TYPES OF HEATING, VENTILATION AND AIR-CONDITIONING SYSTEM

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ABSTRACT

Heating, Ventilation and Air-Conditioning (HVAC) system is one of the most widely used system in pharmaceutical industries. It plays an important role in ensuring the manufacture of good quality products. A well designed HVAC system will provide comfortable condition for operators and to prevent microbial contamination of sterile product and cleans areas. It prevents spreading and contaminant of virus and pathogens used in the manufacturing of pharmaceuticals. These system are used in the pharmaceutical plant to prevent contamination and to provide comfortable working conditions. Central HVAC systems locate away from buildings in a central equipment room and deliver the conditioned air by a delivery duct system. Central HVAC systems contain all-air, air-water, and all-water systems. Two systems should be considered as central such as heating & cooling panels and water-source heat pumps. Local HVAC systems can be located inside a conditioned zone or adjacent it and no requirement for ductwork.

KEYWORDS:-HVAC system, heating system, central HVAC system

INTRODUCTION

Heating, Ventilation and Air-Conditioning system-It is the technology of indoor and vehicular environmental comfort. It provides thermal comfort and acceptable indoor air quality. It is responsible occupants, volatile organic compound (VOC's) emitted from interior furnishings, chemicals used for cleaning, etc. properly designed system will also provide a comfortable indoor environment year round when properly maintained. These system design is to sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics and heat transfer.

It is an important part of residential structure such as hotels, single family homes, apartment buildings, medium to large industrial or office buildings such as hospitals and skyscrapers such as cars, trains, ships and submarines, and in marine environments. [1]

Ventilating or ventilation (HVAC)-It is the process of exchanging or replacing air in any space to provide high door air quality. It involves temperature control, oxygen replenishment, and to remove moisture, CO2, dust, heat and other gases. It also remove unpleasant odour, dust particles excessive moisture, introduces outside air, keep interior building air circulating.

Ventilation also includes both the exchange of air to the outside as well as circulation of air within the buildings. Most important factor of ventilation for maintaining acceptable indoor air quality in buildings. [2]

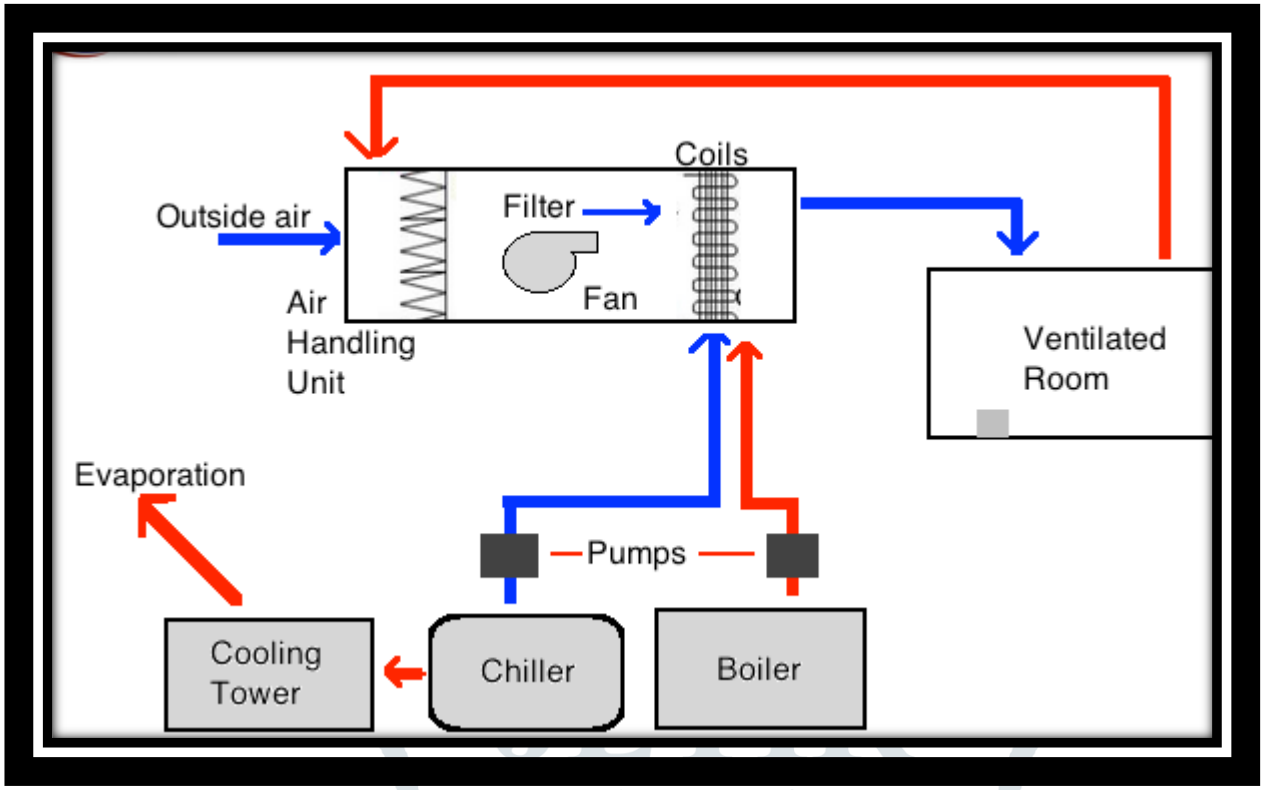

Figure 1: Diagram of HVAC system

ADVANTAGES

- Indoor air quality
- Energy conservation
- Moisture consistency
- It may be higher than the typical gas furnace.
- It saves construction space, installation time and fees, and required power usage.

DISADVANTAGES

- It can be an energy guzzling system.
- It cause of source of never ending agony for a user.
- Ozone depletion and Global warming potential are two measurable used to decide which refrigerant one should option for.
- Selection of refrigerant has a direct relationship to the environmental and operational impacts.
- Cost

APPLICATION

- Synthetic fiber
- Pharmaceuticals
- Hospitals and medical research Centre
- Theatre/Auditorium/Multiplex
- Embassies, Airport, Airlines
- Non-medical research Centre
- Other industries and process plants
- Offices/Hotels[3]

COMPONENTS OF HVAC SYSTEM

The basic components of an HVAC system that delivers conditioned air to satisfy thermal comfort of space and occupants and to the achieve the indoor air quality are listed below [7]:

- Mixed-air plenum and outdoor air control
- Air filter
- Supply fan
- Exhaust or relief fans and an air outlet
- Outdoor air intake
- Ducts
- Terminal devices
- Return air system.
- Self-contained heating or cooling unit
- Cooling tower
- Boiler
- Control
- Water chiller
- Humidification and dehumidification equipment

TYPES OF HVAC SYSTEM [8,12]

1)CENTRAL HVAC SYSTEM:-It may serve one or more thermal zones, and its major equipment is located outside of the served zone(s) in a suitable central location whether inside, on top, or adjacent to the building .Central systems must condition zones with their equivalent thermal load. Central HVAC systems will have as several control points such as thermostats for each zone. The medium used in the control system to provide the thermal energy sub-classifies the central HVAC system.

- The thermal energy transfer medium can be air or water or both, which represent as all-air systems, air-water systems, all-water systems. It include water-source heat pumps and heating and cooling panels. All of these subsystems are discussed below. Central HVAC system has combined devices in an air handling unit, as which contains supply and return air fans, humidifier, reheat coil, cooling coil, and preheat coil, mixing box, filter, and outdoor air.

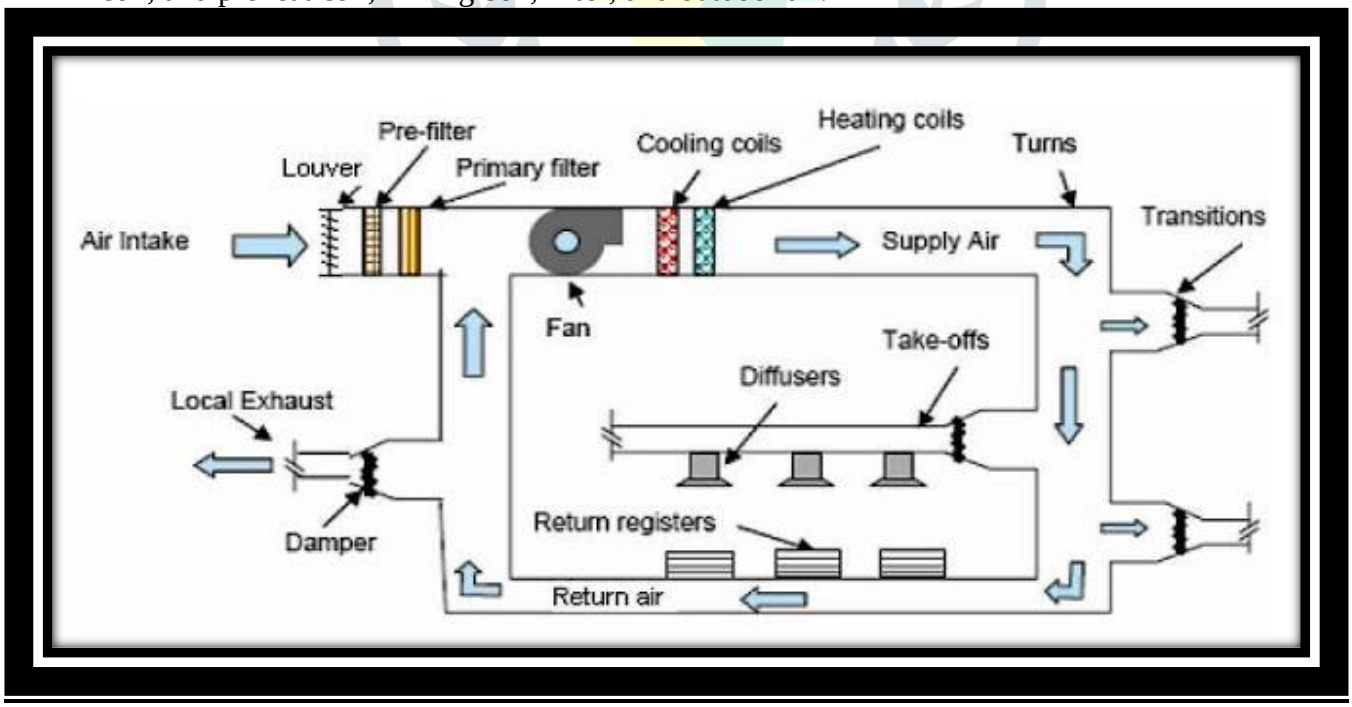

Figure 2: Equipment for central HVAC system

1.1) All-air systems

The thermal energy transfer medium through the building delivery systems is air. These systems can be sub-classified based on the zone as single zone and multizone, airflow rate for each zone as constant air volume and variable air volume, terminal reheat, and dual duct.

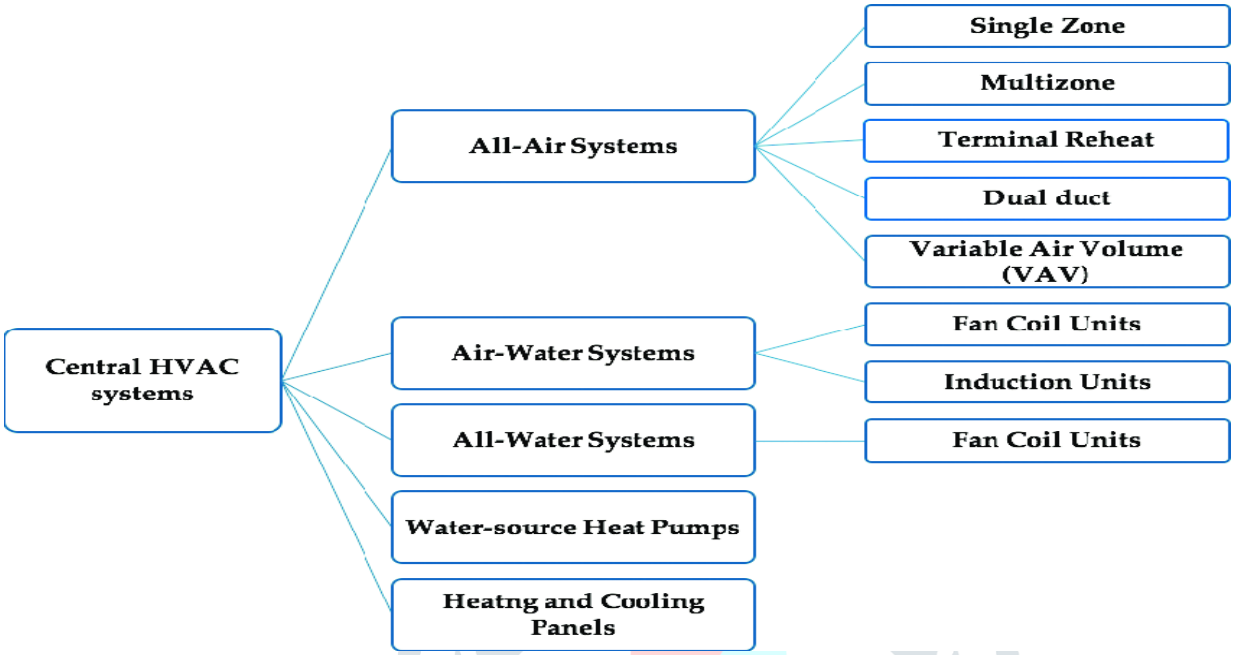

Figure 3: Horizontal hierarchy representation of the main types of central HVAC systems

a) Single zone: - It consists of an air handling unit, a heat source and cooling source, distribution ductwork, and appropriate delivery devices. The air handling units can be wholly integrated where heat and cooling sources are available or separate where heat and cooling source are detached. The integrated package is most-commonly a rooftop unit and connected to ductwork to deliver the conditioned air into several spaces with the same thermal zone. The main advantage of these systems is simplicity in design and maintenance and low first cost compared to other systems. However, its main disadvantage is serving a single thermal zone when improperly applied.

b) Multi-zone:- In a multi-zone all-air system, individual supply air ducts are provided for each zone in a building. Cold air and hot (or return) air are mixed at the air handling unit to achieve the thermal requirement of each zone. A particular zone has its conditioned air that cannot be mixed with that of other zones, and all multiple zones with different thermal requirement demand separate supply ducts. It consists of an air handling unit with parallel flow paths through cooling coils and heating coils and internal mixing dampers. It is recommended that one multi-zone serve a maximum of 12 zones because of physical restrictions on duct connections and damper size. If more zones are required, additional air handlers may be used. The advantage of the multi-zone system is to adequately condition several zones without energy waste associated with a terminal reheat system. However, leakage between the decks of air handler may reduce energy efficiency. The main disadvantage is the need for multiple supply air ducts to serve multiple zones.

c) **Terminal reheat:-** A terminal reheat all-air system is a multiple zone, which considers an adaptation of single zone system. This can be performed by adding heating equipment, such as hot water coil or electric coil, to the downstream of the supply air from air handling units near each zone. Each zone is controlled by a thermostat to adjust the heat output of heating equipment to meet the thermal condition. The supply air from air handling units is cooled to the lowest cooling point, and the terminal reheat adds the required heating load. The advantage of terminal reheat is flexible and can be installed or removed to accommodate changes in zones, which provides better control of the thermal conditions in multiple zones. However, the design of terminal reheat is not energy-efficient system because a significant amount of extremely cooling air is not regularly needed in zones, which can be considered as waste energy. Therefore, energy codes and standards regulate the use of reheat systems.

d) Dual duct: - These system is a terminal-controlled modification of the multi-zone concept. A central air handling unit provides two conditioned air streams such as a cold deck and a hot deck. These air streams are distributed throughout the area served by the air handling unit in separate and parallel ducts. Each zone has a terminal mixing box controlled by zone thermostat to adjust the supply air temperature by mix the supply cold and hot air. This type of system will minimize the disadvantages of previous systems and become more flexible by using terminal control.

e) Variable air volume:- The previous four types of all-air systems are constant volume systems. These system consists of a central air handling unit which provides supply air to the VAV terminal control box that located in each zone to adjust the supply air volume.

The temperature of supply air of each zone is controlled by manipulating the supply air flow rate. The main disadvantage is that the controlled airflow rate can negatively impact other adjacent zones with different or similar airflow rate and temperature. Also, part-load conditions in buildings may require low air-flow rate which reduces the fan power resulting in energy savings. It may also reduce the ventilation flow rate, which can be problematic to the HVAC system and affecting the indoor air quality of the building.

1.2) All-water systems:-

This type of system is relatively small compared to other types because the use of pipes as distribution containers and the water has higher heat capacity and density than air, which requires the lower volume to transfer heat. All-water heating-only systems include several delivery devices such as floor radiators, baseboard radiators, unit heaters, and convectors. However, all-water cooling-only systems are unusual such as valance units mounted in the ceiling. The primary type that is used in buildings to condition the entire space is a fan-coil unit.

a) **Fan-coil units:-**Fan-coil unit is a small unit used for heating and cooling coils, circulation fan, and proper control system . The unit can be vertically or horizontally installed. The fan-coil unit can be placed in the room or exposed to occupants, so it is essential to have appropriate finishes and styling. For central systems, the fan-coil units are connected to boilers to produce heating and to water chillers to produce cooling to the conditioned space. The desired temperature of a zone is detected by a thermostat which controls the water flow to the fan-coil units. In addition, occupants can adjust fan coil units by adjusting supply air louvers to achieve the desired temperature. The main disadvantage of fan-coils is ventilation air and only can be solved if the fan-coil units are connected to outdoor air. Another disadvantage is the noise level, especially in critical places.

1.3) Air-water systems:-

Air-water systems are introduced as a hybrid system to combine both advantages of all-air and all-water systems. The volume of the combined is reduced, and the outdoor ventilation is produced to properly condition the desired zone. The water medium is responsible for carrying the thermal load in a building by 80–90% through heating and cooling water, while air medium conditions the remainder. There are two main types: fan-coil units and induction units.

a) Fan-coil units:-Fan-coil units for air-water systems are similar to that of all-water systems except that the sup-ply air and the conditioned water are provided to the desired zone from a central air handling unit and central water systems (e.g., boilers or chillers). The ventilation air can be separately delivered into space or connected to the fan-coil units. The major types of fan-coil systems, are 2 pipes or 4-pipes systems.

b) Induction units:-These units are externally similar to fan-coil units but internally different. An induction unit induces the air flow in a room through cabinet by using high-velocity airflow from a central air handling unit, which replaces the forced convection of the fan in the fan-coil by the induction or buoyancy effect of the induction unit. This can be performed as mixing the primary air from the central unit and the secondary air from the room to produce a suitable and conditioned air into the room/zone.

1.4) Water-source heat pumps:-

It is used to provide considerable energy savings for large building under the extreme cold weather. A building of various zones can be conditioned by several individual heat pumps since each heat pump can be controlled according to the zone control. A centralized water circulation loop can be used as a heat source and heat sink for heat pumps. Therefore, heat pumps can act as the primary source of heating and cooling. The main disadvantage is the lack of air ventilation similar to the all-water systems as in fan-coil units. For a heating process, the boiler or solar collectors will be used to supply heat to the water circulation, while a cooling tower is used to reject heat collected from the heat pumps to the atmosphere. This system does not use chillers or any refrigeration systems. If a building requires a heating process for zones and cooling process for other zones at the same time, the heat pump will redistribute heat from one part to another with no need for a boiler or cooling tower operation.

1.5) Heating and cooling panels:-

Heating and cooling panels are placed on floors or walls or ceilings where can be a source of heating and cooling it also can be called as radiant panels. This type of system can be constructed as tubes or pipes impeded inside the surface where the cooling or heating media is circulated into the tubes to cool or heat the surface. The tubes are contacted to the adjacent large surface area to achieve the desired surface temperature for cooling and heating process. The heat transfer process is mainly by the radiation mode between the occupants and the radiant panels, and the natural convection mode between the air and panels. Temperature restriction is recommended for radiant floor panels, a range of 66–84°F, to achieve thermal comfort for occupants. Radiant ceiling or wall panels can be used for cooling and heating process. The surface temperature should be higher than the air dew point temperature to avoid condensation on the surface during the cooling process. Also, the maximum surface temperature is 140°F for ceiling levels at 10 ft. and 180°F for ceiling levels at 18 ft. This temperature is recommended to avoid too much heating above occupants' heads. The main advantage is no space required, only a few inches for the panels to be installed and no more collected dirt in the standard ceiling or the ductwork. Many designs are available to produce attractive panels.

2. LOCAL HVAC SYSTEM

Some buildings can have multiple zones or have a large, single zone, which needs central HVAC systems to serve and provide the thermal needs. However, other building may have a single zone which needs equipment located inside the zone itself, such as small houses and residential apartments. This type of system is considered as local HVAC systems since each equipment serving its zone without crossing boundaries to other adjacent zones (e.g., using an air conditioner to cool down a bedroom, or using an electrical heater for the living room However, these local systems are not connected and integrated to central systems, but still part of a large full-building HVAC systems. There are many types of local HVAC systems are:-

2.1) Local heating systems

A single zone will require a complete, single package of heating system which contains heat source and distribution system. Some examples include portable electric heaters, electric resistance baseboard radiators, fireplaces and wood stoves, and infrared heaters.

2.2) Local cooling systems

Local cooling systems can include active systems as air-conditioning systems that provide cooling, a proper air distribution inside a zone, and control of humidification, and natural systems as convective cooling in open window, evaporative cooling in fountains.

2.3) Local ventilation systems

Local ventilation systems can be forced systems by using devices such as window fan to allow air movement between outdoor and a single zone without changing in the thermal environ-ment of the zone. Other systems used for ventilation are air circulation devices such as desk or paddle fans to improve thermal comfort of the space by allowing the heat to be transferred by conventional mode.

2.4) Local air-conditioning systems

A local air conditioning system is a complete package that can contain cooling and heating source, a circulation fan, a filter, and control devices. There are three main types listed below

a) **Window air-conditioner:-**This system is a packaged device consisting of a vapor compression refrigeration cycle that contains a compressor, a condenser, an expansion valve, and an evaporator, in addition to a fan, a filter, control system and housing. Window air-conditioners can be installed in a framed or unframed opening in building walls and in window openings without any ductwork and distribution the cooling or heating air effectively inside the conditioned space. The air conditioning contains both evaporator and condenser where the condenser is located outside the space while the evaporate is inside the space, however, it serves the entire single zone with the thermal requirements. The heating process can be achieved by adding electric resistance coil in the air conditioning or reversing the refrigeration cycle to act as a heat pump. Many feature designs are produced to provide aesthetical values and improve the quality and response.

b) **Unitary air-conditioner:-**It is similar to window air conditioners from the equipment perspective, but it is designed for commercial buildings. It is installed on the exterior wall of the building and generally located Horizontal hierarchy representation of the main types of local HVAC systems. Every single zone will contain one unitary air-conditioner as in each guest room in many hotels.

c) **Packaged rooftop air-conditioner:-**It consists of a vapor compression refrigeration cycle; heat source such as heat pump and electric resistance; an air handler such as dampers, filter, and fan; and control devices. This system may be connected to ductwork and serve a large-size single zone that cannot be served by unitary or window air conditioners.

3) Split systems

It contain two central devices the condenser, located outdoor, and the evaporator, located indoors. The two devices are connected by a conduit for refrigerant lines and wiring. This system solves some issues of small-scale single-zone systems since the location and installation of window, unitary or rooftop air conditioners may affect the esthetic value and architectural design of the building. The split systems can contain one condenser unit and connected to multiple evaporator units to serve multiple zones as possible under same conditions or different environmental conditions.

Requirement of HVAC system [6]

Four requirements are the bases for any HVAC systems. They need primary equipment, space requirement, air distribution, and piping.

The Primary equipment includes heating equipment such as steam boilers and hot water boilers to heat buildings or spaces, air delivery equipment as packaged equipment to deliver conditioned ventilation air by using centrifugal fans, axial fans, and plug or plenum fans, and refrigeration equipment that delivers cooled or conditioned air into space. It includes cooling coils based on water from water chillers or refrigerants from a refrigeration process.
Space requirement is essential in shaping an HVAC system to be central or local. It requires five facilities as the following:

1. Equipment rooms: The total mechanical and electrical space requirements range between 4 and 9% of the gross building area. It is preferable to be centrally located in the building to reduce the long duct, pipe, and conduit runs and sizes, to simplify shaft layouts, and centralized maintenance and operation.

2. HVAC facilities: Heating and refrigeration equipment require many facilities to perform their primary tasks of heating and cooling the building. The heating equipment requires boiler units, pumps, heat exchangers, pressure-reducing equipment, control air compressors, and miscellaneous equipment, while the refrigeration equipment requires water chillers or cooling water towers for large buildings, condenser water pumps, heat exchangers, air conditioning equipment, control air compressors, and miscellaneous equipment. The design of equipment rooms to host both pieces of equipment should consider the size and the weight of equipment, the installation and maintenance of equipment, and the applicable regulations to combustion air and ventilation air criteria.

3. Fan rooms: It contain the HVAC fan equipment and other miscellaneous equipment. The rooms should consider the size of the installation and removal of fan shafts and coils, the replacement, and maintenance. The size of fans depends on the required air flow rate to condition the building, and it can be centralized or localized based on the availability, location, and cost. It is preferable to have easy access to outdoor air.

4. Vertical shaft: It provide space for air distribution and water and steam pipe distribution. The air distribution contains HVAC supply air, exhaust air, and return air ductwork. Pipe distribution includes hot water, chilled water, condenser water, and steam supply, and condenser return. The vertical shaft includes other mechanical and electrical distribution to serve the entire building including plumbing pipes, fire protection pipes, and electric conduits/closets

5. Equipment access: the equipment room must allow the movement of large, heavy equipment during the installation, replacement, and maintenance.

CONCLUSION:-

HVAC systems have several requirements including primary equipment such as heating equipment, cooling equipment, and delivery equipment; space requirement such as HVAC facilities, equipment room, and vertical shaft; air distribution; and piping. Type of HVAC systems can be divided into central HVAC sys-terms and local HVAC systems. This classification depends on zone types and the location of HVAC equipment. The central HVAC systems can serve multiple and single zones and locate away from the building, which needs distribution devices. They also can be sub-classified into all-air HVAC systems, air-water systems, all-water systems, water-source heat pumps, and heating and cooling panel systems. The local HVAC systems are mostly placed inside or adjacent to the living spaces and serve one single zone. They consist of local heating systems, local air-conditioning systems, local ventilation systems, and split systems

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