Lesson
36
Selection Of Air Conditioning Systems

The specific objectives of this chapter are to:

1. Introduction to thermal distribution systems and their functions (*Section 36.1*)

2. Selection criteria for air conditioning systems (*Section 36.1*)

3. Classification of air conditioning systems (*Section 36.3*)

4. Working principle, advantages, disadvantages and applications of all air systems, namely:
a) Single duct, constant volume, single zone systems (*Section 36.4.1*)
b) Single duct, constant volume, multiple zone systems (*Section 36.4.2*)
c) Single duct, variable air volume (VAV) systems (*Section 36.4.3*)
d) Dual duct, constant volume and variable volume systems (*Section 36.4.4*)
e) Outdoor air control in all air systems (*Section 36.4.5*)
f) Advantages of all air systems (*Section 36.4.6*)
g) Disadvantages of all air systems (*Section 36.4.7*)
h) Applications of all air systems (*Section 36.4.8*)

5. Working principle, advantages, disadvantages and applications of all water systems (*Section 36.5*)

6. Working principle, advantages, disadvantages and applications of air- water systems (*Section 36.6*)

7. Working principle, advantages, disadvantages and applications of unitary refrigerant based systems (*Section 36.7*)

At the end of this chapter, the student should be able to:

1. Explain the function of a thermal distribution system

2. Discuss the criteria used for selection of air conditioning systems

3. Classify air conditioning systems

4. Discuss the working principle with suitable diagrams, advantages, disadvantages and applications of different types of all air systems, all water systems, air-water systems and unitary refrigerant based systems.

36.1. Introduction:

In order to maintain required conditions inside the conditioned space, energy has to be either supplied or extracted from the conditioned space. The energy in the form of sensible as well as latent heat has to be supplied to the space in winter and extracted from the conditioned space in case of summer. An air conditioning system consists of an air conditioning plant and a thermal distribution system as shown in Fig. 36.1. As shown in the figure, the air conditioning (A/C) plant acts either as a heat source (in case of winter systems) or as a heat sink (in case of summer systems). Air, water or refrigerant are used as media for transferring energy from the air conditioning plant to the conditioned space. A thermal distribution system is required to circulate the media between the conditioned space and the A/C plant. Another important function of the thermal distribution system is to introduce the required amount of fresh air into the conditioned space so that the required Indoor Air Quality (IAQ) can be maintained.

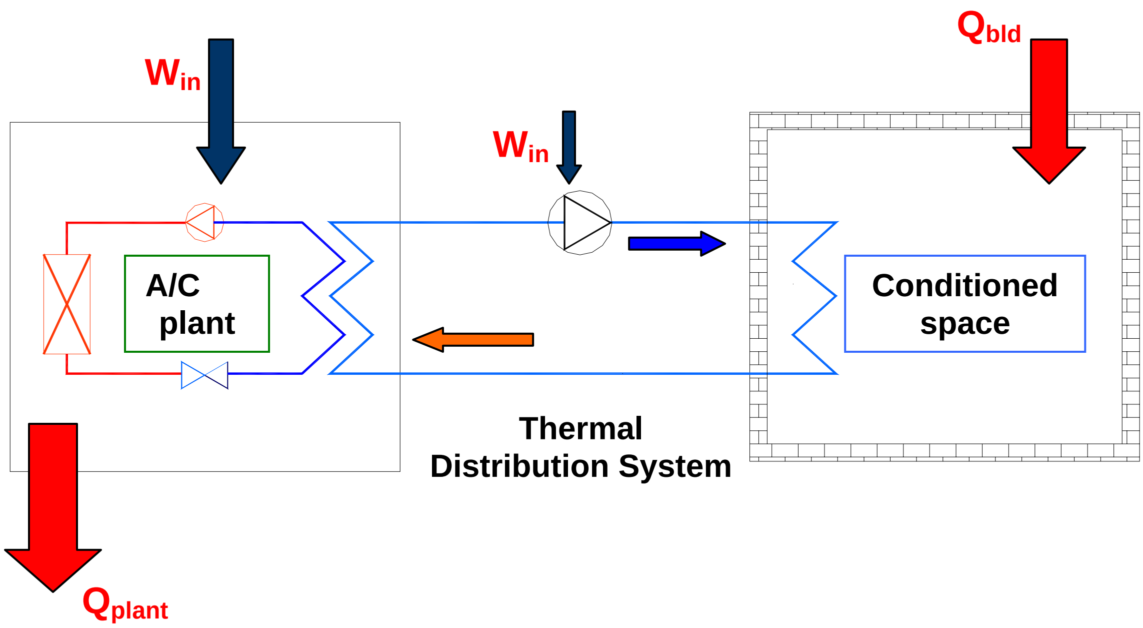

Fig.36.1: *Schematic of a summer air conditioning system with the thermal distribution system*

36.2. Selection criteria for air conditioning systems:

Selection of a suitable air conditioning system depends on:

1. Capacity, performance and spatial requirements
2. Initial and running costs
3. Required system reliability and flexibility
4. Maintainability
5. Architectural constraints

The relative importance of the above factors varies from building owner to owner and may vary from project to project. The typical space requirement for large air conditioning systems may vary from about 4 percent to about 9 percent of the gross building area, depending upon the type of the system. Normally based on the selection criteria, the choice is narrowed down to 2 to 3 systems, out of which one will be selected finally.

36.3. Classification of air conditioning systems:

Based on the fluid media used in the thermal distribution system, air conditioning systems can be classified as:

1. All air systems
2. All water systems
3. Air- water systems
4. Unitary refrigerant based systems

36.4. All air systems:

As the name implies, in an all air system air is used as the media that transports energy from the conditioned space to the A/C plant. In these systems air is processed in the A/C plant and this processed air is then conveyed to the conditioned space through insulated ducts using blowers and fans. This air extracts (or supplies in case of winter) the required amount of sensible and latent heat from the conditioned space. The return air from the conditioned space is conveyed back to the plant, where it again undergoes the required processing thus completing the cycle. No additional processing of air is required in the conditioned space. All air systems can be further classified into:

1. Single duct systems, or
2. Dual duct systems

The single duct systems can provide either cooling or heating using the same duct, but not both heating and cooling simultaneously. These systems can be further classified into:

1. Constant volume, single zone systems
2. Constant volume, multiple zone systems
3. Variable volume systems

The dual duct systems can provide both cooling and heating simultaneously. These systems can be further classified into:

1. Dual duct, constant volume systems
2. Dual duct variable volume systems

36.4.1. Single duct, constant volume, single zone systems:

Figure 36.2 shows the classic, single duct, single zone, constant volume systems. As shown in the figure, outdoor air (OD air) for ventilation and recirculated air (RC air) are mixed in the required proportions using the dampers and the mixed air is made to flow through a cooling and dehumidifying coil, a heating coil and a humidifier using a an insulated ducting and a supply fan. As the air flows through these coils the temperature and moisture content of the air are brought to the required values. Then this air is supplied to the conditioned space, where it meets the building cooling or heating requirements. The return air leaves the conditioned space, a part of it is recirculated and the remaining part is vented to the atmosphere. A thermostat senses the temperature of air in the conditioned space and controls the amount of cooling or heating provided in the coils so that the supply air temperature can be controlled as per requirement. A humidistat measures the humidity ratio in the conditioned space and controls the amount of water vapour added in the humidifier and hence the supply air humidity ratio as per requirement.

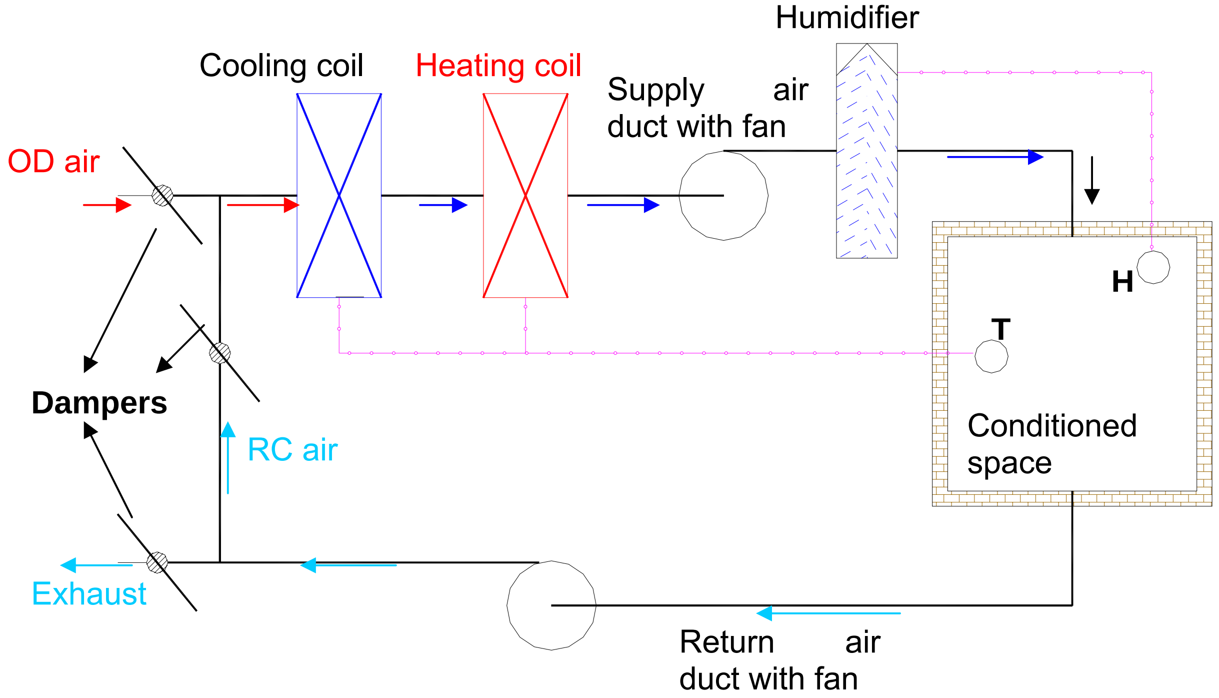

Fig.36.2. *A constant volume, single zone system*

This system is called as a single duct system as there is only one supply duct, through which either hot air or cold air flows, but not both simultaneously. It is called as a constant volume system as the volumetric flow rate of supply air is always maintained constant. It is a single zone system as the control is based on temperature and humidity ratio measured at a single point. Here a zone refers to a space controlled by one thermostat. However, the single zone may consist of a single room or one floor or whole of a building consisting of several rooms. The cooling/ heating capacity in the single zone, constant volume systems is regulated by regulating the supply air temperature and humidity ratio, while keeping the supply airflow rate constant. A separate sub-system controls the amount of OD air supplied by controlling the damper position.

Since a single zone system is controlled by a single thermostat and humidistat, it is **important to locate these sensors** in a proper location, so that they are indicative of zone conditions. The **supply air conditions** are controlled by either coil control or face-and-bypass control.

In coil control, supply air temperature is controlled by varying the **flow rate of cold and hot water** in the cooling and heating coils, respectively. As the cooling season gradually changes to heating season, the cooling coil valve is gradually closed and heating coil valve is opened. Though coil control is simpler, using this type of control it is **not possible to control the zone humidity** precisely as the dehumidification rate in the cooling coil decreases with cold water flow rate. Thus at low cold water flow rates, the humidity ratio of the conditioned space is likely to be higher than required.

In face-and-bypass control, the cold and hot water flow rates are maintained constant, but the amount of air flowing over the coils are decreased or increased by opening or closing the by-pass dampers, respectively. By this method it is possible to **control the zone humidity more precisely**, however, this type of control occupies more space physically and is also expensive compared to coil control.

Applications of single duct, single zone, constant volume systems:

1. Spaces with uniform loads, such as large open areas with small external loads e.g. theatres, auditoria, departmental stores.

2. Spaces requiring precision control such as laboratories

The Multiple, single zone systems can be used in large buildings such as factories, office buildings etc.

36.4.2. Single duct, constant volume, multiple zone systems:

For very large buildings with several zones of different cooling/heating requirements, it is not economically feasible to provide separate single zone systems for each zone. For such cases, multiple zone systems are suitable. Figure 36.3 shows a single duct, multiple zone system with terminal reheat coils. In these systems all the air is cooled and dehumidified (for summer) or heated and humidified (for winter) to a given minimum or maximum temperature and humidity ratio. A constant volume of this air is supplied to the reheat coil of each zone. In the reheat coil the supply air temperature is increased further to a required level depending upon the load on that particular zone. This is achieved by a zone thermostat, which controls the amount of reheat, and hence the supply air temperature. The reheat coil may run on either electricity or hot water.

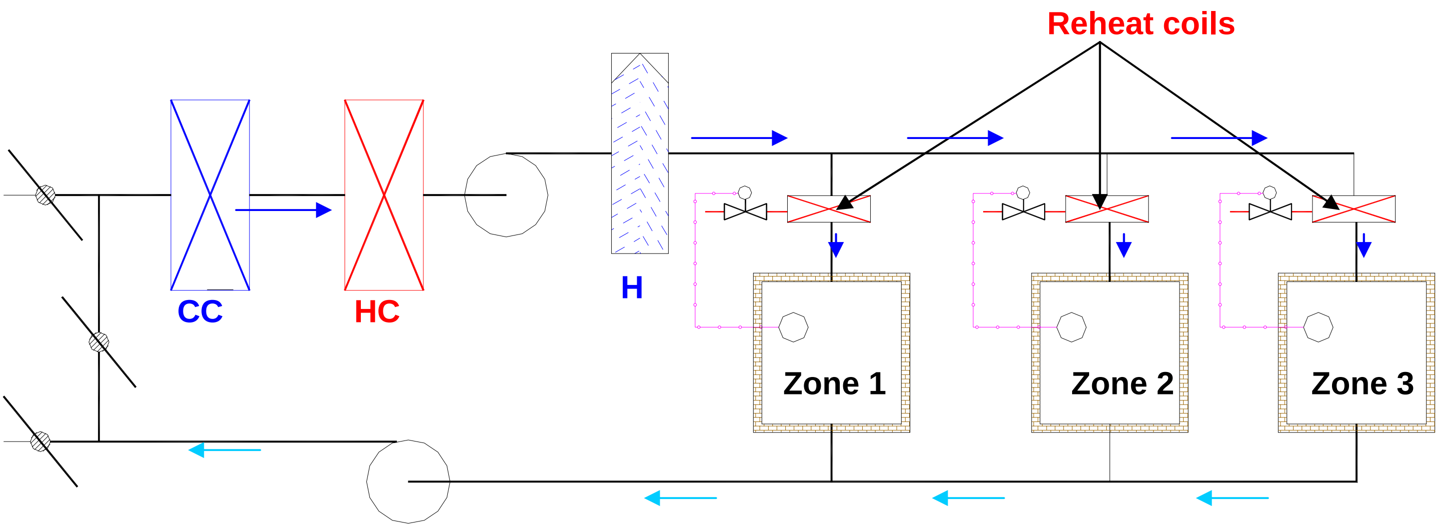

Fig.36.3. *Single duct, constant volume system with multiple zones and reheat coils*

Advantages of single duct, multiple zone, constant volume systems with reheat coils:

a) Relatively small space requirement

b) Excellent temperature and humidity control over a wide range of zone loads

c) Proper ventilation and air quality in each zone is maintained as the supply air amount is kept constant under all conditions

Disadvantages of single duct, multiple zone, constant volume systems with reheat coils:

a) High energy consumption for cooling, as the air is first cooled to a very low temperature and is then heated in the reheat coils. Thus energy is required first for cooling and then for reheating. The energy consumption can partly be reduced by increasing the supply air temperature, such that at least one reheat coil can be switched-off all the time. The energy consumption can also be reduced by using waste heat (such as heat rejected in the condensers) in the reheat coil.

b) Simultaneous cooling and heating is not possible.

36.4.3. Single duct, variable air volume (VAV) systems:

Figure 36.4 shows a single duct, multiple zone, variable air volume system for summer air conditioning applications. As shown, in these systems air is cooled and dehumidified to a required level in the cooling and dehumidifying coil (CC). A

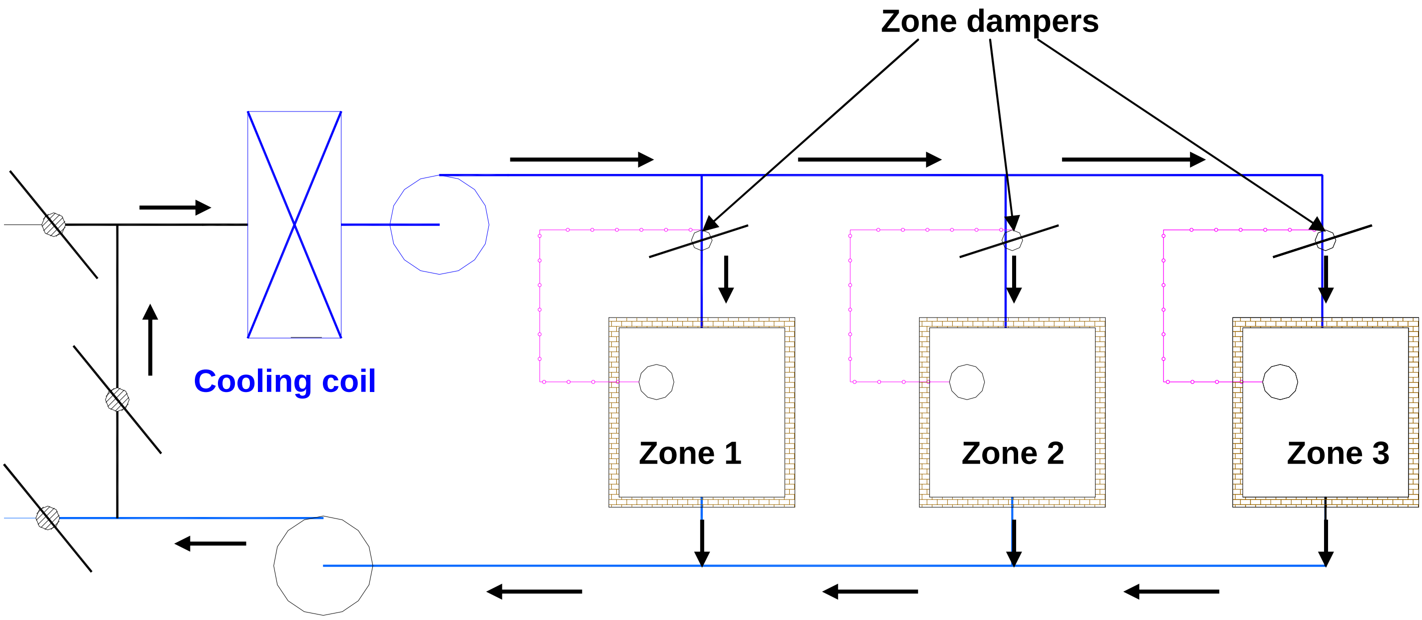

***Fig.36.4**: Single duct, multiple zone, variable air volume system*

variable volume of this air is supplied to each zone. The amount of air supplied to each zone is controlled by a zone damper, which in turn is controlled by that zone thermostat as shown in the figure. Thus the temperature of supply air to each zone remains constant, whereas its flow rate varies depending upon the load on that particular zone.

Compared to constant volume systems, the variable air volume systems offer advantages such as:

a) Lower energy consumption in the cooling system as air is not cooled to very low temperatures and then reheated as in constant volume systems.

b) Lower energy consumption also results due to lower fan power input due to lower flow rate, when the load is low. These systems lead to significantly lower power consumption, especially in perimeter zones where variations in solar load and outside temperature allows for reduced air flow rates.

However, since the flow rate is controlled, there could be problems with ventilation, IAQ and room air distribution when the zone loads are very low. In addition it is difficult to control humidity precisely using VAV systems. Balancing of dampers could be difficult if the airflow rate varies widely. However, by combining VAV systems with terminal reheat it is possible to maintain the air flow rate at a minimum required level to ensure proper ventilation and room air distribution. Many other variations of VAV systems are available to cater to a wide variety of applications.

36.4.4. Dual duct, constant volume systems:

Figure 36.5 shows the schematic of a dual duct, constant volume system. As shown in the figure, in a dual duct system the supply air fan splits the flow into two streams. One stream flow through the cooling coil and gets cooled and dehumidified to about 13°C, while the other stream flows the heating coil and is heated to about 35–45°C. The cold and hot streams flow through separate ducts. Before each conditioned space or zone, the cold and hot air streams are mixed in required proportions using a mixing box arrangement, which is controlled by the zone thermostat. The total volume of air supplied to each zone remains constant, however, the supply air temperature varies depending upon load.

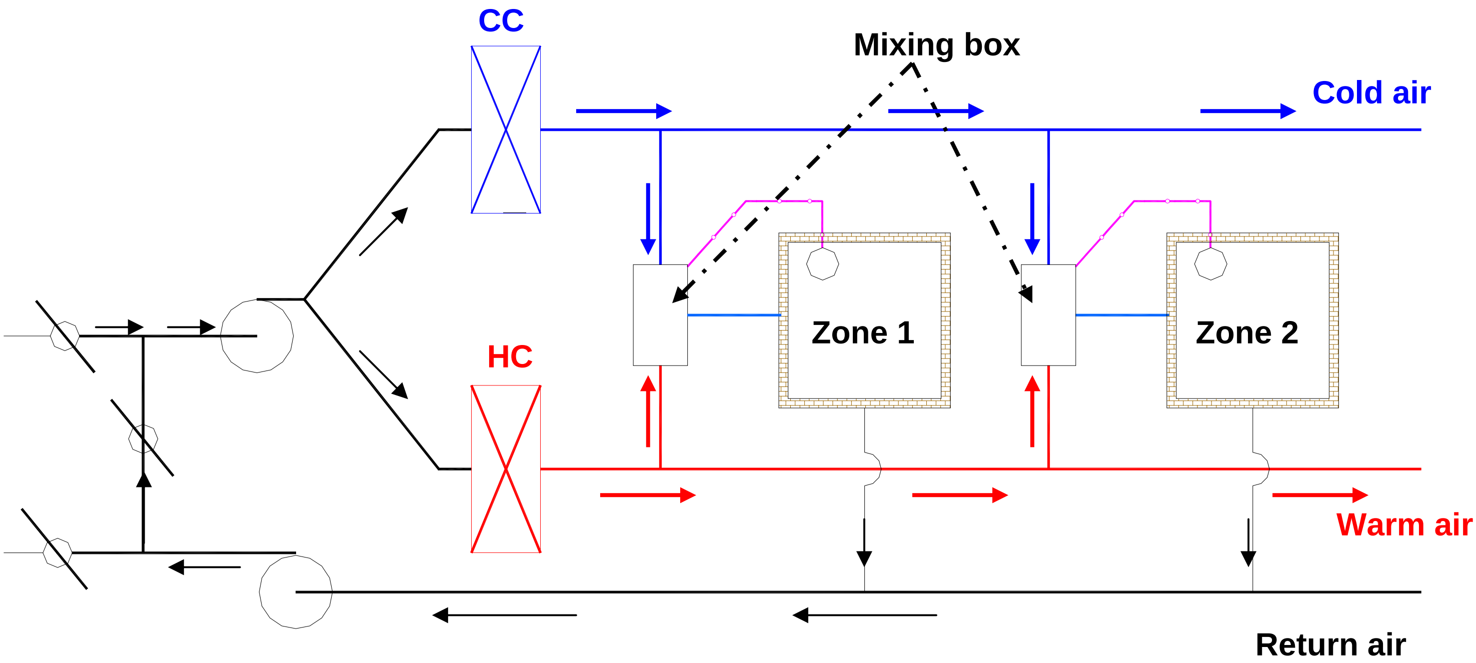

***Fig.36.5**: Dual duct, constant volume system*

Advantages of dual duct systems:

1. Since total airflow rate to each zone is constant, it is possible to maintain proper IAQ and room air distribution.
2. Cooling in some zones and heating in other zones can be achieved simultaneously
3. System is very responsive to variations in the zone load, thus it is possible to maintain required conditions precisely.

Disadvantages of dual duct systems:

1. Occupies more space as both cold air and hot air ducts have to be sized to handle all the air flow rate, if required.
2. Not very energy efficient due to the need for simultaneous cooling and heating of the air streams. However, the energy efficiency can be improved by completely shutting down the cooling coil when the outside temperature is low and mixing supply air from fan with hot air in the mixing box. Similarly, when the outside weather is hot, the heating coil can be completely shut down, and the cold air from the cooling coil can be mixed with supply air from the fan in the mixing box.

36.4.5. Dual duct, variable air volume systems:

These systems are similar to dual duct, constant volume systems with the only difference that instead of maintaining constant flow rates to each zone, the mixing boxes reduce the air flow rate as the load on the zone drops.

36.4.6. Outdoor air control in all air systems:

As mentioned in a previous lecture, outdoor air is required for ventilation purposes. In all air systems, a sub-system controls the amount of outdoor air by controlling the position of exhaust, re-circulated and outdoor air dampers. From mass balance, since the outdoor airflow rate should normally be equal to the exhaust airflow rate (unless building pressurization or de-pressurization is required), both the exhaust and outdoor air dampers open or close in unison. Again from mass balance, when the outdoor air damper opens the re-circulated air damper closes, and vice versa. The control system maintains a minimum amount of outdoor air (about 10 to 20% of supply air flow rate as required for ventilation) when the outdoor is too cold ($\leq -30^oC$) or too warm ($\geq 24^oC$). For energy conservation, the amount of outdoor air can be increased gradually as the outdoor air temperature increases from -30^oC to about 13^oC. A 100 percent outdoor air can be used when the outdoor air temperature is between 13^oC to about 24^oC. By this method it is possible to reduce the annual energy consumption of the air conditioning system significantly, while maintaining the required conditions in the conditioned space.

36.4.7. Advantages of all air systems:

1. All air systems offer the greatest potential for energy conservation by utilizing the outdoor air effectively.

2. By using high-quality controls it is possible to maintain the temperature and relative humidity of the conditioned space within **$\pm$ 0.15^{o}C** (DBT) and **$\pm$ 0.5**%, respectively.

3. Using dual duct systems, it is possible to provide simultaneous cooling and heating. Changeover from summer to winter and vice versa is relatively simple in all air systems.

4. It is possible to provide good room air distribution and ventilation under all conditions of load.

5. Building pressurization can be achieved easily.

6. The complete air conditioning plant including the supply and return air fans can be located away from the conditioned space. Due to this it is possible to use a wide variety of air filters and avoid noise in the conditioned space.

36.4.8. Disadvantages of all air systems:

1. They occupy more space and thus reduce the available floor space in the buildings. It could be difficult to provide air conditioning in high-rise buildings with the plant on the ground floor or basement due to space constraints.

2. Retrofitting may not always be possible due to the space requirement.

3. Balancing of air in large and particularly with variable air volume systems could be difficult.

36.4.9. Applications of all air systems:

All air systems can be used in both **comfort as well as industrial air conditioning** applications. They are especially suited to buildings that require individual control of multiple zones, such as **office buildings, classrooms, laboratories, hospitals, hotels, ships** etc. They are also used extensively in applications that require very close control of the conditions in the conditioned space such as **clean rooms, computer rooms, operation theatres, research facilities** etc.

36.5. All water systems:

In all water systems the fluid used in the thermal distribution system is water, i.e., water transports energy between the conditioned space and the air conditioning plant. When cooling is required in the conditioned space then cold water is circulated between the conditioned space and the plant, while hot water is circulated through the distribution system when heating is required. Since only water is transported to the conditioned space, provision must be there for supplying required amount of treated, outdoor air to the conditioned space for ventilation purposes. Depending upon the number of pipes used, the all water systems can be classified into a 2-pipe system or a 4-pipe system.

A 2-pipe system is used for either cooling only or heating only application, but cannot be used for simultaneous cooling and heating. Figure 36.6 shows the schematic of a 2-pipe, all water system. As shown in the figure and as the name implies, a 2-pipe system consists of two pipes – one for supply of cold/hot water to the conditioned space and the other for the return water. A cooling or heating coil provides the required cold or hot water. As the supply water flows through the conditioned space, required heat transfer between the water and conditioned space takes place, and the return water flows back to the cooling or heating coil. A flow control valve controls the flow rate of hot or cold water to the conditioned space and thereby meets the required building heating or cooling load. The flow control valve is controlled by the zone thermostat. As already mentioned, a separate arrangement must be made for providing the required amount of ventilation air to the conditioned space. A pressure relief valve (PRV) is installed in the water line for maintaining balanced flow rate.

A 4-pipe system consists of two supply pipelines – one for cold water and one for hot water; and two return water pipelines. The cold and hot water are mixed in a required proportion depending upon the zone load, and the mixed water is supplied to the conditioned space. The return water is split into two streams, one stream flows to the heating coil while the other flows to the cooling coil.

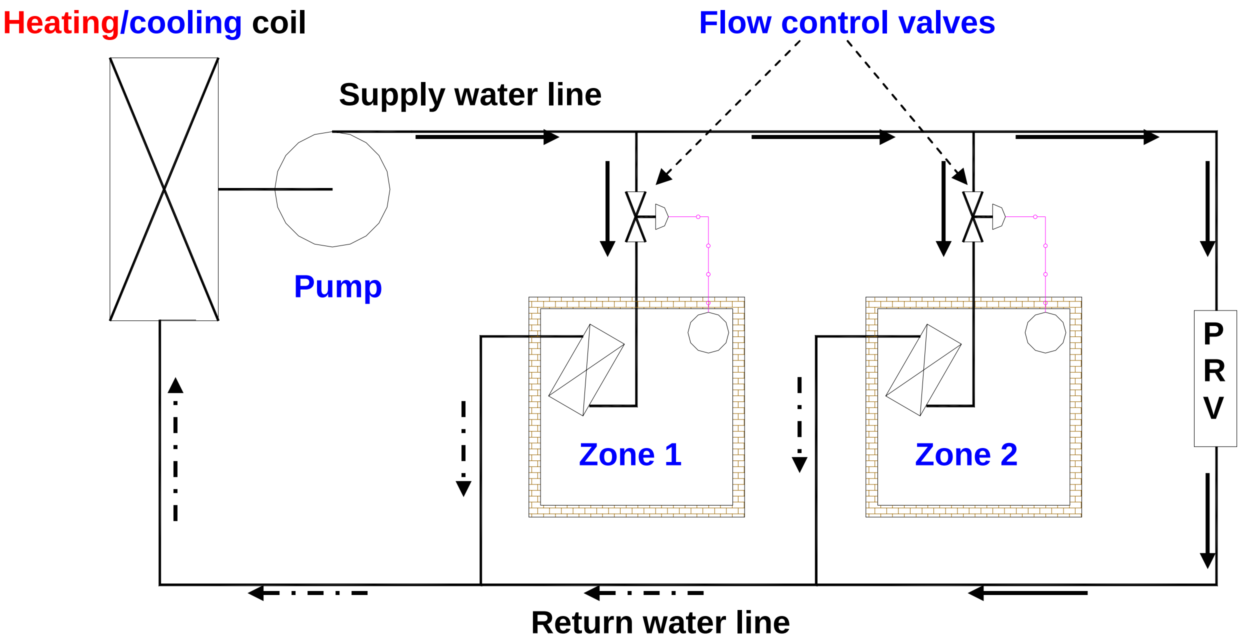

Fig.36.6: *A two-pipe, all water system*

Heat transfer between the cold/hot water and the conditioned space takes place either by convection, conduction or radiation or a combination of these. The cold/hot water may flow through bare pipes located in the conditioned space or one of the following equipment can be used for transferring heat:

1. Fan coil units
2. Convectors
3. Radiators etc.

A fan coil unit is located inside the conditioned space and consists of a heating and/or cooling coil, a fan, air filter, drain tray and controls. Figure 36.7 shows the schematic of a fan coil unit used for cooling applications. As shown in the figure, the basic components of a fan coil unit are: finned tube cooling coil, fan, air filter, insulated drain tray with provision for draining condensate water and connections for cold water lines. The cold water circulates through the finned tube coil while the blower draws warm air from the conditioned space and blows it over the cooling coil. As the air flows through the cooling coil it is cooled and dehumidified. The cold and dehumidified air is supplied to the conditioned space for providing required conditions inside the conditioned space. The water condensed due to dehumidification of room air has to be drained continuously. A cleanable or replaceable filter is located in the upstream of the fan to prevent dust accumulation on the cooling coil and also to protect the fan and motor from dust. Fan coil units for domestic air conditioning are available in the airflow range of 100 to 600 l/s, with multi-speed, high efficiency fans. In some designs, the fan coil unit also consists of a heating coil, which could be in the form of an electric heater or steam or hot water coil. Electric heater is used with 2-pipe systems, while the hot water/steam coils are

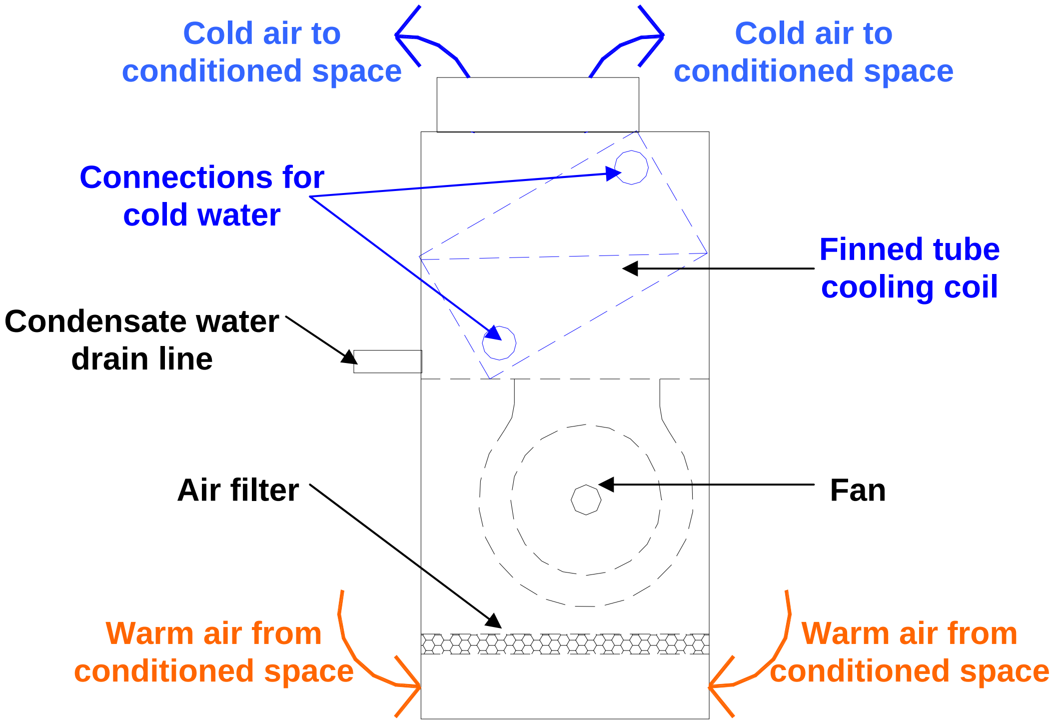

Fig.36.7: *A basic fan coil unit for cooling purposes*

used with 4-pipe systems. The fan coil units are either floor mounted, window mounted or ceiling mounted. The capacity of a fan coil unit can be controlled either by controlling the cold water flow rate or by controlling air flow rate or both. The airflow rate can be controlled either by a damper arrangement or by varying the fan speed. The control may be manual or automatic, in which case, a room thermostat controls the capacity. Since in the fan coil unit there is no provision for ventilation, a separate arrangement must be made to take care of ventilation. A fan coil unit with a provision for introducing treated ventilation air to the conditioned space is called as **unit ventilator**.

A **convector** consists of a finned tube coil through which hot or cold fluid flows. Heat transfer between the coil and surrounding air takes place by natural convection only, hence no fans are used for moving air. Convectors are very widely used for heating applications, and very rarely are used for cooling applications.

In a **radiator**, the heat transfer between the coil and the surrounding air is primarily by radiation. Some amount of heat is also transferred by natural convection. Radiators are widely used for heating applications, however, in recent times they are also being used for cooling applications.

36.5.1. Advantages of all water systems:

1. The thermal distribution system requires very less space compared to all air systems. Thus there is no penalty in terms of conditioned floor space. Also the plant size will be small due to the absence of large supply air fans.

2. Individual room control is possible, and at the same time the system offers all the benefits of a large central system.

3. Since the temperature of hot water required for space heating is small, it is possible to use solar or waste heat for winter heating.

4. It can be used for new as well existing buildings (retrofitting).

5. Simultaneous cooling and heating is possible with 4-pipe systems.

36.5.2. Disadvantages of all water systems:

1. Requires higher maintenance compared to all air systems, particularly in the conditioned space.

2. Draining of condensate water can be messy and may also create health problems if water stagnates in the drain tray. This problem can be eliminated, if dehumidification is provided by a central ventilation system, and the cooling coil is used only for sensible cooling of room air.

3. If ventilation is provided by opening windows or wall apertures, then, it is difficult to ensure positive ventilation under all circumstances, as this depends on wind and stack effects.

4. Control of humidity, particularly during summer is difficult using chilled water control valves.

36.5.3. Applications of all water systems:

All water systems using fan coil units are most suitable in **buildings requiring individual room control**, such as hotels, apartment buildings and office buildings.

36.6. Air-water systems:

In air-water systems both air and water are used for providing required conditions in the conditioned space. The air and water are cooled or heated in a central plant. The air supplied to the conditioned space from the central plant is called as **primary air**, while the water supplied from the plant is called as **secondary water**. The complete system consists of a central plant for cooling or heating of water and air, ducting system with fans for conveying air, water pipelines and pumps for conveying water and a room terminal. The room terminal may be in the form of a fan coil unit, an induction unit or a radiation panel. Figure 36.8 shows the schematic of a basic air-water system. Even though only one conditioned space is shown in the schematic, in actual systems, the air-water systems can simultaneously serve several conditioned spaces.

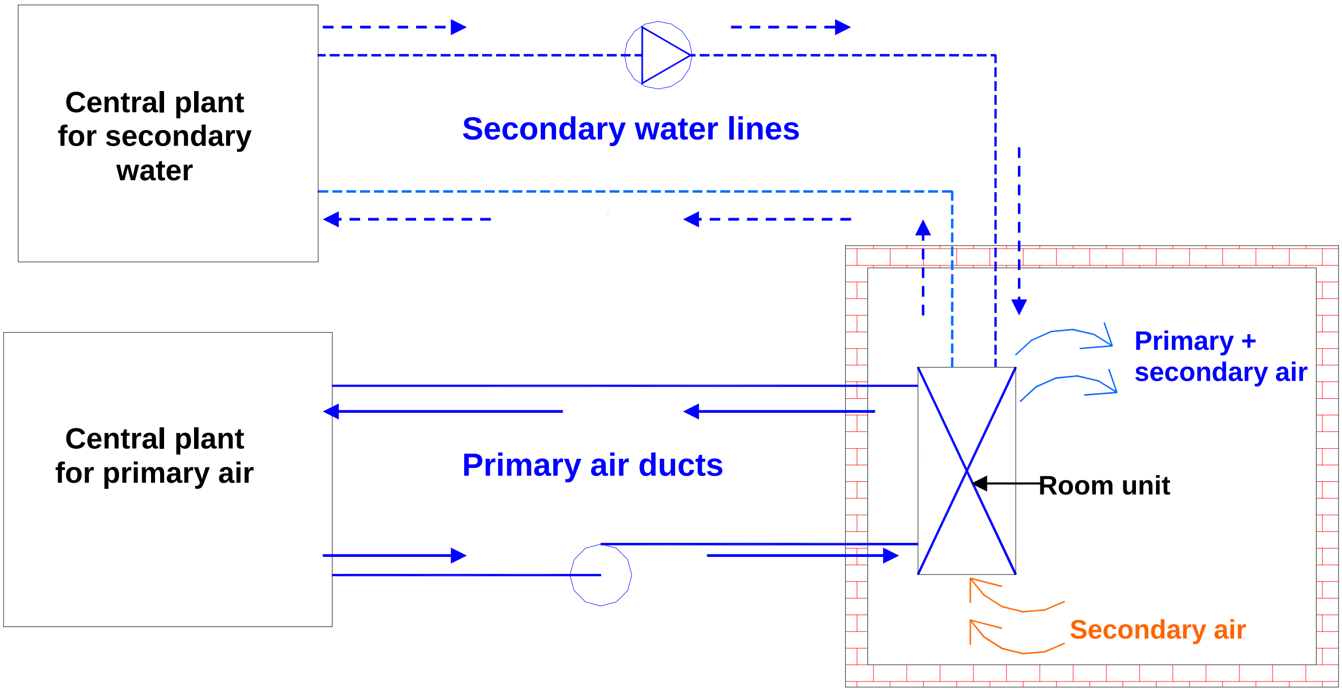

***Fig.36.8**: A basic air-water system*

Normally a constant volume of primary air is supplied to each zone depending upon the ventilation requirement and the required sensible cooling capacity at maximum building load. For summer air conditioning, the primary air is cooled and dehumidified in the central plant, so that it can offset all the building latent load. Chilled water is supplied to the conditioned space to partly offset the building sensible cooling load only. Since the chilled water coil kept in the conditioned space has to take care of only sensible load, condensation of room air inside the conditioned space is avoided thereby avoiding the problems of condensate drainage and related problems in the conditioned space. As mentioned, the primary takes care of the ventilation requirement of the conditioned space, hence unlike in all water systems, there is no need for separate ventilation systems. In winter, moisture can be added to the primary air in the central plant and hot water is circulated through the coil kept in the conditioned space. The secondary water lines can be of 2-pipe, 3-pipe or 4-pipe type similar to all water systems.

As mentioned the room unit may be in the form of a fan coil unit, an induction unit or in the form of a radiant panel. In an induction unit the cooling/heating coil is an integral part of the primary air system. The primary air supplied at medium to high pressure to the induction unit, induces flow of secondary air from the conditioned space. The secondary air is sensibly cooled or heated as it flows through the cooling/heating coil. The primary and secondary air are mixed and supplied to the conditioned space. The fan coil units are similar to the ones used in all water systems.

36.6.1. Advantages of air-water systems:

1. Individual zone control is possible in an economic manner using room thermostats, which control either the secondary water flow rate or the secondary air (in fan coil units) or both.

2. It is possible to provide simultaneous cooling and heating using primary air and secondary water.

3. Space requirement is reduced, as the amount of primary supplied is less than that of an all air systems.

4. Positive ventilation can be ensured under all conditions.

5. Since no latent heat transfer is required in the cooling coil kept in the conditioned space, the coil operates dry and its life thereby increases and problems related to odours or fungal growth in conditioned space is avoided.

6. The conditioned space can sometimes be heated with the help of the heating coil and secondary air, thus avoiding supply of primary air during winter.

7. Service of indoor units is relatively simpler compared to all water systems.

36.6.2. Disadvantages of air-water systems:

1. Operation and control are complicated due to the need for handling and controlling both primary air and secondary water.

2. In general these systems are limited to perimeter zones.

3. The secondary water coils in the conditioned space can become dirty if the quality of filters used in the room units is not good.

4. Since a constant amount of primary air is supplied to conditioned space, and room control is only through the control of room cooling/heating coils, shutting down the supply of primary air to unoccupied spaces is not possible.

5. If there is abnormally high latent load on the building, then condensation may take place on the cooling coil of secondary water.

6. Initial cost could be high compared to all air systems.

36.6.3. Applications of air-water systems:

These systems are mainly used in **exterior buildings with large sensible loads** and where close control of humidity in the conditioned space is not required. These systems are thus suitable for office buildings, hospitals, schools, hotels, apartments etc.

36.7. Unitary refrigerant based systems:

Unitary refrigerant based systems consist of several separate air conditioning units with individual refrigeration systems. These systems are factory assembled and tested as per standard specifications, and are available in the form of package units of varying capacity and type. Each package consists of refrigeration and/or heating units with fans, filters, controls etc. Depending upon the requirement these are available in the form of window air conditioners, split air conditioners, heat pumps, ductable systems with air cooled or water cooled condensing units etc. The capacities may range from **fraction of TR to about 100 TR for cooling**. Depending upon the capacity, unitary refrigerant based systems are available as single units which cater to a single conditioned space, or multiple units for several conditioned spaces. Figure 36.9 shows the schematic of a typical window type, room air conditioner, which is available in cooling capacities varying from about 0.3 TR to about 3.0 TR. As the name implies, these units are normally mounted either in the window sill or through the wall. As shown in the figure, this type of unit consists of single package which includes the cooling and dehumidification coil, condenser coil, a hermetic compressor, expansion device (capillary tube), condenser fan, evaporator fan, room air filter and controls. A drain tray is provided at the bottom to take care of the condensate water. Both evaporator and condensers are plate fin-and-tube, forced convection type coils. For rooms that do not have external windows or walls, a split type room air conditioner can be used. In these air conditioners, the condensing unit comprising of the condenser, compressor and condenser fan with motor are located outside, while the indoor unit consisting of the evaporator, evaporator fan with motor, expansion valve and air filter is located inside the conditioned room. The indoor and outdoor units are connected by refrigerant piping. In split type air conditioners, the condensed water has to be taken away from the conditioned space using separate drain pipes. In the room air conditioners (both window mounted and split type), the cooling capacity is controlled by switching the compressor on-and-off. Sometimes, in addition to the on-and-off, the fan speed can also be regulated to have a modular control of capacity. It is also possible to switch off the refrigeration system completely and run only the blower for air circulation.

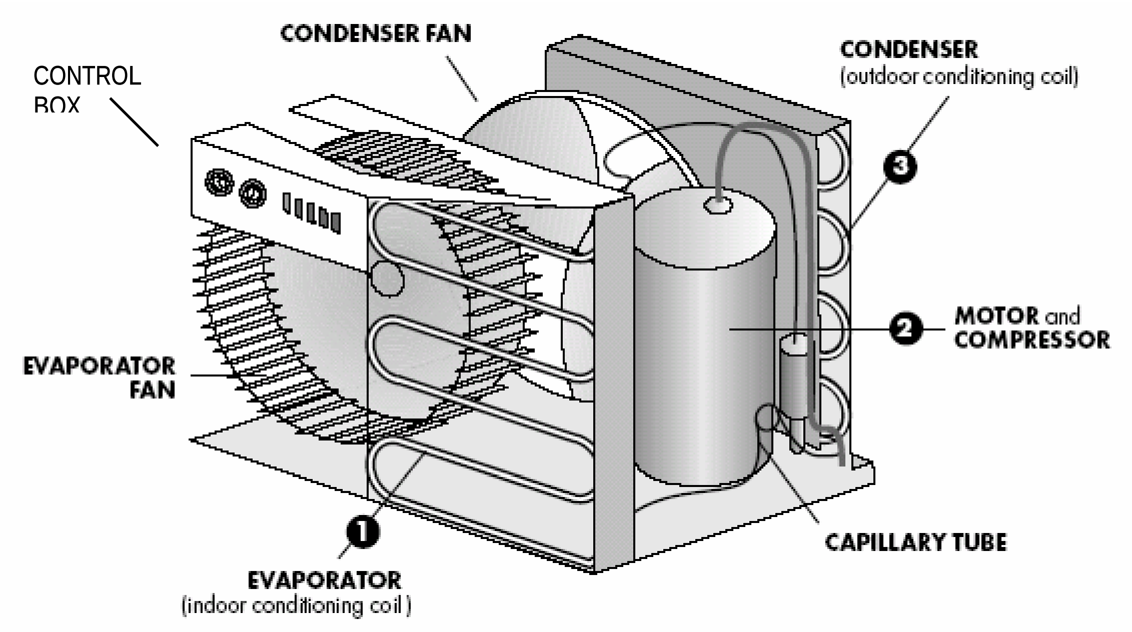

***Fig.36.9**. A typical window type room air conditioner*

Figure 36.10 shows a typical package unit with a remote condensing unit. As shown, in a typical package unit, the remote condensing unit consists of the compressor and a condenser, while the indoor unit consists of the plate fin-and-tube type, evaporator, a blower, air filter, drain tray and an arrangement for connecting supply air and return air ducts. These units are available in capacities ranging from about **5 TR to upto about 100 TR.** The condenser used in these systems could be either air cooled or water cooled. This type of system can be used for providing air conditioning in a large room or it can cater to several small rooms with suitable supply and return ducts. It is also possible to house the entire refrigeration in a single package with connections for water lines to the water cooled condenser and supply and return air ducts. Larger systems are either constant air volume type or variable air volume type. They may also include heating coils along with the evaporator.

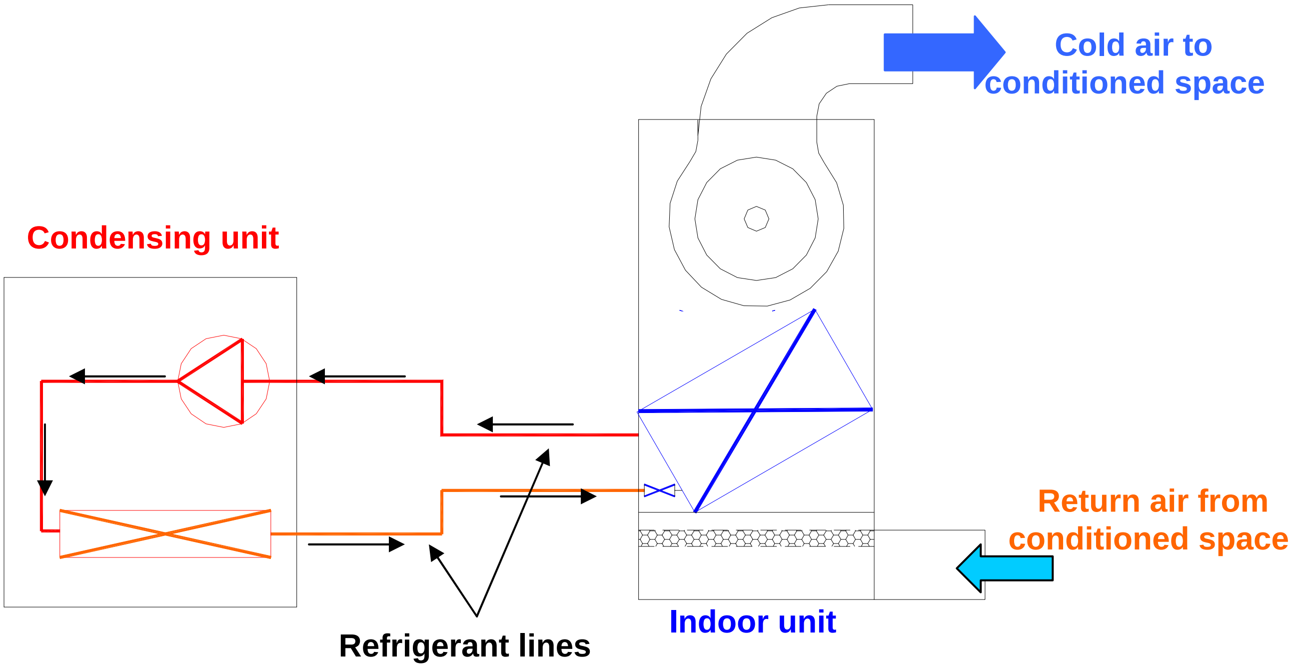

***Fig.36.10**: A typical package unit with remote condensing unit*

Most of the unitary systems have a provision for supplying outdoor air for ventilation purposes. The type of control depends generally on the capacity of the unit. The control system could be as simple as a simple thermostat based on-off control as in room air conditioners to sophisticated microprocessor based control with multiple compressors or variable air volume control or a combination of both.

36.7.1. Advantages of unitary refrigerant based systems:

1. Individual room control is simple and inexpensive.

2. Each conditioned space has individual air distribution with simple adjustment by the occupants.

3. Performance of the system is guaranteed by the manufacturer.

4. System installation is simple and takes very less time.
5. Operation of the system is simple and there is no need for a trained operator.

6. Initial cost is normally low compared to central systems.

7. Retrofitting is easy as the required floor space is small.

36.7.2. Disadvantages of unitary refrigerant based systems:

1. As the components are selected and matched by the manufacturer, the system is less flexible in terms of air flow rate, condenser and evaporator sizes.

2. Power consumption per TR could be higher compared to central systems.

3. Close control of space humidity is generally difficult.

4. Noise level in the conditioned space could be higher.

5. Limited ventilation capabilities.

6. Systems are generally designed to meet the appliance standards, rather than the building standards.

7. May not be appealing aesthetically.

8. The space temperature may experience a swing if on-off control is used as in room air conditioners.

9. Limited options for controlling room air distribution.

10. Equipment life is relatively short.

36.7.3. Applications of unitary refrigerant based systems:

Unitary refrigerant based systems are used where stringent control of conditioned space temperature and humidity is not required and where the initial cost should be low with a small lead time. These systems can be used for air conditioning **individual rooms to large office buildings**, **classrooms**, **hotels**, **shopping centers**, **nursing homes** etc. These systems are especially suited for existing building with a limitation on available floor space for air conditioning systems.

Questions and answers:

1. Which of the following statements are TRUE?

a) The function of a thermal distribution system is to transfer sensible and latent heat between the air conditioning plant and the conditioned space
b) A thermal distribution system may also supply the required amount of fresh air to the conditioned space
c) Only air flows through a thermal distribution system
d) Air, water, refrigerant or any other fluid can flow through a thermal distribution system

Ans.: a), b) and d)

2. Selection of a suitable air conditioning system depends on:

a) Type of the building
b) Initial and running costs
c) Reliability and serviceability
d) All of the above

Ans.: d)

3. Which of the following statements are TRUE?

a) A single zone, single duct, constant volume system can be used either for cooling or for heating, but not for both cooling and heating simultaneously
b) The cooling capacity of a single zone, single duct, constant volume system is controlled by controlling the supply air temperature
c) Single zone, single duct, constant volume systems are not suitable when the space conditions have to be controlled precisely
d) Single zone, single duct, constant volume systems can be used for large single rooms only

Ans.: a) and b)

4. Which of the following statements are TRUE?

a) Single duct, multiple zone, constant volume systems can be used for simultaneous cooling and heating applications
b) Single duct, multiple zone, constant volume systems can be used for large buildings comprising of several offices
c) Single duct, multiple zone, constant volume systems are energy efficient
d) Single duct, multiple zone, constant volume systems always ensure proper ventilation

Ans.: b) and d)

5. Which of the following statements are TRUE?

a) In single duct, variable air volume systems, the temperature of the supply air remains constant, but the supply air flow rate is varied depending upon the load
b) Variable air volume systems generally consume less power compared to constant volume systems
c) Variable air volume systems occupy less space compared to constant volume systems
d) Variable air volume systems always ensure adequate ventilation and good room air distribution

Ans.: a) and b)

6. Which of the following statements are TRUE?

a) Dual duct systems can provide simultaneous cooling and heating
b) Dual duct systems are constant air volume systems
c) Dual duct systems are energy efficient
d) Dual duct systems occupy more space compared to single duct systems

Ans.: a) and d)

7. Which of the following statements are TRUE?

a) In all air systems, the outdoor and re-circulated airflow rates are controlled independently
b) In all air systems, it is sometimes possible to switch of the cooling coil and use only outdoor air for air conditioning
c) All air systems are highly suitable for retrofitting applications
d) All air systems generally ensure precise control of conditioned space

Ans.: b) and d)

8. Which of the following statements are TRUE?

a) A two-pipe all water system can be used for simultaneous cooling and heating applications
b) In all water systems, separate provision must be made for ventilation
c) An all water system is easier to maintain compared to an all air system
d) Precise control of room conditions is difficult using all water systems

Ans.: b) and d)

9. Which of the following statements are TRUE?

a) All water systems are suitable in buildings requiring individual room control
b) All water systems consume less space compared to all air systems
c) All water systems offer lower initial and running costs
d) All of the above
Ans.: a) and b)
10. Which of the following statements are TRUE?

a) An air-water system uses both air and water in the thermal distribution system
b) In an air-water system, all the latent load on the building is handled by the primary air only
c) In an air-water system, the cooling coil kept in the conditioned space operates under dry conditions
d) Compared to all water systems, an air-water system is difficult to maintain

Ans.: a), b) and c)

11. Which of the following statements are TRUE?

a) Individual zone control is not possible in an air-water system
b) Using an air-water system it is possible to ensure positive ventilation under all conditions
c) Compared to all air and all water systems, the control of an air-water system is more complicated
d) The initial cost of an air-water system could be higher compared to other systems

Ans.: b), c) and d)

12. Which of the following statements are TRUE?

a) A fan coil unit is used with all water systems only
b) A fan coil unit can be used either with an all water system or with an air-water system
c) It is possible to control the cooling capacity by controlling either liquid flow rate or air flow rate in a fan coil unit
d) A fan coil unit used in an all water system requires a provision for draining the condensed water

Ans.: b), c) and d)

13. Which of the following statements are TRUE?

a) In a convector, heat transfer takes place by forced convection
b) Convectors are commonly used for heating applications
c) In a radiator, heat transfer takes place by both radiation and convection
d) A unit ventilator is a fan coil unit with a provision for fresh air entry

Ans.: b), c) and d)

14. Which of the following statements are TRUE?

a) Unitary refrigerant based systems are used for very small capacities only
b) Unitary refrigerant based systems are available only for cooling applications
c) Unitary systems are factory assembled with a performance guaranteed by the manufacturer
d) Unitary systems are also called as package units

Ans.: c) and d)

15. Which of the following statements are TRUE?

a) Small unitary systems have air cooled condensers, while larger systems can be either air cooled or water cooled
b) A split type room air conditioner should be used when the room does not have an exterior wall
c) A split type air conditioner is more reliable compared to a window air conditioner
d) It is possible to provide fresh air in a window air conditioner, whereas this is not possible in a split air conditioner

Ans.: a), b) and d)

16. Which of the following statements are TRUE?

a) In room air conditioners, the cooling capacity is generally controlled by switching the compressor on-and-off
b) Compared to a central air conditioning system, the temperature swing obtained using a room air conditioner is higher
c) Using room air conditioners, it is possible to control the indoor conditions precisely
d) Large unitary systems can be used with limited ducting to serve several rooms simultaneously

Ans.: a), b) and d)

17. Which of the following statements are TRUE?

a) Compared to central systems, the initial cost of a unitary system is less

b) Unitary systems can be installed quickly and their operation is relatively simple

c) Unitary systems consume less power compared to central systems of same capacity

d) Unitary systems are ideal for retrofitting applications

Ans.: a), b) and d)

18. Match the following:

1. A large indoor stadium	a. All water systems
2. Individual rooms of a large hotel	b. All air systems
3. An existing building with good ventilation requirement	c. Unitary systems
4. An existing, small office building	d. Air-water system

Ans.: 1-b, 2-a, 3-d, 4-c

19. Match the following:

1. A large precision laboratory	a. Variable air volume system
2. Perimeter zone of a building	b. Constant air volume system
3. Simultaneous cooling and heating	c. Multiple zone, single duct system
4. A large building complex	d. Dual duct system

Ans.: 1-b, 2-a, 3-d, 4-c

20. Match the following:

1. Electronic chip manufacturing unit	a. Window air conditioner
2. Interior room of an office	b. Package unit
3. A bedroom with a north facing wall	c. All air system
4. A medium sized restaurant	d. Split air conditioner

Ans.: 1-c, 2-d, 3-a, 4-b