Dust Collecting

By Brian Mathews
Engineering Manager
Scientific Dust Collectors
What is Dust?

Dust is any material that can sift through a 0.420mm screen mesh.

- **Common Dust**
  - Corn Starch - 7μm
  - Charcoal (Wood) - 14μm
  - Magnesium - 28μm
  - Sugar - 30μm
  - Human Hair – 40-300μm
How is it Generated?

- **Activities:**
  - Manufacturing – Welding, Cutting, Blasting
  - Industrial – Construction, Agriculture, Mining
  - Mineral Ore processing emits dust when:
    - Ore is broken or reduced in size (crushing & grinding)
    - Operations: Dumping, Loading, Screening, & Transferring
    - Movement of generated dust via wind, workers, or machinery
Why Dust Control is Necessary

- Health Hazards (OSHA)
  - Irritation to Eyes, Ears, Nose, Throat, and Skin
  - Respiratory Complications and Diseases
- Fire or Dust Explosion Risk (NFPA)
- Potential Damage to Equipment
- Hazardous Working Conditions
- Community Relations
Types of Dust Control

- Prevention
- Dilution
- Isolation
- Collection
Types of Dust Control

- Prevention
  - Covers, Enclosures, Shrouds
  - Proper design of processing equipment
    - Crushers, Dryers, Grinders, and Screeners
  - Proper design of material handling and transferring
    - Belt Conveyors, Bucket Elevators, Feeders, Hoppers, Screw Conveyors, and Vibratory Conveyors
Types of Dust Control

- **Dilution**
  - Diluting contaminated air with fresh or filtered air.

- **Isolation**
  - Isolated enclosure for workers or process supplied with fresh or filtered air.
Types of Dust Control

- Collection
  - Dust Collection Systems. Consisting of:
    - Dust Collector
    - Fan with Motor
    - Ductwork
    - Local Exhaust Hoods
    - Dust Storage or Removal
Dust Collectors

Common Types of Dust Collectors:
- Inertial Separators
- Cyclones
- Scrubbers (Air Washers)
- Electrostatic Precipitators (ESP)

Filter Media Collectors:
- Mechanical Shaker
- Baghouses
  - Reverse Air
  - Reverse Pulse Jet
- Cartridges
- Pleated Filters
Inertial Separator Collectors

- Simplest Design
  - Slows down air flow
  - Utilizes gravity force
  - Utilizes inertial force

- Used as Pre-Filter

- Commonly known as “Drop Out Box”
Cyclone Collectors

- Centrifugal Collector (Cyclone)
- Tangential Inlet
- Forms Vortex
- Uses greater force than gravity
Pressure Drop vs. Efficiency

48” ø Cyclone
5,000 CFM
2” WG
\( \eta_{10 \mu m} = 36\% \)

38” ø Cyclone
5,000 CFM
6” WG
\( \eta_{10 \mu m} = 67\% \)
Pressure Drop vs. Efficiency

Larger Cyclone  Less Efficiency  Smaller Cyclone  More Efficiency

Lower Pressure Drop  Higher Pressure Drop

THE RESULT OF A COMMITMENT TO EXCELLENCE
Density vs. Efficiency

38” ø Cyclone
5,000 CFM

$\rho = 30 \text{#/cu.ft}$

$\eta_{10 \mu m} = 67\%$

---

### Cyclone Efficiency

**Airflow:** 5000 CFM

<table>
<thead>
<tr>
<th>Particle Size (in microns)</th>
<th>Efficiency C-38</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.52%</td>
</tr>
<tr>
<td>5</td>
<td>99.90%</td>
</tr>
<tr>
<td>10</td>
<td>94.68%</td>
</tr>
<tr>
<td>15</td>
<td>93.28%</td>
</tr>
<tr>
<td>20</td>
<td>96.16%</td>
</tr>
<tr>
<td>25</td>
<td>97.51%</td>
</tr>
<tr>
<td>30</td>
<td>98.26%</td>
</tr>
<tr>
<td>40</td>
<td>99.01%</td>
</tr>
<tr>
<td>50</td>
<td>99.36%</td>
</tr>
<tr>
<td>60</td>
<td>99.56%</td>
</tr>
<tr>
<td>75</td>
<td>99.72%</td>
</tr>
<tr>
<td>100</td>
<td>99.84%</td>
</tr>
<tr>
<td>125</td>
<td>99.93%</td>
</tr>
<tr>
<td>150</td>
<td>99.98%</td>
</tr>
<tr>
<td>200</td>
<td>99.99%</td>
</tr>
</tbody>
</table>

**Pressure Drop:** 6.0 inWG

---

38” ø Cyclone
5,000 CFM

$\rho = 60 \text{#/cu.ft}$

$\eta_{10 \mu m} = 85\%$
Air Washers (Scrubbers)

Developed to improve performance of inertial collectors

- Types
  - Wet Scrubber (Cyclone)
  - Dynamic Wet Precipitator
  - Orifice Scrubber
  - Venturi Scrubber

- Applications
  - Separate process air streams that are explosive
  - Slurry used in other parts of the process.
  - Chemical reactions or neutralizations
  - Air Absorbers
  - Temperature reduction

<table>
<thead>
<tr>
<th>Application</th>
<th>Cyclone Efficiency</th>
<th>Wet Cyclone Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Handling (Rock)</td>
<td>80-85%</td>
<td>90-93%</td>
</tr>
<tr>
<td>Dryer</td>
<td>75-80%</td>
<td>92-96%</td>
</tr>
</tbody>
</table>
Electrostatic Precipitators

- Single Stage Precipitator
  - Grounded Collecting Plates
  - High Voltage Electrodes
    - 40,000 – 60,000V

High voltage ionizes the air, dust particles become negatively charged and collect.
- Dust Removal via rapping plates with air powered anvil.
Electrostatic Precipitators

**Cons**
- Initial cost higher
- Large footprint
- Not suitable for all dusts

**Pros**
- Efficiency can exceed 99%
- Can remove small particles
- Function at temperatures up to 1300°F
Filter Media

- **Purpose**
  - To separate gaseous air from solid dust particles
  - Allow formation and promotion of filter cake

- **Permeability**
  - Flow rate at 0.5inWG through 1ft² of media.
  - Typical Range: 20-40CFM

- **Air-to-Cloth Ratio**
  - Volume of Air (CFM) per Area of Media (ft²)
  - Typical Range: 1-20
  - Depends on Dust Collector
| Fiber                          | Generic Name | Trade Name | Cotton | Polyamid       | Polypropylene | Polyester | Aramid      | Glass          | PTFE           | Polyphenylene Sulfide (PPS) | Ryton® |
|-------------------------------|--------------|------------|--------|----------------|---------------|-----------|------------|--------------|----------------|----------------|----------------------------|--------|
| Recommended continuous operation temperature (dry heat) |              |            | 180°F | 200°F          | 200°F         | 270°F     | 400°F      | 500°F        | 500°F*          | 375°F          |                          |        |
| (82°C)                        |              |            | 94°C   | 94°C           | 94°C          | 132°C     | 204°C      | 260°C        | 260°C           | 190°C          |                          |        |
| Water vapor saturated condition (moist heat)         |              |            | 180°F | 200°F          | 200°F         | 200°F*     | 350°F      | 500°F        | 500°F*          | 375°F          |                          |        |
| (82°C)                        |              |            | 94°C   | 94°C           | 94°C          | 94°C      | 177°C      | 260°C        | 260°C           | 190°C          |                          |        |
| Maximum (short time) operation temperature (dry heat) |              |            | 200°F | 250°F          | 225°F         | 300°F     | 450°F      | 550°F        | 550°F*          | 450°F          |                          |        |
| (94°C)                        |              |            | 121°C  | 121°C          | 107°C         | 150°C     | 232°C      | 290°C        | 290°C           | 232°C          |                          |        |
| Relative Cost                 |              |            | $      | $              | $            | $          | $          | $            | $              | $              |                          | $$     |
| Relative moisture regain in % (at 68°F and 65% relative moisture) |              |            | 8.5    | 4.0 – 4.5      | 0.1          | 0.4        | 4.5         | 0            | 0               | 0              |                          | 0.6    |
| Supports combustion           |              |            | Yes    | Yes            | Yes          | Yes        | No         | No           | No              | No             |                          |        |
| Biological resistance (bacteria, moldew)               |              |            | No, if not treated | No Effect     | Excellent   | No Effect  | No Effect   | No Effect     | No Effect        | No Effect       |                          |        |
| *Resistance to alkalis        |              |            | Good   | Good           | Excellent    | Excellent  | Fair        | Good         | Fair            | Excellent       | Excellent        |        |
| *Resistance to mineral acids  |              |            | Poor   | Poor           | Excellent    | Fair       | Fair        | Very Good     | Excellent       | Excellent       | Excellent        |        |
| *Resistance to organic acids  |              |            | Poor   | Poor           | Excellent    | Fair       | Fair        | Very Good     | Excellent       | Excellent       | Excellent        |        |
| *Resistance to oxidizing agents |              |            | Fair   | Fair           | Excellent    | Good       | Poor        | Excellent     | Excellent       | Excellent       | Excellent    |        |
| *Resistance to organic solvents |              |            | Very Good | Very Good   | Excellent    | Good       | Very Good   | Very Good     | Excellent       | Excellent       | Excellent        |        |

* At operating temperatures.

Comments: Based on typical fiber manufacturers published specifications.
Mechanical Shaker Collectors

- **Tubular Shakers**
  - Dust gathers on inside of bag
  - Bag kept in place with tensioning
  - Bag diameter from 3” – 12”
  - Best cleaning when system shutdown

- **Modular Design**
  - Processes that cannot shutdown require multiple compartments separated by dampers. Allows for offline cleaning.
Mechanical Shaker Collectors

**Cons**
- Off-line cleaning required
- High maintenance costs
- Larger footprint

**Pros**
- Low initial cost
- Very good in low volume applications
- Works without compressed air
High Pressure Reverse Air

- Basic Unit
  - Bags
  - Hopper
  - Bag Cleaning Fan and Moving Mechanism
High Pressure Reverse Air

- Reverse Air with Pressure Blower
  - Round
  - Pressure Blower
  - Filter Cleaning Manifold with Drive Motor
High Pressure Reverse Air

**Cons**
- Higher initial cost than Mechanical Shaker
- Higher maintenance costs due to multiple drives and fans.

**Pros**
- Operate at higher Air-to-Cloth than Mechanical Shaker
- Smaller footprint
- Low velocity gentle cleaning
- Works well in grain, food, and coal industry
Reverse Pulse Jet Dust Collectors

- **Blow Ring Collector**
  - High Air-to-Cloth Ratio (18-22)
  - Low Pressure Drops
  - Not suitable for high temperature
  - Required frequent maintenance

- **Fabric Pulse Jet (Circa 1963)**
  - Lower Air-to-Cloth Ratio (10-14)
  - Low Pressure Drops
  - Suitable for high temperature
  - Required Compressed Air
Reverse Pulse Jet Dust Collectors

Original design was modified in 1971 by the original patent holder and the cleaning jet characteristics were changed to accommodate longer filter bags. This “generic” cleaning system was then copied throughout the rest of the industry.

<table>
<thead>
<tr>
<th></th>
<th>1963 Design</th>
<th>1971 Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average velocity at throat of the tube, venturi or orifice</td>
<td>15,000 feet per minute*</td>
<td>25,000 feet per minute</td>
</tr>
<tr>
<td>Venturi throat opening</td>
<td>1 7/8 inches diameter</td>
<td>1 7/8 inches diameter</td>
</tr>
<tr>
<td>Jet flow</td>
<td>290 CFM</td>
<td>500 CFM</td>
</tr>
<tr>
<td>Bag diameter and length</td>
<td>4½ inches x 72 inches</td>
<td>4½ inches x 120 inches</td>
</tr>
<tr>
<td>Bag area</td>
<td>7 sq. ft.</td>
<td>12 sq. ft.</td>
</tr>
<tr>
<td>Jet flow</td>
<td>100 CFM</td>
<td>90 CFM</td>
</tr>
<tr>
<td>Bag area</td>
<td>14 FPM**</td>
<td>8 FPM</td>
</tr>
<tr>
<td>Filter flow rating per bag</td>
<td>3 1/2 inches water column</td>
<td>6 inches water column</td>
</tr>
<tr>
<td>Nominal filter ratio</td>
<td>¾ SCFM/1000 CFM of filtered air</td>
<td>1 ¼ SCFM/1000 CFM air flow</td>
</tr>
<tr>
<td>Average pressure drop</td>
<td>0.005 gr./cu.ft.</td>
<td>0.008 gr./cu.ft.</td>
</tr>
<tr>
<td>Average Air Consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average dust penetration at 10 gr./cu.ft. load</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*It should be noted that this was the same velocity as the blow ring outlet.

** Actual filter ratio or filtering velocity was lowered by various dust and process characteristics, primarily because of the dust laden air entering into the hopper. Average filter ratios were approximately 10:1 or 10 FPM filtering velocity through the bags.
Reverse Pulse Jet Dust Collectors

- **Higher Cleaning Velocity**
  - Increase from 15,000fpm to 25,000fpm
  - Created “puffing” phenomenon
    - Dust would be driven a high velocity through adjoining bags and filter cakes causing opacity issues.
  - Created rips & tears in filter bags causing broken bags

- **Bag Modifications**
  - Media laminated with PTFE membrane
  - Use of pleated filter elements
  - Use of bag diffusers
  - Use of baffles between rows of bags

- **Collector Modifications**
  - Broken Bag Detectors on collector outlet duct
High Efficiency Reverse Pulse Jet

- Breakthrough in 1979 by Scientific Dust Collectors
  - Removed flow-restricting venturi
  - Utilized converging-diverging nozzle
    - Generated supersonic flow
  - Discovered that the better the media can be cleaned, the more airflow can be tolerated.

- High Side Inlet
  - Compared to Generic Hopper Inlet
- Baffled Inlet
- Wide Bag Spacing (3” between)
  - Generic allows for 1” between.
- Higher Efficiency
  - Less bags and smaller footprint
  - Increased Bag Life
  - Reduced compressed air usage
High Efficiency Reverse Pulse Jet

Original design in 1971 compared to High Efficiency design by Scientific Dust Collectors

<table>
<thead>
<tr>
<th>Scientific Dust Collectors</th>
<th>1971 Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average velocity at bag opening</td>
<td>10,000 feet per minute</td>
</tr>
<tr>
<td>Bag opening (no venturi)</td>
<td>25,000 feet per minute</td>
</tr>
<tr>
<td>Jet flow</td>
<td>4½” diameter</td>
</tr>
<tr>
<td>Bag diameter and length</td>
<td>740 CFM</td>
</tr>
<tr>
<td>Bag area</td>
<td>4½ inches x 96 inches</td>
</tr>
<tr>
<td>Filter flow rating per bag</td>
<td>10 sq. ft.</td>
</tr>
<tr>
<td>Nominal filter ratio</td>
<td>190 CFM</td>
</tr>
<tr>
<td>Average pressure drop</td>
<td>20 FPM</td>
</tr>
<tr>
<td>Average air consumption</td>
<td>2½ inches water column</td>
</tr>
<tr>
<td>Average dust penetration at 10 gr./cu.ft. load</td>
<td>½ SCFM/1000 CFM of flow</td>
</tr>
<tr>
<td></td>
<td>0.0005 gr./cu.ft.</td>
</tr>
<tr>
<td>1971 Design</td>
<td></td>
</tr>
<tr>
<td>1 7/8 inches diameter</td>
<td></td>
</tr>
<tr>
<td>500 CFM</td>
<td></td>
</tr>
<tr>
<td>4½ inches x 120 inches</td>
<td></td>
</tr>
<tr>
<td>12 sq. ft.</td>
<td></td>
</tr>
<tr>
<td>90 CFM</td>
<td></td>
</tr>
<tr>
<td>8 FPM</td>
<td></td>
</tr>
<tr>
<td>6 inches water column</td>
<td></td>
</tr>
<tr>
<td>1 ¼ SCFM/1000 CFM air flow</td>
<td></td>
</tr>
<tr>
<td>0.008 gr./cu.ft.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generic System</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Bag Length</td>
<td>8'</td>
</tr>
<tr>
<td>Bag Diameter</td>
<td>4½”</td>
</tr>
<tr>
<td>Bag Fabric Area</td>
<td>9.46 ft²</td>
</tr>
<tr>
<td>Air-To-Cloth Ratio</td>
<td>5:1</td>
</tr>
<tr>
<td>Filtered Air Volume per Bag</td>
<td>(5)(9.46) = 47.3 CFM</td>
</tr>
<tr>
<td>Bag/Venturi Throat Diameter</td>
<td>1¾” at venturi</td>
</tr>
<tr>
<td>Bag/Venturi Throat Area</td>
<td>(\pi(1-3/4)^2 = 0.0167) ft²</td>
</tr>
<tr>
<td>Filtered Air Velocity at Bag/Venturi Throat Opening</td>
<td>(\frac{47.3}{0.0167} = 2,832) fpm fan air</td>
</tr>
<tr>
<td>Cleaning Air Jet Velocity at Bag/Venturi Throat Opening</td>
<td>Higher</td>
</tr>
</tbody>
</table>
Supersonic Nozzle

Generous amount of Air Induced

Plain Orifice

Insufficient amount of Air Induced

Turbulent and Unbalanced cleaning up to 18” from the top of the bag

Generic Baghouse with Venturi

Scientific Dust Collectors Nozzle

Note: Maximum Velocity of Cleaning Jet is 511FPS

Note: Maximum Velocity of Cleaning Jet is 217FPS

Unrestricted and Balanced cleaning throughout the entire bag

Volume Flow (CFM)

Distance from Top of Bag (inches)

ZONE 1

ZONE 2

ZONE 3

ZONE 4

SDC Nozzle
Cartridge Dust Collectors

- Pleated Rigid Filter Element
- Filter Bags “Flex” during cleaning

<table>
<thead>
<tr>
<th>Type of Collector</th>
<th>Outlet Dust Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse Jet Fabric</td>
<td>0.00660 grains/cu. ft.</td>
</tr>
<tr>
<td>Shaker Collector</td>
<td>0.00035 grains/cu. ft.</td>
</tr>
<tr>
<td>Cartridge Collector</td>
<td>0.00005 grains/cu. ft.</td>
</tr>
</tbody>
</table>
Cartridge Dust Collectors

- Cartridge Filter Pleats
Types of Cartridge Collectors

- Vertical Cartridge Collector
  - High Side Inlet
  - Cartridge Access via Hopper or Bin Doors
  - Compact design for low volume systems
  - Have large footprint for medium and high volume systems
Types of Cartridge Collectors

- Horizontal Cartridge Collector
  - High Side Inlet
  - Cartridges accessed via front doors. Each cartridge or pair of cartridges has its own door.
  - Compact design for medium to high volume systems
  - Dust tends to cascade down from the top row to bottom row before discharge
  - Top of cartridges are difficult to keep clean due to gravity.
Pleated Bag Dust Collectors

Pleated Bag

- **Features**
  - Molded urethane top and bottom
  - Positive interlocking seal
  - Sonic welded seams

- **Cons**
  - Rigid Element. Tough to repetitively clean
  - More expensive than bags

- **Pros**
  - More filter media than bag
  - Various media options
  - Retrofit applications
**Key Points**

- **Air Velocity (V) [Units: fpm]**
  - Calculated by Velocity Pressure (VP)

- **Air Flow (Q) [Units: CFM]**
  - Where (A) is Area of duct (in ft²)
  - \[ Q = (V)(A) \]

- **System Static Pressure (SP) [Units: inWG]**
  - Calculated from Total Pressure (TP)
  - \[ TP = SP + VP \]
  - \[ VP = TP - SP \]
System:
Flow: 10,000CFM
S.P.: 9.5inWG

\[ W_{\text{FAN}} = \frac{\text{CFM} \cdot \text{SP}}{6356 \frac{\text{CFM} \cdot \text{inWG}}{\text{BHP}}} \cdot \eta_{\text{fan}} \]

\( \eta_{\text{fan}} = 80\% \text{ or } 0.80 \)

\( W = 18.7 \text{ BHP} \)

\[ \text{COST} = \text{BHP} \cdot 0.746 \frac{\text{kW}}{\text{BHP}} \cdot \frac{\$}{\text{kW} \cdot \text{hr}} \cdot \text{#hr} \]

Assume $0.08 \text{ kW/hr.}$ and 8000hrs in a year
Cost = $8,920.00
**DUST COLLECTOR SELECTION DATA FORM**

**Customer:**

Date: ________________

Submitted By: ________________

**Installation:**
- Outside: ________________
- Inside: ________________

**Headroom Limit:**

**Discharge Height:**

**Options:**
- 55 Gallon Drum
- Rotary Air Lock
- Screw Conveyor
- 3 Cubic Yd. Hopper

**Baghouse Unit:**

**Cartridge Unit:**

**Model:**

**Media Access:**
- Top: ________________
- Side: ________________

**Top Access:**
- Walk-in Plenum: ________________
- Railing Top: ________________

**Fan Mounting Options:**
- Ground: ________________
- Top: ________________
- Side: ________________

**Construction:**
- Carbon Steel: ________________
- Stainless Steel: ________________

**NOTES:**

---

**Selecting the correct Dust Collector for the application.**

**Key Points:**
- **Dust Type**
- **ACFM**
- **Customer Preferences**

- **Source**
- **ACFM**
- **Process**
- **Duty**
- **Dust Type**
- **Dust Load**
- **Particle Size**
- **Density**
- **Moisture**
- **Temperature**
- **Abrasive**
- **Corrosive**
- **Hygroscopic**
- **Explosive**
- **Sprinklers**

- **Media**
- **Media Access**
- **Fan Static**
- **Fan Damper**
- **Fan Silencer**
- **Motor Starter(s)**
- **Inlet Transitions**