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PERSPECTIVES

Building Damage Assessments: HVAC&R Systems and Components

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

INTRODUCTION

Heating, ventilating, and air-conditioning systems and equipment are often included in residential and light commercial building damage loss claims or forensic property assessments, especially those system components that are installed outdoors. For those who write or review large estimates, this paper will explain the most common HVAC systems found at these types of properties and how their components work. It will also address common failure modes and types of damage for this type of equipment.

HVAC SYSTEM FUNCTIONS

In today's world, we take heating, air conditioning, and ventilation for granted. We walk into warm homes and offices in winter and cooler and less humid homes and offices in summer with little thought of the equipment regulating our indoor environments. Did you know that air conditioning was first used in 1902 at New York's Sackett & Wilhelms Lithographing and Printing Company?[1] The printer published a four-color edition that required four separate runs. The air conditioning system was installed to keep the humidity level even between printing runs. It was not installed to comfort the workers in their sweltering environment. In 1906, Carrier first began installing air conditioning for comfort applications.

While many of the functions performed by HVAC systems are apparent from the acronym, some are not. Air-conditioning is most often associated with cooling air, but also includes dehumidification as a byproduct of cooling the air. Heating is required in colder climates to offset heat loss through the building envelope and maintain adequate indoor temperatures for occupancy. Ventilation is the process of introducing fresh outdoor air into a building to dilute indoor air pollutants generated by people and building materials (off-gassing). This often includes exhausting air from spaces like bathrooms and kitchens with heavy pollutant sources. HVAC systems almost always include a means of filtering or cleaning the air they circulate, and sometimes include a humidifier.

Common to most HVAC systems is the refrigeration cycle, which uses chemical refrigerant in a closed system to cause heat to move from a "cold" area to a "warm" area. This is counter to the way heat moves naturally, from warm to cold.

The four basic components of a refrigeration system work as follows:

- In the compressor, the warm refrigerant gas is compressed to a high pressure and temperature.
- In the condenser, the hot gas is cooled enough to cause it to condense to a warm liquid. The heat is rejected to the "warm" area, usually outdoors.
- The expansion valve allows the warm liquid to pass to an area of much lower pressure. When the pressure reduces, some of the liquid flashes (evaporates) to a gas and cools the remaining liquid.
- In the evaporator, the rest of the liquid refrigerant evaporates to a gas, absorbing heat from the "cold" area.

Both the condenser and evaporator usually incorporate a blower to move air through the coils. The evaporator will be mounted above a drain pan positioned to collect any moisture (water vapor) that may condense out of the cooled air. Note that some systems may also incorporate a reversing valve so that the evaporator and condenser can switch roles. This is called a heat pump, and it can be used to either cool or heat an area.

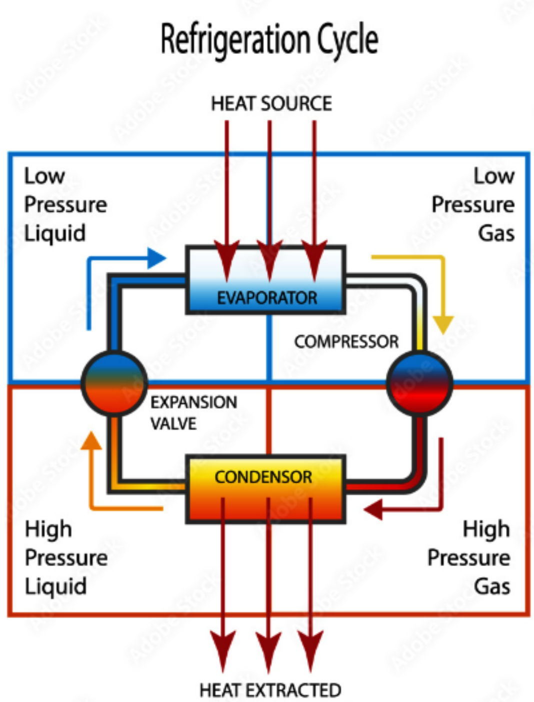

***Figure 1** - The basic refrigeration cycle.*

[1] BBC World Serve, (June 5, 2017) 50 Things That Made the Modern Economy. Tim Harford www.bbc.com. https://www.bbc.com/news/business-39735802

HVAC SYSTEM COMPONENTS AND CONFIGURATIONS

Within the realm of residential and light commercial buildings, there are many types of HVAC systems used, with many variations available within those types. Some of the most common system types include:

- **Packaged units.** These are all-in-one units where all the system components are contained in one cabinet that is mounted on an exterior wall in a wall or window opening. They include packaged terminal air conditioners (PTAC) and window air conditioners. These are typically used in hotels and residential applications. The cooling capacities in packaged units are low.

Figure 2 *- Packaged window air conditioning unit.*

- **Non-ducted split (mini-split) systems.** In this configuration there are two main components mounted separately, an outdoor unit with the compressor and condenser (called a condensing unit) and an indoor unit with the metering device and the evaporator. The indoor and outdoor units are connected by insulated copper tubing that allows the refrigerant to flow between the units. The indoor unit can take several different forms (wall-mount, floor-mount, or ceiling cassette), but it is usually exposed in the space it serves. These systems can have multiple indoor units connected to a single condensing unit. Condensing units are typically mounted on grade but can be mounted on a wall bracket, a shelf, or on a roof.

Figure 3 *- Split system indoor evaporator unit (left) and outdoor condensing unit (right).*

- **Ducted split systems**. This configuration is like mini-split systems except that the indoor unit is concealed in a mechanical room, attic, or basement, and the conditioned air is distributed from the indoor unit to the spaces served through ductwork. These systems are typically used in single-family homes and small commercial buildings and often include a gas furnace for heating.

Figure 4 *- Ducted split system - indoor air handling unit.*

- **Rooftop packaged units (RTUs).** These types of systems are also packaged units in that all components are contained in a single cabinet. However, unlike PTAC and window AC units, RTUs almost always include ductwork to distribute the conditioned air. These systems are rarely used in residential buildings and can vary from small to large and include many options and accessories.

Figure 5 *- Rooftop packaged unit.*

HVAC'S ROLE IN BUILDING DAMAGE ASSESSMENTS

With a basic understanding of these systems and components, where they might be located, and how they may be impacted in a loss event, it is easier to address building damage assessments involving HVAC systems and components.

Outside units, such as the compressor/condenser units for homes or commercial rooftop units that are mounted on stands and curbs, are often damaged by wind or hail. Improperly secured units can be toppled over by wind, and the softer metals on the units (such as the exposed evaporator coil cooling fins) can be damaged by hailstones. Larger, more dense hail may also cause impact damage to the unit chassis.

Rooftop HVAC equipment installations on low-slope roof systems are often the source of roof leaks, particularly at the mounting curbs. Improper flashing of the roof membrane at equipment curbs or at thru-deck penetrations such as pitch pockets (which allow for passage of refrigerant, water, and natural gas piping, as well as electrical cables and conduit through the roof to the HVAC equipment) will often result in water intrusion into the property. Building codes require proper mounting and securing of rooftop units. Units that are simply mounted on timbers or which rest directly on the roof membrane system are not building code compliant and will likely result in damage leading to water infiltration.

Package units mounted outside exterior walls that include thru-wall ducting can be the source of water intrusion if the thru-wall components are not properly protected from rain, or if the thru-wall passages allow for exchange of air (inside/outside), which affects the balance and efficiency of the HVAC system.

Air conditioning equipment can generally be repaired if it is of a recent vintage and exact replacement parts are available. However, for older units and systems, especially those using ozone-depleting refrigerants such as R-22, replacement parts are likely not available. In these instances, the entire unit will need to be replaced. If a split system condensing unit is replaced, then the indoor unit will need to be replaced as well. This is required because most building Energy Efficiency Codes require that all system components be designed to work together and certified for efficiency by an approved testing agency such as the Air-Conditioning, Heating, & Refrigeration Institute (AHRI).[2] Although other avenues are available to certify the operation and efficiency, they are seldom used due to the high cost.

Attic and closet mounted air handlers can be a source of moisture inside the building from condensation on cold surfaces (ducts and refrigerant pipes) and overflowing condensate pans. As an example, condensation dripping from an uninsulated copper line could cause stains on ceilings or finishes. This moisture can also lead to eventual structural deterioration and possible mold contamination.

CONCLUSION

In summary, HVAC systems contribute to well-being and safety in our lives. HVAC systems keep us comfortable at home and make it safer for us at work. These systems can also cause damage to properties if not properly installed and maintained or if they get damaged during a loss event. It's important to know how they function and where they are generally located on a property to perform an HVAC system evaluation of the condition of their components.

A prompt evaluation by an expert is often necessary for proper repair or replacement of HVAC components, since even minor damage to a component could cause or extend business interruption impacts. Depending on the type and complexity of the loss, HVAC claims can require mechanical, electrical, and plumbing experts; environmental, health, and safety experts; fire origin and cause experts; and forensic engineers to assist in the evaluation of the equipment. Additional experts, including building consultants

[2] 2015 International Energy Efficiency Code (Country Club Hills, IL: International Code Council Inc., 2014): C-40

and forensic accountants may be needed to assist with the valuation of the damages and any business interruption impact from the loss.

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