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

What Do They Look Like?
Particulate Matter: Composition

- Heavy Metals
- Sulfates
- Carbon Dust
- Smoke
- Organic
- Sol Salts
- Nitrates
- Aerosols
- Complex Mixture
How Small is PM?

Human Hair (60 μm diameter)  PM$_{10}$ (10 μm)  PM$_{2.5}$ (2.5 μm)

- Hair cross section (60 μm)

PM$_{2.5}$ (2.5 μm)

- Hair
- Skin
- Pharynx
- Trachea
- Primary bronchus
- Secondary bronchi
- Bronchioles
- Alveoli

- 12,000

- 11 Microns and larger
- 7 to 11 Microns
- 4.7 to 7 Microns
- 3.3 to 4.7 Microns
- 2.1 to 3.3 Microns
- 1.1 to 2.1 Microns
- 0.65 to 1.1 Microns
- 0.43 to 0.65 Microns

- Alveoli
- Skin
- Hair
- Primary bronchus
- Secondary bronchi
- Bronchioles
- Trachea
- Pharynx

- 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>
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**How do They Work?**

- HR Manager
- Marketing Manager
- Logistics Manager
- Safety Manager
- Communications Manager
- Security Manager
- QA Manager
- Project Manager
- Public Relations
- Product Development Manager

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**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

Gas Streamlines

Particle

Fiber
Other Mechanisms
- Gravitational settling
- Agglomeration
- Electrostatic attraction

Settling Chamber

Bag Design
NACT 282 - Baghouses

Cartridge Filter Baghouse

Envelope Filter Baghouse

Fan Location
**Methods of Cleaning**

- Shaking
- Reverse Air
- Pulse Jet
- Sonic

**Shaker Mechanism**

**Shaker Bag with Torsion Spring**

(Courtesy BHA)
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 Baghouse

Reverse air baghouse at lumber mill
Reverse Air Cleaning System

Problems

(Sections 503.10)

- Inadequate reverse air flow
- Leakage through poorly sealed dampers
- Improper bag tension
- Corrosion
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Pulse Jet Baghouse

Inside a Pulse Jet Baghouse

Pulse Jet Bag
Pulse Air Distribution System

Snap Ring

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

Graph showing the relationship between static pressure drop (inches of water) and gas flow rate (% of maximum).
Pressure Drop Profile

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

Cleaning Method | Air-To-Cloth Ratio
---|---
Shaker          | < 3:1 (cm\(^3\)/sec)/cm\(^2\) | < 6:1 (ft\(^3\)/min)/ft\(^2\)
Reverse Air     | < 2:1                           | < 4:1
Pulse Jet       | 2.5:1 to 7.5:1                   | <15:1

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
Controlling Gas Entry

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

Effects of Primary Collection

Relative distribution of particles

Cyclones
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Baghouse with Cyclonic Inlet

Industry Description
Bin Vent Filter

Industry Description
Bin Vent Filter
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**
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Radiation Cooling

[Diagram: Typical Startup, Normal Operation Range, Typical Shutdown, Recommended Startup, Normal Operation Range, Recommended Shutdown. Each segment is labeled with temperature ranges and links with 'time' arrows.]

Courtesy BHA
Hoppers and Dust Handling Equipment
(Section 303.5)

Hopper with Strike Plate

Hopper with Compressed Air Cleaner
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Hopper Level Indicator System

Screw Conveyor

Pneumatic Dust Transport System
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)
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Triboelectric Monitoring

CPM™ Technology
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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
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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

Gas Flow Rate

Increased System Resistance

Baseline System Resistance

Gas Flow Rate

To Stack

Fugitive Emissions

Process

Static Pressure

July 12
As particle size gets smaller, reflective surface area increases.
Instrumentation

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