SECTION 4.0

FABRIC FILTERS

This section provides industrial users of fabric filters with guidance and procedures for the proper operation and maintenance of this equipment so as to comply with applicable emission standards. It will also assist Agency personnel who are responsible for making inspections at facilities that use fabric filters to have a better recognition and clearer understanding of the indicators of efficient and reliable equipment operation.

4.1 General Description

Fabric filters are widely used as a control technology for particulate matter (PM). This technology removes PM entrained in the flue gas streams of industrial process ventilation or fuel combustion units by passing the dust-laden gas stream through a porous fabric.

Fabric filters (often referred to as "baghouses", which are actually the structures that house the fabric filter systems) typically consist of one or more compartments containing long cylindrical fabric bags. The compartments in this type of fabric filter system generally contain multiple rows of bags. Another kind of fabric filter is commonly referred to as a cartridge filter. Cartridge filters serve the same function as the bags in standard fabric filter systems, but self-contained cartridges (rather than bags) are used for PM capture.

Fabric filters are very efficient PM-collection devices. They typically achieve efficiencies greater than 99 to 99.9 percent for particle sizes ranging from submicrometer (10^{-6} m) to several hundred micrometers.[1] Because of their high efficiencies, fabric filters are usually considered the best available control technology (BACT) for PM emissions. They are often used for control of toxic particulate emissions.

Fabric filters can be used in series with gas pretreatment equipment for simultaneous control of PM, sulfur dioxide (SO_2) from coal-fired boilers, and corrosive acid gases. The two most common fabric filter methods used for SO_2 and acid gas control are dry sorbent injection and spray drying. In the first technique, a dry powder, sodium-based compound is injected into the flue gas upstream of the fabric filter. The powder collects on the bags as a particulate; SO_2 and acidic materials are removed by reaction with the powder in the suspended state and as the gas is filtered through the sorbent-coated bags. In the spray-drying technique, a lime-based alkaline solution is atomized into the flue gas stream ahead of the fabric filter. The solution evaporates and reacts with the SO_2 and the acidic materials. The dry reaction products are removed as particulate. Figure 4-1 depicts a typical dry scrubbing/fabric filter system.

4.1.1 Filtering Mechanism

The particle collection surface consists of the filtering medium (fabric) and a structural support. Chemically treated or untreated felt fabric or woven cloth of natural or synthetic fibers is used in standard bag designs. Cartridge filter designs use the same material, only they are configured in self-contained cartridges.

Two main phenomena comprise the manner in which particles are collected on the filter. With an unused or recently cleaned filter bag, particles are collected primarily by impaction or direct interception onto the fibers of the fabric itself. A layer of particles continues to build up on the fabric surface. Continued PM filtration builds a dust cake on the fabric surface, which, in turn, increases PM capture. This dust layer (dust cake) replaces the fabric as the filtering medium and is actually more efficient than the uncoated fabric.

Eventually, the dust cake buildup reaches a thickness that increases the pressure drop across the filter above the design set point. When this occurs, it must be removed by some means. The fabric cleaning cycle will remove most of the dust cake. After a few cleaning cycles, a steady-state dust cake forms and remains on the fabric surface, and this residual dust cake forms the basis for particle collection when the filter is put back in service.

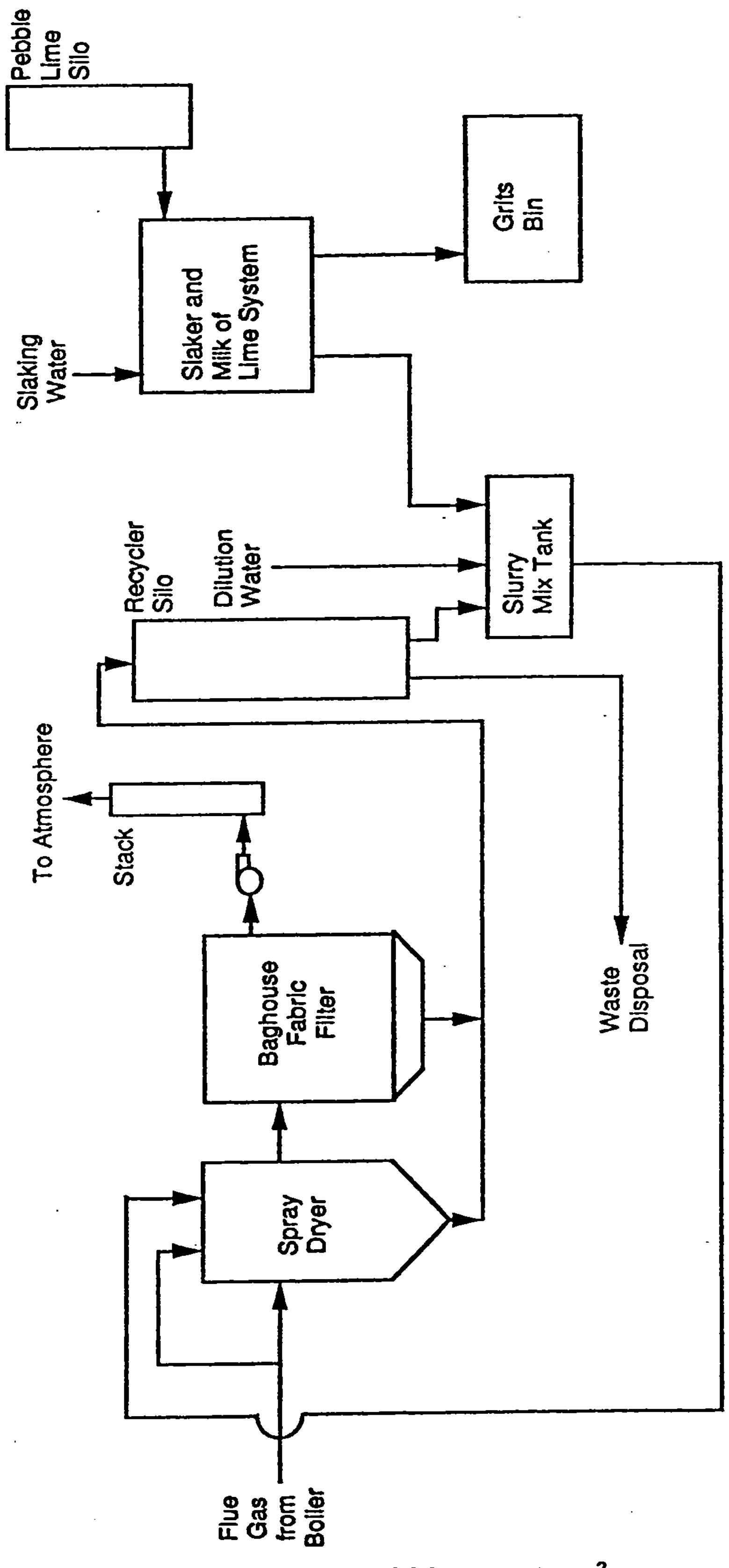


Figure 4-1. Typical dry scrubbing system.[2]

4.1.2 Types of Fabric Filters

Fabric filters are classified by several methods, the most common of which are location of system fan, direction of dirty gas flow, and fabric cleaning mechanism. Each is described in the subsections that follow.

Location of System Fan--

Particulate-laden air is either pushed through or pulled through the fabric filter. Figure 4-2 shows the different fabric filter fan arrangements. The control device is referred to as a positive-pressure fabric filter, when the dirty gas stream is <u>pushed</u> through the system and as a negative-pressure fabric filter when the dirty gas is <u>pulled</u> through the system.

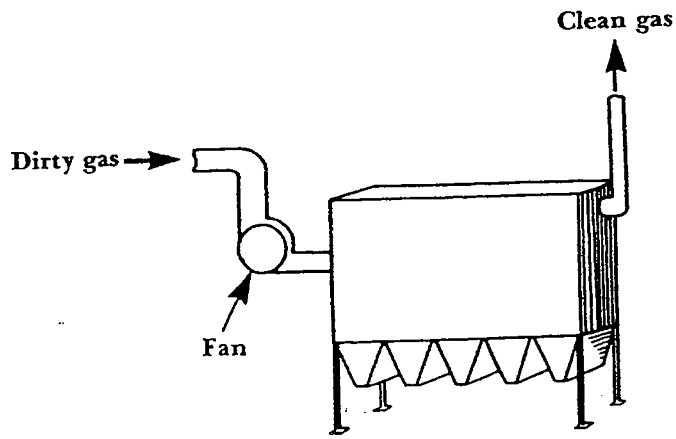
In positive-pressure fabric filter designs, the system fan is situated upstream of the collector. These designs are generally used for extremely high airflows, but this type of fabric filter presents inherent operational and maintenance concerns. Because the fan is located on the dirty side of the collector, PM present in the gas stream can attack the fan and cause premature damage to the fan blades and bearing assembly.

In negative-pressure designs, the system fan is located downstream of the collector. Negative-pressure baghouses must be structurally reinforced to compensate for the suction applied by the induced draft fan and to prevent the infiltration of outside air into the system. Fan reliability is better in these baghouses because the fan handles a clean gas stream.

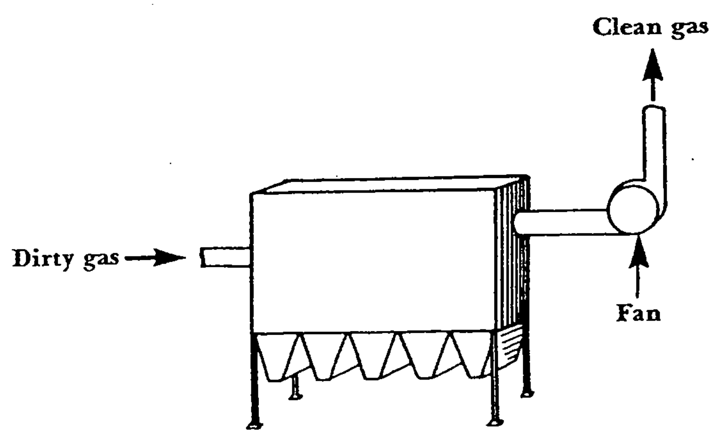
Direction of Dirty Gas Flow--

The two flow directions of dirty gas and the subsequent PM collection are known as interior and exterior filtration. In interior filtration, PM is collected on the interior surface of the filter bag or cartridge. In exterior filtration, PM is collected on the exterior surface of the filter bag or cartridge.

Figure 4-3 depicts an interior filtration system. The particulate-laden gas stream enters the collector and is directed inside the bag by diffuser vanes and a cell plate (also

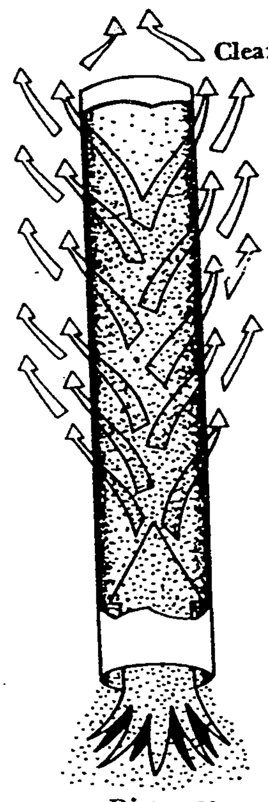


Positive pressure



negative pressure

Figure 4-2. Positive and negative pressure fabric filters.[3]



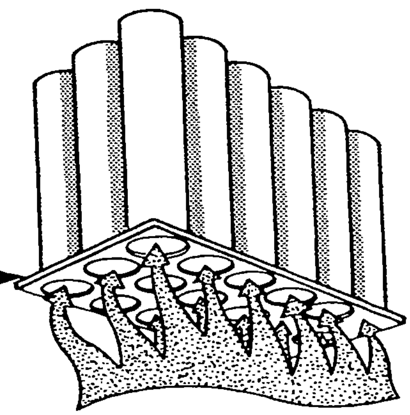


Figure 4-3. Interior filtration (particles collected on the inside of the bag).[3]

referred to as a tube sheet) that separates the bag inlet (dirty side) from the bag outlet (clean side); clean gas then passes through the bag (inside out).

Figure 4-4 depicts an exterior filtration system, in which dust is collected on the outside of the bags. Particulate-laden gases enter the collector and pass through the bags (outside in). Clean gas enters the interior of the bag and passes through the top of the bag. A cell plate separates the bag outlet section (clean side) from the bag inlet section (dirty side). Because the gas stream is pushed from outside to inside in this method, internal bag support is needed to prevent bag collapse. Internal cages or rings are commonly sewn into the bag fabric.

Fabric Cleaning Mechanism--

The fabric cleaning mechanism is also a distinguishing feature among fabric filter designs. The shaking, reverse-air, and pulse-jet cleaning methods are the most common.

Shaking, a low-energy method that gently shakes dust-laden bags to remove the dust cake, is used in interior filtration systems. The primary kinds of shaking motions are horizontal, vertical, and sonic vibration (Figure 4-5).

In shaker-type fabric filters (Figure 4-6), the filter bags are sealed at the top and hung by hook or clasp. The bags are open at the bottom and are attached to the stationary cell plate. Particulate-laden gas enters the bag below the cell plate and passes through the bag interior. The mechanical shaker system normally consists of a motor and cam/crankshaft assembly connected to the bag support frame. The rotary movement of the cam or crankshaft causes the bags to move or shake from the top. As a result, the bag flexes and cracks the dust cake, which then falls into collection hoppers. Other, less-popular shaker fabric filter designs create bag vibration by use of sound waves generated by a sonic horn blast.

Bag cleaning can be done by bag, row, or compartment. The flow of dirty gas to the bags being cleaned is stopped before cleaning is begun to prevent dust reentrainment and to promote efficient dust cake release.

Reverse-air cleaning is also a low-energy cleaning mechanism. Cleaning is accomplished by stopping the dirty gas flow to a bag, bag section, or fabric filter

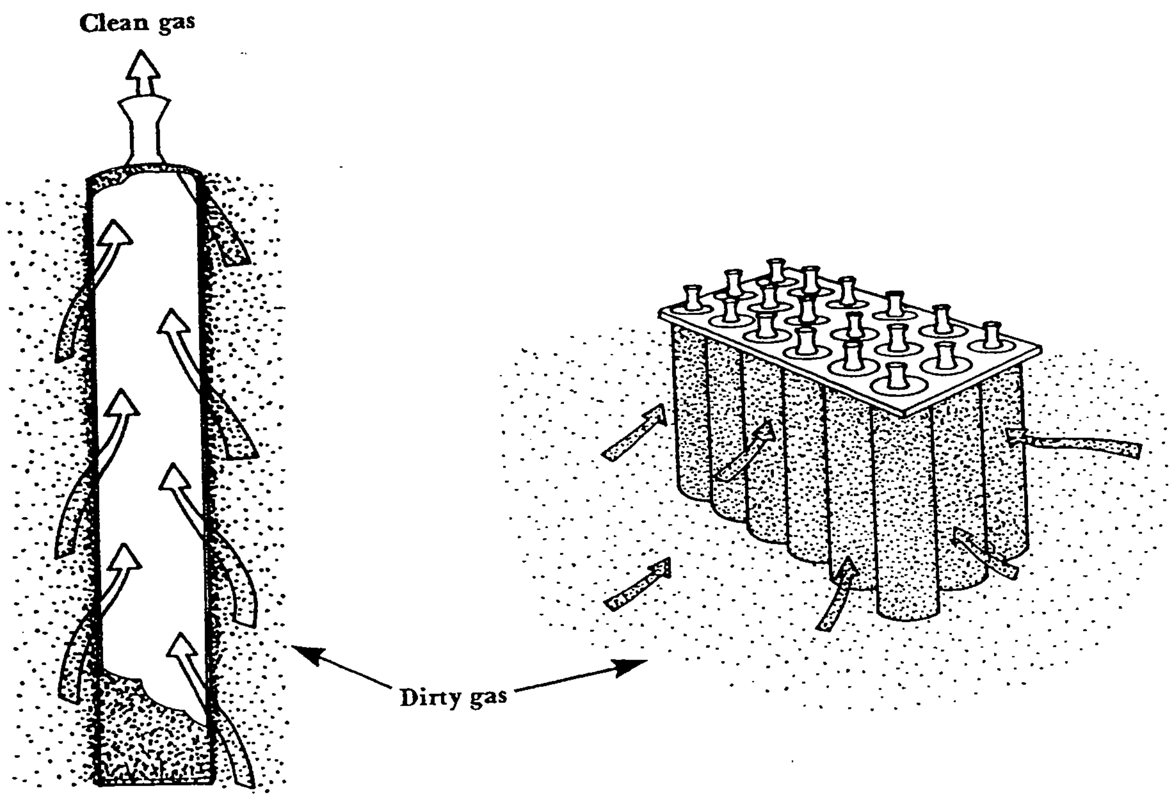


Figure 4-4. Exterior filtration (particles collected on the outside of the bag).[3]

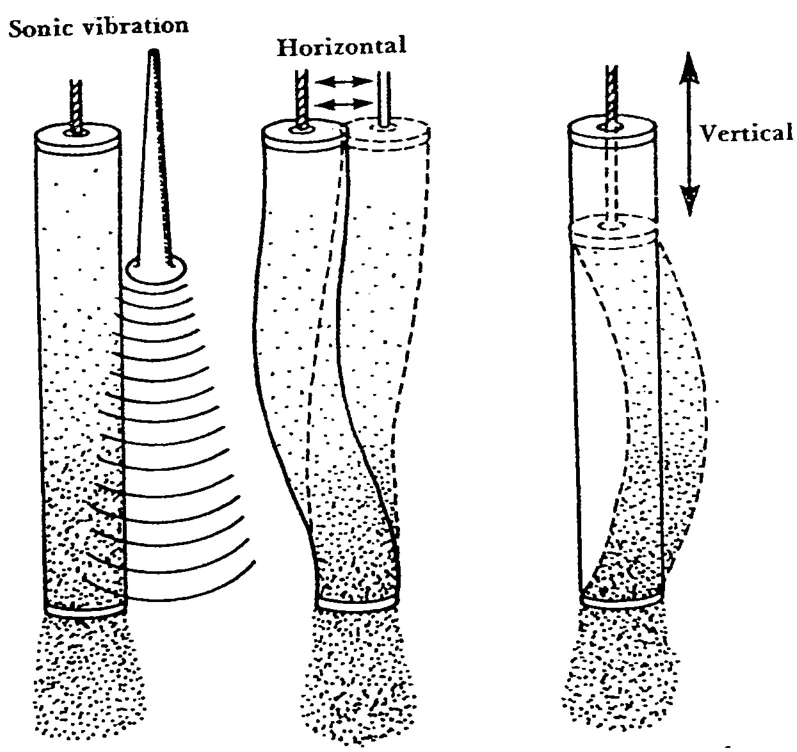


Figure 4-5. Shaking cleaning mechanisms.[3]

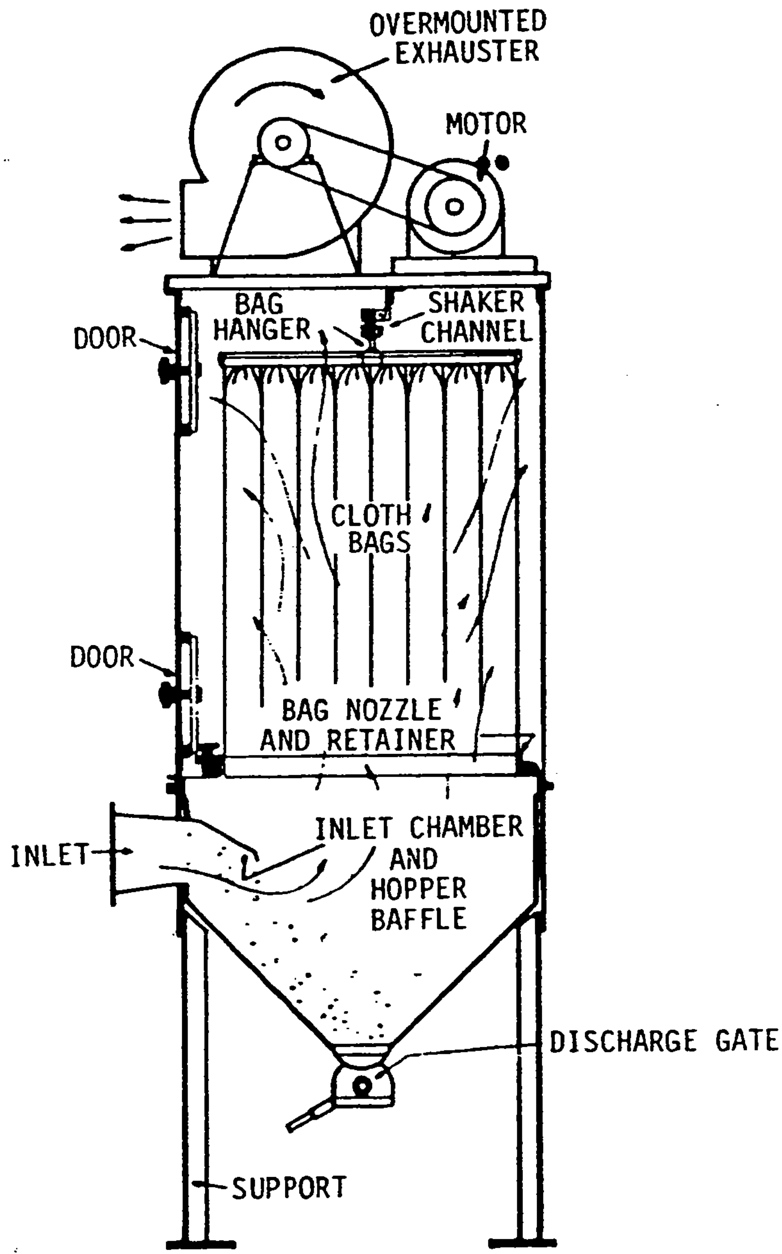


Figure 4-6. Small shaker-type fabric filters (Flakt, Inc.).[4]

compartment and allowing a low-pressure air stream to enter in the opposite direction (Figure 4-7). The reverse air-flow collapses the bags and breaks the dust cake. Reverse-air units are most applicable to interior filtration systems, but they can also be used in exterior filtration systems if internal bag support is provided. Figure 4-8 shows an example of a reverse-air fabric filter.

As in shaker-type fabric filters, the filter bags in reverse-air units are sealed at the top and hung by hook or clasp. The bags are open at the bottom and are attached to the stationary cell plate.

Pulse-jet (or pressure-jet) bag cleaning is the most popular method used in current fabric filter designs. Figure 4-9 shows a pulse-jet fabric filter. Pulse-jet cleaning is used exclusively for exterior filtration fabric filter models and cartridge filter systems. Bags in a pulse-jet system are supported by cages and are suspended from an upper cell plate.

The pulse-jet cleaning technique uses a high-pressure jet of compressed air directed through the top of the bags to the interior of the filter bags. Compressed air for cleaning is supplied through a manifold-solenoid assembly into blow pipes. A bag cup and venturi are installed at the top of the bags to improve the effect of the air blast and also protect the bag top from wear.

The compressed air jet travels down and back up the bag; the standing wave causes the bag to flex and expand (Figure 4-10) and then breaks the dust cake. Pulse-jet units generally use compressed air systems that will feed a common header arrangement that injects air into bags based on a per-compartment cleaning cycle (Figure 4-11).

4.1.3 Auxiliary Equipment

Fabric filter systems include auxiliary equipment such as structural housing (the baghouses) and insulation, dust hoppers, and a system fan.

Most fabric filters consist of two or more separate bag compartments. Baghouse shells are of rigid metal construction. In high-temperature or acidic gas stream applications, the baghouse structure is insulated to prevent moisture or acid condensation in the unit, which can cause corrosion and premature deterioration of the equipment.

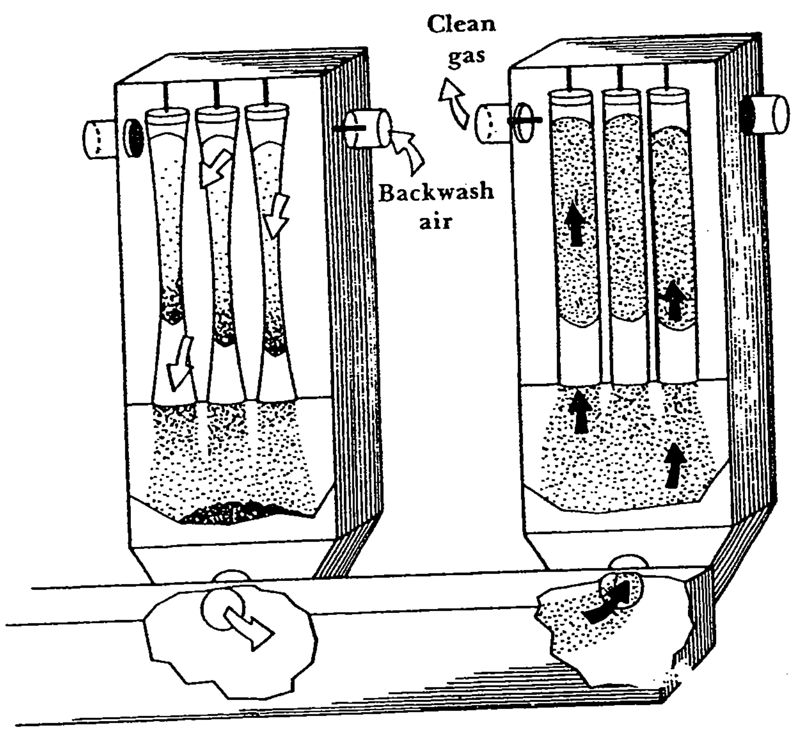


Figure 4-7. Reverse-air cleaning.[3]

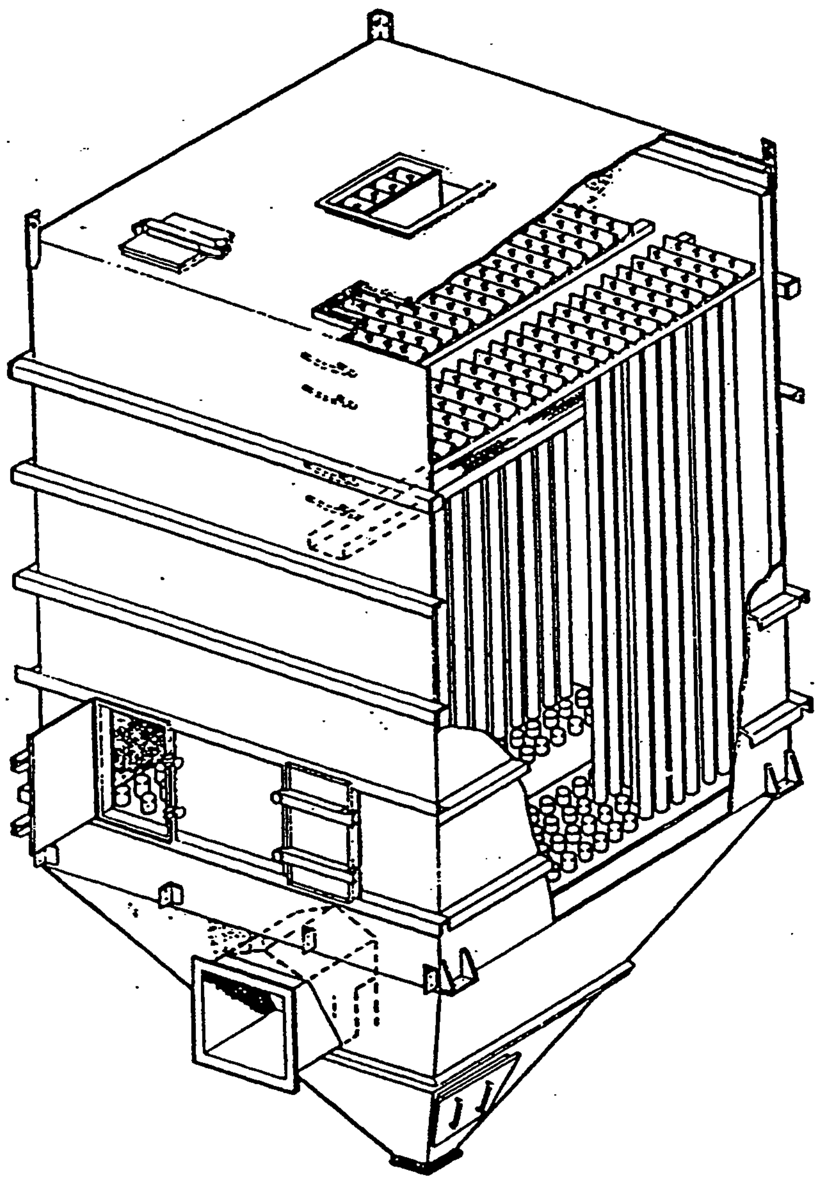


Figure 4-8. Reverse-air fabric filter (MicroPul Corporation).[4]

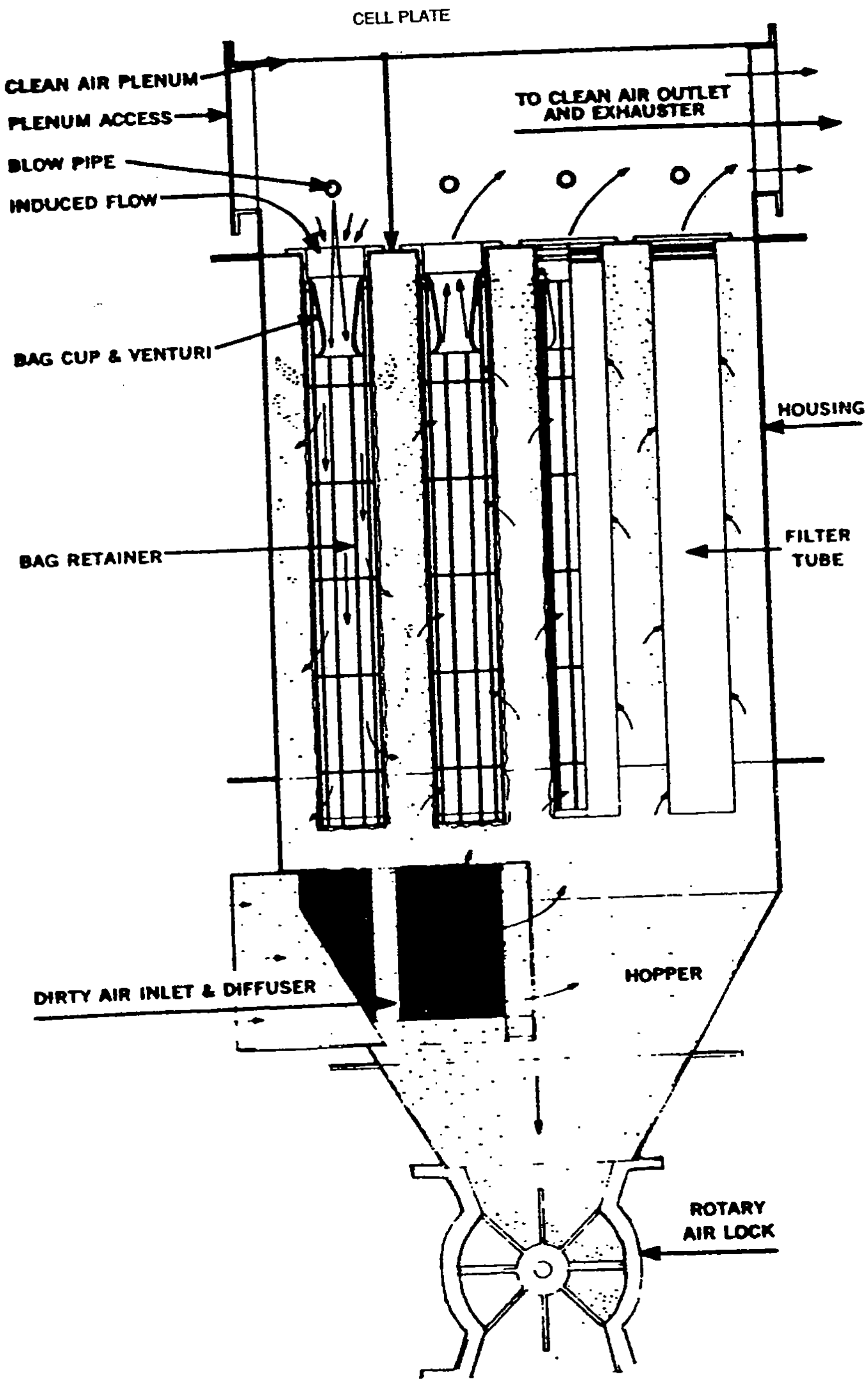


Figure 4-9. Example of a pulse-jet fabric filter (George A. Rolfes Company).[4]

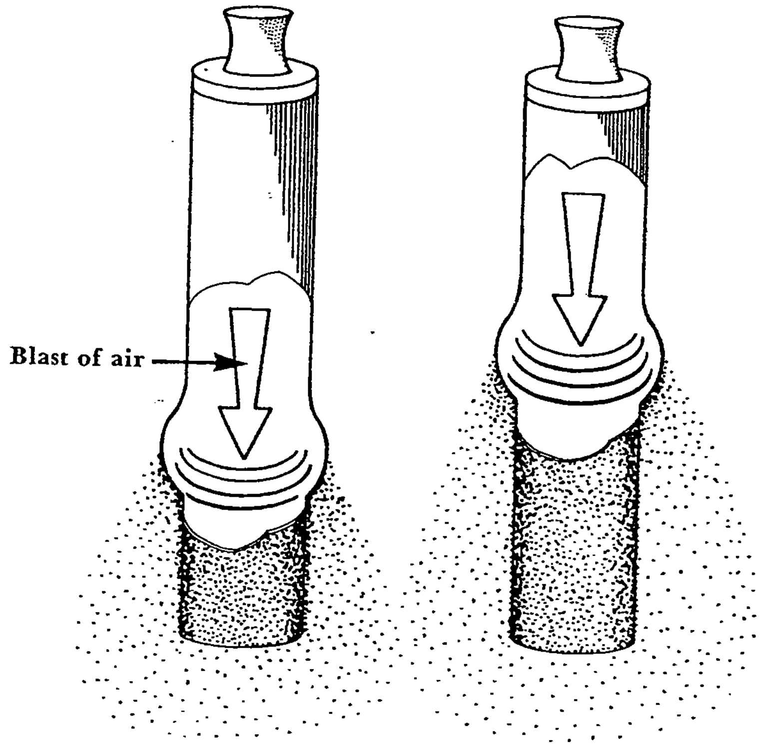


Figure 4-10. Pulse jet cleaning.[3]

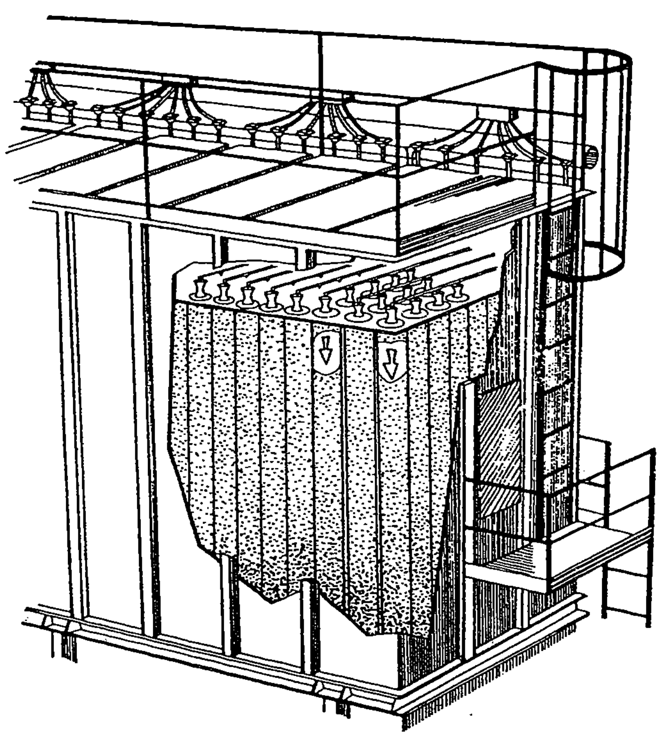


Figure 4-11. Pulse jet air supply.[3]

Hoppers are installed below the bag compartments to collect the dust that is removed from the bags. Hoppers in medium and large fabric filter systems are emptied automatically, either by pneumatic or mechanical systems, at a remote dust accumulation point. Dust collection hoppers in small fabric filter systems are generally emptied into 55-gal drums for disposal.

Hoppers are normally designed with about a 60-degree slope to allow free dust flow to the hopper's bottom opening. Additional hopper/dust flow modifications include strike plates, poke holes, vibrators, and rappers. Hoppers also have access doors for easier cleaning, internal inspections, and maintenance. Figure 4-12 shows a hopper in a fabric filter system.

The hopper's discharge system normally consists of a discharge valve at the hopper bottom, which empties into a dust-conveying system. The most common hopper discharge valves are trickle valves (gravity and motorized), rotary airlock valves, and automatic slide gates. Hoppers in many small fabric filter systems do not have a discharge valve; instead, they empty directly through a chute into a drum. Some small systems have manual slide gates. Figure 4-13 shows a trickle valve and rotary airlock valve.

The two main types of dust-conveying systems are mechanical screw and pneumatic systems (Figure 4-14). Screw conveying systems consist of a revolving screw feeder located at the hopper bottom. Pneumatic conveyors use compressed air to blow the dust discharged from hopper valves. Pneumatic conveying systems almost always include hopper discharge valves. Screw conveying systems, however, do not necessarily require hopper discharge valves.

4.1.4 Key Operating Parameters

Efficient operation and effective life of fabric filter systems can be promoted by proper monitoring of selected key parameters followed by appropriate corrective action. Some parameters are monitored on a continuous basis, whereas others are monitored periodically. The following operating parameters are good indicators of efficient fabric filter operation:

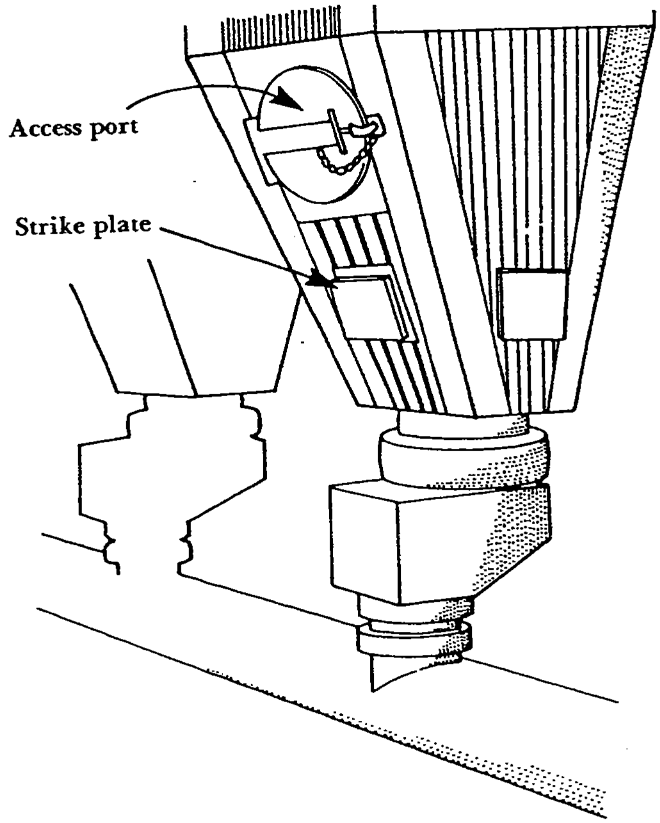


Figure 4-12. Hopper on fabric filter system.[3]

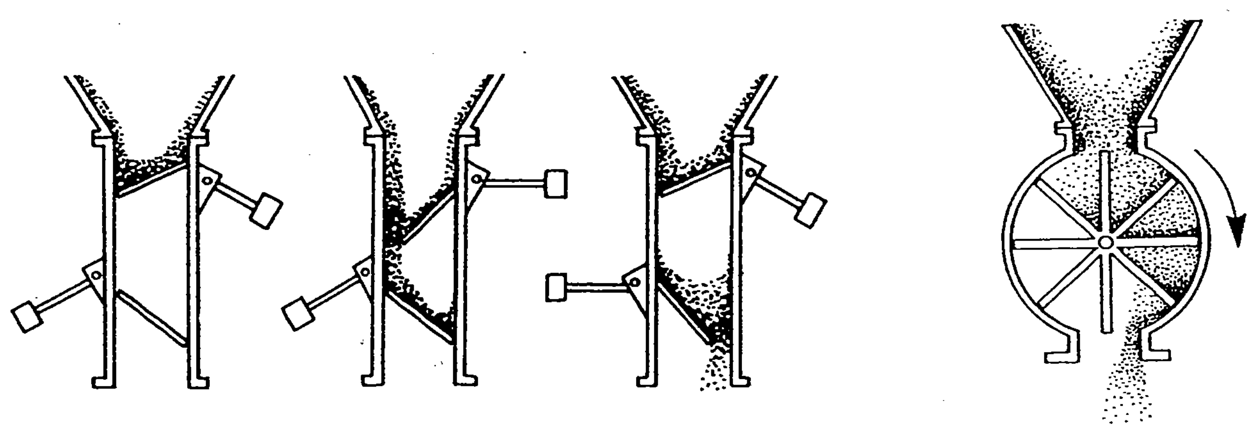
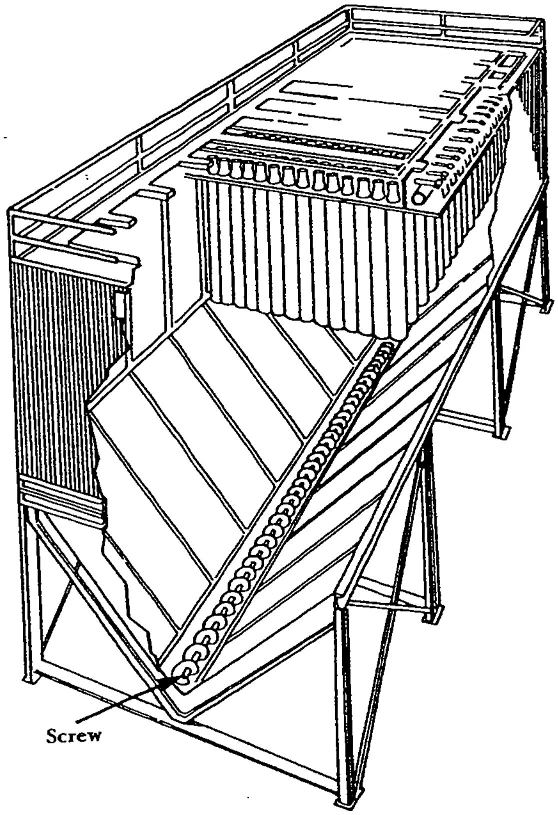
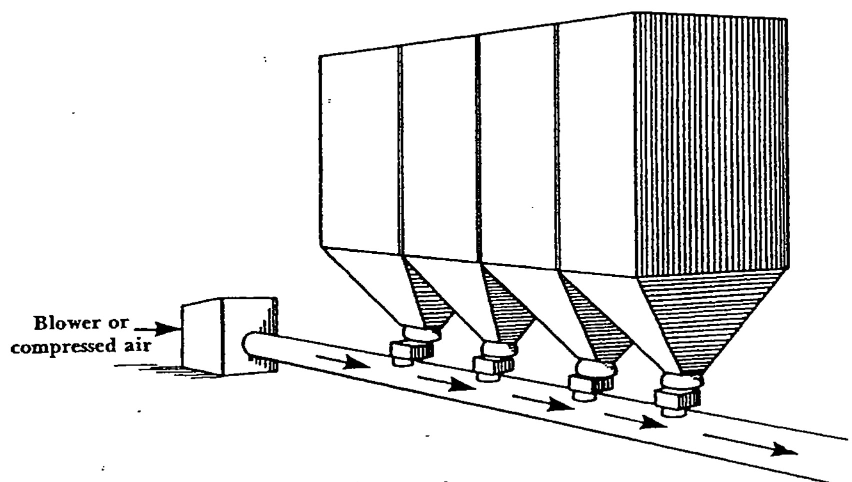


Figure 4-13. Trickle valve discharge device and rotary air lock.[3]



Screw conveyor.



Pneumatic conveyor.

Figure 4-14. Screw and pneumatic conveyors.[3]

Pressure drop (entire system or individual compartments)
System gasflow rate
Gas temperature
Bag tension
Dust removal
Opacity of baghouse exhaust

Pressure Drop--

Pressure drop is often the only parameter monitored in a fabric filter system.[5] Each system is designed to operate within a defined pressure-drop range. Proper fabric filter operation is indicated if pressure drop is fairly steady during operation and gradually increases as the dust cake builds on the bags. After the bag cleaning cycle, the pressure drop decreases instantaneously.

Pressure drop can be measured across an entire fabric filter system or for individual compartments. Pressure drop measurements can indicate permeability of filter cloth, extent of dust deposit before cleaning, cleaning efficiency, and plugging or blinding of the filter fabric.[4]

System Gas Flow Rate--

Because fabric filter pressure drop is a function of velocity, pressure drop values can only be compared for system diagnostic purposes at the same volume flow. Noting and recording system gasflow is also useful in detecting potential inleakage of outside air.

A change in system gas volume (and velocity) will affect the unit's air-to-cloth (A-C) ratio, required cleaning energy and effectiveness, bag life, and PM collection efficiency.[4] Higher gas volumes lead to higher A-C ratios and gas velocities. These, in turn, will shorten bag life as a result of more frequent cleaning, higher particle velocity through the fabric (increased abrasion), greater bag blinding potential, and a higher pressure drop--all of which are factors that limit fabric filter efficiency.[4]

Gas Temperature--

Monitoring of gas temperature (inlet and outlet) can provide information about fabric filter performance and indicate possible reasons for decreased performance or process problems. An acceptable temperature range is normally determined by the manufacturer during the design of the fabric filter unit. An increase in temperature difference between the inlet and outlet may indicate excessive inleakage of outside air into the fabric filter housing.

Inlet temperature monitoring is important for minimizing bag damage due to exposure to temperatures outside the acceptable range. The exposure of the fabric filter to temperatures above the maximum exposure limit can cause immediate bag failure due to complete tensile strength loss and permanent elongation from melting. Short excursions above the upper temperature limit can weaken bags.[4]

Minimum inlet temperature limits are directly related to the acid dewpoint of the gas stream. Operation of a fabric filter below the minimum inlet temperature can allow moisture and/or acid condensation and result in bag blinding or chemical attack of the fabric.

Bag Tension--

Proper bag tension is an important factor for improving bag life and minimizing PM emissions. A bag should be tight enough to prevent excessive fiber-to-fiber and bag-to bag contact and abrasion, but not tight enough to cause the bag to exceed its tensile strength during cleaning.[4] Figure 4-15 presents an example of a properly tensioned bag.

Dust Removal --

Excessive dust buildup in the fabric filter hopper can adversely affect system performance. If the level of dust in the hopper increases substantially, dust can become reentrained in the gas stream and overload the bags, increase their cleaning frequency, and shorten their effective life.

Hopper dust levels are affected by several things, including the proper operation of the hopper discharge valve (if applicable) and dust viscosity. A malfunctioning discharge valve will increase dust levels by not evacuating any previously collected dust. Sticky or tacky dust may cling to hopper walls or bridge across the top of the hopper and thereby prevent the use of the whole hopper volume.

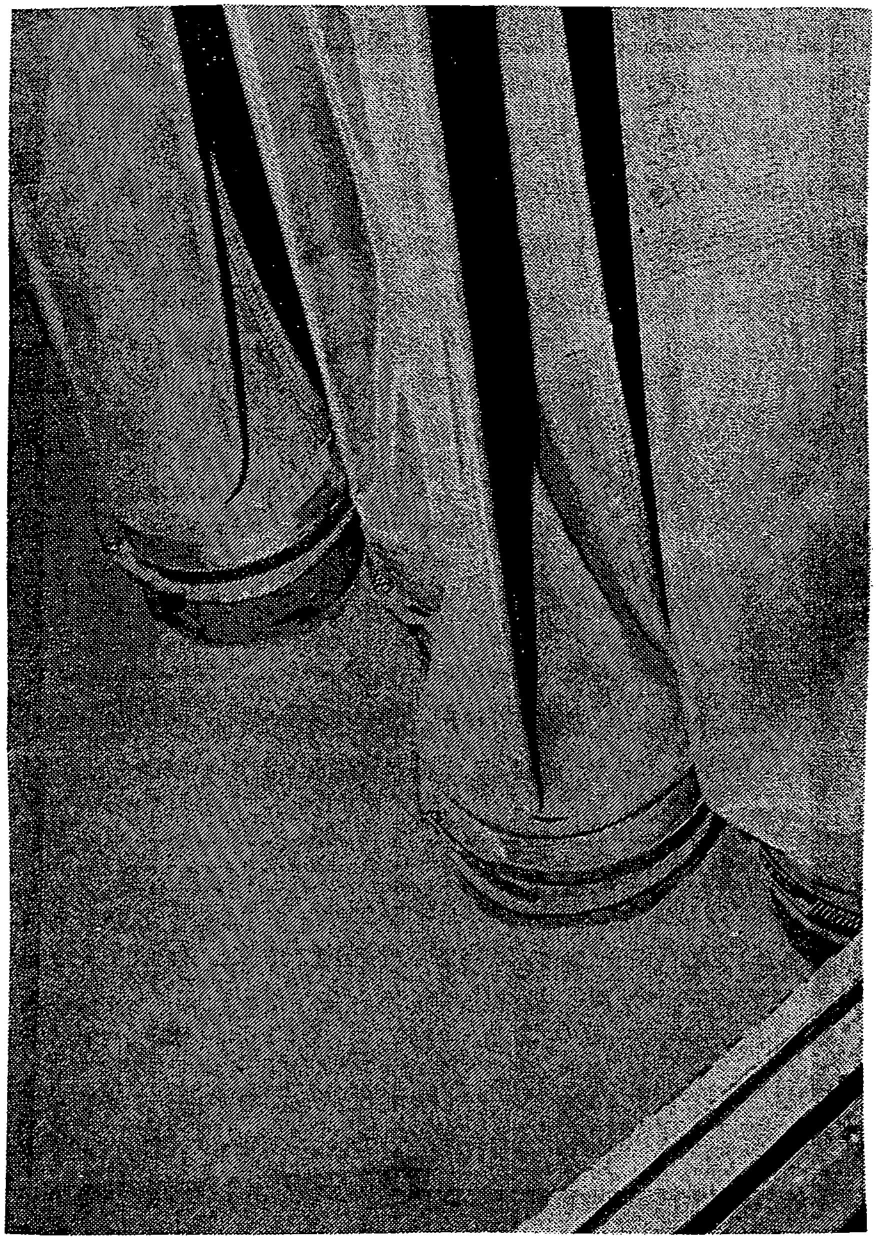


Figure 4-15. Example of a properly tensioned bag that is collapsed during reverse-air cleaning.[4] (PEI Associates, Inc.)

Opacity of Fabric Filter Exhaust--

In excess of 5 percent opacity in visible emissions from a fabric filter stack may indicate a decrease in collector performance that warrants investigation. Although there is no standard mass emission-percentage opacity relationship, sources could develop a site-specific correlation of mass particulate emissions to percentage opacity to provide a relative indication of fabric filter performance with respect to permitted emission limits.

Frequent or continuous monitoring of opacity (by human observer or instrument) can be used to develop curves for tracking decreased fabric filter performance versus length of equipment service life.

4.2 Monitoring Fabric Filter Operation

4.2.1 Monitoring Systems

Routine monitoring of the key operating parameters identified in Subsection 4.1.4 will improve the performance of a fabric filter and increase its effective service life. The readings of some of the instrumentation described in the following subsections (e.g., thermocouples, differential pressure gauges, and opacity transmissometers) can be electronically recorded for permanent records.

Pressure Drop--

Static pressure gauges such as magnehelic gauges or manometers can be installed at the inlet and outlet of the fabric filter to determine the unit's pressure drop. In multicompartment fabric filters, the pressure drop across each compartment can be measured along with the overall pressure drop. Static pressure indicators used for this purpose must withstand high temperature and dust loadings. Over time the pressure-sensing lines can become clogged with dust or damaged by moisture or corrosion, and the gauge can become unreadable. Provisions for cleaning the pressure taps are required to prevent premature instrument failure due to clogging.

Portable pressure meters can be used as an alternative to differential pressure gauges. Hand-held static pressure gauges inserted through pressure taps provide a simple method of taking pressure readings. This technique is less expensive and reduces potential problems of meter moisture or corrosion damage and clogging; however, the readings are not continuous.

Pressure indicators can be installed on pulse-jet fabric filters to measure compressed air header pressure. This type of instrument can be used to signal when the header pressure drops below a set point that may indicate inefficient bag cleaning.[4]

System Gasflow Rate--

A pitot tube traverse is normally used to measure total gas volume. Measurement of inlet and outlet gas flow is important for comparative purposes. Use of the pitot tube method relies upon the procedures specified by U.S. EPA Reference Methods 1 and 2. The pitot tube traverse samples the gas velocity in multiple areas of the duct; the gas volume is calculated by taking the average velocity and the duct cross-sectional area.

Most facilities do not measure gas volume. Other indicators may be used to estimate the gas volume or to indicate changes from a baseline measurement. The alternate parameters include fan operating voltage or amperage, production rate, or gas condition (e.g., percent O_2, CO_2).[4]

Gas Temperature--

Inlet and outlet gas temperatures can be measured by simple thermocouples. The thermocouples can be permanently installed in the duct, or they can be portable and inserted during inspections. Permanent thermocouples can be connected to continuous recorders with digital, analog, or strip-chart display.[4] It may be necessary to have separate thermocouples to measure inlet conditions in compartmental units.[4]

Bag Tension--

Bag tension is an operating parameter that generally cannot be monitored on a frequent basis. Either the entire fabric filter or individual compartments must be off-line to inspect for adequate bag tension. Monitoring of this parameter is described later in this section.

Dust Removal--

Hopper level indicator and alarm systems can be used to monitor the dust level in fabric filter hoppers. When dust levels exceed the level of the detector, an alarm is triggered to prompt corrective action. The level detector should be installed high enough in the hopper to account for normal dust levels, but low enough to allow adequate response time to clear the hopper before the dust buildup reaches the tube sheet and becomes reentrained or blocks the filter inlet.[4]

The two types of level indicators are most commonly used are a capacitance-type probe and a radioactive detector.[4] The former is inserted into the hopper. As dust builds up around the probe, a change in capacitance occurs and sets off an alarm signal. The radioactive type uses a beam that is received by a detector on the opposite side of the hopper. When the dust level interrupts this beam, an alarm signal is tripped.

Hopper dust level can also be monitored by indirect methods. On pneumatic dust-conveying systems, the operator can check for a plugged hopper by checking the amount of vacuum drawn on a hopper as dust is removed. On mechanical screw conveying systems, the current drawn by the conveyor motor can be used as an indicator of normal dust removal. A third method involves the use of a thermocouple inserted into the hopper. A clogged hopper with dust buildup will coat the thermocouple and reduce the temperature.

Opacity of Fabric Filter Exhaust--

Opacity of fabric filter outlet gas streams can be measured by human observation or by a continuous recording instrument. Plant personnel who are certified to make U.S. EPA Reference Method 9 (Appendix A, 40 CFR 60) observations can used to spot- check stack opacity, or they can be used on a defined schedule to observe opacity for longer periods.

Opacity monitors are continuous instruments that measure and record stack opacity levels. Opacity can be measured and recorded on a real-time basis and over selected averaging times. Most current opacity monitor designs are double-pass transmissometers (the light beam passes through the gas stream and is reflected back across the duct to a transceiver). Regardless of the design, opacity monitors must meet the instrument operating requirements specified in Performance Specification 1, Appendix B, 40 CFR 60.

4.2.2 Equipment Inspections

Two general classes of inspections are performed on fabric filter equipment. One class is routine in nature and performed in support of general maintenance activities. Routine inspection and maintenance procedures are discussed in Section 4.3. The second class of inspection, referred to as a diagnostic inspection, is performed to determine the cause of detectable operating problems. These inspections are described in Section 4.4.

4.3 Inspection and Maintenance Procedures for Fabric Filter

The inspection frequency and action items for fabric filters are usually specific to each manufacturer and equipment design; however, some equipment is common to most designs and requires routine inspection. The following are the major elements that should be evaluated during the inspection of the fabric filter system:[4,6]

- Parameter monitors--Includes opacity or broken bag detectors; manometers for determining pressure drop across fabric, compartments, or entire collector; indicators for cleaning sequence, cycle time, compartments off line, temperature, volume flow, air-to-cloth ratio, moisture, pulse-jet header pressure, and reverse-air flow.

- Baghouse exterior--Includes cleaning system operation; cleaning method; overall condition of exterior housing, including structural members, access doors, and gaskets; reverse-air fan operation; and shaker mechanism. External inspection will reveal visual evidence of corrosion; warping of panels; faulty or missing gaskets; loose bolts; and noise, odor, or elevated temperatures, which are indicators of worn bearings, overstressed fan belts, and electric motor problems.

- Fabric filter interior (if feasible)--Condition of bags, i.e., tears, pinholes, and sagging (inadequate tension). A sagging or slack bag can result in the bag folding over the bottom thimble connection and creating a pocket in which accumulated dust can rapidly abrade and tear the fabric. Slackness also prevents effective cleaning action with both reverse-flow or mechanical shaking systems. Dust seepage or bleeding and/or pinhole leaks are evidenced by dust deposits on the clean side of the fabric. Staining and stiffening of the dirty fabric indicates excessive caking caused by moisture condensation or chemical reactions. The latter condition leads to fabric blinding and excessive pressure loss as well as to fabric failure. More than a 1/4-inch dust layer on floor plates or isolated piles of dust suggest excess seepage and/or torn or missing bags. Inspection of the inlet plenum, including bag interior, will reveal any excess dust buildup on bags and distribution plates. As a "rule-of-thumb" for smaller fabric filters, if the amount of dust on a bag after cleaning is more than twice the weight of a new (unused) bag, insufficient cleaning is indicated. The condition of solenoid valves, poppet valves, mechanical linkages, and bag clamps is also indicated.[4,7]

Table 4-1 summarizes the items that should be included as part of regular fabric filter inspections. Most major system components should be inspected routinely and any needed maintenance performed.

4.3.1 Routine Preventive Maintenance Inspections[4]

This section presents suggested procedures for performing routine preventive maintenance inspections of typical pulse-jet, reverse-air, and shaker type fabric filters.

Pulse-Jet Fabric Filters--

Evaluation of Plume Characteristics. An average opacity should be predetermined. Most pulse-jet collectors operate with less than 5 percent opacity, so values approaching 5 percent <u>may</u> suggest operating problems. If puffs are observed, the timing should be noted so that it is possible to identify the row being cleaned just before the puff.

Filtration System. The pressure drop across the collector should be noted. If there is a gauge, its proper operation should first be confirmed by observing meter response during the pulsing cycle. If the condition of the gauge or its connecting lines is questionable, one line at a time should be disconnected to identify any plugged or crimped lines (disconnecting lines may not be possible if a differential pressure transducer is connected to the gauge lines).

TABLE 4-1. GENERAL ITEMS INCLUDED IN ROUTINE FABRIC FILTER INSPECTIONS[4,6,8-12]

- Inspect filter media (bags, cartridge) for blinding, leakage, wear, slack, bag tension, loose bag clamps or thimbles, broken hooks, cages, or discoloration. (weekly)

- Inspect and maintain system instruments (pressure, opacity). (monthly)

- Inspect the overall collector and compartment housings, hooding, and connecting ductwork for leakage, corrosion, or dust accumulation. (semi-annually)

- Inspect all solenoid-operated pneumatic damper actuators, airlocks, and valves for proper seating, dust accumulation, leakage, synchronization, and operation. (weekly)

- Inspect hopper discharge for possible bridging of dust. (daily)

- Measure the pressure drop of the bag. Compare frequency of cleaning with that recommended by the manufacturer. (weekly)

- Inspect fan bolts (for tightness), bearings (for vibration), and temperature. Inspect for erosion or dust buildup in the housing and on the wheel. Check alignment of fan impeller with V-belt drive or coupling and driver. Check sheave for signs of V-belt wear. (semi-annually)

- Inspect all bearings on fans, motors, dampers, etc. for lubrication and free rotation. (monthly)

- Inspect foundation bolts on collector, motor, fan, etc. for tightness. Also inspect bolts on collector housing and structural members. (annually)

- Inspect access door(s) for leaks due to faulty gaskets or warping of door(s) and/or frame(s). (quarterly)

In the absence of a properly operating gauge, portable instruments should be used to measure the static pressure drop at isolated ports installed specifically for this purpose. It is important for measurements at the inlet and the outlet to be made separately so that plugged tap holes and lines can be identified.

Checking the operation of the cleaning system should include noting the air reservoir pressure. The ends of the reservoir and the connections to each of the diaphragm valves should be checked for air leakage. Because these valves are normally activated on a frequent basis, it is usually possible to observe a complete cleaning cycle. Each valve should generate a crisp thud when activated. Absence of this sound could indicate air leakage into the blow pipe (Figure 4-16). If too many of these valves are out of service, the air-to-cloth ratios are probably high, which can cause excessive emissions through the fabric filter or inadequate pollutant capture. Even if all diaphragm valves are working properly, reduced cleaning effectiveness can result from the low compressed-air pressures.

If the compressed-air pressures are too high, especially for units designed with a high air-to-cloth ratio, the intense cleaning action could result in some seepage of dust through the bag fabric when the bag is pushed into the support cage immediately after cleaning. This will cause a momentary puff of 5 to 10 percent opacity.

Holes and tears can lead to puffs or 5 to 30 percent opacity during the cleaning cycle. During the pulse, the material bridged over these areas is removed and the particulate matter is allowed to leak through (Figure 4-17). As soon as the pulse dissipates, material tends to bridge over the holes again and the area eventually heals. As the holes and tears increase in size, the duration of the puff also increases. Continuous emissions result when the holes and tears become too large to bridge over.

The discharge of solids from the filter hopper should be observed if this can be done safely and conveniently. Solids are usually discharged on a fairly continuous basis (following each pulsing of a row).

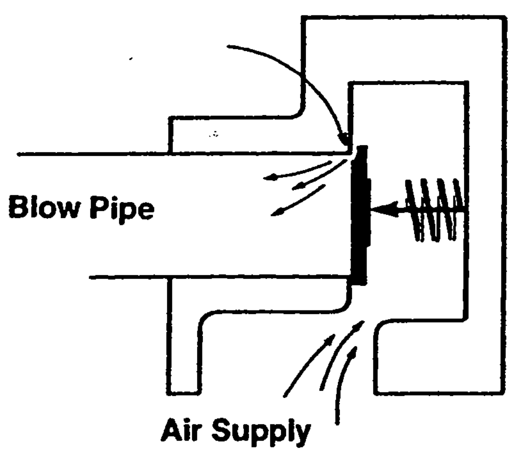


Figure 4-16. Cleaning valve problems (air inleakage into blow pipe). [Illustration reproduced from "The Maintenance of Exhaust Systems in the Hot Mix Plant (IS-52A)" published by the National Asphalt Pavement Association.][4]

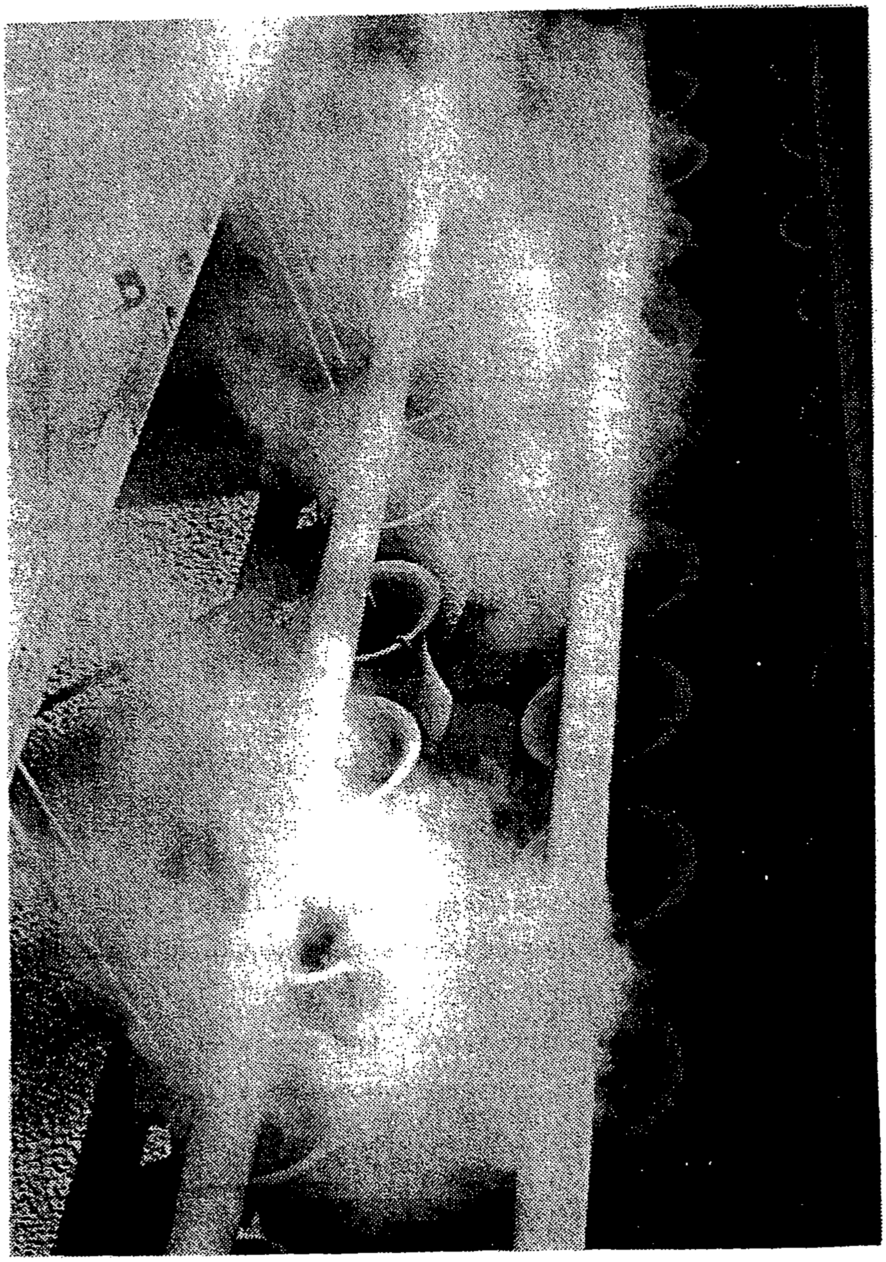


Figure 4-17. Pinhole leaks in bags can be determined by watching for emissions immediately after the cleaning pulse is fired, as shown in this photo. (PEI Associates, Inc.)[4]

Compressed-Air System. The compressed-air system should be inspected to determine whether it contains any water or rust deposits that could cause the system to malfunction. One quick method of checking whether the system has water or rust deposits is to open carefully the valve on the blowdown system and to observe whether any water or other material is being expelled through the valve. Also, if the system has oil traps, the traps can be visually inspected to determine if they are retaining any water or other material.

Reverse-Air and Shaker Fabric Filters--

Evaluation of Plume Characteristics. An average opacity should be predetermined. Most reverse-air and shaker collectors operate with less than 5 percent opacity. Values approaching this opacity may suggest operating problems. A drop in opacity when a specific compartment has been isolated for cleaning usually indicates holes or tears in bags in that compartment. Shaker collectors often have opacity spikes immediately following the cleaning cycle. Both conditions warrant further evaluation.

Filtration System. The pressure drop across the collector should be noted. If there is a gauge, its proper operation should first be confirmed. If the condition of the gauge or its connecting lines is questionable, one line at a time should be disconnected to identify any plugged or crimped lines (disconnecting lines may not be possible if a differential pressure transducer is connected to the gauge lines).

If a properly operating gauge is not available, the static pressure drop should be measured with portable instruments. These measurements should be made at isolated ports installed specifically for the use of portable instruments. It is important to make the measurements at the inlet and the outlet separately so that plugged tap holes and lines can be identified. Care must be exercised during the rodding of tap holes, because on some designs it is possible to poke a hole in the bag adjacent to the tap hole.

The pressure drop across each compartment should be determined during the cleaning cycle. In shaker collectors, the pressure drop should be zero during the cleaning of a compartment. Nonzero values indicate damper leakage problems. In reverse-air collectors, backflow will cause a measurable pressure drop with a polarity opposite that of the filtering cycle. If no gauge is available and the unit operates at an elevated gas temperature, the gas temperature should be measured. Measurement can be made at a point on the inlet duct to the collector or at one of the tap holes (if direct access to the interior of the collector is possible).

The rate of solids discharge also should be checked, if this can be done safely and conveniently. Solids are usually discharged only at the beginning of the cleaning cycle in each compartment.

Air leakage through access hatches, solids discharge valves, hopper flanges, and fan isolation sleeves should be checked by listening for the sound of inrushing air.

Table 4-2 lists recommended inspection items and provides a maintenance schedule for major fabric filter system components.

4.3.2 Daily Inspection and Maintenance

At least twice per 8-hour shift, stack opacity and system pressure drop should be checked. Sudden changes in these values, as well as those for gas temperature and volume flow, may indicate immediate problems.[4]

Daily checks of the fabric filter include pressure drop and opacity readings, the operation of dust removal and discharge system, system fan operation, and an external check of the baghouse structural integrity and bag-cleaning system. If continuous pressure drop and opacity recorders are used, patterns for these two key operating parameters can be developed. Other factors that can be checked on a daily basis are gas temperature and volume. Fan voltage and/or current monitoring can be used as an indicator of abnormal gas volume flow.[4]

Figures 4-18, 4-19, and 4-20 provide example daily inspection forms for shaker, reverse-air, and pulse-jet fabric filters, respectively. The plant employee performing the inspection should fill out these forms and note any problems identified. The completed form should be submitted to the plant's maintenance and engineering departments for recordkeeping. Upon receipt of the form, the maintenance department supervisor should sign it to acknowledge the maintenance activities noted on the form. Figure 4-21 is an

TABLE 4-2. TYPICAL MAINTENANCE INSPECTION SCHEDULE FOR A FABRIC FILTER SYSTEM[4,6,8-12]

Inspection Frequency	Component	Procedure
Daily	Stack Opacity Monitor or Human Observation	Check exhaust for visible emissions.
	Differential Pressure System/Manometer	Check and record fabric pressure loss and fan static pressure. Watch for trends. Check for clogging.
	Reverse-Air/Compressed-Air System	Check for air leakage (low pressure). Check valves.
	Gas Temperature and Volume	Check and record information.
	Collector	Observe all indicators on control panel and listen to system for properly operating subsystems. Check integrity of external structural. Check counterflow audible air infiltration into fan, baghouse (solids discharge valve, access doors, shell), and ductwork.
	Shaker Mechanism	Check for proper operation.
	Rotating Equipment and Drives	Check for signs of jamming, leakage, broken parts, wear, etc.
	System Fan	Check for bolt tension and wear, and lubrication.
	Dust-Removal System	Check to ensure that dust is being removed from the system.
Weekly	Filter Bags	Check for tears, holes, abrasion, proper fastening, bag tension, dust accumulation on surface or increases in folds.
	Damper Valves	Check all isolation, bypass, and cleaning damper valves for synchronization and proper operation. Lubricate as needed.
	Cell Plate	Clean surface, check for warping and leaks.
	Cleaning System	Check cleaning sequence and cycle times for proper valve and timer operation. Check compressed air lines, including oilers and filters. Inspect shaker mechanisms for proper operation. Inspect isolation dampers.

(continued)

Table 4-2. (continued)

Inspection Frequency	Component	Procedure
	Hoppers	Check for bridging or plugging. Inspect screw conveyor for proper operation and lubrication. Inspect compressed-air system for pneumatic units. Check discharge valves for proper function.
	Rotating Equipment and Drives	Lubricate.
	Opacity, Pressure, and Temperature Instruments	Clean and check for proper operation/calibrate.
Monthly	Shaker Mechanism	Inspect for loose bolts, integrity.
	Fan(s)	Check for corrosion and material buildup; check bearings and shaft for wear and V-belt drives and chains for tension and wear.
	Monitor(s)	Check accuracy and calibrate all indicating equipment.
Quarterly	Inlet Plenum	Check baffle plate for wear; if appreciable wear is evident, replace. Check for dust deposits. Check for clean-side dust deposits.
	Access Doors and Airlock	Check all gaskets for wear and proper alignment.
	Shaker Mechanism Tube type (tube hooks suspended from a tubular assembly)	Inspect nylon bushings in shaker bars and clevis (hanger) assembly for wear.
	Channel shakers (tube hooks suspended from a channel bar assembly)	Inspect drill bushings in tie bars, shaker bars, and connecting rods for wear.
Semiannually	Motors, Fans, etc.	Lubricate all electric motors, speed reducers, exhaust and reverse-air fans, and similar equipment.
Annually	Collector	Check all bolts and welds. Inspect entire collector thoroughly; clean and touch up paint where necessary.
	Filter Bags	Conduct ultraviolet light/fluorescent dye tests to check for bag and seal integrity.

DAILY FABRIC FILTER INSPECTION FORM	
Facility Name:	Date of Inspection:
Facility Location:	Time of Inspection:
Process:	Name of Inspector (Print):
Fabric Filter ID:	Signature of Inspector:
INSPECTION ITEM	COMMENTS/CORRECTIVE ACTIONS
1) Shaker Mechanism (external) - motor operating - proper sequence - signs of jamming, broken parts, leakage, wear, deterioration - appearance of bearings, belts, drive rod, shaft OK	
2) Check collector structure for external signs of wear, corrosion, cracked welds, loose belts	
3) Check all system motors and fans, and other rotating equipment and drives - signs of jamming, leakage, broken parts, wear, deterioration	
4) Check dust removal system - proper operation of discharge valve and dust conveying system	
5) Listen for hissing sounds indicating system air infiltration	
6) Check pressure gauges for clogging	
Stack Opacity Reading (Attached Method 9 observation sheet if applicable) _____%	
Gas Temperature inlet __________°F outlet __________°F	
Pressure drop __________ in. w.g.	

Figure 4-18. Example of daily inspection form for shaker fabric filter.

DAILY REVERSE-AIR FABRIC FILTER INSPECTION FORM	
Facility Name:	Date of Inspection:
Facility Location:	Time of Inspection:
Process:	Name of Inspector (Print):
Fabric Filter ID:	Signature of Inspector:
INSPECTION ITEM	COMMENTS/CORRECTIVE ACTIONS
1) Reverse air system - damper valves operational - indications of air leakage	
2) Check collector structure for external signs of wear, corrosion, cracked welds, loose belts	
3) Check all system motors and fans, and other rotating equipment and drives - signs of jamming, leakage, broken parts, wear, deterioration	
4) Check dust removal system - proper operation of discharge valve and dust conveying system	
5) Listen for hissing sounds indicating system air infiltration	
6) Check pressure gauges for clogging	
Stack Opacity Reading (Attached Method 9 observation sheet if applicable) _____%	
Gas Temperature inlet _________°F outlet _________°F	
Pressure drop _________ in. w.g.	

Figure 4-19. Example of daily inspection form for reverse-air fabric filter.

DAILY PULSE-JET FABRIC FILTER INSPECTION FORM	
Facility Name:	Date of Inspection:
Facility Location:	Time of Inspection:
Process:	Name of Inspector (Print):
Fabric Filter ID:	Signature of Inspector:
INSPECTION ITEM	COMMENTS/CORRECTIVE ACTIONS
1) Compressed air system - damper valves operational - indications of air leakage - air compressor operational	
2) Check collector structure for external signs of wear, corrosion, cracked welds, loose belts	
3) Check all system motors and fans, and other rotating equipment and drives - signs of jamming, leakage, broken parts, wear, deterioration	
4) Check dust removal system - proper operation of discharge valve and dust conveying system	
5) Listen for hissing sounds indicating system air infiltration	
6) Check pressure gauges for clogging	
Stack Opacity Reading (Attached Method 9 observation sheet if applicable) _____%	
Gas Temperature inlet __________°F outlet __________°F	
Pressure drop __________ in. w.g.	

Figure 4-20. Example of daily inspection form for pulse-jet fabric filter.

MAINTENANCE REPORT FORM

Department	Unit	System	Subsystem	Component	Subcomponent

Originator: ______________ Date: __________ Time: __________

Assigned To:

1	Mechanical
2	Electrical
3	Instrumentation

Priority:

1	Emergency
2	Same Day
3	Routine

Unit Status:

1	Normal
2	Derated
3	Down

Problem Description: ______________________________

Foreman: ______________ Date: __________

Job Status:

1	Repairable
	Hold for:
2	Tools
3	Parts
4	Outage

Cause of Problem: ______________________________

Work Done: ______________________________

Supervisor: ______________ Completion Date: __________

Materials Used: ______________________________

Labor Requirements: ______________________________

Figure 4-21. Example of maintenance report form.[4]

example of a maintenance report form that can be used to initiate and document the results of any maintenance activities.

4.3.3 Weekly Inspection and Maintenance

The extent of weekly inspection and maintenance depends on access to the equipment; i.e., the unit must be off-line. Lubrication of all rotating equipment, drives, and other moving parts should be scheduled at least weekly. Pressure-sensing lines and temperature probes should be cleaned, checked for proper operation, and calibrated (if necessary). Cell plates should be cleaned and inspected for warping and signs of leaks around the structure walls. Figures 4-22, 4-23, and 4-24 are example weekly inspection forms for shaker, reverse-air, and pulse-jet fabric filters, respectively. Figure 4-25 is an example filter bag identification form that can be used when performing internal inspections of the fabric filter system for bag problems. The plant employee performing the inspection should fill out these forms and note any problems identified. The completed form should be submitted to the plant's maintenance and engineering departments for recordkeeping. Upon receipt of the maintenance form (Figure 4-21), the maintenance department supervisor should sign it to acknowledge the maintenance activities noted on the form.

Shaker Fabric Filters--

The operation and tight seal of isolation dampers should be inspected. The shaker mechanism should be inspected for proper operation (e.g., unrestricted movement). The shaking intensity should be checked for uniformity throughout compartments. Filter bags should be checked for bag tension, fallen or torn bags, presence of any dust deposits on the clean side of the cell plate, holes, abrasion and bag-to-bag contact, proper bag fastening at both ends, and dust accumulation on bag surface or in bag creases and folds.[4]

Reverse-Air Fabric Filters--

The operation and tight seal of isolation and reverse-air dampers should be inspected. Filter bags should be checked for bag tension, fallen or torn bags, presence

WEEKLY SHAKER FABRIC FILTER INSPECTION FORM	
Facility Name:	Date of Inspection:
Facility Location:	Time of Inspection:
Process:	Name of Inspector (Print):
Fabric Filter ID:	Signature of Inspector:
INSPECTION ITEM	COMMENTS/CORRECTIVE ACTIONS
1) Check cell plate for warping, signs of leakage, or cracks.	
2) Dust Hopper - check for bridging or plugging - check operation of discharge valves - screw conveyor motor operating - pneumatic blower compressor/fan motor operating	
3) Check for operation of instrumentation - opacity (Yes/No) - pressure (Yes/No) - temperature (Yes/No)	
4) Check all isolation valves, bypass valves, and cleaning system valves for operability, seat tightness, and proper synchronization	
5) Cleaning system - check sequence and cycle times for proper valve and timer operation - check for unrestrictive movement of shaker system - check for uniform shaking intensity	
6) Filter bags (check and replace/adjust as needed) - bag tension - proper fastening to cell plate - fallen or torn bags - holes in bag - abrasion, bag-to-bag contact - dust accumulation in bag creases, folds, on surface (Attach bag location form)	
7) Lubricate all rotating equipment, drives, and other moving parts	
8) Lubricate damper valves	
Stack Opacity Reading (Attached Method 9 observation sheet if applicable) _____%	
Gas Temperature inlet __________°F	outlet __________°F
Pressure drop __________ in. w.g.	

Figure 4-22. Example of weekly inspection form for shaker fabric filter.

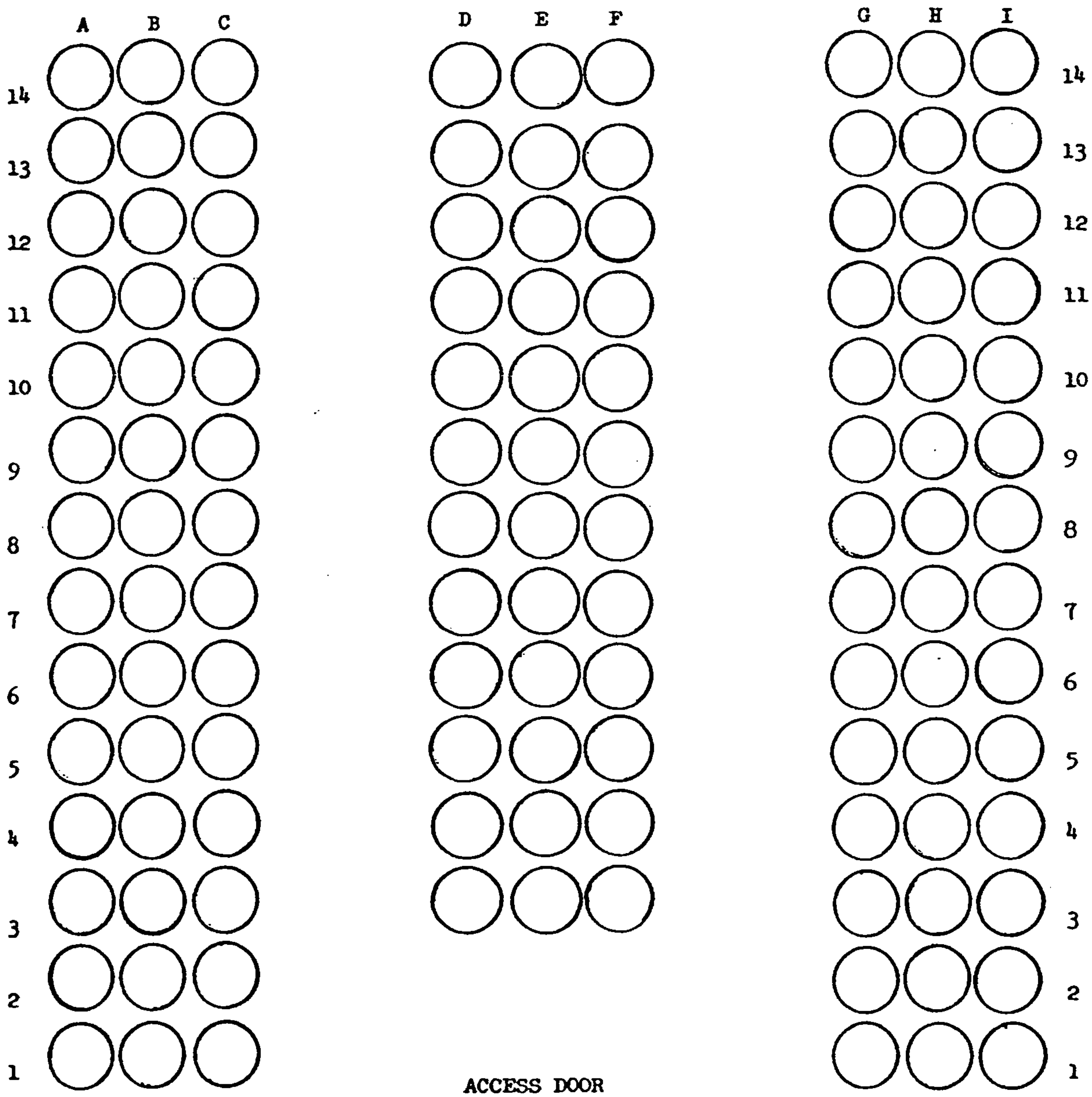
WEEKLY REVERSE-AIR FABRIC FILTER INSPECTION FORM	
Facility Name:	Date of Inspection:
Facility Location:	Time of Inspection:
Process:	Name of Inspector (Print):
Fabric Filter ID:	Signature of Inspector:
INSPECTION ITEM	COMMENTS/CORRECTIVE ACTIONS
1) Check cell plate for warping, signs of leakage, or cracks.	
2) Dust Hopper - check for bridging or plugging - check operation of discharge valves - screw conveyor motor operating - pneumatic blower compressor/fan motor operating	
3) Check for operation of instrumentation - opacity (Yes/No) - pressure (Yes/No) - temperature (Yes/No)	
4) Check all isolation valves, bypass valves, and cleaning system valves for operability, seat tightness, and proper synchronization	
5) Cleaning system - check sequence and cycle times for proper valve and timer operation - check for unrestrictive movement of shaker system - check for uniform shaking intensity	
6) Filter bags (check and replace/adjust as needed) - bag tension - proper fastening to cell plate - fallen or torn bags - holes in bag - abrasion, bag-to-bag contact - dust accumulation in bag creases, folds, on surface (Attach bag location form)	
7) Lubricate all rotating equipment, drives, and other moving parts	
8) Lubricate damper valves	
Stack Opacity Reading (Attached Method 9 observation sheet if applicable) _____%	
Gas Temperature inlet __________°F	outlet __________°F
Pressure drop __________ in. w.g.	

Figure 4-23. Example of weekly inspection form for reverse air fabric filter.

WEEKLY PULSE-JET FABRIC FILTER INSPECTION FORM	
Facility Name:	Date of Inspection:
Facility Location:	Time of Inspection:
Process:	Name of Inspector (Print):
Fabric Filter ID:	Signature of Inspector:
INSPECTION ITEM	COMMENTS/CORRECTIVE ACTIONS
1) Check cell plate for warping, signs of leakage, or cracks.	
2) Dust Hopper - check for bridging or plugging - check operation of discharge valves - screw conveyor motor operating - pneumatic blower compressor/fan motor operating	
3) Check for operation of instrumentation - opacity (Yes/No) - pressure (Yes/No) - temperature (Yes/No)	
4) Check all isolation valves, bypass valves, and cleaning system valves for operability, seat tightness, and proper synchronization	
5) Cleaning system - check sequence and cycle times for proper valve and timer operation - check for unrestrictive movement of shaker system - check for uniform shaking intensity	
6) Filter bags (check and replace/adjust as needed) - bag tension - proper fastening to cell plate - fallen or torn bags - holes in bag - abrasion, bag-to-bag contact - dust accumulation in bag creases, folds, on surface (Attach bag location form)	
7) Lubricate all rotating equipment, drives, and other moving parts	
8) Lubricate damper valves	
Stack Opacity Reading (Attached Method 9 observation sheet if applicable) _____%	
Gas Temperature inlet _________°F	outlet _________°F
Pressure drop _________ in. w.g.	

Figure 4-24. Example of weekly inspection form for pulse-jet fabric filter.

BAG FAILURE LOCATION RECORD



ACCESS DOOR

MODULE NO. ___________

DATE________________

REPLACE - R
PATCH - P

CAP-OFF - C
RETENSION - T

Figure 4-25. Bag failure location record.

of any dust deposits on the clean side of the cell plate, holes, abrasion and bag-to-bag contact, proper bag fastening at both ends, and dust accumulation on bag surface or in bag creases and folds.[4]

Pulse-Jet Fabric Filters--

On the dirty side of the cell plate, filter bags should be inspected for a thin, uniform, exterior deposit of dust. Bags should be checked for abrasion or wear from bag-to-bag contact and for proper bag fastening at both ends. On the clean side of the cell plate, each row of bags should be checked for leakage or holes, the presence of which is indicated by dust deposits on the underside of the compressed-air blowpipes or on the cell plate itself. The cleaning system should be activated (the inspector should use hearing protection). The blowpipes should remain secure during operation, and each row of bags should fire at the same time. Misaligned blowpipes should be adjusted to prevent damage to the upper part of the bags. The compressed air system should be checked for leaks and evidence of oil or water entrainment. Moisture or oil accumulation should be drained from the system.[4]

4.3.4 Long-Term Inspection and Maintenance

Long-term inspection and maintenance procedures (i.e., frequence of application is less than weekly) are likely to be more equipment-specific than common daily and weekly inspection procedures.[4] Long-term procedures generally involve overall integrity checks of major system components. Examples of equipment that can be checked monthly, quarterly, semiannually, and annually were shown earlier in Table 4-2. Long-term inspection forms for fabric filters should be process and fabric filter specific. They can be developed, on a site specific basis, using the format of the daily and weekly inspection forms.

4.4 Equipment Problems and Corrective Measures

4.4.1 Common Equipment Malfunctions[13]

Common Malfunctions--

Regardless of the cleaning mechanism involved, most fabric filter maintenance focuses on the bags and moving mechanical parts, especially parts on the dirty side of the filters. High-maintenance items also vary according to the application. Commonly observed malfunctions are discussed here.

The highest-maintenance item in fabric filter systems is the bag. The most common problems are tears or pinholes, blinding (cake buildup), and bleeding (seepage). These problems can be diagnosed and subsequently minimized with frequent inspections and preventive maintenance. These actions, however, will not eliminate bag failure. Variations in fabric quality, sewing techniques, quality control, and gas flow distribution within the system also contribute to bag failure. During the first several months of operation, a small number of bag failures may result from manufacturing or installation defects. Under normal operating conditions, however, a sudden increase in frequency of failure indicates that the bags have reached or are nearing the end of their operating life.

Visible stack emissions usually indicate bag failure. Where a stack monitor is used, increases in opacity readings are further indicators. In either case, three methods can be used to identify leaking bags: 1) inspection of bags for holes, 2) elimination of bags with excessive dust accumulation, and 3) use of a bag leak detection device.

Valves used to isolate individual bag chambers in a shaker type fabric filter often experience sealing problems. A slight flow and pressurization in the isolated compartment are indicative of a poor bag seal. This condition can be determined by observing the shaking process and noting whether the bags are inflated.

4.4.2 Diagnostic Equipment Inspections[4]

This subsection presents a suggested procedure for performing diagnostic inspections of typical pulse-jet, reverse-air, and shaker type fabric filters when certain problems arise.

Pulse-Jet Systems

High Opacity (continuous or puffs). On top-load type designs, the clean side of several compartments should be checked, provided they can be safely isolated and no pollutant capture problems will occur at the source origin. Even slight dust deposits can be a sign of major problems. Most of the dust in the clean-side plenum is reentrained as a result of the relatively high gas velocities. Dust near one or more of the bag outlets may suggest inadequate sealing on the cell plate. Bag holes or tears may disperse dust throughout the top side of the cell plate and make it difficult to identify the bag with the hole. Fluorescent dye tests may be used later to identify the problem.

High Pressure Drop, High Opacity, or Process Fugitive Emissions. In a top-access system, the possibility of fabric blinding can be checked from the top access hatch. Oil and water in the compressed air line are sometimes partially responsible for the blinding that removes part of the fabric area from service.

In conventional pulse-jet collectors, the possibility for blinding can only be checked at the dirty-side access hatch. The photograph in Figure 4-26 shows easily removable dust. A crusty cake is sometimes evidence of excessive moisture or sticky deposits on the bags.

Continuously High Opacity, Frequent Bag Failures (primarily at bottom). Premature bag failure at the bottom can occur in both types of pulse-jet collectors if the support cages are slightly warped and the bags rub at the bottom. This can be checked from a dirty-side access hatch, or sometimes from below (as shown in Figure 4-27). <u>Only the operator (using extreme caution) should open the hatches at the tops of hopper areas, as hot solids can flow rapidly out of these hatches.</u>

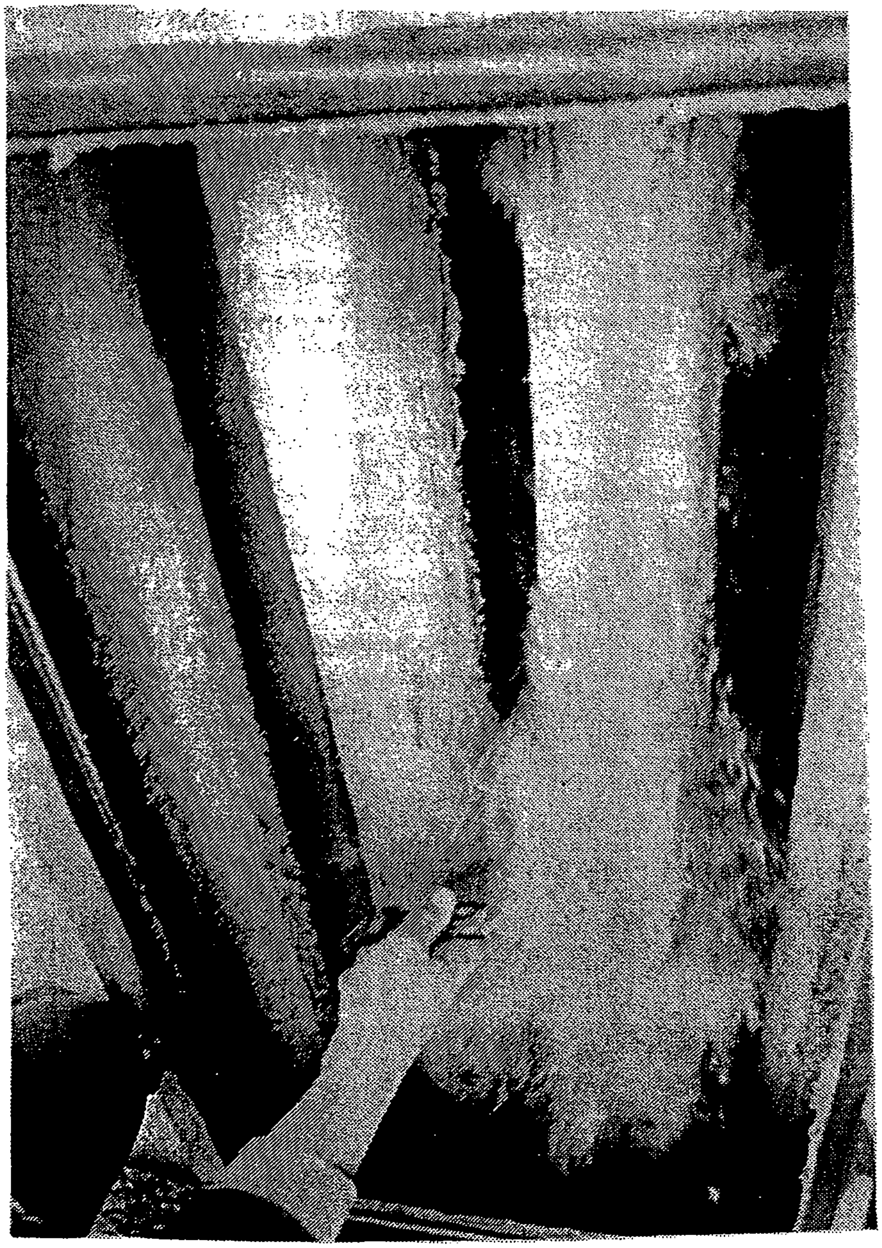


Figure 4-26. Knocking dust off bags to see how easily removable it is (In this case, the material was dry and easily removable, but the cleaning mechanism was not working.)[4]

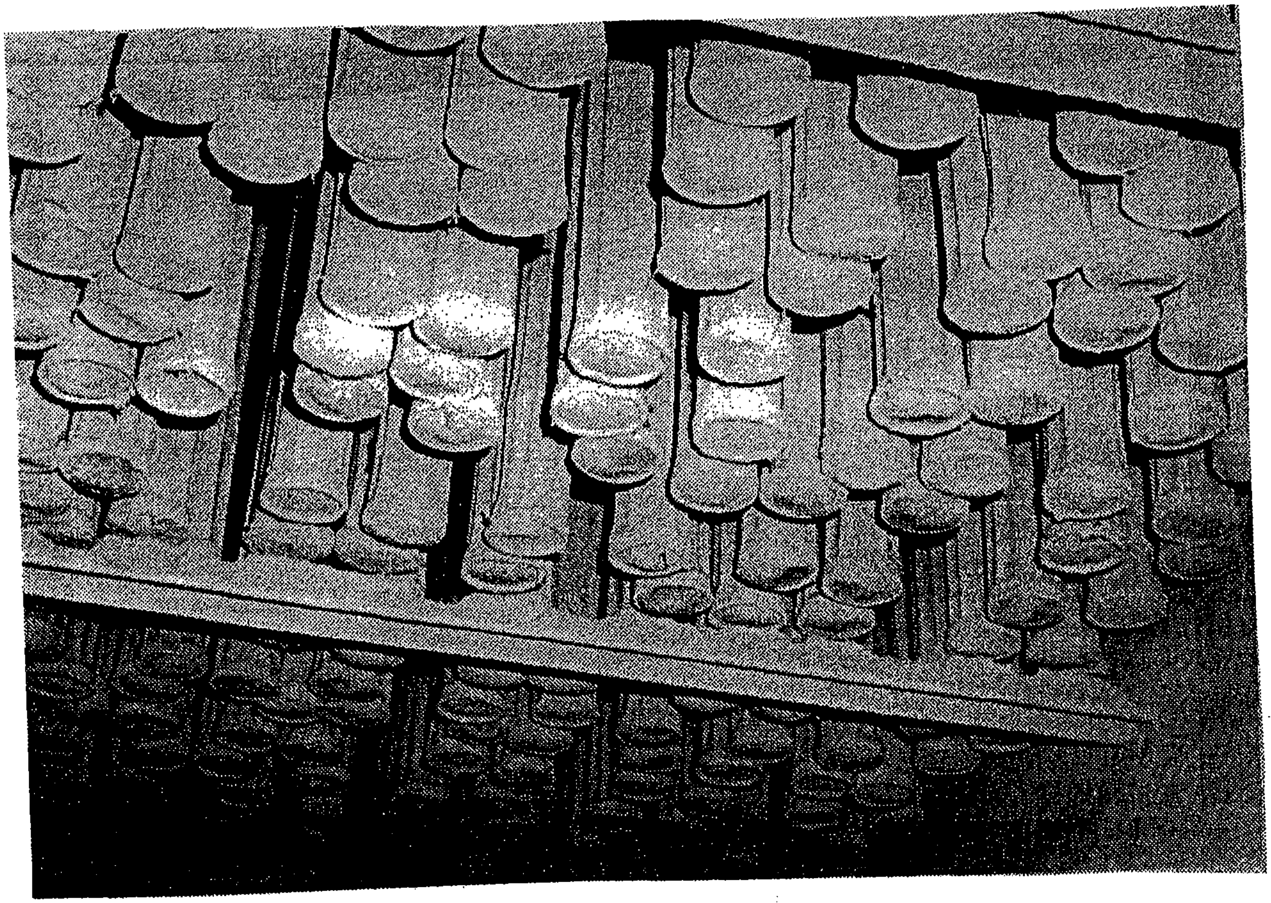


Figure 4-27. Bag-to-bag contact in a pulse-jet fabric filter resulting from poor alignment of cages during installation.[4]

The bag failure charts for the fabric filter should be examined. A distinct spatial pattern may indicate the damage due to abrasion (inlet gas blasting, inlet swirling, or rubbing against internal supports). The date of the bag removal and the elevation of the apparent damage (T-top, M-middle, B-bottom) helps to identify many common modes of failure. By using such charts, operators have been able to minimize both excess emission incidents and bag replacement costs. A rapid increase in the rate of failure often suggests significant deterioration of fabric strength due to chemical attack or high temperature excursions.

When bags are removed from service, a simple rip test should be performed. If the cloth can be ripped by inserting a screw driver and pulling, the bag damage probably resulted from chemical attack, high temperature excursions, moisture attack, or routine fabric exhaustion. Most fabrics damaged by abrasion-related problems cannot be ripped even near the site of the damage.

High Opacity and Distinct Pattern to Bag Holes and Tears. Bag and cage assemblies should be carefully inspected on removal. Often the point of bag failure is next to a sharp point on the support cage. Premature failure may also be caused by cages that do not provide enough support for the fabric.

If all the bags have failed at the top, the compressed-air nozzles may be misaligned (see Figure 4-28). This can cause the pulse to be directed at a narrow area in the top of the bag.

Reverse-Air and Shaker Type Fabric Filters--

Suspected Air Leakage, Low Gas Temperature, or Low Pressure Drop. The O_2 and CO_2 levels at the inlet and outlet of combustion source fabric filters should be checked. The measurement point on the inlet must be between the solids discharge valve and the tube sheet, so that potential inleakage at this point can also be taken into account. There should not be more than a 1 percent rise in the O_2 levels going from the inlet to the outlet (e.g., 6% O_2 in and 7% O_2 out).

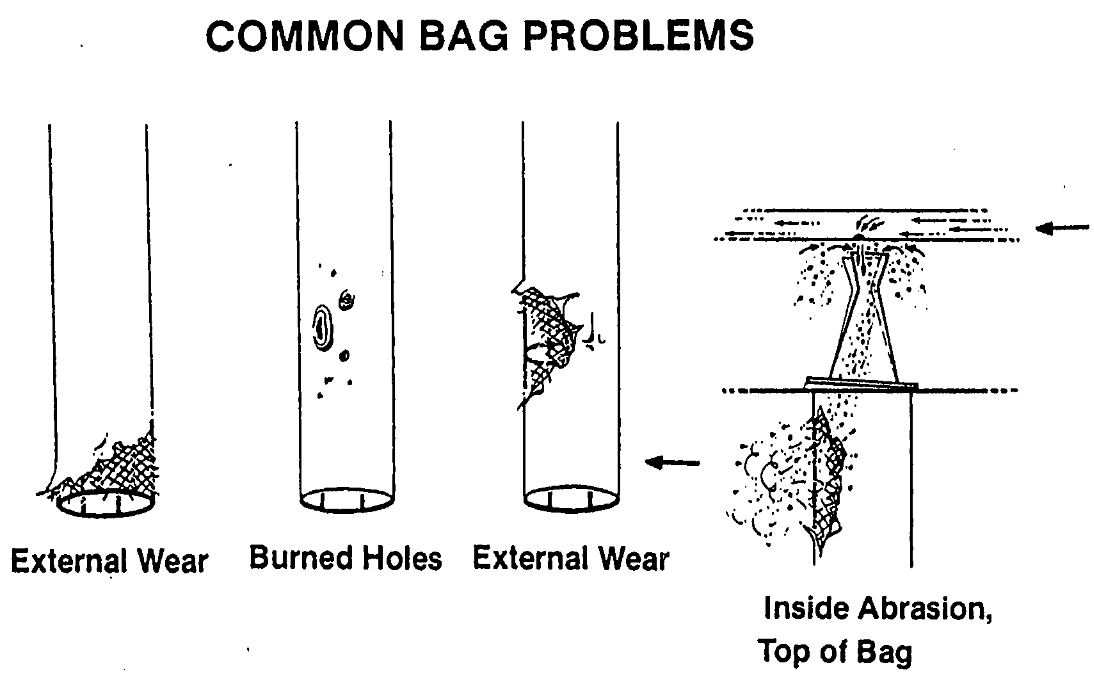


Figure 4-28. Common bag problems with pulse-jet fabric filters, including abrasion at the top of the bags caused by misalignment of compressed air nozzles (National Asphalt Pavement Association).[4]

Continuously High Opacity (During Most of Operating Period) or Pressure Drop Much Greater or Lower than Baseline. The presence and nature of the clean-side deposits should be checked by viewing conditions from the access hatch. Note that the operator must isolate the compartment before attempting to do the internal inspection. All safety procedures must be carefully followed prior to entry.

The presence of snap-ring leakage is often indicated by enlarged craters in the clean-side deposits around the poorly sealed bags. Holes and tears can sometimes be located by the shape of dust deposits next to the holes (see Figure 4-29). Poor bag tension is readily apparent from the access hatch. Improper discharge of material from the bags can often be confirmed by noting that the bags close to the hatch are full of material one or more bag diameters up from the bottom (see Figure 4-30). Deposits on the bags should also be noted.

Anything more than a trace of material on the clean-side tube sheet indicates that emissions from this compartment are probably substantially above the baseline levels.

If the bag failure charts show a distinct spatial pattern, the damage may be due to abrasion (inlet gas blasting, inlet swirling, and/or rubbing against internal supports). Including the date of the bag removal and the elevation of the apparent damage (T-top, M-middle, B-bottom) makes it possible to identify many common modes of failure. Using such charts, operators have been able to minimize both excess emission incidents and bag replacement costs. A rapid increase in the rate of failure often suggests significant deterioration of fabric strength. A simple rip test should be preformed on a bag recently removed from service. If the cloth can be ripped by inserting a screw driver and pulling, the bag damage probably resulted from chemical attack, high temperature excursions, moisture attack, or routine fabric exhaustion. Most fabrics damaged by abrasion-related problems cannot be ripped even near the site of the damage.

The compressed-air system should be inspected for proper installation and to ensure that it has the aftercoolers, automatic condensate traps, and filters for proper operation.[6] The inspector also should determine whether any water or rust deposits are in the compressed-air system that could cause the system to malfunction. One quick method for checking the presence of water or rust deposits is to open the valve on the

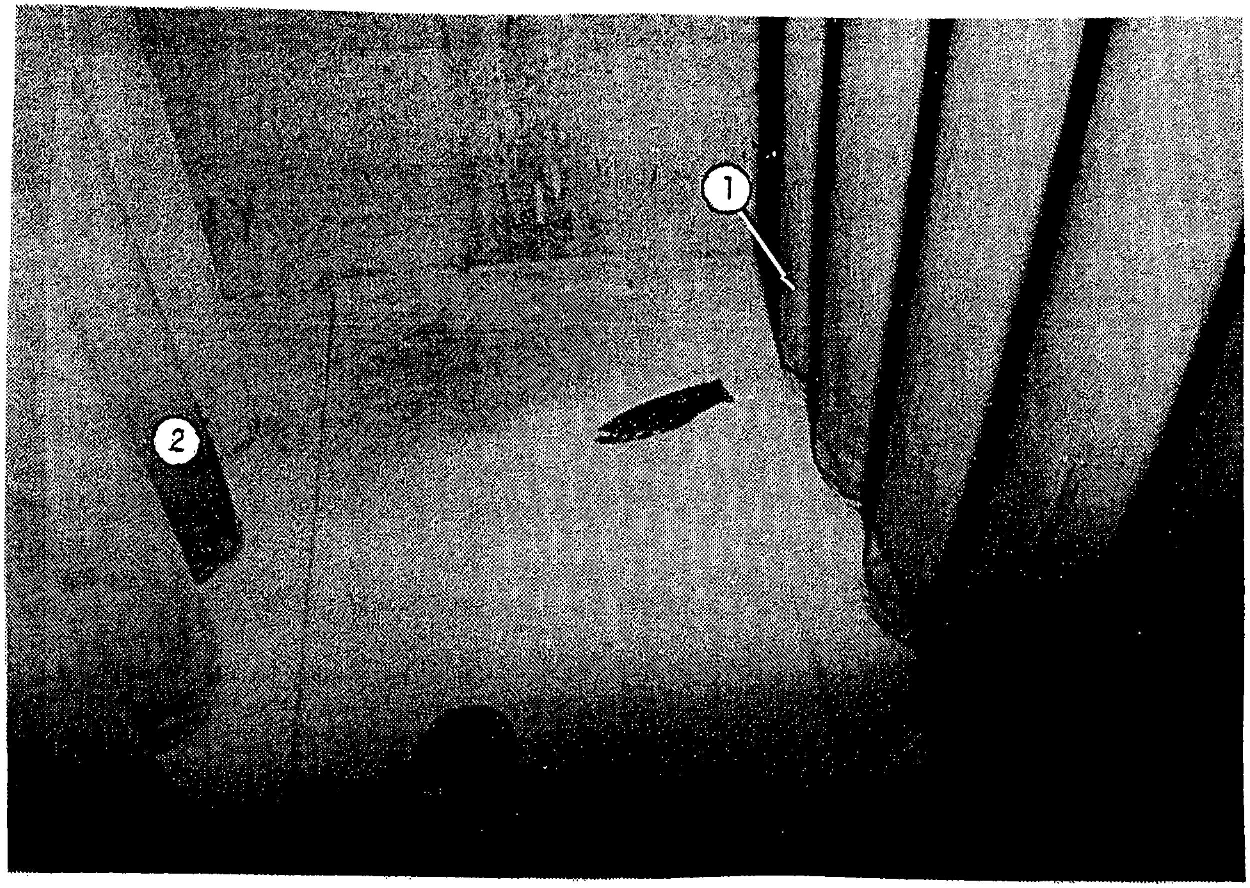


Figure 4-29. Pinhole leak (1) forms a dust jet on the floor near a shaker-type filter. [Note that the darkened bag (2) is being abraded by dust from the pinhole leak and it too will ultimately fail.]
PEI Associates, Inc.[4]

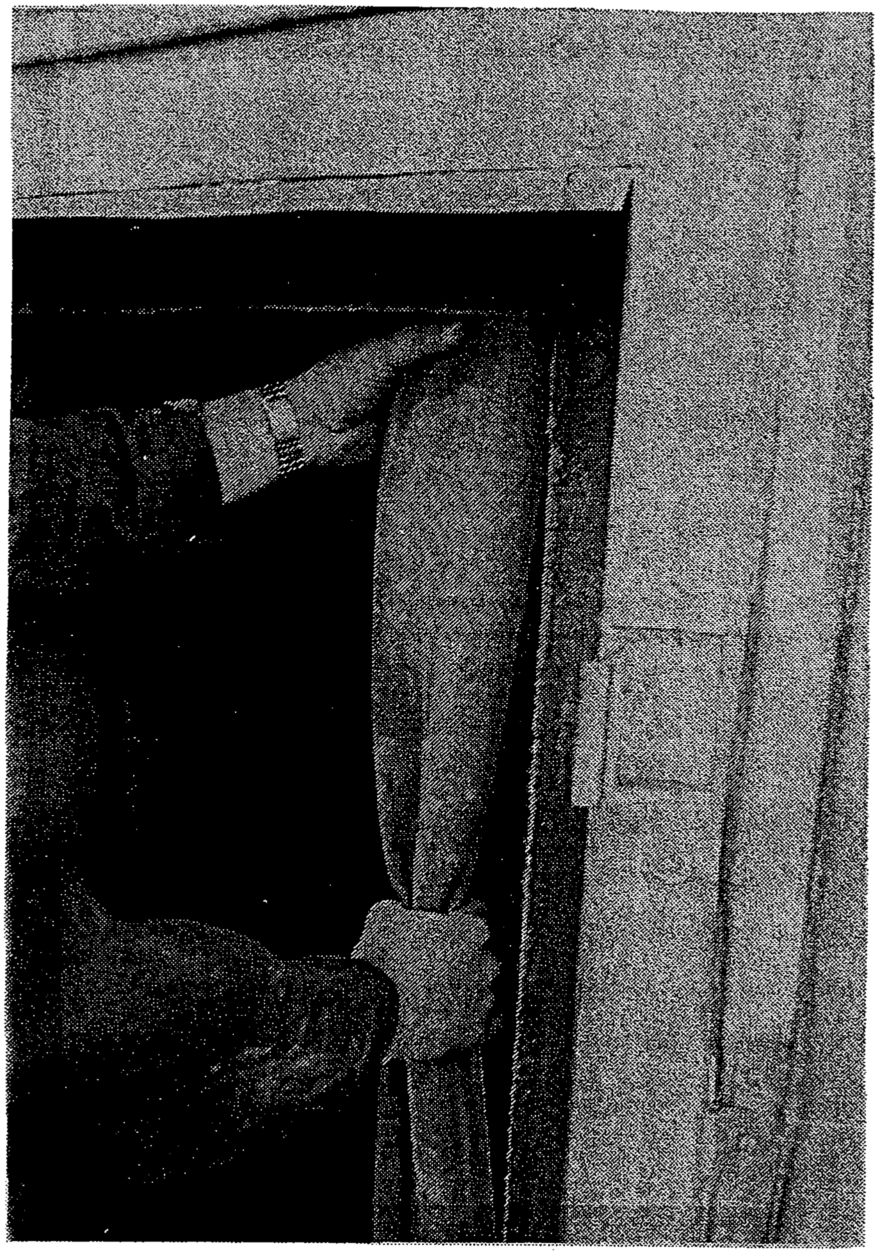


Figure 4-30. Checking for excessive build-up and poorly tensioned bags in a reverse-air fabric filter. This bag passed both tests. (PEI Associates, Inc.)[4]

blowdown system carefully and note whether any water or other material is being expelled through the valve. If the system has oil traps, the traps also can be visually inspected to determine if they are retaining any water or other material.

4.4.3 Corrective Measures and Troubleshooting

Table 4-3 lists the procedures for troubleshooting and correcting common baghouse problems.

Fabric filter equipment suppliers generally specify an inventory of spare parts and replacement equipment when installing a new system. A facility should contact its supplier for a list of specific recommended equipment. The most important item to maintain in inventory stock is a full set of replacement bags. Table 4-4 presents a typical inventory of replacement parts that should be kept on site in the absence of a manufacturer's specific recommendations.

4.5 Operator Training

As for any piece of equipment, proper maintenance of a fabric filter depends on the support of facility management and its willingness to provide its employees with the proper training. Efficient operation of a fabric filter, promoted by adequate inspection and maintenance procedures, is as important as the productive operation of any piece of process equipment. Management and employees must take a proactive approach to its operation to prevent production-stopping equipment malfunctions or failures.

The training and motivation of employees assigned to monitor and maintain a fabric filter are critical factors. These duties should not be assigned to inexperienced personnel that do not understand how a fabric filter works or the purpose behind assigned maintenance tasks.

When a new system is commissioned, training should be provided by the fabric filter manufacturer. The manufacturer's startup services will generally include introductory training for facility operators and maintenance personnel. The field service engineer involved in startup procedures will instruct plant personnel in methods that will ensure proper assembly and operation of the system components, will check and reset system

TABLE 4-3. FABRIC FILTER TROUBLESHOOTING AND DIAGNOSTIC GUIDE 13

The following chart lists the most common problems found in a fabric filter air pollution control system and offers general solutions. In some instances, the solution is to consult the manufacturer. This may not be necessary in plants that have sufficient engineering know-how available.

When the information applies to a specific type of fabric filter, the following code is used:

JP....................Jet-pulse
S......................Shaker
RA....................Reverse-air

Symptom	Cause	Remedy
High system pressure drop	System undersized	Consult manufacturer. Install double bags. Add more compartments or modules.
	Bag cleaning mechanism not adjusted properly	Increase cleaning frequency. Clean for longer duration. Clean more vigorously (must check with manufacturer before implementing).
	Compressed-air pressure too low (JP)	Increase pressure. Decrease duration and/or frequency. Check air dryer, and clean if necessary. Check for obstruction in piping.
	Repressuring pressure too low (RA)	Speed up repressuring fan. Check for leaks. Check damper valve seals.
	Shaking not vigorous (S)	Increase shaker speed (check with manufacturer).
	Isolation damper valves not closing (S, RA, JP)	Check linkage. Check seals. Check air supply of pneumatic operations.

(continued)

Table 4-3. (continued)

Symptom	Cause	Remedy
	Isolation damper valves not opening (S, RA, JP)	Check linkage. Check air supply on pneumatic operations.
	Bag tension too loose (S, RA)	Tighten bags.
	Pulsing valves failed (JP)	Check diaphragm valves. Check solenoid valves.
	Air volume greater than design	Damper system to design point. Install fan amperage controls.
	Cleaning timer failure	Check to see of timer is indexing to all contacts. Check output on all terminals.
	Not capable of removing dust from bags	Check for condensation on bags. Send sample of dust to manufacturer. Send bag to lab for analysis for blinding. Dryclean or replace bags. Reduce air flow.
	Excessive reentrainment of dust	Continuously empty hopper. Clean rows of bags randomly instead of sequentially (JP).
	Incorrect pressure reading	Clean out pressure taps. Check hoses for leaks. Check for proper fluid in manometer. Check diaphragm in gauge.
Low fan motor amperage/low air volume	High baghouse pressure	See "high system pressure drop."
	Fan and motor sheaves reversed	Check drawings and reverse sheaves.
	Ducts plugged with dust	Clean out ducts and check duct velocities.
	Fan damper closed	Open damper and lock in position.
	System static pressure too high	Measure static on both sides and compare with design pressure.

(continued)

Table 4-3. (continued)

Symptom	Cause	Remedy
	Fan not operating per design	Check fan inlet configuration and be sure even airflow exists .
	Belts slipping	Check tension and adjust.
Dust escaping at source	Low air volume	See above causes and remedies under "low-fan motor amperage/low air volume."
	Ducts leaking	Patch leaks so air does not bypass source.
	Improper duct flow balancing	Adjust blast gates in branch ducts.
	Improper hood design	Close open areas around dust source. Check for cross drafts that overcome suction. Check for dust being thrown away from hood by belt, etc.
Dirty discharge at stack	Bags leaking	Replace bags. Tie off bags and replace at a late date. Isolate leaking compartment if possible without upsetting system.
	Bag clamps not sealing	Check and tighten clamps. Smooth out cloth under clamp and reclamp.
	Failure of seals in joints at clean/dirty air connection	Caulk and tighten clamps. Smooth out cloth under clamp and reclamp.
	Insufficient filter cake	Allow more dust to build up on bags by cleaning less frequently. Use a precoating of dust on bags (S, RA).
	Bags too porous	Send bag in for permeability test and review with manufacturer.
Excessive fan wear	Fan handling too much dust	Check bags.

(continued)

Table 4-3. (continued)

Symptom	Cause	Remedy
	Improper fan	Check with fan manufacturer to see if fan is correct for application.
	Fan speed too high	Check with manufacturer.
Excessive fan vibration	Buildup of dust on blades	Clean off and check to see if fan is handling too much dust. Do not allow any water in fan (check drain, look for condensation, etc.).
	Wrong fan wheel for application	Check with manufacturer.
	Sheaves not balanced	Have sheaves dynamically balanced.
	Bearings worn	Replace bearings.
High compressed air consumption (JP)	Cleaning cycle too frequent	Reduce cleaning cycle if possible.
	Pulse too long	Reduce duration. (After initial shock all other compressed air is wasted.)
	Pressure too high	Reduce supply pressure if possible.
	Damper valves not sealing	Check linkage. Check seals.
	Diaphragm valve failure	Check diaphragms and springs. Check solenoid valve.
Reduced compressed-air pressure (JP)	Compressed air consumption too high	Reduce supply pressure if possible.
	Restrictions in piping	Check piping.
	Dryer plugged	Replace desiccant or bypass dryer if allowed.
	Supply line too small	Consult design.
	Compressor worn	Replace rings.
Premature bag failure: decomposition	Bag material improper for chemical composition of gas or dust	Analyze gas and dust and check with manufacturer. Treat gas stream with neutralizer before it enters the system.

(continued)

Table 4-3. (continued)

Symptom	Cause	Remedy
	Operating below acid dew point	Increase gas temperature. Bypass upon startup.
Moisture in system	System not purged after shutdown	Keep fan running for 5 to 10 minutes after process is shut down.
	Wall temperature below dew point	Raise gas temperature. Insulate unit. Lower dew point by keeping moisture out of system.
	Cold spots at structural members	Fully insulate structural members.
	Compressed air introducing water (JP)	Check automatic drains . Install aftercooler. Install dryer.
	Repressuring air causing condensation (RA, JP)	Preheat repressuring air. Use process gas as a source of repressuring air.
High screw conveyor wear	Screw conveyor under-sized	Measure hourly collection of dust and consult manufacturer.
	Conveyor speed too high	Slow down speed.
High air-lock wear	Air lock undersized	Measure hourly collection of dust and consult manufacturer.
	Thermal expansion	Consult manufacturer to see if design allowed for thermal expansion.
	Speed too high	Slow the speed down.
Material bridging in hopper	Moisture in baghouse	Check moisture dew point of exhaust gas. Add hopper heaters.
	Dust being stored in hopper	Remove dust continuously.
	Hopper slope insufficient	Rework or replace hoppers.
	Conveyor opening too small	Use a wide-flared trough.
Frequent screw conveyor/airlock failure	Equipment undersized	Consult manufacturer.
	Screw conveyor misaligned	Align conveyor.

(continued)

Table 4-3. (continued)

Symptom	Cause	Remedy
	Overloading components	Check sizing to see that each component is capable of handling a 100% delivery from the previous component.
High pneumatic conveyor wear	Pneumatic blower too fast	Slow down blower.
	Piping undersized	Review design and slow down blower or increase pipe size.
	Elbow radius too short	Replace with long radius elbows.
Pneumatic conveyor pipes plugging	Overloading pneumatic conveyor	Review design.
	Slug loading of dust	Check tackiness of dust.
	Moisture in dust	Check gas stream dew point.
Fan motor overloading	Air volume too high	Check ducts and structure for leaks.
	Motor not sized for cold start	Damper fan at startup. Reduce fan speed. Provide heat faster. Replace motor.
Air volume too high	Ducts leaking	Patch leaks.
	Insufficient static pressure	Close damper valve. Slow down fan.
Reduced compressed air consumption (RP, PP)	Pulsing valves not working	Check diaphragms. Check springs. Check solenoid valves.
	Timer failed	Check terminal outputs.
High bag failure: wearing out	Baffle plate worn out	Replace baffle plate.
	Too much dust	Install primary collector.
	Cleaning cycle too frequent	Slow down cleaning.
	Inlet air not properly baffled from bags	Consult manufacturer.
	Shaking too violent (S)	Slow down shaking mechanism (consult manufacturer).
	Repressuring pressure too high (RA)	Reduce pressure.

(continued)

Table 4-3. (continued)

Symptom	Cause	Remedy
	Pulsing pressure too high (JP)	Reduce pressure.
	Cages have barbs (JP)	Remove and smooth out barbs.
High bag failure: burning	Stratification of hot and cold gases	Force turbulence in duct with baffles.
	Sparks entering baghouse	Install spark arrestor.
	Thermocouple failed	Replace and determine cause of failure.
	Failure of cooling device	Review design and work with manufacturer.

TABLE 4-4. TYPICAL INVENTORY OF REPLACEMENT PARTS FOR FABRIC FILTERS[13]

Bags (complete set of replacement) and accessories: clamps, nuts, bolts, hangers
Bag retainers (pulse-jet)
Cleaning mechanism
Shaker: bearings, hangers, crankshaft, connecting rod, motor belts
Pulse-jet: venturis, solenoid and diaphragm valves, tubing
Timing mechanism
Screw conveyor: belts, hanger bearings, coupling bolts
Airlocks: bearing and seals
Pneumatic system components (see manufacturer's recommendations)
Damper valves: solenoids, seals, cylinders
Magnehelic gauges
Gasketing, caulking, lubricants, special tools
Electrical switches, relays, fuses

instrumentation and controls, will check for the proper operation of the dust discharging system, and will perform simple troubleshooting.

Following startup training, regular training courses should be held by in-house personnel or through the use of outside expertise. The set of manuals typically delivered as part of a new fabric filter installation will include manufacturer-recommended maintenance procedures. At a minimum, annual in-house training should include a review of these documents and confirmation of the original operating parameters. Training should include written instructions and practical experience sessions on safety, inspection procedures, system monitoring equipment and procedures, routine maintenanceprocedures, and recordkeeping. For plant personnel involved in taking fabric filter opacity readings, U.S. EPA Reference Method 9 requires a semiannual recertification in method procedures.

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