

# **Lesson 6**

## ***Fabric Filter Operation and Maintenance***

### ***Goal***

To familiarize you with typical baghouse operation and maintenance problems.

### ***Objectives***

At the end of this lesson, you will be able to do the following:

1. Identify typical steps for baghouse inspection prior to starting up
2. Identify typical parameters that a facility operator should monitor while operating the baghouse
3. Describe typical operating problems associated with shaker, reverse-air, and pulse-jet baghouses

### ***Introduction***

This lesson provides a general overview of common operating problems and maintenance practices for fabric filter systems. The text is written as a general guide for both baghouse operators and air pollution regulatory agency inspectors and permit reviewers. For the baghouse system operators, there are checklists and general guidelines on what to look for or to avoid during the installation phases, instrumentation and recordkeeping suggestions for evaluating the operating systems, and examples of some common operating problems that can occur.

For the agency inspectors and permit reviewers, this lesson provides information that will be useful for performing field inspections, or for reviewing operation and maintenance (O&M) plans that many state agencies require as part of air permit applications for air pollution control systems. The lesson is intended to provide a general compilation of typical baghouse operating problems and typical checklists used during installation, startup, and operation. The lesson also provides agency permit review engineers with sufficient technical information to determine if the facility baghouse operators have adequate O&M plans in place to assure proper operation of the baghouse and subsequent compliance with the regulations and/or permit limits.

A number of sections of this lesson were extracted from the sources listed in the Suggested Readings section at the end of this lesson. These sources provide much greater detail on fabric filter system O&M procedures.

## **Installation**

Depending on the baghouse chosen, installation and initial operation startup may take from a few days to a few months. In any case, proper installation procedures will save time and money and will also help in future operation and maintenance of the baghouse.

Good coordination between the baghouse designer and the installation and maintenance personnel will help keep the baghouse running smoothly for years. Occasionally this coordination is overlooked. The baghouse is installed, turned on, and forgotten about until it stops working completely. By then it may be too late to keep the unit going, and the baghouse may have to be rebuilt or even scrapped. Some key features for the facility operator to evaluate during the installation period are listed here:

- Easy access to all potential maintenance areas - fans, motors, conveyors, discharge valves, dampers, pressure and temperature monitors, and bags
- Easy access to all inspection and test areas - stack testing ports and continuous emission monitors (opacity monitors)
- Weather conditions - the baghouse must be able to withstand inclement weather such as rain or snow

The following features have been suggested for a properly designed and installed baghouse (McKenna and Greiner 1982):

1. ***Uniform air and dust distribution to all filters.*** Duct design, turning vanes, and deflection plates all contribute to uniform gas distribution. Often, this equipment arrives loose and is field-installed. If improperly installed, it can induce high airflow regions that will abrade the duct or bag filters or cause reentrainment and induce high-dust-concentration regions that can produce uneven hopper loading and uneven filter bag dust cake.
2. ***Total seal of system from dust pickup to stack outlet.*** Inleakage of air at flanges or collector access points either adds additional airflow to be processed or short-circuits the process gases. Inleakage to a high-temperature system is extremely damaging, as it creates cold spots and can lead to dew point excursions (gas temperature falls below the dew point) and corrosion. If severe, it can cause the entire process gas temperature to pass through the dew point and result in condensate on the bags. Early bag failure and high pressure drop will generally result. The best check for leaks is for the installation technician to inspect the walls from inside the system during daylight. Light penetration from outside isolates the problem areas. It is particularly important to seal the dust discharge points in negative systems. Inleakage here will result in incomplete or no discharge, which can lead to reentrainment problems, yielding high pressure drop and hopper fires.
3. ***Effective coatings and paint.*** Most systems are painted on the exterior surfaces only. Extra care should be taken to touch up damaged areas with a good primer and if equipment is not delivered finish-painted, apply it as soon as possible following erection. Unprotected primers allow corrosion to occur and require sandblasting and costly repairs for the facility operators. If the system has been internally protected with a coating, it should be thoroughly inspected for cracks and chips, particularly in corners, and repaired before operation begins. A poor interior coating can be worse than none at all because it will trap corrosive elements between the coating and the surface it was intended to protect.

4. ***Properly installed filter bags.*** The filter bags are the heart of any fabric filter collection system. Improper installation can result in early bag failure, loss of cleaning effectiveness, and thus high pressure drop and operating costs or increased stack emission. Each manufacturer provides instructions on the proper filter bag installation and tensioning (where required). These must be explicitly followed. Very often, early bag failures can be traced to improper installation. It is much easier for the installation technicians to check and recheck bag connections, tensioning, locations, and so on, in a clean, cool, dry collector than it will be one day after startup. Bag maintenance usually accounts for 70% of annual maintenance time and money. Extra efforts in this area during installation can have a significant effect.
5. ***Proper insulation installation.*** Insulation is typically used to prevent O&M problems on high-temperature collector systems. When handling high-temperature gases, it is important to maintain the temperature of the gas and all collector components coming in contact with it above the gas dew point. Much of the time, all or a part of the insulation is field-installed. The installers should check to see that all surfaces and areas of potential heat loss are adequately covered. In particular, they should check to see that field flashing also has insulation beneath it. Cold spots cause local corrosion. Gross heat loss may cause excessive warm-up time or lower the gas temperature below the dew point.
6. ***Total seal between dirty side and clean side of collector.*** Remember, the primary purpose of the dust collector is to separate the particulate matter from the gas by means of fabric filtration. This means that all the gas must pass through the fabric. Any leaks bypassing the fabric filters will directly emit dust to the stack and therefore reduce the collection efficiency of the system. The time to inspect "bypass leaks" is before startup, when everything is clean and accessible. The best technique is to use a bright light on one side of the plenum and visually observe for light penetration on the other. This is the most effective in total darkness. The installers should take extra time to check this important area. Tracking down stack emissions not associated with bag failures can be extremely difficult after startup.
7. ***Properly installed and operating dampers.*** Most systems employ several dampers to isolate areas of the system or control the volume of air flow. Proper alignment of both internal blades and the operating linkage is important. In high-temperature applications, special care must be taken to allow for proper operation and sealing at the operating temperatures. Some dampers may require readjusting after reaching high-temperature operation. In modular systems, single modules are normally isolated for bag cleaning and maintenance. Leakage through these isolation dampers can cause improper bag cleaning. It will also create a very poor ambient condition for maintenance workers to work in. This, in some applications, can pose a health hazard, and in all applications results in lower-quality workmanship or incomplete maintenance.
8. ***Properly operating mechanical components.*** Most mechanical components are designed with a normal operating direction. Cylinder rod location, motor rotation, and so on, must be checked. Remember, when hooking up an AC motor, the installer has a 50% chance of being correct on the first try. Not only will a backward-moving conveyor produce no discharge, but it can pack material so tightly that it bends the screw. Left uncorrected, a reversed screw conveyor will result in a full hopper. The industry abounds with horror stories where full hoppers have led to burned bags, or dust that has set up, requiring jackhammers to remove it.

9. **Smoothly running fans.** Fans must be checked for proper rotation, drive component alignments, and vibration. Fans should be securely mounted to a sufficient mass to prevent excessive vibration.
10. **Clean, dry compressed air.** Most systems employ compressed air to operate dampers, controls, instruments, and so on. Probably more systems suffer shutdowns and maintenance problems due to poor-quality compressed air than for any other reason. Clean, dry air is necessary to maintain proper operation of the pneumatic components. In installations where the ambient temperature drops below 32°F, a desiccant dryer system is generally employed. Sometimes, insulation of air lines and pneumatic components will be required. Often, these considerations are not included in the dust collector system, with "clean, dry compressed air to be supplied by the owner." Remember the air must be clean and dry when it reaches the pneumatic component.

Each baghouse installation should have its own checklist reflecting the unique construction components of the unit. The installation crew should prepare a checklist **before** beginning the final inspection and initial startup. Table 6-1 shows an example of a typical inspection and startup checklist. This checklist would be useful for the facility engineer to make sure that the baghouse is properly installed.

<b>Table 6-1. Inspection and startup checklist</b>
1. Visually inspect: Structural connections for tightness Duct flanges for proper seal Filter bags for proper seating in tube sheet Dampers for operation and sequence System fan, reverse-air fan, and conveyors - check for proper rotation Electrical controls for proper operation Rotary valves or slide gates for operation
2. Remove inspection door and check conveyor for loose items or obstructions.
3. Adjust ductwork dampers - open or at proper setting.
4. Remove any temporary baffles.
5. Test horn alarm system, if included, by jumping connected sensors.
6. Start screw conveyors and check for proper operation.
7. Start reverse-air fan, if included.
8. Start system fan.
9. Log manometer and temperature (if appropriate) readings at 15-minute intervals; log readings.
10. Check to see that reverse-air dampers are cycling.
11. Adjust pressure drop cleaning initiation switch, if included.
12. Determine system air volume and adjust dampers, as required.
13. Check cell plates for dust leaks.
14. Check to see that dust is being discharged from hopper.

Source: McKenna and Greiner 1982.  
 Reproduced by permission of ETS, Inc.

Installation errors can have a disastrous effect on the operation and maintenance of the baghouse. Typical installation errors and their effect on O&M are given in Table 6-2.

<b>Table 6-2. Typical installation errors and their effects on O&amp;M</b>		
<b>Item</b>	<b>Immediate potential effect</b>	<b>Long term effect</b>
Baffle plates and turning vanes - improper installation or left out	Uneven dust distribution; uneven hopper loading; higher pressure loss	Bag wear, duct wear, hopper fires
Poor seal of flanges and access areas	Inleakage resulting in: reduced inlet volume higher fan volume higher operating costs lower baghouse temperature	Localized cold spots resulting in: component corrosion bag degradation
Poor seal at dust discharge flanges	Incomplete discharge, reentrainment; hopper fires	Reentrainment; creeping pressure drop
Cracked or chipped paint and coatings	Aesthetics	Corrosion
Improper bag tensioning (reverse-air bags)	Ineffective cleaning; bag collapse	Bag wear; high pressure drop
Improper bag seating	Stack emission	Compliance failure; bag wear; high pressure drop
Incomplete insulation	Cold spots	Corrosion
Seal between dirty and clean air compartments	Stack emission; dirtying of clean side of plenum	Compliance failure
Duct damper alignment	Loss of flow control	Poor maintenance/ambient air inleakage
Screw conveyor direction reversed	No discharge	Bent screw(s); full hopper; fires
Fan mount	Noise - vibration	Broken components
Fan belt alignment	Noise - improper fan volume	Broken belts
Exposed compressed-air lines without drier	Freeze-up - condensation	Damaged downstream components
Lack of inspection access	Lack of early warning signs	Major problems
Lack of maintenance access	Lack of regular preventive maintenance	Major breakdowns

Source: McKenna and Greiner 1982.  
Reproduced by permission of ETS, Inc.

### **Operation and Maintenance Training**

Before starting up the baghouse, the plant engineer should schedule training sessions for plant employees that operate and maintain the baghouse. In these training sessions the following subjects should be covered: systems design, system controls, critical limits of equipment, function of each baghouse component, operating parameters that should be monitored, good operating practices, preventive maintenance, startup and shutdown procedures, emergency shutdown procedures, and safety considerations.

Supervisors, operators, and maintenance people should attend O&M training sessions. The training could be provided by the baghouse vendor or by a consulting company specializing in baghouses. Many companies have in-house expertise to provide training. The length of training would vary depending on the complexity of the system design. Average training will ordinarily take at least 40 hours for full-time maintenance people.

## **Baghouse Startup and Shutdown**

A specific startup and shutdown procedure should be supplied by the baghouse vendor. Improper startup and shutdown can damage the equipment. If hot moist gases are to be filtered, the baghouse must be preheated to raise the interior temperature in the baghouse above the dew point to prevent condensation and potential corrosion problems. This can be done by using heaters in each compartment or by burning a clean fuel such as natural gas before filtering gases from a coal-fired boiler.

The baghouse must also be brought on-line slowly to avoid permanent damage to the fabric. Clean filters do not have a protective dust cake on them and are sensitive to dust abrasion and penetration by fine particles. Penetration can lead to permanent residual pressure drop. In some applications, bags are precoated with a protective dust layer prior to bringing the unit on-line. This protective dust can be the same dust from the process or other material such as pulverized limestone. In all cases, the filter velocity should always be kept low until a sufficient dust cake is built up on the bags. This is indicated by a pressure drop of 1 to 2 inches H<sub>2</sub>O. The gas flow can then be slowly increased to the designed rate (McKenna and Greiner 1982).

A suggested startup and shutdown list for baghouse system operators is given below.

### **Startup**

1. Make sure all collector components are in working order and in proper mode.
2. Do not allow higher-than-design filtering velocities or air flow.
3. Avoid passing through (below) the dew point within the baghouse when dirty gases are present. The system should be preheated to above the dew point with clean, hot air before the introduction of flue gas. During normal operation, maintain the temperature approximately 25 degrees above the dew point level. The gas dew point level can be obtained by making process exhaust gas measurements (acid concentration, moisture, and gas temperature) and appropriate calculations or by looking it up in literature such as *The Handbook of Chemistry and Physics*.
4. Operate the bypass system to assure its readiness in an emergency situation.
5. Check all indicating and monitoring devices for proper operation.

### **Shutdown**

1. Purge the collector with clean (hot when necessary) dry air before allowing the gas temperature to descend below the dew point. This is imperative when bringing a unit off-line.
2. Do not store dust in the collector. Many maintenance workers have resigned after spending a day with pick and shovel inside a dust collector hopper.
3. The bags should be "cleaned down" after dust flow ends, but not overcleaned. The operator should allow for one or two cleaning cycles then stop the cleaning process.

4. Finally, the operator should check to see that all components are in the proper shut-down mode.

*To test your knowledge of the preceding section, answer the questions in Part 1 of the Review Exercise.*

## **Performance Monitoring**

To determine if a baghouse is operating properly and to aid in troubleshooting when failures occur, the operator must monitor certain operating parameters. Routine monitoring of key parameters, either on a continuous or periodic basis, is imperative for performance evaluation and problem diagnosis. An adequate baseline must be developed to determine when future changes in performance occur. Some typical parameters that are monitored are: inlet and outlet gas temperature (only on units operated above ambient temperature), pressure drop, opacity, and gas velocity. In addition to these parameters that can be routinely measured, it can be important to periodically evaluate the chemical composition of the gas stream, including moisture, acid dew point, and particle loading and size distribution. The following describes how the above parameters affect performance and the techniques used to measure each. In addition, there is also some common auxiliary equipment that should be monitored or periodically checked. These include receiver air pressure, bag tension, fan amperage, and high hopper level.

### **Gas Temperature**

Gas temperature is important because fabrics are designed to operate within a given range. (See Lesson 4 for details on fabric operating conditions.) Exceedances of these fabric temperature limits, even for short periods of time, can weaken or damage the bags. Exposure of the fabric to temperatures above the maximum limits can cause immediate failure due to loss of strength or elongation from melting. Minimum temperatures are related to the dew point temperature of the gas stream. Operation of the baghouse below these dew point temperatures can result in moisture or acid condensation and cause bag blinding or chemical attack of the fabric. Condensation problems are one of the major causes of bag failures.

Temperature measurements are also used to indicate inleakage into the gas stream. Temperature drops across baghouses can range from 1 to 2 degrees on small units to up to 25 degrees on large baghouses (EPA 1984). The facility must establish an acceptable or normal operating range. If this range is exceeded, it indicates that a problem is occurring and needs to be addressed.

To measure temperature, a thermocouple with digital, analog, or strip-chart display is used. The temperature signals are often tied to an alarm limit indicator to notify the operator of trouble. Temperature measurements are generally made at the inlet and outlet of the unit with the inlet being the primary focus.

### **Pressure Drop**

Baghouses are designed to operate within a certain pressure drop range, based on a specific gas volumetric flow rate. Within this range during normal operation, the pressure drop fluctuates with the cyclic cleaning process. The average baghouse pressure drop gradually increases as the filter cake builds on the bags and then takes a step decrease immediately after the compartment has been cleaned. The pressure drop across the bag-

house gives an indication of the resistance to gas flow (drag) and the effectiveness of the cleaning system. Changes in pressure drop (either gradual or especially sudden) can indicate the need for maintenance. In addition, changes in the shape of the cleaning cycle pressure drop curve (i.e. pressure drop vs. cleaning cycle time) can also indicate the need for maintenance or change in system operation.

At a minimum the pressure differential across the baghouse should be continuously recorded by the operator. Static pressure taps are connected to a transmitter/recorder so that the differential can be monitored preferably from a central control room. The most common problem with measuring the pressure drop is plugging of the static tap lines. The pressure sensors should be shielded from direct impact of the dirty gas stream, and a means to clean the lines should also be installed.

### **Opacity**

**Opacity** is a measurement of the amount of light scattering that occurs because of the particles in a gas stream. Although opacity is not a direct measurement of particle concentration, it is a very good indicator of the amount of dust leaving the baghouse, and thus provides a performance measure. Once a unit is operating at normal conditions, the opacity value for the system should be maintained within a narrow range. A continued elevated opacity level indicates operating problems, such as bag failures. The opacity monitor (also called transmissometer) can be used to identify the problem area. For multicompartment baghouses, each compartment can be isolated to identify the compartment where problems are occurring.

There are a number of vendors who sell continuous opacity monitoring systems. Many of these monitors are **double-pass opacity monitors** where the light source is on one side of the stack while the reflector is on the other side of the stack. Continuous opacity monitoring systems provide continuous feedback on a real-time basis and for set averaging periods. Coupled with a strip-chart or data acquisition system, they provide excellent trend information on baghouse operation. See Jahnke (1993) for more information on this topic.

Some facilities use broken bag detectors that give a relative indication of the dust loading leaving the baghouse. Broken bag detectors are **single-pass opacity monitors** where the light source is on one side of the stack and the detector is on the other side (there is no reflector). These are less expensive than double-pass opacity monitors and don't meet the EPA performance specifications for opacity monitors.

### **Gas Volumetric Flow Rate**

As discussed in Lesson 5, baghouses are designed to accommodate a range of gas flows. If gas flow rates increase, the operating pressure drop and air-to-cloth ratio will increase. This in effect means that the baghouse has to work harder and the bag life can be shortened due to more frequent cleaning and high particle velocity.

Presently most sources do not continuously measure gas flow rates. Gas flow rates are generally only measured during emission compliance testing or when there is a perceived problem. Manual pitot tube traverses are normally used to measure gas flow (EPA Method 1 and 2, see *Code of Federal Regulations*, Part 60). Because of new technologies and regulations, some of the larger sources are beginning to install continuous flow measurement systems. Multipoint pitot devices are being used to continuously measure gas velocity.



These devices generally consist of two tubes (in the same structure) with two sets of holes; one to sense the impact pressure and the other to measure static pressure. These devices must be calibrated to the individual stacks where they are installed.

### **Composition of Flue Gas**

Baghouses are designed based on the composition of the flue gas they treat. Important flue gas parameters are moisture level, acid dew point, particle size, and concentration. If the operating temperature falls below the condensation point, either during startup/shutdown or normal operation, blinding of the bags can occur. Similarly, if the temperature falls below the acid dew point, there is a substantial risk of corrosion. These parameters are generally only measured during a diagnostic test or emission compliance stack test. However, it is important to identify both of these minimum temperature points and have operating procedures for startup/shutdown that minimize the condensation potential. Particle size distribution and loading must be considered during design and also during operation; however, within certain limits ( $\pm 10$  to  $20\%$ ) changes in these parameters do not seriously affect baghouse efficiency (EPA 1984). Unless there is a defined problem such as bag blinding or abrasion from particles these parameters are rarely measured.

Typical monitoring devices are listed in Table 6-3.

<b>Table 6-3. Typical baghouse monitoring devices</b>		
<b>Parameter</b>	<b>Method of Measurement</b>	<b>Function</b>
Pilot lights	Electronic on/off signals	Show motors operating, compartments on- or off-line, number of bags being pulsed, etc.
Temperature indicators	Thermocouple	Alert operators of high or low temperature conditions.
Pressure drop	Manometer, magnehelic or photohelic gauges	Determine pressure drop of various points in the baghouse - across each component or the entire baghouse.
Opacity	Transmissometer or visual observation	Indicator of potential problems. Also, broken bags can be located by isolating each compartment to determine which one causes the high opacity.
Gas flow	Calibrated orifice (pitot tube) or an installed flow monitor using an ultrasonic, thermal, or pressure differential measurement technique	Indication of process change
Fan motor current (amps)	Ammeter	Indication of gas flow and early warning signs of potential fan failure if fan is not operating at design levels.

### **Recordkeeping and Routine Maintenance**

Every operation and maintenance manual ever written states that "good recordkeeping is the key to an effective operating system." In the real world, recordkeeping practices range from none to extensive computerized logging and retrieval systems. As stated previously, it is very important to develop a baseline for both the baghouse operation and the process that it controls to evaluate future performance and maintenance trends.

Although most operators agree that recordkeeping is imperative, the specifics on what parameters are monitored and at what frequency are very site-specific. A number of performance parameters were listed in the previous section. In addition to these parameters, the baghouse vendor will generally provide some checklists for performing routine inspections. These checklists should be used as templates to develop forms for the operators to fill out when making their rounds.

In addition to documenting the routine inspections, the operator should document all maintenance performed on the baghouse; especially bag replacement. A majority of the larger plants have computerized work order systems that should be used to develop a special file for baghouse maintenance. In addition, since the most common and expensive failures are for bag replacement, maintaining a trend of bag failures is imperative. A typical bag replacement record as shown in Figure 6-1 should be used. Using this type of tool can help identify failure patterns due to design or operating practices.

### Bag Replacement Record Tube Sheet Layout

Unit \_\_\_\_\_, Compartment \_\_\_\_\_

	A	B	C	D	E	F	G	H	I	J	K
<b>11</b>	0	0	0	0	0	0	0	0	0	0	0
<b>10</b>	0	0	0	0	0	0	0	0	0	0	0
<b>9</b>	0	0	0	0	0	0	0	0	0	0	0
<b>8</b>	0	0	0	0	0	0	0	0	0	0	0
<b>7</b>	0	0	0	0	0	0	0	0	0	0	0
<b>6</b>	0	0	0	0	0	0	0	0	0	0	0
<b>5</b>	0	0	0	0	0	0	0	0	0	0	0
<b>4</b>	0	0	0	0	0	0	0	0	0	0	0
<b>3</b>	0	0	0	0	0	0	0	0	0	0	0
<b>2</b>	0	0	0	0	0	0	0	0	0	0	0
<b>1</b>	0	0	0	0	0	0	0	0	0	0	0

**Access Door**

Mark Failed Bags with X.  
Reason for Failure \_\_\_\_\_  
Date \_\_\_\_\_

Figure 6-1. Bag failure location record

Inspection frequencies of all baghouse components should be established by maintenance engineers. Vendors' recommendations of an inspection schedule should be followed. A listing of typical periodic maintenance follows.

### **Daily Maintenance**

1. Check pressure drop.
2. Monitor gas flow rate.
3. Observe stack outlet visually or with a continuous monitor.
4. Monitor cleaning cycle, pilot lights, or meters on control panel.
5. Check compressed air on pulse-jet baghouses.
6. Monitor discharge system; make sure dust is removed as needed.
7. Walk through baghouse to check for normal or abnormal visual and audible conditions.

### **Weekly Maintenance**

1. Check all moving parts on the discharge system including screw-conveyor bearings.
2. Check damper operation; bypass, isolation, etc.
3. Spot check bag tensioning for reverse-air and shaker bags.
4. Check compressed air lines including line oilers and filters.
5. Blow out any dust from manometer lines.
6. Verify temperature-indicating equipment.
7. Check bag-cleaning sequence to see that all valves are seating properly.
8. Check drive components on fan.

### **Monthly Maintenance**

1. Spot check bag-seating condition.
2. Check all moving parts on shaker baghouses.
3. Check fan for corrosion and blade wear.
4. Check all hoses and clamps.
5. Spot check for bag leaks and holes.
6. Inspect baghouse housing for corrosion.

### **Quarterly Maintenance**

1. Thoroughly inspect bags.
2. Check duct for dust buildup.
3. Observe damper valves for proper seating.
4. Check gaskets on all doors.

5. Inspect paint on baghouse.
6. Calibrate opacity monitor.
7. Inspect baffle plate for wear.

**Annual Maintenance**

1. Check all welds and bolts.
2. Check hopper for wear.
3. Replace high-wear parts on cleaning system.

Sources: Reigel and Applewhite 1980; McKenna and Greiner 1982.

*To test your knowledge of the preceding section, answer the questions in Part 2 of the Review Exercise.*

## Bag Maintenance

Inspecting and changing bags takes a long time and are the highest maintenance costs in a baghouse. Bag failures occur at varying times depending on the operation of the collector. The longer the time before bag changeout, the lower the maintenance cost to the owner. Typical bag life is from two to five years. Table 6-4 lists some common causes and reasons for bag failures.

<b>Table 6-4. Common causes of fabric failures</b>		
<b>Cause</b>	<b>Result</b>	<b>Reason</b>
Improper bag installation	Holes or tears in bags Reduce bag strength	Lack of proper vendor instructions Poor access to bags Improper tensioning, rough handling such as bending or stepping on bags Bags too snug for cages Sharp edges on cages
High temperatures	Loss of fabric strength Attack finish of bag causing self abrasion	Improper fabric for service No high temperature alarm Continual operation at close to fabric temperature limits
Condensation	Alters adhesion characteristics of dust resulting in mudding or blinding Chemical attack	Unit not preheated or purged properly Air inleakage Inadequate insulation
Chemical degradation	Attack fibers and loss of strength	Improper fabric for service
High A/C ratio	Increase in bag abrasion	Change in process
High pressure drop	Increase in bag abrasion Bag tears	Poor cleaning Blind bags Increase in gas velocity
Bag abrasion	Worn or torn bags	Contact between bag and another surface High gas volumes or particle loading Large particle inspection on bag

Bag failures can be spotted through daily monitoring and inspection. Stack opacity is a good indication of bag failure. If the plume is dirty, then some problem exists, either in a single compartment or throughout the baghouse. In a compartmentalized baghouse it is possible to monitor the stack while isolating a compartment. Stack emissions would be reduced if the compartment with broken bags were taken off-line. In a noncompartmentalized baghouse it may be necessary to check the entire unit for broken bags.

Three ways to search for broken bags are (Reigel and Applewhite 1980):

1. Hunt for the hole.
2. Hunt for the accumulation of dust which can be related to a nearby hole.
3. Use a detecting device.

In shaker and reverse-air baghouses where dust is collected on the inside of the bags, bag failures occur frequently at the bottom of bags. Accumulation of dust on the cell plate is some-

times visible, making it relatively easy to spot the failure. It may be necessary to inspect the entire circumference and length of the bag if the hole is higher up on the bag tube. In reverse-air baghouses, other bag failures can also occur near the anti-collapse rings and at the top cuff where the bags are attached. In shaker baghouses, bags tend to fail at the top where they are attached to hooks or clamps.

In pulse-jet baghouses it is normally very difficult to locate bags that have failed. However, in many baghouses dust accumulation on the top tube sheet or in the blow pipe above the failed bag will be readily noticeable (Reigel and Applewhite 1980).

A technique for locating torn bags is to use fluorescent powder and a black light. Fluorescent powder is injected in the inlet to the baghouse. An ultraviolet light is used to scan the clean air inside of the baghouse. Leaks can be detected by the glow of the powder getting through a torn bag. This technique is useful for spotting broken welds or leaks in the cell plates, tube sheets or housing.

The importance of detecting broken bags depends on the baghouse design. In reverse-air and shaker units, leaks in the bags can cause air streams or jets of dust to abrade adjacent bags. This causes what is known as the "domino effect", where one torn bag creates another torn bag. In pulse-jet baghouses however, torn bags generally do not cause tears in adjacent bags since the dust leaves the inside (clean side) of the bags. If opacity limits are exceeded beyond the permit level, corrective action should be initiated immediately and the bag(s) should be changed. It may take several broken bags to cause an opacity violation.

In the past, bags were usually replaced as they failed. However, a new bag in the vicinity of old ones will be forced to take on more dust (air will tend to follow the path of least resistance) and will become worn-out quicker than the old "seasoned" bags (Reigel and Applewhite 1980). It has become accepted practice in reverse-air and shaker baghouses to simply tie off a torn bag and stuff it into the cell plate. If the failure is close to the cell plate then the hole should be plugged by using steel plate plugs with gaskets or sand bags to seal off the hole. In pulse-jet baghouses with top access, a plug is placed over the tube sheet hole of the failed bag.

The operator should keep track of the bag failure rate of individual bags to correct any conditions that would cause premature bag failure. In addition, the tracking is helpful to determine the scheduling of a complete changeout of bags at a convenient time.

### ***Common Operating Problems***

When a baghouse begins to have problems that cannot be readily identified, the operator should contact the vendor to identify and correct the problem. Problems and/or failure of components within a baghouse can occur for a number of reasons. Some problems may be unique to a particular type of baghouse design while others are generic to all fabric filters. The following is a summary of some of these problems (EPA 1984).

#### ***Dust Discharge Failures***

Hopper pluggage can cause serious problems in a fabric filter. Many dusts flow less easily when they are cold. Thus, insulation, hopper heaters, air tight seals, and continuous dust removal may be necessary to minimize the hopper pluggage problems. Regardless of the reason (cooling of the dust, inleakage, failure of the discharge system operation, or simply using the hoppers for storage), failure to remove the dust from the hopper usually results

in having to open up the hoppers to clean them out. The fugitive emissions generated by a single cleaning out of the hoppers may be greater than the emissions emanating from the fabric filter outlet for an entire year. Therefore, the occurrences of hopper pluggage should be minimized. Air inleakage is most common through the dust discharge valves and hopper access doors.

### **Shaker Cleaning System Failures**

Several problems are characteristic of shaker type baghouses:

1. Failure of the shaker motor may lead to excessive dust cake buildup on the bags and an increase in pressure drop. In some applications, when the gas flow is stopped by closing the dampers, the dust will slide off the bag. In most applications, however, the shaker system is needed for adequate removal of the dust and maintenance of a reasonable pressure drop.
2. Shaker linkages must be maintained in a manner that allows the energy provided by the shaker motor to be distributed through the shaking system to the bags. Because these systems are mechanical, periodic lubrication, checking for wear or loose parts, and replacement of broken parts are required to maintain their cleaning effectiveness. The only way to evaluate this system is to watch it in operation to ascertain that all the bags are being cleaned at approximately the same intensity.
3. Bag tension changes with the age of the bag and with the amount of material collected on the dust layer. Bags that are too tight may not transfer the shaker energy effectively and may be damaged during shaking. Bags that are too loose may sag on the tube sheet, and bag abrasion may result from the bag being placed in the gas stream or being contacted by the thimble or other bags. Loose bags also may not use the cleaning energy effectively and may block the flow of dust out of the bags if they sag, fold, or close off above the tube sheet.

### **Reverse-Air Cleaning Systems**

Common problems associated with reverse-air cleaning baghouses include isolation dampers, bag tensioning, and corrosion. The reverse-air system is a low-energy system and no gas flow can be present in the module or compartment being cleaned. The damper systems for fabric filters with this cleaning mechanism tend to be complex because a reverse flow of gas is used to collapse the bag, to break and release the dust cake, and to allow it to be collected and removed from the fabric filter. This requires a positive seal on the reverse-air isolating damper (a poppet damper is often used). Without proper sealing, the bags may not collapse properly and the cleaning action may be ineffective. Unlike the other cleaning systems, relatively little energy is available to clean the fabric, as the reverse flow of gas through the bags is usually small compared with normal, on-line gas flow.

Failure of the isolation dampers is usually easily detected, as the actuators are generally pneumatically or hydraulically operated and the movement of the piston is visible. Too little movement of the piston usually indicates that the damper is not sealing properly. In some situations, the failure of the damper system can be detected by a missing spike and subsequent decrease in pressure drop after the affected module comes off-line for cleaning. Moisture and oil in the compressed-air supply lines can cause blockage during freez-

ing weather and result in the failure of these pneumatically operated systems. Damper operation failures, however, usually result from failures of the controlling timers or pressure drop sensors that are used to activate the cleaning cycle at certain intervals or at certain pressure-drop thresholds.

Buildup of materials around the dampers or deformation of the dampers or their seals can cause problems with proper isolation of a compartment for cleaning. Confirmation of poor damper sealing is only possible by internal examination of the equipment. Even internal inspection of the damper system may be inconclusive because the system must be cooled sufficiently for safe entry. An internal inspection, however, may indicate the presence of light leaks, warped dampers and seals, or buildup or wear of the dampers caused by material passing through the fabric filter. The damper operation and seal should be checked periodically as part of a preventive maintenance program.

As with shaker baghouses, proper bag tension is essential to provide effective bag cleaning. Bags that are too tight may not collapse enough to allow effective flexing of the dust cake. Too much tension can also damage the fabric. On the other hand, insufficient bag tension may cause the bags to collapse to the point where they are closed down during the reverse-air cleaning cycle (even when anticollapse rings are used). Loose bags also may suffer abrasion from being sucked down into the thimble. Thimbles should be rounded and free of sharp edges to prevent tears, if this should occur.

Proper bag tension is a function of attention to detail during the initial installation. Bags must be hung properly, without damage, to achieve the proper bag life expectancy. Bag tension will vary with the age of the bag and also within any given cleaning cycle as material builds up on the bags. Poor bag tension can increase bag wear, cause high pressure drop, and shorten bag life.

Corrosion also can be a problem in this type of fabric filter. In some applications, most notably where acid dew point conditions have not been adequately considered, corrosion of the metal anticollapse rings has resulted in abrasion and wear of the bag at the site of bag ring contact. Special alloy metals or coatings also can be used to minimize or eliminate corrosion problems.

### ***Pulse-Jet Cleaning Systems***

Common operating problems associated with pulse-jet cleaning systems include bag abrasion, bag misalignment, and failure of the pulsing system. Pulse-jet fabric filters are widely used because of their smaller size and their higher available cleaning energy which allows for higher A/C ratios. The higher A/C ratios on this fabric filter type increase the potential for fabric abrasion.

Typically, the bags in a pulse-jet fabric filter are suspended from a tube sheet and supported by a cage. This single-point method of attachment allows the bag to move around during normal operation. One source of bag abrasion is bag-to-bag contact due to improper installation, poor alignment of the bag/cage assemblies with the tube sheet, or bent/warped cages. The rubbing together of the bags (usually at the bottom) can wear a hole in one or more of the bags.

The misalignment of bag/cage assemblies can also cause other problems. In some designs, the misalignment of the cage will prevent proper sealing of the bag with the tube sheet.



This may allow some of the dust to bypass the filter area, which decreases performance but probably causes little or no change in pressure drop. Particularly abrasive dust has been known to wear the bags and the tube sheet so severely at the point of the leak that achieving an adequate seal may be impossible without replacing the tube sheet.

Another abrasion-related problem concerns poor distribution of inlet gas flow such that the larger particles strike the bottom of the bags opposite the inlet. Some designs are equipped with a blast or diffuser plate, which is designed to bring the gas flow below the bottom of the bags. When failure of the bags occurs within about 18 inches of the bottom on the side opposite the inlet, the presence and/or integrity of the blast plate or diffuser plate should be checked.

The pressure supplied by the compressed-air system must be high enough to clean the entire length of the bag during the pulse, but not so high that it damages the upper portion of the bag. Insufficient cleaning of the bag may gradually increase pressure drop and reduce the useful bag life. Too low compressed-air pressure, which is usually more common than excessive pressure, may be caused by wear of the compressor rings, leakage of diaphragms, or excessive draining of the reserve of the compressors by other equipment tied to a common supply line.

The leakage around a diaphragm, which can usually be detected by a continuous audible leak, affects the cleaning effectiveness for all the bags. Although it may take several hours or several days, the pressure drop usually will increase eventually if the leak is severe enough.

Failure of the solenoid(s) or the timer circuit may cause one or more rows not to be cleaned. Effects on fabric filter performance may range from indiscernible to complete cutoff of gas flow, depending upon the percentage area of the bags affected and the dust characteristics. Both mechanical and electronic timers are still in use, and both have certain advantages and disadvantages. Both types must be kept in a dust-free, dry environment and relatively free from the shocks and jolts that can accompany normal operations. Solenoid failures affect the row that has experienced the failure whereas timer failures tend to affect most, if not all, of the fabric filter system.

Several problems may result from improper operation of the pulse pipe cleaning system. First, the pulse pipe may not be properly aligned to provide effective cleaning to that row. Second, the alignment may be such that the nozzles are aimed directly at the bags and can blow holes in them. Lastly, a loose pipe may damage the tube sheet or even the fabric filter enclosure, which would necessitate additional repairs.

Although all of these problems are relatively common in most pulse-jet systems and may produce bag abrasion or shorten bag life, the one problem that seems to occur with greatest frequency is the presence of water and/or oil in the pulse-jet compressed-air supply. Water and oil that are blown into the bags during cleaning tend to absorb through the bag and cause bag blinding as the dust cake becomes wet. The result is an increase in pressure drop and ultimate replacement of the blinded bags. The oil usually comes from leakage of the compressor rings and seals and the moisture from the atmosphere. Compressed-air

systems can be equipped with small water and oil traps that work well if the system is maintained and the humidity is not excessive.

A typical troubleshooting guide is listed in Table 6-5 and should be used only as a general guide. When a baghouse begins to have problems that cannot be readily identified, the operator should contact the vendor to assist in correcting the problem.

<b>Table 6-5. Troubleshooting guide</b>		
<b>Symptom</b>	<b>Possible cause</b>	<b>Remedy</b>
High collector pressure drop	Malfunction of bag-cleaning system	Check all cleaning-system components
	Ineffective cleaning	Modify cleaning cycle Review with designer
	Reentrainment of dust in collector due to low-density material or leakage at discharge	Check discharge valves Lower A/C ratio
	Wetting of bags	Control dew point excursions Dry bags with clean air Clean bags with vacuum or wet wash
	Too high A/C ratio either through added capacity or improper original design	Verify gas volume Reduce inlet volume if possible Review with designer
Abnormally low pressure drop	Change in inlet loading or particle distribution	Test Review with designer Check for changes in process operation or feed malfunction
	Manometer line(s) plugged	Blow back through lines Protect sensing point from dust or water buildup Incorporate autopurging system in sensing lines
	Manometer line(s) broken or uncoupled	Verify with local manometer Inspect and repair
Stack emission	Overcleaning of bags	Reduce cleaning energy and/or cycle time
	Broken bag	See bag maintenance section
	Bag permeability increase	Test bag Check cleaning energy/cycle and reduce if possible
	Clean-to-dirty plenum leakage	Inspect and repair
	Change of inlet conditions	Test and review

*Continued on next page*

<b>Table 6-5. (continued) Troubleshooting guide</b>		
<b>Symptom</b>	<b>Possible cause</b>	<b>Remedy</b>
Puffing	High pressure drop across baghouse	See above
	Low system fan speed	Check drive system Increase speed
	Improper duct balancing	Rebalance system
	Plugged duct lines	Clean out
	Poor hood design	Evaluate temporary modifications and implement
	Improper system fan damper position	Check and adjust
Low dust discharge	Inleakage at discharge points	Inspect and repair seals or valves
	Malfunction of discharge valve, screw conveyor or material transfer equipment	Inspect and repair
	Reentrainment of dust within collector	Lower A/C ratio
	Reentrainment of dust on filter bags	Increase cleaning
Loud or unusual noises	Vibrations	Check source and make appropriate changes
	Banging of moving parts	Check source and make appropriate changes
	Squealing of belt drives	Check source and make appropriate changes
Corrosion	Improper paint material or application	Repaint with appropriate material
	Improper insulation	Add insulation
	Dew point excursions	Carefully monitor and control process
	Improper shutdowns	Follow proper shutdown procedures

Source: McKenna and Greiner 1982.  
Reproduced by permission of ETS, Inc.

*To test your knowledge of the preceding section, answer the questions in Part 3 of the Review Exercise.*

### **Suggested Readings**

McKenna, J. D. and J. H. Turner. 1989. *Fabric Filter-Baghouses I, Theory, Design, and Selection*. Roanoke, VA: ETS.

U.S. Environmental Protection Agency. 1984, December. *Operation and Maintenance Manual for Fabric Filters*. Contract # 68-02-3919.

U.S. Environmental Protection Agency. 1987. *Recommended Recordkeeping Systems for Air Pollution Control Equipment, Part 1: Particulate Matter Control*. Technical Assistance Document. EPA 340/1-86-021.

# Review Exercise

## Part 1

1. Inleakage at flanges or collector access points can cause condensate on the bags which may result in early \_\_\_\_\_ failure and high \_\_\_\_\_.
2. True or False? A poor interior coating is worse than none at all.
3. Gas streams of high temperature should be maintained above the:
  - a. Ignition temperature
  - b. Gas dew point
  - c. Concentration limit
4. Cold spots in the baghouse can cause:
  - a. Local corrosion
  - b. Fires
  - c. Explosions
5. Many systems suffer shutdown and maintenance problems due to:
  - a. Low pressure drop
  - b. Low air-to-cloth ratio
  - c. Low dew point
  - d. Poor-quality compressed air
6. Before the baghouse is started up, the installation crew should prepare and use a \_\_\_\_\_.
7. Who should supply a specific startup and shutdown procedure for baghouses?
  - a. The inspection team
  - b. The baghouse vendor
  - c. The process plant owner
  - d. The air pollution agency
8. True or False? Bringing a baghouse on-line quickly helps seal woven bags and prevents damage to the fabric.
9. To operate properly, bags must be coated sufficiently with:
  - a. Paint
  - b. Condensate
  - c. Dust
  - d. All of the above

10. During shutdown, before allowing the collector temperature to descend below the dew point, purge it with:
- Clean dry air
  - Cool sprays
  - An alcohol cleaner
  - All of the above

**Part 2**

11. It is important to monitor the operating temperature of the baghouse to avoid and/or document:
- Exposure of bags to excessive temperature
  - Excessive air inleakage
  - Condensation occurrences
  - All of the above
12. Measuring the \_\_\_\_\_ across the baghouse gives an indication of resistance to flow and effectiveness of the cleaning system.
- Temperature drop
  - Pressure drop
  - Opacity increase
  - Collection efficiency
13. An opacity monitor is useful to baghouse maintenance because:
- Inspectors can monitor bag cleaning inside the baghouse
  - Inspectors can monitor the process stack gas plume
  - Inspectors can monitor operations of motors and on- and off-line compartments
14. If the gas velocity \_\_\_\_\_ the operating pressure drop and air-to-cloth ratio will increase.
- Increases
  - Decreases
15. True or False? Pressure drop can be very easily measured merely by using two static pressure taps.

**Part 3**

16. The longer the time before the bag changeout, the \_\_\_\_\_ the maintenance cost to the owner.
17. Bag failure can often be indicated by observing \_\_\_\_\_.
18. Broken bags can be discovered by:
- Using a detecting device
  - Visually searching out holes
  - Looking for an accumulation of dust
  - All of the above

19. In reverse-air baghouses, bag failures occur most frequently:
- At the bag bottom and around the anti-collapse rings
  - Near the hook
  - Along the internal support cage
  - All of the above
20. True or False? In reverse-air and shaker baghouse design, the "domino effect" means that one torn bag creates another torn bag.
21. True or False? In a pulse-jet baghouse, the opacity limits are exceeded when one bag is torn.
22. For processes that operate at elevated temperature, dust hopper pluggage can be caused by:
- Lack of insulation
  - Air inleakage through discharge valve
  - Lack of hopper heaters
  - All of the above
23. Poor cleaning in reverse-air systems can be caused by:
- Compressed air
  - Motor linkages
  - Isolation dampers
  - All of the above
24. Bag tension is very important in \_\_\_\_\_ and \_\_\_\_\_  
\_\_\_\_\_ cleaning systems to assure proper operation.
25. For a pulse-jet cleaning system, excessive bag wear can be caused by:
- Bent or warped cages
  - Poor inlet gas distribution
  - High compressed-air pressure
  - All of the above
26. A very common problem of bag failure in pulse-jet systems is:
- Oil or water in compressed air supply
  - Improper bag tension
  - Failure of isolation dampers
  - All of the above

# Review Answers

## Part 1

1. **Bag Pressure drop**  
Inleakage at flanges or collector access points can cause condensate on the bags which may result in early bag failure and high pressure drop.
2. **True**  
A poor interior coating is worse than none at all.
3. **b. Gas dew point**  
Gas streams of high temperature should be maintained above the gas dew point.
4. **a. Local corrosion**  
Cold spots in the baghouse can cause local corrosion.
5. **d. Poor-quality compressed air**  
Many systems suffer shutdown and maintenance problems due to poor-quality compressed air.
6. **Checklist**  
Before the baghouse is started up, the installation crew should prepare and use a checklist.
7. **b. The baghouse vendor**  
The baghouse vendor should supply a specific startup and shutdown procedure for baghouses.
8. **False**  
The baghouse should be brought on-line slowly to avoid permanent damage to the fabric.
9. **c. Dust**  
To operate properly, bags must be coated sufficiently with dust.
10. **a. Clean dry air**  
During shutdown, before allowing the collector temperature to descend below the dew point, purge it with clean dry air.

## Part 2

11. **d. All of the above**  
It is important to monitor the operating temperature of the baghouse to avoid and/or document:
  - Exposure of bags to excessive temperature
  - Excessive air inleakage
  - Condensation occurrences



12. **b. Pressure drop**

Measuring the pressure drop across the baghouse gives an indication of resistance to flow and effectiveness of the cleaning system.

13. **b. Inspectors can monitor the process stack gas plume**

An opacity monitor is useful to baghouse maintenance because inspectors can monitor the process stack gas plume.

14. **a. Increases**

If the gas velocity increases, the operating pressure drop and air-to-cloth ratio will increase.

15. **True**

Pressure drop can be very easily measured merely by using two static pressure taps.

**Part 3**

16. **Lower**

The longer the time before the bag changeout, the lower the maintenance cost to the owner.

17. **Stack opacity**

Bag failure can often be indicated by observing stack opacity.

18. **d. All of the above**

Broken bags can be discovered by doing the following:

- Using a detecting device
- Visually searching out holes
- Looking for an accumulation of dust

19. **a. At the bag bottom and around the anti-collapse rings**

In reverse-air baghouses, bag failures occur most frequently at the bag bottom and around the anti-collapse rings.

20. **True**

In reverse-air and shaker baghouse designs, the "domino effect" means that one torn bag creates another torn bag.

21. **False**

In a pulse-jet baghouse, the opacity limits may not be exceeded when one bag is torn.

22. **d. All of the above**

For processes that operate at elevated temperature, dust hopper pluggage can be caused by the following:

- Lack of insulation
- Air inleakage through discharge valve
- Lack of hopper heaters

23. **c. Isolation dampers**

Poor cleaning in reverse-air systems can be caused by the isolation dampers.

24. **Shaker**

**Reverse-air**

Bag tension is very important in shaker and reverse-air cleaning systems to assure proper operation.

25. **d. All of the above**

For a pulse-jet cleaning system excessive bag wear can be caused by the following:

- Bent or warped cages
- Poor inlet gas distribution
- High compressed-air pressure

26. **a. Oil or water in compressed air supply**

A very common problem of bag failure in pulse-jet systems is oil or water in the compressed air supply.

# Bibliography

- Cross, F. L. and H. E. Hesketh, (Eds.). 1975. *Handbook for the Operation and Maintenance of Air Pollution Control Equipment*. Westport, CN: Technomic Publishing.
- Fine particle fabric filtration. Proceedings: Symposium on the use of fabric filters for the control of submicron particulates. April 8-10, 1974. Boston, MA. *Journal of the Air Pollution Control Association*. 24(12):1139-1197.
- Greiner, G. P. 1993. *Fabric Filter - Baghouses II. Operation, Maintenance, and Trouble Shooting (A User's Manual)*. Salem, VA: Valley Printers.
- Jahnke, J. A. 1993. *Continuous Emission Monitoring*. Van Nostrand Reinhold: New York.
- McKenna, J. D. and G. P. Greiner. 1982. Baghouses. In L. Theodore and A. J. Buonicore (Eds.), *Air Pollution Control Equipment - Selection, Design, Operation and Maintenance*. Englewood Cliffs, NJ: Prentice-Hall.
- McKenna, J. D. and J. H. Turner. 1989. *Fabric Filter-Baghouses I, Theory, Design, and Selection*. Roanoke, VA: ETS.
- Reigel, S. A. and G. D. Applewhite. 1980. Operation and maintenance of fabric filter systems. In R. A. Young and F. L. Cross (Eds.), *Operation and Maintenance for Air Particulate Control Equipment*. Ann Arbor: Ann Arbor Science Publishers.
- U.S. Environmental Protection Agency. 1973. *Air Pollution Engineering Manual*. 2nd ed. AP-40.
- U.S. Environmental Protection Agency. 1984, December. *Operation and Maintenance Manual for Fabric Filters*. Contract # 68-02-3919.
- U.S. Environmental Protection Agency. 1987. *Recommended Recordkeeping Systems for Air Pollution Control Equipment, Part 1: Particulate Matter Control*. Technical Assistance Document. EPA 340/1-86-021.
- U.S. Environmental Protection Agency. 1991. Standards of performance for new stationary sources—general provisions. In *Code of Federal Regulations—Protection of the Environment*. 40 CFR 60. Washington, D.C.: U.S. Government Printing Office.

