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

Proficiency Level 3: Apply

**Learning Objective 3.1:**

* Understand the inspection and maintenance tasks for different heat pump HVAC systems and their components.

**Lecture Notes 3.1:**

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>

Preventative Maintenance for Heat Pump HVAC Systems and Components:

The following sections describe the protocol for performing inspection and maintenance tasks, and suggested corrective actions that require additional work on heat pumps and related HVAC systems and components, as described in ACCA Standard 4: Maintenance of Residential HVAC Systems (reference link above).

Air Distribution System:

Semiannual tasks:

Inspect air filters for buildup of particulates. If the buildup causes a pressure differential that exceeds the system’s design or causes the system’s airflow to fall outside of the operating limits as defined by the manufacturer, then clean or replace the filters.

Inspect the air filter’s housing structure and air seal, and clean if needed. Check any grilles, registers, diffusers, and balancing dampers in the trunk and branches for dirt buildup, and clean if needed.

Annual tasks:

Check ductwork for excess moisture and mold growth. Clean these areas or replace them if the mold cannot be removed. Access panels can be installed in the ductwork if needed for accessibility. Check structure of ductwork insulation for durability. Locate and document any damage to insulation or associated exterior vapor retarders. Repairs to the insulation and retarders can be done as a follow-up corrective action. Check all accessible ductwork and document any faults, such as poor modifications, duct strapping, air leaks, and broken tapes or mastics. Repairs or replacements can be done as a follow-up corrective action.

Controls and Safeties:

Semiannual tasks:

Test the HVAC system’s various operation modes and controls to make sure that the system controls are within the specified range. Clean and adjust the system controls, or if necessary, replace controls as a corrective action.

Test the operation mode of the zoning controls, including valve operations and bypass dampers. Clean or repair the controls and dampers, or if necessary, replace components as corrective actions.

Annual tasks:

Test the operation modes of remote-controlled thermostats. Replace the battery, checking for corrosion on any components. If the system has controls for defrosting, test the defrost mode and check that it is operating correctly.

Test the safety switches for the drain pan and the unit. Clean these switches and adjust the wiring for repairs if necessary. Check that the control board positioning of all selectable pins, jumpers, or dip switches, is in accordance with the Original Equipment Manufacturer’s (OEM’s) guidelines.

Evaporator Coil:

Cabinet:

Semiannual tasks:

Check integrity of the cabinet, cabinet fasteners, and panels, replacing any missing fasteners. Insulation replacement and sealing of air leaks can be done as corrective actions.

Check that there are no obstacles around the cabinet that could interfere with airflow. Document where the cabinet does not meet these clearance requirements. Repairs or replacements to meet the requirements can be done as follow-up corrective actions.

Condensate Removal:

Annual tasks:

Check and clean the condensate drain piping and traps for proper drainage. Inspect for any condensate blowing from the evaporator coil into the cabinet or air distribution system. If there is condensate, adjust the fan speed, clean the coil fins, and check that any deflectors are in place to prevent water carry over. If water carry over persists, components can be repaired or replaced as a corrective action.

Check the drain pan and line for any organic buildup, including mold, bacteria, fungi, etc. Remove the buildup through cleaning, using compatible algae tablets if needed.

Check secondary draining equipment (drain lines, pans, or overflow protection devices) for proper drain flow. If there is water in the secondary drain pan, investigate to determine the cause, and remove any blockages.

Refrigeration:

Annual tasks:

Check that the airflow is operating correctly using the temperature difference or static pressure, and compare to the OEM’s recommended value. If the value does not meet the OEM recommendation, clean the coils and blower, and adjust the system to achieve proper airflow. Components can be repaired or replaced as a corrective action.

Document the dry bulb (DB) and wet bulb (WB) temperature differences along the evaporator coil. If the temperature differences are not within the OEM recommendation, identify the cause by checking the system’s airflow, refrigerant charge, and operating conditions. Make sure the coil fins are visibly clean, straight, and open. Inspect refrigerant lines, joints, components, and coils for oil leaks. If there are any oil-stained joints, check for leaks, and clean or repair as necessary. Inspect the refrigerant line insulation and document the locations of any damaged insulation. Repairs or replacement can be done as follow-up corrective actions

Document the pressure drop across the coil, and clean or adjust as necessary. If the evaporator unit is mounted on the wall or ceiling with a ductless mini-split heat pump, this step does not apply.

Condenser Unit:

Cabinet:

Semiannual tasks:

Check the integrity of the cabinet, cabinet fasteners, and panels, and replace lost fasteners. Repair insulation and any air leaks. Ensure that there are no obstacles around the cabinet that could interfere with airflow, and document where the cabinet does not meet these clearance requirements. Repairs or replacements to meet the requirements can be done as follow-up corrective actions.

Electrical:

Semiannual tasks:

In the electrical disconnect box, check the integrity of the electrical case. Make sure all electrical connections are clean and tight. Any fused disconnects must be properly sized and not bypassed. Any repairs or replacements can be done as corrective actions.

Check that the equipment is correctly grounded. Document the line voltage and check that the reading matches the OEM specifications or equipment nameplate data. Inform the homeowner of these results. Check contactors and relays for signs of pitting or excessive contact arcing. Replace any that are damaged.

Check the printed circuit for damage, such as hot spots. Clean and check that the circuit is operating correctly. Check the other electrical connections and wires for the correct size, type, tightness, and discoloration. Document if there is any damaged electrical wiring, and repair or replace as a corrective action.

Document any motor capacitors that have bulged, split, are incorrectly sized, or otherwise do not meet the OEM specifications. Check the capacitance with a meter and replace capacitors that do not meet specifications. Document the amperage drawn by the motor and compare it to the recommended Full Load Amp (FLA) rating on the nameplate data. If the amperage draw exceeds the recommended rating, diagnose the source of the excess draw. Repair or replace as a corrective action.

Refrigeration:

Semiannual tasks:

Check for oil leaks in all refrigerant lines, joints, components, and coils. Document if there are any oil-stained joints, and clean as a corrective action. If the temperature difference is not within the recommended OEM value, check and adjust the refrigerant charge. If components need to be repaired or replaced to do this, that can be done as a corrective action.

Annual Tasks:

Check and document any damage to the refrigerant line insulation.

Condenser Fan Motor:

Annual tasks:

Check the fan blade blower wheel for a tight connection to the blower motor shaft. Check for free rotation of the fan blades and minimal axial movement in the motor shaft. Motor bearings should only be lubricated as a maintenance measure if recommended by the OEM.

Document the amperage drawn by the fan motor. If amperage exceeds the OEM recommendations, lower the motor speed, and check again. If that does not return the amperage draw to OEM-specified levels, repair or replace problematic components.

Condenser Coil:

Annual tasks:

Check the coil fins for straightness, and if necessary, clean and repair the fins.

Additional Maintenance Tasks for Air-to-Air Heat Pump Condensers:

Semiannual tasks:

Test and document the operation of the reversing valve. If the results are unsatisfactory, consider repairing or replacing the components. If the temperature difference is not within OEM specifications, check and adjust the refrigerant charge. If components need to be repaired or replace to do this, that can be done as a corrective action.

Check and adjust the defrost operations to ensure they are working correctly. Make sure that the outdoor unit condensate drain ports are open and elevated to allow for free flow of condensate, following local codes for avoiding seasonal obstructions such as snow.

Fan Coil:

Cabinet:

Semiannual tasks:

Check the components of the cabinet, including fasteners and panels, and replace any lost fasteners. Insulation replacement and sealing of air leaks can be done as corrective actions. Ensure that there are no obstacles around the cabinet that could interfere with airflow, documenting any that do not meet the clearance requirements. Repairs or replacements to meet the requirements can be done as follow-up corrective actions.

Electrical:

Semiannual tasks:

In the electrical disconnect box, make sure all electrical connections are clean and tight. Any fused disconnects must be properly sized and not bypassed. The electrical case must also be fully intact. Any necessary repairs or replacements can be done as a corrective action.

Check that the equipment is properly grounded. Document the line voltage and compare the reading to OEM recommendations or equipment nameplate data. Inform the homeowner of these results. Check contactors and relays for pitting or contact arcing, and replace if necessary. Check other electrical connections and wires for the correct size and type, tightness of connections, and discoloration. If there is any damage to electrical wiring, it can be repaired or replaced as a corrective action.

Document motor capacitors that have bulged, split, are incorrectly sized, or otherwise do not meet OEM specifications. Replacing capacitors can be done as a corrective action and check the capacitance with a meter. Document the amperage drawn by the motor and compare it to the recommended Full Load Amp (FLA) rating on the nameplate data. If the amperage draw exceeds the recommended rating, diagnose the source of the excess draw, and repair or replace as a corrective action.

Blower Assembly:

Semiannual tasks:

Document airflow across the coil. If the airflow is not what it should be, adjust and clean the coil. Also check that grilles, registers, and balancing dampers are operating and are free of any blockage. Repair or replacement of components as a corrective action may be done. Check the variable frequency drive, such as those found in electronically commutated motors (ECMs), for proper operation.

Annual tasks:

Check and adjust fan belt tension and alignment for optimum operation, as well as the belt and pulleys for damage, and repair or replace components if needed. Check the fan blade blower wheel for proper connection to the blower motor shaft, free rotation of the fan blades, and minimal axial movement in the motor shaft. Motor bearings should only be lubricated following OEM specifications.

Document the amperage draw, and if it exceeds OEM specifications, reduce the motor speed to OEM-specified levels, or repair or replace components.

Evaporator Coil:

Annual tasks:

Check for leaks in the coil, refrigeration components, fittings, and fins. Clean and make sure the fins are open. Check that the airflow is operating correctly using the temperature difference and/or static pressure and compare to the OEM’s target value. If the value does not meet the OEM target, clean the coils and blower as necessary, and adjust the system to achieve proper airflow. Controls can be repaired or replaced as a corrective action.

Document the dry bulb (DB) and wet bulb (WB) temperature differences across the evaporator coil. If the temperature differences are outside of appropriate OEM ranges, check the system’s airflow, refrigerant charge, and operating conditions. Check the refrigerant line insulation and record the type and location of any damaged insulation.

Condensate Removal:

Annual tasks:

Check for any condensate blowing from the evaporator coil into the cabinet or air distribution system. If there is, adjust the fan speed, clean the coil fins, and ensure any OEM supplied deflectors are in place to prevent water carry over. If water carry over persists, components can be repaired or replaced as a corrective action. Check and clean the condensate drain piping and traps for proper drainage operation. Check the drain pan and accessible drain line for any mold buildup and remove through cleaning, using compatible algae tablets if needed.

If There Are Any Auxiliary or Supplemental Electric Heaters in this System:

Semiannual tasks:

Check the electric heater’s capacity and sequence of operation for compliance with the OEM’s recommendation.

Package Units:

Cabinet:

Semiannual tasks:

Check the components of the cabinet, including fasteners and panels, and replace any lost fasteners. Insulation replacement and sealing of air leaks can be done as corrective actions. Check that there are no obstacles around the cabinet that could interfere with airflow. Document where the cabinet does not meet these clearance requirements. Repairs or replacements to meet the requirements can be done as follow-up corrective actions.

Electrical:

Semiannual tasks:

In the electrical disconnect box, check the integrity of the electrical case, and make sure all electrical connections are clean and tight. Any fused disconnects must be properly sized and not bypassed. Any repairs or replacements can be done as corrective actions. Check that the equipment is properly grounded.

Document the line voltage and compare the reading to OEM recommendations or equipment nameplate data. Inform the homeowner of these results. Check contactors and relays for pitting or contact arcing, and replace if necessary. Check other electrical connections and wires for the correct size and type, tightness of connections, and discoloration. If there is any damage to electrical wiring, it can be repaired or replaced as a corrective action.

Document motor capacitors that have bulged, split, are incorrectly sized, or otherwise do not meet OEM specifications. Replacing capacitors can be done as a corrective action and check the capacitance with a meter. Document the amperage drawn by the motor and compare it to the recommended Full Load Amp (FLA) rating on the nameplate data. If the amperage draw exceeds the recommended rating, diagnose the source of the excess draw, and repair or replace as a corrective action.

Indoor Blower Motor:

Semiannual tasks:

Document airflow across the coil. If the airflow is not what it should be, adjust and clean the coil. Also check that grilles, registers, and balancing dampers are operating and are free of any blockage. Repair or replacement of components as a corrective action may be done.

Check the variable frequency drive, such as those found in electronically commutated motors (ECMs), for proper operation. Check the fan belt for tension and alignment as required for optimum operation. Check the belt and pulleys for damage, and repair or replace components if needed.

Annual tasks:

Check the fan blade blower wheel for proper connection to the blower motor shaft, free rotation of the fan blades, and minimal axial movement in the motor shaft. Motor bearings should only be lubricated following OEM specifications. Document the amperage draw, and if it exceeds OEM specifications, reduce the motor speed to OEM-specified levels, or repair or replace components.

Evaporator Coil Section:

Annual tasks:

Check that the coil fins are visibly clean, straight, and open. Check for any condensate blowing from the evaporator coil into the cabinet or air distribution system. If there is, adjust the fan speed, clean the coil fins, and ensure any OEM supplied deflectors are in place to prevent water carry over. If water carry over persists, components can be repaired or replaced as a corrective action.

Check for oil leaks in all refrigerant lines, joints, components, and coils. Document if there are any oil-stained joints, and clean as a corrective action. Check that the airflow is operating correctly using the temperature difference or static pressure and compare to the OEM’s recommended value. If the value does not meet the OEM recommendation, clean the coils and blower, and adjust the system to achieve proper airflow. Components can be repaired or replaced as a corrective action.

Document the dry bulb (DB) and wet bulb (WB) temperature differences across the evaporator coil. If the temperature differences are outside of appropriate OEM ranges, check the system’s airflow, refrigerant charge, and operating conditions.

Condensate Removal:

Annual tasks:

Check for any condensate blowing from the evaporator coil into the cabinet or air distribution system. If condensation is present, adjust the fan speed, clean the coil fins, and ensure any OEM supplied deflectors are in place to prevent water carry over. If water carry over persists, components can be repaired or replaced as a corrective action.

Check and clean the condensate drain piping and traps for proper drainage operation. Check the drain pan and accessible drain line for any mold buildup and remove through cleaning, using compatible algae tablets if needed.

Condenser Blower Motor:

Annual tasks:

Check the fan blade blower wheel for proper connection to the blower motor shaft, free rotation of the fan blades, and minimal axial movement in the motor shaft. Motor bearings should only be lubricated following OEM specifications. Document the amperage draw, and if it exceeds OEM specifications, reduce the motor speed to OEM-specified levels, or repair or replace components.

Condenser Coil Section:

Annual tasks:

Check that the coil fins are visibly clean, straight, and open.

Refrigeration:

Semiannual tasks:

If the indoor temperature difference is not within OEM specifications, check and adjust the refrigerant charge. If components need to be repaired or replace to do this, that can be done as a corrective action.

Annual tasks:

Check and clean refrigerant connecting lines, joints, and coils for oil leaks.

If There Are Any Auxiliary or Supplemental Electric Heaters in this System:

Semiannual tasks:

Check the electric heater’s capacity and sequence of operation for compliance with the OEM’s recommendation.

Additional Tasks for Package Heat Pumps:

Semiannual Tasks:

Check the reversing valve and document if it is unsatisfactory, and consider repairing or replacing the components. If the indoor temperature difference is not within OEM specifications, check and adjust the refrigerant charge. If components need to be repaired or replace to do this, that can be done as a corrective action.

If the system has controls for defrosting, test the defrost mode and check that it is operating correctly. Make sure that the outdoor unit condensate drain ports are open and elevated to allow for free flow of condensate, following local codes for avoiding seasonal obstructions such as snow.

Standalone Accessories:

Condensate Pumps:

Annual Tasks:

Clean the condensate pump, flush it, and test after cleaning to check that it is operating properly. If it is not, repair or replacement may be necessary as a corrective action. Check and clean the condensate drain piping and traps for proper drainage operation.

**Problem Set 3.1:**

1. What frequency should the following steps for HVAC preventative maintenance be performed?
   1. Cleaning air filters
   2. Cleaning ductwork
   3. Cleaning equipment cabinets
   4. Inspecting electrical elements
   5. Draining and cleaning condensate drain piping
   6. Changing refrigerant charge
   7. Cleaning and maintaining coil fins
   8. Testing reversing valve

**Learning Objective 3.2:**

* Understand how to perform standardized cleaning on HVAC systems and ductwork.

**Lecture Notes 3.2:**

Reference: ACCA Standard 6: HVAC Reconditioning for System Cleanliness and Indoor Air Quality (4/9/2021): <https://www.acca.org/communities/community-home/librarydocuments/viewdocument?DocumentKey=b0d7da58-e516-4af6-bf03-0e474d27081d>

Cleaning of HVAC System Components and Subsystems:

The following sections describe the protocol for cleaning HVAC system components and subsystems, as described in ACCA Standard 6: HVAC Reconditioning for System Cleanliness and Indoor Air Quality (Reference link above).

Cooling / Heating Coils:

To clean cooling and heating coils, a detergent must be used and then rinsed off with pressurized water. Care must be taken while cleaning to ensure that the coils do not get damaged. If coils have a depth of four rows or greater, then pressurized chemical and water cleaning methods, such as pressure washers and chemical injection systems, can be used. Surfaces that surround coils, such as electronics and insulation, should be either removed or isolated from any cleaning sprays.

Both the upstream and downstream faces of the coil must be accessible for proper cleaning. If both faces of the coil cannot be completely accessed, then coils should be removed. Cooling coils that use fluorochemical refrigerant systems must have a qualified technician pump down the coil’s refrigerant for temporary storage into the air conditioning system’s condenser unit or into a separate secondary tank, following any applicable Federal, State, and local requirements for capturing refrigerants. After removal of the coil, both ends of the coil and the interconnecting piping to the rest of the system must be properly sealed to prevent infiltration of moisture or other contaminants. When deeper penetration is needed for cleaning, such as when the depth exceeds four rows, the rinse water pressure can be increased as long as it does not damage the fins.

Fan Blades and Fan Housing:

To clean fan blades and housings, they should be wet cleaned and scrubbed with detergent. They must then be carefully rinsed, while preventing the water from reaching the system and causing damage.

Motors:

First, the exterior surfaces of the fan motors should be vacuumed with a HEPA-filtered device, including the housing and external wires. Any remaining debris must then be removed with a damp cloth, using a light, non-corrosive detergent solution. Insulated wires must be hand-cleaned separately one at a time when they are exposed to airstreams. When wiping down the motor wires, avoid pulling on unsupported electrical wires and wiring harnesses. If there is a buildup of debris on the interior of the motor and stator windings, use pressurized air to carefully remove the buildup, and then reclean the motor housing.

Air Handling Units and Interior Heat Exchanger Cabinet Surfaces:

Any buildup of particulates on a surface that contacts flowing air within air handling units must be manually cleaned. Insulation materials used to insulate the interior of air handler cabinets, such as fibrous glass, are inspected for fraying, tearing, and delaminating. Damaged, wet, or moldy insulation also needs to be repaired or replaced before the cleaning process is complete.

Drain Pans and Drain Line:

Drain pans must have all of their surfaces wet cleaned and scrubbed with an appropriate detergent. Any drain pans that show signs of rust or deterioration must be evaluated for replacement. If there is any remaining contamination in the drain pan, it should be removed using a HEPA-filtered wet vacuum, while making sure to prevent particulate buildup from reaching the drain line. The drain line is also cleared out during the remediation process, checking for unobstructed drainage with a pressurized water stream or a HEPA-filtered vacuum.

After cleaning, check the drain pans and line, and document any instance of inadequate drainage. If there are any secondary drains that lead outside, make sure they are secured to prevent air intrusion and provide adequate condensate drainage. The system should be setup to automatically stop operation if the secondary drain is improperly draining.

HVAC Airflow Control Components:

The components of the HVAC airflow control system must be cleaned of all particulate buildup. These components may include Variable Air Volume (VAV) boxes, mixing boxes, automated dampers, turning vanes, sound attenuators, air duct components, and all internal airside surfaces. If all of the components cannot be adequately reached for cleaning, then the system must be dismantled to properly finish cleaning. Once cleaning has been finished, the dampers must be returned to their original fixed positions.

Registers, Diffusers, and Grilles:

To wet clean registers, diffusers, and grilles, they must first be removed from the system. Using a detergent-type cleaner, all surfaces of the diffusers must be manually brushed and rinsed with a clean stream of water, taking care to not damage components, and replacing any wet diffuser insulation. Reset dampers to their original position following cleaning. Do not remove registers if the HVAC system does not have a continuous negative pressure differential.

Ductwork System:

Damaged ductwork, including areas that have excess moisture buildup, should be removed, and replaced. Any ductwork that needs to be replaced should be thoroughly checked for the source of the moisture, and must follow the recognized containment process when being removed while complying with all Federal / State / local code requirements.

Rigid Ducts:

Rigid ducts should have their interior surfaces cleaned by removing any built-up debris or particulates by using pneumatically driven brushing tools, air whipping devices, powered tools (cable or rod), a HEPA-filtered vacuum, or hand brushing, while the duct is at lower pressure than the occupied space. Tools that are used to clean the interior surfaces must also be capable of collecting and removing fine particulate matter, while making sure to not damage the interior.

Fiberglass-lined or Duct Board Ductwork:

Cleaning of ductwork that is lined with a porous material, such as fibrous glass, must be done with a HEPA-filtered vacuum and soft brush to prevent damage of the surfaces. Excessively wet or moldy fibrous glass insulation or duct board must be removed and replaced.

Flexible Non-metallic Ducts:

Cleaning of ducts that are constructed from flexible, non-metallic materials must also be done in a manner to prevent damage to the interior surfaces of the ducts. If moldy ductwork needs to be replaced, it must comply with all Federal / State / local code requirements and manufacturers’ installation instructions.

Duct Service Openings and Closures:

Metal Ducts:

Access to metal ducts is gained through service openings, which must then be resealed with an insulated metal door or panel that meets the requirements of the Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA) and does not cut through the seams or joints of the duct. The replacement fibrous glass insulation must be new, be of the same material type, and have an equal R value to the previous material.

Closures for metal ducts cannot be secured by tape alone, they must use fasteners, such as screws, bend tabs, or other HVAC methods, to permanently secure the closure to the duct surface. The openings that were created for cleaning activities must be resealed according to industry standards and Federal / State / local codes to not alter airflow or air quality.

Service Openings and Closure Fiberglass Duct Board Ducts:

To access the interior of fiberglass duct board ducts, either install access doors into the ductwork or make an intersecting 45-degree cut into the ductwork. Access openings made in ducts constructed from fiberglass duct board must be fastened together using clinching staples on approximately 2-inch centers and pressure-sensitive tape. If staples cannot be used, pressure-sensitive tapes (see “Closure Products” in Section 2.2 of this module) can be used on its own if the adhesion will last the duration of the expected life for the duct system.

Any duct board ducts are listed with Underwriters Laboratories (UL) as UL 181 Class 1 Rigid Air Ducts. Closure systems for Fiberglass duct board ductwork should follow those listed in standard UL 181A (link: <https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL181A>) to ensure airtightness and maximum efficiency at design temperatures.

Flexible Ducts:

If flexible ductwork needs to be accessed for cleaning, it should be done in a way that does not damage the duct surface or structure. Ductwork can be accessed from connection points at both ends of the system, as long as this does not put the integrity of the ducts at risk.

Use of Mastic:

The liberal use of mastics is highly encouraged, and should be applied to the whole joint and mated surfaces. For holes larger than 1/8-to-1/4 inches, one or more layers of fiberglass mesh tape must be placed over the mastic, followed by another layer of mastic that fills and covers the tape’s mesh pattern entirely.

**Problem Set 3.2:**

1. Which of the following is true about the cleaning procedure for cooling coils?
   1. Coils must only be cleaned with pure water solutions.
   2. Pressurized chemical and water cleaning methods can be employed for coils of any depth.
   3. If one, but not both, of the upstream or downstream faces of the coil can be completely accessed, the coil does not need to be removed to be cleaned properly.
   4. Refrigerant must be pumped into temporary storage within the air conditioning system or into a secondary storage container before coil removal.
2. When cleaning air handler units, when should interior insulation be replaced?
3. What are the guidelines for creating openings for cleaning access in metal ducts, fiberglass duct board ducts, and flexible ducts? What are the guidelines for properly closing these access openings?