HVAC Sensors

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PR3/A2: Self-training material for enriching current online experiments

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HVAC stands for Heating, Ventilation, and Air Conditioning. For the purpose of creating comfortable and controlled indoor weather, HVAC systems, are often used. It is necessary for maintaining the ideal conditions of temperature, humidity, and air quality to ensure the safety and comfort of people. A comfortable, healthy, and energy-efficient indoor environment is created by HVAC systems, ensuring that residents can live, work, and relax in ideal conditions throughout the year.

I. What is an HVAC?

In residential, commercial, and industrial buildings, HVAC (Heating, Ventilation, and Air Conditioning) refers to the technologies and systems used to control and regulate indoor environmental conditions, such as temperature, humidity, air quality, and airflow. It is essential for keeping a safe and healthy interior atmosphere as well as for providing thermal comfort. A brief overview of the components of HVAC:

- Heating: during the winter months, HVAC systems offer heating. Furnaces, boilers, heat pumps, and electric heaters are common heating appliances. To increase the temperature indoors, these systems either produce or transfer heat.
- Ventilation: it is the process of bringing fresh air into indoor spaces and removing stale air from them. It helps in fragrance control, dust removal, humidity regulation, and oxygen supply. Fans, air ducts, and air exchangers can all be used as ventilation systems.
- Air conditioning: the process of cooling and dehydrating interior air is known as air conditioning. Typically, refrigeration cycles involving compression as well as expansion of gases called refrigerants are used to accomplish this. Central air conditioning units, split systems, window units, and portable air conditioners are a few types of air conditioning systems.

II. Working of HVAC

The HVAC system is typically controlled by a thermostat that is installed within the building. On the thermostat, the user chooses the desired temperature and mode (heating, cooling, or fan-only). The HVAC system's central component, the air handling unit (AHU), is in the position of controlling and dispersing air. A blower or fan, filters, dampers, and occasionally heating and cooling elements make up this structure. By circulating indoor air with fresh outside air, the HVAC system makes sure there is enough ventilation. Open windows or ventilation mechanisms that use fans to bring outside air inside can also do this. A conditioning gadget, such as an air conditioner or heat pump, is used by the HVAC system if cooling is necessary. The compressor, condenser, expansion valve, and evaporation make up

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the cooling unit. The refrigeration cycle is used to chill down interior air before recirculating it throughout the facility.

Heating: the HVAC system may include a furnace, boiler, heat pump, or electric heaters to provide heating. Heat is generated by the heating source and then dispersed around the room by the air-handling equipment.

Air distribution: the air that is conditioned (either heated or cooled) is pumped into the air handling unit and forced via the ducting system. To provide uniform circulation and temperature throughout the building, ducts transfer the air to various rooms or zones.

Air filtration: to get clear dust, allergies, and other airborne particles, air filters are put in the HVAC system. Capturing pollutants before the air is recirculated within the building, aid in preserving indoor air quality.

Managing interior humidity levels is able to be done by adding humidifying devices or dehumidifiers to HVAC systems. In dry circumstances, humidifiers offer moisture to the air, and in humid ones, dehumidifiers take away extra moisture.

Exhaust systems: HVAC systems can include exhaust systems in certain rooms, such as kitchens and restrooms, that remove stale air, smells, and moisture to the outside.

Controls and sensors: in order to control temperature, humidity, and airflow, the HVAC system is often supplied with controls, sensors, and programming. These components maintain a close watch on the surroundings and alter how the system works.

III. History of HVAC

The invention of methods to regulate the temperature inside and improve ventilation goes back several thousand years in the history of HVAC. Here is an outline of the major turning points in HVAC history:

- Ancient civilizations: for controlling indoor temperatures, several techniques were employed in ancient civilizations such as the Roman Empire and ancient Egypt. While the Egyptians applied evaporative cooling methods, the Romans established a hypocaust system involving raising flooring on pillars and moving warm air beneath them.
- 18th century: Heating and ventilation systems developed during the 18th century's industrial revolution. During this period, steam boilers were used to produce heat that was then distributed through radiators or pipes.
- 19th century: heating, as well as ventilation technology, continued to advance in the 19th century. Andrew Ure's development of the thermostat in 1830 made it possible to control temperature more precisely. Central heating

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systems with gas or coal furnaces started appearing in big houses and buildings in the late 1800s.

- 20th century: HVAC technology made great strides during this time span. Since they provide more effective heating and better temperature control, forced-air and electric heating systems are growing more and more popular. Willis Carrier developed the very first modern air conditioning system in 1902; it was initially intended to regulate humidity in a printing facility. This was a substantial advancement in cooling technology.
- Post-World War II: household air conditioning installation rates increased during this time. The demand for and use of air conditioning systems increased as they became smaller, more affordable, and widely available.

IV. Applications of HVAC

- Residential buildings: in order to provide comfort for heating and cooling, systems are frequently employed in homes and apartments.
- Commercial buildings: in commercial structures like offices, retail stores, restaurants, and hotels, systems are important.
- Industrial facilities: industrial buildings, warehouses, and industrial plants frequently need specialized temperature and humidity management.
- Educational institutions: HVAC systems are crucial for maintaining the comfort of classrooms and common areas for instructors, pupils, and staff in schools, colleges, and universities.
- Healthcare: to ensure patient comfort, prevent the spread of airborne pollutants, and maintain sterile conditions in important spaces like operating rooms and laboratories, these systems help to control temperature, humidity, and air quality.
- Data centers: for equipment reliability, HVAC systems with accurate cooling capabilities are crucial for removing heat and maintaining ideal operating temperatures.
- Laboratories and research facilities: in order to support scientific research, equipment, and sample integrity, HVAC systems offer accurate climate control.
- Hospitality industry: HVAC systems are utilized in hotels, resorts, and other types of hospitality facilities to create pleasant guest rooms, common areas, and eating places.
- Transportation: they provide ventilation and regulate temperatures to keep passengers comfortable while commuting.
- Sports: HVAC systems are employed in indoor sports arenas, stadiums, and gyms to offer a pleasant atmosphere for participants and spectators.

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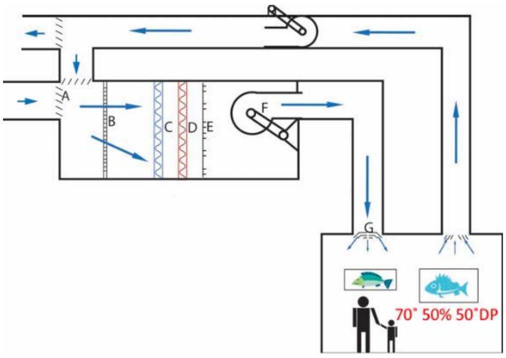
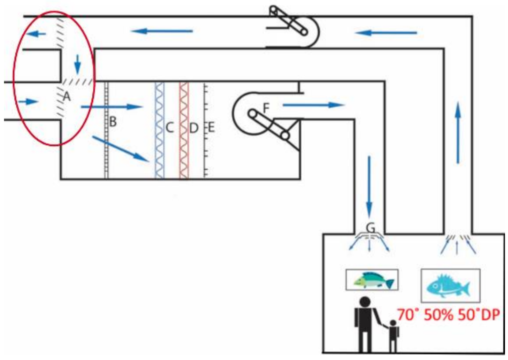
V. Standard components of HVAC



Air Handling System

Dampers (A)

Dampers are the metal doors inside ductwork that help regulate air flow. Can be manually controlled or can be controlled by motors or actuators that open or close them.



Filters (B)

Designed to trap pollutants, dirt, dust, molds, bacteria etc., and to prevent these materials from entering the system and contaminating the environment. Filters can be made from felt, cloth, cellulose, fiberglass, foam, paper, silk, etc., and can filter out varying levels of contaminants based on their construction.

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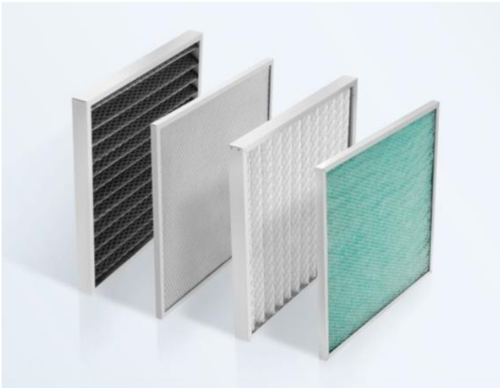
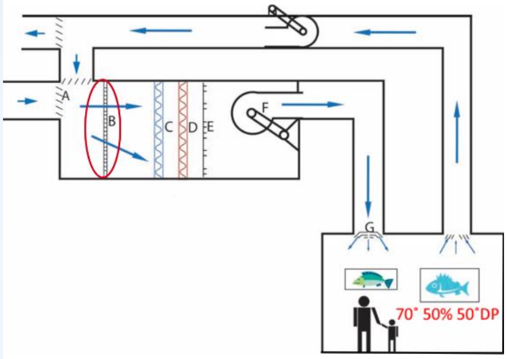
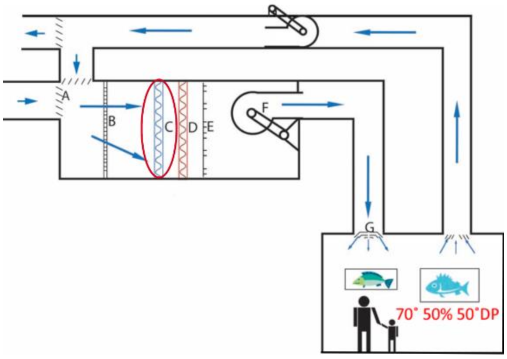




Cooling coils (C)

Also known as evaporator coil connected to a source of cooled refrigerant, i.e. chiller, cooling tower, etc., these coils are used to absorb heat from the air that passes over them. Depending on the temperature of the water in the coil, they can cause condensation to occur when air with a higher dew point pass over it.



Cooling coils can be broken down into two main types: standard fluid coils and refrigerant coils. Both achieve the same result of cooling incoming air, but are designed differently to accommodate the different cooling medium.

- Standard Fluid Coils - fluid coils used for cooling typically utilize chilled water or glycol/water mix (to prevent freezing) as the heat transfer fluid. At Marlo, we manufacture several different types of fluid coils for a wide range of applications, including standard coils, pitched core coils, coils with cleanable tube plugs, and coils

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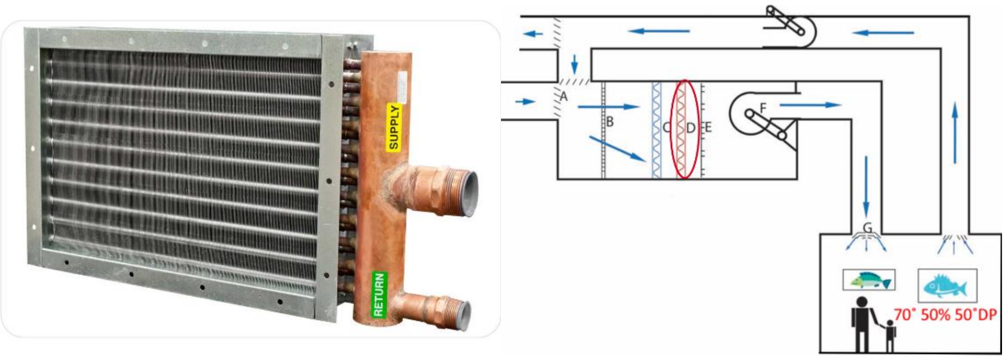
with removable box headers. These coils are used in both comfort cooling and industrial process cooling applications.

- Direct Expansion (DX) Coils - direct expansion (DX) coils, also known as evaporator coils, use refrigerant to remove heat from the incoming air. The refrigerant enters the coil as a liquid, flows through the tubes and absorbs the heat from the warm incoming air, evaporating the refrigerant into a gas. The gas then flows from the evaporator coil to the compressor, where it is compressed to a higher pressure. From there, it flows through a condenser coil, where heat is removed and released into the outdoor air. The gas condenses back into a liquid and the process repeats.

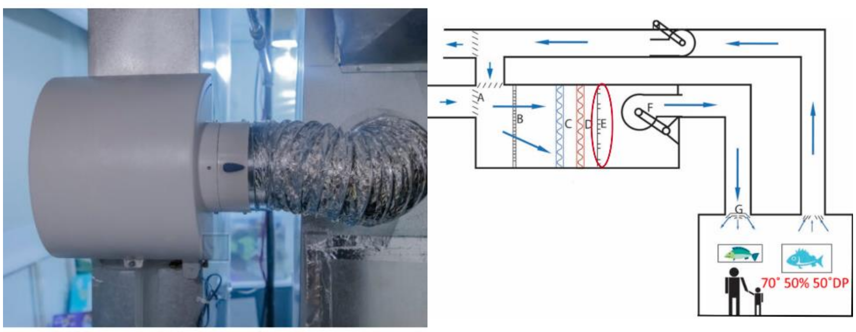
Heating Coils/Reheats (D)

Connected to a heat source, i.e. boiler or electric heaters, these coils are used to reject heat to the air that passes over them.



Humidifiers (E)

A mechanism used to add moisture to the air. In HVAC settings there are four dominant methods for raising the moisture content of air.



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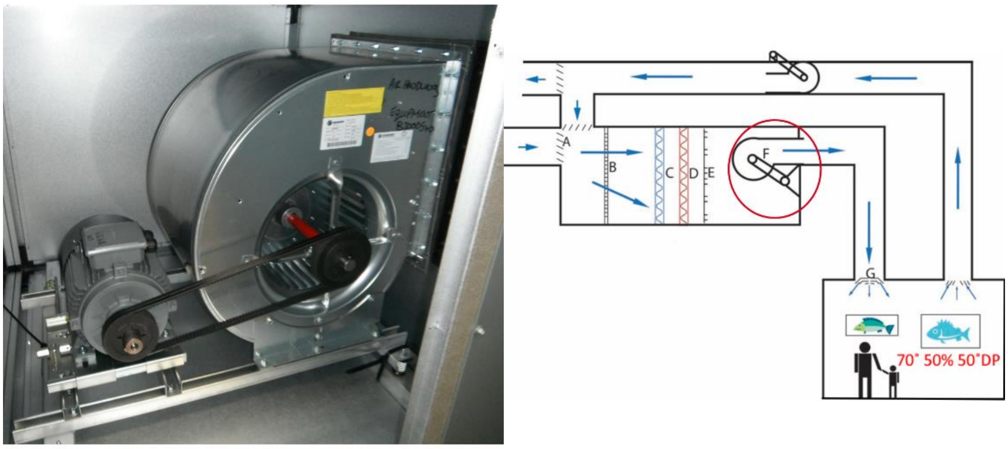
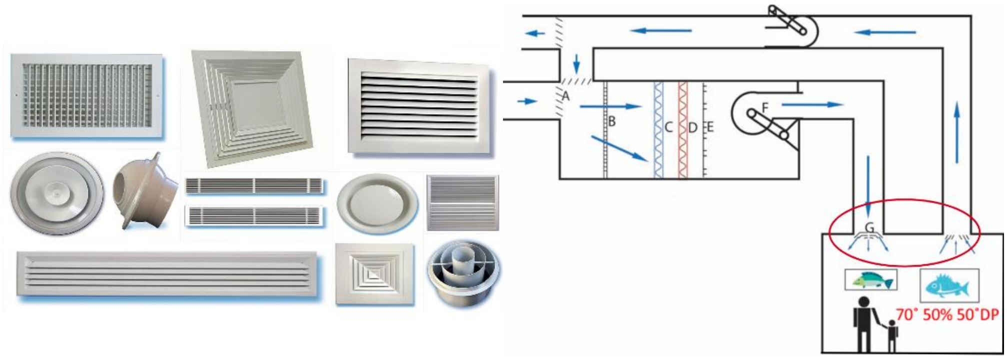
Fans (F)

Fans are motor driven assemblies found inside of the air handling systems that help move air through the system.



Diffuser (G)

In HVAC systems, the air supply diffuser is a device that delivers and ventilates conditioned air in an area, mixes indoor air, and manages air output. It works by reducing the air duct velocity by increasing the static pressure.



VI. Additional components

- Turning vanes

Stationary metal devices inside duct work that are used to direct the flow of air and reduce turbulence in the ductwork.

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- Air mixer

Metal devices in an air handling unit that are used to mix or blend the passing air. Usually located after the outside air intake or after a bypass in the system.

- Building management systems

The computer-based control system that can automate the HVAC, lighting, security, and life safety systems of a facility.

- Controls/Stats

Equipment used to control or regulate an HVAC system:

    - Thermostat – an instrument used to regulate the temperature in a space. The device can activate the HVAC system to operate.
    - Humidistat – an instrument used to regulate the relative humidity in a space. The device can activate the HVAC system to operate. Primarily the cooling coil and the humidifier or dehumidifier.
    - Thermidistat – an instrument that is used to measure temperature and humidity in a space. The device can activate the HVAC system to operate.

- VFD

Variable Frequency Drive (VFD) or Variable Speed Drive (VSD) - a digital control device used on air handling units to control the speed and torque of the supply, return, or relief fans in the unit.

- Desiccant air dryer

A device that uses hygroscopic material to remove moisture from air that is drawn into it.

- Open plenum design

Air is returned to the HVAC system through the ceiling of the space without the use of ductwork. Not recommended for collection spaces. The air can change temperature and moisture conditions due to unconditioned or untreated air that it may mix with in the ceiling.

- Economizing

An economizer is a part of a building’s cooling system that uses cool outdoor air to cool the building instead of operating the air conditioning components. This is typically employed when the outside air is cooler than the cooling set point temperature.

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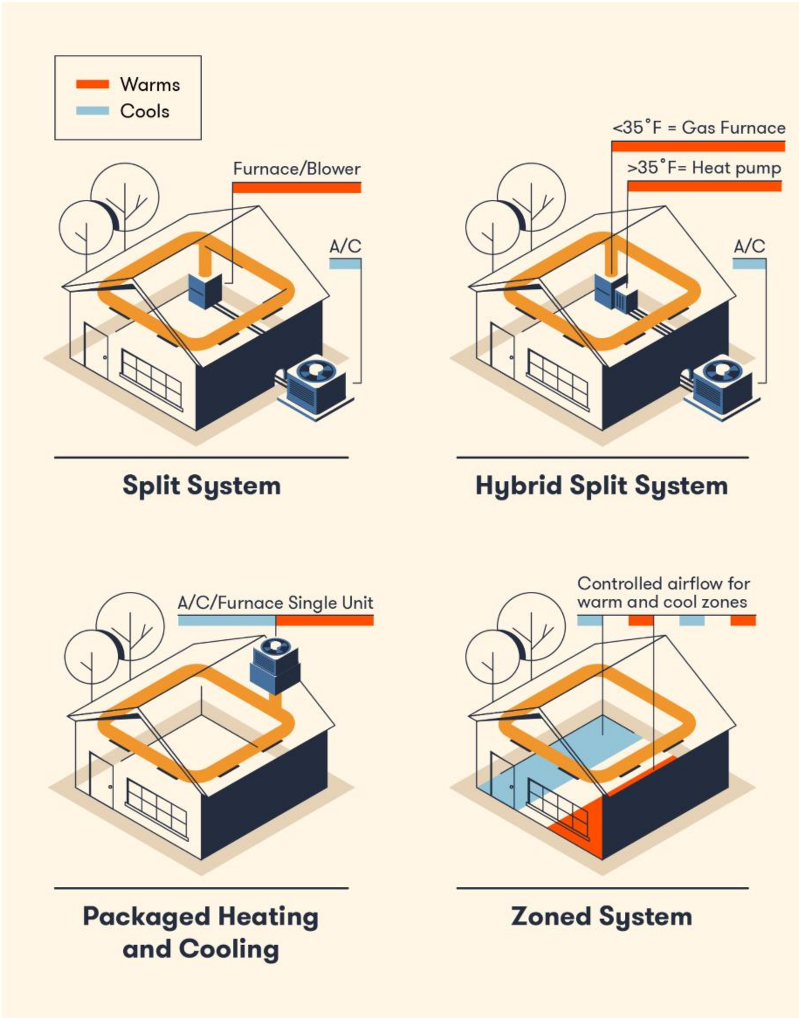
VII. Common types of HVAC systems

Each type of HVAC system falls into one of two categories: ducted or ductless. In a ducted system, the main unit pushes air through a series of air ducts to cool or heat a building. Ductless systems, on the other hand, lack air ducts and use alternative methods to distribute treated air throughout a space.

Types of Ducted HVAC systems

If a building uses vents to pump out hot and cold air, it is likely equipped with a ducted HVAC system. Ducted HVAC systems are standard in residential and commercial buildings and include any heating or cooling system that distributes air through a series of air ducts.



1. Split system: Classic comfort control

Split systems reign supreme in homes for climate control. They're like a tag team: one unit tackles heating (often gas-powered), the other handles cooling. A single thermostat acts as

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the commander, setting the temperature for your entire house. The heating unit usually lives in a basement or closet, while the cooling unit resides outdoors, connected by a network of pipes. The cooling unit uses clever tricks like compressors, coils, and refrigerant to generate cool air, while a fan directs hot air outside.

Key Feature: one thermostat keeps the whole house comfortable.

2. Hybrid split system: saving energy with a gas and electric option

Think of a hybrid split system as a more flexible version of its classic counterpart. It shares the same cooling unit but offers a dual heating personality. It can utilize gas for powerful heating, but also has an electric mode. While electric heat might be slower and less intense, it gives you more control over energy use. This can be a cost-saver in areas with milder climates.

Key Feature: offers flexibility and potentially lower energy bills.

3. Packaged heating and cooling: compact convenience

While not as common as split systems, packaged systems are space-saving champs, ideal for smaller buildings. They combine both heating and cooling components into a single, compact unit. This unit typically finds a home on the roof, attic, or near the building's foundation. Installation and maintenance are often simpler compared to split systems, as they connect to the building's ductwork through just one opening. Depending on your climate, you can choose a packaged heat pump or a packaged air conditioner with optional heating elements.

Key Feature: easy to install and maintain due to the all-in-one design.

4. Zoned system: tailored comfort for every room

Zoned systems give you the power of personalized comfort. Imagine adjusting the temperature in different parts of your building independently. Technicians can achieve this through various zoning methods, often depending on the building size. Larger homes might benefit from separate HVAC systems for each floor. This creates completely independent temperature control but requires installing multiple heating and cooling units. Another approach involves dampers - special valves placed within the air ducts. These dampers, either manual or automatic, regulate airflow to specific areas. By partially closing a damper, you can direct more airflow to cooler zones and vice versa. This allows for individual room temperature control, creating a more comfortable environment and boosting energy efficiency by focusing on areas that truly need heating or cooling.

Key Feature: provides individual temperature control for different areas.

Types of Ductless HVAC systems

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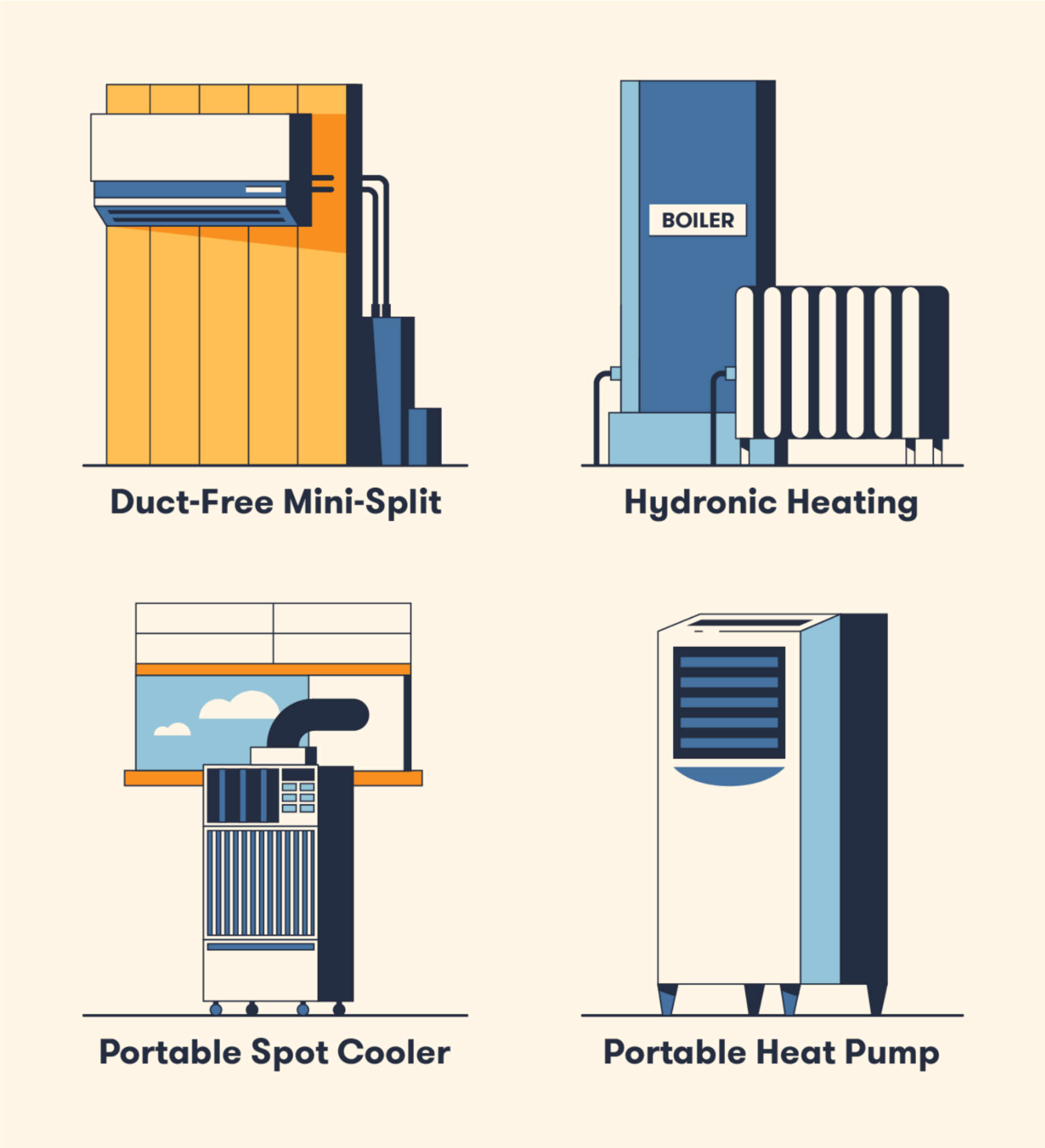
As the name suggests, ductless HVAC systems are designed to heat or cool a space without air ducts. These systems come in various sizes and are commonly used in small buildings or temporary work sites.



1. Duct-Free mini-split: customized comfort without the ducts

Mini-split systems, also known as ductless mini-splits, are individual climate control units perfect for specific rooms. Commonly found in apartments, offices, and hotels, these electric systems keep things cool. They consist of two main parts: an outdoor compressor/condenser unit and an indoor air handling unit for each controlled space. Think of them as tag-teaming

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for temperature – the outdoor unit handles the heavy lifting, while each indoor unit delivers cool air exactly where you need it. Connecting these units are copper tubes and electrical cables, with one outdoor unit powering up to nine indoor units. While the initial installation cost might be higher, mini-splits can be energy-savers in the long run. They eliminate energy loss from leaky ducts, allowing you to cool only the rooms you're using. However, their heating abilities weaken in freezing temperatures, so colder climates might require a separate heating system.

Key Feature: offers individual room temperature control without ductwork.

2. Hydronic heating: warmth from the inside out

Unlike traditional systems that use air, hydronic heating relies on the power of liquid to deliver warmth. A boiler acts like the heart of the system, heating water that then travels through pipes hidden under your floors. Once it reaches its destination (radiators, baseboards, or even radiant flooring), the hot water radiates heat throughout the room, creating a cozy feeling from the ground up.

Key Feature: uses heated liquid to radiate heat throughout a space.

3. Portable spot coolers: beat the heat on the go

Spot coolers are your personal AC units on wheels, perfect for large rooms, warehouses, or even outdoor events. They work like a mini air conditioner, pulling in warm air, cooling it with refrigerant over a coil, and then pumping the cool air back into the space. The process also removes humidity, with the leftover condensation collecting in a drain hose or bucket. These portable units offer ultimate flexibility – plug them in anywhere with power, and their wheels make them easy to reposition. However, they do require an exit for hot air. Spot coolers expel warm air through a flexible exhaust tube that needs to be vented outside a window, door, or dropped ceiling to prevent the hot air from re-entering the cooled space.

Key Feature: portable and easy to set up, perfect for temporary cooling needs.

4. Portable heat pumps: double duty for all seasons

Think of a portable heat pump as a Swiss Army knife of climate control. Similar in size and operation to a spot cooler, it offers both cooling and heating functions. In cooling mode, it works just like a spot cooler. But when you flip the switch to heating, it pulls in outside air, warms it up using a condenser coil, and distributes toasty comfort throughout the room. This versatility makes it a great choice for areas with fluctuating temperatures.

Key Feature: provides both heating and cooling in a portable unit.

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VIII. 10 of the most common HVAC problems and how to fix them

Here are ten of the most common problems that impact your air conditioner, furnace, and ductwork, as well as a few suggestions to solve these common HVAC problems.

1) Dirty filters

Dirty air filters are the most common culprit behind HVAC woes. A dirty filter restricts airflow, forcing your furnace to work harder. This can lead to overheating, premature wear, and uneven temperatures throughout your home. Replacing the filter is a simple task you can tackle yourself. Just ensure you get the right size for your system – your furnace manual should have that information.

2) Dirty ductwork

Dusty and grimy ductwork can spread pollutants throughout your house, reducing air quality and potentially triggering allergies or asthma. Regular cleaning is crucial. You can do it yourself or hire a professional. Video inspection cameras can help pinpoint areas needing the most attention.

3) Problems with pilot light and ignition

Your furnace's ignition system relies on specific elements working in harmony. A malfunctioning pilot light, flame sensor, or burner can prevent ignition. This requires professional diagnosis and repair. Don't attempt to fix it yourself, as gas and high-voltage electricity are involved.

4) Malfunctioning thermostat

A malfunctioning thermostat could be the reason your furnace isn't behaving. Thermostats can be complex, but your owner's manual might have a troubleshooting section to help you identify and fix the problem. Sometimes, it's as simple as replacing the batteries! If that doesn't work, call a technician for assistance.

5) Tripped breakers and blown fuses

A complete loss of power could be due to a tripped breaker or blown fuse. Both often occur when your furnace is overworked, frequently caused by a clogged air filter. Start by replacing the filter. If the problem persists, call a technician to address the issue.

6) Dirty condenser or evaporator coils

Without regular maintenance, your system's ability to heat or cool effectively might decline. Dirty condenser and evaporator coils are likely the culprit. You can hose down the outdoor condenser coil (with the power off!), but extremely dirty coils might require professional cleaning.

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7) Water leaks from the unit

Air conditioners and furnaces produce condensation that drains through pipes. Clogged pipes can cause water to back up and leak from the unit. Try pouring bleach down the drain pipes to clear clogs. If the leak persists, call a professional right away.

8) Uneven room temperatures

Uneven temperatures from room to room can be caused by problems with your HVAC zoning. Ideally, your ducts should deliver conditioned air evenly throughout the house. In some cases, ductwork redesign might be necessary. Often, adjustments can be made to improve temperature distribution.

9) Negative pressure

Negative pressure occurs when outside air pressure is higher than inside pressure. This can impact efficiency and comfort. Unfiltered, unconditioned air gets pulled into your home, reducing both comfort and air quality. Diagnosing the cause can be tricky; it could be a fan speed setting, cracks in the vents, or other factors. Consulting a professional is recommended for this issue.

10) Leaky ducts

Leaks in your ductwork can force your system to work harder to deliver enough conditioned air. This not only makes your home uncomfortable but also leads to higher energy bills. A Data Logging airflow volume hot wire anemometer can help identify leaks for targeted repairs. Consider seeking professional help for diagnosing and fixing leaky ducts.

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