B.1 FABRIC FILTERS

B.1.1 Background

Fabric filters, frequently referred to as baghouses, are typically used to control particulate matter (PM) emissions in exhaust gas streams. Certain gases may also be removed through interactions with the dust layer, or filter cake, that accumulates on the fabric filter bags. Fabric filters are normally used where a high control efficiency is required and where exhaust gas stream conditions are within the limitations of fabric filter operation. These limitations are high moisture, high temperatures, and exhaust gas constituents that attack the fabric or hinder the cleaning process (such as sticky particulate).

Three types of baghouses (pulse-jet, reverse-air, and shaker) are in common use, categorized by the method used for filter cleaning. Various fabric filter materials can be used in each type, depending on temperature, corrosiveness and moisture content of the gas stream, as well as dimensional stability and cost of the selected material. Important design parameters for baghouses are the air-to-cloth (A/C) ratio (ft³ per minute gas/ft² fabric), which is somewhat dependent on particle size and grain loading, as well as operating temperatures and the cleaning mechanism. Minimum operating temperature is especially important where acid gases are expected to be present in the gas stream; below this minimum temperature, acid gases can condense and corrode the fabric filter housing and other metal parts. Condensation within the fabric filter also can cause bag blinding (i.e., blockage of air flow through the bag). Cleaning mechanisms and maximum temperature may dictate the type of cloth that can be used.

Each type of baghouse presents different maintenance and monitoring challenges to operators, particularly in relation to cleaning mechanisms and bag materials. Cleaning at regular intervals is desirable in order to maintain a low pressure-drop across the baghouse and to save energy. Cleaning cycles must be balanced, however, against the increased PM removal efficiency that can be realized as the filter cake accumulates on the fabric.

1. Pulse-jet systems use a blast of high-pressure air (60 to 120 pounds per square inch [psi]) to clean or back-flush the bags. Pulse-jet cleaning can be accomplished with the baghouse on-line. Therefore, pulse-jet systems may only have one compartment. Equipment must be able to withstand the repeated stress of the pulses.

2. Reverse-air systems use a longer, gentler back-flush of low-pressure air (a few inches water column) to clean the bags. Cleaning air is provided to each compartment by a separate, smaller fan and duct system. Because the cleaning is at low pressure, each compartment must be effectively isolated from the gas stream during the cleaning cycle.

3. In shaker fabric filter systems, each compartment must also be taken off-line for cleaning, which is accomplished by a mechanism that vigorously shakes the bags. Combination reverse air/shaker systems are also in use.
4. Sonic horns have been developed that augment reverse-air and shaker cleaning. Acoustic vibration in the range of 150 to 550 hertz (Hz) at 120 to 140 decibels (dB) helps dislodge particles during the regular cleaning cycle.

Common baghouse problems and malfunctions include: broken or worn bags; blinding of the filter material; failure of the cleaning system; leaks in the system or between filter bag and tube sheet; re-entrainment of dust; wetting of the bags; baghouse compartment corrosion; malfunction of dampers or material discharge equipment; and low fan speed.

B.1.2 Indicators of Fabric Filter Performance

The best indicator of fabric filter performance is the outlet PM concentration. A bag leak detection system can be used to monitor for bag breakage and leakage. In the absence of a PM continuous emissions monitoring system (CEMS) or a baghouse leak detection system, the primary indicator of fabric filter performance is the outlet opacity. Other indicators of fabric filter performance include pressure differential, inlet temperature, temperature differential, exhaust gas flow rate, cleaning mechanism operation, and fan current. Each of these indicators is described below. Table B-1 lists these indicators and illustrates potential monitoring options for fabric filters.

Outlet PM concentration. Particulate matter CEMS can be used to continuously monitor PM emission concentrations. These instruments are a fairly recent development and have yet to be put into widespread use.

Bag leak detection signal. For most applications, the performance of fabric filters is most closely associated with the condition of the filter bags; bag tears and breaks can result in dramatic losses in control efficiency. Bag leak detection systems can provide immediate feedback on bag failure. Several types of leak detection systems are available, including triboelectric monitors, light scattering monitors, beta gauges, and acoustic monitors.

Outlet opacity. As is the case for nearly all dry PM controls, opacity is an indicator of control device performance. An increase in opacity or visible emissions generally corresponds to a decrease in fabric filter performance. A continuous opacity monitor (COMS) may be used, or the visual determination of opacity (Method 9) or visible emissions (modified Method 22) may be made by plant personnel.

Pressure differential. The characteristic differential pressure is dependent on the baghouse design, including the type of cleaning mechanism and bag type. For a pulse jet type baghouse, when the fabric filter bags are newly installed, the filter cake builds up on the bags and the pressure differential increases steadily. Once the bags are in operation and the filter cake has built up on the bags, the pressure differential remains fairly constant. As pulses are applied to clean the bags, the pressure differential will change slightly but overall remains constant. However, sudden changes in pressure differential can be a good indicator of several potential problems associated with the operation of a fabric filter. An increase in pressure differential may
indicate blinding of the fabric. A change in pressure differential also can indicate the effectiveness of the cleaning mechanism.

For shaker type and reverse air type baghouses, the pressure differential of a compartment may demonstrate a cyclic increase and decrease, as a result of the cleaning cycle design. For example, the cleaning cycle may be set to activate when the pressure differential of a compartment reaches 5 in. w.c. Upon cleaning, the pressure differential drops to 3 in. w.c. and slowly rebuilds until the cleaning cycle is again activated. Changes in the pressure differential range and cycle can indicate a change in performance.

**Inlet temperature.** Most fabric filters are designed to operate within a specified temperature range based on the type of bags employed. Excessive inlet temperatures can damage the bags. If acid gases are present in the exhaust stream, low inlet temperatures can result in the acid gases condensing and corroding the fabric filter housing and structural components. Condensation within the fabric filter also can result in bag blinding. Inlet temperature excursions outside the normal operating range may indicate that potential operational problems will occur with the fabric filter.

**Temperature differential.** An increase in the temperature differential across the fabric filter is an indication of possible infiltration of outside air. In normal operation of the fabric filter, the difference between the inlet and outlet gas temperature would be expected to remain fairly constant from day to day. Obviously, variables such as the ambient air temperature will affect the temperature differential. However, large changes in the temperature differential may indicate air infiltration that could cause condensation of water vapor and/or acid gases resulting in blinded bags and/or corrosion of the fabric filter components.

**Exhaust gas flow rate.** Increases in the exhaust gas flow rate can indicate infiltration of outside air. The addition of outside air will cause an increase in the temperature differential and cause blinding of the bags or corrosion of the fabric filter components, as discussed above.

**Cleaning mechanism operation.** The operation of the cleaning mechanism can indicate potential problems that can affect fabric filter performance. An increase in cleaning frequency can accelerate bag wear. Inadequate pulse-jet compressed air pressures can result in incomplete cleaning of bags. If cleaning frequency is too long, pressure differential can become excessive and energy costs increase. Excessive compressed air pressure can force dust through the fabric or can shorten bag life. Excessive dust buildup in the fabric filter hopper can result in re-entrainment of PM.

**Fan current.** Changes in fan current generally correspond to changes in exhaust gas flow rate. In negative-pressure fabric filters, a sudden decrease in fan current can indicate infiltration of outside air into the fabric filter.

**Inspections and maintenance.** Inspection and maintenance of a fabric filter are important components of long-term operation of the control device. Fabric filter inspections may include
steps as simple as visually determining whether there are leaks from the fabric filter to more
detailed inspections, including internal inspections of the device and inspection of the cleaning
mechanism, hopper discharge mechanism, and the physical structure. Internal inspections may
include looking over the bags for holes/tears or injection of a fluorescent dye and observation
using a black light. Maintenance of the fabric filter would include regular replacement of filter
bags.

B.1.3 Illustrations

The following illustrations present examples of compliance assurance monitoring for fabric filters:

1a: Daily observations of visible emissions (VE) or opacity using RM 9 or modified
RM 22.
1b: Continuous instrumental monitoring of opacity using COMS or other analytical
device.
1c: Monitoring pressure differential, opacity, and inlet temperature.
1d: Monitoring with a bag leak detection system.

B.1.4 Bibliography
### TABLE B-1. SUMMARY OF PERFORMANCE INDICATORS AND EXAMPLE MONITORING APPROACHES FOR FABRIC FILTERS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Performance indication</th>
<th>Approach No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>8</th>
<th>9</th>
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<th>11</th>
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<tr>
<td></td>
<td></td>
<td>Illustration No.</td>
<td>1a, 1b</td>
<td>1c</td>
<td>1d</td>
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<td>Example CAM Submittals</td>
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<td>A13</td>
<td>A19</td>
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<td><strong>Primary Indicators of Performance</strong></td>
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<tr>
<td>Outlet PM concentration</td>
<td>PM concentration is the most direct indicator of baghouse performance.</td>
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<tr>
<td>Bag leak detector signal</td>
<td>Indicator of bag degradation or rupture. Signal is proportional to particulate loading in exhaust; in some cases, signal can be affected by changes in velocity, particle size/type, and humidity.</td>
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<td>X</td>
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<tr>
<td>Opacity</td>
<td>Increased opacity/VE denotes performance degradation. COMS, opacity observations, or visible/no visible emissions.</td>
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<td>X</td>
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<td>X</td>
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<tr>
<td><strong>Other Performance Indicators</strong></td>
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<tr>
<td>Pressure differential</td>
<td>Indicator of blinding or malfunction of cleaning cycle. Sudden increase in pressure differential can indicate bag blinding; also can indicate if cleaning mechanism is operating properly.</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Inlet temperature</td>
<td>Indicator of potential for overheating of bags or condensation. Most applicable to fabric filters that control thermal process emissions; condensation can result in bag blinding, or increased corrosion of structural components; excessive temperatures can destroy bags or shorten bag life.</td>
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<tr>
<td>Exhaust gas flow rate</td>
<td>Indicator of change in flow resistance; related to pressure differential. Increase in flow rate may result in changes in temperature differential, which may be an indication of infiltration of outside air.</td>
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### TABLE B-1. (Continued)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Performance indication</th>
<th>Approach No.</th>
<th>1</th>
<th>2</th>
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<th>9</th>
<th>10</th>
<th>11</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning mechanism operation</td>
<td>Indicator that bags and hopper are cleaned/emptied properly and at prescribed intervals. Too frequent or too intense cleaning shortens bag life; too infrequent cleaning results in excessive pressure differential; improper or infrequent cleaning of hopper can result in PM re-entrainment.</td>
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<tr>
<td>Fan current</td>
<td>Indirect indicator of gas flow rate. See comments for Gas flow rate above.</td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>Inspection and maintenance</td>
<td>Visual determination of leaks; may include internal inspections, records of bag replacement. Should be paired with other parameters monitored for large units.</td>
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<td>X X X X</td>
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Comments:
- Approach No. 1 includes use of opacity and VE; Illustration No. 1a includes VE/no VE by visual determination and Illustration 1b includes use of a COMS.
- Approach No. 2 corresponds to 40 CFR 63, subpart GG (Aerospace Manufacturing and Rework).
- Approach No. 4 also corresponds to 40 CFR 63, subparts MMM (Pesticides), DDD (Mineral Wool), and NNN (Wool Fiberglass).
- Approach No. 8 corresponds to 40 CFR 63, subpart X (Secondary Lead Smelting) for controlling lead.
- Approach No. 9 corresponds to 40 CFR 63, subpart LLL (Portland Cement).
- Approach No. 10 corresponds to 40 CFR 63, subpart XXX (Ferroalloys Production; an existing source is required to monitor VE, pressure differential, and conduct I & M, and a new source is required to monitor these parameters plus a bag leak defection system.).
- Approach No. 11 corresponds to 40 CFR 63, subpart EE (Magnetic Tape).
1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018]
1.2 Pollutants
   Primary: Particulate matter (PM, PM-10)
   Other: Toxic heavy metals
1.3 Process/Emissions units: Industrial process vents, fuel combustion units, and material handling processes

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Opacity of emissions or visible emissions (VE).
2.2 Rationale for Monitoring Approach: Changes in opacity and changes in VE observations indicate process changes, changes in baghouse efficiency, or leaks.
2.3 Monitoring Location: Per RM 9 (opacity) or RM 22 (VE) requirements.
2.4 Analytical Devices Required: Trained observer using RM 9 or visible/no visible emissions observation techniques (RM 22-like).
2.5 Data Acquisition and Measurement System Operation
   • Frequency of measurement: Daily or as weather permits.
   • Reporting units: Percent opacity or visible/no visible emissions.
   • Recording process: Observers complete opacity or VE observation forms and log into binder or electronic data base as appropriate.
2.6 Data Requirements
   • Baseline opacity or VE observations concurrent with emission test.
   • Historical plant records of opacity observations. (No data are needed if indicator is “any visible emissions.”)
2.7 Specific QA/QC Procedures: Initial training of observer per RM 9 or RM 22, semi-annual refresher training per RM 9, if applicable.
2.8 References: 1, 2, 3, 4, 5, 23.

3. COMMENTS

3.1 Although RM 22 applies to fugitive sources, the visible/no visible emission observation techniques of RM 22 can be applied to ducted emissions. For situations where no visible emissions are the norm, a technique focused towards identifying a change in performance as indicated by any visible emission is a useful and effective technique. The use of the visible/no visible emissions technique reduces the need for onsite certified RM 9 observers.
3.2 For large pollutant specific emission units (post-control potential to emit equal to or greater than 100 percent of the amount required for a source to be classified as a major source), CAM requires the owner or operator to collect four or more data values equally spaced over each hour, unless the permitting authority approves a reduced frequency. Therefore, this monitoring approach may not be acceptable for large emission units unless used in conjunction with other appropriate parameter monitoring for which data are recorded at least four times each hour; e.g., baghouse pressure differential, air flow, temperature. (See Section 3.3.1.2.)
1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018]
1.2 Pollutants
   Primary: Particulate matter (PM, PM-10)
   Other: Toxic heavy metals
1.3 Process/Emissions units: Industrial process vents, fuel combustion units, and material handling processes

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Opacity.
2.2 Rationale for Monitoring Approach: An increase in opacity indicates process changes, changes in baghouse efficiency, or leaks.
2.3 Monitoring Location: Exhaust gas outlet.
2.4 Analytical Devices Required: Opacity meter or COMS as appropriate for gas stream.
2.5 Data Acquisition and Measurement System Operation
   • Frequency of measurement: Once per shift if instruments read manually, or continuously recorded on strip chart or digital data acquisition system.
   • Reporting units: Percent opacity for COMS, or applicable units for other type monitors.
   • Recording process: Operators log data manually, or recorded automatically on strip chart or data acquisition system.
2.6 Data Requirements
   • Baseline opacity measurements (e.g., opacity for COMS) concurrent with emission test.
   • Historical plant records of opacity measurements.
2.7 Specific QA/QC Procedures: Calibrate, maintain, and operate instrumentation using procedures that take into account manufacturer’s specifications.
2.8 References: 1, 2, 3, 4, 5, 23.

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per shift would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)
1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016]

1.2 Pollutants
   Primary: Particulate matter (PM, PM-10)
   Other: Toxic heavy metals

1.3 Process/Emissions units: Incinerators, furnaces, kilns, and other high temperature process units

2. MONITORING APPROACH DESCRIPTION

2.1 Indicators Monitored: Pressure differential, opacity, and inlet temperature.

2.2 Rationale for Monitoring Approach
   • Pressure differential: Increase in pressure differential indicative of fabric blinding or decreased permeability; decrease in pressure differential indicative of change in operation.
   • Opacity or VE: An increase in opacity or changes in VE observations indicate process changes, changes in baghouse efficiency, or leaks.
   • Inlet temperature: Excessive temperature can lead to leaks, breakdown of filter material, and reduced lifetime of filter; temperatures below the dewpoint of the exhaust gas stream may also damage the filter bags.

2.3 Monitoring Location
   • Pressure differential: Across inlet and outlet of each compartment of control device.
   • Opacity or VE: Per RM 9 (opacity) or RM 22 (VE) requirements.
   • Inlet temperature: At fabric filter inlet duct.

2.4 Analytical Devices Required
   • Pressure differential: Pressure transducers, differential pressure gauges, manometers, other methods and/or alternative instrumentation as appropriate.
   • Opacity or VE: Trained observer using RM 9 or visible/no visible emissions observation techniques (RM 22-like).
   • Temperature: Thermocouple, RTD, or other temperature sensing device; see section 4.2 for additional information on devices.

2.5 Data Acquisition and Measurement System Operation
   • Frequency of measurement: Once during each shift, or recorded continuously on strip chart or data acquisition system; for opacity or VE, daily or as weather permits.
   • Reporting units:
     – Pressure differential: Inches of water column (in. w.c.).
     – Opacity or VE: Percent opacity or visible/no visible emissions.
     – Temperature: Degrees Fahrenheit (°F) or Celcius (°C).
• Recording process: Operators log data manually, or recorded automatically on strip chart or data acquisition system; observers complete opacity or VE observation forms and log into binder or electronic database as appropriate.

2.6 Data Requirements
• Baseline pressure differential, opacity and inlet temperature measurements, and cleaning cycle concurrent with emission test.
• Historical plant records on pressure differential, opacity, and inlet temperature measurements.
• Temperature specifications for fabric filter material.

2.7 Specific QA/QC Procedures: Calibrate, maintain, and operate instrumentation using procedures that take into account manufacturer’s specifications.

2.8 References: 1, 2, 3, 4, 5, 23.

3. COMMENTS

3.1 Data Collection Frequency: For large emission units, a measurement frequency of once per shift would not be adequate; collection of four or more data points each hour is required. (See Section 3.3.1.2.)
1. APPLICABILITY

1.1 Control Technology: Fabric filter (baghouse) [016, 017, 018]
1.2 Pollutants
   Primary: Particulate matter (PM, PM-10)
   Other: Toxic heavy metals
1.3 Process/Source Type: Industrial process vents, fuel combustion units, and material handling processes

2. MONITORING APPROACH DESCRIPTION

2.1 Indicator to be Monitored: Bag leak detection monitor signal.
2.2 Rationale for Monitoring Approach: Bag leak detectors that operate on principles such as triboelectricity, electrostatic induction, light scattering, or light transmission, produce a signal that is proportional to the particulate loading in the baghouse outlet gas stream. When bag leaks occur, the cleaning peak height or baseline signal level will increase. Alarm levels based on increases in normal cleaning peak heights or the normal baseline signal can be set to detect filter bag leaks.
2.3 Monitoring Locations: At the fabric filter outlet.
2.4 Analytical Devices Required: Bag leak detector and associated instrumentation.
2.5 Data Acquisition and Measurement System Operation
   • Frequency of measurement: Continuous.
   • Reporting units: Amps, volts, or percent of scale.
   • Recording process: Recorded automatically on strip chart or data acquisition system.
2.6 Data Requirements
   • Historical signal data showing baseline level and cleaning peak height during normal operation or signal data concurrent with emission testing.
2.7 Specific QA/QC Procedures: Calibrate, maintain, and operate instrumentation using procedures that take into account manufacturer’s specifications.
2.9 References: 1, 5, 6.

3. COMMENTS

None.