

Checking drop in cfm due to dirty filter



Assessing HVAC System Cleanliness

Part 2 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).

In Part 1 of this article, we had an overview of different types of HVAC systems and their components, and the need for regular inspection.

HVAC Systems and Indoor Air Quality

It is important for an inspector to understand how HVAC systems impact indoor air quality.

Indoor air quality is a catch-all for a host of issues within a building. Indoor pollutants can be up to 10-100 times higher than outdoor concentrations.

Indoor air pollutants may be caused by a variety of factors, including but not limited to the following:

- Indoor air contaminants
- Interior furnishings (off-gassing)
- Chemicals (copying machines, toner and ink)

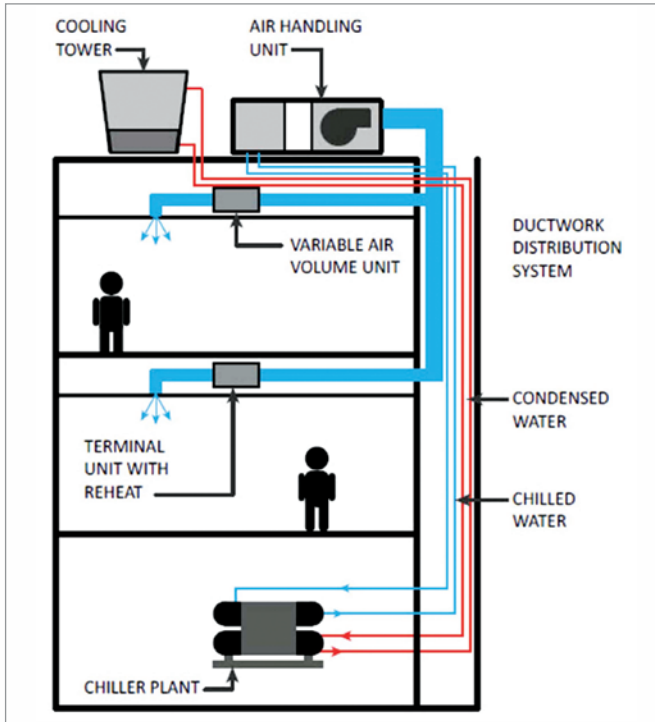


Figure 24: An HVAC system

- Janitorial closets (chemicals)
- Perfumes
- Outside air contaminants
 - Smog
 - Airborne dusts
 - Pollen
 - Nearby building or vehicle emissions
 - Re-entrainment of exhaust air
 - Mist from cooling towers
- Equipment/component failures
 - Failing and deteriorated insulation
 - Failing, broken or worn belts
- Building material/components
 - Off-gassing from flooring
 - Spray-on insulation
- Building materials and components are normally more significant issues in new construction before the products have had time to off-gas the chemical compounds within them.
- Construction and design issues
 - Using work stations with high walls may impede air circulation
 - Exceeding a space's design occupancy
 - Poor placement of air intakes and exhaust
 - Incorrect sizing of the HVAC system
 - Renovation without environmental

Common Indoor Air Problems



- controls
 - Inadequate filtration
 - Filter bypass or failure
 - Low quality filter
 - Inadequate system hygiene and preventative maintenance
 - Dirty coils
 - Improper air balance
 - Duct leakage
 - Lack of preventative maintenance
 - Standing water or moisture in components
 - Drain Pans
 - Humidification

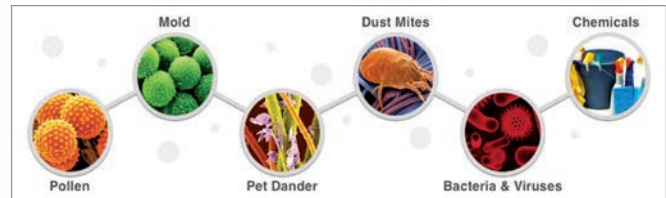


Figure 26: Common causes of indoor pollution

Pressure Differentials

The building envelope consists of the building's roof, walls, windows, and doors. The envelope controls the flow of energy between the interior and the exterior of the building.

Improper air balancing along with building stack effect can have a detrimental effect on the air quality of the building.

ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality* provides guidance on how carbon dioxide levels impact indoor air quality. If occupancy rates within a building exceed the building's code design, this may result in higher CO₂ levels and the ventilation system is not the cause of the issue.



Figure 27: ASHRAE Standard 62.1

Thermal Comfort

It is important to note that, in addition to indoor air pollutants, thermal comfort falls within the ambit of indoor air quality.

The common factors in thermal comfort are:

- Temperature
- Drafts
- Humidity
- Temperature changes
- Air stratification/ poor mixing

Duct Leakage

Duct Leakage is a significant issue that may impact thermal comfort. Leaking supply ducts will not deliver the designed quantity of tempered air to the occupied space. The leakage

wastes energy and forces the HVAC system to work harder to control the indoor temperature.

Pre-Inspection Tasks

Gathering Pre-inspection Information

An assessor typically begins when a client contacts an HVAC contracting company by phone to discuss a facility's situation. Beginning with this call, the assessor should keep detailed notes about all information (discussions, observations, etc.) related to the case.

The client should be informed that the purpose of the site visit and walk-through is to further clarify the purpose of the inspection and to learn more about the building and its history.

At this on-site meeting, the inspector will talk with the client and will clarify any information that was discussed on the phone. The inspector should use this meeting to collect additional information about the facility and any particular situation that is in question.

Table 3: Questions to gather pre-inspection information

Question	How to use the information
What is the purpose of the inspection?	The client should state whether the inspection is part of a routine maintenance program or whether a particular situation has generated the need for it.
Have you received any complaints from building occupants? If so, what have they been?	This may help generate additional questions that will focus the inspection on a particular area or system.
Do you have any information about what may be causing any system problems that you are experiencing?	This will let the inspector know how informed the client is about his or her HVAC system and whether any preliminary inspections have been done.
Is the system cleaned on a regular basis? When was it last cleaned?	This will give the inspector a general overview of how the system has been maintained.

Establishing a Formal Reporting Structure for the Project

While meeting with the facility manager to clarify the purpose of the inspection, the assessor should also determine who the main point(s) of contact will be, who will be receiving the results of the investigation, and whether any other facility staff will be involved with the project.

Key operating personnel at the site, especially those involved in HVAC system operation or maintenance, should also be identified at this time. These individuals will assist the inspector as he or she moves throughout the building and may be able to provide additional information about the system and its condition.

Performing a Walk-through

After talking with the client, establishing a reporting structure, and gathering information about the facility, the inspector may want to go on a walk-through of the facility. The walk-through provides the inspector with an opportunity to become familiar with the physical layout of the HVAC system and associated building characteristics. A person familiar with the HVAC systems in the building should accompany the inspector during this walk-through.

If there are indoor air quality complaints in the building, the inspector should examine the HVAC equipment serving the complaint areas and observe whether the equipment appears to be operating properly and is in good, clean condition. Such equipment might include thermostats, diffusers, fans, dampers, and filters.

As a final step in the building walk-through, the inspector should talk with the client about whether the HVAC system can be turned off and what time of day the inspection should be performed.

Determining Where to Inspect

In very few cases will the client request that the inspector examine every HVAC system component. It will be up to the inspector to determine which components are inspected and which portions of those components receive specific attention.

In particular, inspectors should be aware of the potential for the following types of areas to collect significant dust and debris:

- Areas affected by gravity (bottom of a shaft, dips, and low points) or pressure drops (turns)
- Any protuberances into the air stream (sensors, smoke detectors, vanes, sound attenuators, dampers, etc.); any location where there is a change from one type of ductwork material or design to another (metal to flex, metal to duct board, etc.)
- Any wet sections of the system, such as the condensate drain pan, the first several duct diameters of supply duct after the cooling coil, and humidification systems
- Any areas of the AHU where insulation is damaged
- Cooling towers
- Blower fans
- Filters and the areas immediately surrounding them



Figure 28: Typical defects found during inspection

Additionally, the assessor may want to examine additional areas that the client and/or occupants have expressed particular concern over.

Energy Source Lockout/Tagout

An energy source lockout procedure is used for isolating machines or equipment from their sources of energy and affixing appropriate locks or tags to energy-isolating devices

to prevent any unexpected energisation, startup or release of stored energy that could injure workers.

Inspection Tools

Basic Tools

- Ladders (several lengths, industrial grade)
- Screwdrivers — Phillip and flathead (for access panels)
- Allen keys (standard and metric)
- Pliers
- Hammers and mallets
- Wrenches — adjustable and open end box (for access panels)
- Socket set
- Nut drivers
- Flashlight (headlamps can be very useful)
- Retractable tape measure
- Drill (cordless is best)
- Drill bits
- Electric shears
- Hand shears



Figure 29: Locks and tags used on energy-isolating devices

- Duct knife
- Flat file

Advanced Equipment and Techniques

Inspection Findings and how to Address them

One should keep in mind that each recommendation is made on a case-by-case basis. An assessor's observations combined with his or her training, knowledge and experience will prove invaluable in making these decisions.

Table 4: Equipment and techniques for inspection

Equipment or Technique	Size of access needed	Advantages	Disadvantages
Direct visual inspection	Large to very large	Best used in AHUs and where large access doors are present	Only viable where large access ports are present or installed
Mirrors and periscopes 	Medium (need to insert device and light source)	Low cost and simple use Good for initial inspections	Requires larger access than fibre optic technologies
Borescope 	1" hole	Small access needed Good for small spaces like wall cavities With adapter, can feed image to CCD-based cameras	Short focal length (range of view) Cable can stir up dust and cause contamination Short cable connection gives short range
Push Cameras 	4" hole	Larger focal length than borescope, and greater range	Cables and wheel devices can stir up and cause contamination Can get stuck far from user
Robotic Cameras 	~ 6" x 6" and larger	Contain cameras and lights Can access long horizontal ducts with ranges of 100' and more Fewer access points needed Can travel from main to branch ducts Some models allow for use of camera alone in such mode	Robot car wheels and cable can stir up dust and cause contamination Setup time required Can get stuck far from user Cannot go past turning vanes and other restrictions

Table 5: Findings and recommendations to address them

	Finding	Sample Recommendations
	<p>Apparent microbial growth in condensate drain pans, internal insulation, ductwork, or coils</p>	<p>Microbial growth within an HVAC system is a significant concern. Mold spores can be dispersed by HVAC systems, and according to the EPA, this may result in itchy eyes and runny noses in sensitive individuals.</p>
	<p>Miscellaneous debris in the fan chamber, mixing plenum, or condensate drain pan</p>	<p>Debris in the fan chamber, mixing plenum or condensate drain pan should be removed. Dirt and debris contain nutrients, which may facilitate microbiological growth under certain conditions. Particulate accumulation may also affect system efficiency and airflow as it migrates through the HVAC system.</p>
	<p>Introduction to contaminants (sewer vent, vehicle exhaust, trash)</p>	<p>The introduction of contaminants may cause occupants to complain about unpleasant odors and irritation. In the case of vehicle exhaust, there is also the possibility of contaminant exposure. According to the EPA, make-up air induction should be at least 25' from fugitive emissions such as vents and local exhaust ventilation.</p>
	<p>Mist from cooling towers</p>	<p>Mist from cooling towers may contain biological hazards such as legionella bacteria. Drift eliminators and water treatment chemicals need to be routinely monitored to reduce the potential for exposure.</p>
	<p>Dust or dirt on diffusers</p>	<p>Supply diffuser accumulation may be attributed to the 'coanda effect'. Reducing dust and dirt in the space may help keep the diffusers clean. In all cases, diffusers should be kept clean to prevent additional accumulation of dirt. An accumulation of dirt on diffusers may influence occupant attitudes regarding the building's indoor air quality.</p>
	<p>Dust or dirt in ductwork</p>	<p>A slight coating of gray dust or an adhering oily film in the duct is not unusual. Large deposits of dust, dirt or mold, though, should not be present in air distribution systems. They may contribute to occupant complaints and reduce system energy efficiency.</p>
	<p>Poor filtration</p>	<p>Many HVAC systems operate with low-efficiency filtration. Filtration efficiency should be matched to equipment capabilities and expected air-flows.</p>
	<p>Improperly designed or installed systems, no outdoor air induction</p>	<p>If the system does not provide ventilation for acceptable indoor air quality, the system should be evaluated to determine the most efficient means to bring the system into compliance with generally accepted indoor air quality recommendations.</p>
	<p>Improperly designed or installed systems, insufficient or hindered access to system components</p>	<p>It is critical that systems be configured to allow unhindered access for inspection and cleaning. Systems should be configured and installed to allow ease of access.</p>
	<p>Poorly maintained system</p>	<p>All HVAC equipment should be maintained in accordance with the manufacturer's recommended procedures. If a belt is missing or slipping, it should be adjusted or replaced. Slipping belts may lead to occupant complaints about odours.</p>
	<p>Cooling coil condensate mist carryover to duct or filters</p>	<p>Condensate moisture or mist carryover is of concern because it may provide the moisture needed to facilitate microbiological amplification. If moisture is observed blowing off the coil, the inspector should consider measuring the system velocity and comparing those findings with the manufacturer's recommended velocity.</p>
	<p>Elevated relative humidity due to improper design, installation, configuration or operation</p>	<p>Relative humidity must be controlled in order to limit the growth of microorganisms such as mold and dust mites. The installation of data-logging humidistats may help to indicate elevated relative humidity.</p>
	<p>HVAC system not balanced, insufficient outdoor air</p>	<p>Air distribution systems should be balanced to provide adequate ventilation air throughout the facility.</p>
	<p>Leaking condensate pans</p>	<p>Leaks in condensate drain pans could provide adequate moisture to facilitate the amplification of microbiological growth, especially when water impacts porous materials such a ceiling tiles or drywall.</p>



Chemicals or porous material stored in mechanical room

Many mechanical rooms are considered part of the HVAC system, especially when the system has a return plenum to the mechanical room. To prevent the induction and distribution of chemicals into the ventilation system, the mechanical room should be kept clean and should not be used for storage. Porous material such as cardboard that is stored in the mechanical room may become wet over time and become a microbial reservoir and a source of occupant irritation.



Exposure pathways to unconditioned spaces

Depending on building pressure and temperature differentials, irritants can migrate from one area to another in a building. All exposure pathways to unconditioned spaces (vertical pipe chases) or industrial spaces should be sealed.

Thermostats lost, disconnected or missing

Thermostats are a critical element of an HVAC system. They should be installed to representatively depict thermal conditions in the zone. Improper thermostat placement can lead to occupant discomfort and increased energy consumption.



Leaking or disconnected ducts or torn collars

Leaking or disconnected ducts and torn collars reduce HVAC system efficiency and could generate occupant complaints. All leaks in the air distribution system should be repaired.

Missing ceiling tiles and missing return grilles

In many cases, the space above the ceiling is designed as a return plenum for the HVAC system and is engineered to provide metered return air to the air handler. This means that the installation of additional return grilles may put the HVAC system out of balance. Also, water-stained ceiling tiles may be a source of microbial contamination and should be replaced to prevent the distribution of irritants to occupants. Any missing tiles should be replaced immediately.



Supply and return short-circuiting

It is not uncommon to see supply and return grilles located too close to one another. When this occurs, the filtered and tempered air supplied from the HVAC system does not reach the intended space and the supply air is inducted back into the return system.

High velocity air blowing on occupant

High velocity air blowing on occupants may lead to complaints. Occupants may be uncomfortable when air velocity on exposed skin exceeds 50 feet per minute or 0.8 feet per second.

Presenting Recommendations to the Client

The following tips give guidance about drafting the recommendations:

- It will be helpful to provide an 'interim' or 'draft' copy of the report. This would particularly be helpful if the inspection takes place over several days or weeks and some interim reporting will be of use to alert the client to a potential hazard.
- It may be a good idea to present the report with visuals and possibly even in the form of a PowerPoint presentation.
- After the inspection process is complete, inspectors can provide information on the importance and benefits of routine inspection for maintaining HVAC system hygiene, performance, efficiency and ventilation to meet occupant needs.
- In order to provide consistency and improve thermal comfort, energy efficiency and indoor air quality of commercial HVAC systems, a standard practice for their inspection and maintenance is needed.

Conclusion

The inspection report will review the purpose of inspection, describe what was found during the inspection and present the client with recommendations about what steps can be taken to improve the cleanliness of the HVAC system and its components.

Based on the assessor's observations during the inspection, they must make recommendations to the client about the steps that can be taken to improve the cleanliness. Making these recommendations is a delicate matter and involves assessor training, judgment and experience.

As per ACR, NADCA standard:

- If significant accumulations of contaminants or debris are visually observed within the HVAC system, cleaning is necessary.
- If evidence of microbial growth is visually observed or confirmed by a laboratory test, cleaning is necessary.
- If the HVAC system discharges visible particulate matter into the occupied space, cleaning is necessary.
- If cooling coil, AHU, dampers or diffusers have blockages or deposits that may cause system performance inefficiencies, cleaning is necessary.

Proper HVAC system cleaning actually saves money by lowering operating and maintenance costs of the system. In a typical case, restoring the air handler resulted in a decrease in the pressure drop across the coil of approximately 14%, and a corresponding increase in airflow. So, the fan is producing that much more work in the form of cooling. Restoring the air handler increased the thermal efficiency of the cooling coil by 25% with respect to its ability to transfer its energy to the sensible loads. There is a significant increase in latent heat transfer ability of the coil in the range of 10%. This indicates the ability of the coil, after cleaning, to be able to provide for better building dehumidification capacity control by delivering sub-dew-point air temperatures across the cooling coil.

The HVAC systems are cleaner, and do not provide an environment for fungal, bacterial and microbial growth in their coils, and ducting.

IAQ and the awareness of good IAQ have increased in the building, and the overall comfort and work effectiveness can be greatly enhanced. Overall tenant satisfaction with the building environment has been improved as evidenced by the property manager's communications and positive feedback. ❖