**Building Science Education Solution Center – Preventative Maintenance**

Proficiency Level 2: Understand

**Learning Objective 2.1:**

* Understand the general steps for HVAC contractors carrying out maintenance inspections for HVAC Systems.

**Lecture Notes 2.1:**

Reference: ACCA Standard 4: Maintenance of Residential HVAC Systems (4/8/2019): <https://www.acca.org/communities/community-home/librarydocuments/viewdocument?DocumentKey=1437374d-083c-464f-8619-8df20f558bf6>

Maintenance Inspection:

A maintenance inspection follows these general steps:

1. Initial interview with the homeowner:

On an HVAC contractor’s first visit to a residence, they should ask the homeowner questions to help them learn about the residence’s HVAC system. These questions are framed to cover the current state of the residence’s HVAC system’s performance as well as any concerns the homeowner has about the system, including comfort, indoor air quality, utility costs, and equipment performance. These questions should also go over the home’s history (e.g., initial construction and subsequent renovations). On later visits, HVAC contractors can simplify this interview to just cover any changes that have happened since the previous visit.

1. Inventory of the existing HVAC system:

After the interview with the homeowner, the contractor will take inventory of the residence’s HVAC system. This includes any equipment, controls, components, and accessories. The following information should be collected:

* 1. Equipment type
	2. Equipment make and model number
	3. Serial number (if applicable)
	4. Year of manufacture
	5. Date the equipment first began operation (if known)
1. Plan maintenance actions:

Identify the appropriate investigative and maintenance actions, the recommended frequency for performing these tasks, and suggested corrective actions to recommend to the homeowner based on the investigative and maintenance outcomes for each piece of HVAC equipment in the inventory. Checklists containing these actions can be found in ACCA Standard 4, Section 5, Maintenance Tasks (reference linked above). If there is any HVAC equipment in the home that is not directly covered by one of these checklists, HVAC contractors can create their own list using the reference checklists that cover similar equipment functions as a guideline.

1. Consider code requirements:

Make sure that maintenance actions do not come into conflict with any applicable codes and standards. Some codes relevant to HVAC maintenance inspections are the International Code Council’s (ICC’s) International Residential Code (link: <https://codes.iccsafe.org/content/IRC2018>), the International Association of Plumbing and Mechanical Officials’ (IAPMO’s) Uniform Mechanical Code: (link: <https://codes.iapmo.org/home.aspx?code=UMC>), and the National Fire Protection Association’s (NFPA’s) National Fuel Gas Code (link: <https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=54>). A list of applicable codes can be found in ACCA Standard 4, Appendix B: HVAC Bibliography & Resources (reference linked above.)

1. Determine equipment performance requirements:

Determine the level of performance expected from the HVAC equipment. The HVAC contractor can usually find this data either from the original equipment manufacturer (OEM) or a distributor.

1. Perform testing and maintenance procedures:

Conduct applicable testing and maintenance procedures for HVAC equipment maintenance while following the OEM guidance. Depending on the climate of the region, modifications may be required to properly account for regional differences between different HVAC setups (e.g., different temperature extremes, humidity, altitude, sea salt spray from oceanfront locations, etc.). Consult regional guidance from OEMs, codes, and standards as applicable.

1. Safety concerns:

If a condition is found at any time during maintenance that could result in unsafe operation of the HVAC equipment, the contractor must shut off the equipment immediately and provide written notice to the homeowner of the unsafe condition.

Documentation:

In order to identify the proper corrective action(s) to take to maintain efficient performance for the HVAC system during its expected lifetime, the HVAC contractor must properly document equipment performance data and observations during the maintenance inspection. It is also important to document the outcomes of maintenance and inspection tasks as well as any corrective actions that are used to address any discovered faults. Recorded data includes:

1. The equipment inventory of the home’s HVAC systems.
2. The planned list of maintenance actions, and any deviations from standard procedures that had to be taken.
3. Any violations found in the HVAC equipment that apply to applicable model codes.
4. The actual performance of the HVAC system compared to the expected levels of performance based on OEM data.
5. Other observations that identify potential concerns for health, safety, equipment performance, and energy efficiency that may not have to do with the HVAC system directly (e.g., building envelope problems).
6. Any circumstance where the inspection or maintenance tasks cannot be completed due to inaccessible system components.
7. Any modifications to planned maintenance or inspection tasks due to regional considerations.
8. Any corrective actions taken or recommended to take that will modify the HVAC system to resolve faults discovered during the inspection process.

Some corrective actions can be done as a part of the inspection and maintenance process, but any that fall outside of that scope must first be discussed with and ultimately approved by the homeowner before they can be implemented. All corrective actions must also follow the OEM’s instructions for the equipment and any applicable building codes.

A few items to consider when scheduling maintenance inspections and corrective actions:

* For cooling and heating equipment, maintenance inspection must be done when the equipment is operating within the temperature ranges set by the OEM.
* The HVAC contractor can recommend increasing the degree or frequency of inspection and maintenance if the equipment is found to be underperforming. The contractor can also recommend decreasing the frequency of maintenance from semiannually to annually for heating- or cooling-only equipment that is active during the appropriate season instead of the entire year.
* The homeowner has the final say on approving any changes to the frequency and scheduling of preventative maintenance and recommended corrective actions.

**Problem Set 2.1:**

1. What is the first task for performing a maintenance inspection on a residential HVAC system?
2. What are the requirements that an HVAC system should adhere to?
3. What are two circumstances that can change the recommended frequency of scheduled maintenance inspections?

**Learning Objective 2.2:**

* Understand the general steps for HVAC contractors carrying out cleaning restoration for HVAC systems.

**Lecture Notes 2.2:**

Reference: ACCA Standard 6: Restoring the Cleanliness of HVAC Systems (4/9/2021): <https://www.acca.org/communities/community-home/librarydocuments/viewdocument?DocumentKey=b0d7da58-e516-4af6-bf03-0e474d27081d>

Either an HVAC contractor or an independent Indoor Air Quality Consultant are responsible for determining whether cleaning an HVAC system is both necessary and economically feasible. This is done through inspection, both physically through assessing the components of the HVAC system, and economically by determining whether it is more cost-effective to clean the HVAC system or completely replace the existing equipment or components. A third-party consultant is required when the cleanliness of an HVAC system can affect the homeowner’s health.

To conduct this assessment, the HVAC contractor must be:

* Familiar with the HVAC system’s internal components, such as evaporator coils, secondary high efficiency heat exchangers, electric resistant heaters, and zoning dampers.
* Able to take apart and assemble the HVAC system and associated subsystems so that it can be fully accessed during the assessment, and will be operational once the cleaning is complete.
* Able to identify basic faults in an HVAC system, such as undersized filtration, air distribution problems, and whether the original installation was improperly performed or incomplete.
* Familiar with duct leakage impacts, particle bypass, and infiltration issues.

Building Assessment:

The assessment begins with a survey of the building’s history to see if the HVAC system has been affected by any of the following:

* Particulate buildup (e.g., dust, mold, etc.)
* Damage by fire, smoke, or water
* Unusual odors
* Pest infestation (e.g., birds, rodents, insects, etc.)

Next, the HVAC system is physically assessed. This assessment includes observations for both the cleanliness of the HVAC system and the material integrity of system’s components. These observations include:

* All of the components of the HVAC system, including, but not limited to, the duct system, filter cabinets, supply and return plenums, dehumidifiers, humidifiers, Energy Recovery Ventilators (ERVs), fresh air ducts, air handlers, furnaces, coils, and condensate drains.
	+ For internal inspection, check for rust, corrosion, obstructions, biofilm, air leakage, particulate buildup, material integrity, moisture condition, and drainage.
	+ For external inspection, check for corrosion, biofilm, air leakage, material integrity, location, and condition.
* Any condensate drains, ensuring that they are functioning properly.
* The impact of the HVAC unit’s mechanical room condition on system cleanliness and air quality.

After the information from the building survey and physical observations has been collected and documented, it is evaluated to assess the condition of the HVAC system. From this assessment, the scope of work for the components that need to be addressed is defined and a recommendation is made as to whether these components should be cleaned or replaced. If it is decided to clean these components, a recommendation for cleaning techniques is also made.

HVAC Cleaning:

With the preliminary assessment complete, if it is recommended to do so, the cleaning and restoration of the HVAC system can begin. At all times, the HVAC contractor shall use proper administrative controls, engineering controls, and provide personal protection equipment (PPE) required to safely perform all tasks.

Cleaning particulates from an HVAC system requires the following procedures:

1. The components of the HVAC system must be isolated from the rest of the indoor environment before any contamination can be removed. This process uses negative depressurization techniques with pressure differentials that do not adversely affect the indoor environment or cause hazardous conditions (0.01-0.02 inches of water gauge [in. wg.]) to prevent the release of particles, gases, or vapors into the occupied space. Any exhaust from cleaning equipment inside the building must use a HEPA filter that removes hazardous gases from the air, and exhaust from outside must be prevented from reentering the building, making sure to avoid openings such as air intakes or other building entrances.
2. Buildup of particles should be safely dislodged and removed without damaging components of the HVAC system while cleaning. Methods and tools used for cleaning the buildup can be changed based upon the size, type, and consistency of the particulates (e.g., dry, wet, oily, etc.).
3. Contaminants need to be physically removed from HVAC components. Resurfacing, antimicrobial, ultraviolet light, or other sanitizing methods cannot be used as a substitute for the physical removal of contaminants.

All use of cleaning equipment must follow the manufacturer’s guidelines for the cleaning taking place, and all tools must be cleaned before use. Any occupied areas must be protected from cleaning activities through the use of HEPA filters, particulate collectors, and temporary plastic walls or sheets. Environments that are contaminated from cleaning activities must be isolated from occupied areas through continuous negative pressure conditions.

The HVAC system should be cleaned in the order of its airflow, starting with the return air intakes, then the air handling unit, supply trunk line, branch runs, and finally the discharge points. Following this order of cleaning can help to reduce the chance for recontamination of the system. Further protection of the system is offered by putting air filters within the ducts, and temporarily isolating the cleaned sections and electrical circuitry of the system. Once cleaning activities are completed, the used temporary air filters should be tightly sealed in plastic bags and disposed of following Federal, State, and local regulations.

Specific steps for the cleaning of HVAC system components and subsystems, along with duct service openings and closures, is detailed in Level 3 of this training module.

Post Cleaning Verification:

After the cleaning activities are completed, the HVAC system is checked once more for cleanliness before any surface treatments are applied to the ventilation system, if applicable. HVAC components are evaluated by the homeowner’s representative for visible cleanliness via direct visual inspection, or with a visual inspection system (i.e., mirrors, borescope, and cameras). The homeowner or representative may request that the contractor create additional access openings into the HVAC system to further check for cleanliness. Contractors will conduct quality control during cleaning to ensure that they, as well as any subcontractors working under them, adhere to all applicable standards while conducting their work. Work done by the contractor is according to ACCA Standard 6: HVAC Reconditioning for System Cleanliness and Indoor Air Quality by the following methods:

* Assessment of cleanliness of the system through visual inspection, surface comparison testing, or the National Air Duct Cleaning Association (NADCA) vacuum test from the ACR Standard (link: <https://nadca.com/store/acr-nadca-standard-2021-edition>).
* Activation of the HVAC system will not begin until it is shown to have reached the cleanliness target established during the preliminary assessment.
* Review and acceptance by the homeowner or representative of the pre- and post-cleaning records for system operational measurements, which must be made available and stored on file.

Post-Cleaning Products and Usage:

The following guidelines are for restoration products on HVAC components that that are used after the cleaning process has been done:

Resurfacing and Coating Products:

Any resurfacing products used must follow the manufacturer’s instructions and be specific to the HVAC component that they will be used on. All of the surfaces that will undergo resurfacing must have gone through the post-cleaning verification process described above before any resurfacing products are applied. If the resurfacing product requires EPA registration, the contractor must ensure that that product is applied in strict accordance with its instructions. The HVAC system, ductwork, and other subsystem components must be kept well-ventilated when resurfacing and using coating products. When applying coating products to fibrous glass insulated duct liner or duct board, visually check if the fibrous glass can support the weight of the applied coating product.

Closure Products:

There are two main types of closure products used post-HVAC cleaning for sealing duct joints and rigid fiberglass duct boards: mastics and tapes. Mastics must meet Underwriters Laboratories, Inc. (UL) Standards 181A-M (link: <https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL181A>) for fiberglass ducts, 181B-M (link: <https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL181B>) for flexible ducts, and either UL 181A-M or UL 181B-M for rigid metal ducts and components. Tapes must meet UL Standards UL 181A-H for rigid fiberglass ducts, UL 181A-P for rigid fiberglass ducts, UL 181B-FX for flexible ducts, and either UL 181A-P or UL 181B-FX for rigid metal ducts and components.

Sanitizers, Disinfectants, and Other Antimicrobial Products:

To use cleaning products, such as sanitizers, disinfectants, or other antimicrobial products, for a specific use, they must be registered by the Environmental Protection Agency (EPA) for that purpose. Only a few antimicrobial products for use specific to HVAC systems have been evaluated by the EPA. The product manufacturer’s directions must be followed for cleaning the system before application by using the specified amounts, methods, and conditions. Read all hazards and precautionary statements, and only use the product as according to its label. When using antimicrobial products in the HVAC system, have all occupants exit the household until the specified minimum duration has passed in accordance with the manufacturer’s instructions and labeling.

**Problem Set 2.2:**

1. What types of assessments are needed in order to determine whether an HVAC system’s components should be cleaned or replaced?
2. What are the four principles of particulate removal from HVAC systems?
3. What are three precautionary measures to prevent cleaned HVAC surfaces from becoming re-contaminated during the cleaning process?
4. What are three quality control measures contractors can utilize to verify an HVAC system’s cleanliness after cleaning is done?

**Learning Objective 2.3:**

* Understand how a homeowner can perform preventative maintenance on a ductless air source heat pump.

**Lecture Notes 2.3:**

Residential ductless heat pumps have both indoor and outdoor units that need to be regularly maintained. The following maintenance steps are specific to a Daikin Ductless heat pump in the following video reference. There are similarities to cleaning procedures for other units, but it is advised to consult the manual for the specific instructions for the HVAC system being worked on.

Source: Greenfoot Energy Solutions (8/17/2020): <https://www.youtube.com/watch?v=Dd1rWPgPZrY>

Indoor Unit Maintenance:

1. Turn off the indoor unit and wait until it shuts down completely.
2. Clean the exterior panels of the indoor unit by wiping the surface with a clean cloth.
3. Open up the indoor unit face following the directions, exposing the air intake screens and air filters.
4. Remove the air filters for cleaning. There are two types of air filters, large and small. The large filters should be cleaned every 2 weeks, and the small filters should be cleaned every 6 months and can last up to 3 years. There are two methods to clean the air filters:
	1. Use a vacuum to suck off dust and debris that has built up on the screen.
	2. Use some mild detergent, soak in lukewarm water, and gently wipe away the debris.

Outdoor Unit Maintenance:

After installation, homeowner maintenance on the outdoor unit tends to be minimal.

1. Make sure there is no obstruction by anything large that may restrict airflow.
2. Inspect the coils to see if there is any debris covering them.
3. Gently remove the debris, making sure not to damage the coils. (If the coils are continually obstructed with a lot of dirt or fine dust, it is recommended to call the service department for professional cleaning).
4. In the winter months, clear out any snow around the unit, and maintain a 3-4 foot perimeter of open space around the unit to ensure proper airflow.
5. Inspect the condensate drain to make sure it is not blocked, and that there is no buildup of water in the drain itself.

**Problem Set 2.3:**

What are the preventative maintenance steps for heat pumps that a homeowner can perform on their own?