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Comments, criticisms, and suggestions about the subject matter are invited. Any errors or omissions in the data should be brought to the attention of NADCA’s national headquarters office.
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Foreword

The HVAC Inspection Manual was developed to assist inspectors with conducting comprehensive examinations of HVAC components and systems. By following the methodologies presented in this manual, HVAC inspectors can objectively determine whether a system is contaminated with a significant accumulation of particulate or if HVAC performance is compromised due to contamination buildup. This type of inspection is recommended by several leading industry organizations, as outlined in Section1.

The inspection process begins when a facility manager, building owner, or another industry related professional (referred to as the “client” throughout this manual) contacts an HVAC inspector. This manual walks the inspector through the first interaction with the client and provides guidance regarding the type of questions that should be asked and information that should be collected. During this phase, the inspector will determine why the inspection is being requested and will gather some basic information about the facility. Sample questions that can guide this initial interview are provided as examples that an inspector can refer to when beginning an inspection.

Before describing the actual inspection procedure, the manual provides valuable information regarding risk management, indoor air quality, HVAC systems and components, inspection equipment and tools, engineering controls and inspector safety. Those who have been involved with the installation, operation, and maintenance of HVAC systems for any length of time will know much of this information. They will benefit, though, from the call-out items that highlight specific details that are of particular interest during an inspection.

After outlining these items, the manual moves on to discuss the inspector’s visit to the site and the purpose of performing a building walk-through. Examples of the type of questions that should be asked of the client and information that should be collected about the building are included for the inspector’s reference. Information collected during the site visit and walk-through is used by the inspector to define the scope of the inspection and write an inspection plan.

Guidance regarding how to perform an inspection and what particular areas should be examined is included later in the manual. This section includes helpful details regarding where inspections should begin and in what order they should proceed. It also reviews specific details about systems and components that should be of particular interest to an inspector.

Finally, the manual provides suggestions about how an inspector should present his or her findings to the client. The report drafted by an inspector gives an overview of the reason the inspection was called for, the status of the building, and the observations made during the inspection. The most valuable section of the report—the “recommendations” portion—is discussed in detail. An example inspection report is included in the appendix of the manual and can be used as a reference by inspectors who are drafting their own summaries and recommendations.
The *HVAC Inspection Manual* is intended to serve as a reference guide for all those who are interested in performing HVAC inspections. It also provides the basis of NADCA’s Certified Ventilation Inspector (CVI) Certification program and is built upon by the training course created to augment that program. Overall, the manual and its associated training program are intended to serve as an educational resource for those involved with examining and reporting on the cleanliness of HVAC systems.
Section 1: Introduction to HVAC Inspections

1.1 OVERVIEW OF AN HVAC INSPECTION

The primary objective of this manual is to equip inspectors with the knowledge they need to assess the cleanliness and physical condition of a commercial building’s HVAC system. This visual inspection of HVAC system components is the first step in the NADCA-recommended procedure for the assessment, cleaning, and restoration of HVAC systems, as outlined in ACR, the NADCA Standard. HVAC system inspections are also recommended in the following:

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.1 - 2013: *Ventilation for Acceptable Indoor Air Quality*
- Environmental Protection Agency (EPA) *Building Air Quality: A Guide for Building Owners and Facility Managers*
- National Fire Protection Association (NFPA) Standard 90A: *Standard for the Installation of Air Conditioning and Ventilating Systems*

The role of the HVAC inspector 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.

The inspection process begins when an inspector makes contact with the client or their designated representative and reviews the building’s drawings, history, and HVAC system documentation. A walkthrough 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 client’s 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 suspect microbial growth and makes observations 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. This report presents the inspection’s 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 the attention of an HVAC professional who specializes in a particular area.

1.2 WHY INSPECTIONS ARE NEEDED

Both government and private organizations have been focusing more and more attention on indoor air quality (IAQ) issues in recent years. The EPA’s Indoor Air Quality Building Education and Assessment Model (I-BEAM) program is just one major document that has brought national attention to IAQ. 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.

NADCA and its members are highly aware of these IAQ issues, and the association has been working to set standards regarding all aspects of cleaning and maintaining facilities’ HVAC systems. ACR, the NADCA Standard recommends that:

- Routine HVAC system inspections 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 or microbial growth.

Many other organizations involved with IAQ issues have laid out similar inspection recommendations in the publications and programs listed in Table 1-2.

<table>
<thead>
<tr>
<th>Organizations</th>
<th>Source</th>
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<tbody>
<tr>
<td>American Conference of Governmental Industrial Hygienists (ACGIH)</td>
<td>Bioaerosols: Assessment &amp; Control</td>
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<tr>
<td>Environmental Protection Agency (EPA)</td>
<td>Building Air Quality: A Guide for Building Owners and Facility Managers Indoor Air Quality Building Education and Assessment Model (I-BEAM) program</td>
</tr>
<tr>
<td>National Air Filtration Association (NAFA)</td>
<td>Installation, Operation and Maintenance of Air Filtration Systems</td>
</tr>
<tr>
<td>National Fire Protection Association (NFPA)</td>
<td>NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems</td>
</tr>
<tr>
<td>Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA)</td>
<td>HVAC Duct Construction Standards (several publications)</td>
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In general, an HVAC inspection is undertaken so that the client will know whether HVAC system performance is compromised due to the buildup of particulate or microbiological contaminants or due to physical degradation of key HVAC system components. In addition, knowledge gained from an inspection about whether an HVAC system is clean 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.

Another application of the HVAC inspection is in a situation where a client wants to verify whether cleaning that has been done to a system has been successful. A client may request a full system inspection as a way to follow up on a cleaning. Section 6 of this manual discusses that situation and how the NADCA Vacuum Test can be used as part of this process.

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. (This sort of documentation is at times required as part of the sale of a building.) This is why it is of great importance for the inspector to collect and compile all information collected during interviews and the actual inspection so that the final report can be as complete as possible.

1.3 FREQUENCY OF INSPECTIONS

ACR, the NADCA Standard recommends commercial buildings’ AHUs along with their supply and return ducts should be inspected every year. Based on this existing guidance and the recommendations of other organizations, NADCA formally recommends as part of its HVAC inspector training program that an HVAC system inspection be performed annually. (Note that this recommendation applies to inspections of commercial HVAC systems. Inspections of other building types are outside the scope of this manual.)

This guidance is supported by a number of other leading industry organizations. For example, the NFPA makes the following statement in Section B-4 of Standard 90A: “Inspections to determine the amount of dust and waste material in the ducts (both discharge and return) should be made quarterly. If, after several inspections, such frequent inspection is determined to be unnecessary, the interval between inspections can be permitted to be adjusted to suit the conditions.”

1.4 WHO IS QUALIFIED TO PERFORM AN INSPECTION

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

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

Such personnel should also have experience performing cleanliness verification and the experience and tools needed to create and seal openings during and after inspection. Individuals who hold NADCA’s Certified Ventilation Inspector (CVI) certification have demonstrated knowledge in each of these areas.

This manual and its associated training program are intended to equip individuals to perform visual inspections. Individuals who complete this training and pass the certification examination will be recognized by NADCA as Certified Ventilation Inspectors (CVIs).
In addition to possessing the technical requirements needed 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 solid verbal and written communication skills so that interactions—both in person and in print—are clear and understandable. It is also imperative that an inspector be someone who is sensitive to the situation a building manager may find himself in either prior to, during, or after an inspection.

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. This means that any inspector who also performs ventilation system cleaning and/or restoration must disclose that information to the client before beginning an inspection. The inspector must disclose to the client if he or she has any outside interests related to the outcome of the inspection. During the inspection, the inspector must remain as objective as possible and focus on recording and reporting whether a component is observed to be clean or an issue has been identified. In short, the inspector should be direct and factual in all dealings with the client.

It should be noted that the field of IAQ is a multidisciplinary one, 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. While this training guide provides education in many of these areas of specialty, it in and of itself does not make an inspector an expert in any one of these fields. It is the responsibility of the inspector to, when necessary, contact experts in any areas that are beyond the scope of this training. This includes, but is not limited to, those who specialize in industrial hygiene, air balancing, filtration, microbiology, and bioaerosols.
Section 2: Risk Management

2.1 INSURANCE CONSIDERATIONS

Before engaging in HVAC system inspection, inspectors must be aware of important liability and insurance considerations to help mitigate risk involved with performing inspections. When performing an inspection, the inspector is providing a professional service. The inspection report is the product of that service and standard liability insurance may not protect an inspector from liability related to errors within the inspection report.

Acquiring additional coverage through professional liability insurance, commonly known as Errors and Omissions (“E&O”) insurance, is something that inspectors are recommended to look into before engaging in this work. This type of policy covers claims related directly to the provision of professional services, not to losses involving automobile liability, general liability, fidelity, property, workers compensation, etc. and may not cover the inspector for negligence. Inspectors are recommended to consult with legal counsel and insurance professionals to understand what type of coverage is recommended to help mitigate risk related to performing HVAC system inspection.

2.2 LICENSING REQUIREMENTS

Some states and/or provinces require licensing in order to cut an access opening, remove the access panels on a unit, pull and clean a fan assembly or clean the evaporator coil. It is up to the inspector to ensure that he or she meets any licensing and/or certification requirements in the jurisdiction in which the inspection service will be performed. This would include all local, state, country or province requirements as governed by the authority having jurisdiction.

2.3 INDUSTRY STANDARDS & REFERENCES

It is important for inspectors to maintain a library of industry standards and references that are relevant to HVAC system inspection. When putting forth recommendations based upon the inspection findings, it is important to cite relevant industry standards and/or references upon which the inspector is basing those recommendations. Examples of relevant references and standards may include but not be limited to those published by NADCA, NIOSH, NFPA, NAFA, ASHRAE, EPA, CDC and US GREEN BUILDING Council. An inspector’s ability to support their hypothesis and recommendations with information from industry recognized and peer-reviewed documents will help to create a credible inspection report.

2.4 OTHER CERTIFIED SPECIALTIES

Inspection of commercial HVAC systems opens up a new set of issues for those involved with HVAC system cleaning. As an inspector, it is important to understand that no one can be an expert in all aspects of HVAC system inspection and assessment. Inspectors must realize what their specific qualifications are and not go beyond their area of expertise. For example, there may be circumstances that require an inspector to assemble a team of experts which may include Mechanical Engineers, Test and Balance firms, Industrial Hygienists and Indoor Environmental Professionals (IEP). Each one of these professions, just like HVAC system cleaning, comes with their own set of credentials and expertise.

When utilizing the services of other industry experts, it is important that those experts are properly licensed and/or certified. For example, licensed mechanical engineers, Test and Balance companies that are NEBB or AABC certified and Industrial Hygienists certified through the American Industrial Hygiene Association or equivalent are recommended.
Section 3: HVAC Systems and Components

3.1 OVERVIEW

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 recognize HVAC system components during an inspection.

For each system and component described in this section, the following information is supplied:

- a list of the primary components that inspectors will encounter
- a discussion of how each component impacts the system
- its potential effect on IAQ and system performance
- details on what inspectors should look for regarding each item

3.2 HVAC SYSTEMS

A. Constant Volume Systems

Constant air volume (CAV) systems, as their name suggests, deliver a constant airflow 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—there is no modulation of the fan power, no discharge dampering at the fan, and no dampering at the terminal ends of the duct runs.

These systems often operate with a fixed minimum percentage of outdoor air or with an “air economizer.” An air economizer is a damper and control system that allows outdoor air to be added directly to recirculating ventilation air for cooling or dehumidification purposes during periods of mild weather.
B. Variable Air Volume Systems

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 airflow with dampers (i.e., movable plates that obstruct flow) in a VAV box. Because each zone in a VAV system needs its own relatively costly VAV box, VAV zones typically cover a large area with several spaces that have similar solar exposure, occupancy, heat loss and heat gains, or other determinants of heating or cooling load.

In VAV systems, overcooling or overheating can occur within a given zone if the system is not adjusted to respond to the load appropriately. Under-ventilation frequently occurs if the system is not arranged to introduce at least a minimum quantity (as opposed to percentage) of outdoor air as the VAV system throttles back from full airflow or if the system supply air temperature is set too low for the loads present in the zone.

Constant Volume

- Because constant volume systems can provide supply air at a uniform temperature to all zones (unless reheat systems are used), their use is typically limited to large open areas with few windows and uniform heating and cooling loads (such as factory spaces, exhibit halls, and auditoriums).

- 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. If the thermostat is set to “auto,” the fan that provides fresh air to the occupants will only turn on when the thermostat calls for cooling or heat.

- CAV systems are less energy-efficient than variable air volume (VAV) systems. CAV system controls for outdoor air delivery are simpler to manage.
- If the percentage of outdoor air is constant, the total volume of outdoor air will be reduced as the supply air volume is reduced. A low outdoor air percentage combined with a low VAV box minimum setting may result in inadequate outdoor airflow to occupant spaces. This could occur during part-load conditions.

- Overcooling or overheating within a given zone can occur if the system is not adjusted to respond to the thermal load.
C. Multi-Zone Systems

A single zone system is directly controlled by a thermostat that turns the AHU on and off (or adjusts flow through cooling or heating coils) as required by the space temperature. Single zone systems provide supply air at the same temperature to the entire zone being served. This limits their application to spaces with uniform heating and cooling loads.

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 by heating or cooling the airstream in each zone.

In the most common design, the AHU produces warm air at a temperature near 100°F and cool air at about 55°F. This air is blended with dampers to adjust the supply air temperature to what is called for by the zone thermostat.

- Although multi-zone systems were popular in the 1960s and 1970s, their high energy consumption (for simultaneous heating and cooling) has led to a decline in their use and has resulted in their being banned by local building codes throughout the country.
- The use of multiple dampers in this approach, together with their location in high-velocity areas near the fan, can cause significant pressure drop and additional energy use.
D. Dual-Duct System

The dual-duct concept is fairly simple—a fan discharges air, which is directed through a cooling coil and/or a heating coil where the main system has both warm air and cold air separately ducted. A device called a dual-duct mixing box, which is separate from either the fan or the coil(s), then determines the path the air will take.

The dual-duct mixing box is just that—a mixing box. It has a damper, controlled by a zone’s thermostat, which mixes the correct amount of cool air and hot air to maintain the supply air temperature called for by the zone thermostat. This system works on the same principle as a bathroom shower—turn on a given volume and simply add more or less hot or cold water to achieve the proper water temperature.

Dual-duct systems are similar to the multi-zone concept in that both cool supply air and warm supply air are produced by a central AHU. Instead of blending the air in the fan room with a single duct to each of the multiple zones, a dual-duct system uses separate hot air ducts (the hot deck) and cold air ducts (the cold deck) that run parallel throughout the air distribution network. Air is mixed at terminal mixing boxes in each zone. Mixing of warm air and cool air in the mixing boxes is controlled by dampers in response to the zone thermostat. Dual-duct systems may be either CAV or VAV systems.

Dual-duct systems were popular in the early days of air conditioning. They work well, but consume more energy relative to more modern systems. They became much less popular after the energy crisis of 1973.

- Like multi-zone systems, dual-duct systems are not energy efficient and are now prohibited under many new construction codes.
- Dual-duct systems are likely to have high-velocity ductwork upstream of the mixing box.
- The dampers in dual-duct mixing boxes can leak, even when they are supposed to be fully closed.
- Dual-duct systems may provide poor humidity control because of the different humidity levels in the hot and cold airstreams to be mixed.
E. Heat Pump

A home refrigerator takes warm air out of a cold region, raises it to a higher temperature, and then discharges it into the room. This requires mechanical energy. For many home refrigerators, the amount of heat extracted is equal to about six times the mechanical energy required to extract the heat. The heat discharged is about seven times the mechanical energy. These values decrease when the difference between the high and low temperatures is increased.

A heat pump works similar to a refrigerator. It extracts heat from the atmosphere or ground and releases it at a higher temperature into the building. For moderately cool outdoor temperatures, the heat discharged is many times the mechanical and electrical energy supplied to the system. A heat pump can be a practical heating system in climates where the air temperature does not drop much below 50°F. At lower air temperatures, heat may be drawn from the ground or from groundwater, though this can be costly.

Most heat pump systems installed now must also include an auxiliary electric-resistant heating element within the unit to supplement heating capacity when the heat pump becomes inefficient. The electric heat elements also improve overall heating time.

The Air-Conditioning and Refrigeration Institute (ARI) publishes standard ratings for heat pumps and lists them under the following names and abbreviations:

- Unitary Air-source (HP)
- Ground Water-source (GWHP)
- Packaged Terminal (PTHP)
- Water-source (WSHP)
- Ground-source Closed Loop (GSHP), also known as geothermal heat pumps

The most commonly encountered heat pump systems in commercial buildings are WSHPs. In this arrangement, each zone contains a closed-loop WSHP that can provide heating or cooling, along with air filtration and dehumidification. The water source for all the heat pumps in the building circulates in a closed piping loop, connected to a cooling tower for summer cooling and a boiler for winter heating.

- Field conditions are often harsh on heat pumps; as a result, regular maintenance is critically important to maintaining heat pump efficiency.
- Common problems that have been reported in field studies of commercial and residential heat pumps include low airflow, incorrect refrigerant charge, refrigerant leaks, control problems, and excessive duct leakage.
- Heat pumps should be evaluated for their installation and the pitch of their internal condensate pans. If the units are not suspended properly from the overhead structure effective draining may not take place.
F. Ceiling Plenum Supply and Return

In some buildings, elements of the building construction also serve as part of the air distribution system. Pressurized 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 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. It is particularly important to maintain the integrity of the ceiling and adjacent walls in areas that are designed to be exhausted, such as supply closets, bathrooms, and chemical storage areas.

- Look for materials and supplies (e.g., paint and cleaners) that could contaminate circulating air or disrupt airflow. These are usually prohibited by building codes.
- Look for condensation on pipes in plenum areas. Such moisture creates a growth area for microbes.
- Look for water-damaged ceiling tiles, which may indicate leakage and potential microbiological growth.
- Look for negative pressure field in the dropped ceiling return plenum extending to exterior, which accidentally couples the HVAC system to the building enclosure.

G. Fan Coil Unit

In this unit, a fan draws air through a filter and then blows it across a coil of hot water (for heating) or chilled water (for cooling). In the cooling mode, condensate from the coil must be collected in a drip pan and removed by a drain. Although most fan-coil units are located beneath windows on exterior walls, they may also be mounted horizontally at the ceiling. They often discharge conditioned air directly into the zone or room without a ducted distribution system. Fan-coil units are typically used in buildings that have many zones located primarily along exterior walls, such as schools, hotels, apartments, and office buildings.

- If self-contained units (such as fan coil units and unit ventilators) are overlooked during maintenance activities, it is not unusual for them to become a significant source of contaminants, especially for occupants located nearby.
H. Local or Specialized Exhaust

Most buildings are required by law (e.g., building or plumbing codes) to provide for exhaust of areas where contaminant sources are strong, such as toilet facilities, janitorial closets, cooking facilities, and parking garages. Other areas where exhaust is frequently recommended but not always required include:

- reprographics areas
- graphic arts facilities
- beauty salons
- any area where contaminants are known to originate

For successful containment and exhaust of identifiable 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 pressurization control is an important element in air quality and energy management and it is important for an inspector to understand basic building pressurization concepts. Buildings will have a combination of exhaust air and outside make up air keeping the building pressurization 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 pressurization and to note the position of dampers within a system, as this will impact pressurization. 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. For a building to actually operate at a slight positive pressure, it must also be tightly constructed. It is important to understand the design and mechanical criteria for the building being inspected.

To maximize effectiveness, exhaust intakes should be located as close to potential contamination sources as possible. The exhaust system fan should draw sufficient air to keep the room in which the exhaust is located under negative pressure relative to the surrounding spaces, including wall cavities and plenums. Ambient air should flow into, not out of, the exhausted area. This may require louvered panels in doors or walls to provide an unobstructed pathway for replacement air. The integrity of the walls and ceiling of rooms to be exhausted must be well-maintained to prevent contaminated air from escaping into the return air plenum.
3.3 HVAC COMPONENTS

A. Heating, Cooling, and Reheat Coils

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

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 45°F for water). During the heating mode, problems can occur if the hot water temperature in the heating coil has been set too low in an attempt to reduce energy consumption. Sometimes outdoor air brought in to provide sufficient ventilation may not be heated sufficiently to maintain thermal comfort.

In CAV systems, terminal or zone reheat coils are frequently used at or near the diffuser into a zone. Heat is often supplied by an electric resistance element, although a hot water coil or other heat source may also be used. The reheat coil is turned on or off to reheat cooled air just before it enters a room, in response to the setting on the room thermostat.

Microchannel coils have been used in the automotive industry for many years but have only recently been adapted to the HVAC industry. The coil components are joined together into a single coil using aluminum-zinc alloy brazing materials in a nitrogen-charged brazing furnace.

B. 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.

According to ASHRAE Standard 62.1-2013, it is generally preferable to keep relative humidity (RH) below 65% in office facilities. Office buildings located in cool climates and that have high interior heat gains, thermally efficient envelopes, and economizer cooling may require humidification to maintain relative humidity within the comfort zone. When humidification is needed, it must be added in a manner that prevents the growth of microbiologicals within the ductwork and air handlers.
Steam humidifiers should utilize potable water, rather than treated boiler water, so that occupants will not be exposed to boiler treatment chemicals. Systems using media other than potable water must be rigorously maintained in accordance with the manufacturer’s recommended procedures to reduce the likelihood of microbiological growth.

Mold growth problems are more likely if the humidistat set point located in the occupied space is above 45%. The high limit humidistat, typically located in the ductwork downstream of the point at which water vapor is added, is generally set at 70% to avoid condensation in the ductwork (with a potential for subsequent mold growth). Adding water vapor 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.

C. Filters, Filtration, and Filter Beds

Filters are primarily used to remove particles from the 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).

In its User’s Guide for ANSI/ASHRAE Standard 52.2-2012, NAFA defines MERV as “a single number that is used, along with the air velocity at which the test is performed, to simplify the extensive data generated by the method of testing. MERV is expressed on a 16-point scale and is derived from the PSE for each of the three groups.” See Table 2-1.

Low-efficiency filters (ASHRAE Dust Spot rating of 10% to 20% or less) are often used to keep lint and dust from clogging the heating and 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 the 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.

In buildings that are designed to be exceptionally clean, designers may specify that the equipment utilize both a medium-efficiency pre-filter and a high-efficiency extended-surface filter (ASHRAE Dust Spot rating of 85% to 95%). Some manufacturers recommend high-efficiency extended-surface filters (ASHRAE Dust Spot rating of 85%) without pre-filters as the most cost-effective approach to minimizing energy consumption and maximizing air quality in modern HVAC VAV systems that serve office environments.
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 the 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 a 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. Large HVAC systems may have four or more filters arranged in a filter bed occupying the entire cross-sectional area of a duct.

Dry filters are commonly used in commercial building HVAC systems. The fine, closely packed strands of fabric or fiber intercept small particles of 0.5 to 5 micrometers. 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.

Table 2-1: Application Guidelines

<table>
<thead>
<tr>
<th>MERV</th>
<th>Intended Dust Spot Efficiency</th>
<th>Average Arrestance</th>
<th>Particle Size Ranges</th>
<th>Typical Applications</th>
<th>Typical Filter Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std 52.2</td>
<td>Std 52.1</td>
<td>1-4</td>
<td>&lt;20%</td>
<td>60 to 80%</td>
<td>&gt; 10.0 µm</td>
</tr>
<tr>
<td>5-8</td>
<td>&lt;20 to 60%</td>
<td>80 to 95%</td>
<td>3.0 - 10.0 µm</td>
<td>Industrial Workplaces Commercial Better/Residential Equipment Protection</td>
<td>Pleated Filters Extended Surface Filters Media Panel Filters</td>
</tr>
<tr>
<td>9-12</td>
<td>40 to 85%</td>
<td>&gt;90 to 98%</td>
<td>1.0 - 3.0 µm</td>
<td>Superior/Residential Equipment Protection Better/Industrial Workplaces Better/Commercial Buildings</td>
<td>Non-Supported/Pocket Filter/Rigid Box Rigid Cell/Cardtridge V-Cells</td>
</tr>
<tr>
<td>13-16</td>
<td>70 – 98%</td>
<td>&gt;95 to 99%</td>
<td>0.30 – 1.0 µm</td>
<td>Smoke Removal General Surgery Hospitals &amp; Health Care Superior/Commercial Buildings</td>
<td>Rigid Cell/Cardtridge Rigid Box/Non-Supported/Pocket Filter V-Cells</td>
</tr>
</tbody>
</table>

Note: This table is intended to be a general guide to filter use and does not address specific applications or individual filter performance in a given application. Refer to manufacturer test results for additional information.

(1) ASHRAE does not have a test procedure for HEPA testing and has thus dropped the MERV 17 – 20 classifications.

(2) ANSI/ASHRAE 52.1 ranges are provided for reference only. The ANSI/ASHRAE 52.1 Standard was discontinued as of January 2009.

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.

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. Gaseous filters must be regularly maintained (replaced or regenerated) in order for the system to continue to operate effectively.

- 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 microbiologicals.

D. Condensate Drains

Dehumidification can only take place if the chilled fluid is maintained at a cold enough temperature (generally below 45°F for water). Under these conditions, condensate collects in the drain pan under the cooling coil and exits via a deep seal trap. Standing water will accumulate if the drain pan system has not been designed to drain completely under all operating conditions (sloped toward the drain and properly trapped). Under these conditions, molds and bacteria can proliferate unless the pan is cleaned frequently.

It is important to verify that condensate lines have been properly trapped and are charged with liquid. 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 odor.
- 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).
E. 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. In some cases, a porous lining or insulation layer may be present on the inside or outside of the pan to prevent further condensation.

F. P-Traps

A trap is used to isolate the drain system from the condensate pan by creating a water barrier at the base of the 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 (on a draw-through unit) from the drain line (and possibly a connected sewer). ASHRAE provides recommended dimensions for traps to allow proper drainage in both draw-through and blow-through situations.

Two significant conditions are commonly associated with improperly trapped condensate drains, and they depend on whether the drain is under positive pressure (downstream of the supply fan) or negative pressure (upstream of the supply fan). In cases where a trap is not adequately designed and installed and under negative pressure, there is a chance that the condensate pan may not drain properly. Also, if a poorly designed or installed drain is in close proximity to a contaminant source (such as a sewer vent), contaminants may be sucked into the HVAC system.

On some air handlers, there may be multiple condensate drains or fittings for the installation of the drains. The inspector should check to ensure the drain is connected to the lowest fitting present in the condensate drain pan. This will permit the pan to drain to a lower level and prevent it from holding water.

Some air handlers have condensate drains for both the cooling coil and the heating exhaust stack. Condensate drains are common on high efficiency heaters. Some manufacturers recommend that the two condensate drains be connected together prior to running the condensate drain to the building drain or condensate pump. If this condition exists, the inspector should ensure that the drains are plumbed as recommended. There should be a trap in the heating stack condensate drain before it connects to the cooling coil condensate drain. This will help prevent combustion gases from being inducted into an air handler under certain circumstances. The condensate drains must always be installed in accordance with the manufacturers’ recommendations.

- 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.

- 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.
- Where unit drains are plumbed to floor drains, the floor drains should also be checked.
- Trap primers are sometimes used to ensure that the traps do not dry out during the heating season.
G. Dampers

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

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. Blades in box dampers may be aligned either horizontally or vertically.
- **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. Fire and smoke dampers can be triggered to respond to indicators such as high temperatures or signals from smoke detectors.

- If the outside air intake has a bird screen, the screen should be unobstructed (e.g., 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 inspection to see that it is at the proper setting. Actuators should be operational and dampers should seal well when closed.
- Many HVAC designs protect cooling coils by closing the outdoor air damper if the airstream temperature falls below the set point of a freezestat. Inadequate ventilation can occur if a freezestat trips and is not reset or if the freezestat is set to trip at an excessively high temperature.
H. 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. The damper blade stack closes automatically when a temperature-sensitive fuse link detects elevated temperatures. The blade stack consists of interlocking portions of blade arranged in accordion-fashion at the top of the damper frame.

There are two primary categories of fire dampers:

- Static fire dampers close when the HVAC system blower is not running.
- Dynamic fire dampers close when the HVAC system blower is running and will close under maximum rated airflow.

In addition to these two categories, there are three basic design types:

- In an A-type fire damper, the blade stack is located at the top of the frame and protrudes into the air stream.
- In a B-type fire damper, the blade stack is located in a channel at the top of the frame that keeps it out of the air stream.
- For higher pressure systems, a C-type damper is used that includes a transition plate and collar to keep the blade closed at the higher pressures or flows. Collars are available in round, rectangular, and oval configurations.

Note that both A and B-type dampers are for low pressure systems (generally less than 3 inches w.g.).

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

I. Fans & 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. Elements of the building construction can also serve as part of the air distribution system, as discussed in Section 3.2 G. Proper coordination of fan selection and duct layout during the building design and construction phase, combined with ongoing maintenance of mechanical components, filters, and controls is necessary for effective air delivery.

Fan performance is expressed as the ability to move a given quantity of air at a given resistance or static pressure (measured in inches of water column). 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.

It is common to find some differences between the original design duct layout and the final installation, as ductwork must share limited space with structural members and other “hidden” elements of the building system (e.g., electrical conduit, plumbing pipes). 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 found 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. These are the most common type in commercial buildings and are in most residential units.
- **Backward-inclined flat fans**—this fan type has a unique feature—a non-overloading characteristic. This means that the horsepower required by the fan actually decreases when the flow rate increases past a certain point.
- **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.

Supply fan chambers should be clean and free of trash and storage items.
- Check the fan blades for cleanliness and any signs of corrosion problems.

### J. 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 the 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

All of these systems have been discussed above as individual components.

The sources of heating or cooling fluids used in AHUs are generally boilers or chillers in central systems in large buildings. In some designs, small decentralized units are used to provide cooling or heating to interior or perimeter zones. Moreover, in smaller buildings, packaged (also called self-contained or unitary) equipment supplies both heating and cooling by means of electricity or natural gas. Such packaged units use air or water direct expansion (DX) systems (i.e., the refrigerant vapor-compression cycle used in household refrigerators). Packaged heat pump units reverse this process in the heating mode to provide space heating.
Packaged units are built at the factory and contain all the components required to deliver heating or cooling to a building: cooling coil, heating coil or furnace, air filters, supply air fan, dampers, condenser, and compressor. Some designs separate the main HVAC components from each other. A split-system DX (Direct Expansion) unit splits the hot side from the cold side of the system. In a typical split system, the fan, indoor coil, furnace, filters, and dampers are in one assembly (the indoor unit) and the compressor, condenser, and outdoor coil are in another assembly (the outdoor unit). This approach has evolved over the years because it has low costs, and also because it normally results in reduced noise inside the building or house (at the expense of increased outside noise).

One efficient application of packaged equipment is a rooftop air conditioner. This is an air-cooled unit that can be mounted on a roof. Packaged rooftop units have generally been applied to low-rise buildings of one to two stories, although they may also be used in larger buildings to serve a single zone, typically in a VAV system.

Self-contained or split systems are often used to control conditioned space for computer rooms and other spaces requiring precision control of temperature and humidity. These systems are available in above-the-ceiling units, high-density rack enclosure systems, wall-mounted, floor-installed, stand-alone, and rooftop-mounted units. Stand-alone and rooftop units can range in size up to 60 tons of air conditioning.

K. Ducts

Ducts are used to distribute conditioned air throughout a building and to 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.

A more thorough discussion of duct materials is presented in Section 3.4.

- Self-contained or packaged units seldom supply outdoor air. Outdoor air ventilation requirements must be met by other means (e.g., windows, doors, infiltration).
- Packaged units are typically considered a low-priority maintenance item. If these units are overlooked during maintenance activities, it is not unusual for them to become a significant source of contaminants.
- Air handlers that are located in difficult-to-access places (e.g., in places that require ladders for access, have inconvenient access doors to unbolt, or are located on roofs with no roof hatch access) will be more likely to suffer from poor air filtration and lack of overall maintenance.

- 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 housekeeping practices in the occupied space.
- Problems with biological pollutants can be prevented by minimizing 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.
L. 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.

Loose or batted fiberglass is often used on the outside of metal ducts for insulation purposes. Duct board has fiberglass insulation on the interior that is uncovered and exposed to conditioned air. A double-walled (DW) lined duct has an inner and outer metal surface that has fiberglass sandwiched between these metal surfaces. A DW lined duct is considered in the porous family (i.e., can be penetrated by moisture) if it is not continually sealed on the inside wall.

- Check for continuous seals on the inside walls of DW-lined ducts.
- Check for evidence of water condensation, such as musty odors or rust.

M. Zone Mixing Boxes

Zone mixing boxes are used to mix room air with supply air and then distribute the mixture to the conditioned space. Room air is drawn up into the box by a small fan, mixed with supply air, and then blown out to one or more diffusers in the zone. A VAV mixing box is equipped with a VAV damper and sometimes a reheat coil. The fan/motor unit may be arranged either in parallel with the supply air damper or in series with the supply air damper.

Induction boxes are another form of mixing boxes. In this case, high pressure supply air (usually as high as 2.5 inch w.g.) flows through a modulating nozzle, creating a vacuum that pulls in recirculated room air, mixes these two air streams, and then blows the mixture out to zone diffusers. As the call for supply air is reduced, the nozzle closes down while the recirculated air damper opens—thus maintaining a nearly constant flow of air to diffusers while adjusting delivery temperature.

- Ensure that mixing boxes are fully accessible for inspection.
- Check the fan, filter, and coil of mixing boxes for cleanliness and proper operation and control.
N. VAV Boxes

VAV systems meet changing load requirements by adjusting the amount rather than the temperature of chilled air that flows to a zone. Each zone has a thermostat that controls the airflow via dampers (movable plates that obstruct airflow) in a VAV box. The dampers have adjustable minimum and maximum settings.

Some VAV boxes also have reheat coils to warm the air in the event the minimum flow provides too much cooling. VAV boxes typically cover a large area with several spaces that have a similar cooling load.

As discussed above, other design options for VAV boxes are fan-powered mixing boxes and induction boxes.

- Check that minimum and maximum settings are operational.
- Housing interiors should be clean and unobstructed and temperature controls should be working.

O. 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.
P. Grilles and Registers

Thermal comfort and effective contaminant removal demand that air delivered into a conditioned space be properly distributed within that space. Terminal devices are the 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. The number, design, and location (ceiling, wall, or floor) of terminal devices are very important. Done incorrectly, they can cause an HVAC system with adequate capacity to produce unsatisfactory results, such as drafts, odor transport, stagnant areas, or short-circuiting.

There are slight 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.

Q. Diffusers

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.

A properly operating diffuser spreads the supply air out along the ceiling nearly as far as the wall (or halfway to neighboring diffusers) before the air begins to drop into the space. “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 the 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.

Some diffusers are built directly into other components, such as light fixtures. A linear diffuser comes in the form of a long narrow slot or opening. These diffusers may have single, double, or triple slots; form straight, curved, or arched lines; and can be ceiling- or wall-mounted. Advanced diffuser designs are built to ensure adequate air distribution even at low supply airflow, such as with VAV systems.

- 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.
R. HVAC Controls

HVAC systems can be controlled manually or automatically. Most systems are controlled by some combination of manual and automatic controls. The control system can be used to switch fans on and off, regulate the temperature of air within the conditioned space, or modulate airflow and pressures by controlling fan speed and damper settings.

Most large buildings use automatic controls, and many have very complex and sophisticated systems. Regular maintenance and calibration are required to keep controls in good operating order. All programmable timers and switches should have “battery backup” to reset the controls in the event of a power failure. In many cases, large facilities may have a central control room located off-site. It may be necessary to coordinate with this control room during the inspection.

S. Sound Attenuators

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

Two general types of attenuators, or silencers, are used in HVAC systems: passive and active. 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; instead, concentric duct sections are formed and the interior space is filled with a sound-absorbing material, such as fiberglass. The interior duct is perforated to allow the sound to penetrate the absorbent material.

The second general type of silencer is an active silencer, which uses active noise cancellation (ANC) techniques. These systems, located on the exterior of ducts and fan housings, use a microphone to sample sound, a signal processing computer to analyze the sound and synthesize an inverse sound wave, and a speaker to project the inverted sound wave and cancel out the original sound.

- Check that thermostats are properly located, are not placed outside of occupied space (e.g., in return plenum), and are not affected by heat from nearby equipment.
- Test whether the thermostat is working by setting it to an extreme temperature and observing the response.
- Check air filters located upstream of ducts with acoustical liners to ensure adequate particulate control.
- Look for areas of duct lining that may have become contaminated with microbiological growth.

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- Look for areas of duct lining that may have become contaminated with microbiological growth.
T. Mist Eliminators

Mist eliminators are commonly associated with humidification equipment in HVAC systems. Humidity may be added to conditioned (normally heated) air in a number of ways, including by the use of high-pressure spray atomization and compressed air atomization. These systems produce comparatively large water droplets that do not readily evaporate in the space available in typical AHUs. Therefore, these droplets must be taken out of the air by mist eliminators.

- Check that mist eliminators are straight, clean, with no carryover of water into downstream ducting.
- If water gets past the mist eliminator into an unsealed or un-drained portion of the duct, microbial growth will likely result.

Mist eliminators in HVAC systems typically employ inertial impaction droplet capture mechanisms. In baffle-type units, water droplets impinge on baffle walls as the supply air changes direction. Baffles may be either “zigzag” or “slanted” in design. Water drips down the baffle walls to a collection pan below. Like condensate drain pans, these pans must be sloped and drained properly to avoid microbial growth.

3.4 DUCT TYPES

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.

A. 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.
B. 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.
- Double-wall (DW) lined duct has a fiberglass lining sandwiched between an inner and outer metal layer.
- DW-lined duct is in the porous family if it is not continually sealed on the inside wall.

C. Duct Board

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

- In areas where a thermal liner or fiberboard has become water soaked, replacement is required. Correcting the problems that allowed the ductwork to
D. Flex

Flex ducts may have a foil exterior reinforced with fiber scrim. 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.

• Air distribution problems can occur, particularly at the end of duct runs, if departures from the original design increase the friction in the system to a point that approaches the limit of fan performance. Inappropriate use of long runs of flexible ducts with sharp bends causes excessive friction.

Flex duct

E. 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.

F. Wall Voids

As discussed in Section 3.2 G, elements of building construction can also serve as part of the air distribution or return system. Pressurized supply plenums or return air plenums can be located in the void space of walls, above ceiling tiles, or below the deck of a floor. It is important to maintain the integrity of the walls and ceiling in areas that are designed to be exhausted, such as supply closets, bathrooms, and chemical storage areas.

• Excessive leakage may occur at the diffuser/light fixture interface in troffer-type diffusers. If installed in a return plenum, such leakage has been known to cause gross short-circuiting between supply and return, wasting much of the conditioned air.
G. Transite

Transite is a trade name for asbestos cement. These ducts are sometimes used in high-temperature applications, such as fume hood exhaust and sub-slab HVAC systems. These systems should be treated as asbestos-containing material (ACM) for purposes of inspection, repair, or cleaning. They should not be cut into or damaged in any way.

H. PVC

Polyvinyl chloride (PVC) duct pipe is corrosion-resistant. It is generally produced by seamless extrusion in circular sections that are 6 to 24 inches in diameter. PVC duct pipe has a maximum operating temperature of 140°F. Because of its resistance to chemical attack, it is often used in fume hood installations for local exhaust purposes in chemical laboratories.

I. CPVC

Chlorinated polyvinyl chloride (CPVC) duct pipe is also corrosion-resistant. It has a maximum operating temperature of 200°F making it ideally suited for fume handling systems with elevated temperatures.

- Check to ensure that no cracks or holes in the ducts from fume hoods or other local exhaust sources allow such exhausted contaminants to be released back into a wall void or occupied area.

- Check to ensure that no cracks or holes in the ducts from fume hoods or other local exhaust sources allow such exhausted contaminants to be released back into a wall void or occupied area.
Section 4: HVAC Systems & Indoor Air Quality

4.1 OVERVIEW

It is important for an inspector to understand how HVAC systems impact indoor air quality. Indoor air quality encompasses several variables and often requires many disciplines to provide a comprehensive evaluation. Inspectors may encounter indoor air quality issues during an inspection that require the attention and expertise of indoor air quality professionals such as Industrial Hygienists, Indoor Environmental Professionals (IEP) and test and balance firms. Inspectors must recognize what their specific qualifications are and not go beyond their area of expertise when it comes to understanding and identifying indoor air quality issues.

Indoor air quality is a catch all for a host of issues within a building. The EPA has published a number of documents on the subject, most of which can be found online and are a great source of information to aid in an investigation. According to studies conducted by the EPA and NIOSH, indoor pollutants can be up to 10 – 100 times higher than outdoor concentrations.

It is recommended that the inspector not come into an inspection with an already formed hypothesis as this will affect how he or she designs the investigation. Often, the ventilation system is the conduit or pollutant pathway rather than a source of pollutants and there may be multiple issues and sources of pollutants within the facility.

4.2. CAUSES OF INDOOR AIR POLLUTANTS

The following section provides a basic overview of some of the many causes of indoor air pollutants, some of which fall outside the scope of the inspection. As stated previously, inspectors are not indoor air quality experts and as such should reference recognized authorities on this topic including the EPA, CDC and NIOSH.

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

- Indoor air contaminants
  - Interior furnishings (off-gassing)
  - Chemicals (copying machines, toner & ink)
  - Janitorial closets (chemicals)
  - Perfumes

- Outside air contaminants
  - Smog
  - Airborne dusts
  - Pollen
  - Nearby building/vehicle emissions
  - Re-entrainment of exhaust air
  - Mist from cooling towers

- Equipment/component failures
  - Failing & deteriorated insulation
  - Failing, broken or worn belts
Improper Air Balance
Forced air heating and cooling should be balanced; generally speaking, the amount of air being delivered through the supply ductwork should be equal to the amount that is being drawn through the return side of the ductwork. If the two volumes are unequal, pressure imbalances can occur resulting in increased infiltration, back drafting of gas burning appliances and possible health and safety problems.

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 controls

Inadequate filtration
- Filter bypass or failure
- Low quality filter

Filtration
The filtration systems for most commercial buildings have been designed first to protect building equipment and do little to filter out fine particles. As a result, in most systems, dust will gradually accumulate in a ventilation system often remaining undisturbed until either an event loosens the dust causing it to blow out or the dust builds up to the point where the air begins breaking the dust loose.

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

Improper Air Balance
Forced air heating and cooling should be balanced; generally speaking, the amount of air being delivered through the supply ductwork should be equal to the amount that is being drawn through the return side of the ductwork. If the two volumes are unequal, pressure imbalances can occur resulting in increased infiltration, back drafting of gas burning appliances and possible health and safety problems.

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.
4.3 TYPES OF POLLUTANTS WITHIN HVAC SYSTEMS

There are a variety of types of pollutants that may impact indoor air quality including:

- Particulate: e.g., soot, dust and pollen
- Gas phase: e.g., Carbon Monoxide
- Aerosols: Solid or liquid airborne particles
- Bioaerosols: Airborne particles of biological origin
- Biological contaminants: Bacteria, fungi, viruses, animal dander, mites, etc.
- Fungi: e.g., molds, rusts, mildews, mushrooms & yeasts

4.4 HOW HVAC SYSTEMS IMPACT INDOOR AIR QUALITY

The following section provides a basic overview of some of the ways in which HVAC systems impact indoor air quality. HVAC systems may serve as pollutant pathways through the following:

**Supply Air**
- Dust, dirt and debris distributed through the supply air
- Microbial spores and MVOCs being distributed into the occupied space
- Failing/deteriorated insulation material being distributed into the air stream

**Return Air**
- Dust, dirt and debris drawn into the system from normal building use
- Pollutants from indoor maintenance activities drawn into the system
- Particulate drawn in from indoor construction activities

**Exhaust Air**
- Exhaust ducts leaking contaminants into the occupied space

**Make Up Air**
- Outdoor contaminants being pulled into the system

**Outside Air**
- Outdoor contaminants being pulled into the system
ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality provides guidance on how carbon dioxide levels impact indoor air quality. As an inspector it is important to be familiar with relevant standards and codes as indoor air quality issues may not be related to the ventilation system, but rather another building-related issue. For example, 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.

4.5 THERMAL COMFORT ISSUES

It is important to note that in addition to indoor air pollutants, thermal comfort falls within indoor air quality and may be a reason inspections are requested. Thermal comfort does not necessarily indicate an indoor air quality issue, but does have a place in the investigation. ANSI/ASHRAE Standard 55 – Thermal Environmental Conditions for Human Occupancy provides guidance on thermal comfort issues and is an important reference for this topic, including acceptable ranges for thermal comfort.

Below are the common factors in thermal comfort.

- 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.
Section 5: Pre-Inspection Tasks

5.1 OVERVIEW

Establishing the intended purpose of an inspection can be the single most important preparation for fieldwork. It will influence the scope of work and the estimate the inspector delivers, the tools and methods he or she chooses, the products that are delivered, and ultimately the overall satisfaction of the customer.

An important factor in establishing the purpose of the work is how well the inspector knows the client. If the inspector has a long relationship with the customer and is familiar with the building, the inspector’s professional judgment will go a long way to designing the inspection. It will also help guide the inspector in assessing the purpose of the inspection.

This section guides the inspector through the information collection process. Whether the inspector knows the client well or is meeting him or her for the first time, the questions outlined in this section can be helpful in gathering information and establishing a purpose for the inspection. In general, the information collection process will follow this model:

- The client will contact the inspector. The inspector should listen to the client to determine what he or she wants to learn from the inspection.
- The inspector should set up a time to meet with the client. During this meeting, the inspector will go over the types of questions outlined in this section.
- The inspector will determine with the client who the main point of contact will be for the facility and whether any other facility staff will be involved with the project.
- The inspector and client will review information about the building and its history. They may also arrange for a pre-inspection building walk-through.

All this information is collected so that the inspector has sufficient information on hand to draft a purpose statement that accurately describes the reason that the inspection is being undertaken. That purpose statement, along with a scope of work that will also be drafted, will be used by the inspector to guide his or her work and the drafting of the formal report for the client.

5.2 GATHERING PRE-INSPECTION INFORMATION

A. First Contact with Client

An inspection typically begins when a client contacts an HVAC inspector by phone to discuss a facility’s situation. Beginning with this call, the inspector should keep detailed notes about all information (discussions, observations, etc.) related to the case. During this first conversation, the inspector should gather as much information about the project as possible. This information will be used to prepare a proposal and establish a fee for the inspection services. These services will include the site visit, building walk-through, formal inspection, and inspection report.
The inspector should inform the client that such a proposal will be drafted and that the next step in the process will be a site visit where additional information will be collected and the proposal will be reviewed and approved. Though every project is different, a typical site visit will require about half of a day. This should be communicated to the client as part of the initial phone consultation.

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. The inspector will also use the visit to determine what tools and equipment will be required for the job and to confirm that the inspection can be completed in the timeframe outlined in the proposal.

### B. Client Interview & Site Visit

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. He or she should also use this time as an opportunity to clarify the client’s reason for requesting the inspection.

Table 5–2 lists several general questions that can be used to guide this conversation. It should be noted that these questions are only guidelines; this should not be considered an exhaustive list of questions to ask the client. Questions will need to be modified based on the situation, and follow-up questions may need to be asked based on the client’s response.

<table>
<thead>
<tr>
<th>Questions</th>
<th>How to use the information</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the purpose of the inspection?</td>
<td>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. This will give the inspector an overview of what the client is looking for and what the current status of the building is.</td>
</tr>
<tr>
<td>Have you received any complaints from building occupants? If so, what have they been?</td>
<td>This may help generate additional questions that will focus the inspection on a particular area or system.</td>
</tr>
<tr>
<td>Do you have any information about what may be causing any system problems that you’re experiencing?</td>
<td>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.</td>
</tr>
<tr>
<td>Is the system cleaned on a regular basis? When was it last cleaned?</td>
<td>This will give the inspector a general overview of how the system has been maintained.</td>
</tr>
<tr>
<td>What would you like to learn from the inspection?</td>
<td>This helps the inspector begin to define what areas of the system will need to be inspected and what the client is looking for.</td>
</tr>
<tr>
<td>What type of deliverables are you looking for?</td>
<td>This tells the inspector what type of deliverables (photos, samples, detailed field notes, etc.) should be collected.</td>
</tr>
<tr>
<td>Would you like recommendations to be included in the inspection report?</td>
<td>While the majority of clients will be looking for the inspector to make recommendations based on the inspection findings, some may have reasons that they do not want recommendations. The inspector should respect the wishes of the client and format the report accordingly.</td>
</tr>
<tr>
<td>How would you like the final report to be presented?</td>
<td>The inspector will learn whether the client would like the report to be presented in person or whether electronic submission of the document will be acceptable.</td>
</tr>
</tbody>
</table>

Additional example questions are provided on the “Client Interview Form” included as part of the Appendix.
C. Establishing a Formal Reporting Structure for the Project

While meeting with the facility manager to clarify the purpose of the inspection, the inspector 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.

In many cases, the client will be the person who makes contact with the inspector and who will continue on as the main point of contact throughout the inspection. In other cases, another individual will be designated as the main point of contact. This point of contact will typically be the person responsible for providing the inspector with information about the building and for accompanying the inspector as he or she inspects the HVAC system and its components.

Determining who will receive the inspection report (and information about observations made along the way) should also be discussed during this meeting. (This person may or may not be the same as the main point of contact.) The inspector should respect the decision that is arrived at and should not share information with other personnel who may inquire about observations and recommendations. Those individuals should be directed to the contact person determined during this meeting.

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. Operating personnel will most likely not receive inspection information/observations directly from the inspector.

D. Reviewing Building Information

After establishing a reporting structure with the facility staff, the inspector will begin to collect information about the building, its history, and its current condition.

Table 5–3 lists several general questions that can be used to guide this conversation. It should be noted that these questions are only guidelines; this should not be considered an exhaustive list of questions to ask the client. Questions will need to be modified based on the situation, and follow-up questions may need to be asked, based on the client’s response.

If little or no building documentation exists, the inspector will need to call on his or her experience to make observations and educated assumptions throughout the inspection. In these cases, the inspector should be sure to include a special note in the final report that states that no as-built documentation was available and that assumptions had to be made during the course of the inspection because of the lack of documentation.
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. This 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.

During the walk-through, the inspector should compare building drawings to installed systems and note any discrepancies on the drawings. The walk-through also provides an opportunity for the inspector to look for suspected problem areas as well as areas that invite detailed inspection. Information on ceiling heights, as well as the use of diffusers or other elements of ceiling design, should be collected. Observations about whether staff appear to be following established operating procedures, if they exist, should also be made.

Table 5-3

<table>
<thead>
<tr>
<th>Questions</th>
<th>How to use the information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are as-built drawings (blueprints) of the facility available?</td>
<td>This is vital as it provides the actual “map” to be followed. As built drawings are very important in the planning of an inspection, the determination of how long it will take, the assessment of access issues, etc.</td>
</tr>
<tr>
<td>What is the basic type of HVAC system that is operating in the building?</td>
<td>This information will provide initial insight into underlying issues, which is essential for organizing the inspection. It will also help guide safety and shut-down procedures.</td>
</tr>
<tr>
<td>Have any particulate accumulations been noted in the HVAC system?</td>
<td>This response will give the inspector ideas for potential starting points for the inspection.</td>
</tr>
<tr>
<td>Have any other issues been noted in or around the system?</td>
<td>This question encourages the inspector to describe all potentially relevant information, such as water leaks, spills, animals, chemicals, etc.</td>
</tr>
<tr>
<td>When was the building constructed?</td>
<td>This will let the inspector know what type of basic materials can be expected and whether any other structural issues exist that will help or hinder the inspection.</td>
</tr>
<tr>
<td>Have significant changes been made to the original structure?</td>
<td>Information about changes to the building will let the inspector know whether there is a likelihood of construction debris, pressurization issues, change of use issues, etc., that could impact cleanliness.</td>
</tr>
<tr>
<td>What is the facility currently being used for?</td>
<td>This prepares the inspector for encountering issues related to the use of the facility being changed over time.</td>
</tr>
<tr>
<td>What was the facility used for in the past?</td>
<td>Information about the building’s history prepares the inspector for issues related to previous uses of the facility.</td>
</tr>
<tr>
<td>Has the HVAC system been maintained according to any particular system?</td>
<td>This information provides clues about the level of cleanliness that can be expected for various systems and components.</td>
</tr>
<tr>
<td>Are maintenance records available for review?</td>
<td></td>
</tr>
</tbody>
</table>

Additional example questions are provided on the “Client Interview Form” included as part of the Appendix.

E. 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. This 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.

During the walk-through, the inspector should compare building drawings to installed systems and note any discrepancies on the drawings. The walk-through also provides an opportunity for the inspector to look for suspected problem areas as well as areas that invite detailed inspection. Information on ceiling heights, as well as the use of diffusers or other elements of ceiling design, should be collected. Observations about whether staff appear to be following established operating procedures, if they exist, should also be made.
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.

F. Formulating a Purpose for the Inspection

Based on the client interview, building documentation review, and the building walk-through, the inspector should write a purpose statement that will guide the inspection. This purpose statement takes into consideration everything from the reason that the client has requested the inspection to the observations made during the walk-through.

The purpose statement should be a short (one to five sentence), descriptive statement that summarizes the reason for the inspection. The purpose statement should not give an assessment or opinion of the facility’s condition. (Note that the purpose statement will be different from the scope of the inspection which gives a detailed overview of what will be examined.)

For example, a client may call an inspector in when he or she observes an excessive amount of dust collecting in one room of a facility. Occupants working in the room may believe that the dust is coming from within the HVAC system, while the client may believe that the dust is being caused by the frequent opening of a door that accesses the outside of the building. In a situation like this, the purpose statement may read something like this:

> The purpose of this inspection is to inspect the HVAC system serving the room in question and determine whether the system and its condition are contributing to the excessive accumulation of dust in the room.

Note that the purpose statement is quite specific in laying out what the problem is and what question will be answered by the inspection. Also note that while a more general purpose statement like “The inspection will determine whether the system is dirty” may not be inaccurate, it does not provide the level of detail that a purpose statement should include. In all cases, the purpose statement should be presented to and approved by the client before the inspector continues along in the process.
5.3 SCOPE OF WORK

After the purpose statement has been drafted and approved, the inspector can move on to writing the scope of the inspection. The scope will outline which systems will be inspected, what portion of those systems will be examined, whether any sampling will be done, and whether any additional inspection will be performed based on what is observed. Information about drafting a scope of work is included in this section.

A. Purpose of the Scope of Work

The scope of work is used by the inspector to define the parameters of the inspection he or she will perform. It involves the following steps, which are outlined in this section:

- reviewing plans and reports
- determining systems to be inspected
- determining where to inspect
- drafting the scope of inspection
- drafting the disclaimer statement

B. Reviewing Plans & Reports

An inspector should begin the process of creating a formal written plan by reviewing the general area in question on a copy of the building’s plans. Reviewing and marking the building plans should involve the following steps:

1. Make paper copies (in a manageable and readable size and format) of applicable HVAC plans. Notes can be made directly on these plans during study design and while in the field.
2. Work with the facility representative to determine whether the system has changed after the plans were written. Note any system changes on the paper copies.
3. Mark and outline the general spaces to be investigated. If, for example, there are complaints in a cafeteria area, start by marking out the cafeteria. Then also mark attached spaces such as kitchen and dishwashing areas.
4. Examine the boundary of the study area for penetration by ducts and plenums. Mark each of the following components with a different color: air supply, air return, separate exhaust (e.g. kitchen hoods). See Figure 5-3 for an example of how to create these markings.
5. Mark airflow direction with arrows.
6. Work back, upstream from the space in each of the duct systems serving the study space. Note system elements including turning vanes, mixing boxes, dampers, humidification equipment, and coils.
7. Work back to the air handing unit or fan serving the area back to the outdoor air intake.
8. With contrasting colors used to mark the space, work forward from ventilation hoods to air outlets or stacks, and from return air registers back to the AHU.
9. Mark areas where material deposition might be expected. These will be areas where the velocity of the air stream slows.
10. Locate additional system components outside of the duct system that can also affect air quality. Examples include cooling towers and air intake relief dampers.
Figure 5-3: Example of marking supply and return ducts serving inspection area.
C. Determining Systems to Inspect

Using the marked-up set of plans, the inspector should work with the client to identify which systems and portions of the systems will be investigated. In many cases, the client will be looking to the inspector for his or her professional judgment on this matter. In other cases, though, the client will offer guidance regarding which areas should be inspected. The inspector should respect these instructions and only examine areas that have been specified by the client.

Table 5-4 outlines NADCA’s recommendations regarding the minimum portion of a system that should be inspected in various situations. In all situations, a portion of ceiling or wall cavity plenums should be inspected to assess their cleanliness.

Outside of these recommendations, it is also wise for an inspector to remain aware of conditions near the HVAC system that may be affecting its performance. For example, if the VAV boxes under inspection draw air in from the ceiling plenum space, the inspector should be sure to examine the area within several feet of the intake. Conditions such as loose, flaking fire-proofing material and large amounts of dust could affect the HVAC system, even though they are not technically part of it.

D. Determining Where to Inspect

In very few cases will the client request that the inspector examine every inch of ductwork and 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

A representative number of visual observations should be made in each of these areas to adequately assess the condition of the ductwork. In a system with simple, relatively straight duct runs, only two to four access points may be required to adequately determine the condition of the ductwork. A more complex system with longer runs may require significantly more access points to adequately observe the system condition.

Additionally, the inspector may want to examine additional areas that the client and/or occupants have expressed particular concern over. The inspector should take these reports into account when determining the scope of an inspection and should consider including special mention of them in the scope statement. Listening to the client and noting his or her concerns can go a long way toward establishing credibility and a trusting relationship with the client.
E. Drafting the Scope of Inspection

The scope of the inspection defines its purpose, goals, and parameters. The purpose of the inspection along with any information collected during the site visit are used to draft the scope. The statement of scope can be considered the written plan that will guide the inspection. It must be presented to and approved by the client before any inspection work is done.

For example, the following scope could be used in a situation where a facility manager at an office building called in an inspector after receiving several complaints about temperature extremes and high humidity from occupants:

<table>
<thead>
<tr>
<th>Situation</th>
<th>Portion to Inspect</th>
</tr>
</thead>
</table>
| Complaint areas | ■ Inspect all air supply and ventilation systems serving the area.  
■ Inspect return air ducts if the supply and ventilation inspections either do not explain the problem or if they indicate that the return air system may be contaminated. |
| Inspecting an air supply system | ■ Always inspect the outdoor air intake and the entire AHU.  
■ Inspect the main trunk leaving the AHU and at least 10% of the branches leaving the main trunk.  
■ Note that a branch is considered to be inspected if the beginning and end of the run are examined and found to be problem-free and if there are no elements within the run that might cause concern. (See Figure 5-3) |
| During routine inspections where no local problems are indicated | ■ Inspect at least 10% of similar systems.  
■ For example, if a building is served by 10 AHUs with associated ducted air supplies, at least two of the AHUs and associated systems should be inspected. |
| When problems are found when inspecting a sample of similar systems | ■ Inspect more (or even all) of the similar systems.  
■ For example, if 2 of 10 identical hood ventilation systems serving an area are being inspected and are found to have heavy deposition, the inspector should almost certainly examine the remaining systems. |

Table 5-4

Scope of Inspection Services
An HVAC inspection will be performed at the Smith Office Building at the request of the facility manager.

The inspection will involve a visual inspection of all air handling units (AHUs) servicing the affected areas and 10% of the linear feet of ductwork serving those units. During the inspection, real-time monitoring of temperature and relative humidity will be done. Additionally, the inspection will examine whether water infiltration is contributing to the conditions being reported.

This inspection is being completed in order to assess the HVAC system with respect to temperature and humidity levels. This inspection is related to the investigation of the conditions reported within the office.
When writing the scope, it is good to keep the following in mind. The scope:

- Includes a short description of the facility and its current use. It does not describe the condition of the facility.
- Outlines which systems are part of the inspection and what portions of those systems will be examined.
- Notes whether any measurements will be taken and whether any sampling will be done. It identifies the measurements and sampling that will be performed.
- Notes whether additional areas may be examined based on what is observed during the original portion of the inspection.
- It typically concludes with the purpose statement that was drafted earlier in the process.

The scope is reviewed and approved by the client and is then used by the inspector to guide his or her work. When that work is completed and the final report is being written, the inspector uses the scope statement as the introduction to the final report.

**F. Drafting the Disclaimer Statement**

As states have different requirements and regulations regarding written disclaimers, it is very important that the inspector is aware of general liability issues and is certain about the propriety of any disclaimers before submitting any type of disclaimer statement to a client in connection with a proposed inspection.

While the scope outlines what will be inspected, a disclaimer statement should be drafted to outline what will not be inspected and what is not included during the course of the inspection. Once reviewed and approved by legal counsel, this statement should also be presented to, reviewed and signed by the client prior to the inspection taking place.

While the following items may be found in a disclaimer, it is crucial to remember that because laws regarding disclaimers vary from state to state not all disclaimers listed below are necessarily enforceable in every state and/or jurisdiction:

- The inspection is visual and is based on the conditions that exist in the system at the time of inspection.
- The inspection is not intended to include all systems and all components.
- The inspection report is not a guarantee or warranty.
- The inspector assumes no liability for mistakes or errors beyond the cost of the report.
- The inspection is not intended to reflect the value of the facility.

In addition to the actual wording of the disclaimer statement, inspectors also need to be aware of their state’s requirements which may include details such as font size and the actual location of any disclaimer statement on the proposal itself.

It should be noted that disclaimers may not protect the inspector from responsibility for any mistakes he or she may make or negligent work that he or she may perform. A disclaimer is intended to make clear the limits of the inspector’s accountability.
5.4 ENGINEERING CONTROLS

Prior to performing an inspection, the inspector must be aware of the safety issues related to performing the inspection. This section gives inspectors a brief overview of two major safety issues: the prevention of cross contamination and the assurance of worker safety. Additional information on both of these topics can be found in specialized publications, which are referenced in each of the following sections.

A. Cross Contamination

A major concern when inspecting an HVAC system is to ensure that no action the inspector takes causes cross contamination or leads to the dispersal of deposited contaminants. This issue will affect the equipment used and how the work is planned and conducted.

When performing any work that might release contamination, the inspector must contain contamination by using physical barriers and negative air pressure. Any materials released during work should be removed using equipment such as a HEPA-filtered vacuum. Selected equipment and techniques used to prevent cross contamination are described below. Additional details on how to prevent cross contamination can also be found in ACR, the NADCA Standard.

B. Impact Mitigation

Cross contamination precautions should be taken to avoid releasing contaminants into occupied spaces and to avoid mobilizing and dispersing contaminants during the inspection of HVAC systems.

C. Containment

Physical activity within an indoor environment is likely to cause a temporary rise in airborne particles. Work site containment methods, such as the installation of temporary containment walls, should be used to create a barrier between the work site and the rest of the building. The walls can be custom-assembled or are available as kits from several manufacturers. The extent of work site containment controls employed during an inspection is dependent upon the building use and the initial HVAC system contamination evaluation done during the building walk-through.

D. Equipment Maintenance

Tools, equipment, and instrumentation used during an inspection should be clean and must not introduce contaminants into the indoor environment or HVAC system. All equipment should be maintained in good working order, consistent with applicable industry standards and requirements. All equipment should also be serviced as needed throughout a project to limit possible cross contamination. In cases of severe microbial growth or in situations where hazardous substances are known to be present within the HVAC system, there should be an on-site hygiene/integrity inspection of the equipment.

E. Service Openings

When cutting access doors or service openings, special care should be taken to prevent cuttings from being released into either the occupied space or supply or return ducts.
F. HVAC Duct Pressurization

At a minimum, the HVAC system should be shut off during the inspection, or the portion of the system under inspection should be blocked off on the air supply side and at the supply registers.

In some cases (particularly where deposits are heavy), the ducts should be kept at an appropriate pressure differential relative to surrounding occupied space. The pressure differential may be achieved through the use of a negative air machine or similar device.

A negative air machine has a fan or blower, typically with HEPA and carbon filters, and is used to pressurize a room or area negatively to contain material mobilized during cleaning procedures. While this machine will collect dust and other materials, it is not intended to function as a vacuum cleaner. ACR, the NADCA Standard requires that a negative air pressure machine or similar device be used to keep the portion of the HVAC systems being serviced under a (negative) pressure differential.

G. Use of a HEPA Vacuum

If any materials are released during the course of the inspection, they should be removed using equipment such as a HEPA-filtered vacuum. A HEPA-filtered vacuum will filter the air that passes through it and will help the inspector achieve the 99.97% particulate removal at a 0.3 micron particle size standard as required by ACR, the NADCA Standard.

5.5 SAFETY CONSIDERATIONS

A. Smoke and/or Fire Detection Equipment

HVAC inspections should not impair, alter, or damage any smoke and fire detection equipment located within the facility or attached to and serving the HVAC system. When required, temporary modifications, alterations, deactivation, and reactivation of smoke and fire detection equipment may be necessitated. Special permits, code-required notification, or other related communications shall be the responsibility of the facility manager.

B. Inspection Program Safety Concerns

The Occupational Safety and Health Act of 1970 is a federal law that guarantees every working man and woman a safe and healthy workplace. Compliance with this law is mandatory for every employer and employee (with few exceptions).

While federal law requires compliance with all aspects of OSHA, this section will focus on those applicable to conducting an HVAC system inspection. More information on OSHA and safety can be found by contacting OSHA. The NADCA Safety Manual is also a valuable reference for those performing work on HVAC systems. It provides guidance on developing a safety program that complies with OSHA’s rules and requirements.
C. Personal Protective Equipment

**Foot Protection** - Work shoes need thick soles and ankle support. Steel toes will help protect an inspector’s feet from dropped objects. Laces (if applicable) should be tied tight, and any excess string should be tucked away. Heat-resistant soles protect against hot surfaces like those found on rooftops.

**Eye Protection** - Suitable eye protectors must be provided where there is a potential for flying particles, molten metal, liquid chemicals, caustic liquids, chemical gases or vapor, and/or potentially injurious light radiation to injure the eyes or face. Protectors must meet the following minimum requirements:

- Provide adequate protection against the particular hazards for which they are designed
- Be reasonably comfortable when worn under the designated conditions
- Fit snugly without interfering with the movements or vision of wearer
- Be durable
- Be capable of being disinfected
- Be easily cleanable
- Be kept clean and in good repair

**Respirators** - Each employer is responsible for air monitoring to identify the contaminants and their concentrations. In cases where employees risk exposure to dangerous, hazardous, or life-threatening contaminants or substances that exceed permissible exposure limits, respirators must be used in compliance with OSHA’s respirator standard. The OSHA standard requires employers to develop and implement a written respiratory protection program, with workplace-specific procedures that address the major elements of the program. The following records should be maintained:

- The number and type of respirators in use
- Employee training programs and attendance
- Inspection and maintenance reports
- Medical evaluations
- Fit testing records
- Medical certification that the employee is capable of wearing a respirator under his or her given working conditions

An approved respirator is one that has been certified jointly by the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) under the provisions of 30 CFR 11 or 42 CFR Part 84 (as of July 10, 1998). Every employee who wears a respirator must receive fitting instructions, including a demonstration and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits and seals properly.

Choosing the right equipment involves determining what the hazard is and its extent, choosing appropriate equipment, and ensuring that the device is certified. Equipment must be used pursuant to the conditions accompanying the certification.
The effectiveness of the fit of the face piece can be tested with one of the following:

- **Qualitative fit test**—involves the introduction of a harmless odoriferous or irritating substance into the breathing zone around the respirator being worn. If no odor or irritation is detected by the wearer, a proper fit is indicated.
- **Quantitative fit test**—offers more accurate, detailed information on respirator fit. It can involve introducing a harmless aerosol to the wearer while he or she is in a test chamber, the measurement of the ambient particulates in the air, or the recording of controlled negative-pressure measurements.

While the wearer performs exercises that could induce face piece leakage, the air inside and outside the face piece is measured for the presence of aerosol, ambient particulates, or pressure change to determine whether any leakage into the respirator occurs.

Employees need to be medically cleared to wear respirators before commencing use. A physician or other licensed health care professional within the scope of his/her practice needs to medically evaluate employees to determine under what conditions they can safely wear respirators. The OSHA Respirator Medical Evaluation Questionnaire is used for this determination.

OSHA’s respirator rule requires employers to provide training to all employees who must use respirators. The training must recur annually, or more often if necessary, and be comprehensive and understandable. As part of the annual training regimen, employers are required to ensure that each employee can demonstrate knowledge of:

- Selection criteria
- Medical evaluations
- Procedures for proper use
- Fit testing
- Maintenance procedures

All respirators must be maintained in a sanitary condition and inspected routinely before and after each use (with the exception of those respirators used for emergency escape and rescue). Respirators that do not pass inspection must be replaced or repaired immediately.

### D. Hazardous Communication Standard (HAZCOM)

OSHA’s HazCom requires that inspectors who may be exposed to hazardous chemicals be trained about the dangers associated with those chemicals and the protective measures that they need to take when working with those substances. Under HazCom, there are four major elements of compliance:

- Safety Data Sheets (SDS) obtained from the hazardous substance manufacturer or supplier
- Labels
- Training
- A written hazard communication program

When an inspector reviews the hazards of the products he or she is using, the difference between a physical and a health hazard should be noted. A substance presents a physical hazard if it is flammable, explosive, or reactive. A substance presents a health hazard if exposure to it can cause acute (immediate) or chronic (long-term) health problems.
E. Energy Source Lockout/Tagout

An energy source lockout procedure is used for isolating machines or equipment from their source of energy and affixing appropriate locks or tags to energy-isolating devices to prevent any unexpected energization, startup, or release of stored energy that could injure workers.

Workers engaged in the following activities are covered by lockout/tagout when the following conditions occur:

- The inspector must either remove or bypass machine guards or other safety devices, resulting in exposure to hazards at the point of operation.
- The inspector is required to place any part of his or her body in contact with the point of operation of the operational machine or piece of equipment.
- The inspector is required to place any part of his or her body into a danger zone associated with a machine operating cycle.

In the above situations, the equipment must be de-energized and locks or tags must be applied to the energy-isolation devices.

The inspector, with assistance from appropriate technical support (i.e. the client), will make a survey to locate and identify all isolating devices to be certain which switches, valves, or other energy-isolating devices apply to the equipment to be locked out. More than one energy source (electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other type) might be involved.

When the energy-isolating device cannot be locked out, the inspector must use tagout. When using tagout, the inspector securely attaches a tag to the energy-isolating device in a way that it will not be detached during the course of the inspection. All persons who might access the area should be informed of why the tag is being used and should be made aware that the tag should only be removed by the inspector who is examining the system.

Before lockout and tagout devices are removed and energy is restored to the machine or equipment, the authorized employee(s) must take the following actions or observe the following procedures:

- Inspect the work area to ensure that nonessential items have been removed and that machine or equipment components are intact and capable of operating properly.
- Check the area around the machine or equipment to ensure that all employees have been safely positioned or removed.
- Ensure that locks and tags are removed only by those employees who attached them.
- Notify affected employees after removing locks or tags before starting equipment or machines.

In the event a lockout device must be removed by anyone other than the person who installed it, the inspector and/or facility manager should take and document the following steps and present them in writing to the facility’s safety coordinator:

- Call the employee.
- Attempt outside plant contact.
- Notify the employee’s supervisor.
- Notify the facility’s safety coordinator or designate.
- Verify that the equipment is clear and it is safe to turn it on.
- Remove the lock.
Special circumstances exist when:

- Machines need to be tested or repositioned during servicing
- Outside (contractor or inspection) personnel are at the work site
- Servicing or maintenance is performed by a group (rather than one specific person)
- Shifts or personnel changes occur during servicing or maintenance

F. Permit Required Confined Space Entry

A confined space is defined as one that:

- Has limited or restricted means of entry or exit
- Is large enough for an employee to enter and perform assigned work
- Is not designed for continuous occupancy by the employee

A permit-required confined space refers to those spaces that meet the above definition of a confined space and that also contain health or safety hazards, thereby requiring a permit for entry. Permit-required confined space has one or more of these characteristics:

- Contains or has the potential to contain a hazardous atmosphere
- Contains a material that has the potential for engulfing an entrant
- Has an internal configuration that might cause an entrant to be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section
- Contains any other recognized serious safety or health hazards

An inspector should not enter a permit-required confined space until a plan for doing so has been drafted and approved by the appropriate personnel.
SECTION 6: INSPECTION TASKS

6.1 INSPECTION TOOLS

A. Choosing Tools & Equipment

The choice of equipment and tools will vary between job sites and even within a single building. During the inspector’s site visit, he or she should have determined which pieces of equipment would be needed and which tools would be required to complete the inspection.

The equipment chosen for an inspection should cause a minimum amount of impact on the system. For example, using a push camera with a long focal length to examine long straight runs of duct minimizes the number of entry points that need to be created. Also, confined spaces like wall cavities may be best explored with a borescope or fiberscope. Their short focal length is sufficient for a confined space, and they offer the advantage of requiring small access ports.

Once tools and techniques are chosen, the inspector should ensure that supplies, including prefabricated access doors and plugs, will be on hand.

The inspection outlined in this manual is primarily visual. Depending on the facility and the systems under examination, an inspector may be called on to create new access ports into the system so that all systems and components can be observed. In addition to making basic visual observations, the inspector may also be called on to measure airflow, pressure, temperature, and humidity. He or she may also find it useful to collect samples during the inspection.

This section focuses on the equipment and instrumentation that an inspector may use during an HVAC inspection. (Supplemental information regarding sampling is included in the appendix of this manual.)

B. Basic Tools

Unless arrangements are made with the client to use some of the facility’s equipment, the inspector should bring the following items to use during the inspection:

- Ladders (several lengths, industrial grade)
- Screwdrivers – Phillip & flathead (for access panels)
- Allen keys (standard & metric)
- Pliers
- Hammers & mallets
- Wrenches – adjustable & open end box (for access panels)
- Socket set
- Nut drivers
- Flashlight (headlamps can be very useful)
- Retractable tape measure
- Drop cloth
- Portable HEPA vacuum

The tools an inspector will take to an inspection site will vary based on the areas being inspected and the sensitivity of the environment under examination.
C. Tools and Supplies for Installing Access Points

Unless an HVAC system has numerous access doors and ports already installed, it may be necessary for the inspector to install service openings so that visualization and airflow measurement equipment can be inserted.

The following tools are generally necessary for cutting holes for access openings and for drilling holes for the insertion of visualization equipment:

- Drill (cordless is best)
- Drill bits, including Phillips and slot screw
- Electric shears (best for cutting access openings)
- Hand shears
- Duct knife
- Flat file (for smoothing cut edges)
- Spare bits (common sizes)
- Spare batteries (for cordless tools)
- Battery charger (for cordless tool batteries)

The inspector should also carry the supplies needed to convert rough openings to permanent access points and to return the remainder of the system to the condition it was in prior to the inspection.

Necessary supplies include:

- Access doors—Metal panels used for closing service openings in the HVAC system should be the same gauge as or heavier than that of the surrounding ductwork.
- Access plugs—these are used for closing holes drilled for the insertion of visualization equipment (e.g., borescopes) or airflow measurement probes.
- Insulation edging

When installing access points, NADCA’s Standard 05-1997, Requirements for the Installation of Service Openings in HVAC Systems, should be followed. In some areas, the creation of a service opening may require a special license or qualification. Compliance with these state and local contractor licensing requirements is absolutely essential. An inspector should contact the state or local licensing board, department, agency, or registrar responsible for contractor licensing in order to determine whether the state or locality in which he or she is doing business requires a license for installing access points.
D. Basic Supplies

Supplies should be carried so that an inspector can make minor repairs, such as replacing access plugs or missing sheet metal screws. These supplies can also be used to replace fasteners damaged during the opening of access ports.

What follows is a list of suggested supplies:

- Access plugs
- Hole edging (to protect camera and borescope cables)
- Sheet metal screws
- Selection of galvanized bolts and nuts
- Insulation edging
- Mastic
- Duct tape
- Metal tape
- Scrim-faced tape
- NFPA fire-rated tape
- Metal strapping
- Wall anchors
- Zip ties

An inspector’s experience and the type of job site being worked on will determine the supplies that are carried.

E. Visualization Equipment

HVAC inspections almost always require the use of visualization equipment. The choice of equipment will vary between job sites and within a single building. The equipment chosen should be sufficient to detect anticipated problems and should also cause minimum impact on the system. See Table 6-2.

Remote equipment, which takes advantage of fiber optic cable’s capability to transmit images (light), is being used increasingly and is particularly useful in finding evidence of mold growth in hard-to-reach spaces such as wall cavities. Similarly, video cameras can transmit images through a cable and are useful for imaging hidden locations. Cameras have the advantage of capturing images for later use in analyses and for documenting remediation.
**Borescopes**
A rigid borescope is a long, thin, rigid rod-like optical device that allows an inspector to see into inaccessible areas by transmitting an image from one end of the scope to the other. A borescope works by forming an image of the viewing area with an objective lens. That image is transferred along the rod by a system of intermediate lenses. The image arrives at the ocular lens, which creates a viewable virtual image. The ocular can be focused for comfortable viewing.

Borescopes typically range from 6 to 16 millimeters in diameter and can be as long as 2 meters. They often incorporate a light near the objective lens that is used to illuminate the viewing area. This light source and the instrument’s focal length should both be kept in mind when choosing a borescope for use in an HVAC inspection. Also, an inspector should consider the overall design of the borescope. Different borescopes are designed to provide direct, forward oblique, right angle, and retrospective viewing of an area.

**Push Cameras**
Push cameras refer to a category of equipment that has been traditionally used for examining piping and sewers. They also lend themselves to duct investigations. They consist of a small camera head, a length of cable, and a viewing screen. Models can also include a video recorder for capturing images to document inspections.

**Robot/Camera Systems**
Robotic cars that carry cameras have been used for a variety of inspections in hard-to-reach areas and in hazardous environments. Some models offer pan-and-tilt operation in addition to lighting. These devices are useful for horizontal duct runs and have ranges of 100 feet or more.

**Digital Cameras**
Digital cameras can be used during an inspection to provide photo documentation of findings. Cameras equipped with zoom lenses are preferable. The zoom feature allows an inspector to capture an image at the magnification desired, rather than enlarging it later via a computer.

It should be noted that digital photographs may not be considered admissible evidence in some court proceedings. If an inspection is related to litigation (or potential litigation), an inspector should discuss the issue of digital photography with the client and determine what type of photographic deliverables are needed and in what format they should be supplied.
Additionally, the following newer technology can also be useful for performing inspections:

- Fiber optic scopes
- Video borescopes
- Cameras with Bluetooth technology
- Thermal & infrared cameras

Table 6-2: Visualization Tools

<table>
<thead>
<tr>
<th>Equipment or technique</th>
<th>Size of access needed</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct visual inspection</td>
<td>Large to very large</td>
<td>■ Best used in AHUs and where large access doors are present</td>
<td>■ Only viable where large access ports are present or installed</td>
</tr>
</tbody>
</table>
| Mirrors and Periscopes         | medium (need to insert device and light source) | ■ Low cost and simple use  
■ Good for initial inspections | ■ Require larger access than fiber 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 a borescope, and greater range                   | ■ Cables and wheel devices can stir up dust 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 feet or more  
■ Fewer access points needed  
■ Can travel from main to branch ducts  
■ Some models allow for use of camera alone in push 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 |


6.2 INSPECTION METHODS

This section directs an inspector through performing the inspection that he or she outlined in the scope of work discussed earlier. Before beginning the process, and inspector should be sure to have reviewed the safety information included in Section 5 of this manual.

Inspections should start at the outdoor air intake and then move in a progressive fashion through the rest of the system (e.g., the filters, AHUs, heating coils, cooling coils, supply air ducts, return air ducts, and exhaust ducts). The duct system should be diagrammed or traced out so that the connections and materials of construction are clear.

Please see the short case studies which follow for examples of how an inspector would determine the order in which systems/components would be inspected.

A. Accessing the System

After the scope is written and approved, the inspector will know where he or she will need to access the HVAC system. Often, the system can be accessed through existing openings, such as vents, grilles, and ductwork end caps. AHUs and furnaces often have factory-installed access doors.

For example, a single access port at either end of a long horizontal run can be sufficient enough to allow for a push camera to be inserted and used. In another example (Figure 6–3), the shaded duct is accessed through a dropped tile ceiling. Two access points are indicated by the drawn arrows at points #1 and #2.

If access cannot be gained through existing openings, it may be necessary to cut new openings in the HVAC system. In these cases, the inspector should follow the procedures and guidelines contained in NADCA’s Standard 05.

Figure 6-3:
Example of marking portion of system to be inspected and access points (shaded diagonal area).
**Background**
A mechanical contractor had just installed a new AHU in a commercial building that houses a biotech lab. The system utilized 95% final filters. Shortly after startup, a black residue formed on many of the supply diffusers served by that system. Based on the direction of the black streaks, the building owner believed that the residue was likely coming from the HVAC system.

**Initial Assessment (from client interview)**
The building owner speculated that the mechanical contractor (MC) had not properly installed the filters prior to startup, which allowed debris to “blow by” the filter rack and through the duct system where some of it stuck to the diffuser. The MC did not feel that this had happened, but had no other explanation for the residue. If “blow-by” was deemed the cause of the residue, the MC had agreed to be responsible for remediation costs and was assuming the burden of proof.

**Purpose**
The inspector was called on to deduce the source of the black residue by answering the following questions:
- Is the residue coming from the HVAC system?
- Is there a significant buildup of dust/debris on the supply side?
- If so, where is buildup found?
- Are there signs of “filter blow-by?”
- If not, then what other possible causes can be identified?

**System description**
The system in question is a constant volume single-zone system. It consists of an approximately 35-foot-long AHU located in a mechanical room on the fifth floor of the building. It utilizes 100% outdoor air and provides both heating and cooling. The ductwork is rectangular unlined metal with flex branch ducting connected to four-way ceiling supply air diffusers.

**Criteria**
Look for the following:
- Visible dust buildup that would not be expected in a new AHU.
- Dust patterns and the direction they indicate.
- The quantity of dust visible on the supply side.

Closely examining dust patterns can often point toward the source of the dust. If dust is being forced out of a small crevice, for example, an inspector would expect a pattern “fanning out” from any such crevices.

The amount of dust will be subjectively determined. A very thin light adhering dust film will be considered normal.

**Chain of communication and custody**
The MC is the paying client and agreed to allow all reporting and documentation to be provided directly to the building owner’s representative. It was agreed additionally that representatives of both involved parties may accompany the inspector who will communicate all observations, findings, and documentation openly to both parties.
**Documentation**
High resolution digital photographs will be taken of all the areas. A robotic video camera will be utilized if deemed useful to the inspection. Notes will be taken corresponding to the photographs.

**Inspection plan**
The inspection will begin at the outside air (OA) intake and will move downstream to supply diffusers.

All areas will be inspected in their entirety, except for the ductwork and diffusers. A representative area of those components (~10%) will be inspected.

The inspector should take pictures and notes. When appropriate, he or she should show the areas in question directly to the parties involved. No samples should be taken unless deemed important to fulfill the purpose. The internal HVAC conditions are to be documented and conclusions drawn as to account for them. No further recommendations are required.

<table>
<thead>
<tr>
<th>Area</th>
<th>How to access</th>
<th>How much to inspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>OA intake</td>
<td>walk-in</td>
<td>100%</td>
</tr>
<tr>
<td>filter rack</td>
<td>walk-in</td>
<td>100%</td>
</tr>
<tr>
<td>coil</td>
<td>walk-in</td>
<td>100%</td>
</tr>
<tr>
<td>fan</td>
<td>walk-in</td>
<td>100%</td>
</tr>
<tr>
<td>plenum</td>
<td>walk-in</td>
<td>100%</td>
</tr>
<tr>
<td>ductwork</td>
<td>access port</td>
<td>~10%</td>
</tr>
<tr>
<td>diffusers</td>
<td>occupied space</td>
<td>~10%</td>
</tr>
</tbody>
</table>

**Observations**
No dust streaks were seen at the filter rack. Significant dust streaks were seen on the plastic housings of the 95% filters. Significant dust streaks could be seen emanating from gaps in the V-shaped housings. Dust streaks were also seen at various AHU wall penetrations. The AHU walls were approximately 3” thick and contained an inner insulating material, probably fiberglass. There were large gaps observed at many penetrations such as sensors and motorized damper linkages. Dust streaks coming from these gaps were readily visible. The supply ductwork was deemed visibly clean as it contained virtually no dust.

**Conclusion**
The answers to the questions posed in the **Purpose** are as follows:
- Yes, dust is coming out of the HVAC system.
- There is significant build-up on the supply side.
- Build-up is found in the AHU and on the diffusers.
- There are no signs of filter “blow-by”.
- Other possible causes include **defective filters** and **AHU defects**.

**Recommendations**
Not applicable in this case.
Case Study #2

**Background**
A building engineer for a large commercial bakery and office building had received indoor air complaints from two office workers in the same area. They reported experiencing flu-like symptoms while at work. In response, the building engineer asked the company’s industrial hygienist (IH) what to do. The IH, who had previously only worked on the industrial side and who had never addressed issues on the office portion of the facility, decided to take swab samples for mold at the supply diffuser above the workers. The results came back with a half dozen species of mold found on that diffuser. None of the species found were known to be indicative of long-term moisture.

Understanding that mold spores are likely found on any and all surfaces indoors, the engineer nonetheless realized he had to investigate the mold issue. He called the HVAC inspector to find out if the HVAC system should be cleaned. The inspector suggested a visual inspection of the HVAC system in order to assess the extent to which it is likely to be a source of airborne mold spores in the indoor air.

**Initial Assessment (from client interview)**
It was agreed that suspect microbial growth was present and that it therefore would be expected to reside on a supply air diffuser as with any other surface. HVAC system cleaning (including possible application of anti-microbial products) might provide some benefit, but wouldn’t be deemed “necessary” unless significant visible mold was seen in the system.

Since mold was now officially suspected as possibly being “in” the HVAC system, it was deemed prudent to perform an HVAC inspection in order to rule it in or out as a source. It was further agreed that the lack of mold growth found in the HVAC system would not guarantee the lack of a mold problem — it would just point to other areas for further checking.

**Purpose**
The inspection will determine if the HVAC system contains visible mold growth.

**System description**
The system consists of a simple rooftop package unit connected to a duct board main duct and flex duct branches. The diffusers are four-way with a perforated screen. The system utilizes a ceiling plenum return.

**Criteria**
Look for the following:
- Visible mold growth

**Chain of communication and custody**
The inspector will provide all information to the building engineer. Observations and findings are not to be discussed with building occupants.

**Documentation**
High resolution digital photos will be taken and a robotic video camera will be used.
**Inspection plan**
The inspection will begin at the rooftop air handler and proceed downstream to supply diffusers. The air handler at the OA intake and filter compartment will be inspected. The main duct will be inspected at the drop and at the far end—approximately 50 feet.

<table>
<thead>
<tr>
<th>Area</th>
<th>How to access</th>
<th>How much to inspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>OA intake</td>
<td>exterior</td>
<td>100%</td>
</tr>
<tr>
<td>filter comp.</td>
<td>open door</td>
<td>100%</td>
</tr>
<tr>
<td>main duct</td>
<td>cut access</td>
<td>50%</td>
</tr>
<tr>
<td>flex duct</td>
<td>from interior</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Observations**
All areas appeared clean and normal.

**Conclusions**
The HVAC system does not contain significant visible apparent mold growth.

**Recommendations**
There seems to be no compelling reason to clean the HVAC system. Cleaning the system may provide some benefit, but resources are likely better spent elsewhere since no visible suspect microbial growth is evident in the system. If an IAQ problem is deemed to exist, then a professional, experienced in non-industrial IAQ, could be contacted for further evaluation of building.
B. What to Look For

The information presented in this section provides inspectors with guidance on what to look for with regard to each HVAC system component and the typical problem areas that should be inspected. These items are intended to provide an overview of most issues that may be encountered. This is not intended to be a comprehensive list of all the areas and components an inspector should examine.

It should also be noted that some dust or deposits are normal and will be observed in most commercial environments. The client should be made aware that slight levels of debris will likely be found but that its presence will not necessarily indicate the need for cleaning.

In all systems, the inspector should look at the AHU, paying particular attention to the following areas:

- Coils
- Condensate drain pans
- Drain lines
- Blowers
- Filter compartment
- Mixing dampers
- Plenums
- Heat exchangers
- Entire air passageway in the AHU

The inspector should also examine areas in the air stream of each system. Examples of these areas that should be looked at in each system include:

- The beginning and end of several branch ducts close to and farthest from the AHU
- Turning vanes
- Dampers
- Flex ducts
- Linear diffuser plenums
- Humidifier
- Sound attenuator
- Duct riser
- Low points in the system
- Diffuser
- Outside air damper and intake

The inspector should also make note of any structural changes in the duct system.

In addition to these general areas that should be examined on all systems, an inspector should pay particular attention to the following areas of specific systems.

**VAV system**
- Inspect for particulate and microbial contamination and debris in the VAV box.
- Check the coil and filter, if present, as well as dampers and insulation.

**Multi-zone system**
- Inspect for particulate and microbial contamination and debris immediately downstream of the AHU in each zone.
- Check middle and end of the main trunk line in more than one zone (both upper and lower zone).
Dual-duct system
- Inspect for particulate and microbial contamination and debris in both the hot and cold decks. (There is a higher likelihood of contamination in the cold deck so the inspection here should be more intense.)
- Also inspect the mixing box and single ducts downstream of mixing boxes. (In medium and high velocity systems, there should be more focus downstream of the mixing boxes.)
- The AHU inspection must include both hot and cold decks.
- In high pressure systems, the inspection areas are the same, although there should be more focus on the low pressure side as there is a higher likelihood for contamination on this side.

Heat pump
- If the heat pump is ducted, look in both the make-up air and return air sides.
- If there is a ceiling plenum return or supply, inspect the area around the intake as well as the filters.
- Also inspect for particulate and microbial contamination and debris in the following areas:
  - insulation
  - fan scroll and blades
  - make-up air filters
  - trunk downstream of the heat pump
  - reheat coils (if present)
- If there is a condensate pump, it should be tested to ensure operation.
- Check the pitch of the entire unit for adequate drainage.

Ceiling plenum supply
- Because this system typically operates with outside air intake, inspect for particulate and microbial contamination and debris in the:
  - intake screens and filters
  - duct discharge point above ceiling
  - fire proofing
  - make-up air duct
  - dampers
  - intake fans
  - internal insulation
  - reheat coils (if present)
- Look for missing ceiling panels and dust or debris on the ceiling surface and other horizontal surfaces.
- Check for microbial growth under water pipes and other potential water sources, including condensate pans.

Ceiling plenum return
- Inspect for particulate and microbial contamination and debris in ceiling insulation and fireproofing.
- As with the ceiling plenum supply, check for missing ceiling panels and dust or debris on the ceiling surface and other horizontal surfaces.
- Check for microbial growth under water pipes and other potential water sources, including condensate pans.
Diffusers and grilles

- Clean and clear obstructions on all diffusers and grilles.
- Determine the source of any excess dirt, dust or moisture.

Filters

- Check to make sure that the filter is installed properly (e.g., the arrow on the filter is pointing in the direction of the airflow).

C. Cleanliness Verification

ACR, The NADCA Standard outlines three methods for cleanliness verification. An inspector may need to use these methods for verifying cleanliness of HVAC system components.

Method 1 - Visual Inspection:
A visual inspection of porous and non-porous HVAC system components shall be conducted to assess that the HVAC system is visibly clean. An interior surface is considered visibly clean when it is free from non-adhered substances and debris. If a component is visibly clean then no further cleanliness verification methods are necessary.

Method 2 - Surface Comparison Testing:
The Surface Comparison Test may be used to determine cleanliness of both non-porous and porous HVAC component surfaces. The component’s surface conditions are evaluated by comparing visible characteristics of the test surface before and after implementing a specific procedure of contact vacuuming.

Method 3 - NADCA Vacuum Test:
The NADCA Vacuum Test is used for scientifically evaluating particulate levels of non-porous HVAC component surfaces. Using this procedure, a NADCA Vacuum Test Template is applied to the component’s airside surface. A vacuum cassette with filter media is attached to a calibrated air sampling pump and the open face of the filter cassette is passed over two 2 cm x 25 cm openings within the template.

For additional information on performing cleanliness verification, inspectors should reference ACR, The NADCA Standard.
D. Documenting Existing Conditions

The “HVAC Inspection Checklist” is included in the appendix of this manual and is intended to assist the inspector with collecting information as the inspection is performed. The checklist may not cover all variables that need to be considered, and (depending on the facility being inspected) may include too many variables or variables that are outside the scope of the inspection.

An inspector should use this checklist as a guideline and should add any additional fields that are necessary and remove any fields that are unnecessary. It is also recommended that inspectors who use the checklist arrange the sections of the checklist in the order that they will be completed. As the inspector looks at each area, he or she should use the checklist to make notes regarding system cleanliness and any factors that might be impacting that cleanliness.

For example, an inspector has been called in to an office to inspect the HVAC system and determine whether any conditions within the system may be contributing to respiratory irritation being reported by occupants. When examining the filters in the system under inspection, the inspector notices no excessive moisture on the filters but does notice a heavy layer of dust on some of the filters.

The inspector should use his or her checklist as follows:
The sample checklist is a good starting point that the inspector can use to begin collecting data. Everything observed during the inspection, though, may not be easily recorded as part of the checklist.

<table>
<thead>
<tr>
<th>Condition</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture/dampness: Not excessive?</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Filter loading: No excessive dirt/dust?</td>
<td></td>
<td>X</td>
<td>Filters in Room 206 Excessive loading.</td>
</tr>
</tbody>
</table>

Field Notes
For large issues and situations that require additional description, making detailed field notes is a much more effective way of collecting and recording information. An inspector should carry a notebook or electronic device in which he or she is able to record these longer, more descriptive notes.

In the situation where excessive filter loading was noticed, there may have been several additional related observations that the inspector wanted to note. Because all notes will not fit in the small space provided by a checklist, the inspector may need to take additional notes (such as the following):

Room 206:
Excessive filter loading noticed on all filters
Erratic airflow noted in same room
Facility manager noted that filters are changed sporadically
No samples collected
Field notes should include the following information:

- Where the situation was observed
- A description of the situation
- Information about whether a sample was collected or a measurement was done
- Information about any potential causes that were observed

Field notes, along with any information collected on the checklists, will provide the basis for the inspector’s report.

**Photo Documentation**
Cameras can be used during the inspection to capture images that can then be shared with the client. When combined with a description of the situation that is drafted based on field notes, photos can provide strong evidence of the condition of a system and its overall cleanliness. (See Section 6.2 for information about choosing an appropriate camera for use during HVAC inspections.)

**Sampling**
The need for sampling should be discussed during the inspector’s first meeting with the client, and the two parties should come to an agreement about the collection of samples. In general, an inspector should take samples only when he or she has been directed to do so by the client. (A discussion of basic sampling techniques and basic tests that can be performed on them is included in Appendix E of this manual.)

There are several reasons that sampling may be used:

- To prove the presence (or absence) of a microbe
- To determine if a site or material is a microbial reservoir
- To test settled dust for microbial content

Although sampling is not required by any government agency, insurance companies may ask for samples to be collected if a suspicious material is observed. If the inspector does not feel comfortable collecting samples, a qualified individual should be contacted to perform the sampling. Regardless of the reason the sampling is being done, a statistically valid number of samples should be collected to ensure the accuracy of the results. When collecting samples, an inspector should take digital photographs at each sample location and record a detailed description of each that should include:

- The time and date the sample was collected
- The person who collected the sample
- The temperature and relative humidity at the site
- Moisture meter measurements (if applicable)

Sample interpretation is the most difficult portion of the sampling process, and there are no established guidelines available for the interpretation of microbiological sample results. It should be noted that mold and bacteria are normally present in the environment. This can make it difficult for an inspector to accurately determine whether a surface or material is contaminated.

Whenever sampling is done, it is important that the inspector create and use “chain of custody” forms. These forms are used to track a sample as it moves from the person who collected it to the person who analyzes it. The use of such forms demonstrates the professionalism of the inspector. These forms are also essential to have on hand, if an inspection would ever be discussed in court.
Section 7: Post-Inspection Tasks

7.1 REPORTING THE INSPECTION FINDINGS

Because the report that an inspector drafts is the only physical deliverable that the client will receive, it is imperative that it is clear, accurate, properly organized, and well-written. In general, the report will review the purpose of the 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.

This section walks the inspector through all the steps needed to create and present an HVAC inspection report:

- Reviewing the information that was collected during the inspection
- Organizing the findings and drafting the report
- Summarizing the inspection and its outcomes
- Determining what recommendations are given
- Describing recommendations to the client in the report
- Presenting the report to the client
- Following up after the report is presented

A. Review of Information Collected

Before sitting down to draft the inspection report and outline recommendations for the client, the inspector should gather all materials that were used during the inspection. In general, the inspector will have accumulated the following information:

- Notes from the initial client interview
- Information from the building history discussion
- Notes from the building walk-through
- The purpose statement that guided the inspection
- The scope statement that outlined what was inspected
- Any field notes that were taken
- Any forms that were used during the inspection
- The results of any samples that were tested and measurements that were done
- Any photographs that were taken
- Any additional information gathered from discussions with the client

The inspector should collect all this information into one location and review all of it before beginning to draft the report.
In addition to collecting all these materials into one location, it should also be noted that the inspector needs to prepare for presentation any materials that will eventually be given to the client as part of the formal report. This may involve the following:

- Any field notes that were taken and that may be used in the report should be typed and organized.
- Any checklists that were used should also be reworked. Sections that were not used and/or were marked “N/A” during the particular inspection should be removed, and any notes taken on the checklists should be typed.

B. Organizing the Findings and Writing the Report

Although NADCA does not define a particular report format that inspectors must use, it does require that inspectors present clients with some type of formal written report at the conclusion of each inspection. The HVAC system inspection report should clearly convey the findings of the inspection, which will include visual observations, instrument readings, and sample analyses. There are several ways that an inspector can organize his or her report to achieve these goals.

For example, the report may include some or all of the following sections:

- Introduction
- Background, purpose, scope, and objectives
- Materials and methods
- Test results/findings
- Discussion of results
- Conclusions
- Recommendations
- References
- Appendices

The example report in the appendix of this manual illustrates one way that a report may be organized.

Drafting an outline that lists each of these sections, the sub-sections that will fall under them, and details that will be included in each sub-section can be helpful in organizing the report. Every report, regardless of what section headings are used and what type of sub-sections are created for it, will include three main portions:

- Summary of findings
- Body of the report
- Recommendations

Guidance on drafting each of these portions is included in the following sections.

**Summary of Findings**

Early in the inspection process, a purpose statement was drafted. This purpose statement summarized the reason for the inspection and was used to help draft the scope statement. The scope of the inspection, which was considered the written plan that guided the inspection, can be used in the final stage of the inspection as part of the summary of the inspection report.
The scope statement should have summed up the purpose of the inspection, what the client hoped to gain from the inspection, an overview of the building’s history and situation, and an overview of what the inspector looked at. With very few changes, the inspector can use this statement to begin the “Summary” section of his or her report to the client.

The “Summary” section can be continued with a description of what was found during the inspection and a broad overview of what recommendations will be given. When drafting this portion of the report, the inspector should keep the following guidelines in mind:

- The “Summary” should be relatively short— one to four paragraphs.
- It should briefly describe the main findings of the inspection. These findings should be stated as facts, not as subjective assessments. (For example, “A thin coat of dust was found on the turning vanes,” would be a factual statement. Descriptions such as, “The turning vanes were dirty,” should be avoided in the “Summary.”)
- The “Summary” should give an overview of the type of recommendations that are made in the report. It should not detail each recommendation.
- The “Summary” should clearly direct the client to read the entire report so that he or she is aware of the full range of findings and recommendations that have come out of the inspection.

**Body of the Report**
After the “Summary” section of the inspector’s report prepares the reader to learn more about the inspection and its findings, the body of the report presents those findings in an organized, factual manner. (It should be noted that recommendations based on the inspector’s findings are included in a separate portion of the report, which is discussed later in this section.)

This body of the report is an organized presentation of the inspector’s field notes. When drafting this section, the inspector should keep the following in mind:

- The section should be a factual presentation of what the inspector observed during his or her examination of the building. It should not include any assessments or recommendations.
- The findings should be organized in the order of their priority/severity.
- Any laboratory reports and data collected should be included in the report appendix.
- Any checklists used should also be included in the appendix (after any sections that were not applicable to the subject building are discarded).

**Recommendations**
Based on what the inspector observes during his or her inspection of the building, he or she must make recommendations to the client about steps that can be taken to improve the cleanliness. Making these types of recommendations is a delicate matter and is one that involves the inspector’s training, judgment, and experience.

Because this HVAC system inspection is designed to determine the cleanliness of a system, it is likely that many of the inspector’s recommendations will focus on whether the system or some of its components need to be cleaned.
The following guidance on making cleaning recommendations is drawn from ACR, the NADCA Standard:

- If significant accumulations of contaminants or debris are visually observed within the HVAC system, then cleaning is necessary.
- If evidence of microbial growth is visually observed or confirmed by analytical methods, then cleaning is required.
- If the HVAC system discharges visible particulate into the occupied space, or a significant contribution of airborne particles from the HVAC system into the indoor ambient air is confirmed, then cleaning is necessary.
- If heat exchange coils, cooling coils, airflow control devices, filtration devices, or air handling equipment are determined to have restrictions, blockages, or contamination deposits that may cause system performance inefficiencies, airflow degradation, or that may significantly affect the design intent of the HVAC system, then cleaning is necessary.

In addition to these basic cleanliness issues, the inspector may encounter other situations during his or her inspection that warrant being reported to the client. Table 7–1 lists many of the most common observations that an inspector will make and provides general examples of the types of recommendations and guidance that may be given to a client. This guidance will vary based on the severity of a finding and the type of facility under inspection.
Inspectors should keep in mind that each recommendation is made on a case-by-case basis. An inspector’s observations combined with his or her training, knowledge, and experience will prove invaluable in making these decisions.

**Table 7–1**

<table>
<thead>
<tr>
<th>Finding</th>
<th>Example Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent microbial growth in condensate drain pans, internal insulation, ductwork, or coils. (Growth may appear in the form of an accumulation of unusual looking dust with contrasting colors, a downy or furry surface, or a musty odor.)</td>
<td>Microbial growth within an HVAC system is a significant concern and should be a priority when making recommendations. Mold spores can be dispersed by HVAC systems, and according to the EPA, the dispersion of mold spores may result in itchy eyes and runny noses in sensitive individuals. While some moldy conditions are obvious, other situations may require the assistance of an industrial hygienist or another professional with experience in microbiological assessments to characterize the contamination. HVAC systems should be decontaminated in accordance with documents such as the New York City Department of Health’s Guidelines on Assessment and Remediation of Fungi in Indoor Environments, and ACR, the NADCA Standard.</td>
</tr>
<tr>
<td>Miscellaneous debris in the fan chamber, mixing plenum, or condensate drain pan</td>
<td>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. If significant loading is occurring, the inspector should try to determine if the cause is due to poor maintenance/cleaning or some other condition, such as filter bypass. While the EPA suggests monthly inspections of these areas, cleaning frequency should be based on the accumulation of particulate. Each system is different, but thorough cleaning should be performed at least annually.</td>
</tr>
<tr>
<td>Introduction of contaminants (sewer vent, vehicle exhaust, trash)</td>
<td>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 feet from fugitive emissions such as vents and local exhaust ventilation. Additional information about preventing induction of contaminants can be found in building codes, ASHRAE documents, etc.</td>
</tr>
<tr>
<td>Refrigerant leakage</td>
<td>Leaking refrigerants may contain irritants, asphyxiants, and toxins. Refrigerant leaks must be identified and repaired immediately.</td>
</tr>
<tr>
<td>Finding</td>
<td>Example Recommendations</td>
</tr>
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</tr>
<tr>
<td>Mist from cooling towers</td>
<td>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. Physical cleaning to prevent sediment accumulation and installation of drift eliminators may also be necessary based on the observed conditions.</td>
</tr>
<tr>
<td>Dust or dirt on diffusers</td>
<td>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. Diffusers should be cleaned with a HEPA vacuum or with a mild detergent.</td>
</tr>
<tr>
<td>Dust or dirt in ductwork</td>
<td>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. An inspector should determine why large amounts of dust, dirt, or mold accumulated in the system and correct the system failure. He or she should also recommend that the client earmark funds in the operating budget to allow for inspecting and cleaning of the ducts periodically.</td>
</tr>
<tr>
<td>Filter by-pass</td>
<td>Install the proper-sized filters. Also, seals are normally recommended for filters. Spacers, which are constructed of sheet metal or some other non-porous material, may be necessary if the filter rack is not completely filled by the filters. Wood should not be used for any component of an HVAC system.</td>
</tr>
<tr>
<td>Poor filtration</td>
<td>Many HVAC systems operate with low-efficiency filtration. This may be as a result of a designer or operator not being aware of the importance of HVAC system air filtration. Filtration efficiency should be matched to equipment capabilities and expected airflows. An inspector may want to refer the client to an air filtration professional who can determine if the filter efficiency of an existing HVAC system should be upgraded.</td>
</tr>
<tr>
<td>Finding</td>
<td>Example Recommendations</td>
</tr>
<tr>
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<td>--------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Improperly designed or installed systems, no outdoor air induction</td>
<td>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. A qualified professional should determine how to modify an existing system so that adequate outdoor air is properly distributed for each application.</td>
</tr>
<tr>
<td>Improperly designed or installed systems, insufficient or hindered access to system components</td>
<td>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. A qualified professional or manufacturer’s representative should determine how a system may need to be modified to allow access to critical components if the system was not designed for access or if installation of the equipment has blocked the intended access of critical components.</td>
</tr>
<tr>
<td>Poorly maintained system (e.g., belts missing)</td>
<td>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 odors.</td>
</tr>
<tr>
<td>Cooling coil condensate mist carryover to duct or filters</td>
<td>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. The inspector should also try to determine if modifications have been made to the system to increase airflow. Increasing the airflow in a system may cause moisture to carry over into the supply duct or filters depending on the configuration of the system. Moisture carryover is often the cause of microbial amplification in the first several feet of internally insulated supply ductwork. If this condition is observed, the cause of the moisture should be identified and corrected and any contaminated system components should be remediated in accordance with ACR, the NADCA Standard.</td>
</tr>
<tr>
<td>Finding</td>
<td>Example Recommendations</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Delamination of ducts</td>
<td>Delamination or erosion of fiberboard duct or internally insulated ducts may occur over time as the result of high velocity air passing over the surface. This condition can significantly reduce system efficiency and may lead to occupant complaints if fibers or other irritants are distributed throughout the facility. Damaged fiberboard duct or internal insulation should be repaired or replaced. If damaged materials need to be repaired, the inspector should reinforce that precautions need to be taken to prevent workers and occupants from being exposed to the hazardous chemicals used during the repair.</td>
</tr>
<tr>
<td>Damage to AHU insulation, usually from maintenance operations</td>
<td>Damage to the AHU’s internal insulation may cause the breakdown of insulation and lead to the distribution of irritants. All damaged insulation should be repaired or replaced.</td>
</tr>
<tr>
<td>Elevated relative humidity due to improper design, installation, configuration or operation</td>
<td>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 or control elevated relative humidity. Console dehumidifiers can be installed to control relative humidity until more permanent controls are in place. If all efforts to reduce relative humidity are unsuccessful, a qualified HVAC professional experienced in humidity control should evaluate the system.</td>
</tr>
<tr>
<td>HVAC system not balanced, insufficient outdoor air induction (little or no airflow, especially VAV systems with improperly set minimum)</td>
<td>Air distribution systems should be balanced to provide adequate ventilation air throughout the facility. ASHRAE Standard 62–2013 and other documents, provide minimum ventilation rates in breathing zones. If little or no air is being provided to the zone, there is a good chance that sufficient outdoor air is not being inducted.</td>
</tr>
<tr>
<td>Finding</td>
<td>Example Recommendations</td>
</tr>
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<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Building pressure problems (should be slightly positive to keep fugitive emissions out of the building)</td>
<td>In accordance with generally accepted design standards and mechanical codes, it is typical for commercial buildings to induct, filter, and temper outdoor make-up air to prevent the buildup of irritants in buildings. If the building is not kept at a slight positive pressure or if there is not enough make-up air/outdoor air brought into the building, there is an increased likelihood that fugitive emissions will be inducted into the facility. This is why outdoor air is brought into the building at a designated location to positively pressurize the building and prevent the unwanted induction of potentially contaminated, unfiltered, and untempered air. A qualified professional should determine if sufficient make-up air/outdoor air is being inducted and provide recommendations if needed.</td>
</tr>
<tr>
<td>Leaking condensate pans</td>
<td>Leaks in condensate drain pans could provide adequate moisture to facilitate the amplification of microbiological growth, especially when the water impacts porous materials such as ceiling tiles or drywall. Chronic leaks, if not repaired, may lead to occupant complaints. All leaks need to be repaired immediately and all wetted material should be dried in accordance with documents such as the EPA’s Mold Remediation in Schools and Commercial Buildings.</td>
</tr>
<tr>
<td>Improperly trapped condensate drains</td>
<td>Two significant conditions are commonly associated with improperly trapped condensate, depending on whether the drain is under positive pressure (downstream of the supply fan) or negative pressure (upstream of the supply fan). In a case where a trap is not adequately designed and installed and is under negative pressure, there is a chance that the condensate pan may not drain properly. Also, if a poorly designed or installed drain is in close proximity to a contaminant source (such as a sewer vent) it may be sucked into the HVAC system. The condensate drain must be installed in accordance with the manufacturer’s recommendations.</td>
</tr>
<tr>
<td>Chemicals or porous material stored in mechanical room</td>
<td>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.</td>
</tr>
<tr>
<td>Finding</td>
<td>Example Recommendations</td>
</tr>
<tr>
<td>--------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Exposure pathways to unconditioned spaces (penetrations)</td>
<td>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. Pipe chases, wire runs, and cracks in the wall may all contribute to the induction of irritants (dust, odors, untempered air, etc.). In many cases, these exposure pathways should also be sealed to prevent the spread of fire. For this reason it is important to use the proper sealant.</td>
</tr>
<tr>
<td>Improperly installed or malfunctioning humidifiers (water treatment chemicals used in humidifiers)</td>
<td>Humidifiers are a common source of moisture and are often found to be contributing to microbiological growth. If a humidifier is used, it must be properly installed and frequently inspected to ensure proper operation. Also, the inspector should ensure that any humidifiers are not using steam or hot water from a plant’s boiler. This water contains treatment chemicals that may irritate building occupants.</td>
</tr>
<tr>
<td>Thermostats lost, disconnected, or missing</td>
<td>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. If the current thermostat configuration is not adequate, the inspector may want to recommend that the client add additional thermostats that are capable of using the average zone temperature to activate the HVAC system.</td>
</tr>
<tr>
<td>Leaking or disconnected ducts or torn vibration collars</td>
<td>Leaking or disconnected ducts and torn vibration collars reduce HVAC system efficiency and could generate occupant complaints, especially if it appears the system is not properly balanced. In addition to reduced efficiency, disconnected ducts and torn vibration collars rob cooling and heating capacity from the system. All leaks in the air distribution system should be repaired.</td>
</tr>
<tr>
<td>Missing and stained ceiling tiles and missing return grilles</td>
<td>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.</td>
</tr>
<tr>
<td>Finding</td>
<td>Example Recommendations</td>
</tr>
<tr>
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</tr>
<tr>
<td>Supply and return short-circuiting</td>
<td>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. A qualified HVAC design engineer and an air balancing professional should evaluate these types of situations and make recommendations.</td>
</tr>
<tr>
<td>High velocity air blowing on occupant</td>
<td>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 .8 feet per second. If occupants are blocking diffusers due to high velocity air, the system design and balance should be checked to ensure there is not a design or balance problem.</td>
</tr>
<tr>
<td>No filters in VAVs</td>
<td>Filters are recommended in most air handlers because they help clean the air and prevent the accumulation of dust, both of which may pose a fire hazard. If filters were prescribed by the manufacturer for installation in VAV units, then the appropriate filters should be installed.</td>
</tr>
<tr>
<td>Leaking pipes at VAVs</td>
<td>Leaking pipes associated with VAV units are of concern because they may contribute to microbiological growth. Leaks are often associated with poorly insulated chilled liquid lines and malfunctioning valves. Ceiling tiles are often wetted when maintenance staff bleed pipes periodically. If ceiling tiles are wetted, they should be quickly dried or replaced. Chronic wetting of ceiling tiles may lead to microbiological contamination.</td>
</tr>
</tbody>
</table>
7.2 DESCRIBING RECOMMENDATIONS TO THE CLIENT

After an inspector has described his or her findings and decided which recommendations will be given for each, he or she must draft those recommendations. The following tips give guidance about drafting these recommendations:

- Present a recommendation for each finding that is described. Be clear and factual. The inspector should only provide an assessment of what should be done and how it should be done.
- Avoid offering opinions about the severity of the situation. Writing that the situation is a “hazard” or labeling something as “only being a minor issue” may prompt the client to respond (or fail to respond) appropriately to a recommendation.
- Consider the use of the building when making recommendations regarding cleanliness. What constitutes a “dirty” system and necessitates cleaning in one building may not do so in another building. For example, a thin coat of dust may not be acceptable for a client in a hospital setting, but it may be within the acceptable bounds set by a client at a manufacturing facility. Refer the client to a specialist when necessary. If the inspector observes a situation that falls under the scope of another HVAC professional’s area of specialty, he or she should avoid describing what specific action needs to be taken. Instead, the recommendation should explain that the client should contact the appropriate type of specialist who can then address the situation observed.

The recommendations included in the inspection report are what make the inspection valuable to the client. Time and care should be devoted to drafting this section.

7.3 PRESENTING THE REPORT TO THE CLIENT

This stage of the process can be as simple as mailing (or emailing) the report to the client. Presenting the report is best done, however, in person with all appropriate persons present. Presenting the report in person has the advantage of helping to ensure that the client understands what the report is stating.

The inspector must keep in mind how the report will be used. Many times, the client will be presenting the report to a “higher up” individual or another department in the organization. The client may also be another consultant who will be presenting the report to the building owner. The client may even be another contractor who is paying for the report to determine whether they are responsible for some kind of suspected contamination.

Also, the inspector needs to understand that conflict and “finger-pointing” are a possibility at this stage. Information gained from the inspection may even be seen as grounds for legal action. A fully informed client who understands the overall message of the report—including its limitations—will best be able to handle any political or organizational issues that arise.

In some situations, it is very 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 (or conversely, to put the client’s mind at ease that no such hazard was found at the outset of the inspection). It may be appropriate and helpful, for example, to email inspection text, pictures, or even video to a client soon after the items are collected if a suspected hazardous condition is driving the inspection.
At the discretion of the inspector, any such interim information should be clearly marked “Draft,” “Preliminary Findings,” etc. Steps like this must be taken to ensure that the information is not misconstrued as a finished product.

Depending on the various factors surrounding the inspection, it may be a good idea to present the report with visuals and possibly even in the form of a PowerPoint presentation. However, the inspector should stay cognizant of the sensitive nature of inspections and consider a more low-key, secure, and confidential method of presenting data if the situation warrants it. It cannot be emphasized enough that the inspector’s professionalism and credibility are perhaps never more on the line than during the reporting phase and how it is handled.

7.4 FOLLOWING UP AFTER THE REPORT IS PRESENTED

After presenting the report to the client, the inspector will have a good sense of whether the client plans to act on any of the recommendations outlined in the report. Ideally, the inspector will have developed a trusting relationship with the client and will be able to offer his or her time for additional follow-up consultations if the client is so inclined.

A client who has HVAC system cleaning done in response to an initial HVAC inspection might want to confirm that this cleaning was effective. The inspector should explain the value of using cleanliness verification methods as described in ACR, the NADCA Standard. These methods include a visual inspection, surface comparison testing, and the NADCA Vacuum Test.

Inspectors can also follow up with the client by referring them to specialists for particular areas of the system that appear to require remediation. For example, a client whose system is suspected of containing microbial growth should be referred to a professional who specializes in identifying and removing such growth. A facility found to have improperly balanced systems should be referred to an air balancer for additional follow-up in that area. The inspector should provide the client with references to other professionals as appropriate and serve as a general resource for a client who is interested in improving the overall cleanliness of a facility’s HVAC system.

7.5 ROUTINE INSPECTION FOR HVAC SYSTEM HYGIENE AND PERFORMANCE

After the inspection process is complete, inspectors can provide information on the importance and benefits of routine inspection for maintaining HVAC system hygiene, performance and efficiency and ventilation to meet occupant needs. ANSI/ASHRAE/ACCA Standard 180 was created to address the often inconsistent practices for inspecting and maintaining HVAC systems in commercial, institutional, and other buildings where the public may be exposed to the indoor environment.

According to Standard 180, in order to provide consistency and improve the thermal comfort, energy efficiency, and indoor air quality of commercial HVAC systems, a standard practice for their inspection and maintenance is needed. Standard 180 also states that when systems are not maintained, they do not continue to provide the level of work they were designed for. Therefore, routine system inspection is important and should be encouraged by the inspector.
A. References

**American Conference of Governmental Industrial Hygienists**
Bioaerosols: Assessment and Control

**American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.**
ANSI/ASHRAE Standard 62.1: Ventilation for Acceptable Indoor Air Quality
ANSI/ASHRAE/ACCA Standard 180

**Environmental Protection Agency**
Building Air Quality: A Guide for Building Owners and Facility Managers Indoor Air Quality Building Education and Assessment Model (I-BEAM) program Mold Remediation in Schools and Commercial Buildings

**Institute of Inspection Cleaning and Restoration Certification**
ANSI/IICRC S500 Water Damage Restoration
ANSI/IICRC S520 Mold Remediation

**National Air Duct Cleaners Association**
ACR, the NADCA Standard for Assessment, Cleaning, & Restoration of HVAC Systems
Requirements for the Installation of Service Openings in HVAC Systems

**National Air Filtration Association**
NAFA Guide to Air Filtration
Installation, Operation and Maintenance of Air Filtration Systems

**National Fire Protection Association**
NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems

**New York City Department of Health**
Guidelines on Assessment and Remediation of Fungi in Indoor Environments

**North American Insulation Manufacturers Association**
Standard AH 122 - Cleaning Fibrous Glass Insulated Ducts
Standard AH 116 – Fibrous Glass Duct Construction
A Guide to Insulated Air Duct Systems

**Sheet Metal and Air Conditioning Contractors’ National Association**
HVAC Duct Construction Standards
# B. Sample Client Interview Form

*(Note to the inspector: This is a sample form that has been created to assist during the interview process. This form should not be considered comprehensive, as it will need to be amended to incorporate site-specific issues for each inspection.)*

<table>
<thead>
<tr>
<th>Nature of the Call</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is call based on immediate complaint or problem?</td>
<td></td>
</tr>
<tr>
<td>If yes, does complaint or problem involve building occupants getting sick?</td>
<td></td>
</tr>
<tr>
<td>If yes, does complaint or problem involve a clearly identified issue with the HVAC system (such as insufficient airflow or temperature or humidity problems)?</td>
<td></td>
</tr>
<tr>
<td>If no, is there a longer-term chronic problem/complaint?</td>
<td></td>
</tr>
<tr>
<td>If no, does the problem involve known contaminants such as VOCs or hazardous materials?</td>
<td></td>
</tr>
<tr>
<td>If no, does the problem appear to be caused by poor performance of the HVAC system?</td>
<td></td>
</tr>
<tr>
<td>If none of the above, what is impetus for call (e.g., routine inspection, real estate transaction, due diligence)?</td>
<td></td>
</tr>
<tr>
<td>Do you want us to check the mechanical integrity of the HVAC system as well as its cleanliness?</td>
<td></td>
</tr>
<tr>
<td>What are your perceptions about the current status of the HVAC system?</td>
<td></td>
</tr>
<tr>
<td>Building &amp; Activities</td>
<td>Notes</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Which building(s) will be involved in this inspection? (If more than one, repeat questions for each building.)</td>
<td></td>
</tr>
<tr>
<td>When was building first constructed and put into service?</td>
<td></td>
</tr>
<tr>
<td>Has building been significantly renovated since it was first put in service (e.g., new wing or other floor space)? If so, what were dates and scopes of these modifications?</td>
<td></td>
</tr>
<tr>
<td>Has any other building envelope or system work been undertaken recently (specifically work on or near the AHU or the intake units)?</td>
<td></td>
</tr>
<tr>
<td>What activities take place in the building? Have there been any significant changes in space use over time (e.g., the addition or subtraction of laboratories, kitchens, printing operations, etc.)?</td>
<td></td>
</tr>
<tr>
<td>Do any activities generate dust, particles, or fumes?</td>
<td></td>
</tr>
<tr>
<td>Are there any special HVAC needs such as computer rooms, laboratory hoods, or kitchen exhausts?</td>
<td></td>
</tr>
<tr>
<td>HVAC System</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Is there more than one HVAC system in the building? (If more than one, repeat the following questions for each system.)</td>
<td></td>
</tr>
<tr>
<td>Is the HVAC system the same age as the building?</td>
<td></td>
</tr>
<tr>
<td>Have there been any significant modifications to HVAC system since its initial commissioning? If so, what were dates and scopes of these modifications?</td>
<td></td>
</tr>
<tr>
<td>Has system ever been cleaned before? If so, when?</td>
<td></td>
</tr>
<tr>
<td>Do you know what type of system it is?</td>
<td></td>
</tr>
<tr>
<td>CV or VAV? Single or multi-zone? Single or dual-duct? Local ventilation systems?</td>
<td></td>
</tr>
<tr>
<td>Where is location of outdoor air intake?</td>
<td></td>
</tr>
<tr>
<td>Does the ductwork have any internal linings?</td>
<td></td>
</tr>
<tr>
<td>If yes, In part or all of the system? How old is the lining?</td>
<td></td>
</tr>
<tr>
<td>Any duct board in the system?</td>
<td></td>
</tr>
<tr>
<td>Have any accumulations of dirt or debris been noted in the HVAC system?</td>
<td></td>
</tr>
<tr>
<td>HVAC System (Con’t.)</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Does the system include humidification equipment?</td>
<td></td>
</tr>
<tr>
<td>Has any moisture been noted in the system?</td>
<td></td>
</tr>
<tr>
<td>Does location of the outdoor intake seem to contribute to odors, particulate accumulation, microbial contamination, or moisture intrusion into the HVAC system?</td>
<td></td>
</tr>
<tr>
<td>Has there been a history of system breakdowns or a recurrent failure of components?</td>
<td></td>
</tr>
<tr>
<td>Is there a preventative maintenance program in place for the HVAC system?</td>
<td></td>
</tr>
<tr>
<td>Are drawings available for the HVAC system and, if so, who has these?</td>
<td></td>
</tr>
<tr>
<td>Can the HVAC system be turned off for purposes of the inspection?</td>
<td></td>
</tr>
</tbody>
</table>
### Occupant Complaints

<table>
<thead>
<tr>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>If call was prompted by acute or chronic occupant problems/complaints, the following questions may be in order:</td>
</tr>
<tr>
<td><strong>Is the problem or complaint experienced by several people or just one individual?</strong></td>
</tr>
<tr>
<td><strong>Are complaints in one area or are they spread throughout building (i.e., one HVAC zone or more, one side of the building or all sides, one floor/room or many)?</strong></td>
</tr>
<tr>
<td><strong>Do complaints seem to follow any pattern in time (i.e., in relation to individual activities or other activities in building)?</strong></td>
</tr>
<tr>
<td><strong>Is there any correlation between complaints and recent changes in the building or outside activities?</strong></td>
</tr>
</tbody>
</table>

### Client Expectations

<table>
<thead>
<tr>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What are your expectations regarding the likely findings of the inspection?</strong></td>
</tr>
<tr>
<td><strong>What do you hope this inspection will accomplish for you?</strong></td>
</tr>
<tr>
<td><strong>What type of deliverables would you like to have included as part of our HVAC inspection report?</strong></td>
</tr>
<tr>
<td><strong>Do you have a particular format in mind for the presentation of the results?</strong></td>
</tr>
<tr>
<td><strong>What should be the chain of communication and data flow?</strong></td>
</tr>
</tbody>
</table>
B. HVAC Inspection Checklist

Section 1: Outdoor Air Intake and Dampers in AHU

Section 2: Mixing Plenum and Dampers in AHU

Section 3: Filters

Section 4: Heating Coil in AHU

Section 5: Cooling Coils and Condensate Pans in AHU

Section 6: Mechanical Room

Section 7: Steam Humidifier

Section 8: Spray Humidifier or Air Washer

Section 9: Air Ducts

Section 10: Air Plenums

Section 11: Diffusers, Grilles, and Registers

Section 12: Fan and Fan Chambers

Section 13: Exhaust Fans in Special Use Areas

Section 14: Terminal Boxes (VAV/CAV)

Section 15: Fan Coil/Unit Ventilator/Induction Units

Section 16: Heat Pump
## SECTION 1: OUTDOOR AIR INTAKE AND DAMPERS IN AHU

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution sources:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No exhaust outlet within 25 ft.?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recorded distance ______</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No cooling tower within 25 ft.?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recorded distance ______</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance records and policy?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No trash container within 25 ft.?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recorded distance ______</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No other source within 25 ft.?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other sources?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating hours:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open during all occupied hours?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Operating plan?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Bird screen:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesh &lt; 0.5”?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Specified mesh ______</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Recent service work on roof?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Operating hours for make-up air systems?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-property sources?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Is there an attached garage?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>If so, is the pressure relationship known?</td>
<td></td>
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</tr>
<tr>
<td>Odors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No noticeable odors from outdoors (e.g., roof tar, vehicle exhaust)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air intake:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No obstruction, bird droppings, or nests?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the intakes non-porous?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bird screen:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No obstruction, no nests, clean?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face and bypass dampers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good condition?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of movement?</td>
<td></td>
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</tr>
</tbody>
</table>
### SECTION 2: MIXING PLENUM AND DAMPERS IN AHU

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixing plenum:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No obstructions?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>All dampers:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tight?</td>
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</tbody>
</table>

### SECTION 3: FILTERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated dust spot efficiency of __________. MERV rating?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Odor:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No noticeable odor?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easily accessible for maintenance?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter bank style, frame gaskets, filter clips?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is filter fit correct with no bypassing air?</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Moisture/dampness:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not excessive?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Filter loading:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No excessive dirt/dust?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-filter/final filters?</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
## SECTION 4: HEATING COIL IN AHU

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easily accessible for inspection and maintenance?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coil condition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean, no obstruction or corrosion, no leaks visible? Fin damage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As-built static data?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current static data?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Face and bypass dampers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good condition?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of movement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bypass damper motors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth operation?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reheat coils:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No obstruction, no leaks?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## SECTION 5: COOLING COILS AND CONDENSATE PANS IN AHU

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling coils:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easily accessible for inspection and maintenance?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean, no rust?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As-built static data?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current static data?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fin damage or restrictions?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No condensation drainage problems?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a p-trap?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensate drain pans:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No noticeable odor?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easily accessible for inspection and maintenance?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean, no residue, clogs, or debris?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No standing water, overflow, or leakage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No visible bacterial or fungal growth (slime)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Properly sloped and draining?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# SECTION 6: MECHANICAL ROOM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OK</th>
<th>Not OK</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed air: Mechanical room used as mixing chamber?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMS / DDC: Operator on-site/controlled off-site?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Odors: No unusual odors?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness: No dirt/dust, buildup on floors and equipment?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage: No cleaning supplies, maintenance supplies, trash, etc.?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture: No water leaks, pooling of water, past water damage?</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Noise: No excess noise and vibration?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Leakage: No penetrations to adjacent spaces? Are there floor drains? Are there trap primers?</td>
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</table>
### SECTION 7: STEAM HUMIDIFIER

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<tbody>
<tr>
<td>System maintenance plan?</td>
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<tr>
<td>Maintenance records?</td>
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<tr>
<td>Drainage:</td>
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</tr>
<tr>
<td>Proper drainage?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain line trapped?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pans clean?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No standing water or overflow?</td>
<td></td>
<td></td>
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<tr>
<td>Deposits:</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No mineral deposits?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial contamination:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No visible biological growth?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If duct liner is within 12 feet, no dirt or mold growth?</td>
<td></td>
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</tr>
<tr>
<td>Water source?</td>
<td></td>
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<tr>
<td>Proximity to porous material?</td>
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### SECTION 8: SPRAY HUMIDIFIER OR AIR WASHER

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<td>System maintenance plan?</td>
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<tr>
<td>Maintenance records?</td>
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<tr>
<td>Spill containment:</td>
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<tr>
<td>System in place?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pans clean, no standing water or overflow?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial contamination:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No signs of mold or bacteria?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drains:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Properly trapped?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Proximity to porous material?</td>
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# SECTION 9: AIR DUCTS

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<td>Condition?</td>
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<tr>
<td>No damage, dents, leaks?</td>
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</tr>
<tr>
<td>Connections sealed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy access for maintenance?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No excess dirt or erosion?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No debris?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No water condensation?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No dampness, mold, biological growth?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No pooling water?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire damper:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Open and accessible for maintenance?</td>
<td></td>
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<tr>
<td>Access doors:</td>
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</tr>
<tr>
<td>Properly installed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Grilles:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean and unobstructed?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return air path:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Clean and unobstructed?</td>
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## SECTION 10: AIR PLENUMS

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<tbody>
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<td>Type of plenum:</td>
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<tr>
<td>Ceiling, ducted, other?</td>
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<tr>
<td>Accessibility:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Easily accessible for maintenance?</td>
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</tr>
<tr>
<td>Odors:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No unusual odors in plenum or space?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No debris, excess dirt, excess dampness, signs of biological growth?</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Leaks:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No leaks from other systems (look for stained ceiling tiles)?</td>
<td></td>
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<tr>
<td>Fireproofing and insulation:</td>
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<tr>
<td>Age of fireproofing material?</td>
<td></td>
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</tr>
<tr>
<td>Secure, clean, no erosion?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Does not contaminate space?</td>
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<td>Fire dampers:</td>
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<tr>
<td>Open?</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>How many?</td>
<td></td>
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<tr>
<td>Ceiling tiles:</td>
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<tr>
<td>All tiles in place?</td>
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<tr>
<td>No stains?</td>
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<td>Openings:</td>
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### SECTION 11: DIFFUSERS, GRILLES, AND Registers

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<tr>
<td>Allocation:</td>
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<tr>
<td>Every room has supply air (or transfer path/grilles) plus return (or exhaust) air?</td>
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<tr>
<td>Supply diffusers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No excess dirt or dust?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open, noticeable flow of air?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return or exhaust:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not close to supply diffuser?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No excess dirt on registers?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal diffuser and register noise?</td>
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### SECTION 12: FAN AND FAN Chambers

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<td>Chamber:</td>
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<tr>
<td>Clean, no trash or storage?</td>
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<tr>
<td>Drain traps wet or sealed?</td>
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<td></td>
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</tr>
<tr>
<td>No air leaks, door seals tight?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No standing water?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No corrosion?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan blades clean, not damaged?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Belts with proper tension, no excess wear?</td>
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<tr>
<td>Guards installed?</td>
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### SECTION 13: EXHAUST FANS IN SPECIAL USE AREAS

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<td>Is exhaust installed?</td>
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<td>Fans:</td>
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<tr>
<td>Working during occupied hours?</td>
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<tr>
<td>Registers:</td>
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<td></td>
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<tr>
<td>Open, clear?</td>
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<tr>
<td>Make-up air path:</td>
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<tr>
<td>Adequate make-up air?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Clear path?</td>
<td></td>
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</tr>
<tr>
<td>Noise:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No excessive noise?</td>
<td></td>
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<td></td>
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<tr>
<td>Grilles:</td>
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<td></td>
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<tr>
<td>Clean, unobstructed?</td>
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### SECTION 14: TERMINAL BOXES (VAV/CAV)

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<td>Overall exterior condition?</td>
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<td>Ducts?</td>
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</tr>
<tr>
<td>Noise:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No air or fan noise or vibration?</td>
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<td></td>
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</tr>
<tr>
<td>Accessibility:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>All parts accessible for maintenance?</td>
<td></td>
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<td>Filter:</td>
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<tr>
<td>Condition and installation?</td>
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<tr>
<td>Style?</td>
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<td>Rating?</td>
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<td>Reheat coils:</td>
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<tr>
<td>Clean and operational?</td>
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</table>
### SECTION 15: FAN COIL/UNIT VENTILATOR/INDUCTION UNITS

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<td>No obstruction?</td>
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<tr>
<td>Condition:</td>
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<tr>
<td>No rust, no corrosion?</td>
<td></td>
<td></td>
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<tr>
<td>Blades and scrolls?</td>
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<td></td>
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</tr>
<tr>
<td>Ducts:</td>
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</tr>
<tr>
<td>Visible ductwork condition and insulation?</td>
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</tr>
<tr>
<td>Noise:</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No unusual noise or vibration?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>All parts accessible for maintenance?</td>
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</tr>
<tr>
<td>Dampers:</td>
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<tr>
<td>Operational, no obstructions?</td>
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<td></td>
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<tr>
<td>Pipes:</td>
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<td>No leaks?</td>
<td></td>
<td></td>
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<tr>
<td>Wall/floor cavity sealed?</td>
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<tr>
<td>Drain pan:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Clean, no residue, no biological growth (e.g. slime)?</td>
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</table>
## SECTION 16: HEAT PUMP

<table>
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<td>Sloped, no standing water, no leaks?</td>
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<tr>
<td>No overflow, trapped drain?</td>
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<tr>
<td>Exterior condition:</td>
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<tr>
<td>No corrosion, air leakage?</td>
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<tr>
<td>Ducts:</td>
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<tr>
<td>Visible ductwork condition?</td>
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</tr>
<tr>
<td>Noise:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No unusual noise or vibration?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All parts accessible for maintenance?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter:</td>
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<td></td>
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<tr>
<td>Condition?</td>
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</tr>
<tr>
<td>Installed properly?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coil and drain pan:</td>
<td></td>
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<tr>
<td>Evaporator coil and drain pan clean?</td>
<td></td>
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<tr>
<td>Pan drains?</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Discharge air streams:</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>No unusual odors?</td>
<td></td>
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</tr>
<tr>
<td>Leakage:</td>
<td></td>
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<td></td>
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<tr>
<td>No uncontained leakage from system?</td>
<td></td>
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</tr>
</tbody>
</table>
D. Sample Case Study

BACKGROUND ON THE CASE STUDY
The following case study is a hypothetical situation and does not represent any one building. It was assembled to illustrate a number of points raised in the body of this manual, and it includes several “alternatives” that illustrate how different observations and findings might be handled. Because actual inspection sites vary greatly, an inspector should use his or her professional judgment when conducting and reporting on HVAC inspections.

INSPECTION OVERVIEW
Acme Ventilation Services was contacted by the Smith and Jones Insurance Company (S&J) in late November to inspect its HVAC systems as part of its recently established building maintenance program. S&J was the owner of an office building that had housed several tenants over its lifetime.

ESTABLISHING THE PURPOSE OF THE INSPECTION
Bill Johnson of Acme first established the purpose of the requested inspection asking the customer a series of questions: Satisfied that this was a routine inspection, Bill asked more questions to build a picture of the facility. He decided to send one of his staff for a morning meeting with the customer to determine the layout of the building and system prior to quoting the entire job. He reached an agreement with the customer that, if they went forward with the project, the visit would be included in the project price. Otherwise, S&J would pay for three field hours for the initial walk-through visit. Below are some of the questions that were asked during the site visit.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the purpose of the inspection?</td>
<td>The inspection is part of a newly established routine maintenance program.</td>
</tr>
<tr>
<td>Have you received any complaints from building occupants?</td>
<td>The client knew of no noteworthy complaints.</td>
</tr>
<tr>
<td>Is the system cleaned on a regular basis? When was it last cleaned?</td>
<td>The system had never been cleaned although S&amp;J does have a mechanical contractor perform regular filter replacement and maintenance.</td>
</tr>
<tr>
<td>What would you like to learn from the inspection?</td>
<td>The client wants to establish a baseline for the program, determine the condition of the ducts, and see if there are any potential problems.</td>
</tr>
<tr>
<td>What type of deliverables are you looking for?</td>
<td>The client wasn’t sure, but wanted material sufficient to establish a baseline.</td>
</tr>
<tr>
<td>Questions</td>
<td>Responses</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Are as-built drawings (blueprints) of the facility available?</td>
<td>Only original design drawings were available. They included a reflected ceiling plan, a mechanical system diagram, and an HVAC controls diagram.</td>
</tr>
<tr>
<td>What is the basic type of HVAC system that is operating in the building?</td>
<td>The information gathered is outlined below.</td>
</tr>
<tr>
<td>Have any particulate accumulations been noted in the HVAC system?</td>
<td>The mechanical contractor had noted none in the air handling units.</td>
</tr>
<tr>
<td>Have any other issues been noted in or around the system?</td>
<td>No</td>
</tr>
<tr>
<td>When was the building constructed?</td>
<td>10 years ago</td>
</tr>
<tr>
<td>Have changes been made to the structure?</td>
<td>No</td>
</tr>
<tr>
<td>What is the facility currently being used for?</td>
<td>It had been an office building for its entire history.</td>
</tr>
<tr>
<td>Has the HVAC system been maintained according to any particular system?</td>
<td>A mechanical contractor changes filters. No other records were available.</td>
</tr>
</tbody>
</table>
During the phone interview and walk-through, Acme developed the following understanding of the site:

**Facility**
The building, located in the Baltimore area, contained roughly 100,000 square feet of office space on four floors. It was built 10 years ago and was always owned by S&J. It has, however, housed several different tenants over the years.

**HVAC System**
Constant air volume systems
- four identical 10-ton roof top units served
- four separate duct systems (one per floor)
- all 10 years old
- all made by the same manufacturer
- gas fired heaters
- direct expansion cooling (no cooling tower)
- 2” pleated filters
- outdoor air intakes above grade
- no exhaust stacks within 25 feet of building

**Supply ductwork**
- rectangular sheet metal
- 10 feet of lined fiberglass thermo-acoustic liner for sound attenuation
- exterior fiberglass blanket insulation
- radius turns (no turning vanes)
- each floor was served by a riser to its associated air handler
- each riser was connected to the center of an “H”-shaped main duct
- round flexible metal duct connected the “H” to supply registers

**Return ductwork**
- rectangular sheet metal
- radius turns (no turning vanes)

**Building interior**
- 8-foot-high tile dropped ceiling
- separately ducted bathroom exhausts

**Available information**
- design drawings, no as-builts or coil static pressure
- no filter logs or maintenance records

**ESTABLISHING THE SCOPE OF THE INSPECTION AND WRITING A PROJECT PLAN**
After finishing the walk-through, Bill established the scope of the project and put together an inspection plan that allowed him to budget, quote the job, and serve as a statement of work for the project. Bill understood that observations made during the inspection could require a change in scope. The client also understood this and would be available during the inspection to modify work as needed.
After a review of the plans and his field notes, Bill outlined the following scope:

- Bill could have selected several of the air handlers to inspect either at random or based on his review of the site. In this case, he chose to inspect all four of the AHUs because they were clustered on the roof and he felt that the relatively small additional cost of inspecting all four was worth the additional information gained. Each of the four handlers would be inspected to identify any obvious problems such as missing, damaged, or poorly fitting filters. The acoustic liner for each system would also be inspected.

- Because the four duct systems were largely identical, there was no need to look initially at all of them. Two systems (floors) would be chosen randomly for inspection, and Bill chose the systems serving floors 2 and 4, using a random number generator on his calculator. A die would have worked equally well.

- If problems were found in any of the air handlers, these systems would also need to be inspected. If this occurred, the client would be consulted during the inspection to minimize the need for a return visit.

- Supply ducts:
  - portions of the ducts from the riser
  - the main legs of the “H”
  - 10% of the flexible ducts (chosen at random)

---

**Alternative A**
The client indicated that the third floor had undergone extensive renovation approximately four years ago at the request of one of the tenants. Bill flagged that floor and system for inspection because inadequate controls during construction could allow construction debris and dust into an HVAC system. The renovation also may have meant that System #3 was different from the other systems and a random selection of systems to be inspected was no longer advisable.
CHOOSING EQUIPMENT FOR THE INSPECTION
Bill chose the following equipment to perform this inspection:

Basic
- 6’ step ladder
- portable HEPA vacuum
- digital camera
- cutting tools and drills
- drop cloths
- dust curtains
- basic supplies for installing and closing access points

Visualization
- robotic camera

Because the facility’s ducts had long runs with few turns and no turning vanes, Bill thought that his robotic camera would work efficiently and was in little danger of getting stuck. His model of robotic camera allowed the camera to be separated from the car and be used as a push camera. He planned to use this push method to examine the flexible ducts from the supply register side.

Because there were no critical healthcare-related or manufacturing environments, Bill decided that full containment equipment or a negative air machine were not necessary.

Alternative B
In a system with 90-degree elbows and turning vanes, Bill might have decided to use his push camera and not use the robotic car because of the danger of getting the car stuck. Because the push camera can often move through turning vanes, he would have had to create fewer access points than he would have for the robotic car in this case.

Alternative C
Had the building had a ceiling plenum return, Bill would have had his inspectors examine the fit of the ceiling to determine whether there was leakage and short circuiting of the return air. He would have also been looking for debris or stored materials in the plenum.
INSPECTION AND OBSERVATIONS

AHUs
Bill and his team first went to the roof and inspected the four AHUs. They found:
- all outdoor air intakes were above grade
- no exhaust stacks were within 25 feet of intakes
- filters had a low dust load, fit well, and were installed properly
- face of the cold coils appeared to be clean
- panel gaskets are beginning to lose elasticity
- dried residue in the condensate pan of AHU #1, possible evidence of past standing water, maybe during the previous summer
- external grease fitting on the shaft was over-greased, with grease dripping onto insulation.

Based on the AHU inspections, Bill saw no evidence of obvious problems but decided to inspect the riser of AHU #1 to ensure that pooling water had not led to microbial growth.

Supply Ducts
Bill first shut off the AHU for each system that was inspected. The sound attenuators in each of the four supply ducts appeared to be sound with no noticeable degradation or erosion. To examine the riser of AHU #1, Bill lowered a push camera down. He saw relatively clean ducts with no evidence of microbial growth or staining. Based on this observation, he decided to inspect only systems #2 and #4 as originally planned.

For systems #2 and #4, Bill’s field crew cut access points where the middle of the “H” met the side runs. They cut access ports and vacuumed all metal shavings from the cutting from inside the duct. They next installed prefabricated access panels for future access. From these two access points, they were able to send the robot in three different directions, efficiently covering most of the system. They found the following:
- light dust
- galvanized manufacturer’s stenciled logos on each of the duct’s sides
- no evidence of glass fiber on flanges or screws

For 10% of the supply diffusers selected at random, they removed the faceplate and fed the push camera into the duct until it met the main rectangular branch. They found only minor dust. One of the flexible ducts was found to be loose. They secured the duct with ties they carried and made notes in their field books.

Return Ducts

They examined 10% of the return ducts at random by removing the faceplates and feeding in the push camera approximately 25 feet. They found more dust than in the supply duct (because the return is not filtered) but not at a level to cause concern.

The field crew returned the space to its prior condition, vacuuming any debris that fell from the diffusers and turning the AHUs back on.
ASSEMBLING THE REPORT

The Acme staff assembled their field notes, the video footage, and the building’s plans and went over their findings back at their office. They agreed that the system had a dust level consistent with the system’s age and filtration. They further agreed that duct cleaning was not, in their opinion, necessary. Bill drafted a report based on his field team’s notes, his judgment, and his viewing of the video footage.

Alternative D

The filter in AHU #1 was misaligned, allowing air to bypass the filter. The dust load in this duct was substantially higher than in the other three AHUs. A dark stain (suspected to be microbial growth) was found in AHU #1. The Acme team noted the conditions and showed the video footage to the client. The client was concerned about the stain and the dust load and asked that the system be cleaned. They further asked that the stain not be sampled, preferring instead to eliminate the problem. Based on this request, Acme recommended that both the system’s coil and ductwork be cleaned.

Alternative E

A series of patchy dark staining (suspected to be microbial growth) was found on the sound attenuation insulation just downstream of AHU #4. The Acme team noted the conditions and showed the video footage to the client. The client agreed to have the stains sampled. Swab samples were collected and sent to a laboratory for examination by microscope and culturing. The samples came back confirming active microbial growth. Acme gave two recommendations to the client:

- The source of the conditions leading to mold growth should be found. (Two suspected causes were later found and rectified: malfunctioning humidification equipment and poorly draining condensate pans.)
- The insulation should be replaced and adjacent ducts should be cleaned.

Alternative F

Systems #2 and #4 both had light to moderate dust loads, but also appeared to have a yellowish/whitish dust. Acme explained the advantages and disadvantages of collecting and evaluating a sample and recommended that the dust be gathered as a bulk sample and sent to a laboratory for analysis. Because the client wanted to know the source of the dust, they agreed to the sampling.

Two weeks later, the results of the test indicated that it had a cellulose component, indicating that it was paper or cardboard dust. In a follow-up visit, Acme found that a paper shredder was located near the air return for Systems #2 and #4. While it was difficult to determine if this was the source of the dust, Acme recommended that the shredder be moved. The client understood that the dust was not toxic, but decided to have the two systems cleaned anyway.
Sample Report Cover Letter

December 8, 2015

Mr. Jones
Director, Property Management
Smith and Jones Insurance Company
Baltimore, MD

Dear Mr. Jones,

Please find enclosed the results of the HVAC inspection conducted at your facility on Smith and Jones Road on November 26, 2015. As we discussed last week, your system’s condition was consistent with the age and use of your building.

Alternative D
However, as we showed your facility maintenance staff, the dust load in System #4 was substantially higher than that of other systems and some staining was found. At the request of Smith and Jones, we have made recommendations for cleaning the system. The report outlines our findings and contains recommended procedures for performing that cleaning.

Alternative E
As we discussed, however, a series of patchy dark staining, later confirmed to be microbial growth, was found on the sound attenuation insulation just downstream of AHU #4. We found HVAC system problems consistent with conditions conducive to mold growth: malfunctioning humidification equipment and poorly draining condensate pans. In the report, we include recommendations for fixing the problem and for replacing the insulation.

Alternative F
However, Systems #2 and #4 had yellowish/whitish dust accumulations that we later traced to the bulk paper shredders near the loading dock. Based on our earlier discussions and your request, we include in the report discussion of how the ducts should be cleaned.

Our report details our findings by location, and the included video file shows footage of your HVAC system.

Should you have any questions or wish for further assistance, please feel free to call us at 1-800-555-0400. We appreciated the opportunity to work with you on this project.

Sincerely,

Bill Johnson
ACME Ventilation
Sample Inspection Report & Cover

HVAC Inspection Report

For

Smith and Jones Insurance Company
Smith and Jones Road Baltimore, MD

by

Acme Ventilation Services
Anytown, USA
1-800-555-0400

November 26, 2015
Sample Table of Contents

Table of Contents

- Project Scope ................................................................................. 1
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- Summary of Findings .................................................................. 3
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Sample Project Scope

Smith and Jones Office Building
November 26, 2015

Project Scope

The project’s scope was to conduct a visual inspection of the HVAC systems serving the building. The purpose of the inspection was to determine the general condition and cleanliness of the system in the areas inspected and to use the information to comment on the overall condition of the building’s HVAC systems. Where portions of a system were not directly inspected, we used the condition of similar systems and professional judgment to estimate actual conditions. While this method is accepted practice and is often the only practical approach, the reader should understand that the only way to assess the condition of a system with certainty is to inspect it directly.

Personnel certified to perform HVAC system inspections performed the study. Their conclusions and recommendations are based primarily on direct observation. More complex questions about indoor air quality and human health are beyond the scope of the study.

During this inspection, we examined air handlers #1-4 and examined the ducts in Systems #2 and #4 in detail.

Alternative A
Because the third floor of the building had extensive renovation approximately four years ago, there was a possibility that construction debris and dust entered the HVAC system during construction. In any case, alterations to the system would mean that it was no longer similar to Systems #1, #2, and #4. For these two reasons, we flagged System #3 for inspection as well.
Sample Methods

Smith and Jones Office Building
November 26, 2015

Methods

The building AHUs are housed on the roof. Because they are easy to access and because there were no maintenance records available for the units, we decided to inspect all four. Because the HVAC systems of the four floors are similar in design and construction, a representative sample of the systems is a good method for assessing the building without the expense of examining every system in it. Using a random number generator, we chose Systems #2 and #4 for further investigation.

(Note: The following section would be tailored to a firm’s particular capability. The aspects covered by the report are generally a minimum. Firms with additional capability would shift some of the non-covered items to the list of covered items.)

Acme developed an inspection plan designed to inspect representative portions of the systems and that required minimum alteration of the existing system. The components of each air handler related to air quality were inspected, including:

- casketing
- humidification equipment
- cleanliness of hot and cold coils
- dust and debris load of fans
- filter racks and filters
- drains
- outdoor and return air dampers
- insulation

This inspection is limited to the cleanliness of the HVAC system as it relates to indoor air quality. The function of the air handler is not in the scope of the inspection. Airflow, temperature, control operation, fan function, air velocity, and static pressure are not considered in this survey.

(Note: The following section would be tailored to a firm’s particular capability. The aspects covered by the report are generally a minimum. Firms with additional capability would shift some of the non-covered items to the list of covered items.)

The following aspects of the supply and return ducts are covered under this inspection:

- dust and debris load
- microbial surface growth
- presence and quality of joint sealing materials
- staining
- fit and function access ports
- integrity of liners and sound attenuating insulation

The following are not covered in this inspection:

- structural integrity and safety of duct structure
- air velocity and flow in the ducts
- sufficiency of ventilating, cooling, and heating air
- thermal aspects of insulation
- static pressure and losses
Sample Summary of Findings

Smith and Jones Office Building
November 26, 2015

Summary of Findings

Air Handling Units
Four rooftop air handlers serve the building, with one serving each floor. These units were installed when the building was constructed 10 years ago and are in good overall condition. Following is a summary of the characterization of the units:

- four 10-ton roof top units serve four separate duct systems (one per floor)
- all 10 years old
- all made by Hephaestus Corporation
- all serviced by the Bernoulli Corporation (mechanical contractor)
- gas fired heaters
- direct expansion cooling (no cooling tower)
- 2” pleated filters • outdoor air intakes above grade
- no exhaust stacks within 25 feet of building

The amount of settled dust in the four units was consistent with a well-maintained system and regular filter replacement. There was no accumulated debris, and the internal insulation was in good condition. Minor rusting was observed in isolated spots in each air handler (consistent with the age of the units) and does not appear to pose a structural or integrity problem. It is not an air quality issue.

Alternative A
AHU #3 was replaced during the renovation. It differed from the original units in several ways. The filters are 1” pleated and don’t appear to fit the frames, possibly because of a poorly located bracket. Because of the potential for dust to enter the duct system, we flagged System #3 (third floor) for inspection.

Condensate pans were empty as one would expect during the heating season, but dried residue may indicate standing water during summer cooling months. Filters had dust loads consistent with those replaced at recommended intervals. They fit well with no apparent bypass of air.

The door gaskets are losing their elasticity and may be allowing air to leak into the cabinet. The coils appeared to be relatively clean with no visible accumulation of foreign material or obvious coil damage. Because as-built values for static pressure drop across the coils were not available, a pressure drop test to determine internal dirt buildup was not practical.

Alternative D
The filter in AHU #1 was poorly aligned, allowing air to bypass the filter. As discussed in the duct section, the dust load in this duct was substantially higher than duct System #4. A dark stain suspected to be microbial growth is found in the AHU. Based upon this evidence and field staff discussions with the building’s staff we recommended that the system’s coils and ductwork be cleaned.
Sample Summary of Findings

Smith and Jones Office Building
November 26, 2015

Summary of Findings

**HVAC Ductwork**
The supply ductwork had light dust accumulations consistent with regular replacement of the 2” pleated filters. The light dust appeared to be stuck to the duct surfaces as a film and thus would not become airborne readily. The return ductwork had slightly heavier accumulations of dust and debris than the supply ducts. This is generally expected in return air ducts because the air they carry is unfiltered. There appears to be seam caulking loose within the system. There were no apparent gaps in the duct joints and the material itself is unlikely to pose any risk.

**Alternative E**
A series of patchy dark stains, suspected to be microbial growth, was found on the sound attenuation insulation just downstream of AHU #4. Video footage of this area is included with this report package. Swab samples were collected and sent to a laboratory for examination by microscope and culturing. Results of that sampling are included in the attached laboratory report including applicable chain of custody forms.

The samples confirmed active microbial growth. Based on industry guidance, the insulation should be replaced and adjacent ducts should be cleaned. We investigated further to determine conditions that could be aiding the growth of mold. We found two potential causes: malfunctioning humidification equipment and poorly draining condensate pans. These two sources should be repaired as soon as possible.

**Alternative F**
Systems #2 and #4 both had light to moderate dust loads but also appeared to have a yellowish/whitish dust. We gathered a bulk sample of the dust for laboratory analysis. Results of that sampling are included in the attached laboratory report including applicable chain of custody forms. The test indicated that it had a cellulose component, indicating that it was paper or cardboard dust. We found that a paper shredder was located near the air return for Systems #2 and #4 and recommend that it be moved.
Sample Recommendations

Smith and Jones Office Building
November 26, 2015

Recommendations

Acme Ventilation Inc., makes the following recommendations to the Smith and Jones Company. All recommendations are based on the Building Air Quality Action Plan prepared by the U.S. Environmental Protection Agency (EPA) and National Institute for Occupational Safety and Health (NIOSH), and the American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 62.1, Ventilation for Acceptable Indoor Air Quality, and Standard 55, Thermal Environmental Conditions for Human Occupancy. They are also based on observations and measurements recorded at the time of the inspection.

Coils
There was no data available at the time of the survey regarding the last date of coil cleaning or as-built static pressure across the coils. We therefore recommend that the coils be thoroughly cleaned and static pressure drop be collected for use as a baseline. This data can be used to determine when future coil cleaning is necessary in accordance with NFPA Standard 90A.

Insulation
The degrading insulation observed should be either repaired or replaced. Any repairs should be made in accordance with NFPA Standard 90A. Remaining insulation should be surveyed regularly to ensure that it is structurally stable and dry.

Ducts
Cleaning of the HVAC systems with only light dust is unlikely to yield improvements in system performance and (provided that the material is nuisance dust) is unlikely to have any impact on the relative indoor air quality.

AHUs
Regular cleaning and/or inspection of the unit should be performed and include the filter compartments, condensate pans, coils and fan compartment. The rusted surfaces should be cleaned and treated with a rust converter product to help extend the serviceable life of the unit. A number of the gaskets were found to have lost their elastic properties and are thus providing an inadequate seal. The door and panel gaskets should be repaired or replaced as needed.

Alternative E
The series of patchy dark stains found on the sound attenuation insulation just downstream of AHU #4 were confirmed to be active microbial growth. Based on industry guidance, the insulation should be replaced and adjacent ducts should be cleaned. The malfunctioning humidification equipment and poorly draining condensate pans found should be repaired as soon as possible.

Alternative F
While the yellowish/whitish dust found in Systems #2 and Systems #4 was not found to be toxic, we recommend that the paper shredder be moved and the ducts be cleaned to eliminate the chance that the dust will be entrained in the airflow during future balancing or repair of the system.
## Sample Unit Inspection Worksheet

### Unit Inspection Worksheet

<table>
<thead>
<tr>
<th>CLIENT #</th>
<th>S &amp; J</th>
<th>DATE:</th>
<th>November 26, 2015</th>
<th>LOCATION: Rooftop</th>
<th>UNIT: AHU#1</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>BRAND:</th>
<th>Hephaestus</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUST:</td>
<td>Minor rust bottom of fan compartment around coiled frame.</td>
</tr>
<tr>
<td>WATER DAMAGE:</td>
<td>Minor rust</td>
</tr>
<tr>
<td>MAKE-UP AIR PLENUM:</td>
<td>Good</td>
</tr>
<tr>
<td>STRUCTURAL INTEGRITY:</td>
<td>Good</td>
</tr>
<tr>
<td>FILTER PLENUM:</td>
<td>Good, light dust</td>
</tr>
<tr>
<td>FIBROUS GLASS:</td>
<td>Good</td>
</tr>
<tr>
<td>COIL:</td>
<td>Integrity:</td>
</tr>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Static Pressure:</td>
<td>N/A</td>
</tr>
<tr>
<td>Cleanliness:</td>
<td>Good</td>
</tr>
<tr>
<td>FILTERS:</td>
<td>Type:</td>
</tr>
<tr>
<td></td>
<td>2” Pleated</td>
</tr>
<tr>
<td></td>
<td>Fit:</td>
</tr>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Condition:</td>
<td>Good</td>
</tr>
<tr>
<td>CONDENSATE PAN:</td>
<td>Good</td>
</tr>
<tr>
<td>FAN COMPARTMENT:</td>
<td>Light dust</td>
</tr>
<tr>
<td>GASKETS:</td>
<td>Good</td>
</tr>
<tr>
<td>ADDITIONAL OBSERVATIONS:</td>
<td>Minor rust bottom of fan compartment (see photo #1).</td>
</tr>
</tbody>
</table>
Sample Unit Inspection Worksheet

Unit Inspection Worksheet

CLIENT # S & J DATE: November 26, 2015

TECHNICIAN: Bob Smith, ASCS

LOCATION: Rooftop UNIT: AHU#2

<table>
<thead>
<tr>
<th>BRAND:</th>
<th>Hephaestus</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUST:</td>
<td>Minor rust fan compartment</td>
</tr>
<tr>
<td>WATER DAMAGE:</td>
<td>Minor rust</td>
</tr>
<tr>
<td>MAKE-UP AIR PLENUM:</td>
<td>Good</td>
</tr>
<tr>
<td>STRUCTURAL INTEGRITY:</td>
<td>Good</td>
</tr>
<tr>
<td>FILTER PLENUM:</td>
<td>Light to moderate dust</td>
</tr>
<tr>
<td>FIBROUS GLASS:</td>
<td>Good condition but delaminating on top of filter and return compartment</td>
</tr>
</tbody>
</table>

COIL:
- Integrity: Good
- Static Pressure: N/A
- Cleanliness: Good

FILTERS:
- Type: 2" Pleated
- Fit: Good
- Condition: Good

CONDENSATE PAN: Minor rust

FAN COMPARTMENT: Light dust

GASKETS: Filter compartment door needs attention

ADDITIONAL OBSERVATIONS: Delaminating fiberglass on top of filter and fan compartment (see photo #2).
## Sample Unit Inspection Worksheet

### Unit Inspection Worksheet

**CLIENT #:** S & J **DATE:** November 26, 2015  **TECHNICIAN:** Bob Smith, ASCS

**LOCATION:** Rooftop  **UNIT:** AHU#3

<table>
<thead>
<tr>
<th>BRAND:</th>
<th>Hephaestus</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUST:</td>
<td>Minor rust fan compartment floor and coil frame.</td>
</tr>
<tr>
<td>WATER DAMAGE:</td>
<td>Minor rust</td>
</tr>
<tr>
<td>MAKE-UP AIR PLENUM:</td>
<td>Good</td>
</tr>
<tr>
<td>STRUCTURAL INTEGRITY:</td>
<td>Good</td>
</tr>
<tr>
<td>FILTER PLENUM:</td>
<td>Light dust</td>
</tr>
<tr>
<td>FIBROUS GLASS:</td>
<td>Good condition but delaminating on top of filter and fan compartment</td>
</tr>
</tbody>
</table>

**COIL:**
- **Integrity:** Good
- **Static Pressure:** N/A
- **Cleanliness:** Good

**FILTERS:**
- **Type:** 2” Pleated
- **Fit:** Good
- **Condition:** Good

**CONDENSATE PAN:**
- **Condition:** Good

**FAN COMPARTMENT:**
- **Condition:** Light dust

**GASKETS:**
- **Condition:** Good

**ADDITIONAL OBSERVATIONS:** See Photo #3
## Unit Inspection Worksheet

**CLIENT #** S & J **DATE:** November 26, 2015  **TECHNICIAN:** Bob Smith, ASCS

**LOCATION:** Rooftop  **UNIT:** AHU#4

<table>
<thead>
<tr>
<th>BRAND:</th>
<th>Hephaestus</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUST:</td>
<td>Minor rust fan compartment floor and coil frame.</td>
</tr>
<tr>
<td>WATER DAMAGE:</td>
<td>Minor rust</td>
</tr>
<tr>
<td>MAKE-UP AIR PLENUM:</td>
<td>Good</td>
</tr>
<tr>
<td>STRUCTURAL INTEGRITY:</td>
<td>Good</td>
</tr>
<tr>
<td>FILTER PLENUM:</td>
<td>Light dust</td>
</tr>
<tr>
<td>FIBROUS GLASS:</td>
<td>Good condition but delaminating on top of filter and fan compartment</td>
</tr>
<tr>
<td>COIL: Integrity:</td>
<td>Good</td>
</tr>
<tr>
<td>Static Pressure:</td>
<td>N/A</td>
</tr>
<tr>
<td>Cleanliness:</td>
<td>Good</td>
</tr>
<tr>
<td>FILTERS: Type:</td>
<td>2” Pleated</td>
</tr>
<tr>
<td>Fit:</td>
<td>Good</td>
</tr>
<tr>
<td>Condition:</td>
<td>Good</td>
</tr>
<tr>
<td>CONDENSATE PAN:</td>
<td>Good</td>
</tr>
<tr>
<td>FAN COMPARTMENT:</td>
<td>Light dust</td>
</tr>
<tr>
<td>GASKETS:</td>
<td>Good</td>
</tr>
<tr>
<td>ADDITIONAL OBSERVATIONS:</td>
<td>See Photo #4</td>
</tr>
</tbody>
</table>
## Sample Unit Inspection Worksheet

### Unit Inspection Worksheet

<table>
<thead>
<tr>
<th>CLIENT #</th>
<th>S &amp; J</th>
<th>DATE:</th>
<th>November 26, 2015</th>
<th>TECHNICIAN:</th>
<th>Bob Smith, ASCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION:</td>
<td>Main Supply</td>
<td>AREA SERVED:</td>
<td>Third Floor</td>
<td>UNIT:</td>
<td>AHU#3</td>
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</table>

<table>
<thead>
<tr>
<th>PARTICULATE:</th>
<th>Light Dust</th>
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</thead>
<tbody>
<tr>
<td>RUST:</td>
<td>None Observed</td>
</tr>
<tr>
<td>WATER DAMAGE:</td>
<td>None Observed</td>
</tr>
<tr>
<td>STRUCTURAL INTEGRITY:</td>
<td>Good</td>
</tr>
<tr>
<td>FIBROUS GLASS:</td>
<td>Unlined</td>
</tr>
<tr>
<td>REHEAT COIL:</td>
<td>N/A</td>
</tr>
<tr>
<td>ADDITIONAL OBSERVATIONS:</td>
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</table>
Sample Appendix

Smith and Jones Office Building
November 26, 2015

Appendix 1 Laboratory Reports

Laboratory Report Cover Sheet

*Example: Use as many as needed for any test collected.*

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>November 26, 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>S &amp; J</td>
</tr>
<tr>
<td>Location</td>
<td>Ducts 2 and 4</td>
</tr>
<tr>
<td>Area Served</td>
<td>2\textsuperscript{nd} and 4\textsuperscript{th} Floors</td>
</tr>
<tr>
<td>AH Unit</td>
<td>AHU#2 and #4</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Fermi Laboratory</td>
</tr>
<tr>
<td>Analysis</td>
<td>Microscopy</td>
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<tr>
<td>Chain of Custody</td>
<td>• Complete</td>
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<tr>
<td></td>
<td>• Attached</td>
</tr>
<tr>
<td>Report</td>
<td>Attached</td>
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Appendix 2 Ventilation System 
Cleanliness Background

Because ducts and other HVAC system components carry heated and cooled air that building occupants breathe, inspecting the HVAC system for contaminants is a basic and important way to find and minimize sources of indoor air pollution.

Contaminants found in the HVAC system can potentially be transferred to building occupants. The presence of contaminants can also indicate system problems that can contribute to chronic contamination. Where there are existing or suspected problems, locating and identifying contaminants (for example, water damage) can provide important clues to solving these problems.

**Water and moisture problems**
Signs of water damage are important to investigate because of the potential for microbiological proliferation in standing water in ventilation systems. They may also indicate HVAC system problems, such as poorly draining condensate pans or building problems such as roof leaks. When there has been water damage within sheet metal ductwork, there are usually accumulations of water scale adhered to the duct walls. This is from minerals that remain after water evaporates. Unless this scale is loose and traveling through the system as airborne particles, the scale itself is not a problem. It is important, however, to find the source(s) of the water entering the duct.

**Microbial growth and sampling**
Sampling for microbiological contamination in ductwork can be costly and does not always provide useful information. Mold, fungus, and bacteria are common to the natural environment and most tests will yield positive results depending upon the test sensitivity. Simply finding microbes present does not necessarily indicate a problem. In addition, exposure limits are not currently established. On the other hand, if there is evidence of active microbial growth, the growth should be remediated and the source of the growth and conditions that led to it should be found and eliminated.

**Particle contamination**
Particles can enter ventilation ductwork in two ways: (1) It can be introduced into ductwork during construction, renovation, or maintenance procedures; or (2) It can enter the ductwork as airborne particulate contamination in the ventilation airstream. It is normal to find some degree of particulate contamination in ventilation ductwork; not all particulate is a threat to indoor air quality. All air delivered through the ductwork of ventilation systems contains some particles because no filtration system removes every particle, only those larger than the matrix of the filtering material.
Lighter particles typically blow through a system to the termination points and into the room air unless it adheres to an obstruction in the airflow such as a turning vane, sheet metal screw, duct joint, etc. Heavier particles tend to drop out of the air stream when the velocity of the air stream is insufficient to carry them. Heavier particles often deposit where there are interruptions to smooth airflow such as bends, dampers, and branch duct take-offs, because airflow becomes unsteady and allows the particles to drop out. A light film of gray dust on the interior bottom of ductwork is not unusual to find and is generally of little concern. It typically leaves a transparent film that dulls the reflection of light.

Particles deposited in ducts can become airborne and transfer to occupied space if the airflow in the ducts increase for any reason. Typical activities that increase air velocity are repair and replacement of fans, changes in damper settings and system balance, and changes in duct dimensions upstream. For this reason it is a good idea to check the cleanliness of ducts prior to rebalancing an HVAC system or replacing air handler components.
E. Guidance on Sampling

The collection of samples is an activity that is generally outside the scope of HVAC inspections. In certain cases, though, a client may request that an inspector collect or have samples collected and analyzed in order to determine whether microbial growth is present. Samples are collected using precautions that keep them uncontaminated and are then transferred to a reliable laboratory for evaluation.

MICROORGANISM SAMPLING METHODS

The following types of sampling may be done as part of an HVAC inspection:

**Bulk sampling**

Bulk sampling involves physical removal of material for a variety of analytical methods. It is useful for wallboard, insulation, carpet, as well as for larger deposited material. A loose dust bulk sample can be collected by scooping it up and placing it in a sealed container. A cubic inch of material is more than sufficient for analysis.

**Filtration sampling**

This method involves collection onto a filter matrix. It requires minimal equipment—just the use of filter cassettes and a vacuum pump. This method is not recommended for collecting culturable bacteria because of desiccation stress. A sample of dust that is thinly dispersed across a surface can be collected by attaching a 6” length of plastic tubing to the inlet port of a white-banded AA 37mm MCEF air monitoring filter cassette or to a yellow-banded pre-weighed 37mm PVC filter air monitoring cassette. A personal or area air sampling pump is then attached to the outlet port. The free end of the tubing is rubbed along the surface where the suspect dust has settled. The filter cassette becomes a dust sample collection container. The cassette should be filled to at least a quarter full, if at all possible.

**Tape sampling**

This method is primarily used for smooth surfaces. A length of 1” wide transparent scotch-type tape is used. The tape is dabbed against the surface where the suspect dust has settled until the tape is loaded with particles. It is then attached to a glass microscope slide or the inside of a thickwall zip-lock plastic bag. The tape should not be folded in upon itself.

**Swab sampling**

Swab sampling can be used for smooth, roughened, or irregular surfaces. These swabs can be used for qualitative microscopy or for retrieval of culturable samples. Four-inch filter circles are ideal for this and can be obtained from a laboratory. To collect a sample, the inspector should wipe the dry (never wet) filter circle along the surface where the suspect dust has settled. The wipe should be loaded as heavily as possible. When finished, the filter circle should be folded in half or in quarters and enclosed in a sealed container. This method is appropriate for the visual identification of particles in such matrices as house dust, road dust, foundry dust, soil, lint, furnace or room filters, sediments in well water, paper dust, construction dust, other airborne or settled dust, and stack emissions.