

Checking drop in cfm due to dirty filter



Assessing HVAC System Cleanliness

Part 1 of 2

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Introduction

The lifespan, efficiency and cost-effectiveness of any HVAC system hinge on its state of cleanliness and regular and effective maintenance. HVAC inspectors can objectively determine whether a system is contaminated with a significant accumulation of particulate matter, or if HVAC performance is compromised due to contamination buildup.

The inspection process begins when a facility manager, building owner, or another industry related professional (referred to as the 'client') contacts an HVAC service provider. Visual inspection of HVAC system components is the first step for the assessment, cleaning, and restoration of HVAC systems.

The role of the HVAC assessor is to assess the cleanliness of the HVAC system, which is defined by the presence of dirt, obstructions, excess moisture and microbial contamination that might affect system performance or occupant health and comfort. The inspection involves visual examination of critical HVAC system components using cameras and scopes, where necessary. The inspector (if qualified) also reports observations regarding potential operational malfunctions or other maintenance needs that are observed during the course of the inspection.

About the Author

Sanjeev Rastogi is a graduate mechanical engineer with masters from BITS Pilani. He started his professional journey from Grasim at Nagda (Madhya Pradesh) in utilities maintenance and worked there for 13 years. During the last 12 years he has been working in Blue Star, heading the Service Specialists Group. He is a National Environmental Balancing Bureau (NEBB), USA accredited Testing Adjusting and Balancing (TAB) professional; and a National Air Duct Cleaners Association (NADCA), USA certified Air System Cleaning Specialist (ASCS).

The Inspection Process

The inspection process begins when an assessor makes contact with the client or their designated representative and reviews the building's drawings, history and HVAC system documentation. A walk-through is conducted so that the inspector can become familiar with the physical layout of the building and its HVAC system. After discussing the purpose and scope of the inspection with the client or their representative, the inspector drafts a written plan that will be reviewed and approved before a detailed inspection is performed.

The actual HVAC inspection includes all equipment associated with air handling units (AHUs), as well as supply air ducts, return air ducts, outdoor intake make-up ducts and air exhaust systems that are within the inspection scope outlined by the inspector and client. The inspector looks for dirt, debris and suspected microbial growth and makes observations



Figure 1: Contamination of drain



Figure 2: Duct contamination

regarding damaged or poorly functioning HVAC system components. Depending on whether contamination is found, the inspector may or may not choose to take measurements and collect samples during the inspection.

All discussions, interviews and observations are recorded and used by the inspector to write a formal report that is presented to the client at the conclusion of the inspection. The report presents the inspection findings including measurements and sample results (if taken). Most importantly, the report makes recommendations about whether the building's system should be cleaned and whether any situations observed during the inspection may require attention of an HVAC professional who specialises in a particular area.

The Need for Inspections

Both government and private organisations have been focusing more and more attention on indoor air quality (IAQ) issues in recent years. In the private sector, the U.S. Green Building Council (USGBC) is one group that is working to raise public awareness of the effects that building construction and system performance have on occupants' health and comfort.

- Routine HVAC system inspections should be performed as part of a proactive energy and indoor air quality management plan.
- HVAC systems should be cleaned when an HVAC cleanliness inspection indicates that the system is contaminated with an accumulation of particulate matter or microbial growth.

In general, an HVAC inspection is undertaken so that the client will know if system performance is compromised due to the buildup of contaminants or due to physical degradation of key HVAC system components. In addition, knowledge gained from a cleanliness inspection is important to sustaining

acceptable IAQ in both residential and commercial buildings. The information gained from an inspection can allow the client to establish due diligence if he or she is ever questioned about how a facility has been maintained.

Clients may also be interested in having an inspection done so that they are able to compile a complete package of documentation on the building and its status.

Frequency of Inspections

The National Air Duct Cleaners Association, USA (NADCA) Standard recommends commercial buildings' AHUs along with their supply and return ducts should be inspected every year.

Who is Qualified to Perform an Inspection?

Personnel who will be performing HVAC system inspections should have, at least, a verifiable working knowledge of:

- Basic HVAC system design
- Fundamental HVAC engineering practices
- Current industry HVAC cleaning and restoration techniques
- Applicable industry standards

In addition to possessing the technical requirements to perform an inspection, a potential HVAC inspector needs to possess additional traits that will allow him or her to interact with clients in what can be very sensitive situations. An inspector must have strong verbal and written communication skills so that interactions – both in person and in print – are clear and understandable.

Finally, an inspector must be able to present himself as a credible, trustworthy source of information regarding the status of a building's HVAC system. The inspector should be direct and factual in all dealings with the client.

It should be noted that IAQ is a multidisciplinary field, relying on the expertise of many professions to respond to the varied demands of the indoor environment. HVAC system inspection requires a broad range of knowledge of many IAQ disciplines. This includes, but is not limited to, those who specialise in industrial hygiene, air balancing, filtration, microbiology and bio-aerosols.

NADCA conducts an Air System Cleaning Specialist (ASCS) certification course. This certification is a world-wide credential recognising a person's knowledge and skills related to HVAC system hygiene. Today, many job specifications require that a certified ASCS be on a project. Having an ASCS certified technician on a company's staff can benefit in many ways, including meeting bid specifications and attracting more customers.

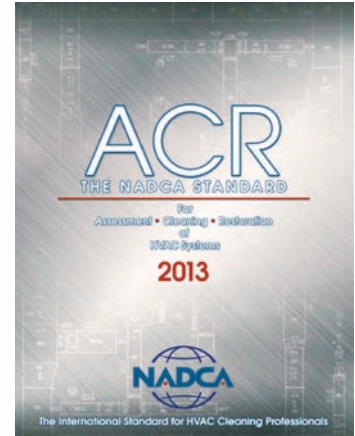


Figure 3: The NADCA Standard

HVAC Systems

This section provides an overview of the systems and components commonly found in commercial buildings' HVAC systems. An inspector will need to understand basic HVAC design and operation and be able to recognise HVAC system components during an inspection.

Constant Volume Systems

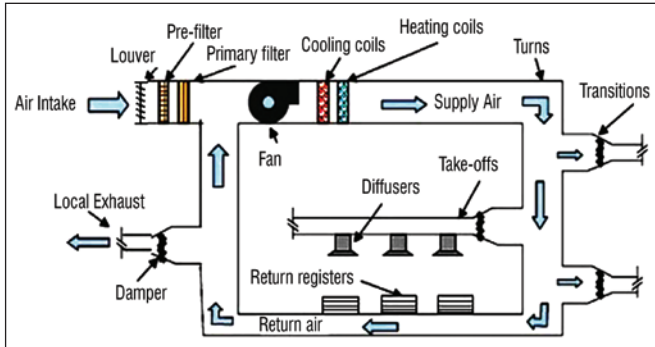


Figure 4: Constant air volume system

Constant air volume (CAV) systems, as the name suggests, deliver a constant air flow to each space. Changes in space temperatures are made by heating or cooling the air or switching the AHU on and off, not by modulating the volume of air supplied.

Variable Air Volume Systems



Figure 5: Variable air volume system

Variable air volume (VAV) systems maintain thermal comfort by varying the amount of heated or cooled air delivered to each space, rather than by changing the air temperature. Each zone has a thermostat that controls the air flow with dampers in a VAV box.

- Commercial office buildings are required to introduce outdoor air to provide ventilation for acceptable IAQ. Outdoor air is usually brought into the building by the HVAC system that serves the zone. It is critical to ensure that the thermostats are set to the "on" position, not the "auto" position, so that outdoor air is continuously supplied to the occupants.
- CAV systems are less energy-efficient than VAV systems.

Multi-zone Systems

A single zone system is directly controlled by a thermostat that turns the AHU on and off, as required by the space temperature. Single zone systems provide supply air at the same temperature to the entire zone being served.

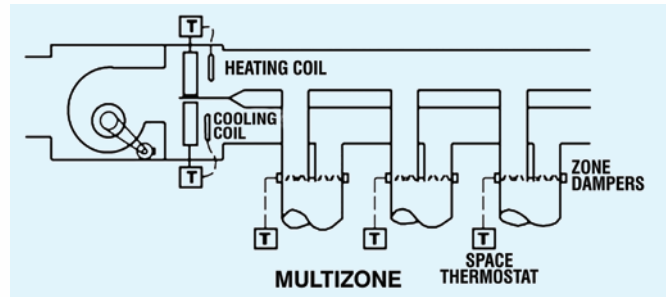


Figure 6: Multi-zone system

In a multi-zone system, each zone is served by a dedicated duct that connects directly to the central AHU. Supply air temperatures are controlled by thermostats in each zone. Multi-zone systems can provide two or more zones with air at different temperatures.

Ceiling Plenum Supply and Return

In some buildings, elements of building construction also serve as parts of the air distribution system.

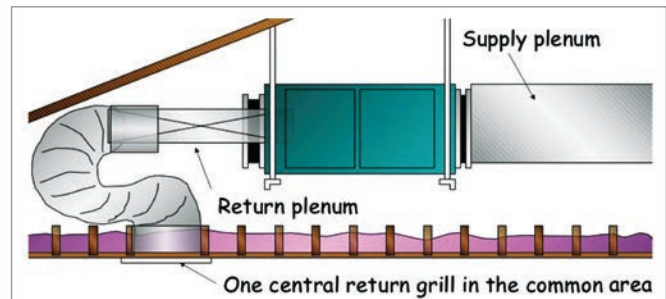


Figure 7: Ceiling plenum

Pressurised supply plenums or return air plenums can be located in the cavity space above the ceiling or below the deck of the floor. This type of system approach often reduces initial HVAC system costs, but requires that the designer, maintenance personnel and the contractors obey strict guidelines related to life and safety codes for materials and devices that are located in the plenum. In a ceiling plenum with tiles, the removal of ceiling tiles will disrupt airflow patterns.

Fan Coil Unit

In this unit, a fan draws air through a filter and blows it across a coil of chilled water. The condensate from the



Figure 8: Fan coil unit

coil must be collected in a drip pan and removed by a drain system.

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Exhaust System

Most buildings are required to provide for exhaust areas where contaminant sources are strong, such as toilet facilities, janitorial closets, cooking facilities and parking garages.

For successful containment and exhaust of indefinable sources, the exhausted area must be maintained at a lower overall pressure than surrounding areas. Any area that is designed to be exhausted must also be isolated (disconnected) from the return air system so that contaminants are not transported to another area of the building.

Building pressurisation control is an important element in air quality and energy management and it is important for an inspector to understand basic building pressurisation concepts. Buildings will have a combination of exhaust air and outside make up air keeping the building pressurisation in balance. An imbalance in the system can result in a building being under positive or negative pressure, both having ramifications.

The inspector needs to be aware of building pressurisation and to note the position of dampers within a system, as this will impact pressurisation. To reduce the effects of unwanted infiltration, designing and operating a building at slightly positive or neutral pressures will reduce the rate of entry of outdoor pollutants through unintended pathways when the systems are operating.

To maximise effectiveness, exhaust intakes should be located as close to potential contamination sources as possible.

- For smoking lounges, check to ensure that rooms operate at negative pressure relative to the surrounding areas.
- Check that the exhaust ducting on the discharge fan is intact all the way to the outside vent; otherwise, contaminated air can be released back into the building.

HVAC Components

Cooling Coils

Cooling coils are placed in the air stream to regulate the temperature of air delivered to the space. Malfunctions of coil controls can result in thermal discomfort. Condensation on pipes that are under-insulated and leakage in piped systems will often create moist conditions conducive to the growth of molds, fungus, and bacteria.

- Malfunctioning coils, including dirty coils, can waste energy and cause thermal discomfort.
- Leaky valves that allow chilled water through the coil when there is no demand, waste energy and create thermal discomfort.

During the cooling mode (air conditioning), the cooling coil provides dehumidification as water condenses from the airstream. Dehumidification can only take place if the chilled fluid is maintained at a cold enough temperature (generally below 7°C for water).



Figure 9: Cooling coils

Humidification and Dehumidification Equipment

In some buildings (or zones within buildings), there are special needs that warrant the strict control of humidity (e.g., operating rooms, computer rooms). This control is most often accomplished by adding humidification or dehumidification equipment and controls.

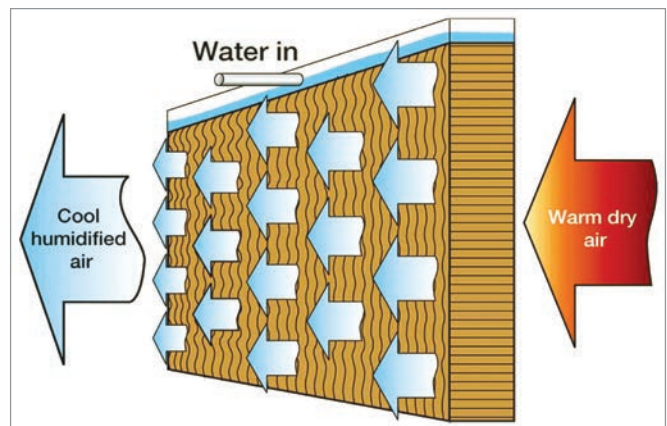


Figure 10: Humidification

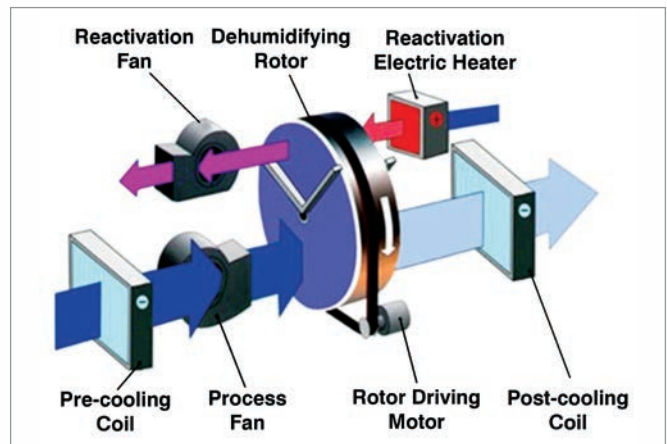


Figure 11: Dehumidification

According to ASHRAE Standard 62.1-2013, it is generally preferable to keep relative humidity (RH) below 65% in office facilities. When humidification is needed, it must be added in a manner that prevents the growth of microbiologicals within the ductwork and air handlers.

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Steam humidifiers should utilize potable water, rather than treated boiler water, so that occupants will not be exposed to boiler treatment chemicals. Adding water vapour to a building that was not designed for humidification can have a negative impact on the building structure and the occupants' health, if condensation occurs on cold surfaces or in wall or roof cavities.

- Duct linings should not be allowed to become moist from humidification water sprays.
- On spray humidifiers, check to see that all nozzles are working and free of deposits or other obstructions.

Filters

Filters are primarily used to remove particles from air. The type and design of the filter determines its efficiency at removing particles of a given size and the amount of energy needed to pull or push air through the filter. Filters are rated by different standards and test methods such as dust spot, arrestance or Minimum Efficiency Reporting Value (MERV).

MERV is expressed on a 16-point scale.

Table 1: Filter efficiencies

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, μm			
	Range 1 (0.3-1.0)	Range 2 (1.0-3.0)	Range 3 (3.0-10.0)	Average Arrestance, %
1	n/a	n/a	E_{320}	$A_{\text{avg}} < 65$
2	n/a	n/a	E_{320}	$65 \leq A_{\text{avg}} < 70$
3	n/a	n/a	E_{320}	$70 \leq A_{\text{avg}} < 75$
4	n/a	n/a	E_{320}	$78 \leq A_{\text{avg}}$
5	n/a	n/a	$20 \leq E_3 < 35$	n/a
6	n/a	n/a	$35 \leq E_3 < 50$	n/a
7	n/a	n/a	$50 \leq E_3 < 70$	n/a
8	n/a	$20 \leq E_2$	$70 \leq E_3$	n/a
9	n/a	$35 \leq E_2$	$75 \leq E_3$	n/a
10	n/a	$50 \leq E_2 < 65$	$80 \leq E_3$	n/a
11	$20 \leq E_1$	$65 \leq E_2 < 80$	$85 \leq E_3$	n/a
12	$35 \leq E_1$	$80 \leq E_2$	$90 \leq E_3$	n/a
13	$50 \leq E_1$	$85 \leq E_2$	$90 \leq E_3$	n/a
14	$75 \leq E_1 < 85$	$90 \leq E_2$	$95 \leq E_3$	n/a
15	$85 \leq E_1 < 95$	$90 \leq E_2$	$95 \leq E_3$	n/a
16	$95 \leq E_1$	$95 \leq E_2$	$95 \leq E_3$	n/a

Low-efficiency filters (ASHRAE Dust Spot rating of 10% or less) are often used to keep lint and dust from clogging cooling coils of a system. In order to maintain clean air in occupied spaces, filters must also remove bacteria, pollens, insects, soot, dust, and dirt with an efficiency suited to the use of the building.

Medium-efficiency filters (ASHRAE Dust Spot rating of 30% to 60%) can provide much better filtration than low-efficiency filters. To maintain proper airflow and minimize the amount of additional energy required to move air through these higher efficiency filters, pleated-type extended-surface filters are recommended.

Air filters, whatever their design or efficiency rating, require regular maintenance (cleaning for some and replacement for most). As a filter loads with particles, it becomes more efficient at particle removal but increases the pressure drop through the system, therefore reducing airflow. Filter manufacturers can provide information on the pressure drop through their products under different conditions. Low efficiency filters, if loaded to excess, will become deformed and even 'blow out' of their filter rack. When filters blow out, bypassing of unfiltered air can lead to clogged coils and dirty ducts. Filtration efficiency can be seriously reduced if filter cells are not properly sealed to prevent air from bypassing.

Filters should be selected for their ability to protect both the HVAC system components and general indoor air quality. In many buildings, the best choice is a medium-efficiency, pleated filter because they have higher removal efficiency than low-efficiency filters and they last longer (without clogging) than high-efficiency filters. Filters are often placed just upstream of cooling coils to minimize buildup of dirt and particles on the coils, which would reduce their efficiency.

The pleating on filters causes the filters to have greater surface area and thus lower face velocity and pressure drop. The media is contained in a cardboard frame that is generally thrown away with the fabric when it becomes dirty.

High-efficiency particulate air filters (*HEPA filters*) use thin, dry media (such as paper or glass fiber mats) with very small pores that trap superfine particles down to 0.01 micrometer in diameter. They are heavily pleated to reduce face velocity but still contribute pressure drops of up to 2 inches w.g. HEPA filters are used mostly in demanding situations such as electronics and pharmaceutical production facilities, hospital operating rooms and facilities that house radioactive particles.

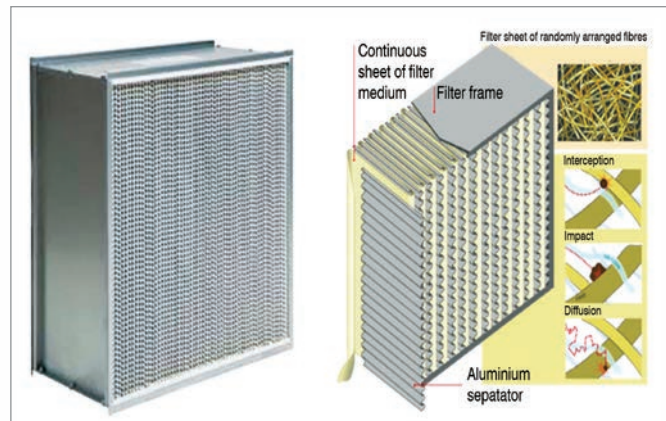


Figure 12: HEPA filter

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Table 2: Classification of HEPA filters

HEPA class	retention (total)	retention (local)
E10	> 85%
E11	> 95%
E12	> 99.5%
E13	> 99.95%	> 99.75%
E14	> 99.995%	> 99.975%
E15	> 99.9995%	> 99.9975%
E16	> 99.99995%	> 99.99975%
E17	> 99.999995%	> 99.9999%

Filters are also available to remove gases and volatile organic contaminants from ventilation air; however, these systems are not generally used in normal occupancy buildings. In specially designed HVAC systems, permanganate oxidizers and activated charcoal may be used for gaseous removal filters. Some manufacturers offer 'partial bypass' carbon filters and carbon-impregnated filters to reduce volatile organic compounds in the ventilation air of office environments.

- Check to ensure that filter arrows are pointed in the direction of the airflow.
- Filters should fit tightly in the filter housing to avoid blow-by.
- If dirt accumulates in ductwork and if the relative humidity reaches the dew point (so that condensation occurs), the available nutrients and moisture may support the growth of microorganisms.

Condensate Drain

Dehumidification can only take place if the chilled fluid is maintained at a cold enough temperature (generally below 7°C for water). Under these conditions, condensate collects in the drain pan under the cooling coil and exits via the seal trap. Standing water will accumulate if the drain pan system has not been designed to drain completely under all operating conditions. Under these conditions, molds and bacteria can proliferate unless the pan is cleaned frequently.

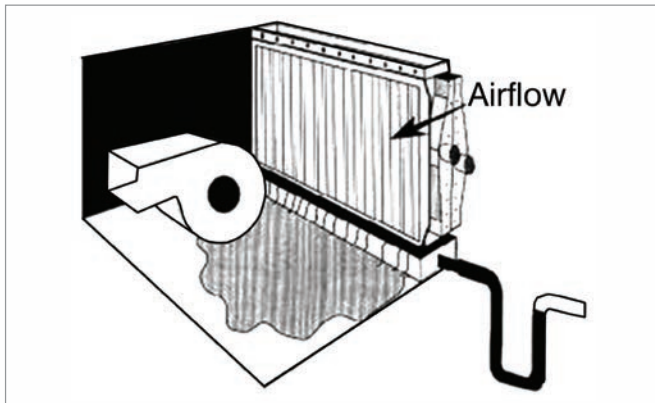


Figure 13: Condensate drain

An improperly trapped line can be a source of contamination, depending on where the line terminates. A properly installed trap could also be a source of contamination, if the water in the trap evaporates and allows air to flow through the trap into the conditioned air.

- Check to see that drain pans are accessible for inspection and cleaning.
- Check for visible growth (e.g., slime) or noticeable odour.
- Check to see that the drain pan is under positive or negative pressure.
- Check drain lines for proper insulation (which helps prevent dripping that can cause microbial contamination).

Condensate Pans

Cooling coils dehumidify air and cause condensate water to drip off the coils and into a drain pan. The drain pan is normally sloped to direct the water towards a drainage point, which is normally at the bottom of the pan.

- Check that drip pans are accessible for inspection.
- Check that pans are clean, with no residue, standing water, or leaks.
- Check for visible growth (e.g., slime) or noticeable odors.

P-Traps

A trap is used to isolate the drain system from the condensate pan by creating a water barrier at the base of a U-shape pipe, much the same way as a sink drain. This ensures proper draining of water in the condensate pan. A trap consists of a pipe section with a U-shaped bottom located below the drainage point of the pan. The P-trap must be kept wet to prevent drawing air into the unit (in a draw-through unit) from the drain line (and possibly a connected sewer).

- Check to make sure that a P-trap has been installed and is unobstructed.
- Check to see that the trap is wet and provides an effective barrier against air draw-through.

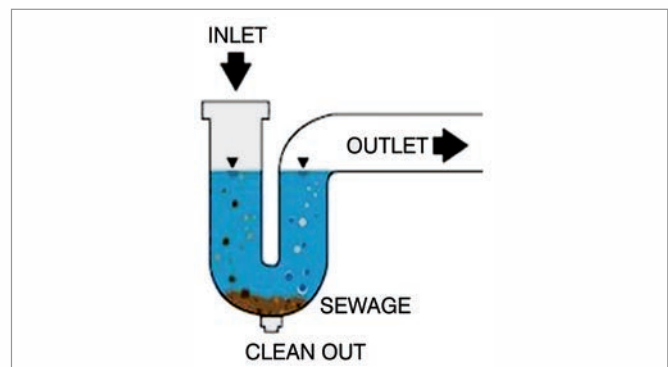


Figure 14: P-trap operation

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Dampers

Dampers are used throughout a typical HVAC system to adjust the flow of outside air, return air, exhaust air, and supply air.

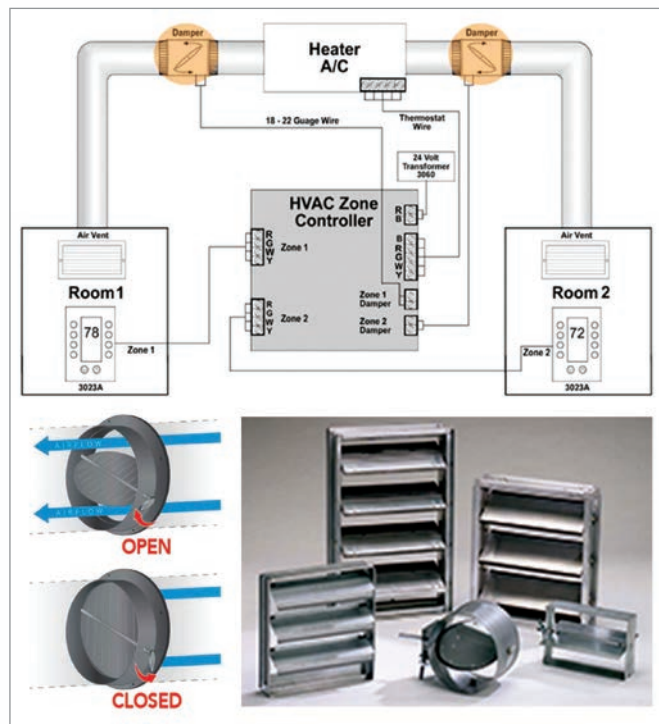


Figure 15: Dampers

The four most common types of dampers are:

- **Round Butterfly Damper:** round butterfly vane on an axle through its center, for use in round ducts.
- **Single-blade Damper:** single vane on an axle through its center, for use in square ducts.
- **Parallel-blade box damper:** series of small blades in a large rectangular box that open and close in parallel, altering the direction of airflow when the blades are partially closed.
- **Opposed-blade Box Damper:** series of small blades in a large rectangular box in which adjacent blades open and close in opposite directions, allowing the direction of airflow to remain unchanged when the blades are partially closed.

Damper positions may be relatively fixed (e.g., set manually during system testing and balancing) or may change in response to signals from the control system. If controlled, dampers are normally opened and closed by means of an actuator connected by linkages to a motor and control system. Some newer designs feature damper movement driven by plastic gears.

- If the outside air intake has a bird screen, the screen should be unobstructed (i.e. free of bird droppings) with no more than 1/2 inch mesh size.
- If a damper is designed to modulate, it should be checked during the day inspection to see that it is at proper setting. Actuators should be operational and dampers should seal well when closed.

Fire and Smoke Dampers

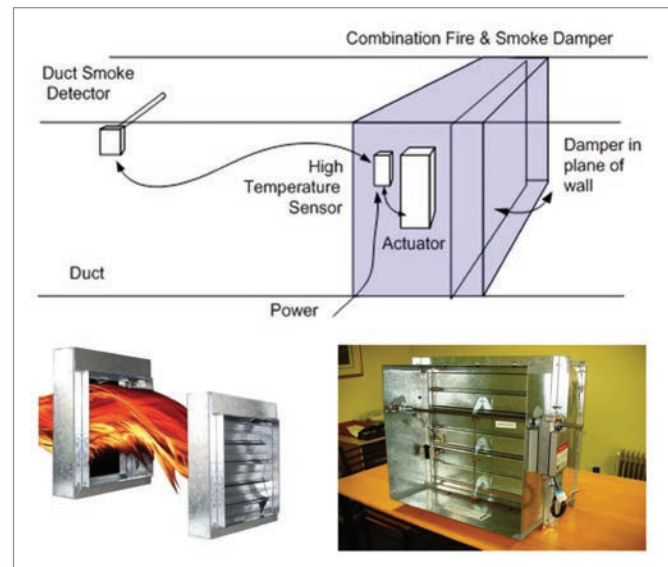


Figure 16: Fire and smoke dampers

Fire and smoke dampers can be triggered to respond to indicators such as high temperatures or signals from smoke detectors. Fire dampers are typically used as part of the HVAC system when a duct passes through a fire-rated barrier, such as a wall, partition, or floor.

- Check that the fire damper is fully open and not obstructing airflow, which would increase pressure drop and reduce air distribution.

Fans and Blowers

Fans provide the difference in air pressure required to distribute air throughout a system. Air distribution systems commonly use ducts that are constructed to be relatively airtight.



Figure 17: Fans and blowers

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Fan performance is expressed as the ability to move a given quantity of air at a given resistance or static pressure. Airflow in ductwork is determined by the size of the duct opening and the velocity of the air through the duct. The static pressure in a system is calculated using factors for duct length, speed of air movement and changes in the direction of air movement.

Air distribution problems can occur, particularly at the end of duct runs, if modifications to the original design increase the friction in the system to a point that approaches the limit of fan performance. The inappropriate use of long runs of flexible ducts with sharp bends also causes excessive friction. Poor system balancing is another common cause of air distribution problems.

The most common fan types used in commercial and residential buildings are:

- **Forward-curved Fans:** The unique characteristic of these fans is that they transfer large volumes of air for a minimum wheel diameter.
- **Backward-inclined Flat Fans:** This fan type has a unique feature – a non-overloading characteristic.
- **Axial Fans:** These fans are suitable for moving large quantities of air at low pressures while producing very little noise. They typically have shorter ducts and take up less space than centrifugal (e.g., forward and backward inclined) fans.

Air Handling Units

An air handling unit (AHU) generally consists of:

- a supply fan to move the air through the distribution system
- heating and/or cooling coils to adjust the temperature of air
- filters to remove particulate matter from the air
- associated inlet and outlet dampers to control the flow of recirculated air, make-up air, and supply air

The sources of heating or cooling fluids used in AHUs are generally boilers or chillers in central systems in large buildings. Packaged units use air or water direct expansion (DX) systems. Packaged heat pump units reverse this process in the heating mode to provide space heating.



Figure 18: Air handling unit

Ducts

Ducts are used to distribute conditioned air throughout a building and return air from conditioned spaces to the AHU. Ducts may be rigid or flexible. The most common rigid ducts are composed of metal, typically galvanized steel or aluminum. They may be round, rectangular or in the form of a spiral oval. Metal ducts are typically used in headers and branches, although rigid fiberglass ducts are sometimes used in these areas as well.

Flexible ducts are frequently used for the final connection from branches to diffusers because they are easier to align than rigid ducts. Some ducts may have acoustic fiber liners to reduce noise, especially just downstream of the fan.

- Problems with dust and other contamination in the ductwork are a function of filtration efficiency, regular HVAC system maintenance, the rate of airflow and good house-keeping practices in the occupied space.
- Problems with biological pollutants can be prevented by minimising dust and dirt buildup, promptly repairing leaks and water damage, preventing moisture accumulation in the components that are supposed to be dry, and cleaning the drain pans that collect and drain condensate water.

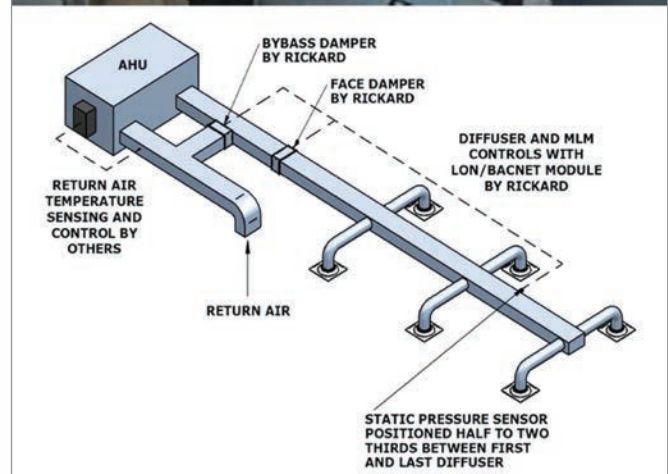
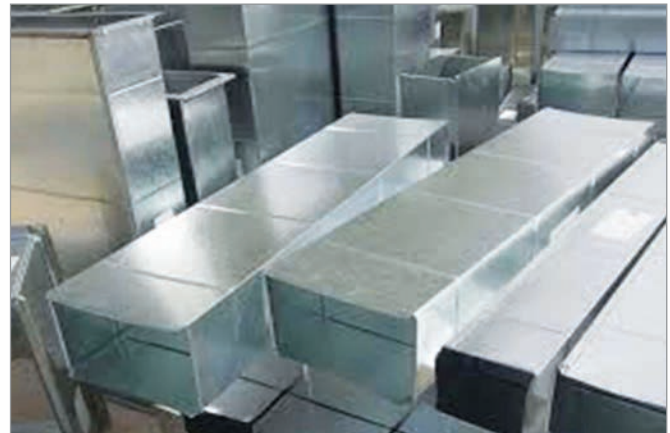


Figure 19: Ducts

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Types of Ducts

Ducts are used to distribute conditioned air throughout a building and often to return air from conditioned spaces to air handlers. Ducts come in a variety of materials and design types, as discussed in this section.



Figure 20: Types of ducts

Metal

Metal ducts are the most durable and can be cleaned aggressively. Metal also does not absorb moisture. The most common metal used in commercial buildings is galvanized steel. Metal ducts are normally either round or rectangular. Spiral oval ducts are used for medium and high-pressure systems.

- Excessive air leakage from metal supply ducts can occur as a result of loose-fitting joints and connections or 'blow outs' of improperly fabricated seams.

Lined

Duct lining, or insulation, slows the warming of chilled air as it travels through warm ceiling plenums. It also prevents condensation on the outside of ducts. This helps to eliminate staining, rusting and damage of equipment and ceiling material. The most common lining in use in commercial buildings is fiberglass. Acoustic fiber linings are also sometimes used for sound dampening.

- The porous surface of fibrous glass duct liner presents more surface area (which can trap dirt and subsequently collect water) than sheet metal ductwork. It is therefore particularly important to pay attention to the proper design, installation, filtration, humidity and maintenance of ducts that contain porous materials.

Duct Board

Duct board is fabricated from fiberglass insulation, which can be penetrated by moisture.

- In areas where a thermal liner or fibreboard has become water soaked, replacement is required.

Flex

Flex ducts are often used to connect supply air branches to registers or diffusers because they are easier to work with and achieve a good connection. Not all flex lines can be cleaned.

- Inappropriate use of long runs of flexible ducts with sharp bends causes excessive friction.

Concrete

Concrete ducts are sometimes used in commercial buildings to house pipes and cables. A concrete chase may be used as a return duct in some buildings. The concrete may be painted or unpainted. Concrete is also common as the floor or base material for AHUs.

- Cracks or holes in concrete return ducts located in crawl spaces or below slabs could allow soil gases, moisture and mold spores to enter the circulating air stream.

Insulation

Insulation is used on ducts to slow the heat transfer of supply air as it moves through unconditioned spaces. Insulation may also be used by designers to avoid condensation in cases where the supply air is very cold or where there is high ambient humidity in the plenum. In these cases, moisture may condense on the outside of the duct without insulation and then drip to cause staining, rusting, mold growth or ceiling damage.

Turning Vanes

Turning vanes are used in duct systems to direct airflow around turns and corners and maintain smooth airflow contours. They act to reduce the pressure drops and turbulence associated with such turns.

Turning vanes may be found in low- and medium-pressure systems but are rarely found in high-pressure systems. Vanes with air foil shapes are common and offer the best performance. The vanes may be made of metal or fiberglass.

- Parts of the turning vanes can come loose and fall out, leading to less efficient airflows and flow obstructions.

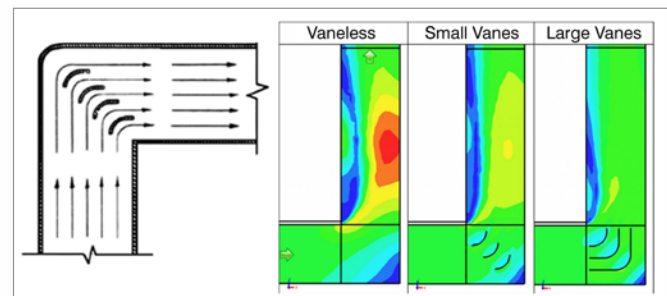


Figure 21: Turning vanes

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Grilles, Registers and Diffusers

Thermal comfort and effective contaminant removal demand that air delivered into a conditioned space be properly distributed within that space. Terminal devices are supply diffusers, return and exhaust grilles and associated dampers and controls that are designed to distribute air within a space and collect it from that space. There are minor differences between grilles, registers, and diffusers. Grilles deliver conditioned air into a space through a perforated or slotted panel without attempting to control the flow or mix it with room air. A register is a grille that is fitted with a damper for volume or direction control. Return air is generally drawn into the return air duct or plenum through a grille or register.



Figure 22: Grilles and registers

Diffusers are designed to inject supply air into a zone at higher velocities to distribute the air more widely and entrain it with room air for better mixing.

Throw is the horizontal distance the air travels before slowing to a specified speed – usually 50 feet per minute. *Spread* is the lateral dispersion achieved before dropping, and *drop* is the measure of downward migration of supply air that occurs before steady flow begins. Diffuser catalogs publish the throw, drop, spread, and pressure drop of their designs at various flow rates.

- Check that diffuser housing interiors are clean and unobstructed.
- At reduced airflows (such as with VAV systems), diffusers may ‘dump’ their air in a narrow column, which results in poor air distribution and may chill occupants directly below the diffuser.

Sound Attenuators

The largest source of noise in an HVAC system is generally the fan. Other potential sources include duct constrictions or expansions, protrusions and the ducts themselves (in high-velocity systems).

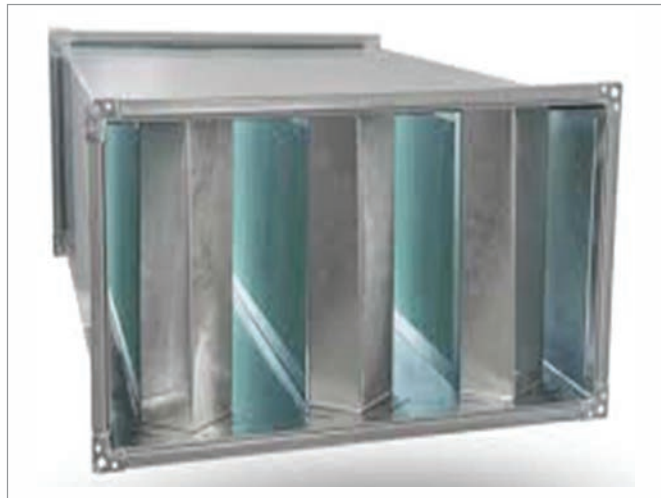


Figure 23: Sound attenuator

In passive silencers, air passes through narrow passages created by the placement of pods of sound-absorbing material. This causes an increase in air-side pressure drop, typically ranging from 0.3 to 0.5 inches w.g. Passive silencers may be built into the entrance and exit of fan housings. To avoid this pressure drop, silencers can be built with no interior elements. ❄️

In Part 2 of this article, to be published in the December 2018 issue of the Journal, we shall see how IAQ is impacted by HVAC system cleanliness, and how the latter is inspected.