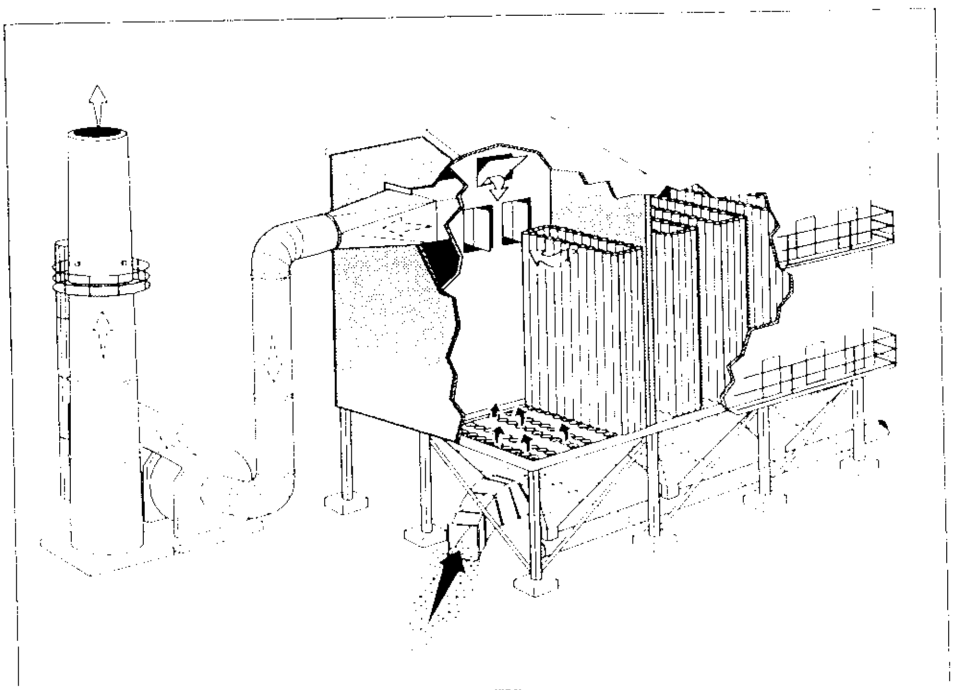
Environmental
Programs

Fabric Filter Operation Review

Self-Instructional Manual

APTI Course SI: 412A

Second Edition



Industrial Extension Service   College of Engineering   North Carolina State University

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Course Description

The course focuses on the operational aspects of fabric filters. You will learn how various fabric filter designs operate and how to evaluate the effectiveness of fabric filter designs in achieving particle collection. Major topics include the following:

- General description of fabric filters
- Bag cleaning methods
- Fabric selection and filter types
- Design parameters affecting collection efficiency
- Operation and maintenance problems associated with fabric filters
- Industrial applications

Objectives

Upon completion of this course, you will be able to do the following:

1. Identify a fabric filter system and briefly describe its operation
2. Briefly describe the collection mechanisms for particle collection by the dust cake and bag in a fabric filter system
3. Name two types of filter construction used for bags in a fabric filter
4. List three ways to remove dust particles from the bag in a fabric filter
5. List seven types of fibers used in making fabric filter material
6. Identify the key design parameters influencing collection efficiency
7. Describe minimum instrumentation and record keeping necessary to properly operate and maintain a fabric filter system
8. Describe typical operation and maintenance problems associated with fabric filters

Audience

This course is intended primarily for air permit reviewers and air quality inspectors employed by state and local agencies. The course also provides useful training for technical personnel in private industry who prepare air permit applications and are responsible for operating fabric filters in compliance with air quality regulations.

Course Length and CEUs

This course will take approximately 28 hours to complete. The number of Continuing Education Units (CEUs) awarded with successful completion of the course is 2.8.

Prerequisites

Prior to taking this course, the student must complete and/or pass the final examination for the following APTI courses:

SI:422 *Air Pollution Control Orientation Course* or SI:452 *Principles and Practices of Air Pollution Control*

You should also be able to use a calculator with various math functions.

Required Materials

- Self Instructional Manual, *Fabric Filter Operation Review*
- Final Examination
- Calculator

Supplemental Materials

- Video titled, *Pulse-Jet and Reverse-Air Fabric Filters: Operating Principles and Components*

Taking the Course

Start this self-instructional course at Lesson 1 and proceed sequentially through the manual until you have completed Lesson 8. The review exercises located at the end of every lesson test your mastery of the objectives covered in that lesson. The review exercises in Lesson 8 will give you the opportunity to test your abilities in solving problems similar to the example problem presented in that lesson. The video, *Pulse-Jet and Reverse-Air Fabric Filters: Operating Principles and Components*, is optional. If you acquire a copy, view it at the end of Lesson 3.

Each lesson contains the following:

Learning goal and objectives

Text material

Review exercises and exercise answers

For each lesson, follow these steps:

1. Do the assigned reading and view the assigned videotape (optional).
2. Complete the review exercise.
3. Check your answers against the key.
4. Review the instruction for any questions that you answered incorrectly.

Completing the Course

A final examination accompanies this book. Take the final exam after you have finished the course. The exam is a closed book exam. Do not use your notes or books.

The final examination counts as 100% of your grade and is provided in a separate envelope. To receive your certificate of completion and 2.8 Continuing Education Units (CEUs), you must score 70 or above on the exam. Follow these procedures:

1. Arrange for someone to be your test supervisor and give him/her the envelope.
2. Complete the final exam under the supervision of your test supervisor according to the test directions.
3. After you have finished the exam, have the test supervisor sign a statement on the answer sheet certifying that you took the exam in accordance with the specified test directions.
4. Have your test supervisor mail the exam and answer sheet to the appropriate registrar below:

Registrar - Private Sector

NCSU Environmental Programs
Box 7513
Raleigh, NC 27695 - 7513
Phone: (919) 515-4659
Fax: (919) 515-4386

or

Registrar - EPA/State Agency

U.S. Environmental Protection Agency
MD-17
Research Triangle Park, NC 27711
Phone: (919) 541-2497
Fax: (919) 541-5598

Your exam and grade results will be mailed to you.

Lesson 1

Fabric Filtration Design and Baghouse Components

Goal

To familiarize you with the operation of fabric filters and their components.

Objectives

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

1. Describe how a fabric filter operates to collect particulate matter
2. Describe three different types of filter structures
3. Briefly describe three major components of a baghouse: housing (or shell), collection hoppers, and discharge devices
4. Briefly describe two filtration designs: interior and exterior

Introduction

Many industries today face the problem that their exhaust gas contains too many particles (particulate matter). Industry can choose among several different types of particulate control devices to reduce emissions including: fabric filters, electrostatic precipitators (ESPs), and scrubbers. This course focuses on the use of fabric filters (also called baghouses) to collect particles. Baghouses are now being used in many industries (steel, cement, pharmaceutical, chemical, metal-working, municipal waste incinerators and coal-fired boilers) because they are efficient collectors of all-sized particles. New regulations (CAAA-1990) place greater emphasis than they have in the past on collecting fine particles, those less than 10 μm in diameter (PM_{10}). Fabric filters are especially suited for the control of fine dusts.

Fabric filters take advantage of the fact that particles are larger than gas molecules. Therefore, when dirty gas is filtered through a membrane, the particles are captured on the filter while the clean gas escapes. Particles, while larger than gas molecules, come in many different sizes, shapes, and textures. Fabric filters are designed to accommodate the unique properties of the exhaust gas and particles being filtered.

Filters can be constructed in different ways and the filter material is selected based on its appropriateness for the given process (e.g. process gas temperature and pH). You will learn several different ways in which collected dust can be removed from filters as well as where dust is stored until it is properly disposed.

The job of the inspector, the permit reviewer, or the preparer of fabric filter installation plans is to determine if, based on the plans and fabric filter design, the device will collect dust as it is supposed to. This course will give you the tools to evaluate fabric filter design and performance.

Particle Behavior

Like any other physical entities, particles behave in fairly predictable ways, governed by the laws of physics. Particles from an industrial source generally float along in the gas stream. If we put something in their path, they would bump into it and under the right circumstances, stay there. That's what a filter is designed to do. But a filter, by definition, has tiny pores to allow the gas molecules to flow through it. These molecules create a continuous stream around the fibers in the filter. Small particles could easily be carried with the gas stream through the pores and into the atmosphere. But larger particles don't have a chance. Because of their greater inertia, they can't make the turn around the fiber. Instead they keep going straight ahead until they impact on the fiber's surface. We call this behavior **impaction** (see Figure 1-1).

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, they end up grazing it on the side or being "intercepted". This works too as a collection mechanism and we call this **direct interception** (see Figure 1-2).

Impaction and direct interception account for almost 99% collection of the particles greater than 1 micrometer (μm) in aerodynamic diameter in fabric filter systems (Bethea 1978). This tells you that fabric filters are pretty good air pollution collection devices for particles of this size.

Fabric filters can also collect very small particles, less than 1 μm in aerodynamic diameter. You would think 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 struck by gas molecules. This individual or random motion causes them to be distributed throughout the fluid (gas) and is known as **Brownian motion** or **Brownian diffusion** (see Figure 1-3). The particles may have a different velocity than the gas stream and at some point could come in contact with the fiber and be collected.

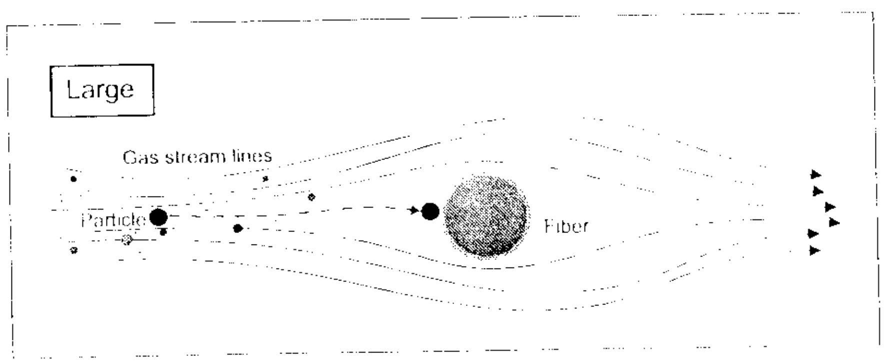

Figure 1-1. Impaction

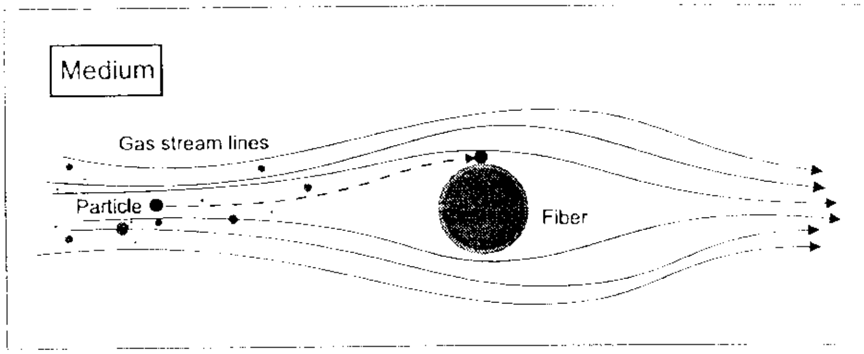

Figure 1-2. Direct interception

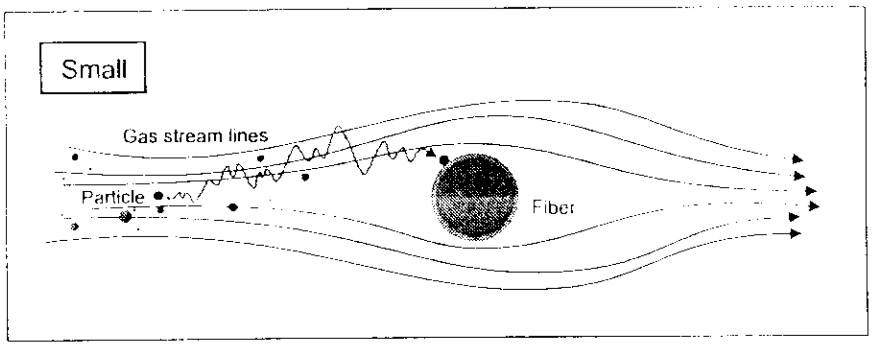

Figure 1-3. Diffusion

Particles can also be collected because of other properties that occur in the gas stream. Relatively large particles may be overcome by the force of gravity and settle in the collection hopper. This force is particularly important when dust-laden gas enters the baghouse through a hopper inlet where the large particles fall out of the gas stream before actually hitting the filters (bags). Particles can agglomerate or grow in size and then be more easily collected by the fibers. These larger particles are easier to filter from the gas stream.

Some particles have a small electrostatic charge and can be attracted to a material of opposite charge. Electrostatic charges could, on the other hand, have the reverse effect if the charges of the particles and fiber are the same. In this case the particles would tend to repel from being collected on the fabric. Electrostatic charges can be particularly useful for the capture of particles in the submicron range. The use of a selected fiber material or a specially coated material may enhance particle capture (Frederick 1974). Different materials will develop electrostatic charges of varying degree and sign.

Fabric Filter Components

Fabric filtration is one of the most common air pollution control techniques used to collect particulate matter. Two basic types of filters are disposable and nondisposable.

Disposable filters are similar to those used in a home heating or air conditioning system. They can be constructed as mats or as depth filters (12 inches or more). **Mat filters** are usually made using fiberglass bats with a thin metal plate on the outside of the filter used for structural reinforcement. **Depth filters** are generally constructed using fiberglass fibers, glass fiber paper or some other inert material such as fine steel fibers to form a deep mesh. The filters are very efficient (99.9%) for the collection of particles less than 1 μm in diameter but must be replaced when they become loaded with particulate matter (when the pressure drop across the filter exceeds design specifications). Depth filters are widely useful for the collection of toxic dust materials.

Nondisposable fabric filters consist of a fabric material (nylon, fiberglass, or other). These filters are commonly used to clean dirty exhaust gas streams from industrial processes. The particles are retained on the fabric material, while the cleaned gas passes through the material.

The collected particles are then removed from the filter by one of the following cleaning mechanisms: (1) shaking, (2) reversing the air flow, or (3) pulses of air. The removed particles are temporarily stored in a collection hopper until they are disposed of or are reused in the process.

Nondisposable fabric filter systems are used on many different industrial processes to control particulate emissions.

A fabric filter consists of the following components (see Figure 1-4):

- Bags, fabric, and support
- Housing or shell
- Collection hoppers
- Discharge devices
- Filter cleaning device (discussed in Lesson 2)
- Fan

Filter Medium and Support

The particle collection surface is composed of the filtering material and a support structure. Most U.S. baghouse designs employ long cylindrical **bags** (or tubes) that contain felted fabric or woven cloth as the filtering medium. Woven filters are made of yarn consisting of fibers constructed into fabric with a definite repeated pattern. Felted filters are composed of randomly placed fibers that are compressed into a mat and attached to a loosely woven backing material called a scrim. Felted filters are normally thicker than woven filters. Lesson 4 presents more detailed information on both types of filters.

The cloth can be supported at the top and bottom of the bag by metal rings or clasps; or by an internal cage that completely supports the entire bag (Figure 1-5).

Dust is collected on either the inside or outside of the fabric material depending on the baghouse design.

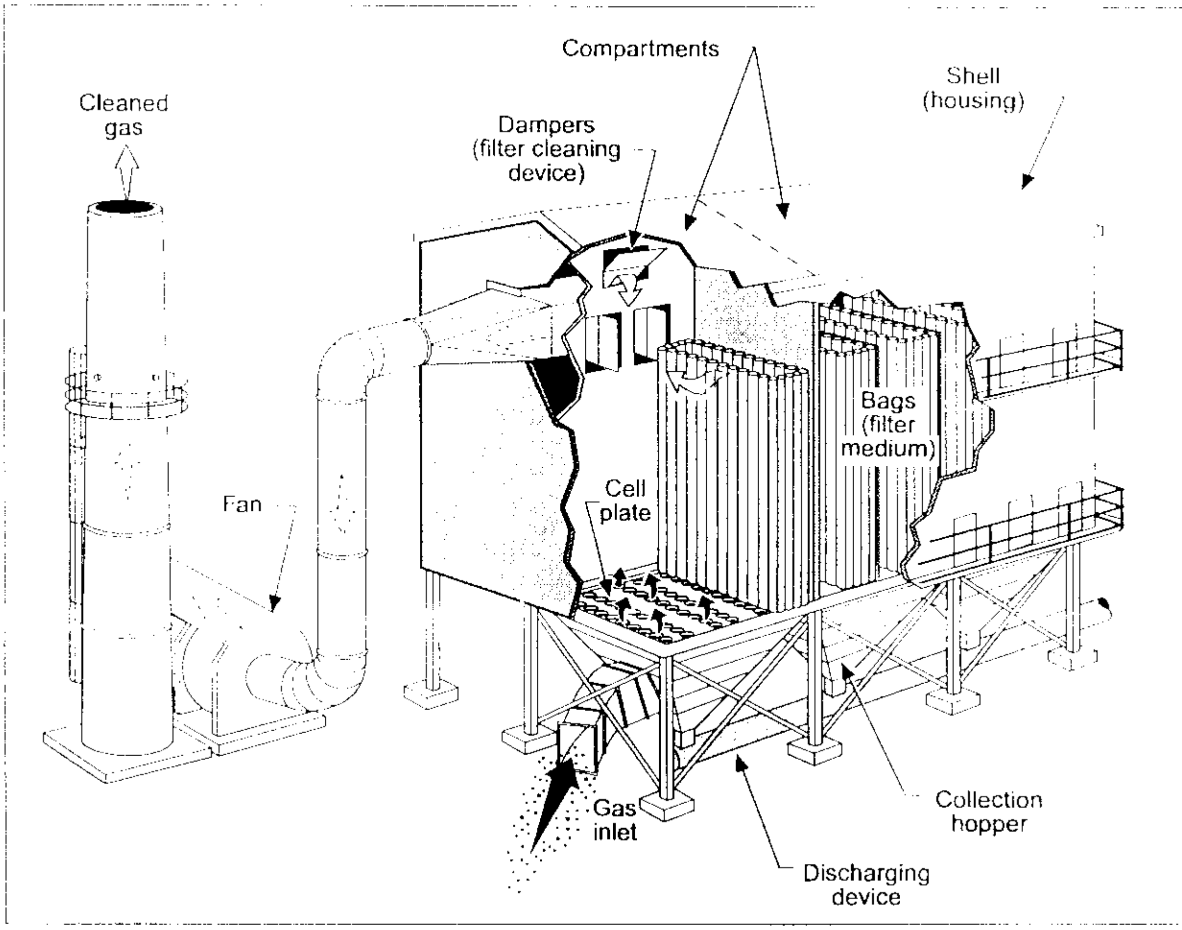

Figure 1-4. Typical fabric filter system (reverse-air cleaning baghouse)

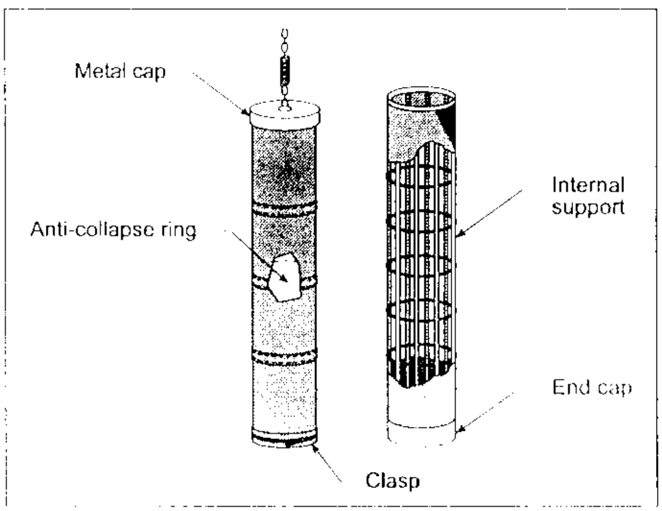

Figure 1-5. Bags and support

Some European and U.S. baghouse designs employ an envelope filter arrangement as shown in Figure 1-6. The **envelope filter** consists of felted or woven fabric supported by a metal retaining cage. The metal cage keeps the fabric taut as the dust filters through and collects on the outside of the material. Clean air passes out the open end of the envelope.

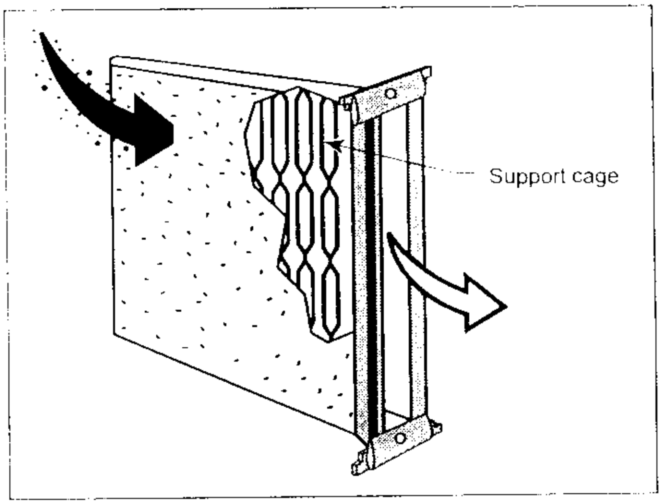

Figure 1-6. Envelope filter

Recently, cartridge filters have been used for filtering particulate matter from small industrial processes. **Cartridge filters** are made using cylindrical pleated filter media (similar to the air cleaning filters used in all automobiles). The cartridges are approximately 2-3 feet long and usually have diameters from 18 to 24 inches (Figure 1-7). Dust is collected on the outside surface of the pleated filter of the cartridge while clean air flows on through the center. The accumulated dust is cleaned periodically from the cartridge filter by using blasts of air into the center of the cartridge (pulse-jet cleaning described in more detail in Lesson 3). A reported benefit of cartridge units is that they can be constructed using double mat filters, which are efficient (90%) at collecting very small particles ($< 0.3\ \mu m$). Standard bag filters typically achieve 10-20% initial collection efficiency of particles in that size range (McKenna and Turner 1989).

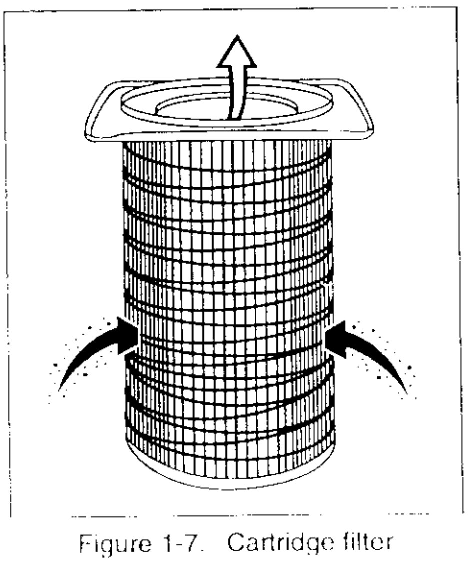

Figure 1-7. Cartridge filter

Housing or Shell

Baghouses are constructed as single or compartmental units. The single unit is generally used on small processes that are not in continuous operation such as grinding and paint spraying processes. Compartmental units consist of more than one compartment and are used in continuous operating processes with large exhaust volumes such as electric melt steel furnaces and industrial boilers. Compartmentalized units can have a compartment off-line for bag cleaning and maintenance while the remaining baghouse compartments continue to filter. In both cases, the bags are housed in a shell made of a rigid metal material. Often it is necessary to include insulation with the shell particularly when treating high temperature flue gas. This is done to prevent moisture or acid mist contained in the flue gas from condensing in the unit, thus causing corrosion and rapid deterioration of the baghouse.

Collection Hoppers

Hoppers are used to store the collected dust temporarily before it is disposed in a landfill or reused in the process. Dust should be removed as soon as possible to avoid packing which would then make removal very difficult if not impossible. Hoppers are usually designed with a 55 to 70° slope to allow dust to flow freely from the top of the hopper to the bottom discharge opening. Some manufacturers add devices to the hopper to promote easy and quick discharge. These devices include strike plates, poke holes, vibrators, and rappers. Strike plates are simply pieces of flat steel which are bolted or welded to the center of the hopper wall. If dust becomes stuck in the hopper, rapping the strike plate several times with a mallet will free this material. Hopper designs also usually include access doors or ports. Access ports and poke holes provide for easier cleaning, inspection, and maintenance of the hopper (Figure 1-8). Vibrators are used sometimes to cause vibrations on the hopper walls to help remove dust from the walls.

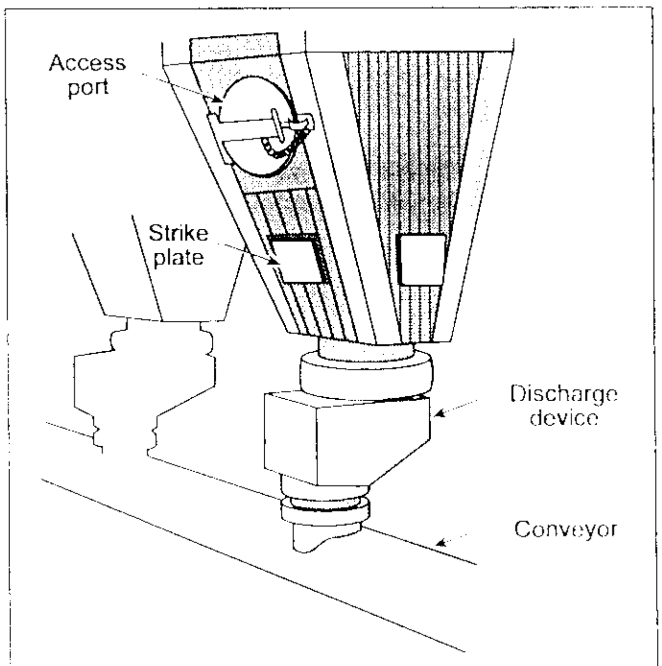

Figure 1-8. Hopper

Discharge Devices

A discharge device is necessary for emptying the hopper. These devices must be properly designed, insulated (in many cases), and operated for the fabric filter system to operate as intended. These design features and common operating problems associated with discharge devices will be discussed in more detail in later lessons.

Discharge devices can be manual or automatic. The simplest manual discharge device is the **slide gate**, a plate held in place by a frame and sealed with gaskets (Figure 1-9). When the hopper needs to be emptied, the plate is removed and the material discharges. Other manual discharge devices include **hinged doors** or **drawers**. The collector must be shut down before opening any manual discharge device. Thus, manual discharge devices are used on baghouses that operate on a periodic basis. However, slide gates are occasionally used along with double dump and rotary valves to isolate the valves when maintenance is done on the valve.

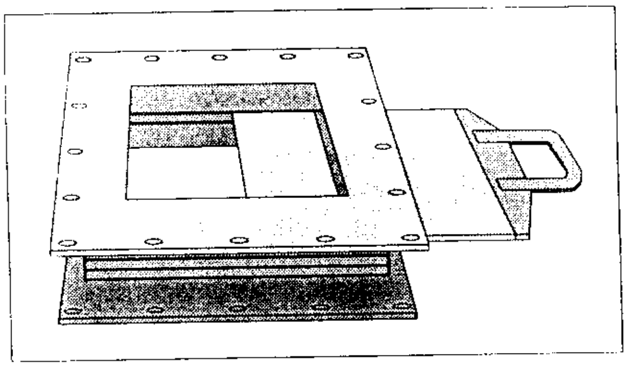

Figure 1-9. Slide gate

Automatic continuous discharge devices are installed on baghouses that are used in continuous operation. Some devices include double dump (also called double flap or trickle valves), rotary airlock valves, or screw conveyors. These devices are located on the bottom of the hopper.

Double-dump discharge devices are shown in Figure 1-10. As dust collects in the hopper, the weight of the dust pushes down on the counterweight of the top flap and dust discharges downward. The top flap then closes, the bottom flap opens, and the material falls out. This type of valve is available in gravity-operated and motorized versions.

Rotary airlock valves are used on medium or large sized baghouses. The valve is designed with a paddle wheel which is shaft-mounted and driven by a motor (Figure 1-11). The rotary valve is similar to a revolving door: the paddles or blades form an airtight seal with the housing; the motor slowly moves the blades to allow the dust to discharge from the hopper.

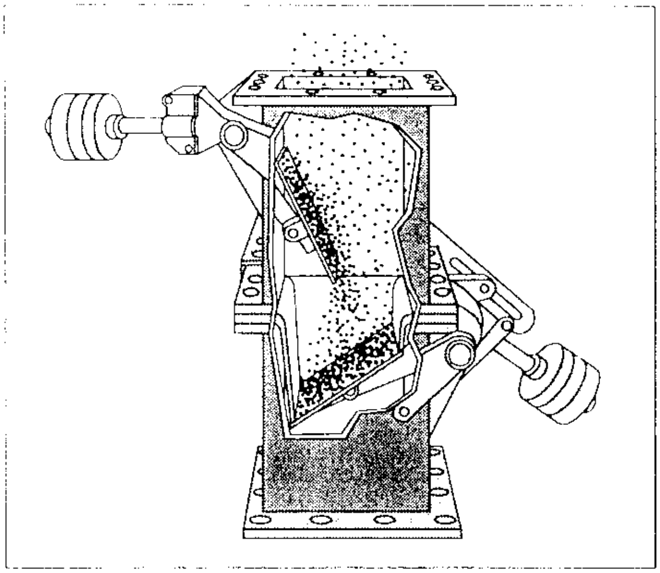

Figure 1-10. Double-dump discharge device

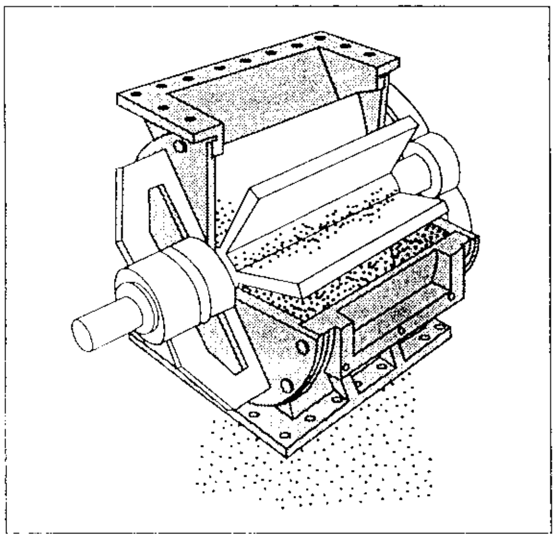

Figure 1-11. Rotary airlock discharge device

Screws located in the bottom of the hopper can also discharge collected dust from the hopper. These devices employ a revolving screw feeder located at the bottom of the hopper to remove the dust from the hopper bin (Figure 1-12).

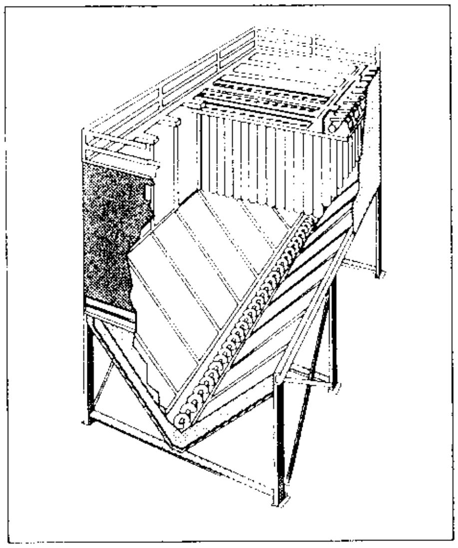

Figure 1-12. Screw conveyor located in hopper
Source: Reproduced by permission of Cedarapids, Inc.

After the dust leaves the discharge device it is transported to the final disposal destination by **screw, drag** or pneumatic conveyors. **Screw conveyors** use a revolving screw feeder similar to the one shown in Figure 1-12. **Drag conveyors** use paddles, or flaps that are connected to a drag chain to pull dust through the conveyor trough (Figure 1-13). Drag conveyors are frequently used for moving sticky dusts or hygroscopic dusts such as calcium chloride dust generated as collected fly ash/acid gas reaction products from municipal waste combustors. **Pneumatic conveyers** use either an air blower or suction to transport dust from the hopper (after it leaves the discharge device) to the disposal site (see Figure 1-14). Pneumatic conveyors can be positive pressure or vacuum-type systems.

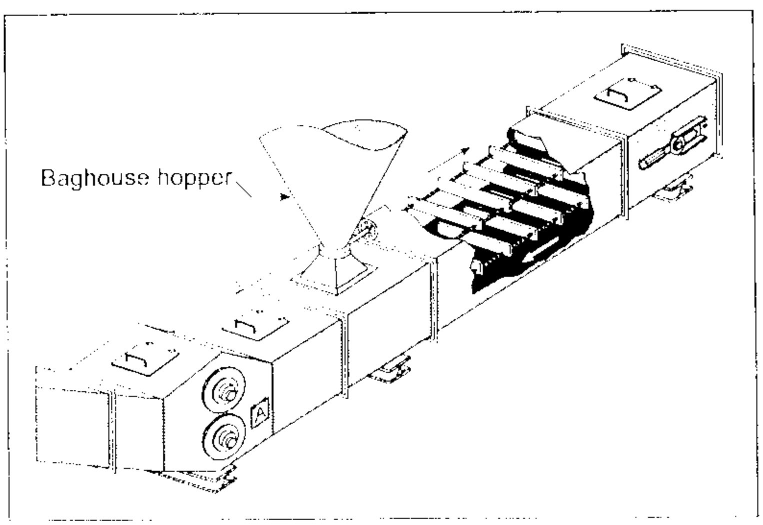

Figure 1-13. Drag conveyor

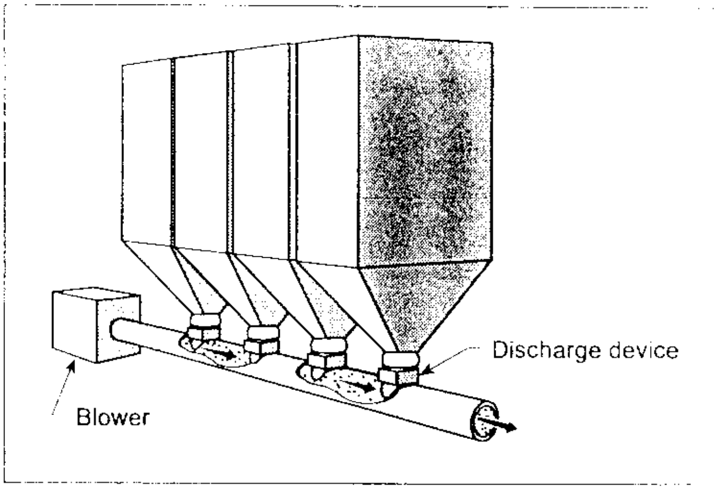

Figure 1-14. Pneumatic conveyor for transporting dust from baghouse

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

Fabric Filter Systems/Bag Designs

Fabric filters are usually constructed using many cylindrical bags that hang vertically in the unit (Figure 1-15). The number of bags can vary from as few as four to more than a thousand depending on the size of the control system. When dust layers have built up to a sufficient thickness, the bag is cleaned, causing the dust particles to fall into a collection hopper. Bag cleaning can be done by a number of methods. Collected dust particles are temporarily stored in the hopper and are discharged using double dump (double flap) or rotary airlock discharge devices. Then dust is transported by a pneumatic or screw conveyer. The baghouse is enclosed by sheet metal to contain the collected dust and to protect the bags from atmospheric conditions.

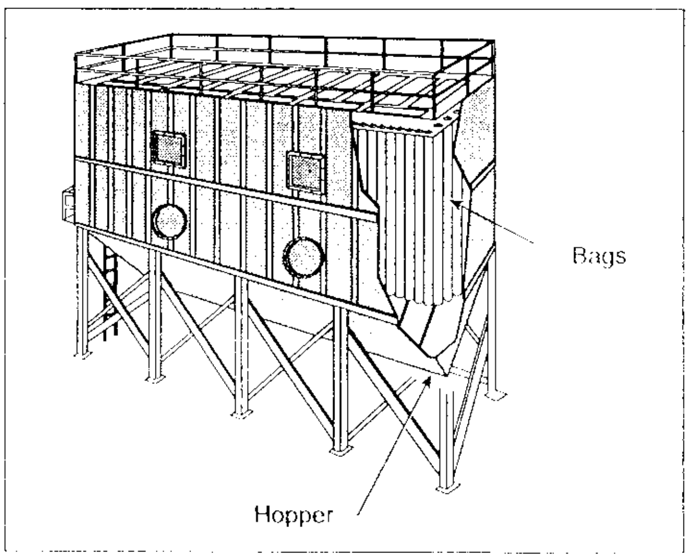

Figure 1-15. Typical baghouse

The envelope baghouse consists of compartments that contain envelopes of fabric mounted on frames and attached to the walls of the collector (Figure 1-16).

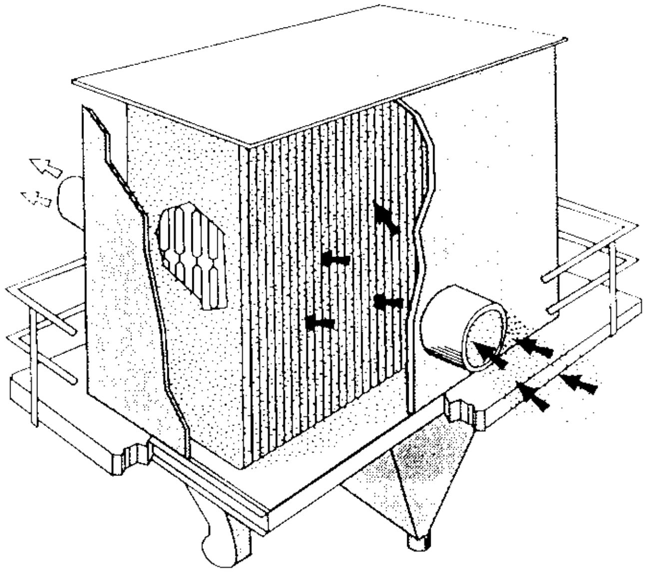

Figure 1-16. Envelope baghouse

Cartridge systems operate similarly to a baghouse that uses bag tubes (Figure 1-17). Cartridge baghouses are usually used on smaller industrial processes handling exhaust flow rates less than 50,000 cfm.

Positive and Negative Pressure Baghouses

Dirty gas is either pushed or pulled through the baghouse by a fan. When the dust-laden gas is pushed through the baghouse, the collector is called a **positive pressure** baghouse (Figure 1-18). Vendors can construct positive pressure baghouses with weaker support structures than negative pressure baghouses since the positive pressure will counterbalance the atmospheric pressure on the baghouse shell. Thus, these units are less costly than negative pressure baghouses. Limitations, however, do exist since the fan is located on the dirty side of the system. Premature deterioration of fan blades, bearings, and duct work can occur in this configuration due to particle abrasion. This is very important in terms of operation and maintenance of the baghouse. The fan is an integral component; if it becomes worn out, it will cause a shutdown of the entire baghouse. Fans are also relatively expensive to replace.

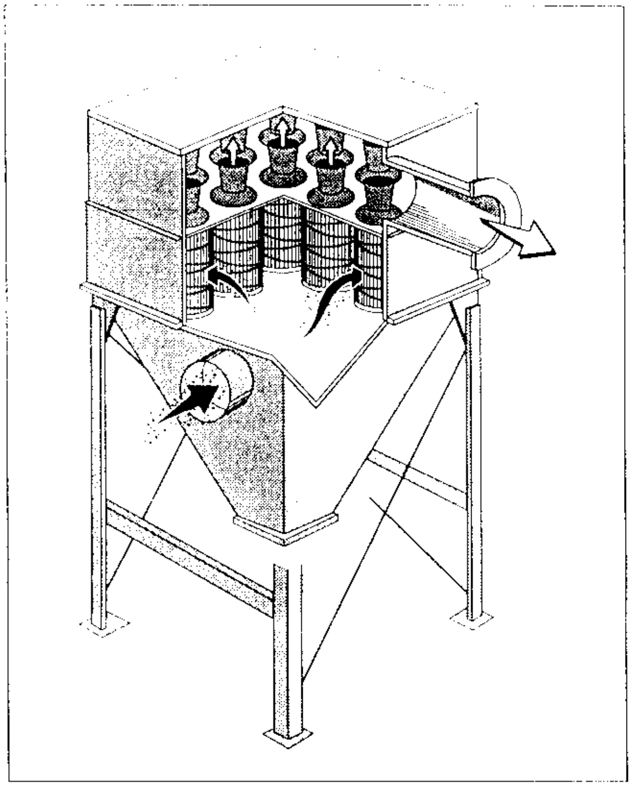

Figure 1-17. Cartridge baghouse

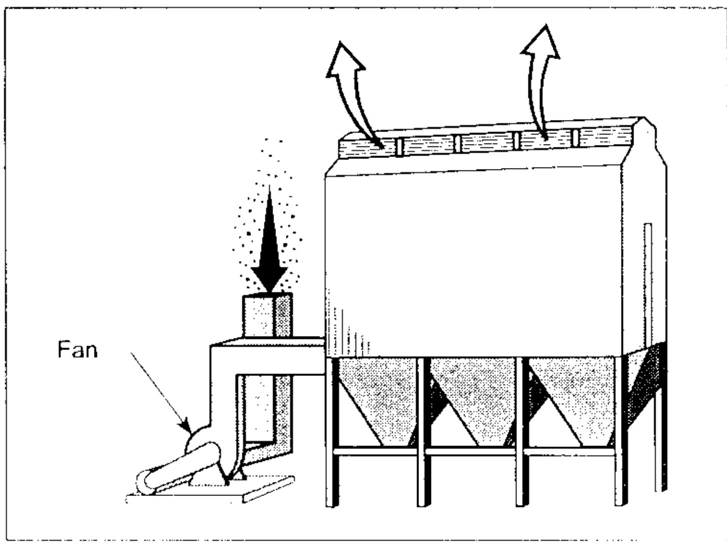

Figure 1-18. Positive pressure baghouse

Positive pressure baghouses usually have short stubby stacks or outlets at the top of the baghouse called roof monitors. This is a problem when stack testing for determining the compliance status of the source, because there is not a defined duct or stack where the test engineer can insert the probe. However, the EPA has promulgated Method 5D which describes the apparatus and sampling procedure for determining particulate matter concentrations from positive pressure baghouses (40 CFR, Part 60, Appendix A). Positive pressure systems are used when filtering process streams that contain low moisture content and low dust concentration of nonabrasive dusts. They are also used when handling dusts which are easily ignited due to air infiltration-related fires.

When the fan is on the downstream side of the baghouse, the dirty gas is pulled through the baghouse and the collector is called a **negative pressure** baghouse (Figure 1-19). The structure of a negative pressure baghouse must be reinforced because of the suction on the baghouse shell. The construction costs will therefore be higher than for positive pressure systems. Since the baghouse housing is under negative pressure, there are no pressure leaks, so general housekeeping in the immediate vicinity is minimized. The wear and tear on the fan is much less than with positive pressure systems since the particulate matter is removed by the bags before it can enter the fan. This may be the overriding factor in selecting a negative pressure baghouse. However, air infiltration into these designs can cause corrosion and hopper discharge problems. Negative pressure systems are used when filtering process streams that contain high moisture content, corrosive gases, and high concentrations of abrasive dusts.

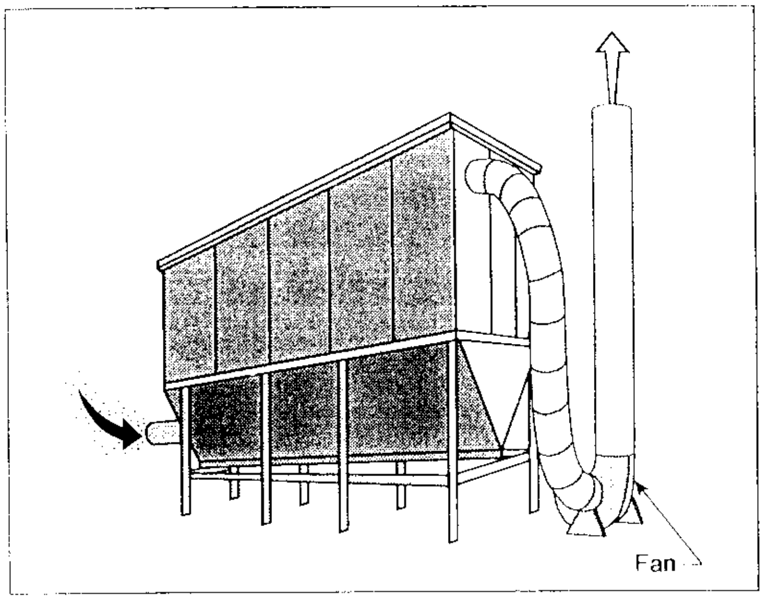

Figure 1-19. Negative pressure baghouse

Filtration Designs

There are two filtration designs used in baghouses: interior filtration and exterior filtration. In baghouses using **interior filtration**, particles are collected on the inside of the bag. The dust laden gas enters through the bottom of the collector and is directed inside the bag by diffuser vanes or baffles and a tube sheet. The **tube sheet**, also called a **cell plate**, is a thin (1/8 to 1/4 in.) metal sheet surrounding the bag openings. The dirty flue gas is directed into the bags through the openings in the tube sheet. The tube sheet separates the clean gas section from the baghouse inlet. The particles are filtered by the bag and clean air exits through the outside of the bag (Figure 1-20).

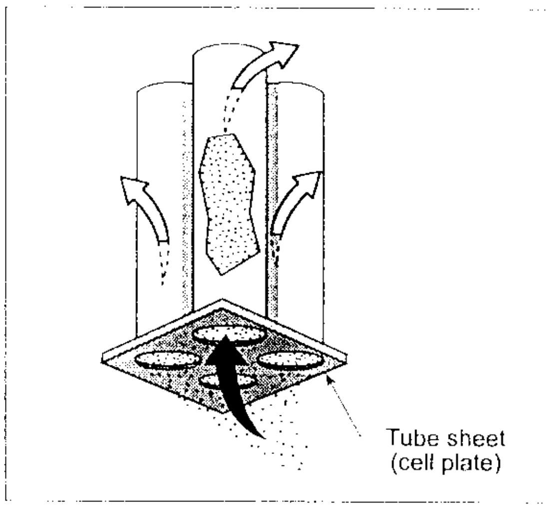

Figure 1-20. Interior filtration (particles collected on the inside of the bag)

In **exterior filtration** systems, dust is collected on the outside of the bags. The filtering process goes from the outside of the bag to the inside with clean gas exiting through the inside of the bag (Figure 1-21). Consequently, some type of bag support is necessary, such as an internal bag cage. Bags are attached at the top to a tube sheet (or cell plate) and are closed at the bottom by an end cap (usually just sewn).

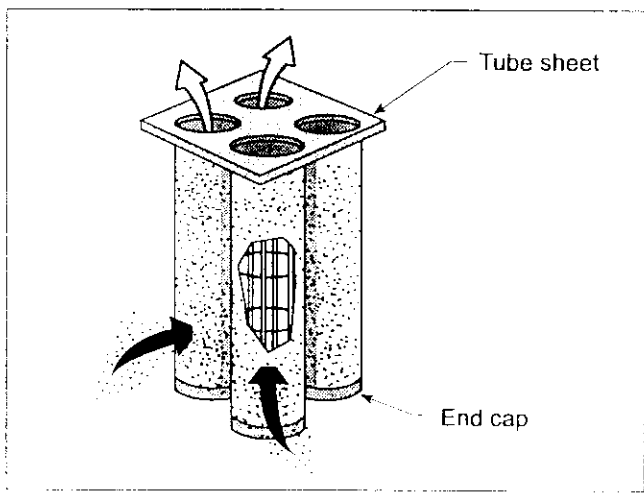

Figure 1-21. Exterior filtration (particles collected on the outside of the bag)

The dust laden gas inlet position for both filtration systems often depends on the baghouse model and manufacturer. If the gas enters the top of the unit, a downwash of gas occurs, which tends to clean the bags somewhat while the bags are filtering. This usually allows slightly higher gas volumes to be filtered through the baghouse before cleaning is required. If the gas enters the bottom of the unit, the inlet is positioned at the very top part of the dust hopper (Figure 1-22). Bottom or hopper inlets are easier to design and manufacture structurally than are the top inlets. However, when using hopper inlets, vendors must carefully design gas flows to avoid dust reentrainment from the hopper and to make sure that the flue gas is distributed evenly to each compartment.

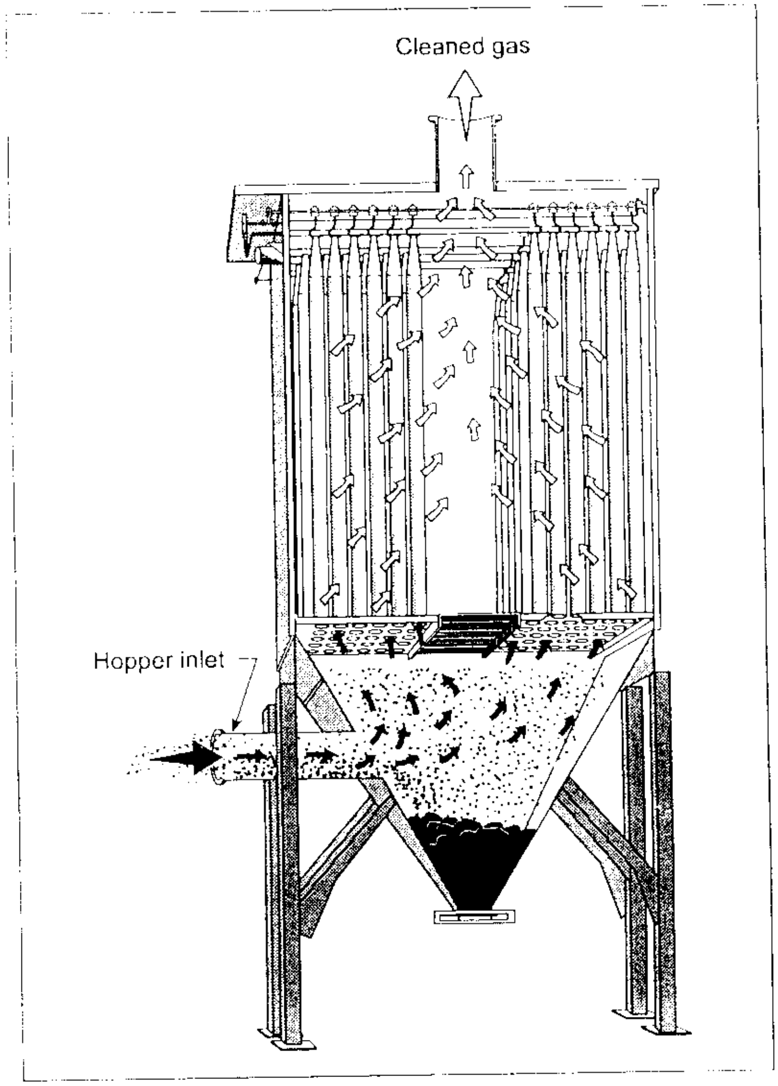

Figure 1-22. Dust inlet to the baghouse
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To test your knowledge of the preceding section, answer the questions in Part 2 of the Review Exercise.

Review Exercise

Part 1

1. The collection forces (mechanisms) responsible for 99% collection of particles greater than 1 μm aerodynamic diameter are ______________ and ______________.

2. ______________ charges can help capture particles in the sub-micron range.

3. Disposable filters can be constructed as ______________ or as ______________.

4. Nondisposable filters consist of some type of ______________ material.

5. Filters that continuously clean dirty exhaust gas streams from industrial processes are called ______________ filters.

   a. Disposable
   b. Nondisposable

6. List the five major components of a baghouse.
   ______________,
   ______________,
   ______________,
   ______________,
   ______________.

7. Bag cloth is supported at the top and bottom of the bag by ______________ or ______________, or by a(an) ______________ cage that completely supports the entire bag.

8. Baghouses use a number of shapes for the filters including: ______________, ______________, or ______________.

9. The bags in a baghouse are housed in a(an) ______________ that is usually made of metal (steel).

10. Sometimes it is necessary to use ______________ with the shell to prevent moisture or acid from condensing in the baghouse.

11. Fabric filters that process large exhaust volumes from continuous industrial operations are constructed as ______________ units.

12. Dust cleaned from the bags is collected and temporarily stored in a ______________.

13. A continuous discharge device that uses the weight of collected dust in the hopper to operate the flaps is a(an) ______________.

14. A(An) ______ ______ ______ discharge device works similarly to a revolving door.

15. A(An) ______ ______ ______ uses a screw feeder located at the bottom of the hopper to remove dust from the bin.

16. A(An) ______ ______ ______ generally uses either a blower or suction to remove dust from the hopper.

Part 2

17. Most U.S. baghouse designs use many cylindrical bags that ______ ______ ______ ______ in the baghouse.

18. Baghouse systems can be grouped according to the placement of the fan before or after the baghouse. ______ ______ ______ pressure baghouse systems have the fan before the baghouse. ______ ______ pressure baghouse systems have the fan after the baghouse.

19. Fan blades, bearings, and duct work can deteriorate when the fan is located on the ______ ______ ______ ______ of the baghouse.

20. When dust is collected on the inside of the bag, the filtration design is called ______ ______ ______ ______. When dust is collected on the outside of the bag, it is called ______ ______ ______.

21. For interior filtration, dust enters the bottom of the bag through a ______ ______ ______ ______ ______.

Review Answers

Part 1

1. **Impaction**
   Direct interception
   The collection forces (mechanisms) responsible for 99% collection of particles greater than 1 μm aerodynamic diameter are impaction and direct interception.

2. **Electrostatic**
   Electrostatic charges can help capture particles in the sub-micron range.

3. **Mats**
   Depth filters
   Disposable filters can be constructed as mats or as depth filters.

4. **Fabric**
   Nondisposable filters consist of some type of fabric material.

5. **b. Nondisposable**
   Filters that continuously clean dirty exhaust gas streams from industrial processes are called nondisposable filters.

6. **Bags, fabric, and support**
   Filter cleaning device
   Collection hopper
   Shell
   Fan
   The five major components of a baghouse are the following:
   - Bags, fabric, and support
   - Filter cleaning device
   - Collection hopper
   - Shell
   - Fan

7. **Rings** or **clasps**
   Internal
   Bag cloth is supported at the top and bottom of the bag by rings or clasps or by an internal cage that completely supports the entire bag.

8. **Bags**
   Envelopes
   Cartridges
   Baghouses use a number of shapes for the filters including: bags, envelopes, or cartridges.

9. **Shell**
The bags in a baghouse are housed in a shell that is usually made of metal (steel).

10. **Insulation**
Sometimes it is necessary to use insulation with the shell to prevent moisture or acid from condensing in the baghouse.

11. **Compartmentalized**
Fabric filters that process large exhaust volumes from continuous industrial operations are constructed as compartmentalized units.

12. **Hopper**
Dust cleaned from the bags is collected and temporarily stored in a hopper.

13. **Double-dump** (double flap or trickle valve)
A double-dump discharge device operates continuously and uses the weight of collected dust in the hopper to operate the flaps.

14. **Rotary airlock**
A rotary airlock discharge device works similarly to a revolving door.

15. **Screw conveyor**
A screw conveyor uses a screw feeder located at the bottom of the hopper to remove dust from the bin.

16. **Pneumatic conveyor**
A pneumatic conveyor generally uses either a blower or suction to remove dust from the hopper.

Part 2

17. **Hang vertically**
Most U.S. baghouse designs use many cylindrical bags that hang vertically in the baghouse.

18. **Positive**
Negative
Baghouse systems can be grouped according to the placement of the fan before or after the baghouse. Positive pressure baghouse systems have the fan before the baghouse. Negative pressure baghouse systems have the fan after the baghouse.

19. **Dirty side**
Fan blades, bearings, and duct work can deteriorate when the fan is located on the dirty side of the baghouse.

20. **Interior filtration**
Exterior filtration
When dust is collected on the inside of the bag, the filtration design is called interior filtration. When dust is collected on the outside of the bag, it is called exterior filtration.

21. **Tube sheet (or cell plate)**
For interior filtration, dust enters the bottom of the bag through a tube sheet (or cell plate).

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