Commercial HVAC

An Online Continuing Education Course for Engineers

Course Number: HV-8002

Credit: 8 Hours / 8 PDH / 8 CPD

Course Introduction

Commercial air-conditioning or HVAC (Heating, Ventilation and Air Conditioning) refer to the mechanical systems which heat, cool, filter or dehumidify air in a room or building. HVAC systems control the ambient environment (temperature, humidity, air flow, and air filtering) in homes and commercial buildings and are crucial in maintaining environmental conditions in critical applications such as data centers, medical rooms, computer server rooms, and other cleanroom applications.

1. In cooling mode, excess room heat is absorbed by a special liquid - a refrigerant - sealed within the system. As the refrigerant absorbs the heat from the room it changes into a gas and passes through small, copper tubes to an outdoor unit (condenser) where the heat is released, into the atmosphere. The gas then changes back into a cold liquid, returning to the indoor unit where the air is fanned over it and out into the room. This cycle is automatically repeated to maintain the preset room temperature.

   The cooling operation not only cools the air but also removes moisture out of the air. Moisture condenses on the indoor coil like it does on the outside of a glass of ice water on a hot, humid day. As the warm air passes over the coil and is cooled it can't hold the same amount of moisture. The extra moisture is then carried away through the built in drain pan.

2. In heating mode, the cooling cycle is reversed and the system is called a heat pump. A heat pump extracts "free" heat from the outdoor air, even on the coldest days when the temperature may fall as low as -10 degrees Celsius and transfers the heat indoors. Heat pump units therefore avoid the need for a boiler and allow you to cool and heat with the same unit, with savings in costs and energy throughout the year. Another way to heat the space is to use electric or hot water baseboards or radiant panels.

Engineering of an air-conditioning system starts with the selection of design conditions; air temperature and relative humidity are principal factors. Next, calculate the loads on the system (for example heat load arises from equipment, lights, exterior solar, and people). Finally, equipment is selected and sized to perform the indicated functions and to carry the estimated loads. Each space is analyzed separately. A cooling load will exist when the sum of heat released within the space and transmitted to the space is greater than the loss of heat from the space. A heating load occurs when the heat generated within the space is less than the loss of heat from it. Similar considerations apply to moisture.

The rate at which heat is conducted through the building envelope is a function of the temperature difference across the envelope and the thermal resistance of the envelope (R value). Overall R values depend on materials of construction and their thickness along the path of heat flow, and air spaces with or without reflectances and emittances, and are evaluated for walls and roofs exposed to outdoors, and basements or slab exposed to earth. In some cases, thermal insulations may be added to increase the R value of the envelope.

Solar heat loads are an especially important part of load calculation because they represent a large percentage of heat gain through walls, windows, and roofs, but are very difficult to estimate because solar irradiation is constantly changing.

Humidity as a load on an air-conditioning system is treated by the engineer in terms of its latent heat, that is, the heat required to condense or evaporate the moisture, approximately 1000 Btu/lb of moisture. People at rest or at light work generate about 200 Btu/h. Steaming from kitchen activities and moisture generated as a product of combustion of gas flames, or from all drying processes, must be calculated. As with heat, moisture travels through the space envelope, and its rate of transfer is calculated as a function of the difference in vapor pressure across the space envelope and the permeance of the envelope construction.

Heat pumps and air conditioners are generally sized in tons. Typical sizes for single family residences are between two and five tons. Each refrigeration ton equals to the heat extraction rate of 12,000 Btu per hour. It is important to note that actual capacity is not constant and will change based on outdoor or indoor temperatures. The published capacity rating of air conditioners and heat pumps is based on performance at the ARI standard temperature levels of 95ºF outside, 80ºF inside.

TYPES OF COOLING SYSTEMS

The most common air-cooling systems are either direct expansion (DX) type or the chilled water type.

DIRECT EXPANSION (DX) SYSTEMS

In DX systems, the air is cooled with direct exchange of heat with refrigerant passing through the tubes of the finned cooling coil. All these systems are comprised of a hermetically sealed or open compressor(s), evaporator (cooling coil fabricated out of copper tubes and aluminum fins), a supply air blower, filter, a condenser and heat rejection propeller fan. These come in two types:

1. ***Unitary System*** - In a unitary system, the complete cooling system is in one casing. Since all equipment is prepackaged, the installation cost is usually lower, and the performance quality is often higher than field-erected systems. Window air-conditioners, package units are typical examples of unitary DX systems.

    - Room air conditioner (capacity range of 0.5 to 3 TR per unit, suitable for an area of not more than 1000 square feet).
    - Packaged unit integral air-cooled condenser (capacity range of 3 to 50 TR, suitable for a maximum area of 1000 – 10000 square feet).

2. ***Split System*** - The second DX concept, where the evaporator is separate from the condenser/compressor, is called a split system. These are commonly found in residential and small commercial installations with capacity ranges varying 1 to 50 TR and suitable for an area of 100 – 10000 square feet. The new ductless systems which can be conveniently mounted on the ceiling or wall are in this family.

HYDRONIC or CHILLED WATER SYSTEMS

In a chilled water system the air is cooled with chilled water passing through the tubes of a finned coil (cooling coil). The refrigerant is used to chill the water, which is circulated throughout the building. When a chilled water system is the refrigeration unit it is called a 'chiller'. These are usually pre-packaged by the manufacturer with the evaporator and condenser attached, so that only water pipes and controls must be run in the field.

Chilled water systems are further categorized as air-cooled or water cooled system depending on how the heat is rejected out of the system. The chilled water system is also called central air conditioning system. This is because the chilled water system can be networked to have multiple cooling coils distributed through out a large or distributed buildings with the refrigeration equipment (chiller) placed at one base central location. Chilled water systems are typically applied to the large and/or distributed areas. Capacity ranges from 20- 2000 TR and are suitable for an area of 3000 square feet and above.

AIR CONDITIONING SYSTEM DESIGN CONFIGURATIONS

The air-conditioning components and equipment may be designed and assembled in literally a dozen or a hundred different ways but in practice these are broadly classified into three categories:

1. **Centralized Ducted "All – Air" Systems -** These are systems in which the primary movement of heat around the building is via heated and cooled air. These systems are the most common in large spaces such as office buildings, common public areas, retail, shopping, manufacturing areas, airports, hotel lobbies etc.
2. **Centralized Fluid Based Hydronic Systems -** These are systems in which a fluid - typically water but possibly refrigerant - is used to move heat around the building. These systems are fairly common in office rooms, hotel rooms, schools, building perimeter control etc.
3. **Decentralized Systems -** These are systems in which heating and cooling is conducted locally, with little or no bulk movement of heat around the building. Individual unit ventilators are dispersed in small rooms and around the perimeter of a building. These systems are relatively common in schools, small hotels, domestic applications, residential homes and small offices.

The boundaries between these system types are not absolute, but they form useful categories within which to put the many different systems. The choice largely depends on the following -

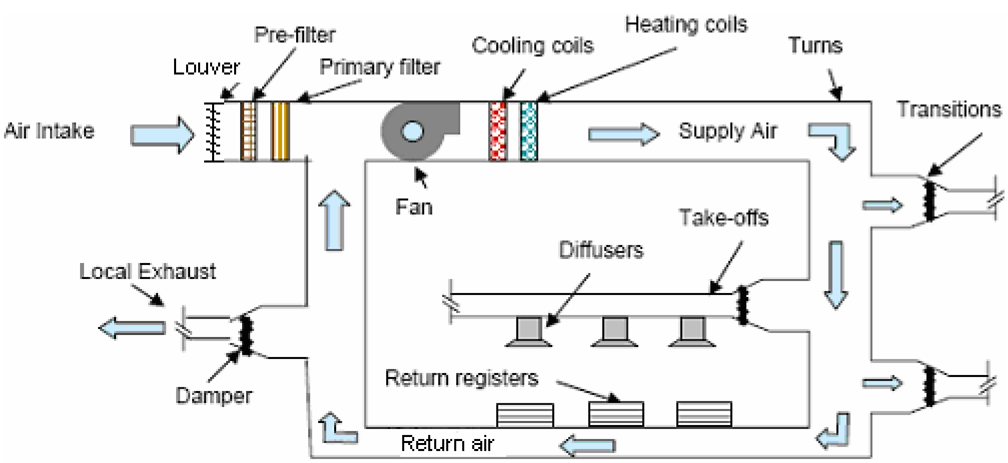
1. System constraints - Cooling load, zoning requirements, acceptable tolerance to temperature/humidity, degree of control etc
2. Architectural Constraints - Size and appearance of terminal devices, acceptable noise level, space available to house equipment and its location relative to the conditioned space, acceptability of components obtruding into the conditioned space
3. Financial Constraints - Capital cost, Operating cost, Maintenance cost

We will review some of the options and issues under each of these categories.

ALL – AIR SYSTEMS

In an 'All-Air system', the refrigerant or chilled water is used to cool and dehumidify the air in the air handling unit (AHU). The cool air is then circulated throughout the building thru the ductwork. Heating can also be accomplished either by hot water or electrical strip heaters. The centralization of these systems allow for better management and system operation. On the other hand, they also require a mechanical room adjacent to the controlled space for locating the AHU and large ductwork in building space.

The diagram below indicates the main components of a typical air-conditioning system.



Typical air-conditioning system

This is an air-based system, which is the most dominant air-conditioning type for large buildings. Fresh air is drawn into the building through the intake louver, mixed with return air, heated or cooled to a controlled temperature, circulated around the building and provided to the occupied space. Local temperature control is provided by a terminal reheat unit attached to a temperature controller within the occupied space. Exhaust air is extracted from the space and dumped to the outside. In general, the majority of the return air is recycled via the return air duct. The individual components of this system are:

1. **Air Handling Unit –** This is a cabinet that includes or houses the central furnace, air conditioner, or heat pump and the plenum and blower assembly that forces air through the ductwork.

2. **Intake louvers -** These are the external louvers through which supply air is drawn into the building. Intake is generally equipped with volume control damper to regulate the amount of fresh air and economizing the quantity of outside air during favorable outside conditions.

3. **Filters -** These are used to remove particles of dust or dirt from the supply air.

4. **Heating coils -** These heat up the incoming airstream ... ter is passed over banks of electric heating ...

5. **Coolir** ... or water is passed ...

6. **Supply** ...

7. **Ductwo** ... f sheet metal, fib ... walls, floors, and ceilin ... metal, fiberglass ...

8. **Supply Du** ... ch room has at leas ...

9. **Return Duc** ... ouses have only o ...

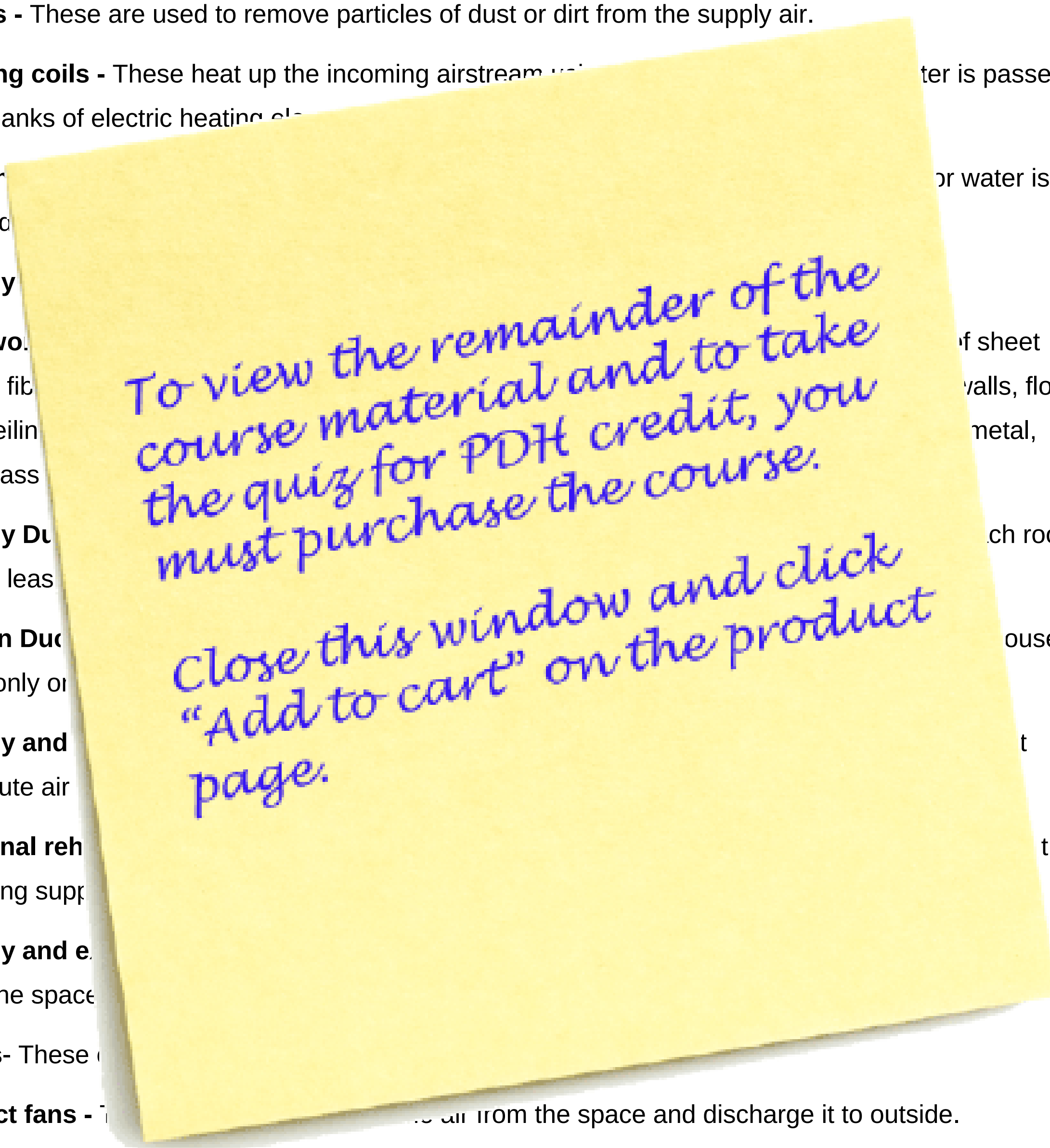
10. **Supply and** ... t distribute air ...

11. **Terminal reh** ... the air being supp ...

12. **Supply and e** ... d from the space ...

13. **Boots**- These ...

14. **Extract fans -** ... e air from the space and discharge it to outside.



15. **Return air duct -** These are interconnections between inlet and outlet ductwork sections, which let a controlled amount of air recirculate around the air conditioning system when full fresh air is not required.

16. **Exhaust louvers -** These are the external louvers through which extract air is discharged from the building.