TABLE 6-1 (Cont.). Troubleshooting Guide – Cyclone Collectors

CYCLONE COLLECTOR TROUBLESHOOTING		
Symptom	**Possible Problem**	**Solution**
4. Plugging	Cyclone discharge is too small for actual loading	Redesign cyclone with larger discharge diameter.
	Material may be accumulating in dead space if cyclone has dished head	Replace dished head with flat roof, false roof, or refractory-lined flat roof.
	Material may be naturally sticky or hygroscopic	Improve internal surface finishes, PTFE coating, electropolish, etc.
		Use vibrators.
		Provide easy access for cleaning.
	Condensation	Insulate and/or heat trace.
5. Erosion	Too high an inlet velocity	Reduce flow rate.
		Redesign inlet for lower velocities.
	Naturally erosive particulate	Minimize inlet velocity.
		Abrasion-resistant construction.
		Ensure proper cyclone geometry.
		Design for easy repairs and/or replacement.

6.3.4 Removing Dust from Filter Hopper. With a pulse-jet collector, the collected dust must be continuously removed from the filter hopper to promote dust dropout as described above. Because the filter is under the highest negative pressure in the local exhaust ventilation system, an airlock is needed to remove the collected dust without significant ambient air leakage into the filter housing. Depending on the connected process, the collected dust could be recycled back into the process or it may have to be discarded. Allowing the filter hopper to run nearly full, like a surge bin, will cause operating problems and can crush cages and ruin bags. Refer to Sections 6.3.14 and 6.3.15 for more information on Hopper Operating strategy or Chapter 8, Figures 8-2 and 8-3 in the Design Manual.

6.3.5 Cleaning Dust Cake Off Filter Surface. Depending on the dust loading to the filter, buildup of a dust cake on the bag surfaces can rapidly create a high pressure differential at the filter. This will add resistance to the local exhaust ventilation system and reduce exhaust airflows at the connected hoods and enclosures to design volumes. The dust cake must be routinely removed from the bags to keep pressure differentials at expected values. As mentioned previously, three primary methods are used: pulse jet (compressed air), reverse air (low pressure air), and shaker (mechanical shaking).

6.3.6 Baghouse Components Housing. The housing is a dust-tight compartment that contains the filter bags and their assemblies. It usually has access doors to both the clean and

TABLE 6-2. Dropout Box Troubleshooting Table

DROP OUT BOX TROUBLESHOOTING		
Symptom	**Possible Problem**	**Solution**
1. Low collection efficiency	Baffle plate altered	Check interior
	Leakage	Check for leaks
2. Plugging	Discharge too small	Enlarge discharge
	Material sticking	Improve surface finish
3. Erosion	Holes in baffle	Replace with higher Brinnell material

TABLE 6-3. Troubleshooting Mechanical Classifiers

Symptom	Possible Problem	Solution
1. Wrong cutpoint	Not set up properly, too much moisture	Change air settings
2. Abrasion	Material too hard	Appropriate liners
3. Material sticking	Too much moisture	Adjust moisture content vibrators
4. Moisture	Rain, dust suppression equipment (sprays)	Find source of moisture. Drying to reduce moisture. Wait for drier conditions.

dirty air plenums for easy servicing. Always lock out the system, obtain the proper confined space permit, and put on the proper safety gear before opening the access doors to the housing.

A key factor in housing design is access for changing bags. Top bag removal designs provide access to the top of the tube sheet and bags through either a walk-in clean air plenum or removable panels on top of the baghouse as shown below in Figure 6-6. Bottom bag removal designs, as shown in Figure 6-7, typically require an access platform inside the baghouse to reach all the bags from the dirty side housing of the baghouse.

Hopper

The hopper is an air plenum where a significant amount of dust settles out of the contaminated air, reducing the dust load on the filter bags. It also provides a distribution pattern of air to the bags and receives dust dislodged from the bags as they are cleaned. The hopper must be kept empty during operation of a pulse jet baghouse. If the hopper is trough-shaped, the hopper outlet usually feeds collected dust into a screw conveyor and airlock valve as shown in Figure 6-8. For pyramid hopper designs an airlock or double-dump valve can be all that is required. An airlock is not used for smaller filters when an airtight connection to a drum or other waste material receptacle is incorporated. The waste removal device must be absolutely airtight in order for the dust collector to work properly. Even a small air leak can encourage finer particulate back to the bag surface, causing an artificial challenge to the filter media and therefore high resistance (increased pressure drop).

6.3.7 Filter Media Types. Filter bags are available in a variety of shapes: tube, PFE, pleated, envelope/pillowcase, and cartridges (see Figure 6-9). Some of the bag shapes require rigid wire cages to support the bag and prevent its collapse from the differential pressure between the clean and dirty sides of the baghouse. Cartridges and some pleated filter bags do not require cages. The physical characteristics of the dust and process conditions are used to decide which shape to use.

Tubular/Sock Bag Filters

The most common filter bags are the tubular or sock-like bags, which are, in most cases, supported vertically within the housing by rigid wire cages. (Reverse air and shaker-style filters often do not have cages to support the filters). Air passes through these filters and leaves dust trapped on the outer surface of the bags. The bag material is designed to operate at top efficiency with a coating of dust. This coat of dust partially fills the spaces in the mesh of the fabric and becomes part of the filtration process. Without this coating of dust on the bag surface, filtration efficiency is severely reduced.

When installing new filter bags in a baghouse, reference the “New Bag Startup Procedure” in Section 6.3.20. The clean startup procedure is also outlined in most filter vendor operation and maintenance manuals. Failure to follow the proper procedure can cause premature blinding (clogging) of the filter bags and drastically shorten bag life. In addition, use replacement bags that meet the baghouse manufacturer’s specifications. Poor quality bags and cages are the source of many baghouse operational failures. Proper filter media selection is key

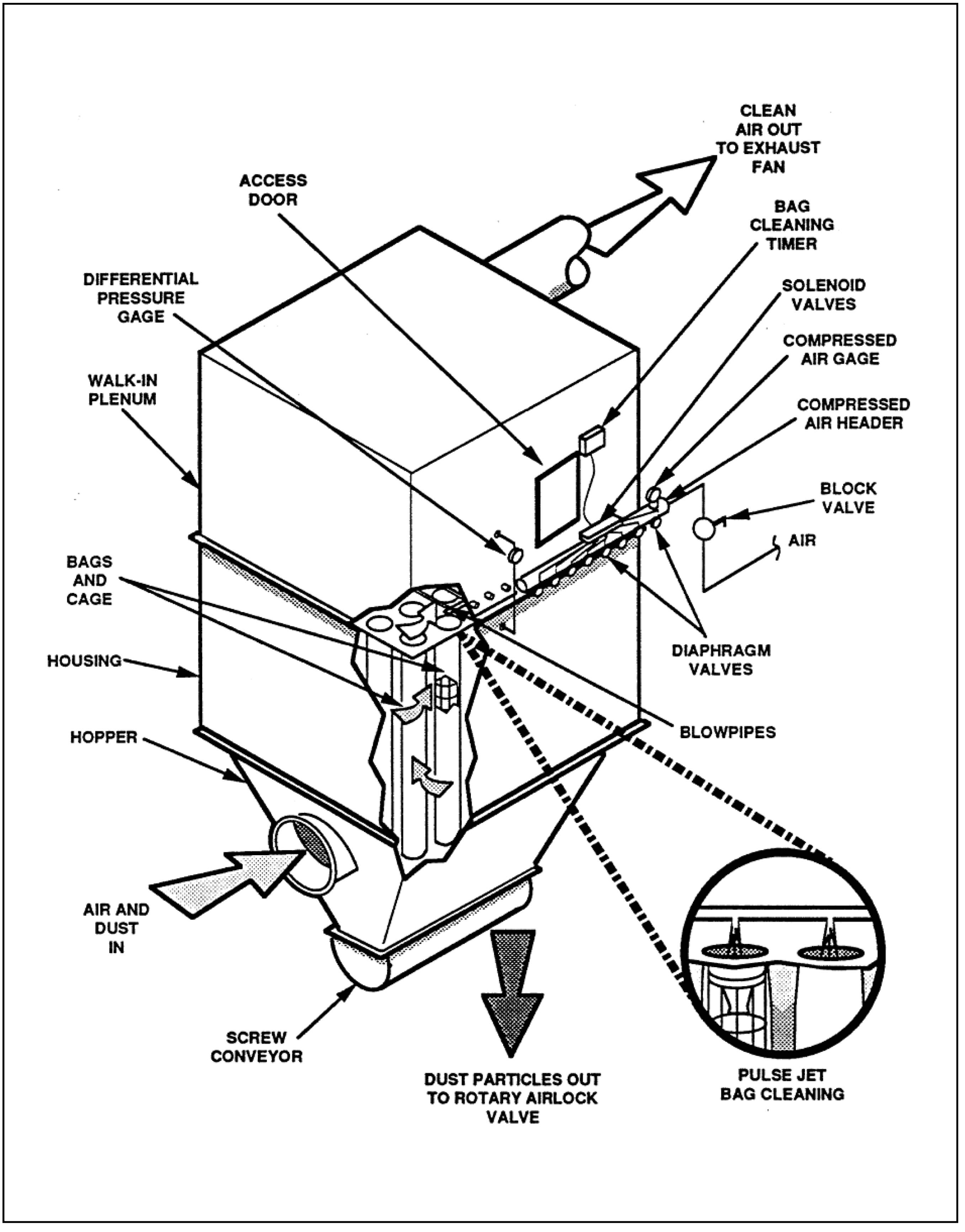


FIGURE 6-5. Pulse-Jet baghouse

FIGURE 6-6. Top access hatch, top bag removal design

to efficiency as well as longevity of the materials. Specific media are available for most applications.

Filter failures come in two primary forms: high operating pressure drop and media material failure. The causes are varied, complex and often multiple.

Cartridge-Style Pulse-jet Filters

The use of pleated filters, such as cartridges has increased in popularity. Cartridge collectors are just another type of pulse-jet fabric filter (see Figure 6-10). They come in two types:

- Down-flow – where the air enters above the media, and
- Up-flow – similar to other fabric filters; has a "can" velocity and interstitial velocity.

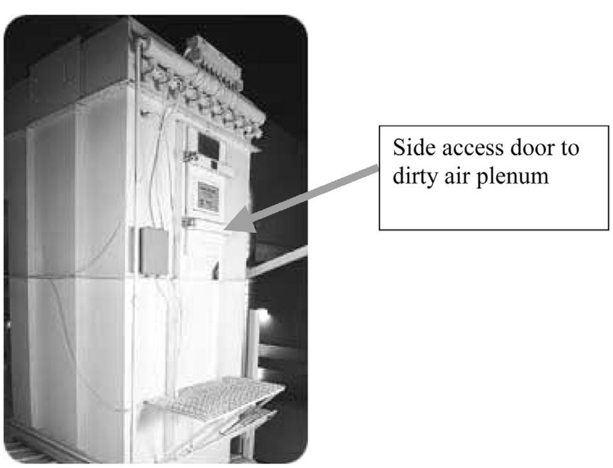


FIGURE 6-7. Side access, bottom bag removal design

The advantage of cartridges over conventional bags is the ability to fit much more media in the same sized housing. This advantage is most apparent in the application of extremely small spherical particulate, such as welding smoke or other metal fumes. Generally, items that cause problems with a standard filter will also subvert a cartridge. Dusts that are fibrous, hygroscopic, abrasive, hot, sticky, etc. are usually more difficult to handle in a cartridge collector. In addition, the nature of the cartridge media may put more restrictive temperature limits on the baghouse.

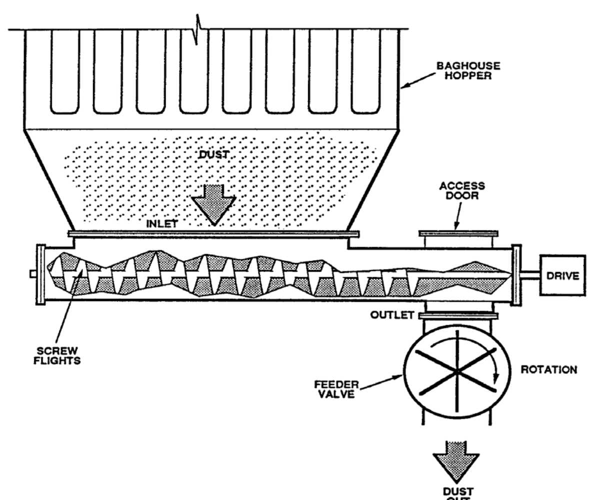
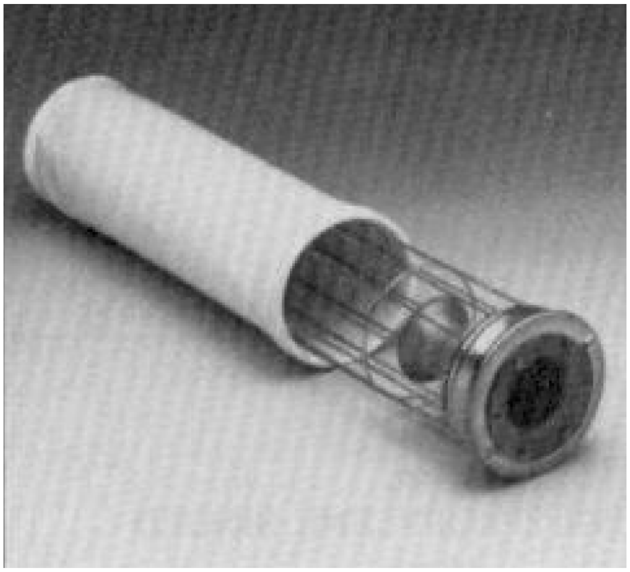


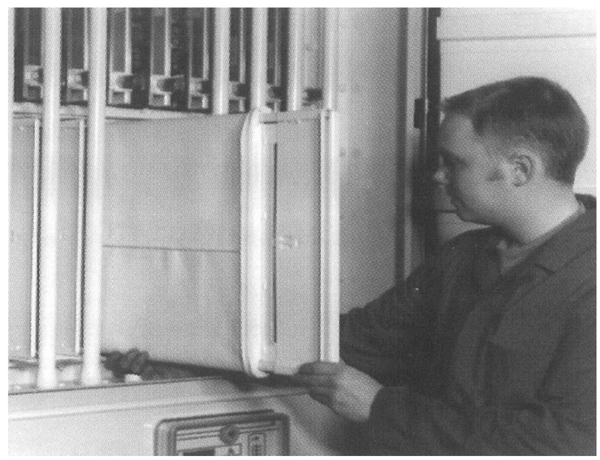
FIGURE 6-8. Trough-shaped filter hopper with screw conveyor and rotary airlock valve



Tubular or Sock Filter and Cage

Cartridge Filter

Star or Pleated Filter and Cage



Envelope Filter

FIGURE 6-9. Examples of types of filter media

Cartridge filters generally have a more linear increase in pressure drop as opposed to the normal plateau of pressure drop experienced for the bulk of a bag filter's "lifetime." Cartridge life can be over two years with some applications. In addition, cartridge change-out does not usually require a restricted access permit and can be done in a bag-in/bag-out format for very toxic particulate (i.e., radionuclides). Cartridge change-out is usually accomplished in less time when compared to a similarly-sized pulse-jet collector with bags.

Cartridges do not have a cage to support the fabric. They are typically made of cellulose, polyester or a blend of the two. Expanded Teflon® laminated filter media is available as well. Because of the large amount of media in a small package, very low air-to-media ratios (cubic feet per minute airflow divided by square feet of fabric area or filter face velocities) are possible, which gives an associated increase in filtration efficiency. Air-to-media ratios greater than 2:1 are rare and should not be exceeded without a written guarantee from the manufacturer.

6.3.8 Bag Cleaning System. Bag cleaning systems use high pressure compressed air (pulse-jet), low pressure air (reverse air), or mechanical shaking to remove the dust cake from the bags. Note that most, but not all, of the dust cake is removed from the media surface. A thin layer of dust on the bag surface is normal and necessary to achieve the filter collection efficiency needed to meet environmental emission permit requirements.

Pulse-Jet Cleaning

Accumulated dust on the exterior of a bag is periodically

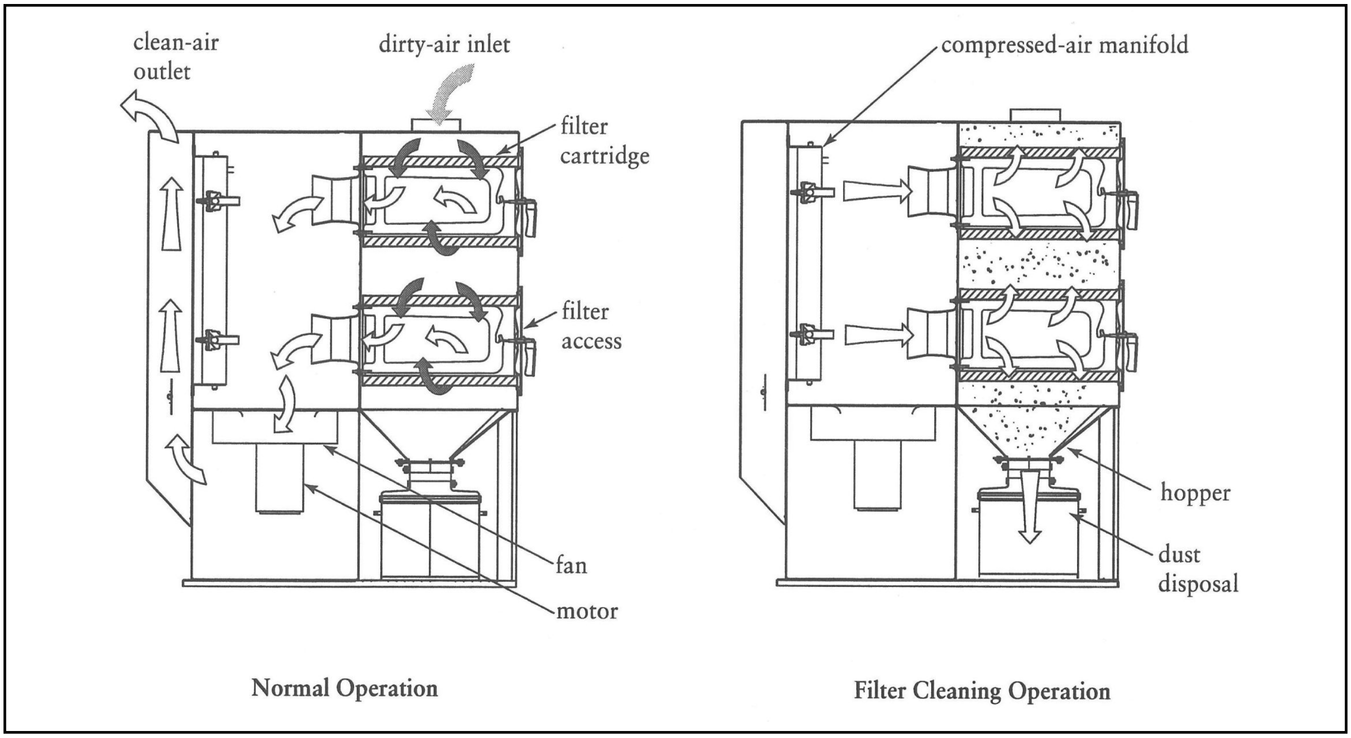


FIGURE 6-10. Cartridge collector operation

removed by directing a short pulse of compressed air. Airflow is from outside the bag to the inside and the bag is supported by an inner metal cage. The cage is usually made of steel suitable to the application (mild steel, galvanized or stainless). An aerodynamically designed venturi at the top of each bag causes the pulse of compressed air to induce a flow of clean air into the bag. A wave that temporarily expands the filter media is set up that travels down the bag and rebounds from a solid plate at the bottom. The shock-wave momentarily pressurizes the bag, stops the flow of dust-laden air into it, and accelerates the fabric and dust cake away from the support cage.

The effect is enhanced by the plate at the bottom of the cage. Some dust falls off and drops into the hopper for discharge. Finer dust does not fall and returns to the surface of the bag. This action of fine dust returning to the bag surface is called re-entrainment. Particulate of low aerodynamic particle density (like feathers, or paper fines) are re-entrained in the upward movement of air between and below the bags bringing the fines back to the bag surface until they can form particles of such a size and density that they can fall to the bottom of the hopper. Any air leaks near the bottom of the hopper (worn rotary valve, etc.) significantly exacerbate this problem, causing high filter pressures and premature bag failure.

The instantaneous cleaning action progresses row-by-row while the flow of dust-laden air proceeds into the filter continuously. Each row being cleaned is off-stream for approximately 1/10th to 1/15th of a second (100 to 150 milliseconds). This is the ideal time setting for pulse duration (often called "ON time"). More pulse time usually does not clean better, and can waste compressed air and energy. The entire fabric area of a pulse-jet filter is in virtually continuous operation. Most cartridge collectors and envelope-style collectors employ pulse-jet cleaning mechanisms.

Several components are used in the bag cleaning system. All components must be kept in good condition because failure of one part can cause overall baghouse performance problems. The cleaning system is illustrated in Figure 6-11. More detailed views are provided in Figures 6-12 and 6-13.

The pulse timer is the heart of the cleaning system. The steps of the bag cleaning sequence are started by the pulse timer which must be set for the length of the pulse of compressed air ("Duration" or "On Time") and the time before the next pulse is started for the next row of bags ("Interval" or "Off Time"), appropriate for the dust being filtered. The detailed cleaning sequence follows (see Figure 6-12):

- The timer signals the solenoid valve to open.
- Air is vented from one side of the diaphragm valve through the open solenoid valve.
- The diaphragm valve opens to vent the compressed air header to the blowpipe for a row of bags.

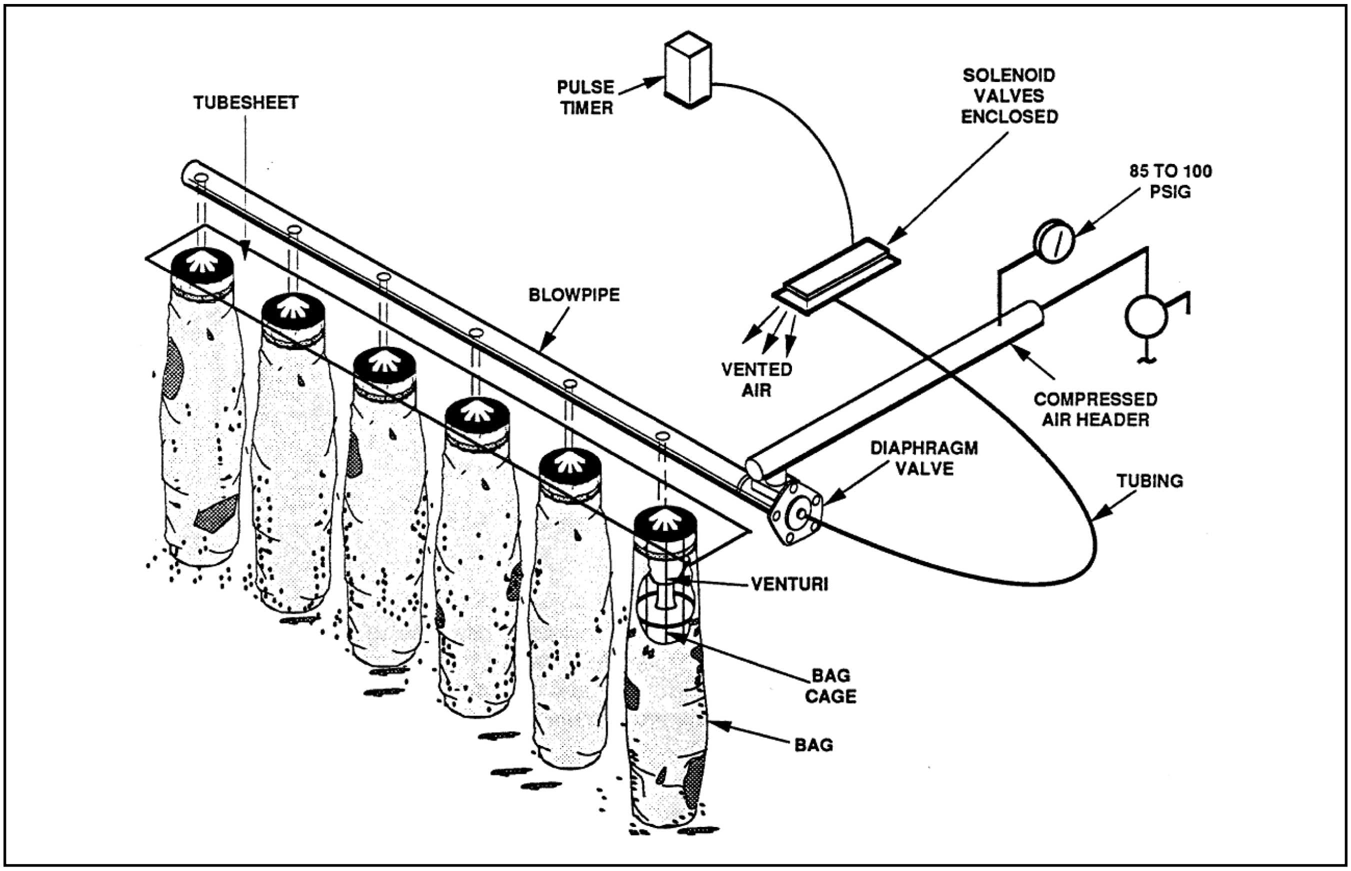


FIGURE 6-11. Pulse-Jet cleaning system

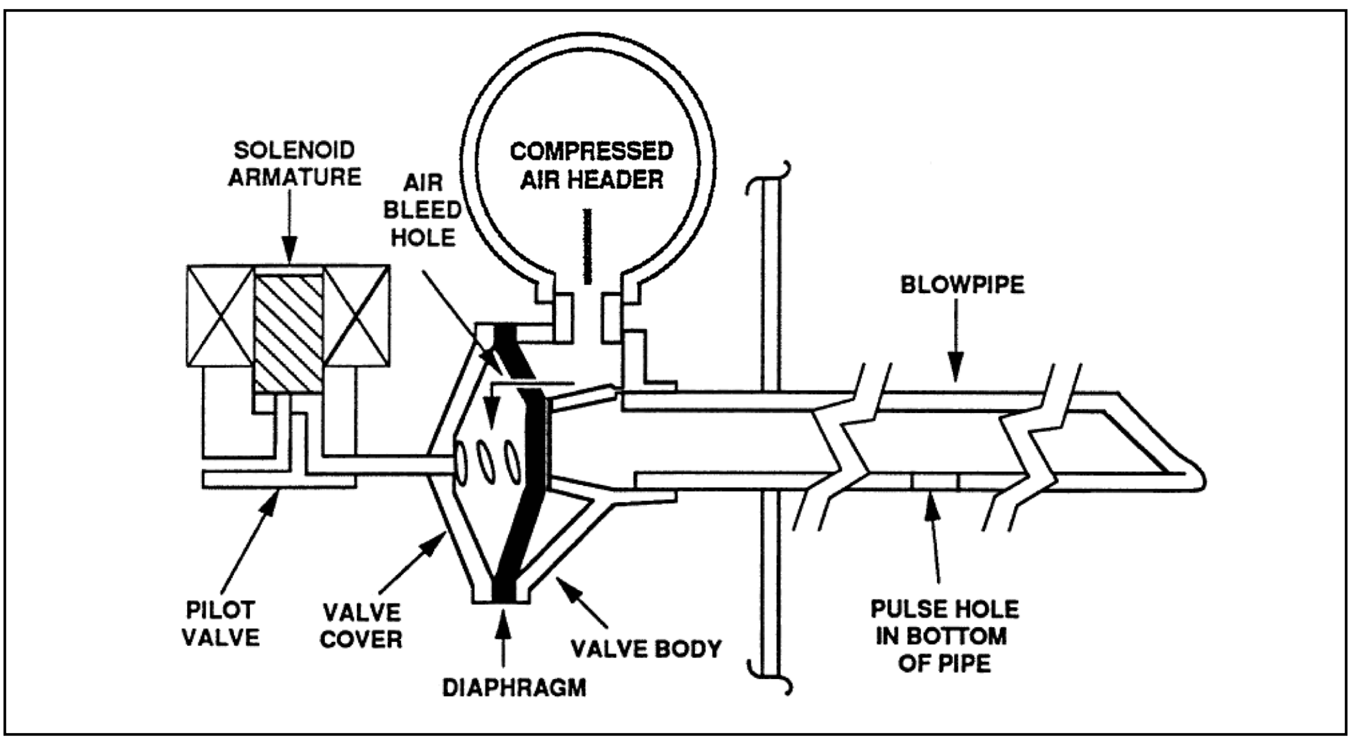


FIGURE 6-12. Normally closed solenoid valve

- Compressed air is released into the center of the venturi throat through holes drilled in the bottom of the blowpipe.
- The jet of compressed air induces nearby air to also flow into the bag with the jet of compressed air.
- The entering air stops airflow briefly and sends a shock wave down the length of the bag. The shock wave continues upward by bouncing off the plate at the bottom of the bag cage.
- The shock wave accelerates the bag fabric away from the cage and knocks the dust layer off into the hopper below.

The cleaning system then sequences to the off position (see Figure 6-13).

- The timer signals the solenoid to close.
- Pressure can now build on the back side of the diaphragm, forcing the diaphragm against the blowpipe end and airflow to the blowpipe is stopped.
- The whole sequence takes approximately 1/10th of a second for one row of bags. As the bags in one row are being cleaned, the other rows continue to filter dust-laden air without interruption.
- The timer starts the sequence for the next row of bags.
- Each row of bags is cleaned in turn. Cycling through all rows of bags takes several minutes. See the vendor manual for the proper settings for your baghouse.

When the cleaning system's solenoid is closed, compressed air passes through a small bleed hole in the diaphragm or air bleed passage in the valve body, and is checked at the pilot valve by the solenoid armature. Pressure in the valve cover increases until it equals the pressure in the air header. Since the pressure is considerably lower in the blowpipe, the diaphragm seats tightly against the valve body (most valves use a spring to assist in seating the diaphragm). This is shown in Figure 6-8.

When a 100 millisecond (1/10th of a second) electrical pulse from the timer energizes the solenoid coil, the solenoid armature lifts off of its seat and allows compressed air to flow through the pilot valve to atmosphere. Pressure drops in the valve cover, and the higher pressure in the valve body moves the diaphragm into the open position. Air flows from the compressed air header through the blowpipe to clean the bags. At the conclusion of the 100 millisecond electrical pulse, the pilot valve closes and pressure rises again in the valve cover to return the diaphragm to the closed position (see Figure 6-13).

6.3.9 Establishing the Bag Cleaning System Set Points. The ON time (pulse duration) and OFF time (pulse interval) settings should be changed only with careful planning. The baghouse vendor has recommended settings for startup. Follow vendor procedures for adjusting timing to achieve a desired bag differential pressure. Very rapid bag cleaning frequency can lead to shortened bag life. Too infrequent pulsing will cause differential pressures higher than the desired design filter pressure drop. Keep records of when and why timer settings were changed and what results were achieved.

With a differential pressure (ΔP) sensor/controller, such as a pressure transducer, it is possible to set up the cleaning con-

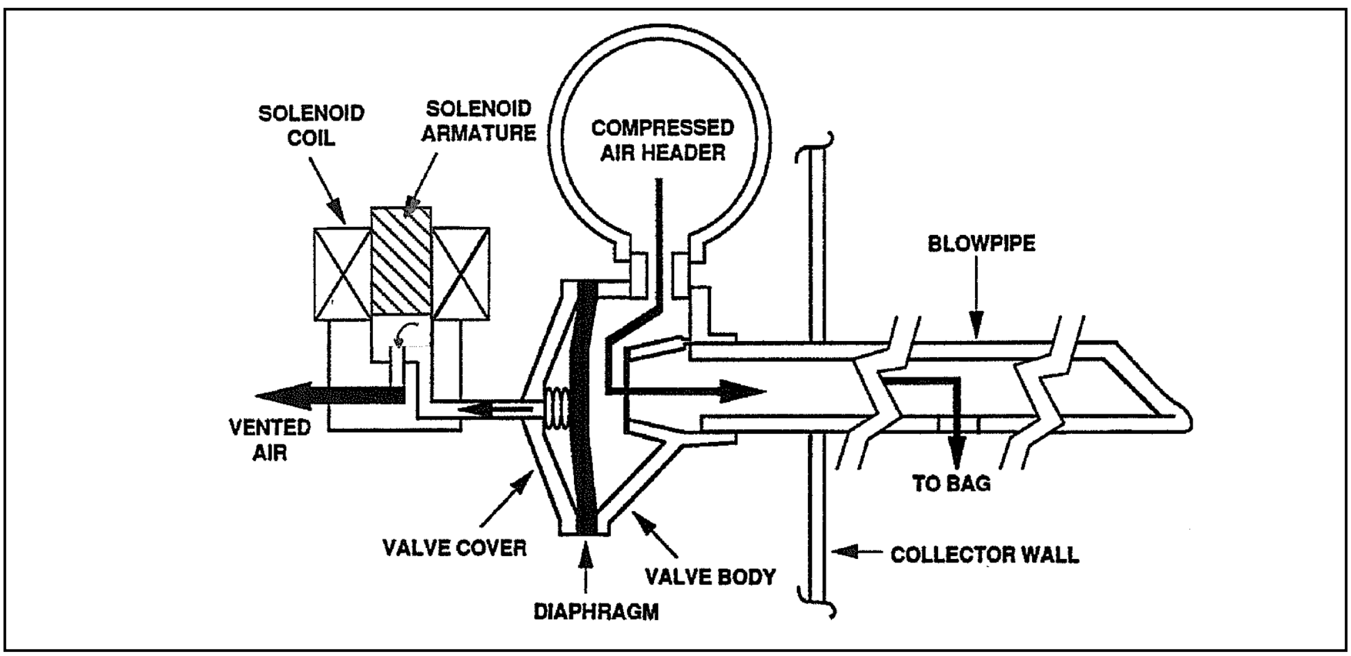


FIGURE 6-13. Solenoid valve – pulsing position

trols to start the cleaning cycle at a high ΔP set point and stop the cycle at a low ΔP set point. Specify a controller that remembers the last row cleaned. New cleaning controls offer features like digital pressure transducers with 4–20 mA outputs, digital high, low and alarm set points, offline cleaning and many other features.

6.3.10 Reverse Air Filters. Accumulated dust is removed by isolating one section or compartment of the baghouse from use long enough to send airflow from a smaller cleaning fan to the clean side (in a reverse direction) through the filter media. This dislodges the dust from the surface and the heavier particles fall to the hopper for final removal. Typically, collector design must take into account the fact that one compartment will be temporarily offline and air-to-media ratios must reflect such a consideration. Reverse air cleaning methods are gentler on bag media, which can add to bag longevity (see Figure 6-14).

6.3.11 Shaker-Style Filters. Accumulated dust is removed by shaking the entire bag assembly once the system fan is de-energized (see Figure 6-15). Shaker-style filters are therefore not continuous-duty and are typically used on processes where the local exhaust ventilation system can be turned off during production breaks and between shifts. Air typically moves from inside the bags to outside and therefore does not require a metal support cage. Filter pressure will steadily increase during use and will recover when the baghouse tubes are shaken. Extremely fine dust and fumes that do not agglomerate well and that do not fall well in an updraft style baghouse can do very well in shaker-style collectors. Therefore, re-entrainment is not an issue on shaker-style collectors.

6.3.12 Baghouse Indicators and Controls. Baghouses can be complex subsystems of local exhaust ventilation systems. They require indication of operating parameters such as pressure, alarms of problems like hopper high level combustible dust mitigation subsystems, and controls for systems like bag cleaning. The Piping and Instrument Diagram (see Figure 6-16) shows most of the indicators and controls installed with a baghouse; although all local exhaust ventilation systems do not require the use of all the devices shown.

6.3.13 Pressure Indication. Pressure is an important parameter for the normal operation of a fabric filter. It indicates whether airflow through the filter is at target or design values and whether the cleaning system is adequately functioning. Table 6-4 shows the common measurements needed and the sensor or devices used to provide the measurement.

Differential Pressure Gauge

Gauges should be mounted on baghouses to indicate differential pressure (also called pressure drop or ΔP). Differential pressure can be measured across the media (filter ΔP) or across the whole collector (flange to flange), and is the difference in static pressure between points on the clean and dirty side of the baghouse. Because bags are filtering the dust from the air, they create a variable, partial blockage of air within the baghouse. A pressure drop allowance is made during local exhaust ventilation design for this partial blockage. Remember that the system designer always designs for a MAXIMUM pressure drop during the design phase.

Pressure indication can be a dial indicating gauge or a U-tube manometer. Although a dial gauge is easier to read, the U-

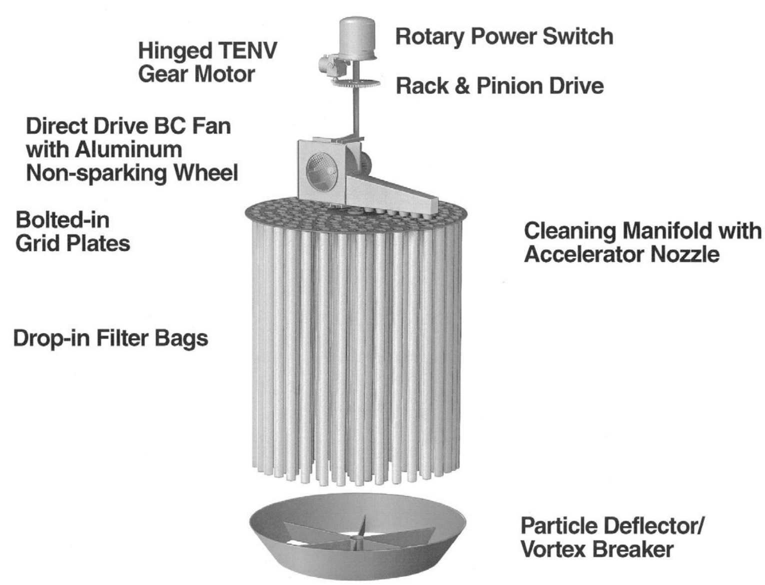


FIGURE 6-14. Reverse air dust collector

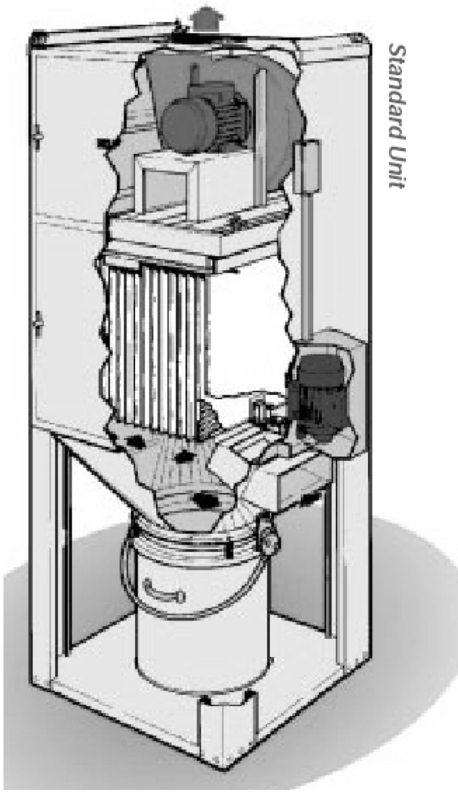


FIGURE 6-15. Bag cleaning by shaking action with airflow stopped

tube manometer is simple, has no mechanical parts to clean, and is a primary standard so it does not need calibration. Differential pressure between two and six inches of water is typical for most local exhaust ventilation designs. The pressure reading will bounce slightly when a row of bags is cleaned.

If a differential pressure gauge is mounted on the baghouse, ensure that the tubes connecting the gauge are free from blockage, particularly at the dirty side tap. Provide an easy way to clean out the dirty side tap as it can plug with dust. For instructions on how to calibrate the gauge, refer to the vendor's manual. If no differential pressure gauge exists for the baghouse, it is still possible to measure the pressure difference as a part of your routine system monitoring. Clean and dirty site pressure taps are a standard provision for baghouses. To take this measurement, open the taps and measure the static pressure at each point. The difference between the static pressures is the differential pressure. One can also connect each tap to a U-tube manometer and record the pressure difference (see Figure 6-17). In either case, ensure that the taps are properly sealed when not in use.

Compressed Air Pressure Gauge

The pressure gauge on the baghouse compressed air header (see Figure 6-18) also provides important data for day to day operation. It is important that adequate pressure be available at the baghouse for cleaning the bags. Most baghouses need between 85 and 100 psig air and the baghouse maintenance manual should be consulted for manufacturer's recommendations. For dust with extremely high aerodynamic particle diameters (fluffy) and poor agglomerative properties, pulse pressures of less than 85 psig sometimes can provide better results, but review with collector vendor before making this adjustment.

Movement of the pressure gauge needle during the cleaning cycle will also indicate if the diaphragm valves are operating. When the diaphragm valve opens to clean a row of bags, the compressed air header pressure will normally drop by 10 to 20 psig for a short period and then should rapidly recover to the starting pressure reading. If the drop in pressure differs from normal operations, it could indicate a diaphragm valve problem.

6.3.14 Dust Removal System. The dust removal system is a major part of larger fabric filters. Dust must be removed continuously for optimum filter operation in a pulse jet collector. Level sensors can be installed to indicate hopper backup. Because mechanical equipment is being used to remove the dust, the continuing rotation of that equipment and position of any installed diverters provide information to the logic control system to warn of failure of those components. The types of devices used to indicate motion, position, and level are described below, followed by a description of how the inputs are used by the logic control system.

Motion Indication

Motion switches are commonly used in local exhaust ventilation systems to electronically "prove" rotation of airlock valves and screw conveyors in the dust removal system. They are simple ON/OFF devices that send a signal to the logic control circuit whenever the absence of rotation is detected. They are used to give inputs to logic control circuits or sound alarms.

One of the many methods used to detect rotation is a combination of a metal tab on the shaft and a proximity switch. The L-shaped tab is fastened to the end of the shaft. A proximity switch, which can detect the presence of metal, is positioned on a bracket by the shaft. As the shaft turns, the L-shaped tab revolves, passing the end of the tab by the proximity switch. Electronic circuitry is programmed to time the interval between proximity switch detections of the tab. If the expected time interval is missed, the electronic circuit sends a signal to the logic control circuit.

Position Indication

These devices are used to indicate positions for a diverter valve or similar two-position damper. In a dust removal system, the logic control circuit uses the signal to "prove" that material is flowing to the proper destination. One local exhaust ventilation application is a filter fines reclaim system; fines are sent either to the process to be recycled or to a container to be

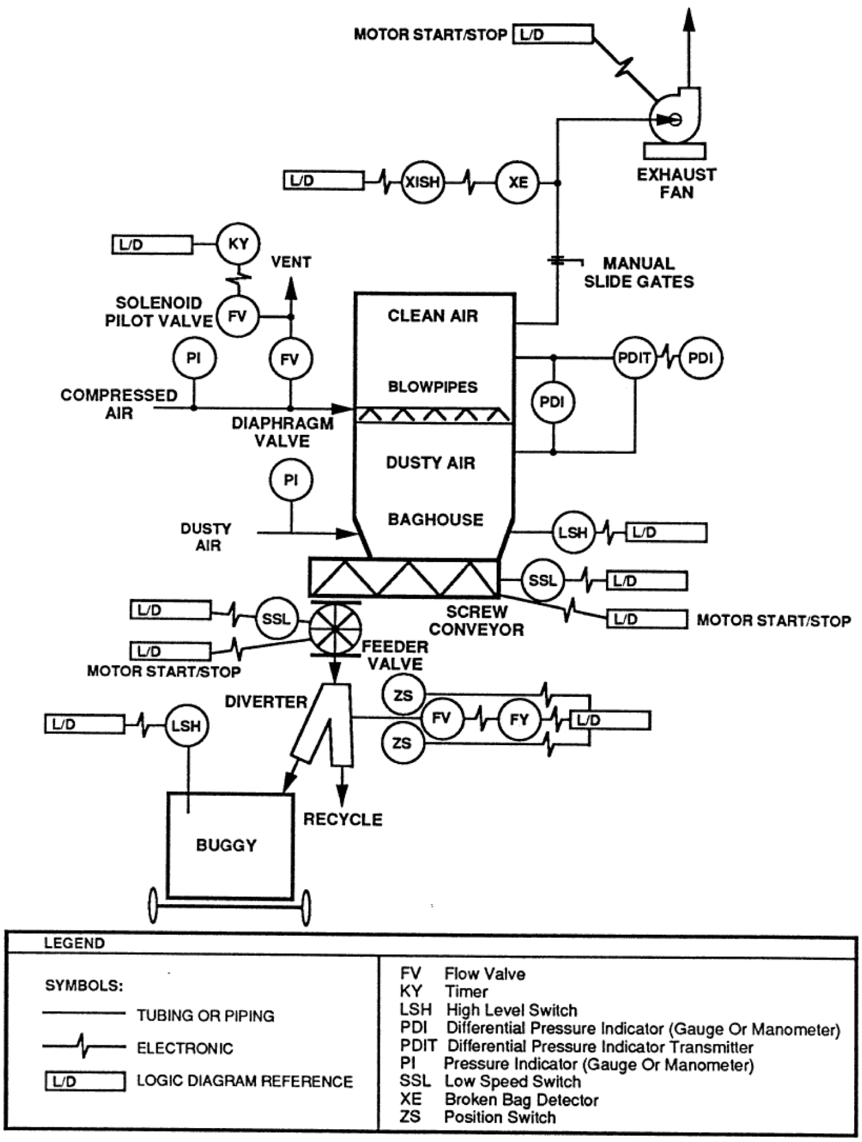


FIGURE 6-16. Baghouse indicators, alarms, and controls

scrapped.

Either proximity switches or contact micro-switches are mounted at each valve position on the valve frame. A simple ON/OFF signal is sent to the logic control circuit when the valve mechanism activates the switch.

Level Indication

Level switches are used to detect the presence or absence of solid materials in process equipment. They are simple ON/OFF devices that send an electronic signal whenever a level is detected. The signal is used as input to a logic control circuit or to sound an alarm. Level switches in the hopper of a baghouse filter or in a chute are common applications. Some of the types of level sensors are described below.

VIBRATION – The level is sensed when the vibrations of the cylindrical probe are dampened (slowed) enough by the presence of material to activate the probe's electronic switch.

ROTARY PADDLE – The level is sensed when the rotation of a paddle, suspended on a shaft in a bin, is stopped by the presence of material and an electronic switch is activated.

ULTRASONIC – The level is sensed by sound waves reflected off the material, much like the SONAR used by submarines.

6.3.15 Typical Filter Dust Removal Control System. To put motion, position, and level components together into the control logic for the filter dust removal system shown in Figure 6-16 requires a number of different detectors to ensure