Working, Design Considerations and Maintenance of Bag Type Fabric Filters

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Committed to improve the Quality of Life

The information contained in this booklet represents a significant collection of technical information on working, design considerations and maintenance of bag type fabric filters (mechanical shaker, reverse air and pulse jet type baghouses/filters). This information will help to achieve increased reliability at a decreased cost. Assemblage of this information will provide a single point of reference that might otherwise be time consuming to obtain. Most of information given in this booklet is mainly derived from the literature on the subject indicated in the reference list given at the end of this booklet. For more information, please refer them. All information contained in this booklet has been assembled with great care. However, the information is given for guidance purposes only and the ultimate responsibility for its use and any subsequent liability rests with the end user. Please see the disclaimer uploaded on http://www.practicalmaintenance.net.

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Content

Introduction

Gas-solid separation devices associated with pneumatic conveying systems have two functions. To recover the conveyed material as much as possible and to minimize pollution of the environment by the working material. Different separation mechanisms used based on the size of particles are: gravity settling chambers, cyclone separators and bag type fabric filters.

If a bulk material consists of relatively large and heavy particles, with no fine dust, it may be possible to collect the material in a simple bin, where the solid material falls under gravity to the bottom of the bin while the gas is taken off through a suitable vent.

However, if a bulk material is of slightly smaller particle size, it may be required to enhance the gravitational effect. The most common method for this is to impart spin to the gas-solid stream so that the solid particles are thrown outwards while the gas is drawn off from the centre of the vortex. A cyclone separator works on this principle.

If particles are fine and especially if they are also of low density, separation in a cyclone may not be fully effective, and in this case the gas-solid stream may be vented through a fabric filter.

For materials containing extremely fine particles or dust, further refinement in the filtration technique may be necessary, for example, use of wet washers or scrubbers and electrostatic precipitators.

In general, the finer the particles that have to be collected, the higher will be the cost of a suitable separation system.

Airborne dusts which may be encountered in industrial situations are generally less than about 10µm in size.

Particles of this size can be taken into the body by ingestion, skin absorption or inhalation. The former is rarely a serious problem and, although diseases of the skin are not an infrequent occurrence, it is inhalation that presents the greatest hazard for workers in a dusty environment.

Particles falling in the size range of approximately 0.5 - 5 µm, if inhaled, can reach the lower regions of the lungs where they will be retained. Prolonged exposure to such dusts can cause permanent damage to the lung tissues (pneumoconiosis) symptomized by shortness of breath and increased susceptibility to respiratory infection.

In view of above, information about working of bag type fabric filters, fabric materials, different types of bag type fabric filters, design considerations, maintenance of fabric filters (pulse jet type) and useful terms related with fabric filters is given in this booklet.

Working of Bag Type Fabric Filters

In pneumatic conveying systems handling fine or dusty material, the method of filtration that has become almost universally adopted is a bag type fabric filter. These filters are commonly called baghouses. Most baghouses use long, cylindrical bags (or tubes) made of woven or felted fabric as a filter medium.

Dust laden gas or air enters the baghouse through hoppers by suction (normally) or positive pressure and is directed into the baghouse compartment. The heavier dust particles fall off at the entry itself, while the lighter dust particles along with gas get carried upward to the bags. The gas is drawn through the bags, either on the inside or the outside depending on cleaning method, and dust accumulates on the filter media which increases the resistance to gas flow. Due to this, the filter must be cleaned periodically when sufficient pressure drop occurs.

During cleaning, dust that has accumulated on the bags is removed from the fabric surface and deposited in the hopper for subsequent disposal. Depending on the type/construction of baghouse, cleaning can be carried out while the baghouse is on-line (filtering) or is off-line (in isolation).

If gas enters into the baghouse tangentially at the bottom of the casing, it gives the dust laden gas a circular motion which helps in removing the heavy and coarser particles that are present in the gas stream in a manner similar to a cyclonic collector. These collected particles are directly discharged into the hopper. It is only the very fine particles that get carried to and collected by the bags. Thus the total dust load on bags is reduced.

Baghouses are very efficient particulate collectors. They collect particles with sizes ranging from submicron to several hundred microns in diameter at efficiency of 99 percent or better. The layer of dust, called dust cake or cake, collected on the fabric is primarily responsible for such high efficiency. The cake is a barrier with tortuous pores that trap particles as they travel through the cake.

Typically, inlet concentrations of pollutant to baghouses are 1 to 23 grams per cubic meter (g/m^3) [0.5 to 10 grains per cubic foot (gr/ft^3)], but in extreme cases, inlet conditions may vary between 0.1 to more than 230 g/m^3 (0.05 to more than 100 gr/ft^3).

Standard fabric filters can be used in pressure or vacuum service, but only within the range of about ± 640 millimeters of water column (25 inches of water column). Well-designed and operated baghouses have been shown to be capable of reducing overall particulate emissions to less than 0.05 g/m^3 (0.020 gr/ft^3), and in a number of cases, to as low as 0.002 to 0.011 g/m^3 (0.001 to 0.005 gr/ft^3).

Differential Pressure (ΔP)

The pressure drop, called differential pressure (ΔP) between the clean gas side and the dirty gas side of the baghouse is one of the most important variables that must be considered in baghouse design. Pressure drop through a baghouse is caused due to the air flow's resistance when air passes through the filtering bag and the filter cake. Typically, the pressure drop is expressed in inches or centimeters of water. This parameter is important because higher pressure drop means higher energy cost. The energy generally will be consumed by the fans that are used to push or pull the air stream through the baghouse.

The differential pressure is measured by a differential pressure gage (Magnehelic® gauge) or manometer. However, over time the pressure sensing lines can become clogged with dust or damaged by moisture or corrosion, and the gauge can become unreadable. Hence, provision for cleaning the pressure taps is required to prevent premature instrument failure due to clogging.

A sudden drop in the differential pressure denotes a leak in the system. Whereas a sudden or sharp rise in the differential pressure denotes that the filter bags are becoming blinded or “caked” with particulate. Hence the differential pressure gauge is the best indicator of baghouse’s current operating status, and offers critical information for troubleshooting.

Advantages and Disadvantages of Fabric Filters

Fabric filters in general provide high collection efficiencies on both coarse and fine (submicron) particulates. They are relatively insensitive to fluctuations in gas stream conditions. Operation is relatively simple. Unlike electrostatic precipitators, fabric filter systems do not require the use of high voltage, therefore, maintenance is simplified and flammable dust may be collected with proper care. Fabric filters are useful for collecting particles with resistivities either too low or too high for collection with electrostatic precipitators. Fabric filters therefore may be good candidates for collecting fly ash from low-sulfur coals or fly ash containing high unburned carbon levels, which respectively have high and low resistivities, and thus are relatively difficult to collect with electrostatic precipitators.

However, there are gas temperature limits to the application of fabric filters because of the limits of the fabric itself. At high temperatures, the fabric can thermally degrade, or the protective finishes can volatilize. Accordingly, fabric filters have usually been limited to gas temperatures below approximately 260°C (500°F), which is the maximum long-term temperature of the most temperature-tolerant fabric. Fabrics can burn if readily oxidizable dust is being collected. Fabric filters have relatively high maintenance requirements (e.g., periodic bag replacement). Fabric life may be shortened at elevated temperatures and in the presence of acid or alkaline particulate or gas constituents. They cannot be operated in moist environments; hygroscopic materials, condensation of moisture, or tarry adhesive components may cause crusty caking or plugging of the fabric or require special additives. Respiratory protection for maintenance personnel may be required when replacing fabric. Medium pressure drop is required, typically in the range of 100 to 250 mm of water column (4 to 10 inches of water column).

Particle Collection in Fabric Filters

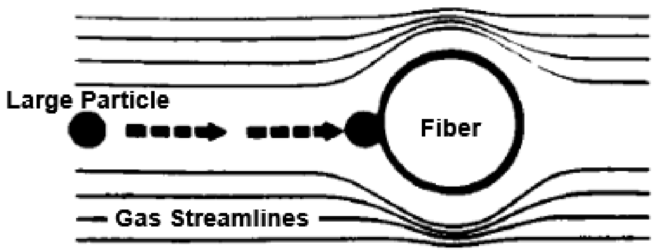
Information about particle collection mechanisms in a fabric filter and fabric filtration mechanisms is given in this chapter.

Particle Collection Mechanisms in a Fabric Filter

Fabric filters take advantage of the fact that particles are larger than gas molecules. Therefore, when dirty gas is filtered through a filter, the particles are captured on the filter while the clean gas escapes.

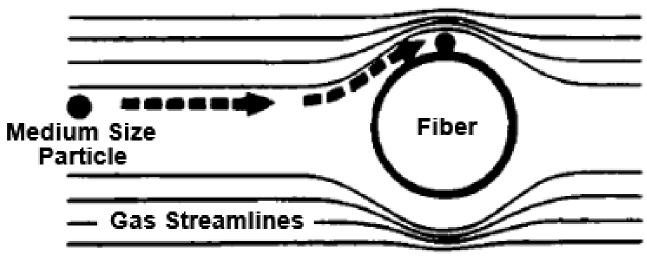
Fabric filters operate through a combination of mechanical particle capture mechanisms/principles. These mechanisms include; straining, impaction, direct interception and diffusion. Straining is the process of removing larger particles (larger than filter pore/opening) or agglomerations thereof. Large particles are removed by impaction, medium sized particles are removed by direct interception and very small size particles are removed by diffusion as explained below.

Particles from an industrial source generally float along the gas stream. If we put something in their path, they would bump into it and under the right circumstances, stay there. As a filter is having tiny pores in it, it allows the gas molecules to flow through it. These molecules create a continuous stream around the fiber in the filter.



Impaction

In case of large particles, because of their too much inertia, they can’t make turn around the fiber and keep going straight ahead until they impact on the fiber’s surface and stay there as shown in above figure. This behavior is called impaction.

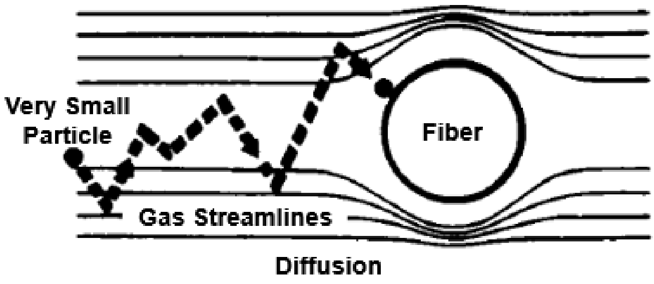


Direct Interception

Medium sized particles have less inertia. Actually they tend to start going around the fiber with the gas stream, but they can’t quite make it. So, instead of hitting the fiber head on, as shown in above figure (if the distance between the center of the particle and the outside of the fiber is less than the particle radius), they end up grazing it on the side or being “intercepted”. This behavior is called direct interception.

Impaction and direct interception account for almost 99% collection of the particles greater than 1 micrometer (μm) in aerodynamic diameter in fabric filter system.

Aerodynamic diameter is the diameter of a sphere of density 1000 kg/m^3 with the same settling velocity as the particle of interest. The aerodynamic diameter standardizes for: Shape (sphere) and Density (the density of a water droplet).



Fabric filters can also collect very small particles, less than 1 µm in aerodynamic diameter. One would think that this size particle would be carried right along with the gas stream. In fact, these particles are so small, they just sort of bounce around and deflect slightly when they are stuck by gas molecules. This individual or random motion causes them to be distributed throughout the gas as shown in above figure and is known as **Brownian Motion** or **Brownian Diffusion**. The particle may have a different velocity than the gas stream and at some point could come in contact with the fiber and be collected. This behavior is called diffusion.

Fabric Filtration Mechanisms

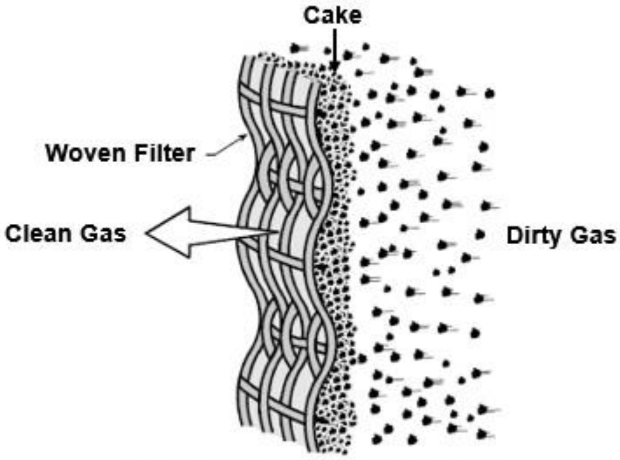
A fiber is any long, thin (length / diameter ≥ 100) hair-like material. A fabric is a stable collection of fibers attached to each other so as to retain a permanent structure.

Woven fabrics are the traditional textile fabric. Fibers are first formed into yarns (threads) and the yarns are then woven together to make a woven fabric. Woven fabrics have a definite repeated weave pattern. Various weaving patterns (for example, plain weave, twill weave, etc.) increase or decrease the amount of space between yarns and affects the permeability of the fabric. A tighter weave has lower permeability and, therefore, captures fine particles more efficiently. A **nonwoven (felted) fabric** is made from long fibers, bonded together by chemical, mechanical, heat or solvent treatment. A nonwoven fabric, fibrous mat, is often called needlefelt or felt. Most bags are either completely or partially made by weaving since nonwoven fabrics are generally attached to a woven base called a scrim.

Fabric filtration can be subdivided into two mechanisms/modes: cake filtration and noncake/depth filtration.

Cake Filtration

In a woven fabric filter, particles get collected by a 'sieving' mechanism in which particles too large to pass through the mesh of the fabric are caught and retained on the surface of the filter. The caught particles gradually build up a cake on the fabric surface so that the labyrinthine nature of the gas flow path continually increases while the effective mesh size decreases. Some particles escape through the filter until the cake is formed. The collection efficiency of the filter will therefore tend to improve with use. However, the pressure drop across the filter increases. Hence, optimum operating cake layer/thickness is a trade-off between collection efficiency and pressure drop and regular cleaning is essential to maintain the pressure drop at an operational level.



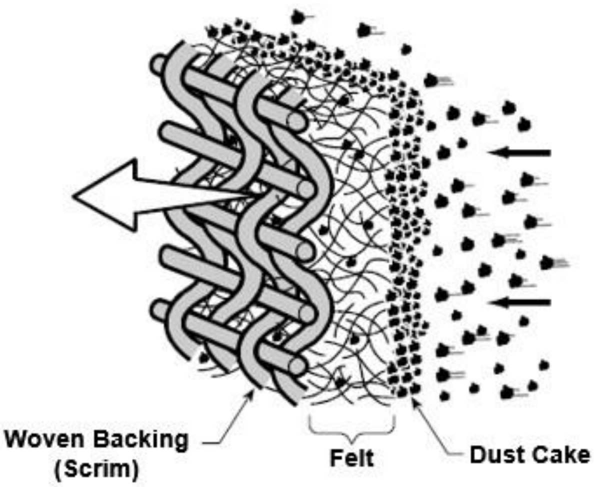
Sieving (on a woven fabric filter)

As collection efficiency during the initial cake construction period is lower than after a uniform cake has been established, operation without a dust cake is undesirable and is minimized. As shown in above figure, because filtering takes place primarily due to presence of the dust cake, this type of filtering is called cake filtration.

It is recommended that during the initial cake construction period, the air flow rate be lowered to half of the standard for about two hours and then increased stage by stage to prevent the finer particles from clogging the filter.

As the dust cake is formed on surface of the woven fabric, they are suitable for low energy cleaning methods such as shaking or reverse air flow through the filter bags.

Noncake/Depth Filtration



Depth Filtration (in a nonwoven fabric)

In a nonwoven fabric, particles are mostly caught by their impingement on the fibres within the fabric. Hence, this type of filtration is often referred to as 'depth filtration' to distinguish it from 'sieving'. The actual flow paths followed by the gas passing through a depth filter are extremely tortuous, and a particle unable to follow these paths is given a trajectory which sooner or later brings it into contact with a fiber where it adheres, largely as a result of Van der Waal's forces. Since particles have to be removed from depth, a high energy cleaning technique such as pulse jet is required for their cleaning.

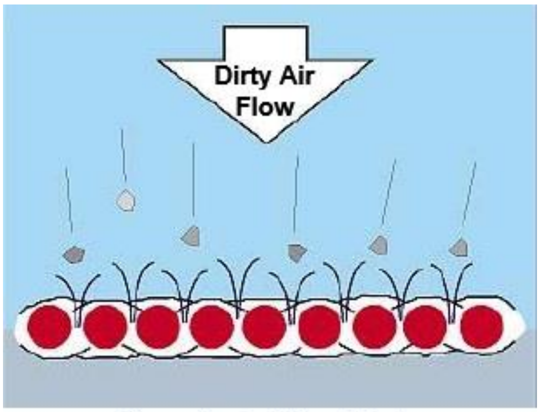
Dust cake forms slower in a nonwoven fabric than in a woven fabric because the flow is relatively uniform across the fabric surface rather than concentrated through a discrete number of openings in the weave of woven fabric. In a woven fabric, filling of the openings (the free area) with dust occurs more rapidly because of the concentrated flow through them. The relatively high cleaning frequency, characteristic of nonwoven fabric also suppresses cake formation. Due to this, dust cake never becomes fully established and the primary filtration media is the dust-loaded fabric itself. Hence this type of filtering is called noncake filtration. A nonwoven fabric is generally used for filtering very fine particles.

Felted bags should not be used in high humidity situations, especially if the particles are hygroscopic (these particles have an affinity to absorb moisture and thus become sticky) because clogging or blinding could result in such situations.

It may be noted that in both these filtration mechanisms, the filtration media includes collected dust. In dust cake filtration, collected dust is the primary filtration media, implying that understanding the dust properties is the key to understanding the filtration performance. In nondust cake filtration, the fabric and the collected dust both make up the filtration media so that both fabric and dust properties are important in understanding noncake filtration.

Pre-coating / Seeding

For a baghouse to operate efficiently, the fabric filters must first capture the particles and then release them during the cleaning cycle. The effectiveness of this process depends on the development of the dust cake (initial control layer of dust) that protects the fabric interstices.

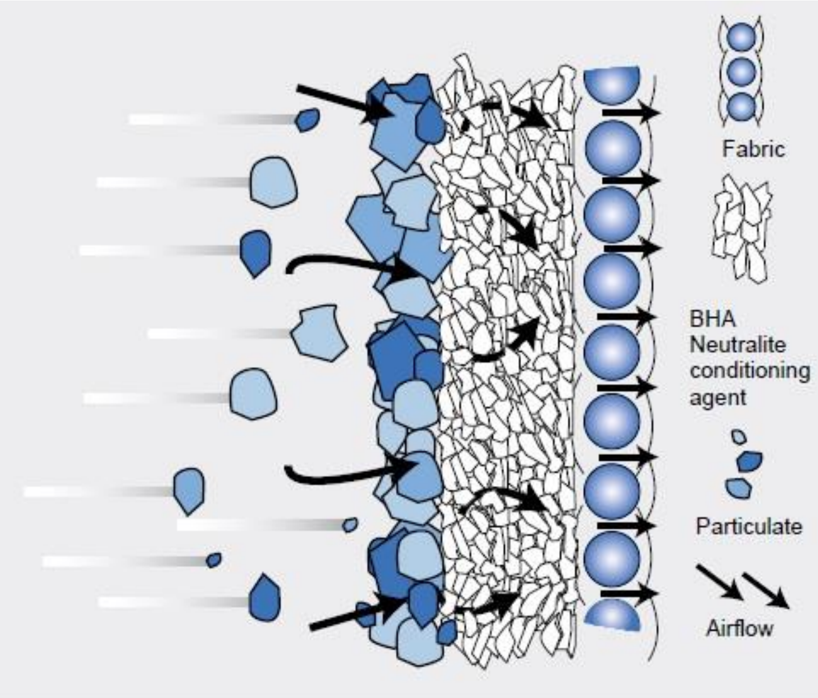


Unprotected New Fabric

As shown in above figure, unprotected new fabric interstices work like miniature venturis to accelerate airflow through the fabric, causing particulate impingement resulting in blinding.

Pre-coating is the application of a relatively coarse, dry dust to a filter element before start-up to provide an initial filter cake for immediate high efficiency and to protect filter elements from blinding.

Fine, moist, or adhesive dusts will contribute to premature blinding of filter media. Pre-coating of the filter media with a layer of an inert dust of known particle size distribution, such as lime, calcium carbonate ($CaCO_3$) or fly ash, can minimize problems associated with these type of dusts.



Filter Media Pre-coated with BHA Neutralite®

However, a variety of particle sizes and shapes are needed to produce an efficient and porous dust cake. Particles that are having similar shapes and sizes will form a very dense dust cake that restricts airflow. As per General Electric Company, Neutralite® Powder manufactured by them creates a more efficient and porous dust cake as it consists of microscopic particles that vary dramatically in shape, while most other pre-coats have only one particle size. As Neutralite is also lighter than lime and fly ash, it will not fall off the bags during cleaning.

General Electric Company recommends use of Neutralite® SR (Spark Retardant) if the operation has the potential for hot sparks in the gas stream entering the baghouse. It offers following additional benefits in addition to benefits provided by the regular Neutralite powder.

- Provides a protective barrier between the fabric and sparks in the gas stream
- Helps extinguish sparks before they damage the bag
- Absorbs up to 300% its weight in moisture and 250% its weight in oil and hydrocarbons to help prevent filter bag damage

BHA Neutralite® Conditioning Agent and BHA Neutralite® SR, light-density aluminum silicate powders sold by CLARCOR Industrial Air are similar to Neutralite® Powder and Neutralite® SR sold by General Electric Company.

For more information on Neutralite® and surface treatment of filtration media, please see websites of General Electric Company (www.ge-energy.com/airquality) and CLARCOR Industrial Air (www.clarcorindustrialair.com / www.bha.com).

Fabric Materials

Fabric filter bags are generally round tubes, made of woven fabric or nonwoven fabric. Information about important properties, characteristics and use of various fabric materials is given in this chapter.

Inlet gas characteristics are extremely important in selecting the material for the filtration medium. Typically, gas temperatures up to about 260°C (500°F), with surges to about 290°C (550°F), can be accommodated with the appropriate fabric material. Spray coolers or dilution air can be used to lower the temperature of the pollutant stream. This prevents the temperature limits of the fabric from being exceeded. Lowering the temperature, however, increases the humidity of the pollutant stream. Therefore, the minimum temperature of the pollutant stream must remain above the dew point of any condensable in the stream. The baghouse and associated ductwork should be insulated and possibly heated if condensation may occur.

Filter fabric is manufactured from various materials, which provide different beneficial characteristics. Following selection chart (Source: GE Energy) summarizes some of the common fabric materials and conditions they are most suited to handle.

Fabric Material	**Properties**				
	Maximum Continuous Operating Temp. °C	Abrasion	Filtration Properties	Alkalines	Mineral Acids
Polypropylene	77°C	Excellent	Good	Excellent	Excellent
Acrylic	130°C	Good	Good	Fair	Good
Polyester	135°C	Excellent	Excellent	Fair	Fair
PPS (Ryton®)	190°C	Good	Excellent	Excellent	Excellent
Aramid (Nomex®)	204°C	Excellent	Excellent	Good	Fair
P84	180-260°C	Fair	Excellent	Fair	Good
Fiberglass	260°C	Fair	Fair	Fair	Poor
Teflon®	260°C	Good	Fair	Excellent	Excellent

Following table summarizes important characteristics and use of various fabric materials.

Fabric Material	**Characteristics and Use**
Polypropylene	The primary benefit of polypropylene is that it is non-hygroscopic (does not chemically react with water). It exhibits great resistance to static build-up and abrasion, and provides a slick surface for good dust cake release during bag cleaning. Polypropylene is widely used in the food, detergent, chemical processing, pharmaceutical, and tobacco industries. However, oxidizing agents, copper, and related salts damage polypropylene.
Acrylic	These synthetic fibers offer good hydrolytic resistance over a limited temperature range, 127°C for continuous and 135°C for surge application. Acrylic fibers are used in the manufacture of ferrous and nonferrous metals, carbon black, cement, lime, and fertilizers. They are also used extensively in wet filtration applications.
Polyester	Polyesters are among the most widely used fabrics for general applications. The primary damaging agents are water (hydrolysis) and concentrated sulfuric, nitric, and carbolic acids.
PPS [Ryton®]	Developed in 1973, the first commercial fibres from PPS (poly phenylene sulphide) appeared in the early 1980s with the introduction of Ryton® by Phillips Fibers Corp. and subsequently by Toyobo as Procon® and by Toray as Torcon®. It has excellent resistance to both acids and alkalis, which makes it very useful in combustion-control applications. Its early applications have been on industrial coal-fired boilers, waste-to-energy incineration (with and without

	spray dryers), titanium dioxide, and installations where Nomex does not perform well due to chemical or hydrolytic attack. It will hydrolyze, but only at temperatures above 190°C.
Aramid [Nomex®]	It has excellent thermal stability, shrinking less than 1% at 177°C. The fiber is flame resistant, but when impregnated with combustible dusts, will support combustion that will melt and destroy the fabric. Unacceptably short bag life will result where sulfur oxides (SOx) and moisture are present and frequent dew point excursions occur, such as in coal-fired boilers. Some acid-retardant finishes have been developed for Nomex, but have been found to improve bag life by no more than 50%, leaving most bag life cycles unacceptably short.
P84	P84 is an aromatic polymer fiber produced in felt form only. The unique shape of the fiber produces improved capture efficiency characteristics. Composites are made from this material to take advantage of the superior filtration characteristics of P84 while reducing its cost. Any of the felted materials can be combined with P84 to produce a fabric composite that exhibits the characteristics of both materials.
Fiberglass (Glass Fibers)	Most fiberglass fabrics are woven from minute 0.0038 mm (0.00015 inch) filaments. Many variations of yarn construction, fabric weaves, and fabric finishes are available. It is also produced in a felted form. Fiberglass has the highest operating temperature range available in conventional fabrics. Above 260°C, the fiberglass itself is not directly damaged, but the finish which provides yarn-to-yarn lubrication begins to vaporize, resulting in accelerated mechanical wear of the glass fibers. Fiberglass is noncombustible, has zero moisture absorption (cannot hydrolyze), has excellent dimensional stability, and has reasonably good strength characteristics. Woven glass fabrics have high tensile strength characteristics but relatively low flex strength, especially in the fill (circumference) direction of the bag, and low abrasion resistance. Care must be taken to minimize flexing and rubbing. Fiberglass fabrics have relatively good resistance to acids, but impurities in the glass fibers are attacked by hydrofluoric, concentrated sulfuric, and hot phosphoric acids. They also have poor resistance to hot solutions of weak alkalis, acid anhydrides, and metallic oxides. For these reasons, glass fabrics should not be operated below the acid dew point. Fiberglass fabrics are used extensively with coal-fired boilers and high temperature metals applications.
Teflon®	Teflon® is unique among synthetics in its ability to resist chemical attack across the entire pH range throughout its operating temperature range of 232°C continuous. This fluorocarbon fiber is non-adhesive, has zero moisture absorption, and is unaffected by mildew or ultraviolet light. The primary shortcomings of Teflon® are its high cost and relatively poor abrasion resistance. Applications of Teflon® include coal-fired boilers, waste-to-energy incinerators, carbon black, titanium dioxide, primary and secondary smelting operations, and chemical processing.

Surface Treatment of Filtration Media

Various types of finishes are available to enhance the filter media performance. The principal aim being to reduce the adhesion of caked solids to the fabrics, and thus make the cleaning process easier and more effective. Following selection charts summarizes some of the finishes, their purpose and availability/applications.

Following finishes are available for non-fiberglass.

Finish	Purpose	Available For
BHA-TEX® Expanded PTFE Membrane	For capture of fine particulate, improved filtration efficiency, cake release, and airflow capacity	Polyester, Aramid, Acrylic, Polypropylene (felt and woven), P84, PPS, Teflon/PTFE
Singe	Recommended for improved cake release	Polyester, Polypropylene, Acrylic, Aramid, PPS, P84 (felts)
Glaze/Eggshell	Provide short-term improvements for cake release (may impede airflow)	Polyester, Polypropylene (felts)
Silicone	Aids initial dust cake development and provides limited water repellency	Polyester (felt and woven)
Flame Retardant	Retards combustibility (not flame-proof)	Polyester, Polypropylene (felt and woven)
Acrylic Coatings (Latex Base)	Improved filtration efficiency and cake release (may impede airflow in certain applications)	Polyester and Acrylic felts
PTFE Penetrating Finishes	Improved water and oil repellency: limited cake release	Polyester, Aramid (felt), PPS

Following finishes are available for fiberglass.

Finish	Purpose	Applications
BHA-TEX® Expanded PTFE Membrane	For capture of fine particulate, improved filtration efficiency, cake release, and airflow capacity	Cement/lime kilns, incinerators, coal-fired boilers, cupola, ferrosilica/alloy, furnace
Silicone, Graphite, Teflon®	Protects glass yarns from abrasion, adds lubricity	For non-acid conditions, primarily for cement and metal foundry applications
Acid Resistant	Helps shield glass yarn from acid attack to extend life	Coal-fired boilers, carbon black, incinerators, cement, industrial, and boiler applications
Teflon® B	Provides enhanced fiber to fiber resistance to abrasion and limited chemical resistance	Industrial and utility base load boilers under mild pH conditions, cement and lime kilns
Blue Max CRF-70®	Provides improved acid resistance and reduces fiber to fiber abrasion, resistant to alkaline attack, improved fiber encapsulation	Coal-fired boilers (high and low sulfur) for peak load utilities, fluidized bed boilers, carbon black, incinerators

For applications that demand the highest filtration efficiencies (near ZERO emissions), the filter media may be laminated with expanded PTFE membrane (e.g. BHA-TEX® / GORE-TEX®). However, since expanded PTFE membrane is delicate and can get easily damaged, care should be taken in handling the filter bags laminated with expanded PTFE membrane. GORE-TEX® is a tradename of W. L. Gore & Associates, Inc.

Apart from the properties of the fibres themselves, specifications for filter fabrics should include the ‘weight per unit area’, which gives an indication of the thickness, and therefore the strength and durability of the fabric, and an indication of its permeability.

The permeability of the material depends upon the construction of the fabric, which depends on whether it is woven or nonwoven/felted, its thickness, tightness of weave, and so on. This information allows an estimate of the pressure drop across a filter to be made.

For general applications, it is recommended that weight of nonwoven/felted fabric should be 475 g/m^2 (14 oz/yd^2) to 543 g/m^2 (16 oz/yd^2).

Bag Failure Mechanisms and Fabric Testing

Information about bag failure mechanisms and fabric testing is given in this chapter.

Bag Failure Mechanisms

Three failure mechanisms can shorten the operating life of a bag. They are related to thermal durability, abrasion, and chemical attack.

The most important design parameter is the upper temperature limit of the fabric, or thermal durability. As per previous chapter (on fabric materials), fabrics have upper temperature limits which they can withstand continuously. Hence the process exhaust temperature will determine which fabric material should be used for the dust collection.

Another problem frequently encountered in baghouse operation is abrasion. Bag abrasion can result from bags rubbing against each other and from the type of bag cleaning method. For example, in a shaker baghouse, vigorous shaking may cause premature bag deterioration, particularly at the points where the bags are attached. In pulse jet units, the continual, slight motion of the bags against the supporting cages can seriously affect bag life.

Bag failure can also occur from chemical attack to the fabric. Hence proper fabric selection and good process operating practices can help eliminate bag deterioration caused by chemical attack. It may be noted that changes in dust composition and exhaust gas temperatures (lowered to its dew point) from industrial processes can greatly affect the bag material.

Fabric Testing

A number of standard ASTM tests can be conducted on bag filters either to verify the bag filter's conformity with purchase specifications or to use as a troubleshooting tool for bag failures. Four of the standard tests performed are: permeability, MIT flex, Mullen burst strength and tensile strength. These tests can be conducted if the installed baghouse is having problems with bag life or unusually high pressure drop.

Permeability

The permeability test is used to determine the amount of air that can flow through a given cloth area. Permeability is defined in ASTM Standard D-737-69 as the volume of air that can flow through one square foot of cloth at a pressure drop of no more than 0.5 in. w.g. (125 Pa). Because air permeability is not a linear function of the pressure difference measured across fabric surfaces, the ASTM method prescribes that permeability tests be made at a pressure drop of 0.5 in. w.g. (125 Pa). Certain fabrics may be too dense or too open to maintain this pressure drop. In these cases, the ASTM method states that measured pressure drop be given in the test report. Most often it is measured with a Frazier porosity meter or a Gurley permeometer.

The permeability of clean felts usually ranges between 15-35 ft/min (8-18 cm/s), while lighter-weight woven materials have permeability values greater than 50 ft/min (25 cm/s). Permeability can be measured on clean or dirty bags. Dirty bags are usually tested in the "as received" state. They are then cleaned by vacuuming or washing and retested. These measured values can be compared to the original clean permeability of the fabric to determine if bags that have been in service have become blinded. It is also possible that the pores in the fabric will open wider after extended use, which is shown by permeability values higher than the original values. This condition, however, does not occur as frequently as blinding.

MIT Flex

The MIT Flex Test is used to measure the ability of fabrics to withstand self-abrasion from flexing. This test method is described in ASTM Standard D-2176-69.

The flex test has frequently been used to help determine the rate of deterioration of fiberglass bags used in baghouses installed on coal fired utility boilers.

Mullen Burst Strength

The Mullen burst strength test, described in ASTM Standard D-231, is designed to show the relative total strength of fabrics to withstand pulsing or pressure.

For new fiberglass fabrics, the Mullen burst test provides a good indication of whether the fabric has been weakened by the heat cleaning given the fabric before coating it with materials such as Teflon or silicon graphite.

Tensile Strength

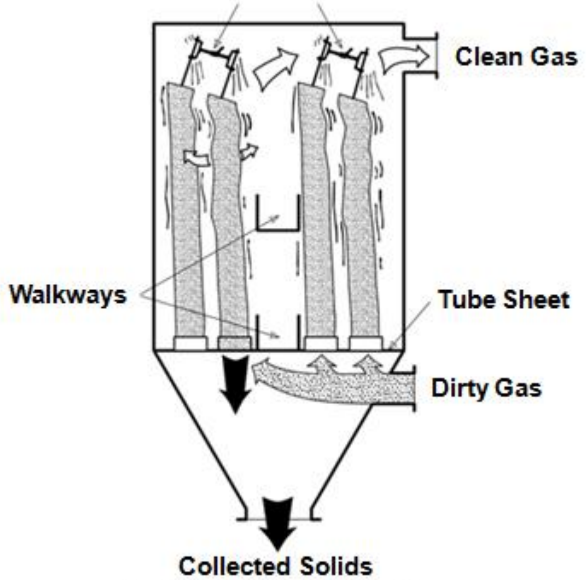
The tensile strength test provides data on fabric stretch, elongation, and tear. This test method is described in ASTM Standard D-1682-64 for breaking load and elongation of textile fabrics.

Tensile strength varies, depending on fabric type and weight. Synthetic fabrics generally tend to stretch or show greater elongation than natural fabrics. Glass materials usually have high tensile strengths. The tensile test, used in combination with the Mullen burst test to compare strengths of new and used bags, can indicate the deterioration in strength of used bags.

Mechanical Shaker and Reverse Air Baghouses

Baghouses are generally classified by the cleaning method used. The three most common types of baghouses are mechanical shakers, reverse gas and pulse jet. Information about mechanical shaker baghouses, reverse air baghouses and sonic cleaning is given in this chapter.

Mechanical Shaker Baghouses



Mechanical Shaker Baghouse

As shown in above figure, in mechanical shaker baghouses, tubular filter bags are fastened to the tube sheet at the bottom of the baghouse and suspended from a horizontal bar/beam at the top. Dirty gas enters the bottom of the baghouse so that larger particles are separated by gravity settling, often aided by a cyclone action, although this is not necessary, provided that direct impingement of particles on the bags from the conveying line is prevented. Fine particles are then caught on the insides of the fabric bags as the gas flows upwards through the unit.

Cleaning of the mechanical shaker baghouse is carried out by shaking the top horizontal bar from which the bags are suspended. Motion may be imparted to the bags in several ways, but the general effect is to create a rippling movement (simple harmonic or sinusoidal) along the fabric. As the fabric moves outward from the bag centerline during portions of the rippling movement, accumulated dust on the surface moves with the fabric. When the fabric reaches the limit of its extension, the patches of dust have enough inertia to dislodge from the fabric and fall into the collecting hopper.

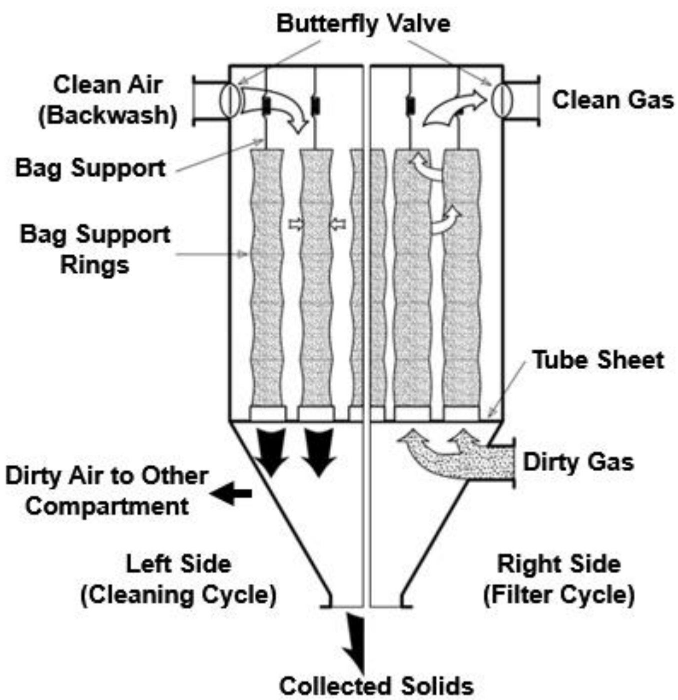
Parameters that affect cleaning include the amplitude and frequency of the shaking motion and the tension in the mounted bag. The first two parameters are part of the baghouse design and generally are not changed easily. Typical values are about 4 Hz for frequency and 50 to 75 mm (2 to 3 inches) for amplitude (half-stroke). The tension is set when bags are installed.

The cleaning will not function properly when on load, and so the filter can only be shaken effectively at the end of a conveying cycle in the absence of gas/air and material flow. There must be no positive pressure inside the bags during the shake cycle because pressures as low as 0.02 in. water can interfere with cleaning. Hence though the cleaning system is cheaper, its application is restricted to batch operations. It is also restricted to installations handling materials which readily form a caked layer on the surface of the filter fabric. For continuous operation, the bag house is constructed with more than one compartment so that when one compartment is being cleaned, the gas/air flow can be diverted to other compartments.

As the air to cloth ratio for shaker baghouses is relatively low (due to use of fabric type filter), the space requirements are quite high. Compared with reverse air cleaned bags (discussed below) the vigorous action of shaker systems tends to stress the bags more, which requires heavier and more durable fabric.

Reverse Air Baghouses

When glass fiber fabrics were introduced, a gentler means of cleaning the bags, which may be a 300 mm in diameter and 10 meter in length, was needed to prevent premature degradation. Reverse air cleaning was developed as a less intensive way to impart energy to the bags.



Reverse Air Baghouse

As shown in above figure, in a reverse air baghouse, the bags are fastened to the tube sheet at the bottom of the baghouse and suspended from adjustable hangers (for adjusting bag tension) at the top. Dirty gas flow normally enters the baghouse and passes through the bags from the inside, and the dust collects on the inside of the bags.

Like mechanical shaker baghouses, for continuous operation, reverse air baghouses are compartmentalized. Before a cleaning cycle begins, filtration is stopped in the compartment to be cleaned. Bags are cleaned by injecting clean air into the dust collector in a reverse direction, which pressurizes the compartment. The pressure gently collapses the bags partially toward their centerlines, which causes the dust cake to crack and detach from the fabric surface causing the dust cake to fall into the hopper below.

Because felted fabrics retain dust more than woven fabrics and thus, are more difficult to clean, felts are usually not used in reverse air baghouses.

Some reverse air baghouses employ a supplemental shaker system to assist cleaning by increasing the amount of energy delivered to the bag.

The flow of the dirty gas helps maintain the shape of the bags. However, to prevent total collapse and fabric wear due to rubbing during the cleaning cycle, rigid rings are sewn into the bags at intervals.

The correct number of rings depends on the bag diameter and length. Following table may be used as a general guide.

Bag Diameter, inch	**Bag Length, inch**	**Number of Rings**
5 - 6	< 120	1 or 2
	120 - 130	3
	130 - 168	4
	> 168	5
8	< 260	4
	> 260	5
11.5 - 12	260 - 300	5
	300 - 360	6
	360 - 400	7
	> 400	8

For use of reverse air baghouses in utility (power plant), instead of clean air, cleaned flue gas is customarily used for cleaning the bags.

Tensioning Assemblies

Improper tensioning is one of the main causes of bag failure in reverse air baghouses. A bag should be tight enough to prevent excessive fiber-to-fiber and bag-to bag contact and abrasion. Excessive tensioning causes harmful stress on the fabric yarns and sewing threads and also prohibits movement necessary for dust cake release. 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 air or mechanical shaker baghouses. As shown in above figure, CLARCOR Industrial Air and General Electric Company have developed many tensioning assemblies (for example, conical spring) to best fit an application.

Proper tension depends on the filter bag size. The rule of thumb is 2 lbs. to 2.5 lbs. per circumferential inch of the filter bag. The following table may be used as a general guide. You may have to retension new filter bags after two to three months of operation to compensate for any relaxation or stretching of the fabric.

Bag Diameter, inch	Tensioning Level, lbs.
5	30 - 40
8	50 - 65
11.5 - 12	75 - 95

The tensioning levels given in above table may be used for tensioning bags of mechanical shaker baghouses also.

Workers should use proper tensioning tools to ensure that equal and adequate tension is applied to all bags, eliminating guesswork which can lead to bag damage during operation.

In a reverse air baghouse, bag life is 4 to 8 years. However, early detection and correction of bag failure is very important. During cleaning operation, a bag leak or tear directs the high velocity abrasive jet flow out of the torn bag and toward its neighbors. Thus, one bag failure, if left uncorrected, often causes three or four others to fail.

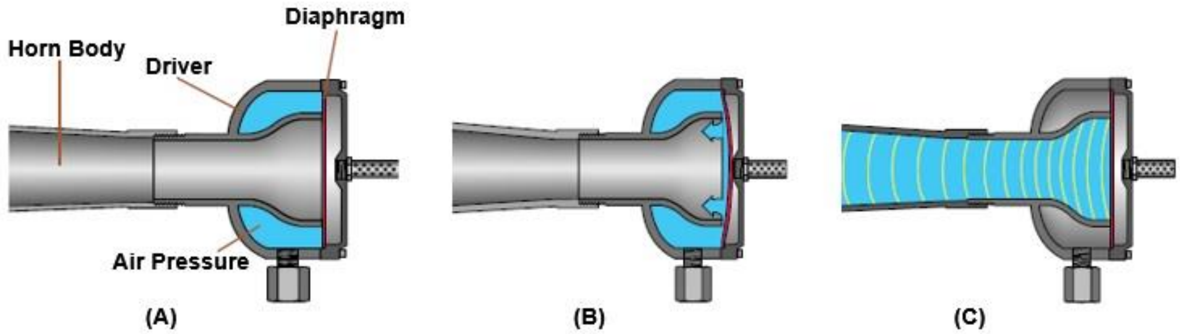
Acoustic/Sonic Cleaning

For any type of cleaning, enough energy must be imparted to the fabric to overcome the adhesion forces holding dust to the bags. Because reverse air cleaning is a low energy method compared with shaking or pulse jet cleaning, additional energy may be required to obtain adequate dust removal. Shaking, as described above, is one such means of adding energy, but another is adding vibrational energy in the low end of the acoustic spectrum. Acoustic / Sonic horns powered by compressed air are a typical means of applying this energy.

Horn construction includes a horn-shaped outlet attached to an inlet chamber containing a diaphragm. Compressed air at 3 to 5 kg/cm2 (45 to 75 psi) enters the chamber, vibrates the diaphragm, and escapes through the horn. Sound waves leaving the horn contact and vibrate dust containing fabric with sufficient energy to loosen or detach patches of dust that fall through the bag to the hopper below. Horns can be flange mounted through the baghouse sides or at the inlet chamber. The horns also can be suspended inside the baghouse structure.

Many times sonic horns are used in mechanical shaker baghouses also. Though sonic horns are used as supplemental equipment for applications that require added energy for adequate cleaning, occasionally sonic horns are used as the only source of cleaning energy.

Acoustic / Sonic Horns Working



Acoustic / Sonic Horns Working

Above figure (courtesy: CLARCOR Industrial Air) shows working of an acoustic / sonic horn. As shown at (A) in above figure, as compressed air is introduced to the driver assembly of an acoustic horn, the pressure builds up rapidly, causing the diaphragm plate to flex. As shown at (B), the air escapes past the flexed titanium diaphragm plate into the horn, reducing the air pressure in the driver. The pressure reduction allows the diaphragm to snap back quickly, creating a strong pulse in the horn body. As shown at (C), the pulses travel through the horn, where they are amplified by the bell shape, and become powerful bursts of acoustic energy capable of blasting particles away from fabric surfaces.

Design Considerations

Acoustic horns typically dislodge dust and particulate more effectively at low frequencies. Hence extremely low frequency sound waves must be located close enough to the structure or vessel, but can potentially cause structural damage or loosen welded or bolted connections. In view of this, acoustic cleaning horns operate at 75 Hz or higher - above the structure's natural frequency - to ensure that structural components are not damaged.

The length of the horn's "bell" is one factor that determines the main, or fundamental, frequency of the horn. The longer the bell, the lower the frequency.

The horns (one to several per compartment for large baghouses) typically operate in the range of 75 to 550 Hz (more frequently in the 75 to 160 Hz range) and produce sound pressures of 145 to 150 db. When properly applied, sonic energy can reduce the mass of dust on bags considerably. Sonic horns are activated for approximately 10 to 30 seconds during each cleaning cycle.

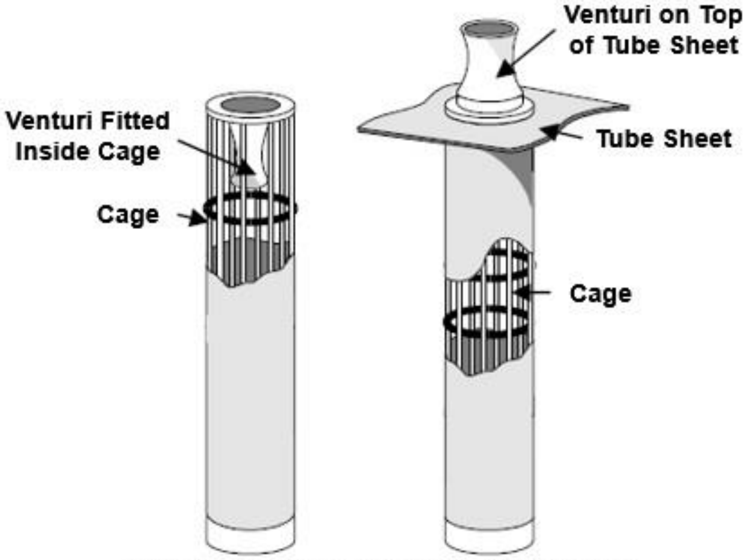
In addition to fabric filters, acoustic horns can be used to produce powerful pulses of sound energy to dislodge dust from boiler tubes, heat exchangers, collecting plates and high voltage discharge electrodes of electrostatic precipitators (ESPs) and hoppers.

CLARCOR Industrial Air (www.clarcorindustrialair.com) and Primasonics International Limited (www.primasonics.com) are the leading supplier of acoustic horns. For more information on acoustic horns, please see their websites.

Pulse Jet Baghouses

Pulse jet baghouses are also commonly called pulse jet bag filters or pulse jet filters. In a pulse jet filter, the bags are cleaned by introducing a high-pressure pulse of compressed air at the top of each bag. Information about working, construction and troubleshooting pulse jet baghouses/filters is given in this chapter.

Working of Pulse Jet Baghouses/Filters



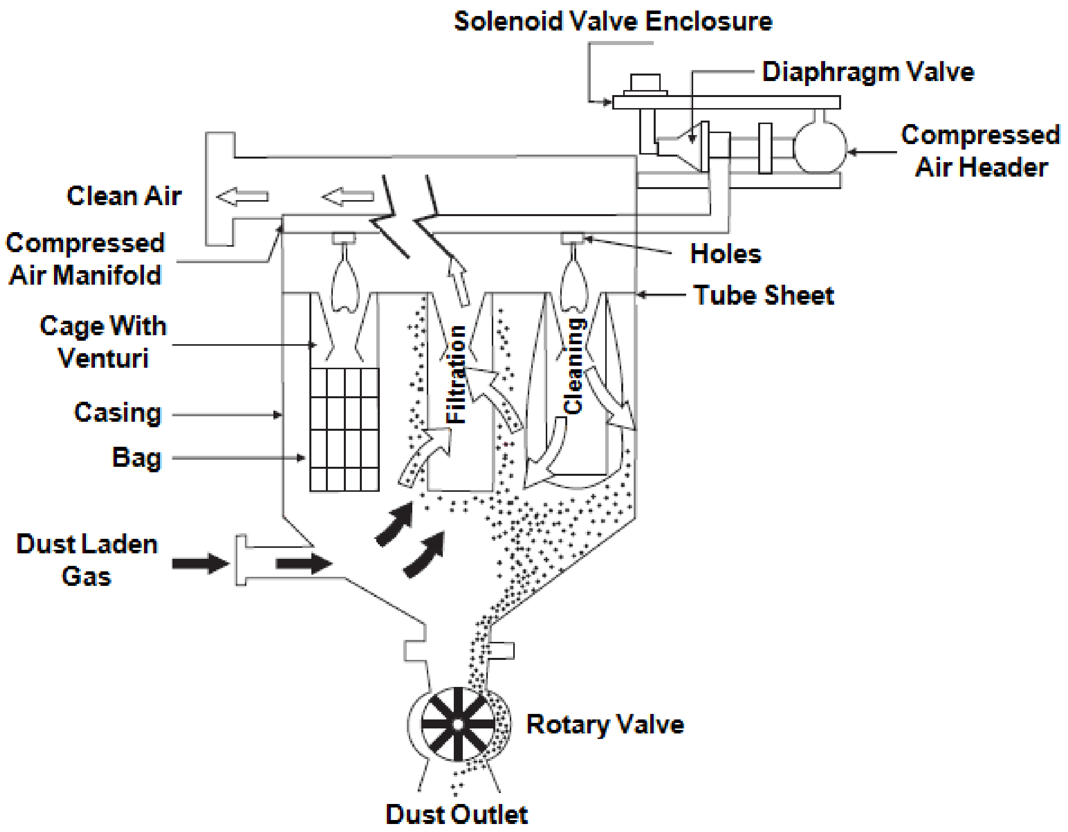
Venturis in Traditional Pulse Jet Cleaning

The term “pulse jet” probably originated with the use of a venturi (**jet** pump) to create a high pressure bag cleaning pulse; and, hence, the term “pulse jet cleaning” initially implied the presence of a venturi. This usage is no longer universal, and the term pulse jet cleaning as used here refers to cleaning action brought about by short (50 to 150 milli second), high pressure pulse created by any technique, with or without a venturi.

As shown in above figure, if a venturi is installed on top of the tube sheet, the entire bag length can be utilized for effective filtering as compared to alternative design using a venturi within the bag.

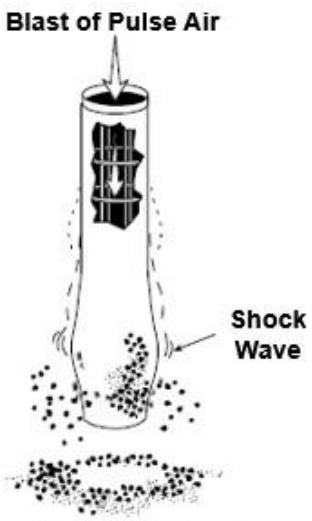
A major difference between reverse air baghouse cleaning and pulse jet baghouse cleaning is primarily one of time scale. The reverse air pulse used in pulse jet baghouse cleaning is a fraction of a second in duration while the reverse air cleaned baghouses described in the previous chapter all use reverse air flow of much longer durations (tens of seconds).

As shown in the following figure, in a pulse jet bag filter, individual bags are supported by a metal/wire/filter cage, which are fastened to the tube sheet at the top of the casing. The metal cage prevents collapse of the bag. Dust laden air/gas enters from the bottom of the casing and flows from outside to inside the bags. the air passes through the bags (filter media) while solids are retained on the outside surface of the bags. A signal from the solid state timer actuates the opening of the normally closed solenoid valve. Opening of the solenoid valve releases the air pressure in the tube connecting the solenoid to the pulse/diaphragm valve, resulting in release of air pressure behind the diaphragm (back cell), causing the valve to open and allowing air to flow from the compressed air header into a compressed air manifold. A row of bags is cleaned by a short burst of compressed air injected through the compressed air manifold (also called blow pipe or purge pipe).



Pulse Jet Bag Filter

As shown in the following figure, the short burst of compressed air creates a rapidly moving air bubble (shock wave) which results in flexing of the bags. This flexing of the bags breaks the dust cake, and the dislodged dust falls into a storage hopper below. It is normal for some of the dust to re-entrain itself onto the filter element. The separated dust from the hopper is removed through an airlock (airlock prevents air from entering the hopper through its outlet) or other airtight device like rotary valve.



Pulse Jet Cleaning

Because air flows in the reverse direction during cleaning operation, these types of filters are also called reverse pulse jet filters.

Pulse jet bag filters can be operated continuously and cleaned without interruption of flow because the burst of compressed air last for only a very short period of time, typically less than a second. Because of this continuous cleaning feature, maximum utilization of the fabric area can be achieved.

Pulse jet cleaning is more intense and occurs with greater frequency than the other fabric filter cleaning methods (mechanical shaker and reverse air) to keep the unit from having a high pressure drop across the filter. The intense cleaning dislodges nearly all of the dust cake each time the bag is pulsed. As a result, pulse jet filters do not rely on a dust cake to provide filtration. Usually felted (nonwoven) fabrics are used in pulse jet filters because they do not require a dust cake to achieve high collection efficiencies. However, sometimes woven bags are also used in a pulse jet filters in cases where a dust cake is desired. It has been found that woven fabrics used with pulse jet filters leak a great deal of dust after they are cleaned.

An off-line pulse jet bag filter is used when the dust in the gas is very light and/or fine. The dust may remain in suspended condition because the upward/reverse gas flow will not allow the dust to settle in the hopper. This phenomenon is called fluidization of dust. The fluidization of dust results in high differential pressure across the bag filter, and ultimately choking of bags.

When bags are cleaned on-line, the order in which the bag rows are cleaned is very important. If bag rows are cleaned in a sequential order, material from one row of filter bags simply gets moved to the row previously cleaned. This not only results in poor cleaning but tends to retain very fine particles on the filter bags and can lead to premature blinding. Cleaning in a random or non-sequential order distances rows from each other and greatly reduces both reentrainment and potential premature blinding of bags.

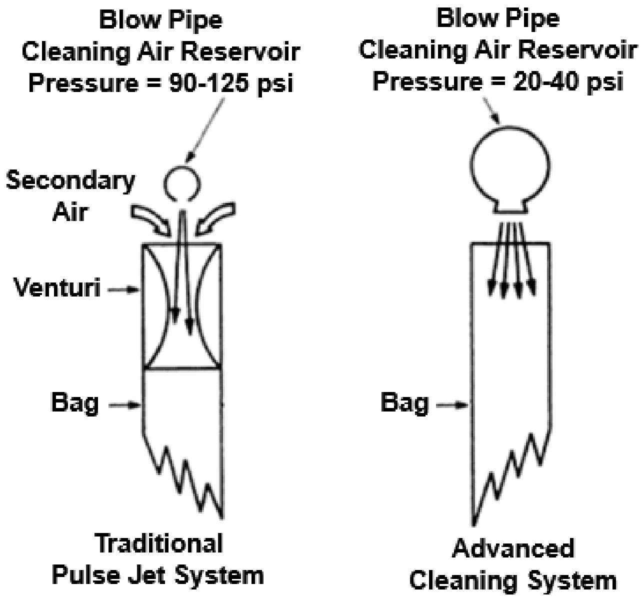
Typically bag life in a pulse jet filter is 3 to 6 years.

In case of traditional pulse jet system with venturis, there is clearly a limit to the length of filter bag that can be effectively cleaned, and a reduction in cleaning efficiency must be expected if very long bags are used.

The phenomenal growth of the Cement Industry has seen the advent of plants of much bigger size. The traditional pulse jet filters have been found to be inadequate to handle large gas flows due to severe limitations on aspects like high space requirement and high compressed air consumption. To overcome this, in the advanced cleaning system, pulse jet filters use low-pressure high-volume air with long bag.

If of sufficient energy (low-pressure x high-volume) to reverse the forward air flow through the bag and expand the bag along its entire length, venturi less advanced cleaning system cleans the bag adequately. The idea behind the introduction of the venturi in the traditional pulse jet bag filter is to use the injected air pulse to form a region of greatly reduced pressure in the venturi throat, thereby aspirating a large quantity of cleaned gas from the outlet plenum to supplement the directly injected cleaning pulse. The venturi thus acts as a jet pump to more efficiently create a cleaning shock wave. However, the importance of the venturis is debatable.

Following figure compares the two systems. In addition to difference in cleaning air reservoir pressure (20-40 psi in advanced cleaning system against 90-125 psi in traditional system), there is difference in the quantity of induced air also between these systems. In case of traditional pulse jet system, as pulse is injected through venturi nozzle, aspirating secondary air flow is 6-7 times greater than the primary air flow. However, in case of advanced cleaning system, as pulse is injected directly into the bag, secondary air flow is just 1-2 times the primary air flow.

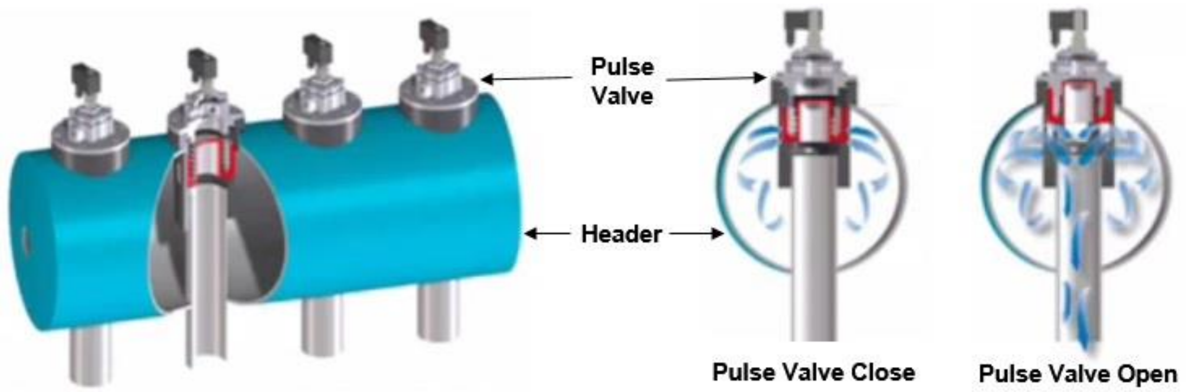


Traditional and Advanced Pulse Jet Systems

As the filter media is not flexed as extensively as in the traditional cleaning system, low pressure (20 to 40 psi) advanced cleaning system increases life of filter bags.

However, the conventional cages cannot be used in advanced cleaning system as there is a tendency for them to bend due to the excessive length. Higher thickness wires are used for cages when the height of bag or cage is 6 m or more. This higher thickness ensures straightness (spacing between bags) of the bags which are freely suspended from the tube sheet.

Thermax is one of the reputed Indian companies in energy and environment engineering. The TKB pulse jet bag filter (PJBF) design offered by them utilizes the advanced cleaning system.



Typical Immersion Type Header Mounted Pulse Valves Cleaning System

As shown in above figure, their low pressure cleaning system uses a special immersion type header mounted pulse valves (piston type valves). As per them, the cleaning system is so effective that it achieves 25% more cleaning pressure on the bag and the impulse is built in half the time it takes in conventional system.

For more information on their low pressure advanced cleaning system, please contact them (www.thermaxindia.com).

Misaligned Blow Pipe and Filter Bags

The critical factor for providing thorough bag cleaning and to prevent damage to venturis and bags is to make sure that the hole/orifice/nozzle in the blow pipe (compressed air manifold) are properly aligned above the filter bags. The holes should also point straight into the bags. As shown in above figure, if holes of the blow pipe are not properly aligned above the filter bags, it may damage venturis. Rotation of the blow pipe could cause the compressed air pulse to strike the side of the bag near the top, and create hole in the bag. For this reason, many times pulse jet filters are provided a mounting on the blow pipe to ensure that it can only be placed in the proper orientation.

For high positive design pressure or vacuum applications, the casing of a small size bag filter is made circular instead of rectangular. The top cover could be a dished end. Due to its circular construction, the bag filter can withstand more +/− pressure as compared to normal rectangular bag filter.

To increase filter area in the same volume of baghouse, star-shaped and pleated (in cross section) bag-cage configurations have been developed. The bag-cage combination is designed as a unit to be installed similarly to a standard bag and cage unit. Such units can be used as replacements for standard bags and cages when additional fabric area is needed, or may be used in original designs. Normal pulse cleaning is used, i.e., no special changes to the cleaning equipment are required. However, cost of a star-shaped bag and cage is about three times the cost of a normal bag and cage.

Further increases in filter area per unit of baghouse volume are obtained by using finely pleated filter media supported on a wire framework. This cartridge can be mounted vertically as a nearly direct replacement for standard bags and cages in existing baghouses.

Types of Cleaning Controls

Normal pressure drop for a bag filter will fall in the range of 2 1/2 to 6 inches of w.c. (water column) after the elements (filter bags) are broken in. The differential pressure reading will increase as the elements get dirty and the filter must eventually be cleaned or airflow will fall to unacceptable levels.

Bag filters are available with “continuous” or "clean on demand" cleaning control. Continuous cleaning type bag filters are cleaned with pre-timed pulses of compressed air regardless of cleaning need. However, clean on demand filters are cleaned based on the pressure drop monitored across the filter bags.

A typical automatic clean on demand system for a pulse jet baghouse consists of a differential pressure gauge (Photohelic® Switch/Gage, a 2-in-1 instrument combining Magnehelic® differential pressure gage with low and high pressure switches) and a programmable controller. The differential pressure gauge measures the difference in pressure between the dirty air side and clean air side of the bags in the baghouse. The pressure gauge sends the differential pressure readings to the controller, which is programmed with a high pressure and low pressure set point. When the differential pressure reaches the high pressure set point, the controller activates the baghouse’s pulse cleaning cycle, which starts cleaning the bags, lowering the differential pressure. When the differential pressure reaches the low pressure set point, the controller shuts down the pulse cleaning cycle. The user sets the high and low differential pressure set points [generally 1/2” to 1” w.c. (12.7 to 25 mm w.c.) apart], whereby cleaning will start and stop. By operating the baghouse at a stable and optimum differential pressure, over or under cleaning of the filter bags can be avoided. Clean on demand control helps to lower compressed air consumption, optimizes the dust collection efficiency (by setting low pressure set point to maintain a light coating of dust on the bags) and life of bags also increases due to less flex cycles on the bags.

Clean on demand filter bag cleaning systems may save energy for facilities with light dust loads. Baghouses that must clean continuously to maintain an allowable maximum pressure differential will not benefit from this technology. Some clean on demand system users have returned to pre-timed pulses (continuous cleaning) as pressure sensors have proved unreliable due to clogged tube connections. Some equipment vendors offer purge air cleaning as an option to overcome the tube clogging problem.

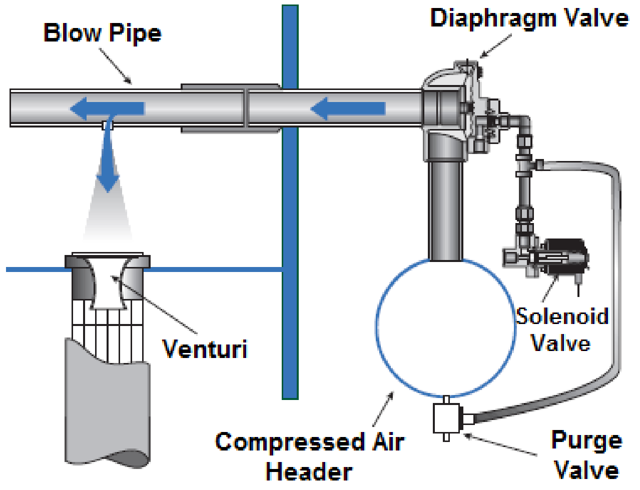
Note

Excessive cleaning of pulse jet bags can simultaneously cause higher-than-normal emissions, higher than-normal static pressure drop, and accelerated bag wear. If there is insufficient dust cake on the bag when it is cleaned, particles or small agglomerates of particles can be dispersed. These particles do not settle by gravity and simply return to the bag at an area where the dust cake is thin; they can accumulate as a low porosity cake, thereby increasing pressure drop (For effective gravity settling of the dust, it is important that during cleaning, large dust agglomerates or sheets be released). Over time, these fine particles can bleed through the bag and cause opacity spiking (emission) after the cleaning pulse.

Dump on Demand

Like clean on demand, dump on demand feature optimizes the transfer hopper operation by reducing valve/gate cycling. A vibrating level probe (or guided wave radar probes) senses a pre-defined ash level in the transfer hopper. When triggered, the airlock’s valves operate to discharge ash into the silo.

Valves on a Pulse Jet System

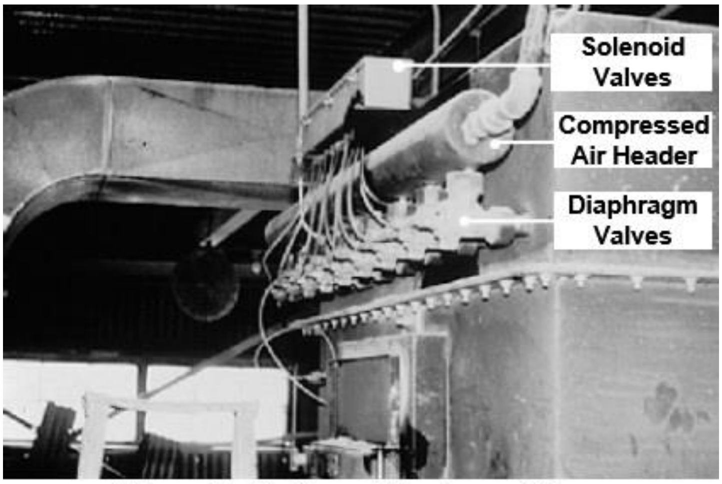


Valves on a Pulse Jet System

Above figure shows various valves on a pulse jet system. The pulse/diaphragm valve and solenoid valve work together for efficient operation of the baghouse cleaning system. The diaphragm valve is controlled by the timer board with a normally closed solenoid valve. The timer board is either installed in the enclosure with the solenoid valves or in a separate NEMA 4 or 7/9 enclosure.

For trouble free operation of diaphragm valves, solenoid valves and filter bags, the compressed air should be clean and dry.

Ambient moisture compressed along with the air can condense once the compressed air begins to cool. Hence, it is recommended to install automatic drain/water trap and filter (5 microns) to dry and clean the compressed air. The better option to dry air is to install a refrigerant or adsorption (desiccant) type air dryer. In a refrigerant type air dryer, air is cooled to near freezing point to remove the moisture and then it is reheated. Adsorption type air dryer works on the physical properties of the desiccant to adsorb and desorb the water vapor.



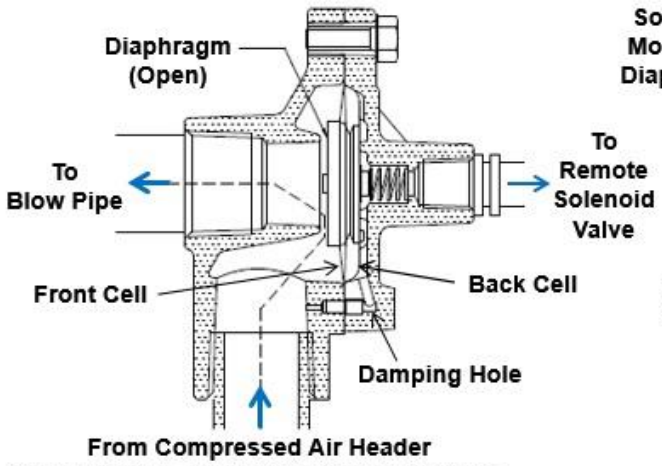
Vulnerable Position of Diaphragm Valves

For baghouses that do not have dryers on the compressed air supply, the compressed air header is usually mounted below the elevation of the diaphragm valves to prevent condensed water carryover into the bags. Above figure shows vulnerable position of diaphragm valve relative to the compressed air header.

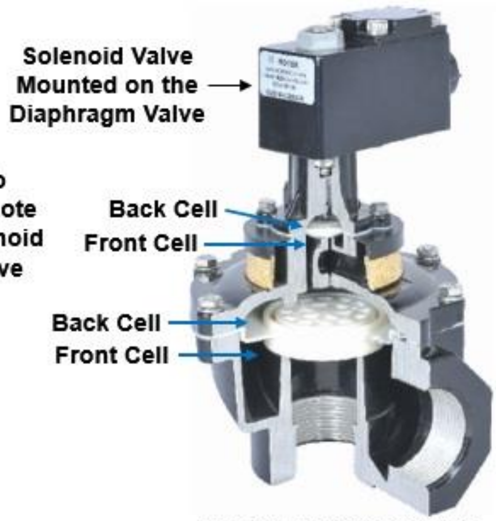
Generally, the compressed air header is sloped and a purge valve is installed to help eliminate water accumulation in it. Without the purge, water from the compressed air can enter the baghouse and cause corrosion to filter bags and an agglomerated, hard-to-clean dust cake. The valve is installed at the bottom of the compressed air header and is connected to a diaphragm valve. Firing of the solenoid valve (of the diaphragm valve) opens the purge valve's discharge port on the air header assembly, removing excess moisture. In absence of automatic purging, one may install a manual purge valve and periodically purge the header manually.

A coalescing filter is often used after the compressor to remove entrained oil droplets. The oil is introduced into the compressed air stream by the vaporization of lubricating oil used in certain types of compressors. After the compressed air cools, the oil vapor can condense to form oil droplets. If they are not removed, the oil droplets can accumulate on the bag surface and eventually cause blockage of gas flow.

Construction of Diaphragm Valves



Cross Section of a Single Diaphragm Valve



Double Diaphragm Valve

Construction of a Diaphragm Valve

Above figure shows construction of a diaphragm valve. In a diaphragm valve, the electrically operated solenoid valve acts directly on only a small volume of high pressure air; which in turn pneumatically operates the diaphragm valve. Such a scheme allows fast/quick opening and gentle closing of a diaphragm valve, a desirable cleaning pulse property.

Integral solenoid valve is mounted directly on the diaphragm valve. Remote solenoids may be mounted in a separate NEMA enclosure. Remote solenoid valve should be mounted as close as possible to the diaphragm valve (usually maximum distance is 3 m / 9.8 ft). If tape or pipe compound is used, apply it to the male piping threads and use sparingly as it may come loose and affect valve operation. For extremely corrosive applications, coated valves are available in a variety of finishes.

Pressure transducers can be fitted to the compressed air header to detect a change in pressure within preset limits. If a diaphragm valve refuses to open or alternatively a diaphragm valve sticks open and does not close, these transducers will allow controller to indicate which diaphragm valve has a fault condition.

Working of Diaphragm Valves

The diaphragm valve is composed of two air cells. One is in front of the diaphragm and the other one is on the back side of the diaphragm. When the compressed air is admitted in the valve, it fills the back cell though the damping hole (orifice). As the area of the back cell is larger than the front cell, the air pressure in the back cell pushes the diaphragm against the outlet of the valve and the valve remains in the "closed" condition.

On receiving electrical signal, the solenoid valve’s port opens to the atmosphere and the compressed air escapes from the back cell quickly. Due to this, the diaphragm moves back and the compressed air blows through the valve outlet.

When the electrical signal disappears, port of the solenoid valve closes again and the compressed air pressure in the back cell rises. This pushes the diaphragm closely against the valve outlet and the diaphragm valve gets closed.

A pulse valve with two diaphragms is designed for large flow and fast ON & OFF response.

When a double diaphragm type pulse valve operates, it releases through a small vent port in the pilot solenoid valve a comparatively small volume of air that’s holding a small secondary diaphragm closed. However, the air pressure holding the main diaphragm closed is released through a large vent port in the valve; which allows an immediate discharge of pulse air into the blowpipe to generate a strong air pulse in the bags.

In a pulse jet baghouse dust collector, the pulse (diaphragm) valves that generate the pulse air for cleaning the bag filters must be able to create a crisp and instantaneous air pulse that travels the entire length of each bag like a shock wave to effectively clean it. Hence, it is recommended to use a larger size double diaphragm valve, (40 mm / 1.5 inch) because it easily accomplishes this and is much more effective than a smaller size double diaphragm valve or any single diaphragm valve.

Tip

For identifying failed (not functioning) diaphragm / solenoid valves, gently place a small wad of tissue paper in the exhaust port of each valve. Allow all valves to cycle through a couple of times and check to see which one(s) still have the tissue left in the exhaust port.

Timer Adjustments

For best results, it is recommended not to change the pulse duration. Pulse interval should not be adjusted until the filter has stabilized. The break-in period (several days) is required for the filter media to develop a stable dust cake. After the break-in period, the pulse interval can be increased in order to conserve energy and compressed air. Increase the pulse interval by adjusting the timer board. Adjust in 5 second increments allowing 24 hrs. of operation between adjustments. Observe the differential pressure of the unit after 24 hrs. The pulse interval can be extended until an increase in differential pressure is observed in the filter.

Cages


Cages

A cage is a cylindrical structure composed of steel wires running parallel to the longitudinal axis of the bag and supported by steel rings at evenly spaced intervals along its length. Its top end terminates in a fitting (collar) for its mounting to the baghouse tube sheet. Cages are placed inside filter bags to provide support to the fabric as flexing occurs during filtration and cleaning cycles.


Fabric Flexing Around Cage Wires

As the design of cage affect the life of filter bags, cages should be designed to optimize filter performance and promote longer bag life. Poorly manufactured cages allow over-flexing of the fabric and abrasion, eventually leading to filter failure.

As shown in above figure, because the fabric flexes around the cage wires during filtering, some fabric wear is possible. To minimize this potential problem, cages with closely-spaced vertical (stringer) wires are used for fabrics that are especially vulnerable to flex-type wear. More economical cages are used for fabrics that are very tolerant to flexing.

To promote a proper bag-to-cage fit, the vertical wires should be placed perpendicular to horizontal rings and consistently spaced so that the cage diameter is the same from top to bottom. Number of horizontal rings also should be adequate to support the cage at maximum vacuum to prevent premature cage collapse due to blinding of the bags.

Cage mesh varies from the basic 10 wire, 11 Gauge (wire diameter = 0.1205 in. / 3.1 mm) structure all the way to the 1/2 in. x 1/2 in. cage grid that is sometimes recommended for fiberglass felt bags. Because of wear observed at the horizontal support rings, the trend has been to reduce them and increase the number of vertical wires (20 wire cages are now common) to reduce the size of the openings.

Wire surface should be burr less and smooth to prevent puncture of bags during installation and operation. It is recommended to avoid cages that have wires welded on the outside of collars or pans (top or bottom end of the cage).

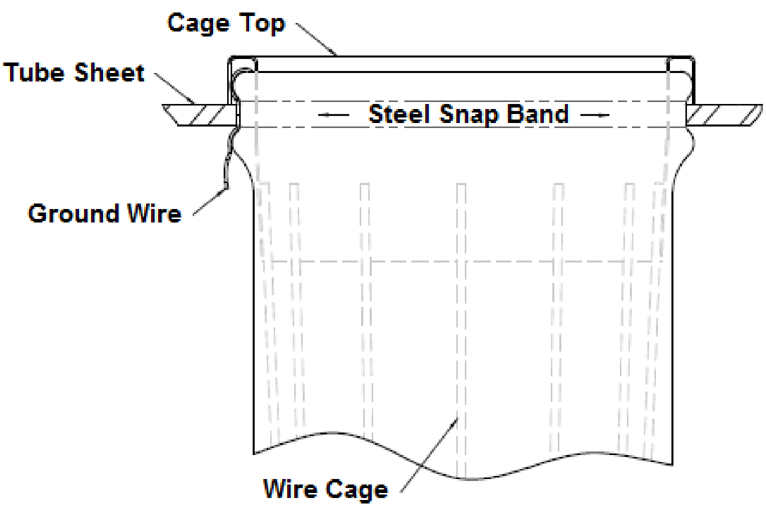
As corrosion of the cage can create sharp edges and lead to excessive or premature wear of the filter bags, corrosion resistant material should be used for corrosive application.

As protective coatings on cages can extend the life of the cage and the bag, coatings such as vinyl, epoxy, zinc, and Teflon® may be used for coating.

Bag and Cage Installation

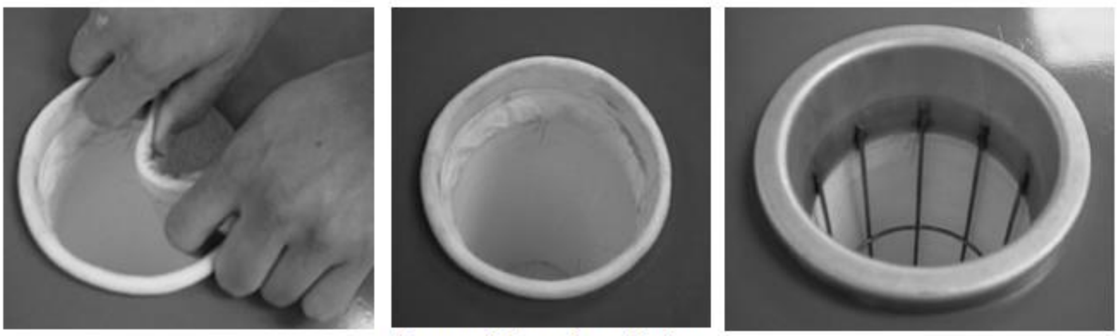
Bag and cage suspension from the tube sheet must make a leak-free seal to insure clean-side / dirty-side isolation.

Snap Band Type Bag



Top Access Bag and Cage Installation

In top access type filter bags, as shown in above figure, generally a steel band is sewn into its cuff to create a tight “pop-in” fit. The steel band snaps out into a round position when inserted into the tube sheet. This allows for quick and easy installation and replacement of the filter bags.



Bag and Cage Installation

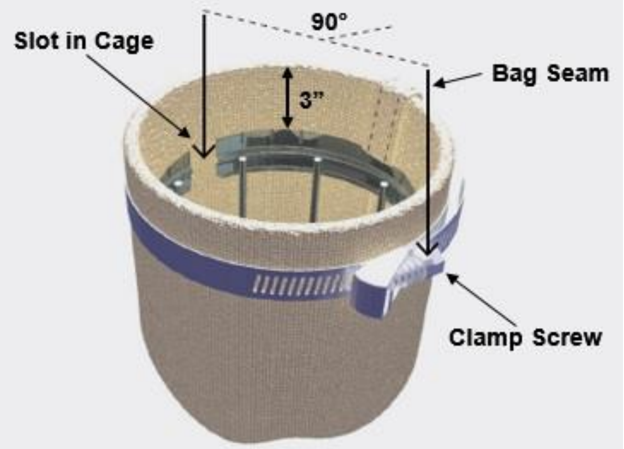
It is recommended to position all the bag seams facing in the same direction. This provides a reference point that helps to identify problems that result from inlet abrasion.

For bag and cage installation in top access type filter bags, as shown in above figure, lower the bottom of the bag through the hole in the tube sheet. Next, fold the snap band (bag top) into a kidney shape to insert it into the tube sheet hole. Positioning the seam first, fit the groove of the snap band to the edge of the tube sheet and allow the band to snap into place. You should hear a sharp popping noise when the band is properly seated around the circumference of the tube sheet hole. Check the fit of the snap band. It should fit securely all around with no wrinkles in the snap band. To complete installation, slide the cage into the bag until it rests on the tube sheet. Be careful when installing the filter bag. Do not let your fingers fall between the snap band and the tube sheet hole when snapping the bag.

If the bags are equipped with a grounding strip, fold the wire over the top of the bag and down its side prior to fitting in the tube sheet. The wire should be between the bag cuff and the tube sheet.

Variety of Clamps

In bottom access type filter bags, generally bag and cage are installed using a clamp. As shown in above figure, variety of clamp designs (Quick Release, Worm Gear, Tool-Less, etc.) are available to make filter installation simple.

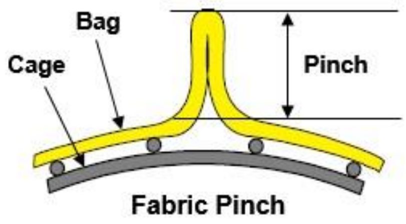


Bottom Access Bag and Cage Installation

As shown in above figure, for installation of bottom access bag and cage, proceed as under.

1. Before entering into the filter housing, slide cage into the bag. Keep the bag seam at 90° from the slot/split in cage collar (or as per OEM’s recommendation).
2. Fold top 3" of bag and ground strip (if supplied) into cage.

3. Slide clamp band over bag and cage, position the clamp screw 180° from the slot/split in cage collar and align it above the cage collar ridge.
4. Enter into the filter housing with bag, cage, and clamp band assembly. Slide the cage collar over the bag cup until locking ridges are engaged. Tighten clamp band until bag and cage assembly cannot be turned by hand.



As shown in above figure, "Pinch" is calculated by subtracting the actual cage circumference from the bag circumference, then dividing the result by 2.

Check the bag fit on cages with a pinch test. You should be able to pinch the fabric at any position as recommended (approximately 12 mm or ½”). Bags that are too tight will not allow the bag to “pop”, knocking the dust cake loose when cleaned. Replace the bags if they are too tight. If it is too loose, the bag over flexes and leads to its failure due to flex fatigue.

Troubleshooting

Diaphragm/Solenoid Valve Problems

If a valve does not open, the problem most likely will be electrical. The solenoid’s coil might have burnt out. It could also be due to faulty power source, not providing enough power or none at all. Timer board is equipped with a blow fuse to protect it from power surges. If a timer board does not function, replace the fuse if blown. Replace the timer board if there in no problem with the fuse. There could also be too much pressure / resistance in the system for the coil to counteract. You can test this by disconnecting the valve from any pressure and then operating it. The coil should warm up slightly and you should hear a clicking sound on activation.

A valve may not close if its spring has broken or has lost elasticity.

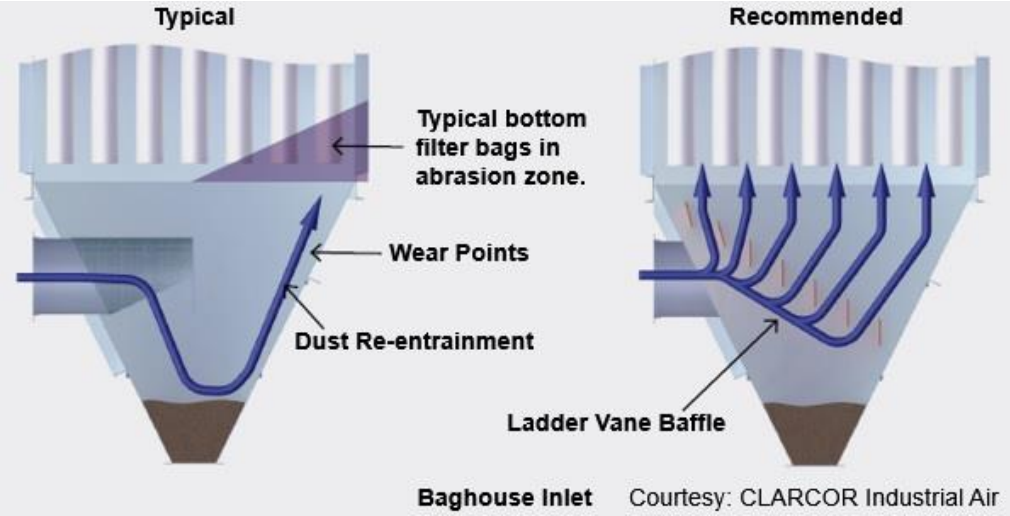
Possible causes for common problems that may be encountered with a pulse jet filter and their solutions are given in the following table.

Troubleshooting - Pulse Jet Filters	
Problems	**Possible Causes with Solutions**
High differential pressure across the tube sheet	Bad gauge or lines: The gauge used to measure the differential pressure between the clean gas side and the dirty gas side of the baghouse may be faulty or the pressure sensing lines may be cracked or clogged.
	Low header pressure: For effective cleaning of the filter bags, the compressed air pressure should as per design/specification [usually between 6 to 8 kg/cm2 (90 to 120 psi)]. Check the diaphragm and solenoid valves for correct operation. A ruptured diaphragm valve or a stuck solenoid valve will drain a compressed air. A cracked or broken line from the solenoid valve to the diaphragm valve will have the same effect. (To overcome problem due to low header pressure, as a result of design/system problem, diaphragm valves, blow pipes and orifices may be made larger).
	Timer board malfunction: Most timers in use today are solid state. They either work or they do not. Timers are equipped with a blow fuse to protect them from power surges. Replace the fuse if blown. Replace the timer board if fuse replacement doesn’t correct the problem.
	Timer board adjustments: Pulse frequency may be adjusted to optimize cleaning efficiency and compressed air use.
	Media blinding: Excessive moisture is the most common cause of blinding. High humidity, condensation and leaks in the duct are typical sources. It may be necessary to preheat and insulate the filter to avoid dew point issues.
	Bag fit on cages: Check the bag fit on cages with a pinch test. Replace the bags if they are too tight because tight bags will not clean properly.
	Overloaded due to excessive flow rate.
Low differential pressure across the tube sheet	Holes in bags: Replace the bad bags.
	Bag and cage installation: Look for dust in the clean air plenum or exhaust air. Bags may be missing or may not be properly installed in the tube sheet.
Dust in exhaust air	Startup period: Allow the filter to run for 48 to 96 hours to establish a dust cake. Some applications will require “seeding” the bags with an appropriate material to establish a cake.
	Holes in bags, bag torn or bag missing: Smoldering or burning ash particles burn holes in filter bags.
	Check bag and cage installation
Overloading of main fan motor	Bags blinded or cleaning mechanism not operating.
Poor bag life	Damaged cages: Filter cages that are bent, have broken wires, or have corrosion will cause premature failure of the filter bags. Inspect and replace as soon as possible. Corrosion problems may require coated or stainless steel cages.
	High air volumes: High air to cloth ratios can shorten filter bag life. Compare current operating conditions to the original design.
	Media blinding: Excessive moisture is the most common cause of blinding.
	Incorrect filter media: High temperatures, chemical content, and dust composition will affect filter media life. Select suitable media.

Fabric Filters Design Considerations

Information about design considerations/parameters for fabric filters is given in this chapter.

Baghouse Inlet Design



Many baghouses use a standard design with off-the-shelf components, often with the inlet duct collar located in the hopper. Some designs also incorporate a baffle over the inlet duct opening to direct incoming air downward into the hopper.

This airflow into the bottom of the hopper can cause collected material to swirl upward and be recirculated into the filter area, producing higher grain loading to the filter bags. If there is no baffle and the incoming material is directed straight across a narrow hopper, it can create excessive abrasion on the sidewall opposite the inlet. Poorly designed baffles can also cause abrasion holes in the filter bags.

To reduce the inlet velocity, it is recommended to enlarge the inlet duct prior to the hopper. As shown in above figure, installing ladder vane baffling will even out the velocity across the entire hopper.

Sizing Parameters for Fabric Filters

It is usual, in the case of pneumatic conveying systems, to specify the size of filter required on the basis of an assumed value of the so-called '**air to cloth/fabric ratio**', which is defined as the ratio of the volumetric air flow rate (at maximum operating condition) divided by the effective area of the filter fabric. It should be noted that this parameter is not, in fact, a ratio but has the dimensions of velocity. It is perhaps best regarded as a superficial velocity of the air through the filter fabric and is called **filtration velocity**.

Air to cloth ratios describe how much dirty gas passes through a given surface area of filter in a given time. A high air to cloth ratio means a large volume of air passes through the fabric area. A low air to cloth ratio means a small volume of air passes through the fabric. When using the air to cloth ratios for comparison purposes the units are $(ft^3/min)/ft^2$ or $(cm^3/sec)/cm^2$. Likewise, when using filtration velocities, the units are ft/min or cm/sec.

The appropriate air to cloth ratio for a given application depends on the particle size distribution, fabric characteristics, particulate matter loadings, and gas stream conditions.

Typical values of air to cloth ratio for felted fabrics are in the region of about 2.5 cm/sec for fine particulate materials and up to about 5.0 cm/sec when handling coarser or granular materials. For woven fabrics, however, these figures should be halved, since the free area actually available for gas flow is much less.

Reverse air cleaning baghouses generally have very low air to cloth ratios. For reverse air baghouses, the filtering velocity (filtration velocity) range is usually between 1 and 4 ft/min (0.51 and 2.04 cm/sec).

For mechanical shaker baghouses, the filtering velocity ranges between 2 and 6 ft/min (1.02 and 3.05 cm/sec). More cloth is generally needed for a given flow rate in a reverse air baghouse than in a mechanical shaker baghouse. Hence, reverse air baghouses tend to be larger in size.

Occasionally, baghouse cleaning is accomplished by two methods in combination. Many baghouses have been designed with both reverse air and gentle shaking to remove the dust cake from the bag. This cleaning is called shake and deflate.

Pulse jet baghouses are designed with filtering velocities between 2 and 15 ft/min (1 to 7.5 cm/sec), with many velocities falling in the 2.0 to 2.5 ft/min range. Therefore, these units typically use felted fabrics as bag material. Felted material holds up very well under the high filtering rate and vigorous pulse jet cleaning. Due to their typically higher air to cloth ratios, pulse jet baghouses are generally smaller in size than reverse air and mechanical shaker baghouses.

Air to cloth ratios for the various cleaning methods are given in the following table.

Typical Air to Cloth Ratio (Filtration Velocity) Comparisons for Three Cleaning Mechanisms

Cleaning Mechanisms	**Air to Cloth Ratio**		**Filtration Velocity**	
	$(cm^3/sec)/cm^2$	$(ft^3/min)/ft^2$	cm/sec	ft/min
Mechanical Shaking	1 to 3:1	2 to 6:1	1 to 3:1	2 to 6:1
Reverse Air	0.5 to 2:1	1 to 4:1	0.5 to 2:1	1 to 4:1
Pulse Jet	1 to 7.5:1	2 to 15:1	1 to 7.5:1	2 to 15:1

Note: Above values may vary for specific applications.

The air to cloth ratio (filtering velocity) is a very important factor used in the design and operation of a baghouse. Improper ratios can contribute to inefficient operation of the baghouse. Operating at an air to cloth ratio that is too high may lead to a number of problems. Very high ratios can cause compaction of dust on the bag resulting in excessive pressure drops. In addition, breakdown of the dust cake could also occur, which in turn results in reduced collection efficiency. At high ratios, some particles, especially small particles, can gradually migrate through the dust layer and fabric. This is possible because dust particles within the cake are retained relatively weakly. After passing through the dust cake and fabric, these particles are re-entrained in the clean gas stream leaving the bag. The major problem of a baghouse using a very low air to cloth ratio is that the baghouse will be larger in size, and therefore have a higher capital cost.

From a maintenance point of view, it is desirable to size a filter to have as low a value of velocity as is economically possible. The particles are then not forced into the fabric, eventually to be permanently trapped in the fabric pores, but to stay near the outer surface for easy removal by the cleaning action. The permanent trapping of particles builds up the residual pressure drop of the fabric. If the pressure drop continually increases, despite more intensive cleaning, the fabric is said to be blinded.

Generally used air to cloth ratio values $(ft^3/min)/ft^2$ for pulse jet and reverse air fabric filters in a variety of industries are given in the following table.

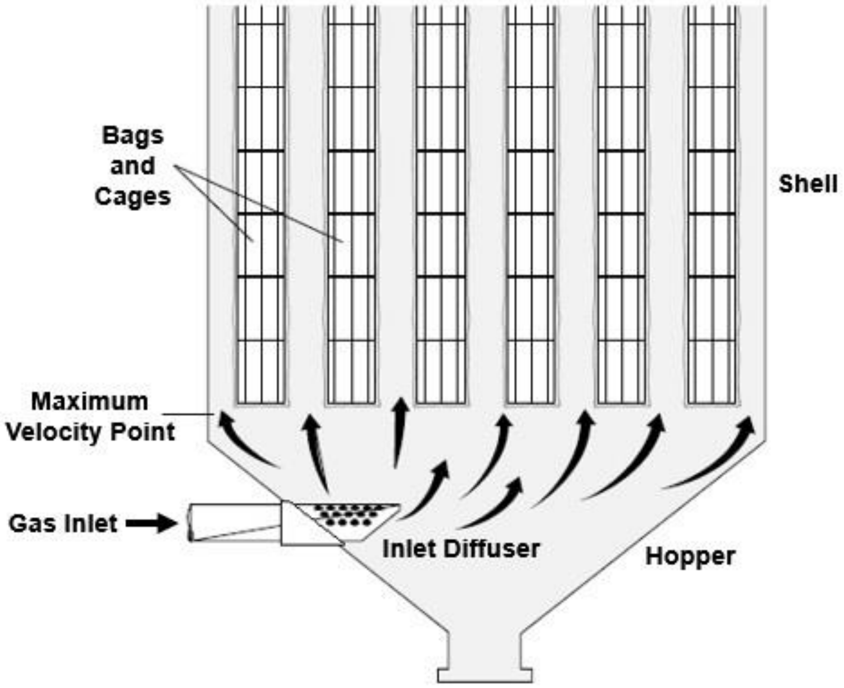
Industry	**Reverse Air** (Usually woven fabrics)	**Pulse Jet** (Usually felted fabrics)
Basic Oxygen Furnaces	1.5 - 2.0	6 - 8
Brick Manufacturers	1.5 - 2.0	9 - 10
Coal Fired Boilers	1.0 - 1.5	3 - 5
Electric Arcs	1.5 - 2.0	6 - 8
Feed Mills	-	10 - 15
Grey Iron Foundries	1.5 - 2.0	7 - 8
Lime Kilns	1.5 - 2.0	8 - 9
Municipal Incinerators	1.0 - 2.0	2.5 - 4.0
Phosphate Fertilizer	1.8 - 2.0	8 - 9
Portland Cement	1.2 - 1.5	7 - 10

The other sizing parameters which should be considered during design are:

- Gas approach velocity
- Bag spacing and length
- Bag "reach" and accessibility

Gas Approach Velocity (CAN Velocity)

Gravity settling of dust cake agglomerates, sheets, and particles released during bag cleaning is a critical step in the fabric filtration process. If fine particles with inherently poor terminal settling velocities return to the bag dust cake surface, there can be adverse effects on both collection efficiency and static pressure drop.



Gas Approach Velocity for Pulse Jet Baghouse

In both pulse jet and reverse air fabric filters, there is a point of maximum inlet gas velocity. In pulse jet units, the point of maximum velocity is the area around the bottoms of the bags. As shown in above figure, all the particulate laden gas to be filtered by the bags must pass through this area in order to reach the bag surfaces. For units that use on-line cleaning (compartment remains in filtering mode while row by row cleaning is in progress), the dust released during cleaning must fall through this area as it settles by gravity. If the upward velocity of the inlet gas stream exceeds the downward terminal settling velocity, the particles will be caught and return to the bag-dust cake surface.

Gravity settling problems can also occur in reverse air fabric filters when there are inadequate reverse air flow rates and when the dampers do not seal properly. In these cases, small particles are not aided by the downward movement of the reverse air, and their settling may even be opposed by modest inlet gas flow into the bags during the cleaning cycle.

In view of above, it is important that the large dust agglomerates or sheets be released, not just small agglomerates or individual particles.

Caution

"Taller bags might seem like a good idea up front to meet specified air to cloth ratio, but it can create serious cleaning and reliability issues if maximum inlet gas velocity is too high.

Bag Spacing and Length

In pulse jet baghouses, the bag arrangement in the baghouse and the length of the bag affects gravity settling problems and causes bag abrasion.

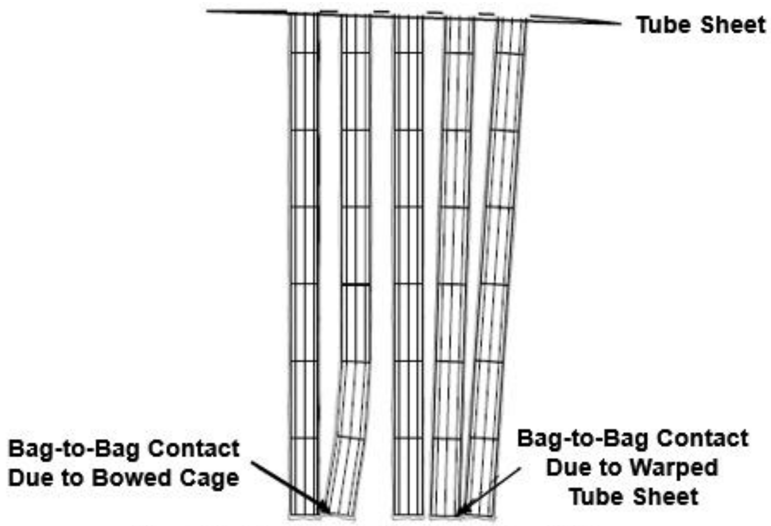
The approach velocity is directly proportional to the height of the bag. An increase in the bag height would increase the approach velocity if the air to cloth ratio remained constant. Furthermore, particles and small dust cake agglomerates would have a longer distance to travel with the taller bag. Both factors increase the susceptibility to gravity settling related emission and pressure drop problems.

Approach velocities are also a function of bag spacing. Units that crowd the bags close together have high approach velocities because there is very little area between the bags for the inlet gas stream to pass through.

Gravity settling and bag cleaning in general would be significantly more difficult at high velocities. It is usually preferable to space the bags far apart to minimize this potential problem. However, there are practical limits to the bag spacing because wide spacing increases the size of the baghouse shell and the area needed for the baghouse.

Pulse jet bag height and spacing are also important for reasons that are entirely separate from the gas approach velocity. Bag-to-bag abrasion can occur at the bottoms of the bags because they hang freely from the tube sheet. Slight bows in the pulse jet bag support cages or slight warpage of the supporting tube sheet can cause bag-to-bag contact at the bottom, as shown in the following figure. Abrasion damage can occur due to the slight movement of the fabric and cage during each pulse cycle. Holes can develop within several weeks to several months of routine operation, depending on the abrasion sensitivity of the fabric being used.

A variety of other practical problems limit bag height. Very tall bags are often difficult to install in a pulse jet baghouse when there is limited overhead clearance to remove the failed bag mounted on the rigid cage. In some cases, failed bags partially fill with solids and, in the case of tall bags, the weight can be substantial. For all these reasons, relatively short bags of 8 to14 ft are preferable to tall bags.

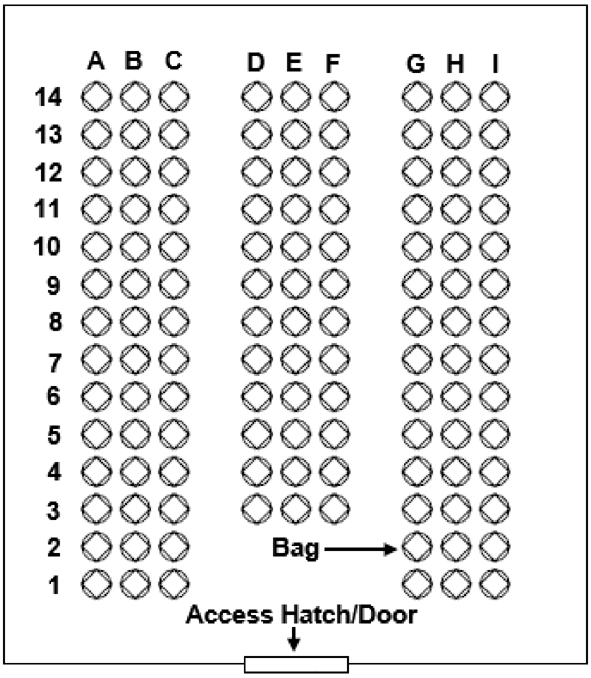


Possible Problems with Tall Pulse Jet Bags

Bag height and spacing are also important for reverse air fabric filters. However, the problems with height are less severe because reverse air bags are fixed at both the top and the bottom. Tall reverse air bags are vulnerable to bag tension problems caused by the weight of dust on the bag. This can lead to bag sagging if the support springs become overloaded. Once this happens, bag abrasion can be rapid because the folds of sagging fabric are usually in the direct path of the bag inlet gas stream.

Bag "Reach" and Accessibility

Access for bag inspection and replacement is important. In the case of reverse air baghouses, sufficient space should be allowed so that each bag can be checked visually and either capped off (bag opening sealed) or replaced if necessary. One measure of the accessibility provided for the maintenance staff is termed the bag reach. This is simply the maximum number of rows of bags from the nearest access walkway.



Layout of Reverse Air Bags

For example, the plan view (top view) drawing of a single baghouse compartment shown in above figure has a reach of three. Each row of bags in the center of the compartment is no more than three rows deep from the nearest walkway. Accordingly, it is possible for plant maintenance staff to find and correct bag problems. Units with less accessible bags are difficult to service. Furthermore, it is possible to damage bags in the outer rows while attempting to work on bags in rows far from the access walkways.

There is no single value for bag reach that is considered appropriate for reverse air baghouses. However, units with a minimum reach are easier to maintain (typical units have a value of 3 or 4).

Comparison of Cleaning Parameters

Comparison of the cleaning parameters for various cleaning methods is given in the following table.

Parameter	Mechanical Shaker Cleaning	Reverse Air Cleaning	Pulse Jet Cleaning (Traditional Type)
Frequency	Usually several cycles/second; adjustable	Cleaned one compartment at a time, sequencing one compartment after another; can be continuous or initiated by a maximum pressure drop switch	Usually, a row of bags at a time, sequenced one row after another; can sequence such that no adjacent rows clean one after another; initiation of cleaning can be triggered by maximum pressure drop switch or may be continuous
Motion	Simple harmonic or sinusoidal	Gentle collapse of bag (concave inward) upon deflation: slowly repressurize a compartment after completion of a backflush	Shock wave passes down bag; bag distends from cage momentarily
Peak acceleration	4 to 8 g	1 to 2 g	30 to 60 g
Amplitude	Fraction of an inch to few inches	NA	NA
Mode	Off-stream	Off-stream	On-stream: in difficult to clean applications such as coal fired boilers, off-stream compartment cleaning being studied
Duration	10 to 100 cycles, 30 sec to few minutes	1 to 2min. including valve opening and closing and dust settling periods: reverse-air flow itself normally 10-30 sec	Compressed air (40 to 100 psi) pulse duration 0.1 sec: bag row effectively off-line
Common bag dimensions	5, 8, 12 in. diameter; 8 to 10, 22, 30 ft length	8, 12 in. diameter; 22, 30, 40 ft length	5 to 6 in. diameter; 8 to 20 ft length
Bag tension	NA	50 to 120 lbs typical, optimum varies; adjusted after on-stream	NA

Baghouse Selection Trend

Significant research has been done with shaker baghouses and the woven fabrics used in them, and many shaker baghouses remain in service. However, the majority of newly erected baghouses are pulse jet type. Where baghouses larger than typical pulse jets are required, they are often custom built, reverse air units. The pulse jet baghouses have become industry standard (popular) at the present time because they occupy less space than the equivalent shaker baghouse and are perceived as being less expensive.

Filter Bags and Accessories Supplier

Rathi's (www.rathigroups.com), A-7, Industrial Estate, Mogappair west, Chennai - 600 058, India are one of the leading filter bags and accessories supplier.

Safety

In general, follow manufacturer's recommendation on safety.

After shutdown of the unit, the fly ash can take a long time to cool down. Therefore, even days after shutdown, the ash can burn personnel coming into contact with it. It may even lead to fatal accident if care is not taken. Hence while dealing with a fly ash hopper, always follow the guidelines given below.

If it is necessary to rod a hopper, either through a hand hole in the ash intake or through a poke hole in the hopper, to clear a plug, the operator must use protection for the body, hands, feet and face against any possible outflow of ash.

Never open a hopper filled with ash except in an emergency.

Never use a ladder for gaining access to a hopper that must be opened.

Never place yourself, or any other person, in the path of an ash flow. If a hopper must be opened, the person opening it must be safely away from the path of any possible ash flow.

Hot/Flammable Dust

- **Latch Safety Chain**
- **Open Door Slowly**
- **Knock Overhead Dust**

Warning for Opening Hopper Door

As shown in above figure, before opening a hopper door, latch safety chain and open the door slowly. Knock overhead dust before entering in the hopper.

No one should enter a hopper for inspection unless the hopper is cool and ventilated. Another person, who is prepared and equipped to help in case of an emergency must be stationed outside the hopper.

Maintenance of Bag Houses

Useful information for maintenance / care of bag houses is given in this chapter.

Leak Detection Powder

Identifying filter bag damage and bad seals at the tube sheet by manual inspection is a time consuming process. In addition, structural air leaks in the baghouse, such as from weld cracks or improperly fitted metal enclosure covers, can't be detected unless they're clearly visible. A more accurate way to test for such leaks is to use a leak detection powder, also called a tracer powder.

A leak detection powder is an inexpensive, lightweight fluorescent powder. It is injected into the baghouse. The powder will take the path of least resistance and move with the air through any leaks, accumulating around the openings. A monochromatic light is then used to make the powder fluoresce (glow brightly), which pinpoints a leak's location and severity.

Visolite Glow Reveals Air Leaks

Above figure shows use of Visolite, a leak detection powder supplied by GE Energy to pinpoint the exact location of air leakage and its severity.

It has become accepted practice in reverse air and shaker baghouses to simply tie off a torn/damaged bag and stuff it into the tube sheet (cell plate). If the failure is close to the tube sheet, then the hole should be plugged. This can be accomplished by steel plate plugs with gaskets or sand bags to seal off the hole. In pulse jet baghouses with top access, a plug is placed over the tube sheet hole of the failed bag. Thus a damaged bag can be effectively removed from the system, allowing baghouse operation to continue at high efficiency although incrementally higher pressure drop. It is recommended to design a baghouse such that its performance does not get affected with 10% of the bags plugged.

In the past, bags were usually replaced as they failed. However, it has been found that a new bag in the vicinity of old ones will be forced to take on more dust (air will tend to follow the path of least resistance) and will become worn out quicker than the old "seasoned" bags.

Vacuum Transfer System for Maintenance

The Vacutrans® shown in the following figure by General Electric Company is a vacuum transfer system powered by compressed air to transfer bulk materials and liquids. It can convey powders, plastic pellets, grain, abrasives and numerous other bulk materials. In bag house maintenance, it can be used to inject leak detection (tracer) powder, seeding material and cleaning.

High Temperature Precautions

Moisture is one of the most predominant causes for fabric filter failures. Care must be taken in applications involving high humidity gas streams. Dryers and other combustion processes pose the greatest danger for condensation in the filter. The filters and gas stream temperatures must be maintained at 50°F above the dew point (the temperature at which water vapor in a gas will condense into a liquid state) of the gas stream. Excursions near or below the dew point of the gas stream will result in condensation on the baghouse and filter media. This moisture will change the desired dust cake into an undesirable mud cake, which is difficult to remove and may permanently damage the filter media. Corrosion is also intensified under these conditions. In view of above, filters operating under high humidity conditions at any temperature should be protected from gas condensation. This will require heating the filter to 50°F above the gas stream temperature and insulating the filter, ducting and hopper.

Thermal insulation and hopper heaters keep solids hot prior to discharge. Hot air keeps the solids in a free-flowing condition. Outer lagging over the insulation keeps the insulation dry and prevents air from passing upward along the outside wall due to a chimney effect (warm air rises; cold air replaces it). In view of this, to prevent cooling of hoppers resulting in clinker formation and choking, care should be taken to prevent damage to outer lagging.

Bags Washing

The bags normally operate with a thin coating or cake of dust, but a large quantity of moisture present in the unit may cause this dust cake to become excessively thick or hard. If this occurs, the automatic cleaning mechanism will not be able to clean the bags down to the normal operating range (2 1/2" to 6" WG). The differential pressure across the bags will slowly and steadily increase, possibly resulting in a complete system failure due to the overloading of the motor on the main exhaust fan.

If there is excessively thick or hard coating on the bags, they should be removed, properly cleaned and re-installed. The filter bags are made of a variety of materials; however, synthetics are more commonly used now which allows them to be laundered. Caution is advised that the laundry selected is familiar with this type of material and can effectively clean and dry without excessive shrinking. After re-installing the bags and re-starting the system, the pressure drop reading on the differential pressure gage (Magnehelic® gauge) should be checked. The pressure reading should be quite low, perhaps 1" to 2" WG. If the differential pressure reading is still too high (8" or above), then the entire set of bags should be replaced since they have most likely become blinded (non-porous) due to a complete saturation of all the interstices within the weave of the cloth with dust and particulates.

Useful Terms

Agglomeration

Multiple particles joining or clustering together by surface tension to form larger particles, usually held by moisture, static charge or particle architecture.

Air Pollution

The presence of any substance in lower levels of the atmosphere, other than moisture, in concentrations high enough to adversely affect the health of any living organism. Air pollutants include suspended dusts, aerosols, fumes, or any gaseous compounds (usually sulfur, nitrogen, or carbon) that result from a manufacturing process.

Air to Cloth/Fabric Ratio

It is the volumetric air/gas flow rate entering the baghouse divided by the total effective area of the filter bags. It is **often referred to as filter/filtration velocity**. It is the velocity at which air passes through the filter media, or rather the velocity that air approaches the media.

Blinding (or Plugging)

The loading, or accumulation, of a dust cake on a filter bag to the degree that the dust cake cannot be dislodged by the cleaning mechanism of the filter. The efficiency of a baghouse with blinded bags is significantly diminished due to a sharp increase in the static pressure drop of the air passing through the bags.

Blowpipe (or Manifold)

In compressed air baghouses, a pipe in the plenum section that runs horizontally several inches over the tube sheet with a hole/orifice over each bag; responsible for distributing the compressed air pulses to each bag.

Carrying Velocity (or Transport Velocity)

The gas/air velocity in a duct required to keep the transported material suspended, usually between 3500 and 4000 feet per minute (1067 and 1219 meters per minute), varying according to the type of material being conveyed. Ducts with a velocity lower than 3500 fpm (1067 m/min.) could allow material to settle out and cause buildup in the duct. Ducts with velocities higher than 4000 fpm (1219 m/min.) can lead to abrasion of the ductwork.

Compartment

A segmented filtering section of a baghouse that can be isolated from the others.

Condensation

The process of changing matter from a vapor state into a liquid state, usually by the extraction of heat.

Dehumidify

To reduce by any process, the quantity of water vapor.

Diaphragm Valve

A pneumatically operated valve (with a diaphragm) that allows a pulse of compressed air to travel from the header to the blowpipes in a compressed air baghouse.

Dust

Small solid particles having a width between 1 micron and 100 microns, created by breaking up of larger particles (through processes such as grinding, drilling, explosion, crushing, etc.).

Dust Loading

The weight of solid particulates suspended in an air or gas stream, usually expressed in terms of grains per cubic foot, grams per cubic meter, pounds per thousand pounds of gas, or parts per million.

Emission Standard

The maximum legal concentration or rate at which air pollutants may be discharged from a single source; may include mandatory guidelines concerning types of emission control equipment that must be used.

Filter (or Air Filter)

Any device, manual or automatic, whose function is the separation of air pollutants (such as dusts, suspended particulates, aerosols, fumes, or smoke) from an airstream; sometimes used to refer to only the filtering element, such as a bag.

Filter Cake

The thin layer of dust that builds on the surface of a bag or filter medium during the filtration process.

Grain

Small unit of mass, used frequently in describing air pollutant concentrations, equal to 1/7000 pound (approximately 64.8 milligrams).

Inch of Water

A unit of pressure (often abbreviated "wg") equal to the pressure exerted by a column of liquid water one-inch-high at a standard temperature (usually 70°F).
For conversions, 1.000 psi = 27.71" wg.

Needled Felt

A felt held together by interlocking adjacent fibers, manufactured by using barbed needles to push and pull loose fibers together. Needled felt is stronger than pressed felt.

Null Period (Settling Time)

A time segment during off line cleaning when the bags are allowed to relax without any cleaning energy supplied. This allows the displaced dust to fall off the bags and settle below the inlet opening.

Opacity

A term to describe the percentage of light that cannot pass through an object; may be used to describe the degree of visibility of an exhaust plume.

Particulate

Any type solid or liquid particle suspended in the air that is usually considered an undesirable air pollutant; includes all types of dusts, fly ash, pollen, smoke and fume particles, and aerosols.

Permeability, Fabric (or Cloth Permeability)

The ability of air to pass through the fabric, given a 0.50" wg pressure differential. Fabric permeability is expressed in units of cfm per square foot of fabric, and measured most often with a Frazier porosity meter or a Gurley permeometer.

Pilot Valve

A normally-closed, two-way solenoid valve which transforms an electrical signal into a pneumatic signal for the purpose of pulling air away from one side of a normally-closed diaphragm valve on the pressurized air supply line for a compressed air (pulse jet) baghouse. This action allows the diaphragm to move away from its seal, allowing compressed air to move unobstructed from the header through the valve and into the blowpipes.

Plume

The path taken by the gas discharge from a smoke stack or chimney.

PM10

The concentration of suspended air particulates that are 10 microns in diameter or smaller; the class of air pollutants that are the most harmful to the respiratory system of humans.

Porosity, Fabric

Percentage of voids per unit volume of fabric, not to be confused with fabric permeability.

PPM (Parts Per Million)

A mass ratio often used to describe small concentration of toxic air pollutants; gives pounds of pollutant per million pounds of air.

Pressure, Gage

Pressure measured relative to atmospheric pressure, may be either positive or negative.

Pulse Cycle

In compressed air baghouses, the interval between the time a pitot valve allows a pulse of compressed air to enter through a diaphragm valve into a blowpipe and the time the next pitot valve in the sequence performs the same operation. Pulse cycles generally range from 5 to 30 seconds but may be much higher.

Pulse Duration

In compressed air baghouses, the interval of time that the electrical signal necessary to open a pitot valve remains active. The duration of this electric signal most often ranges between 50 and 500 milliseconds; but because of a slow response time, the diaphragm valve may remain open for up to four or five times longer.

Reentrainment

The occurrence where dust is collected from the airstream but then returned to the airstream from the same device. This term is used to refer to the situation in baghouses where dust particles on the surface of the filter media are forced back into the air when the bags are cleaned.

Smoke

An air suspension (aerosol) of solid carbon particles, 0.1 microns or smaller in diameter, originating from an incomplete combustion process of carbon-based materials such as coal, oil, tar, and tobacco.

Solenoid Valve

An electromagnetic pilot valve used to activate a diaphragm valve on a pulse jet baghouse.

Tube Sheet (Cell Plate)

Internal divider surface that separates dirty from clean gas plenums and where the bags are seated.

Vapor

The gaseous form of substances which are normally in a liquid or solid phase at standard atmospheric conditions. This change of state is accomplished by either raising the temperature or lowering the pressure.

Venturi

A device shaped like a converging-diverging nozzle inserted through the top of the bag openings in the tube sheet in some compressed air baghouses and used to increase the effectiveness of the compressed air blasts.

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