Course Overview

- What are we looking at?
- Why do we care?
- How does fabric filtration work?
- Types of baghouses
- Design and operation of baghouses
- Operation and maintenance problems
- Baghouse inspection
Why do we care?
Particulate Matter: Composition

- Heavy Metals
- Soot
- Sulfates
- Carbon
- Smoke
- Nitrites
- Aerosols
- Organic
- Soil
- Dust
- Salts

Complex Mixture
## How Small is PM?

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{10}$ (10 μm)</td>
<td></td>
</tr>
<tr>
<td>PM$_{2.5}$ (2.5 μm)</td>
<td></td>
</tr>
</tbody>
</table>

- Human Hair (60 μm diameter)

### Table

<table>
<thead>
<tr>
<th>Structure</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hair</td>
<td>11 Microns and larger</td>
</tr>
<tr>
<td>Skin</td>
<td>7 to 11 Microns</td>
</tr>
<tr>
<td>Pharynx</td>
<td>4.7 to 7 Microns</td>
</tr>
<tr>
<td>Trachea</td>
<td>3.3 to 4.7 Microns</td>
</tr>
<tr>
<td>Primary bronchus</td>
<td>2.1 to 3.3 Microns</td>
</tr>
<tr>
<td>Secondary bronchi</td>
<td>1.3 to 2.1 Microns</td>
</tr>
<tr>
<td>Bronchioles</td>
<td>0.05 to 1.1 Microns</td>
</tr>
<tr>
<td>Alveoli</td>
<td>0.43 to 0.65 Microns</td>
</tr>
</tbody>
</table>

10/22/2018

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12,000
U.S. Mortality Figures In 2005

64,000 = Deaths from particulate air pollution
45,520 = Traffic accident fatalities
32,179 = AIDS deaths
30,694 = Firearm fatalities

Los Angeles - Clear Day

Los Angeles - Smoggy Day
Most Polluted Regions In the U. S.*

<table>
<thead>
<tr>
<th>Ozone (SMOG)</th>
<th>Particulates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Los Angeles Region</td>
<td>1. Pittsburg</td>
</tr>
<tr>
<td>2. Bakersfield</td>
<td>2. Los Angeles Metro</td>
</tr>
<tr>
<td>3. Visalia/Tulare Co.</td>
<td>3. Fresno</td>
</tr>
<tr>
<td>5. Fresno/Madera</td>
<td>5. Birmingham, AL</td>
</tr>
<tr>
<td>7. Dallas/Fort Worth</td>
<td>7. Salt Lake City</td>
</tr>
</tbody>
</table>

*American Lung Association, "State of the Air" Report 5/08

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How do They Work?

Baghouses may be classified in several ways ....

- Method of dust collection
- Bag design
- Fan location
- Method of cleaning
Particle Collection Mechanisms

- Direct interception
- Impaction
- Diffusion
- Gravitational settling
- Agglomeration
- Electrostatic attraction

Direct Interception
Other Mechanisms

- Gravitational settling
- Agglomeration
- Electrostatic attraction

Settling Chamber

Bag Design
Positive Pressure Baghouse

Negative Pressure Baghouse

Cleaning Mechanism
Methods of Cleaning

- Shaking
- Reverse Air
- Pulse Jet
- Sonic

Shaker Mechanism

Shaker Bag with Torsion Spring

Courtesy BHA
Shaker Motor and Hangers

Shaker Cleaning System Problems
(Section 503.9)

- Improper operation or failure of motors
- Inadequate maintenance of linkages
- Improper bag tension
- Hanging mechanism problems

Reverse Air Baghouse
Reverse Air Bag

- metal cap
- anti-collapse ring
- bag clamp
- tube sheet

Thimble Design

- OK
- Better
Reverse Air Cleaning System

Problems

(Section 503.10)

- Inadequate reverse air flow
- Leakage through poorly sealed dampers
- Improper bag tension
- Corrosion
Pulse Jet Cleaning System Problems
(Section 503.11)

- Cage/bag misalignment
- Low compressed air pressure
- Contaminated compressed air
- Diaphragm valve leakage or freezing
- Loose, misaligned pulse pipe
- Timer or differential pressure sensor failure
- Excessive cleaning frequency
Sonic Cleaning

Acoustic Horn

Filter Media
- Woven
- Felted
- Membrane
- Sintered metal
- Ceramic
Fabric Weaves

Plain  Twill  Sateen

Sieving on Woven Fabric

Sieving on Felted Fabric

Fabric Selection Factors

- Maximum Operating Temperature
- Melting Temperature
- Resistance to Corrosive Chemicals
- Flex and Abrasion Resistance
- Permeability (vs. blinding)
- Type of dust
Fabric Treatment Processes
- Calendaring
- Napping
- Singeing
- Glazing
- Coating
- Precoating

Applications for Different Types of Fabrics
- Cotton - Simple applications
- Nylon - Abrasive dusts
- Polyester - Metal industries
- Nomex - Asphalt batch plants
- Teflon - Coal-fired boilers

Fabric Blinding
- Moisture in dust cake
- Lubricating oil (pulse jet)
- Submicron particles
What Is Going Into Your Baghouse?

- Dust Properties
- Gas Flow Rate
- Gas Temperature
- Chemical Composition
Dust Properties

- Mass Loading
- Abrasive Particles
- Size Distribution

Design Considerations

- Pressure Drop
- Air-To-Cloth Ratio
- Collection Efficiency
- Fabric Type
- Cleaning
- Temperature Control
- Bag Spacing
- Compartment Design
- Space and Cost

Pressure Drop (dp)

- Resistance To Airflow
- Inlet Pressure - Outlet Pressure
- Size of Fan
- Filter & Dust Cake
Pressure Drop Across Filter
$$dp_f = k_1 v_f$$

- $dp_f$ = dp across clean fabric
- $k_1$ = fabric resistance
- $v_f$ = filtration velocity

Pressure Drop Across Dust Cake
$$dp_c = k_2 c_i v_f^2 t$$

- $dp_c$ = dp across dust cake
- $k_2$ = resistance of dust cake
- $v_f$ = filtration velocity
- $c_i$ = dust concentration loading
- $t$ = filtration time

Static Pressure Drop vs. Gas Flow Rate
Problems Related to Pressure Drop

- **Pressure Drop Too High** =
  - bag blinding, blockage
  - increase in gas flow rate
  - fugitive emissions

- **Pressure Drop Too Low** =
  - bag failure
  - inleakage

Fugitive emissions due to excessive pressure drop
Air-to-Cloth Ratio

\[ v_f = \frac{Q}{A} \]

- \( v_f \) = filtration velocity
- \( Q \) = volumetric air flow rate
- \( A \) = area of cloth filter

Importance of A/C Ratio

- **A/C Too High:**
  - fan works harder
  - increased abrasion
  - blinding
  - breakdown of dust cake
- **A/C Too Low:**
  - smaller BH required

Cleaning Method | Air-To-Cloth Ratio
--- | ---
Shaker | < 3:1, < 6:1
Reverse Air | < 2:1, < 4:1
Pulse Jet | 2.5:1 to 7.5:1, < 15:1
Controlling Gas Entry

- Precleaner
- Baffle Plate
- Inlet Diffuser
- Inlet Location
- Thimble Design
- Bypass

Effects of Primary Collection

Relative distribution of particles

Size in microns
**Inlet Air Dispersion**

- Wear points
- Dust re-entrainment
- Ladder vane baffle

**Thimble Design**

- OK
- Better

**Dampers**
Gas Temperature Effects

- **High Operating Temp.** =
  - fabric breakdown
- **Low Operating Temp.** =
  - condensation
  - blinding, chemical attack
- **Inlet - Outlet Temp. Too High** =
  - inleakage

Temperature Control

- Gas Cooling
  - Dilution
  - Radiation
  - Evaporative Cooling
- Preheating
- Insulation
- Minimize Inleakage

Insulated Baghouses
Hoppers and Dust Handling Equipment
(Section 303.5)

Hopper with Strike Plate

Hopper with Compressed Air Cleaner
Dust Discharge Problems

- Inleakage
- Corrosion
- Change Process Temp.
- Dust Buildup
- Pluggage
- Fugitive Emissions
Types of Hopper Blockage

- Arching
- Bridging
- Buildup
- Ratholing

How Do We Monitor Compliance

- Opacity
- Triboelectric & Tribokinetic Devices
- Light Modulation
- Pressure Drop
- Temperature
- Bag Failure Patterns
- Clean-side deposits

Performance Monitoring
(Section 501, 502)
Double-Pass Transmissometer

Pressure Drop Profile

Static Pressure Drop Profiles - Reverse Air Baghouse

Null Period

Cleaning Cycle

Filtering Cycle

Normal Profile

Abnormal Profile

Null Period

Cleaning Cycle

Time

D_p

Time

D_p
Maintenance
- Daily
- Weekly
- Monthly

Inversion Bag Cleaning Device
Spare Cages

Inspection Elements

- Pre-Inspection
- On-Site Inspection
- Post-Inspection

Permit Conditions

- Opacity Limits
- Process Weight Limits
- Ranges of Inlet and Outlet Temps.
- Process Rate
- Recordkeeping Requirements
- CEMS Requirements
- Minimum / Maximum Pressure Drop
Air Pollution Control System
Points of Inspection

- Capture (System Entrance/Exit)
- Transport
- Air Mover
- Control Device
- Instrumentation
- Subsystem(s)
- Records

Fugitive emissions due to excessive pressure drop
As particle size gets smaller, reflective surface area increases.
Instrumentation

- Flow Meters
- Thermocouples
- Pressure Gauges
- Transmissometers / CEMs
- Hopper Level Indicators
- Compressed Air Pressure Gauges
General Safety Policies

- Anticipate hazards before leaving for inspection site
- Have all necessary personal protective equipment
- Be aware of and conform to all applicable plant and agency safety policies
- Do one thing at a time
- Don't work alone