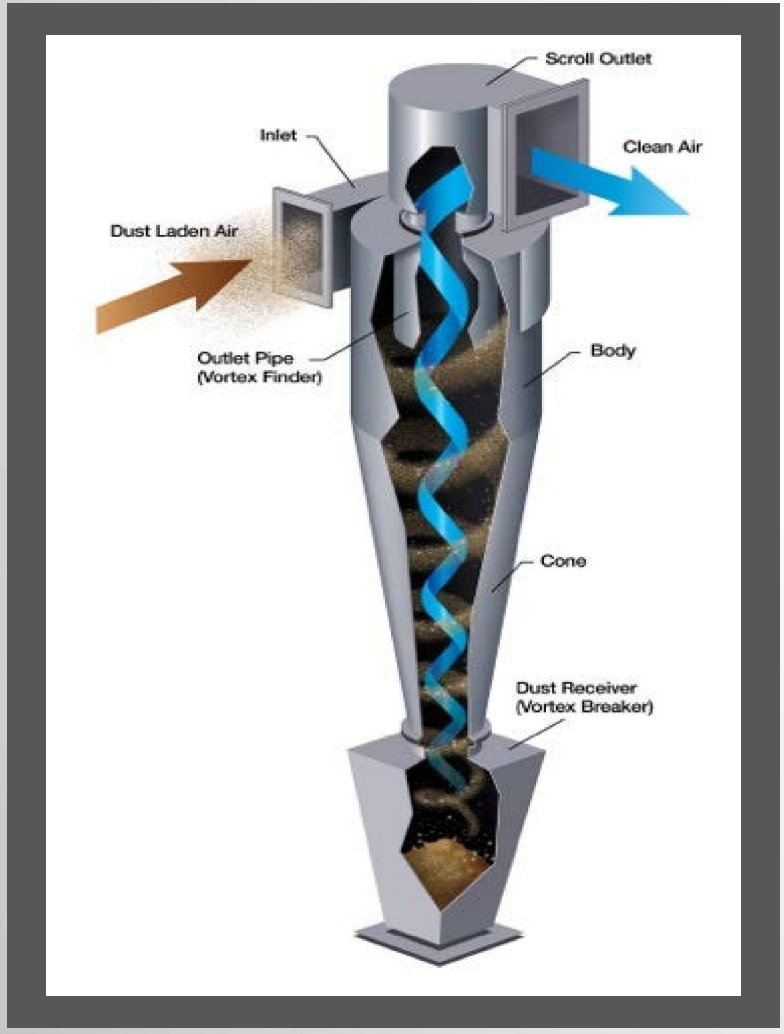


Baghouse

Scrubber

Advantages of a Cyclone

- Often the most economical form of gas/particle separation
- Simple to operate and maintain
- No moving parts
- Severe Service Design:
  - High pressure/vacuum, High Temperature, Erosion, Corrosion, Explosive Dusts, etc.…
- No product contamination



Cyclone Anatomy

Cyclone Performance

- Two main factors determine cyclone efficiency
  - How quickly the particle moves towards the wall or collection area of the cyclone where it is theoretically collected
  - The length of time available for collection: Residence Time
- Two main factors describe cyclone performance
  - Pressure drop
  - Fractional efficiency curve (FEC)

Data Required for Cyclone Design

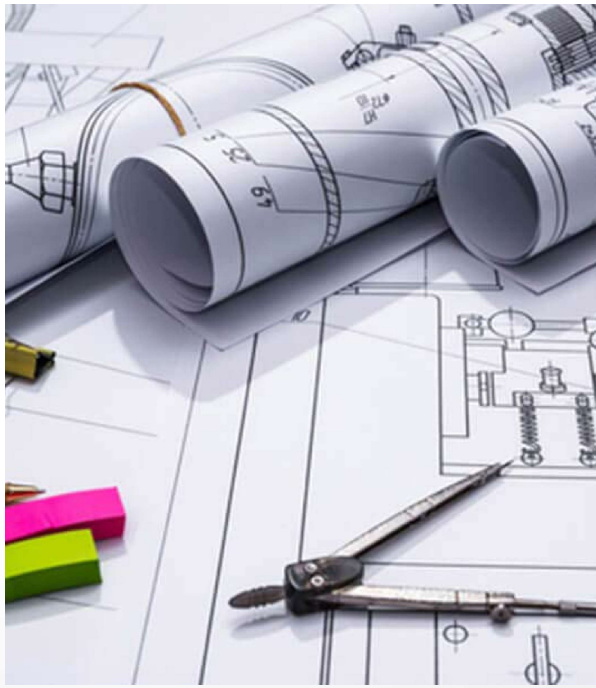
Mechanical

Temperature, pressure, corrosion allowance, MOC, paint requirement, etc.

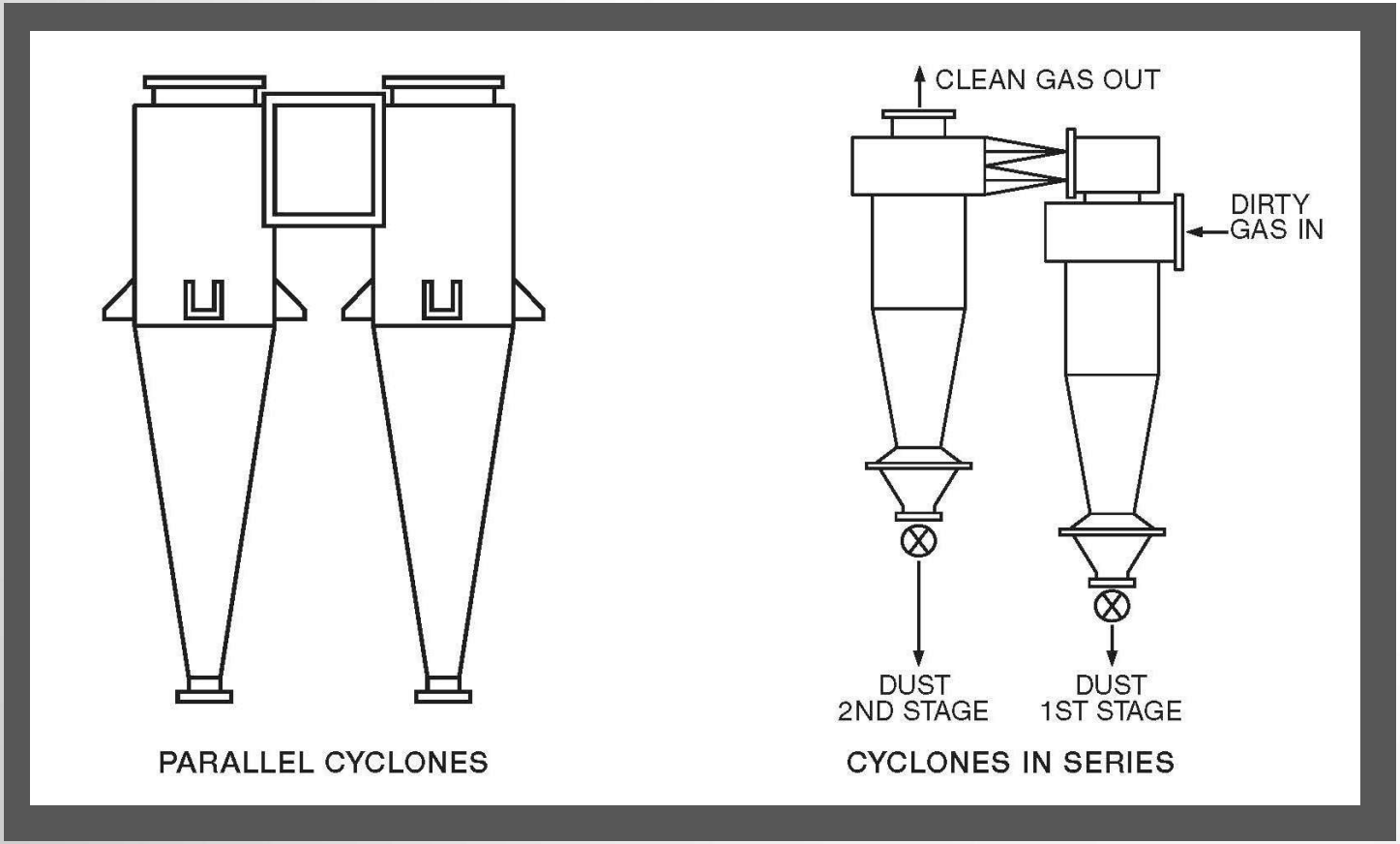
Process

Gas flow, temperature, pressure, gas density, viscosity, particle specific gravity, particle loading, efficiency

<u>Importance of Aerodynamic Particle size distribution</u>
(BAHCO micro classifier, liquid sedimentation, cascade impaction)



Arrangements



Parallel Cyclone Arrangements

Advantages:

- Higher collection efficiency
- Lower energy consumption vs series arrangement
- Parallel arrangements may provide the best solution when headroom is limited

Disadvantages:

- Higher cyclone cost vs a single cyclone
- Larger footprint
- Multiple dust outlets for material handling

Series Cyclone Arrangements

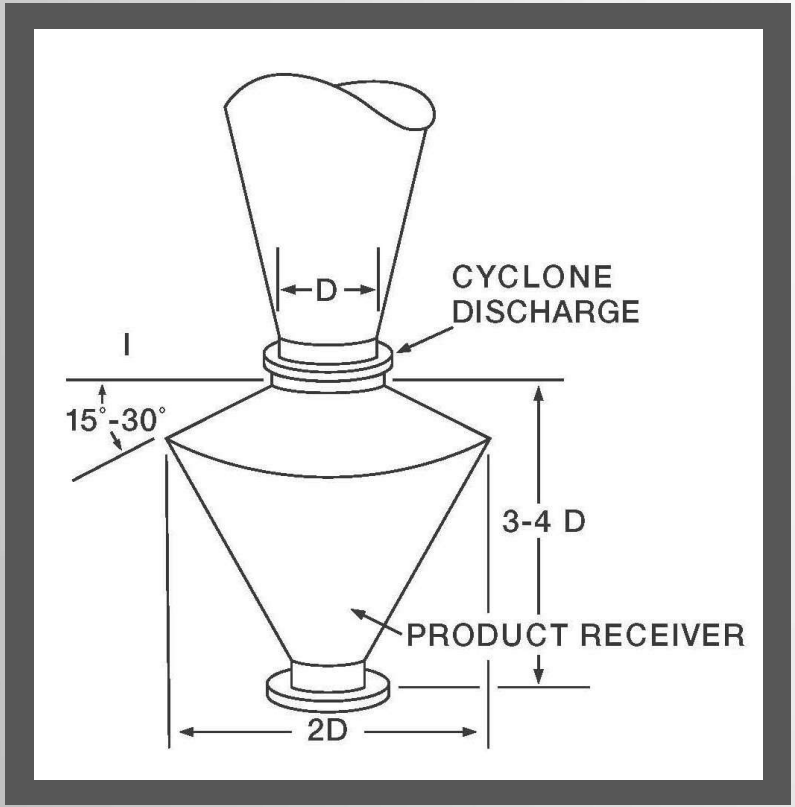
Advantages:

- Increased efficiency vs. a single cyclone
- Adds redundancy to the system
- First stage can be used to remove most loading, and second stage can be designed for removal of remaining fines

Disadvantages:

- Increased cost vs a single cyclone
- Increased energy usage vs a single or parallel arrangement – pressure drop adds

Dust Receivers



- Allows material to disengage from spinning vortex
- Reduces abrasion in the cyclone and seal device below
- Proper dimensions are recommended to realize full benefit
- Pyramid or Conical:
  - Pyramid is less expensive
  - Conical for sticky materials and higher pressure design

Process Design Range of Cyclones: Inlet Velocity

- Below a certain velocity, solids will not be pneumatically conveyed in the cyclone inlet
- With most materials and processes the inlet velocity should not be below 45 ft/s
- Pressure drop, erosion, and particle attrition are exponential functions dependent on inlet velocity.
- Generally inlet velocity is kept below 80 ft/s although values of up to 200 ft/s may be used in certain processes

Process Design Range of Cyclones: Pressure Drop

- Purely an economic consideration when evaluated independently from inlet velocity
- Normal industrial cyclones are typically between 3″ w.c. – 8″ w.c.
- Pressure drops of several PSIG are common with high density gasses, series cyclone systems, or special applications

Process Design Range of Cyclones: Particle Size

- Real limits are economical: cyclones can be built to provide +50% collection at .3 microns, they just aren't economical
- Cyclones are currently providing +90% collection on applications with average particle sizes of 1.4 microns
- Cyclones are commonly providing +99% collection on applications with average particle sizes in the 5 - 10 micron range