Refrigeration and Airconditioning

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Lecture No. # 43

Selection of Air coditioning Systems

Welcome back in this lecture.

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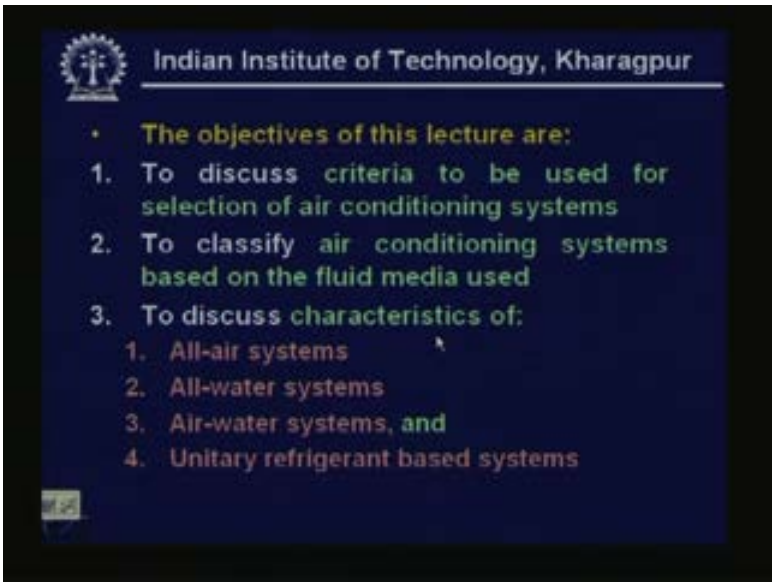

I shall discuss selection of air conditioning systems and the specific objectives of this particular lecture are to discuss criteria to be used for selection of air conditioning systems, to classify air conditioning systems based on the fluid media used to discuss characteristics of all air systems, all water systems air water systems and unitary refrigerant based systems.

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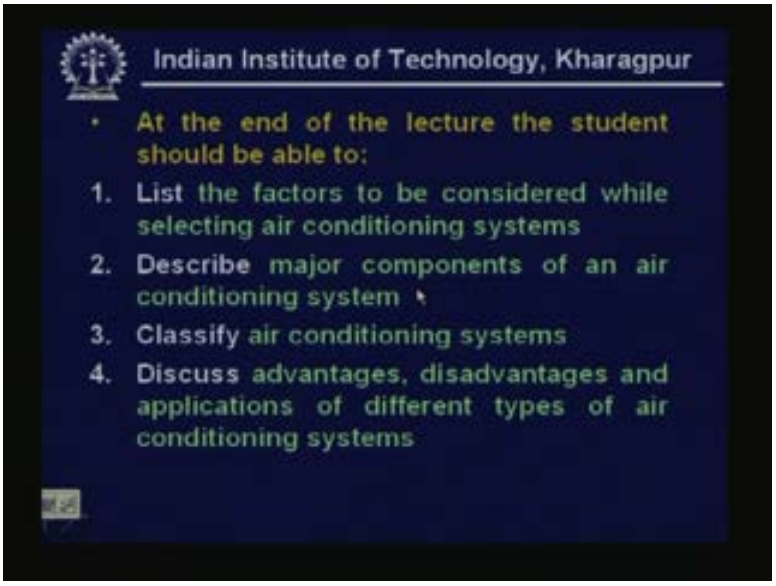

At the end of the lecture you should be able to list the factors to be considered while selecting air conditioning systems, describe major components of an air conditioning system, classify air conditioning systems, and discuss advantages disadvantages and applications of different types of air conditioning systems. Let me give a brief introduction to an air conditioning system.

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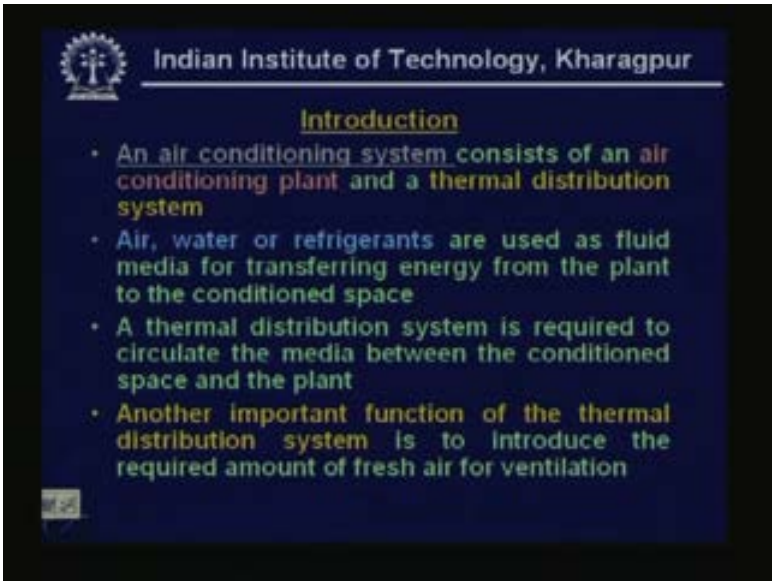

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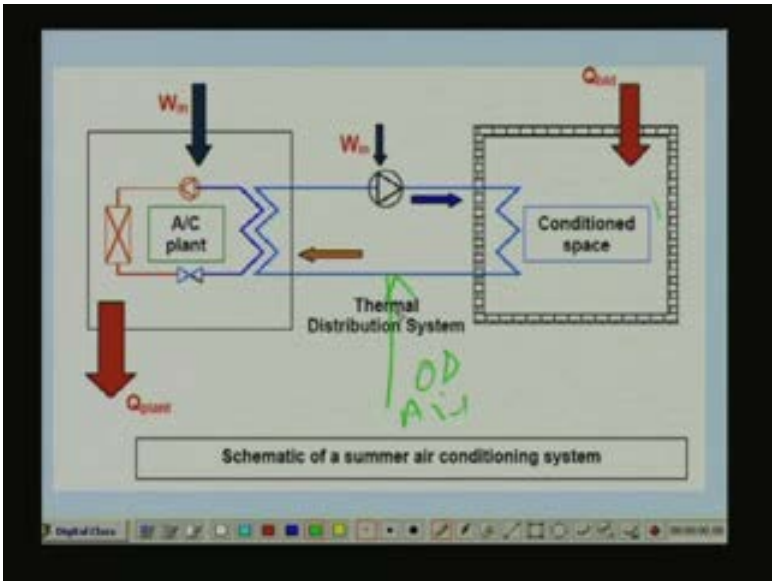
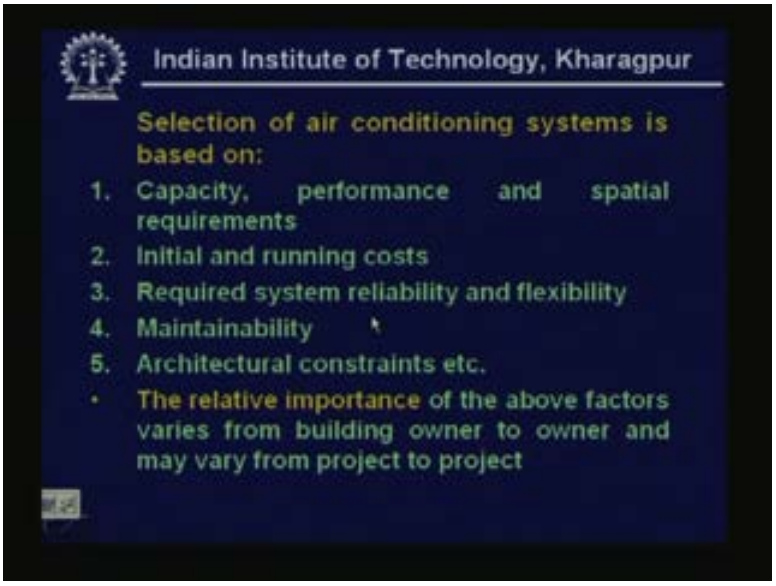


An air conditioning system consist of an air conditioning plant and a thermal distribution system air water or refrigerants are used as fluid media for transferring energy from the plant to the conditioned space or from the conditioned space to the plant. A thermal distribution system is required to circulate the media between the conditioned space and the plant. Another important function of the thermal distribution system is to introduce the required amount of fresh air for ventilation. Let me show a schematic of a typical air conditioning system.

What we have here is a schematic of a summer air conditioning system. So you have the condition space here and the air conditioning plant. And there is a thermal distribution system. This blue pipe line with a pump or a fan and in summer as we know the conditioned space is maintained at low temperature and humidity compared to the surrounding. So there is a continuous transfer of sensible and latent heat loads to the building which needs to be extracted by the air conditioning system okay. So the fluid flowing through the thermal distribution system extract this sensible and latent heat loads from the building okay. And it transmit's this heat load to the air conditioning plant.

In the air conditioning plant the system consumes some amount of work input and at ultimately rejects the heat to the surroundings okay. So this is the typical air conditioning system with the basic components. And as I said in thermal distribution system, if you are using air as a fluid media it is possible to introduce outdoor air for ventilation. For example you can introduce

outdoor air okay. Here itself, and you can treat the outdoor air and you can supply the outdoor air along with the recirculated air to the condition space. (Refer Slide Time: 00:03:43 min)



So that the ventilation requirements of the conditioned space are taking care of selection of air conditioning systems is based on the following criteria. First one is capacity performance and spatial requirements, second is initial and running cost, next required system reliability and flexibility, then maintainability of the system, then architectural constraint etcetera. Normally the relative importance of the above factors varies from building owner to owner and may vary from project to project. For example some building owners may give more importance to initial cost and some building owners may give more importance to the running cost okay. So it varies from a building owner to owner and it also varies from project to project okay.

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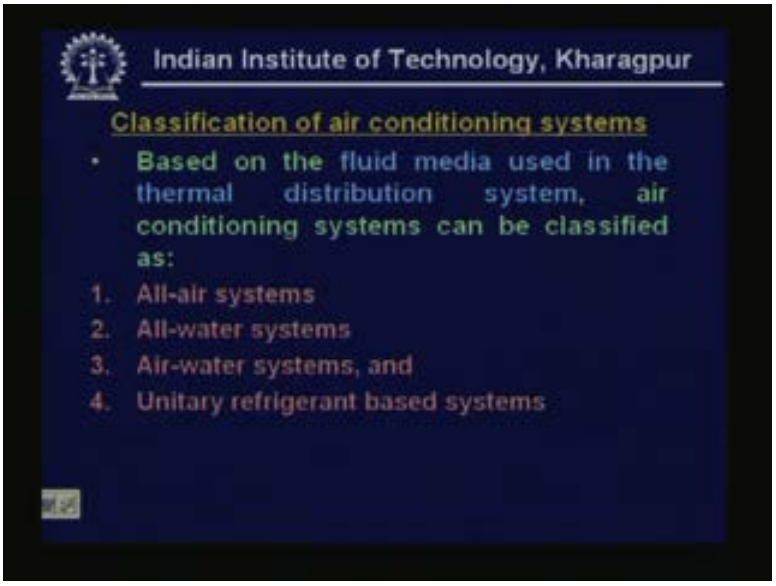

Now let us look at classification of air conditioning systems based on the fluid media used in thermal distribution system. Air conditioning systems can be classified as all air systems, all water systems, air water systems and unitary refrigerant based systems.

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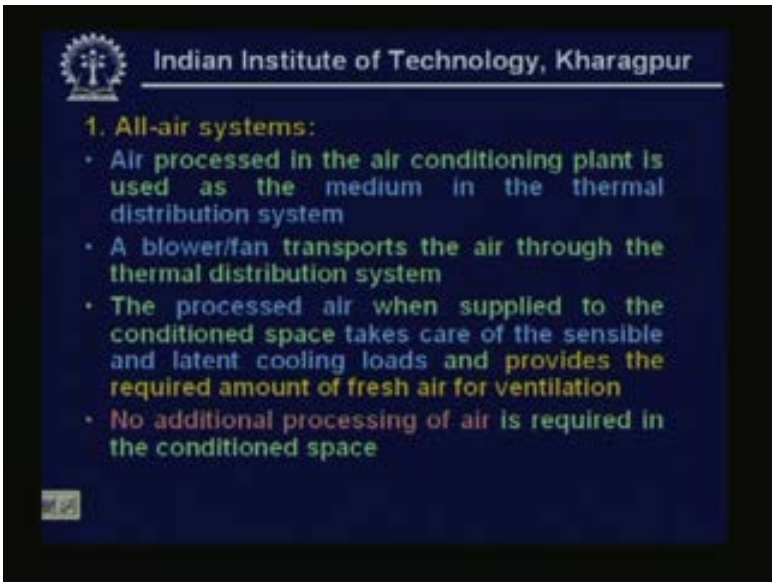

So let us look at these systems one by one first. Let us look at all air systems as the name implies in all air systems processed air is the medium used in the thermal distribution system okay. So the air is processed in the air conditioning plant and it is used as the fluid which flows through the thermal distribution system and a blower or fan transport. The air through the thermal distribution system, the processed air, when supplied to the conditioned space takes care of the

sensible and latent cooling loads and provides the required amount of fresh air for ventilation and no additional processing of air is required in the conditioned space. So these are the typical characteristics of all air systems.

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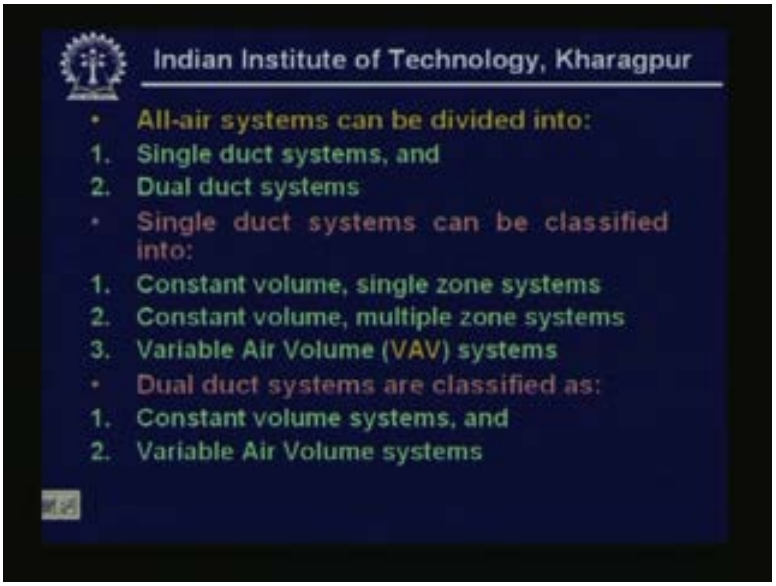

All air systems can be further divided into single duct systems and dual duct systems. And single duct systems can be again classified into constant volume, single zone systems, constant volume multiple zone systems, variable air volume systems and the dual duct systems are classified as constant volume systems and variable air volume systems.

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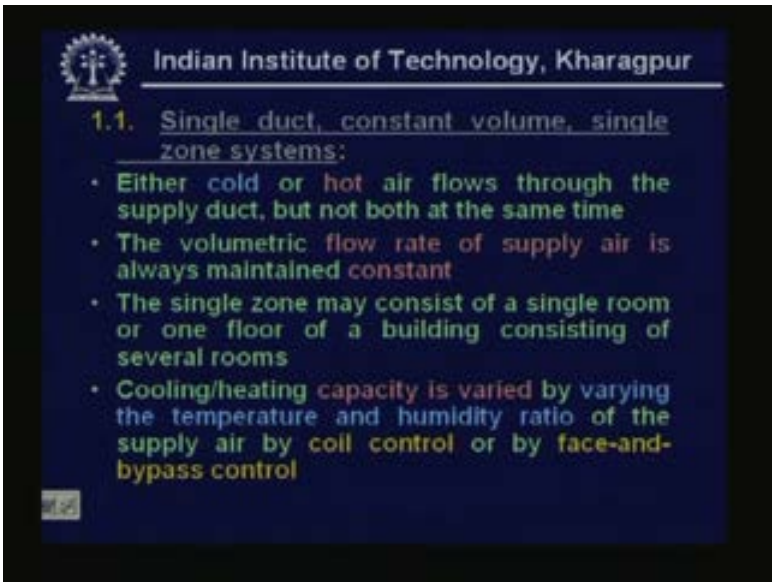

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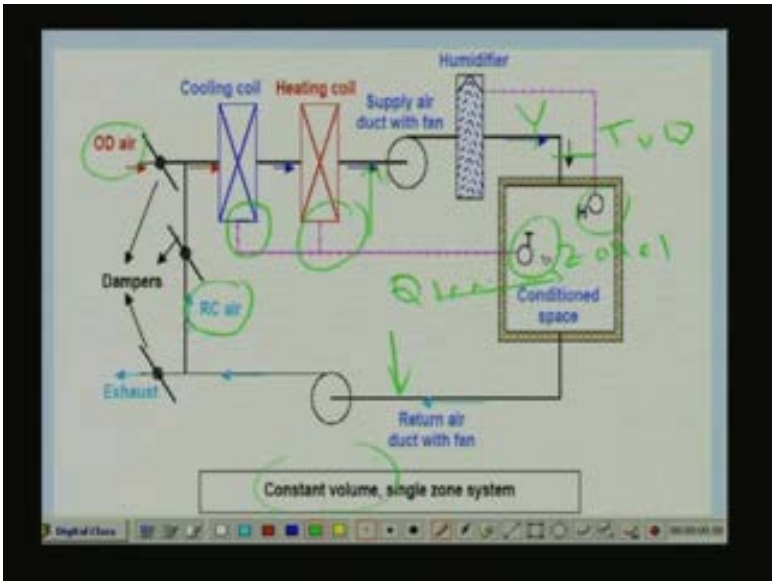

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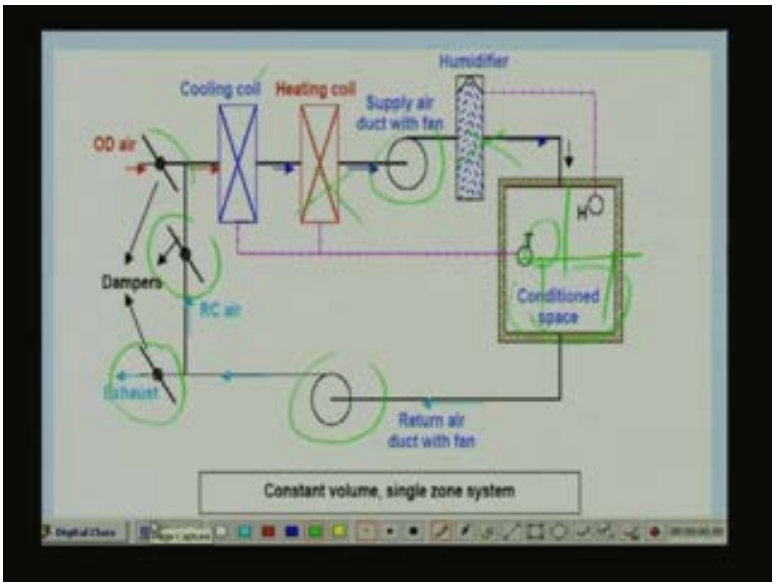

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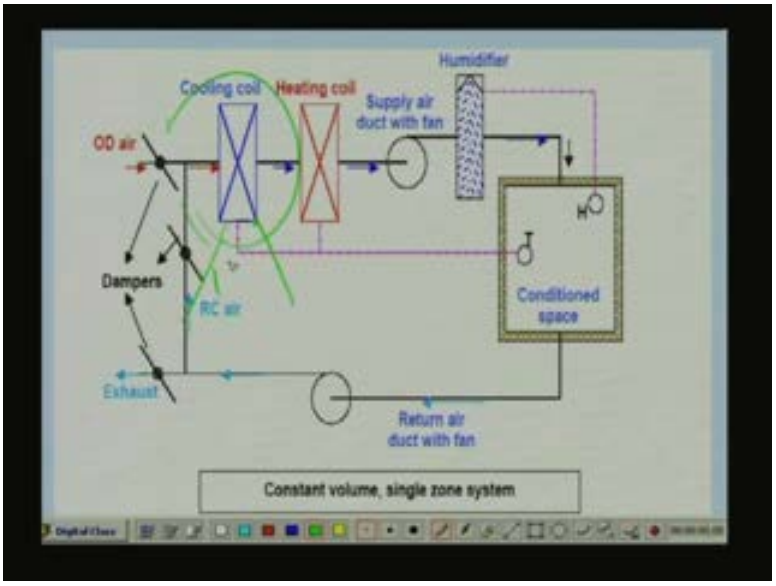

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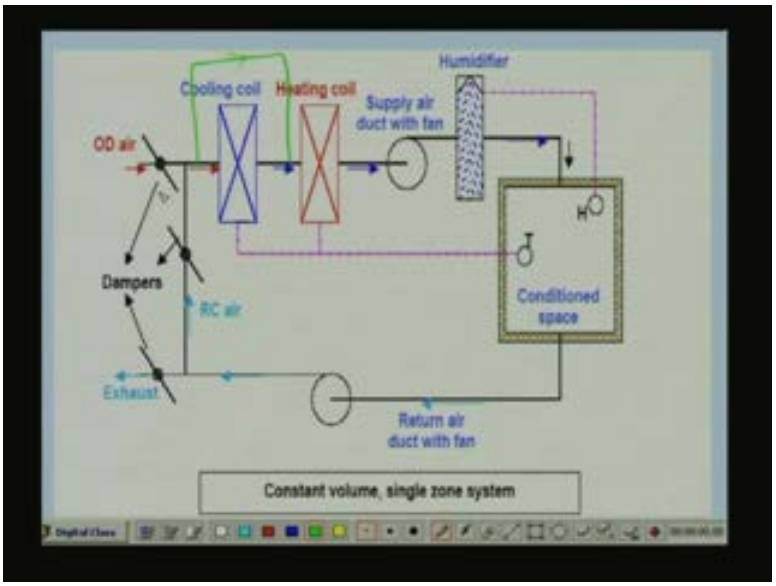

So first let us look at single duct constant volume. Single zone systems as the name implies here, we have a single duct. So through the duct either cold or hot air flows through the supply duct but both do not flow at the same time. That means you do not have simultaneous flow of cold or hot air. Either cold air flows or hot air flows at a given time and the volumetric flow rate of supply air is always maintained constant. That is why you call this as constant volume systems okay.

The volumetric flow rate is kept constant and the single zone may consist of a single room or one floor of a building consisting of several rooms. Here the term zone refers to the space which is

controlled by a single thermostat okay. And this could be a single room or it could be a large floor of a building consisting of several rooms. And cooling and heating capacity in these systems is varied by varying the temperature and humidity ratio of the supply air by coil control or by face and by pass control. So let me explain this system briefly.

So this picture here shows a typical constant volume single zone system. So here we have conditioned space or we call this as your zone okay. Let us say zone one and we have the supply duct and the return duct. So at this point some amount of re-circulated air and some amount of outdoor air for ventilation purposes are mixed and that mixed air flows through a cooling coil. A heating coil and the supply air fan and a humidifier then this processed air finally is supplied to the conditioned space and since it is a constant volume system the volumetric flow rate of supply air to the conditioned space is kept constant okay. Since the load on the building may vary which time we have to vary the cooling capacity okay. So this cooling capacity is varied by varying the temperature and humidity ratio of the supply air okay. Volume is kept constant. So either temperature or humidity ratio or both are varied. How these are varied? These, the conditioned space conditions are sensed by a thermostat T and a Humidistat H the thermostat T is connected to a heating coil and or a cooling coil okay. For example if the temperature inside the conditioned space is less than required then the amount of cooling as to be reduced. So what is done is, the signal is sent to the cooling coil okay.

Since the volumetric flow rate is kept constant the capacity of the cooling coil is reduced to such an extent that the supply air temperature increases okay. So that is how the capacity control is carried out now depending upon the required controls required and the season. For example, in winter we may not have a cooling coil we may simply have a heating coil and a humidifier. Whereas in summer it may not be necessary to have a heating coil and the humidifier okay. Simply a cooling and dehumidification coil may just serve the purpose. But sometimes if higher precision is required in controlling the conditioned space conditions then all the equipment that means cooling coil, heating coil and humidifier may be required okay. Both in summer as well as in winter the supply air fan will be running and the return air fan will also be running okay. And here you can see the damper arrangement. We have the exhaust damper and this, a re-circulated air damper and this is the outdoor air damper. So the damper positions can be controlled by a subsystem by controlling the position of the dampers you can control the amount of the outdoor air there by you can control the ventilation provided to the conditioned space okay.

So this is the typical constant volume single zone systems. As I said you call this as single zone system because the conditioned space ismonitored by a single thermostat okay. And this conditioned space would be a single room or it can consist of several rooms okay. And as I said the cooling capacity can be varied by varying the cooling capacity of the coil okay. You have the coil here. For example in summer you can vary the cooling capacity of the coil. There are two controls for varying the cooling capacity one is what is known as coil control. In coil control what is done is the flow rate of flow rate to the coil is controlled. That means if you are using chilled water then the chilled water flow rate is controlled okay. The other control what is known as face and by pass control this air some amount of air is bypassed okay, so depending upon the conditioned space conditions okay. So this is what is known as by pass face and bypass control okay.

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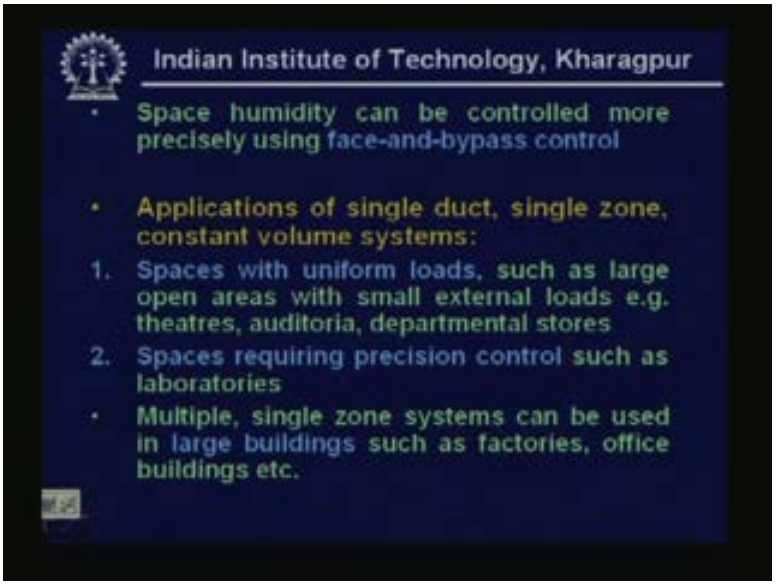

And it is generally observed that space humidity can be controlled more precisely using face and by pass control it is difficult to control the space humidity particularly in summer using cooling coil control alone. And what are the applications of single duct single zone constant volume systems; these are applied in spaces with uniform loads such as large open areas with small external load. That means basically for internally loaded buildings such as theatres auditoria, departmental stores etcetera and these are also used in spaces requiring precision control such as laboratories, where you have to control the temperature and humidity precisely and they can, you

can also use multiple single zone systems in large buildings such as factories office buildings etcetera.

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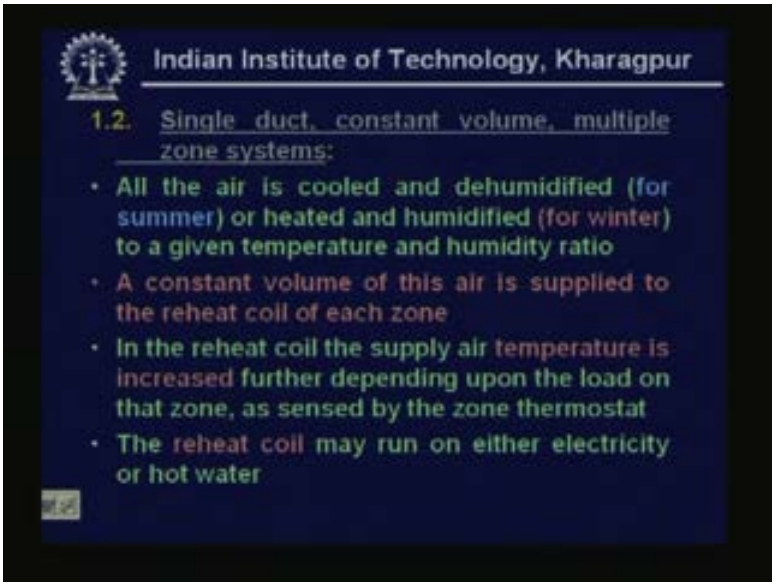

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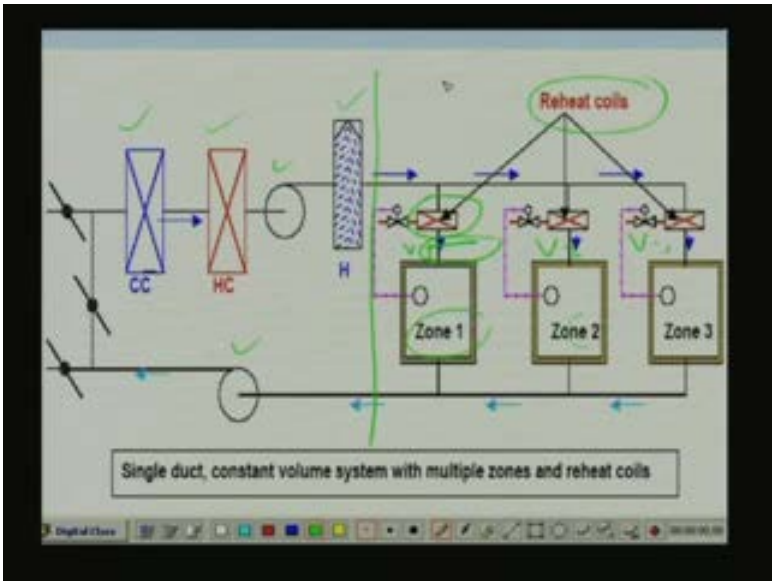

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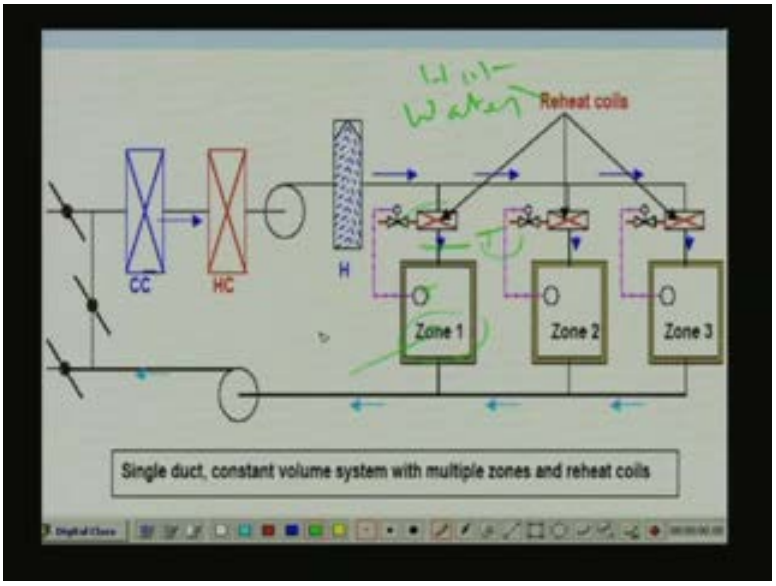

Now let us look at single duct constant volume multiple zone systems. In these systems all the air is cooled and dehumidified for summer or heater and humidified during winter to a given temperature and humidity ratio. A constant volume of this air is supplied to the reheat coil of heat zone the reheat coil the supply air temperature is increased further depending upon the load on that zone as sensed by the zone thermostat. The reheat coil may run on either electricity or hot water. So let me show the schematic of this system.

So we have here single duct constant volume system with multiple zones and reheat coils. You can see that this system is almost similar as far as this portion is concerned. Because you have the return air fan supply, air fan, cooling coil, heating coil and humidifier and all these dampers okay. Only difference is that this system now skaters to several zones okay, several zones with different requirement. For example zone one zone two zone three like that okay. So to each zone what is done is the flow rate is kept constant to each zone. For example zone one the flow rate is V one zone two flow rate is V two zone three flow rate is V three like that okay.

The volumetric flow rate of supply air is kept constant to each zone. So depending upon the load of each zone the supply air temperature at this point is varied by varying the capacity of this reheat coil okay. Reheat coil, in the reheat coil what is done is either hot air, I mean, sorry hot water okay. Hot water or steam or an electrical heater are used for reheating the air okay. And the capacity of the reheat coil is controlled by the zone thermostat here. For example, if want to reduce the capacity for a particular zone then you have to increase the reheat. So that the

temperature at this point will be higher okay. So the air is reheated to a larger higher temperature. So that it can take the reduced load of that particular zone okay. So these are the typical single duct constant volume system with multiple zones and reheat coils.

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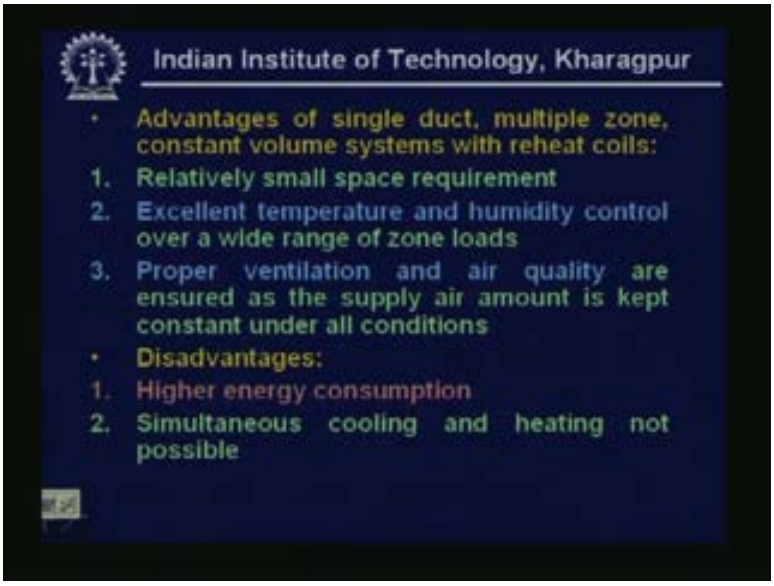

And what are the advantages of this kind of systems? So the advantages are, they occupy relatively small space because we have a single duct and excellent temperature and humidity control over a wide arrange of zone loads it is possible to control very precisely the temperature and humidity control humidity okay. And proper ventilation and air quality are ensured under all conditions as the supply air amount is kept constant under all conditions okay. There is no problem as far as ventilation or indoor air distribution or air qualities are concerned. However these systems have certain disadvantages they consume higher energy okay. Why do they consume higher energy? For example in this reheat system what we are doing is, for example, if you are using it for summer you have to cool and dehumidify the air to a minimum temperature. So that it can take care of the maximum load okay. Now if the load on a particular zone is not maximum. But it is only a part load then what is done is this cold air is heated okay. So that it can take the reduce load.

So what we are doing in this process is first we are consuming energy in the process of cooling and dehumidification of the air to very low temperature again we are consuming energy for heating the air okay. So you are losing energy at both places. so as a result these systems consume relativity higher energy compared to other systems okay. However you can reduce the

energy consumption of these systems. If you can design and if you can select the controls in such a way that at any given time at least one reheat coil is switched off okay. So that way you can reduce the energy consumption. You can also reduce energy consumption by using waste heat in reheat coil. For example solar heat or heat rejected from the condensers okay. There by you can reduce the energy consumption somewhat okay. And another disadvantage of this system is that simultaneous cooling and heating is not possible, for example, if zone one requires cooling whereas zone two requires heating that is not possible using the single duct systems.

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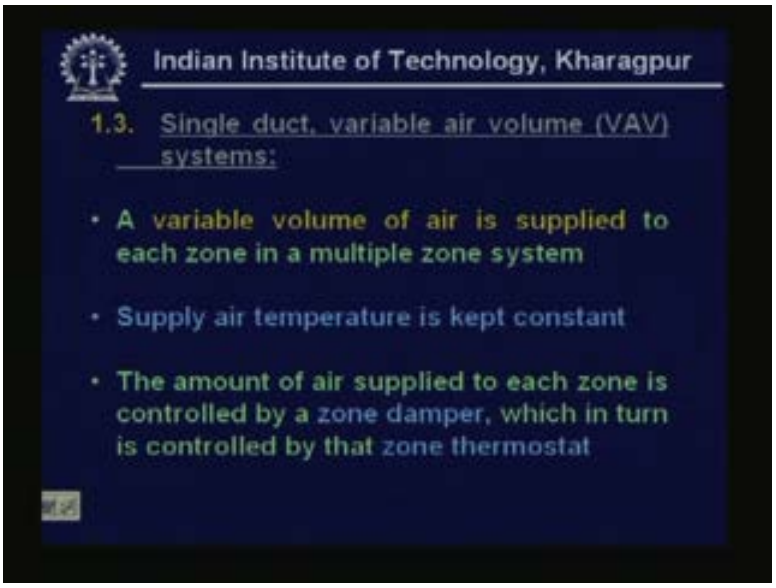

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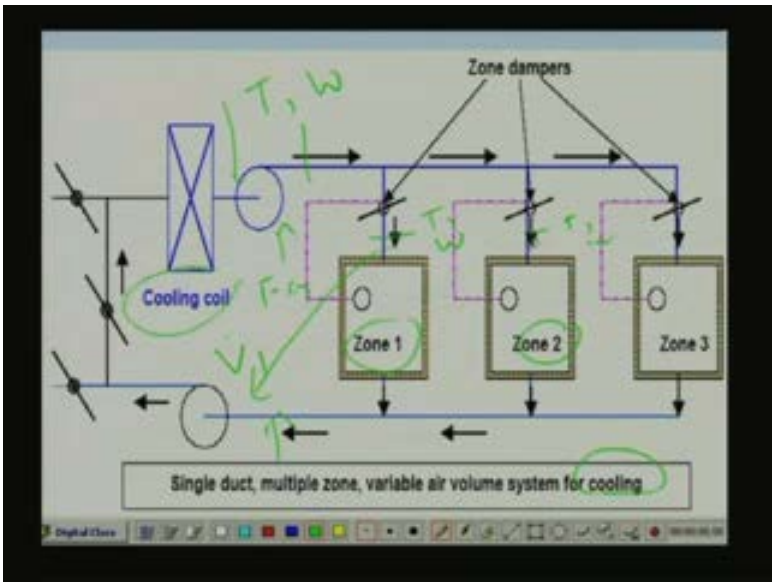

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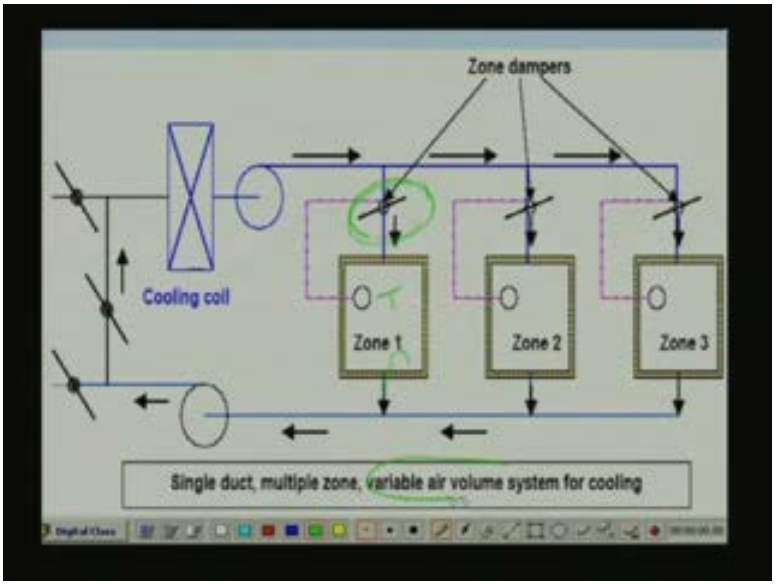

Next let us look at single duct variable air volume system variable air volume systems are quite popular. There also called as VAV systems. As a name implies, in these systems a variable layer volume of air is supplied to each zone in a multiple zone system and supply air temperature is kept constant in that constant volume system volumetric flow rate is kept constant. And supply air temperature is varied whereas in variable air volume system volumetric flow rate is varied whereas the supply air temperature is kept constant the amount of air supplied to each zone is controlled by a zone damper which in turn is controlled by the zone thermostat. So let me show the schematic of this.

So you have here the schematic of a single duct multiple zone variable air volume systems. So you have several zones, zone one, zone two like that again you have the return air duct and supply air duct and a cooling coil. I am talking about cooling. Let us say for that means for summer air conditioning. So air is and cooled and humidified to a particular temperature and humidity ratio. Let us say T n humidity ratio using the cooling coil and this air is supplied to different zones using this fan supply, fan okay. So to each zone the temperature and humidity ratio are constant okay. However each zone may have different loads okay. So these different loads are taken care by varying the volumetric flow rate okay. The volumetric flow rate of air is varied to each zone depending upon the load how the volumetric flow rate is varied the volumetric flow rate is varied by using a zone damper.

So if you change the position of the zone damper then the amount of air flowing into that particular zone changes and the position of this zone damper is controlled by the zone

thermostat. For example if the temperature inside the zone one drops, let us say because the reduced load then the capacity also has to be dropped. So the capacity is dropped by reducing the flow rate through the zone damper okay. So the thermostat senses the lower temperature and it closes the zone damper. So that less amount of air enters into the zone there by it meets the required reduced load okay. So the same thing happens in different zones that is why you call it as variable air volume system.

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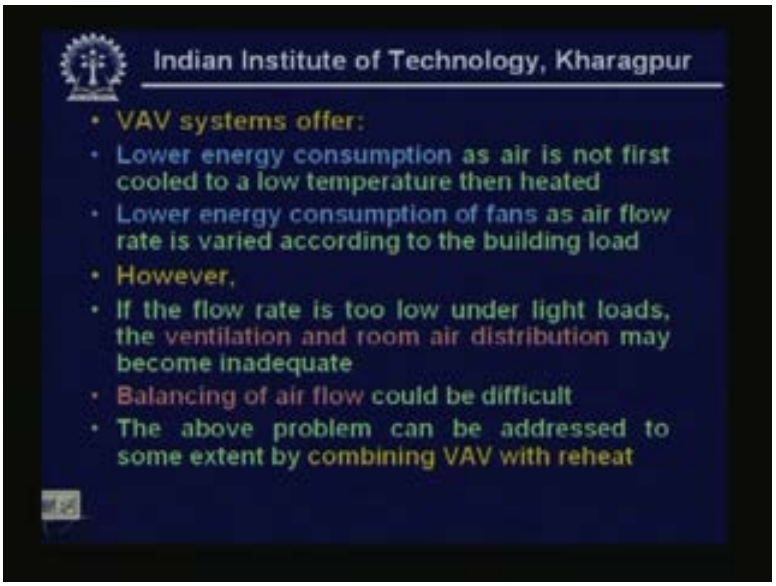

Variable air volume systems offer the flowing futures lower energy consumption air as air is not first cooled to low temperature then heated okay. So unlike in reheat systems in reheat systems what we have done we have cool the air very much okay to a very low temperature. And then we have heated it. So as I said we are losing energy at two places first for cooling and then for heating okay. So this problem is not there in variable air volume systems in variable air volume systems what we are doing is we are not cooling and heating we are only cooling okay. Then we are controlling the capacity by controlling the volumetric flow rate okay. So there by you don't have any reheat coils here okay.

Since you are controlling the volumetric flow rate by keeping the temperature constant the energy consumption. Because of cooling will be same. But there is no energy consumption because of reheating because you do not have any reheat coils okay. That is the reason why we, VAV systems are becoming increasingly popular because of their energy efficiency okay. So another advantage is that the energy consumption of the fans is also lower as air flow rate is

varied according to the building load. If the building load is less then air flow rate will be less, if the air flow rate is less the power consumption of the fan will be less okay. So that is how you get energy benefit's both form the plant as well as from the fans.

However they have certain disadvantages if the flow rate is too low. For example when the load is very light then the volumetric flow rate to that particular room may be very low okay. If it is very low then the ventilation and room air distribution may be inadequate okay. So this may affect the indoor air quality of that particular building okay. This is the serious problem with VAV systems another problem is that balancing of air flow could be difficult particularly at light loads okay. So these are two typical problems, these problems can be addressed to some extend by combining variable air volume systems with reheat. That means we will have reheat coil along with a variable air volume system and the reheat coil is operated when the flow rate drops below the certain level okay.

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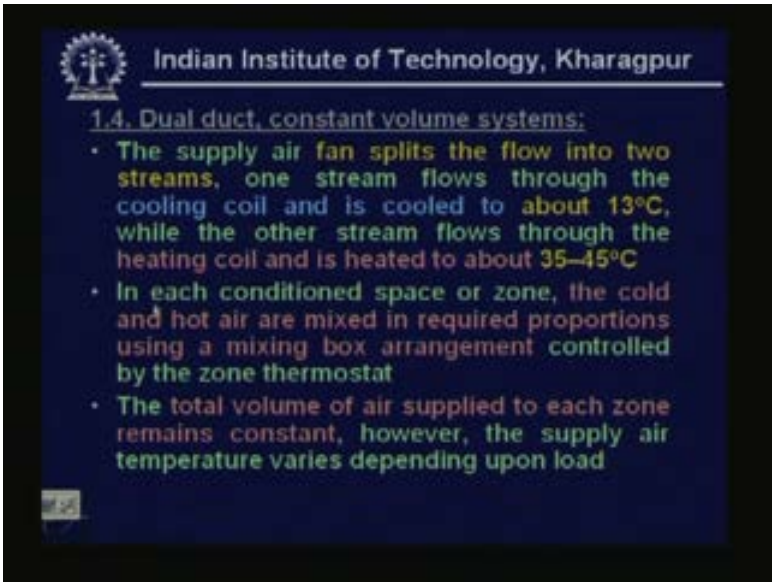

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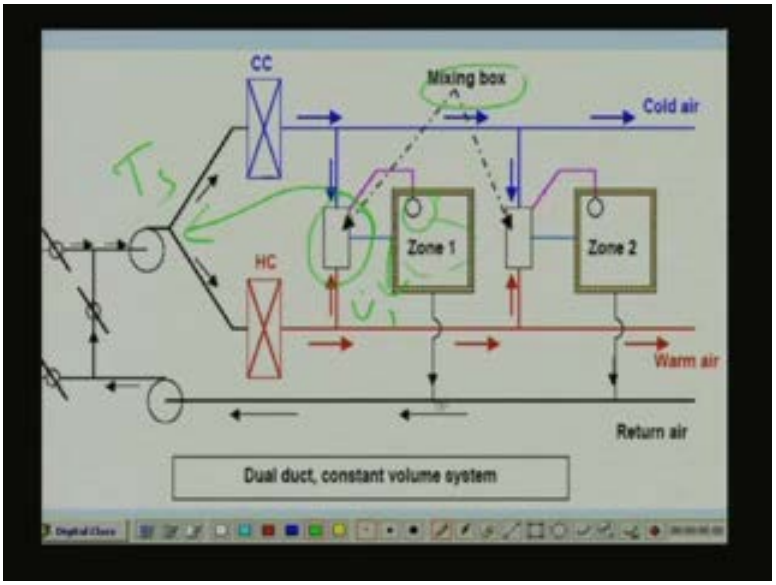

Next look at dual duct constant volume systems. So far we have been discussing single duct system. Now let us look at dual duct system the, in the dual duct system the supply air fan split's the flow into two streams okay. That is why you call it as dual duct both streams flow through two different ducts. One stream flows through the cooling coil and is cooled to about thirteen degree centigrade while the other stream flows through the heating coil and is heated to about thirty-five to forty-five degree centigrade. In each conditioned space or zone the cold and hot air are mixed in required proportions using a mixing box arrangement controlled by that particular zone thermostat.

The total volume of air supplied to each zone remains constant. However the supply air temperature varies depending upon the load okay. So remember that this is a constant volume system. So we are keeping the volumetric flow rate total volumetric flow rate constant but varying the supply air temperature okay. So let me show the schematic of this system. So as I mentioned here this is your supply air fan okay. Some amount of re-circulated air and some amount of outdoor air are mixed okay, and this supply air fan then split's this flow into two streams okay. And these two streams flow through two ducts that is why you call it as dual duct this is one duct this is another duct okay.

In duct one you have a cooling and dehumidification coil. That means air flowing through duct one is cooled and dehumidified okay; to about thirteen degrees centigrade whereas in the duct two you have a heating coil HC stands for heating coil oaky. So the air flowing through duct two is heated to about thirty-five to forty-five degrees centigrade okay. So in one duct you have a hot

air at about forty-five degree centigrade in another duct you have cold air at about thirteen degree centigrade and these hot and cold air are mixed before each zone for example zone one okay. Depending upon its load they are mixed in what is known as a mixing box okay. And a constant volumetric flow rate of this mixed air is supplied to this zone okay. Similarly for zone two, zone three etcetera right.

So what we are doing essentially is we are cooling and heating air in two different stream and we are mixing the air in different proportions depending upon the load of that particular zone. And we are supplying that air at a constant volumetric flow rate to each zones okay. So remember that here volumetric flow rate remains constant but the temperature supply temperature is varied. How this is varied? This varied by varying the position of the mixing box okay. And this is in turn controlled by the zone thermostat okay. And the return air is sent back to the system using a return air duct okay. So this is a dual duct constant volume system.

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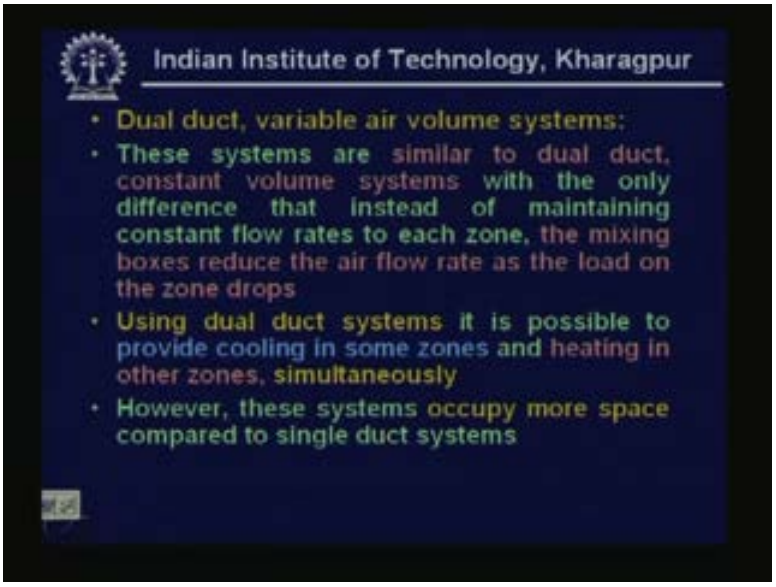

Then we also can have dual duct variable air volume systems. So as the name implies here the temperature is kept constant but the volume is varied okay. How the volume is varied, these systems are similar to dual duct constant volume systems with the only difference that instead of instead of maintaining constant flow rates to each zone the mixing boxes reduce the air flow rate as a load on the zone drops okay. So this is the difference between dual duct variable air volume and dual duct constant volume systems.

Using dual duct systems it is possible to provide cooling in some zones and heating in other

zones simultaneously okay. For example zone one can be cooled and zone two can be heated at the same time okay. This is possible in the dual duct systems because we have two separate ducts through which cold and hot air are flowing separately okay. This is not possible in single duct systems however these systems occupy more space. Obviously because you have two ducts okay one for hot air and one for cold air okay. So since flow space requirement is higher.

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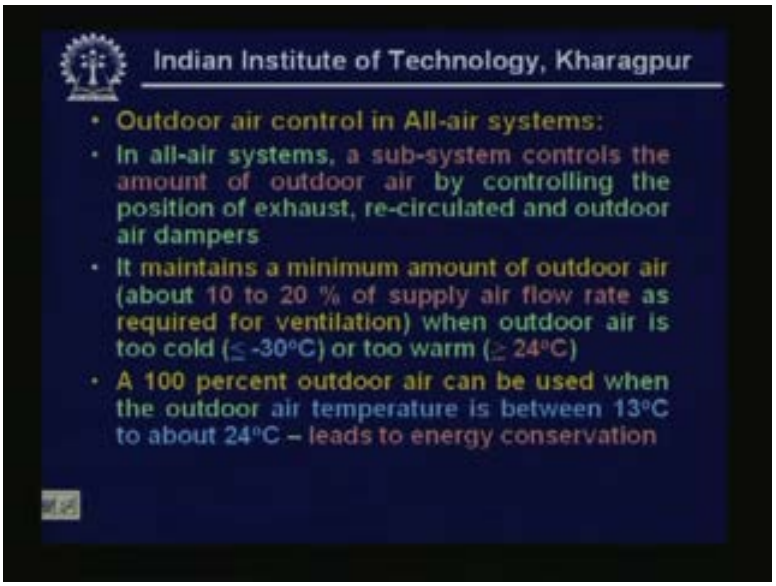

Now let us look at outdoor air control in all air systems okay. This refers to both single duct as well as dual duct systems. In all air systems a sub system controls the amount of outdoor air by controlling the position of exhaust re-circulated and outdoor air dampers okay. There is a separate system which controls the proportions of these exhaust re-circulated and outdoor air damp air flow rates okay. And this system maintains a minimum amount of outdoor air which is about ten to twenty percent of supply air flow rate as required for ventilation when the outdoor air is too cold or too warm okay.

That means what the subsystem does is when the outdoor air is very cold. Let us say it is less then minus twenty four degree centigrade less then minus thirty degree centigrade. Or when it is too warm that means it is greater then let us say about twenty-four degree centigrade okay. Then it supplies a minimum amount of outdoor air to the conditioned space this minimum amount will be about ten to twenty percent depending upon the application and this minimum amount is required for ventilation okay. So this is maintained as long as the temperature of the outdoor air is too cold or too warm okay. However what happens is the amount of outdoor air can be

increased progressively as the outdoor air temperature increases from minus thirty degree centigrade to about thirteen degree centigrade okay. And what you can do is you can maintain hundred percent outdoor air when the outdoor air temperature is between thirteen degrees to above twenty-four degree centigrade okay. So this leads to great energy consumption okay. So what it means is that as I said when the temperature is less then minus thirty or when the temperature is greater then, plus twenty-four you have to provide a minimum amount of outdoor air okay.

However when the temperature is between minus thirty to plus thirteen okay, then you can progressively increase the amount of outdoor air okay. And when the outdoor air temperature is between thirteen degrees and twenty-four degree centigrade then you can supply all outdoor air for conditioning the space okay. That means you do not have to run the cooling system or heating system. When the temperature is between thirteen to twenty-four degree centigrade all that you have to do is you have to run the supply air fan okay. There by the energy consumption are the, of the cooling and heating plant is completely eliminated oaky. So this gives rise to large savings in energy okay. Of course this is possible only when the outdoor temperatures are lie within this ranges okay.

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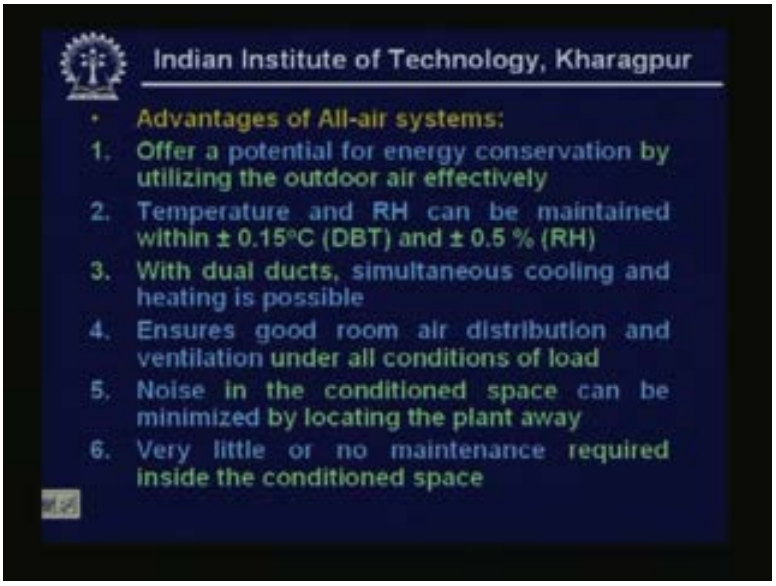

Now let us look at advantages of all air systems. All air systems offer a potential for energy conservation by utilizing the outdoor air effectively. As I have mentioned just now and temperature and relative humidity can be maintained very precisely. That means temperature can

be maintained within plus or minus point one five degree centigrade and relative humidity can be maintained within plus or minus point five percent okay. Very close control and with dual ducts simultaneous cooling and heating is possible and all air systems ensures good room air distribution and ventilation under all conditions of load okay. So the indoor air quality will be good when we are using all air systems and noise in the conditioned space can be minimized by locating the plant away from the conditioned space the plant includes the supply air and return air fans.

So their by the noise generated by all these equipment need not be transmitted to the conditioned space. So you can maintain low noise in the conditioned space and another very important advantage is that these systems require very little or no maintenance inside the conditioned space okay, this in comparison to all water systems.

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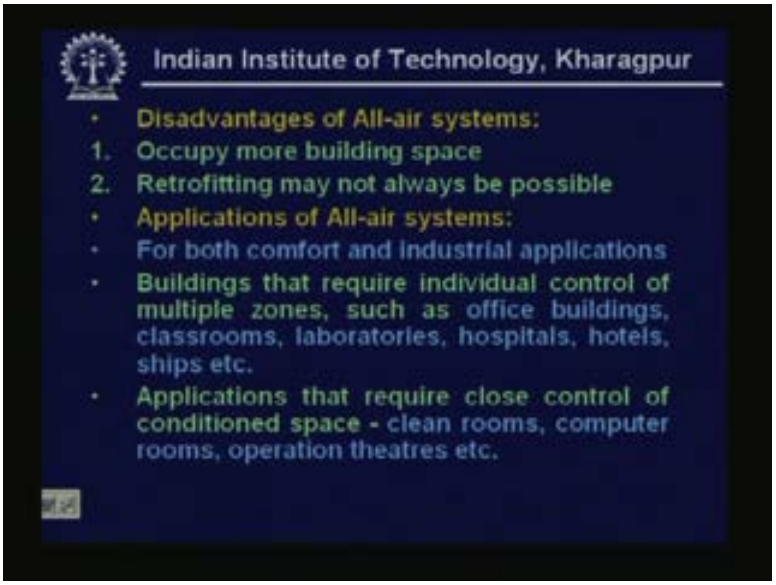

However all air systems also have certain disadvantages they generally occupy more building space compared to all water systems. As a result retrofitting may not be possible always and what are the applications of all air systems they are applied for both comfort as well as industrial air conditioning. And they are used in buildings that require individual control of multiple zones such as office buildings, class rooms, laboratories, hospitals, hotels, ships etcetera. And they are also used in applications that require close control of conditioned space such as clean rooms computer room operation theatres etcetera.

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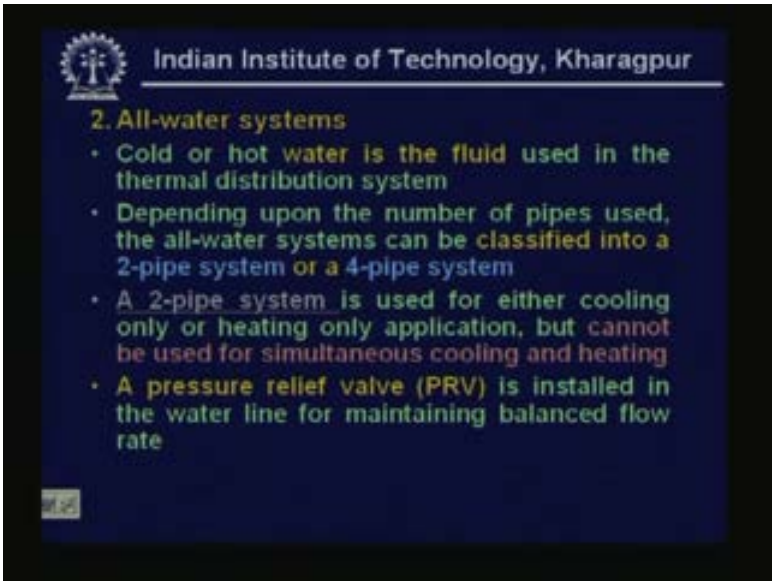

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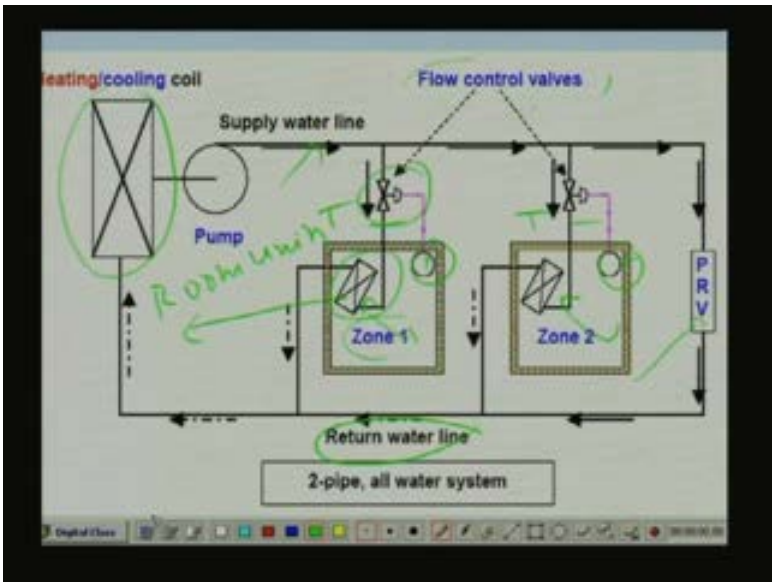

Now let us look at all water systems in all water systems cold or hot water is a fluid used in the thermal distribution system depending upon the number of pipes used the all water systems can be classified into a two pipe system or a four pipe system. A two pipe system is used for either cooling only or heating only application but cannot be used for simultaneous cooling and heating. And in all water systems a pressure relief valve PRV is installed in the water line for maintaining balanced flow rate okay. So let me show a typical two pipe system.

So this is a two pipe all water system it consist of a heating or cooling coil where water is either heated or cold depending upon the requirement and depending upon the season. Then it consist of a supply water line and return water line okay. So through the supply water line either hot

water or cold water flows depending upon the requirement and a pump is used for circulating the water okay. So water is cooled or heated to a particular temperature okay. And this water at the, this particular temperature is supplied to room units kept inside different zones okay. These are the zone or room units okay.

So the hot or cold water flows through these room units and as it flows through it exchanges energy with the conditioned air in the space okay. So that is heat transfer between the unit and the conditioned air as the water flows through the room unit okay. And the capacity of heat zone is controlled by controlling the flow rate of the hot or cold water okay. So you have slow control valves here using the flow control valves you can control the flow rate to the conditioned space. There by you can control the required capacity okay. And the flow control valves are controlled by the zone thermostats okay. You can see that there are zone thermostat which are connected to the flow control valves. If the load is less, then the flow control valve is closed and less amount of water supply to the room unit okay. And as I said a PRV the pressure relief valve is required for balancing the flow rate right.

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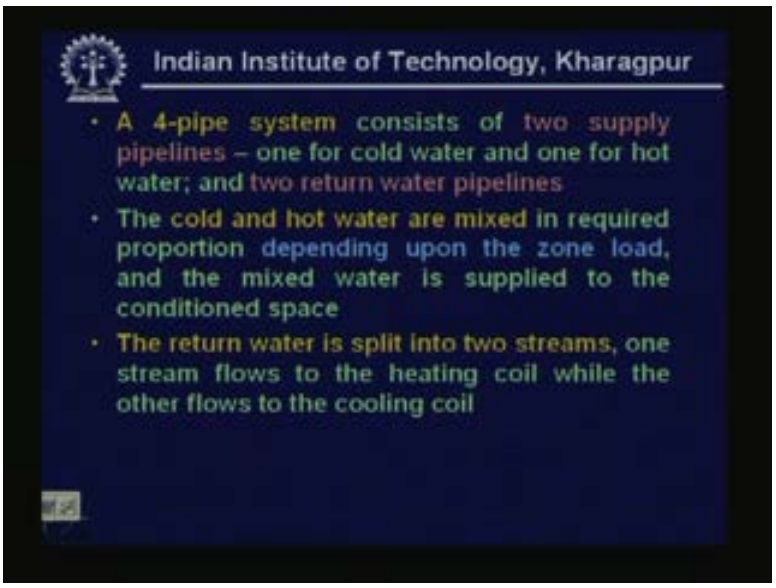

A four pipe system consists of two supply pipe lines one for cold water and one for hot water okay. In a two pipe system we just add one supply line and one return line whereas in a four pipe system you have two supply lines and two return lines okay. Two supply lines are for one for cold water and one for hot water and two return water pipe lines carry water to heating coil and cooling coil okay. That is why you call it as four pipe systems the cold and hot water are mixed

in required proportion depending upon the zone load in a four pipe system 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 other flows to the cooling coil.

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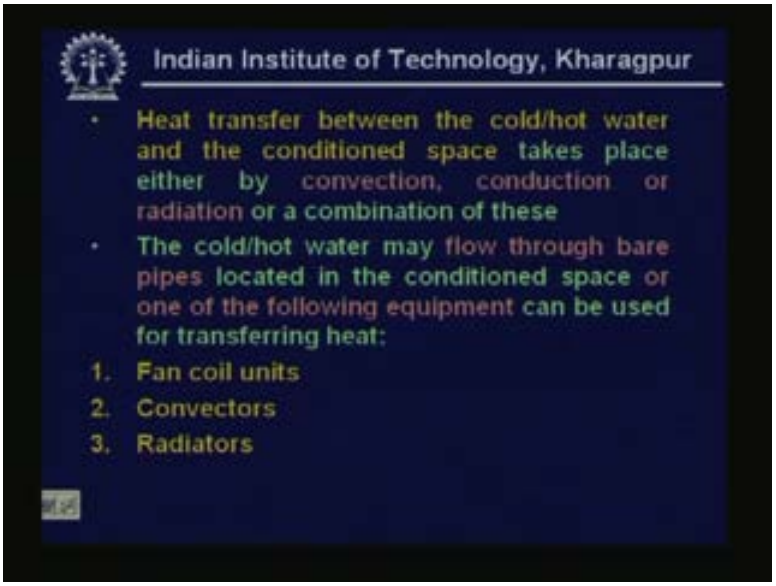

Now heat transfer between the cold and hot water and the conditioned space takes place either by convection conduction or radiation or a combination of these. The cold or hot water may flow through bare pipes located in the conditioned space or one of the following equipment can be used for transferring heat okay. That means the room units can be either a fan coil unit a convector or a radiator.

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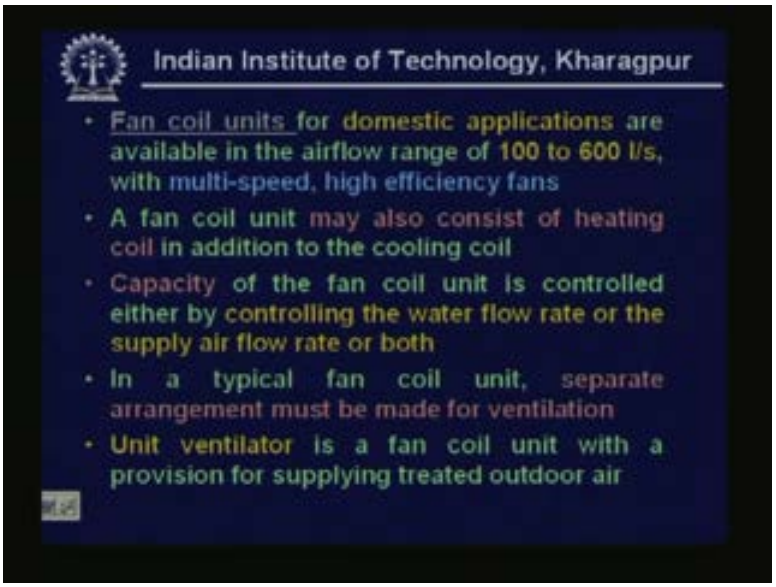

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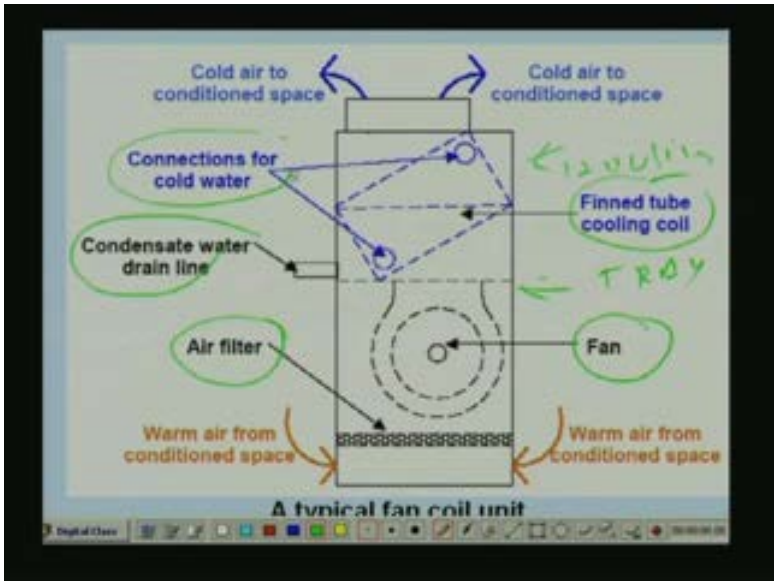

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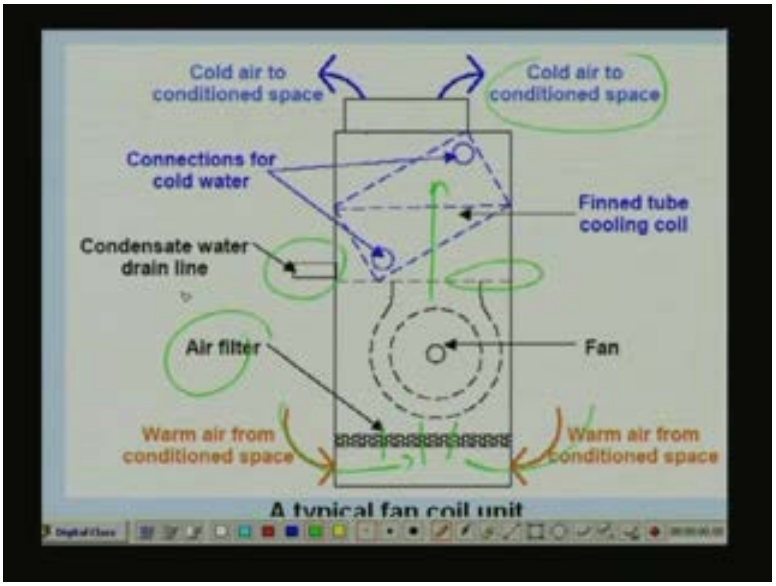

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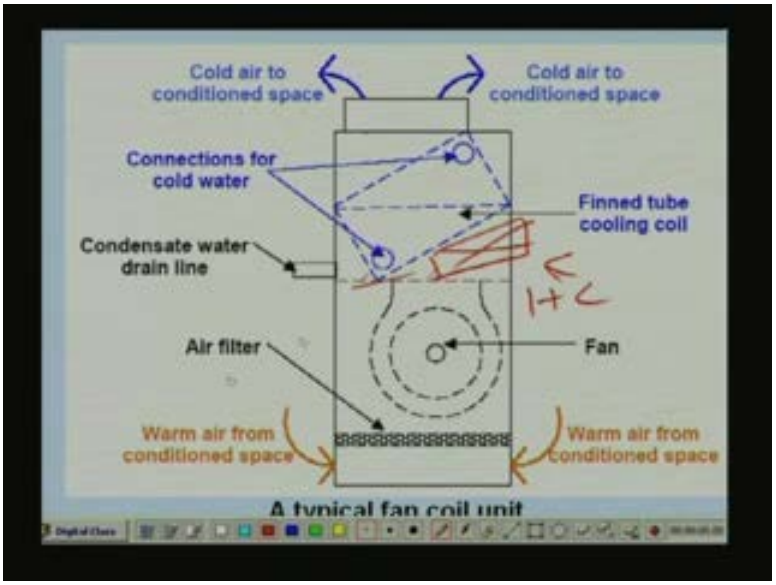

Fan coil units for domestic applications are available in the air flow ranges of range of hundred to six hundred litre per second with multi speed high efficiency fans. A fan coil unit may also consist of heating coil in addition to the cooling coil so let me show the schematic of a typical fan coil unit. Okay. This fan coil unit consist of only a cooling coil okay. That means it is used only for cooling purposes. So you can see that you have a housing here okay. This is a housing which consist of a an air filter okay and a fan and a condensate water drain line and drain tray okay. This is a tray then you have the cooling coil here okay. This is your fin tube cooling coil and these are the connections for cold water okay. Cold water enters, for example through this one and leaves through this or it enters through this and leaves through this okay. And the cool as the name implies the cooling coil is typically a fin plate fin and tube type cooling coil. So the fan drops the warm air from the conditioned space okay. So warm air from the conditioned space flows into the fan coil unit it is filtered as it flows through the air filter. And this filtered air flows over the cooling coil as it flows over the cooling coil it gets cooled and dehumidified and the cold air is supplied to the conditioned space where it takes care of the ensible and latent cooling loads okay.

Since the, there could be latent load so there could be condensation of water. We have to provide a drain tray here and you have to provide a drain line for draining out the condensate water okay. So this a typical fan coil unit.

And in you can also have in addition to a cooling coil, you can also have a heating coil, for example you can have a heating coil here okay. This a heating coil in addition to the cooling coil

for a better control or for all year air conditioning and this heating coil in a two pipe system will be an electrical heater and in a four pipe system this is a hot water coil okay. Now the capacity of the fan coil unit is controlled either by controlling the water flow rate or the supply air flow rate or both. The supply air flow rate can be controlled by controlling the fan speed in a typical fan coil unit separate arrangement must be made for ventilation unit ventilator is a fan coil unit with a provision for supplying treated outdoor air.

As you have seen in the fan coil unit there is no provision for supplying the outdoor air. So ventilation is not taken care of if you are using a fan coil unit alone. So there must be a separate provision for providing outdoor air that means you can have a separate provision like open the windows or you can rely on infiltration or you can have some openings in the walls through which outdoor air can enter into the conditioned space okay. So this arrangement must be made separate from the fan coil unit. However there are certain units called as unit ventilators which are a combination of a fan coil unit and a ducting system we have through which treated outdoor air can be allowed into the conditioned space oaky. Such a unit is called as unit ventilator okay. If you are using a unit ventilator you do not have to make separate arrangement for ventilation.

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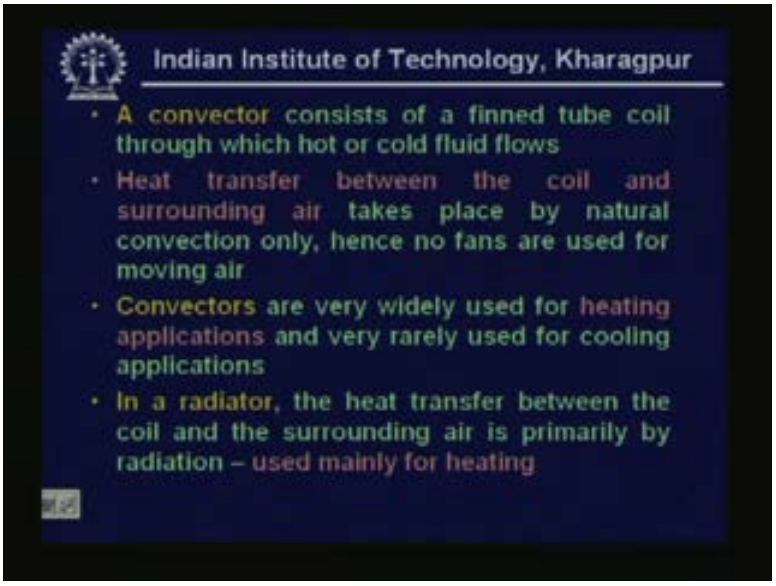

Now a convector consists of a fin tube coil through which hot or cold fluid flows. Heat transfer between the coil and surrounding air takes place by natural convection only hence no fans are used for moving air convectors are very widely used for heating application. But they are very rarely used for cooling applications. Sometimes convectors are used in cold storages. But they

are not, rarely used for air conditioning applications for cooling okay. In a radiator as the name implies the heat transfer between the coil and the surrounding air is primarily by radiation okay. So radiation heat transfer is the primary mode however there will be also be heat transfer by natural convection okay. And radiators are mainly used for heating application however now a days radiant panels are also used for cooling applications also.

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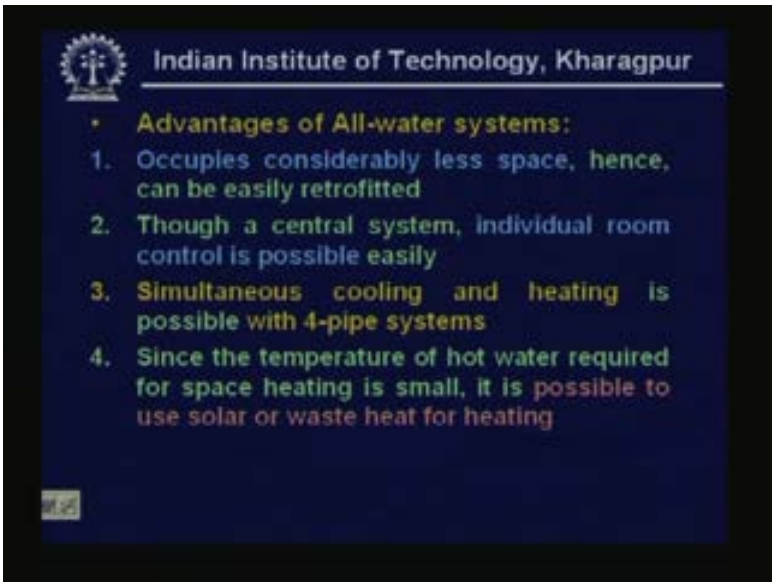

Now let us look at advantages of all water systems. All water systems occupies considerably less space. Because you do not have to have any air ducts you simply have to handle water. Since water has very high density the required volumetric flow rate for a given capacity will be very small so as you know the size of the water pipe line will be very small compared to air ducts. Hence the required space is very less so you can easily use them in retrofitting. That means you can apply the all water systems to existing buildings this is a central system however they, these systems also offer individual room control okay.

For example in a particular room cooling is not required we can simply switch off the, a fan of that particular fan coil unit okay. So it provides individual room control at the same time it is also provides the advantages of the central system. And simultaneous cooling and heating is possible with four pipe systems okay, with hot water flowing through two pipes and hot water flowing through cold water flowing through two other pipes you can have cooling in one zone and heating in another zone and since the temperature of hot water required for space heating is generally small it is possible to use solar or waste heat for heating.

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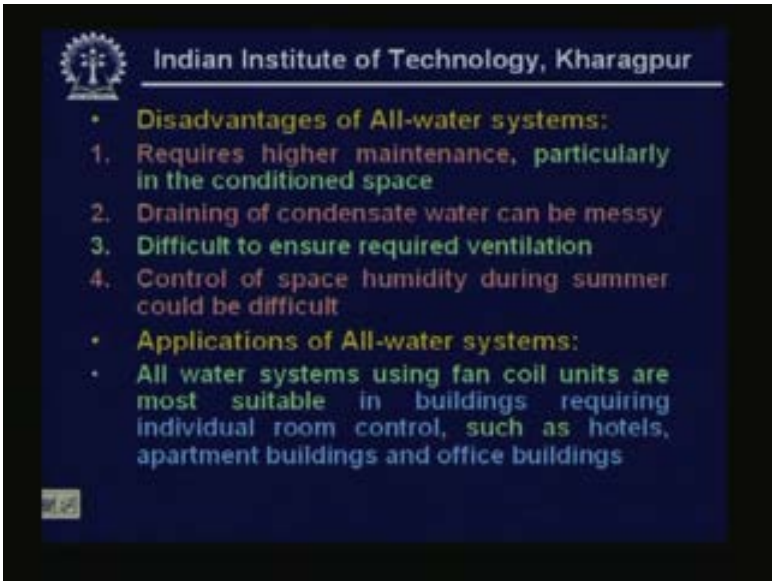

So these are the advantages. Now what are the disadvantages of all water systems. These systems require higher maintenance particularly in the conditioned space okay. Because you have to have, you have to maintain the fan coil unit in the conditioned space and you may also have to maintain the drain pipe condensate draining and all that okay. So as a result required maintenance is higher and draining of condensate water can be messy okay. For example if the drain water line gets blocked then water will spill over into the conditioned space okay. So this has to be taken care of then it is difficult to ensure required ventilation on under all conditions. Because unlike in air water systems in all water systems most of the time if you are particularly, if you are using a fan coil unit you are relying on natural methods for ventilation. For example if you are using open windows or some openings in the walls for providing outdoor air then it is not certain okay.

Because it depends on the wind and stack effect so the amount of outdoor air provided will not remain constant always oaky. So this is the disadvantage of all water systems and control of space humidity during summer could be difficult okay. So you cannot get very precise control over space humidity unlike all air systems. What are the 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 etcetera.

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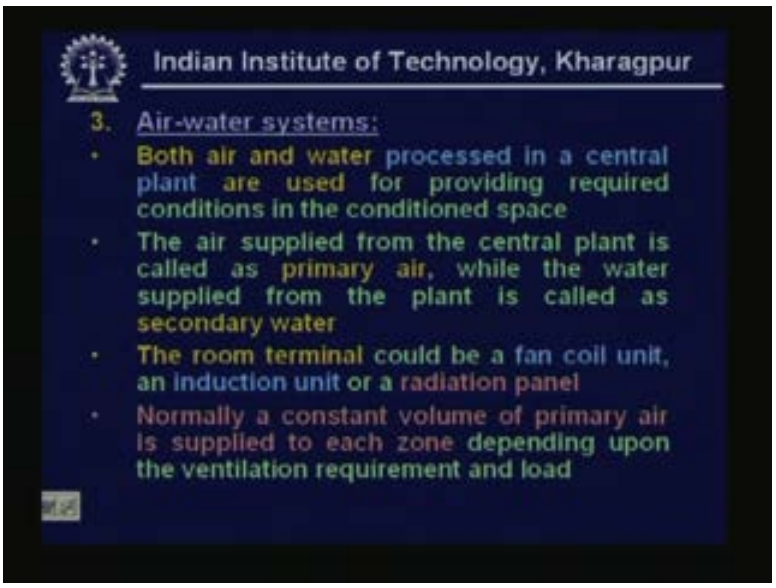

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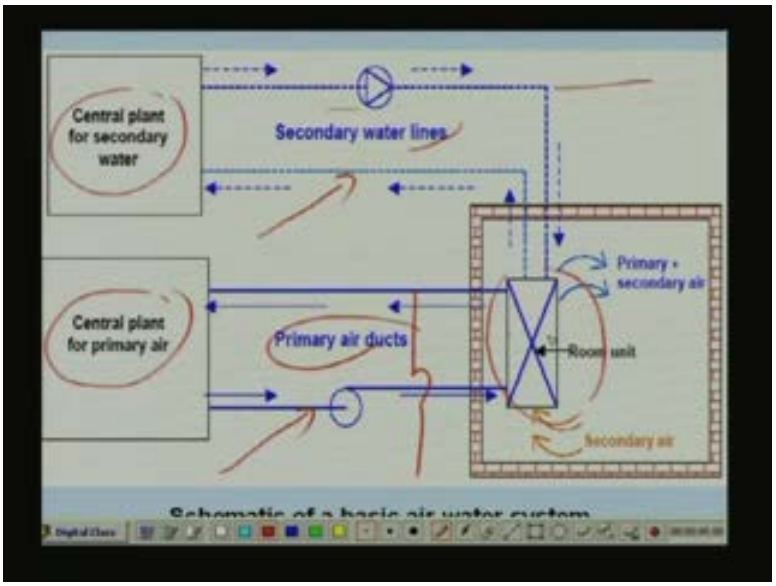

Now let us look at air water systems both air and water processed in a central plant are used for providing required conditions in the conditioned space that is why you call it as air water system. That means the thermal distribution system handles both air as well as water okay. The air supplied from the central plant is called as the primary air while the water supplied from the plant is called as secondary water the room terminal could be a fan coil unit an induction unit or a radiation panel normally a constant volume of primary air is supplied to each zone depending upon the ventilation requirement and load. So this, are typical characteristics of air water systems. So let me show a typical schematic of an air water system.

So as I have already mentioned it consist of a secondary water line okay. And it consist of a primary air duct. That means you have two thermal disturbance system you can say one for water one for air and this water and secondary water and primary air are processed in the central plants one plant for secondary water one plant for the primary air okay. Then the processed primary air and secondary water are supplied to room units kept inside the conditioned space okay. You can have in principle you can have several condition space okay. That means it can be a multiple zone unit. So in the condition space we have as I said a room unit these room unit could be a fan coil unit or an induction unit okay or radiant panel or something.

And here you can see that in the room unit what happens is the primary air and the secondary air are mixed and there cool sensibly okay. Then the mixed primary plus secondary air are supplied to the conditioned space for providing the required cooling and heating requirements okay. So this is what is known as air water system.

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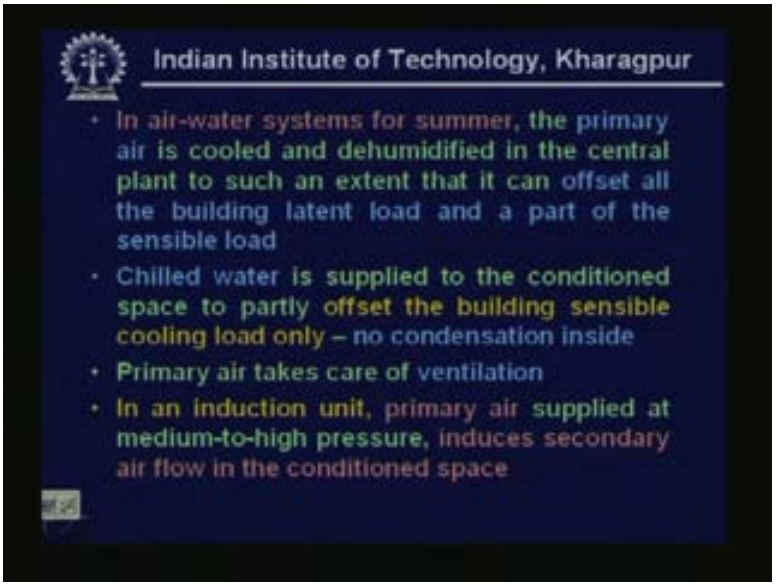

In air water systems for summer the primary air is cooled and dehumidified in the central plant is such an extent that it can offset all the building latent load and a part of the sensible load okay. That means what is done in air water system is the primary air is cooled okay, to such an extent that it can take care of all the latent load on the building okay. So you, that means you have to really cool it to very low temperature and you also have to dehumidified. That means you have to supply cold and dry air insufficient quantity okay, to the conditioned space.

So that it can take care of the latent load completely the latent load on the building and it can also take care of part of the sensible load and it can also, can take care of the ventilation requirement oaky. So these are these are the three purposes of the primary air okay, chill water is supplied to the conditioned space to partially offset the building sensible cooling load only. That means no condensation inside that means the chilled water. For example if you are talking about summer system the chilled water which is the secondary water supplied to the room units has to take care of a part of the sensible load on the building it need not take care of the latent load.

Because the latent load is already taken care of by the primary air since the room unit as to take care of only the sensible load there will not be any condensation of room air on the room unit okay. So there is no question of condensate inside the conditioned space. So the problem related to condensate draining etcetera are not there in air water system. So this an advantage of air water systems compared to all water systems where you have to make provision for condensate draining okay. And as I said primary air takes care of ventilation and if you are using an induction unit. For example I said you can use the fan coil unit or induction unit or a radiant panel if you are using an induction unit primary air supplied at medium to high pressure in uses secondary air flow in the conditioned space okay.

So primary air is supplied to the room unit which is called as an induction unit but a medium to high pressure okay. So as this medium to high pressure flows through the induction unit it creates secondary flows inside the conditioned space okay. So the room air that means the conditioned air which is called as secondary air flows through the room unit because of the conditions created by the primary air and primary air and secondary air are mixed inside the room unit and the mixed air gets cooled sensibly in the room unit and this mixed air is supplied to the conditioned space okay. That is why you call it as an induction unit.

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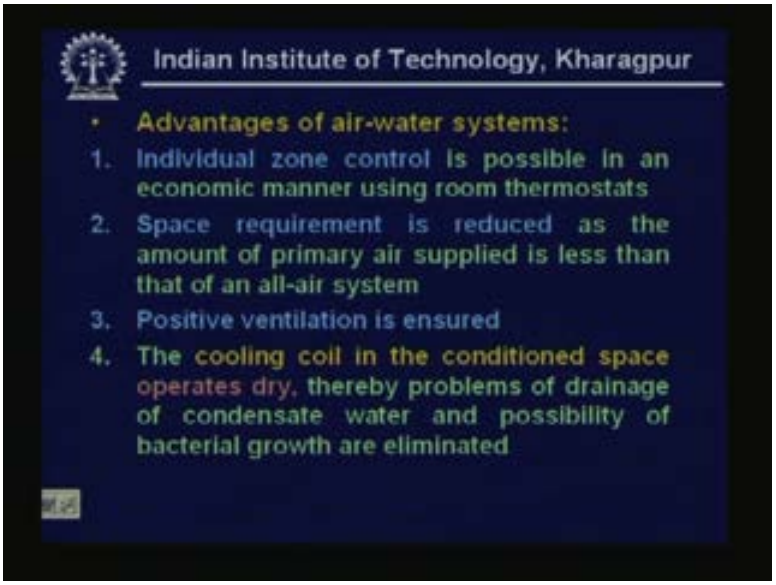

Now let us look at advantages of all water air water systems. Air water systems offer the following advantages individual zone control is possible in an economic manner using room thermostats space requirement is reduced as a amount of primary air supplied is less. Then that of all air systems okay. So the ducts of primary air will be much smaller compared to an all air system and positive ventilation is ensured because you are always supplying a constant volume of primary air to the conditioned space under all conditions. So ventilation is taken care of unlike in all water systems the cooling coil in the conditioned space operates dry there by the problems of drainage of condensate water and possibility of bacterial growth are eliminated okay. So these are main advantages of air water systems now what are the disadvantages of air water systems operation and control are complicated.

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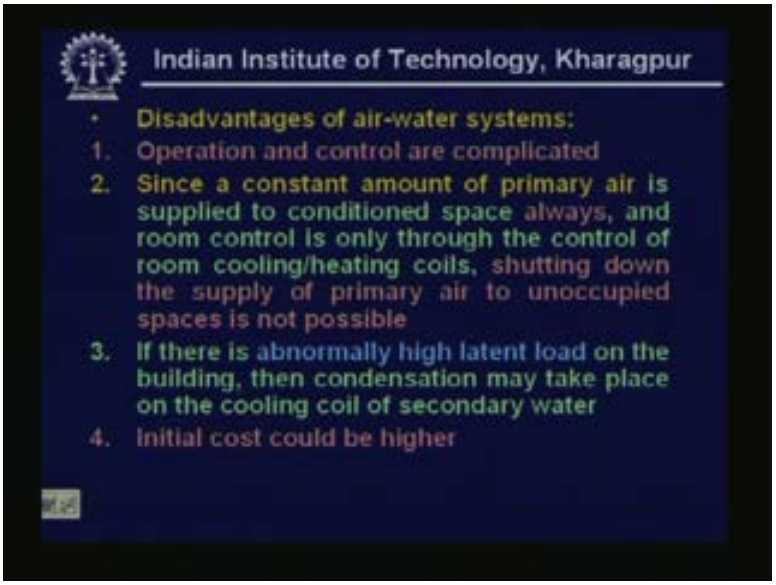

Because you have to control both water as well as air since a constant amount of primary air is supplied to conditioned space always and room control is only through the control of the room cooling or heating coils shutting down the supply of primary air to unoccupied spaces is not possible. That means even if there is nobody in the conditioned space still you have to supply a continuous amount of a constant amount of primary air okay. This is actually wastage but you cannot help it in this kind of a system if there is abnormally high latent load on the building then condensation may take place on the cooling coil of secondary water. That means even though you have you assume that you have taken care of all the latent load by conditioning the primary air if the outside conditions are the inside conditions are such that the latent load on the building is abnormally high. That means more than the design load.

Then some amount of condensation takes place in the room unit itself okay. So there will be condensation in the room unit and if you are not provided any means for draining out the condensate water then there will be problems in the conditioned space. So in air water systems also even though you do not except any condensation still a provision is generally provided for taking out the condensate drain water okay. So this, are the disadvantages of air water systems and in general the initial cost of air water systems could be higher compared to all air or all water systems.

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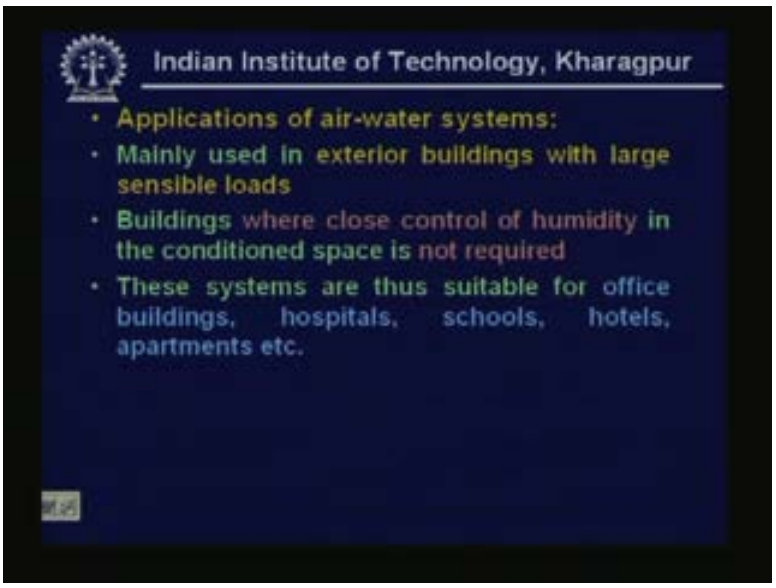

And what are the applications of air water systems they are mainly used in exterior buildings. For example for perimeter zones with large sensible loads and there also used in buildings where close control of humidity in the condition space is not required. That means if want close control of humidity you cannot use this system and these systems are thus suitable for office buildings, hospitals, schools, hotels, apartments etcetera.

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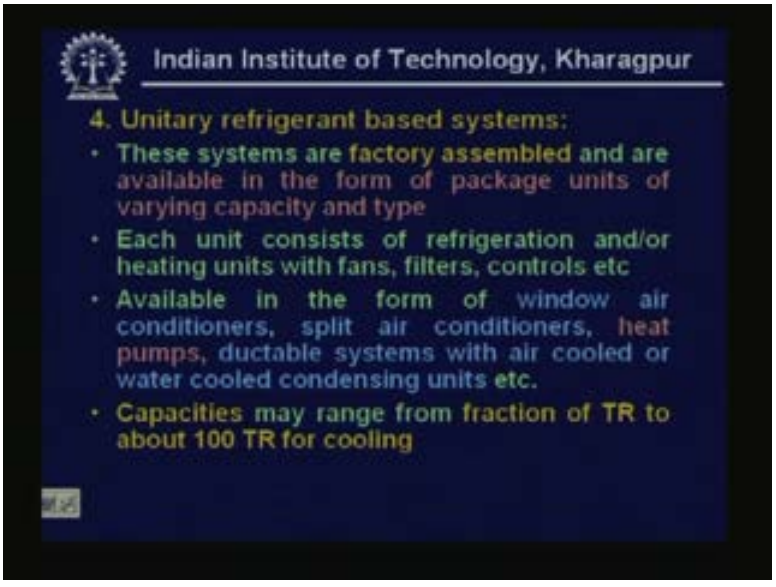

Now let us look at what is known as a unitary refrigerant based systems these systems are factory assembled and are available in the form of packaged units of varying capacity and type each unit consist of refrigeration. And are heating units with fans filters controls etcetera. And these systems are available in the form of window air conditioners split air conditioners air to air heat

pumps ductable systems with are cooled or water cooled condensing units etcetera. And the capacities of unitary systems may arrange from a fraction of tone to about hundred tones for cooling okay. So these are the characteristics of unitary refrigerant based systems.

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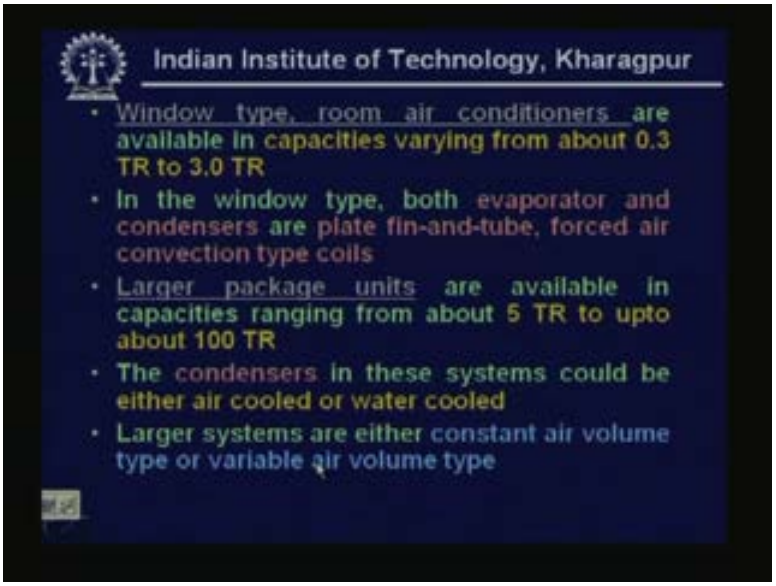

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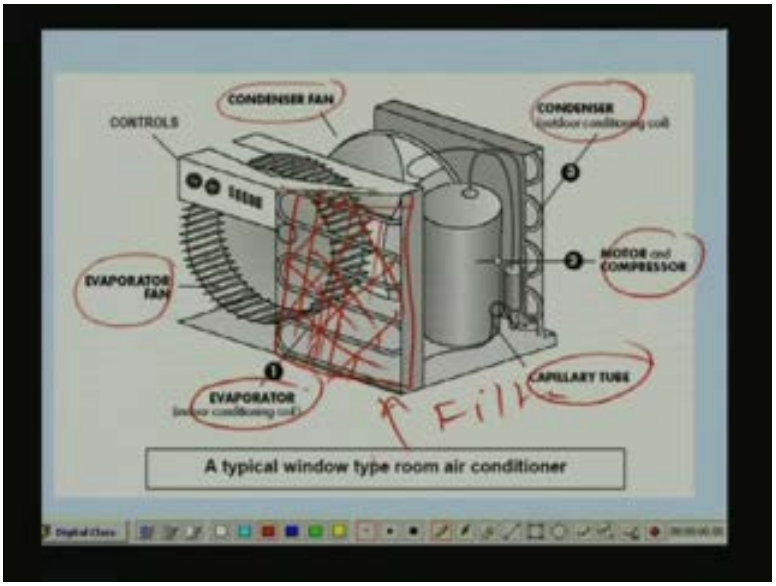

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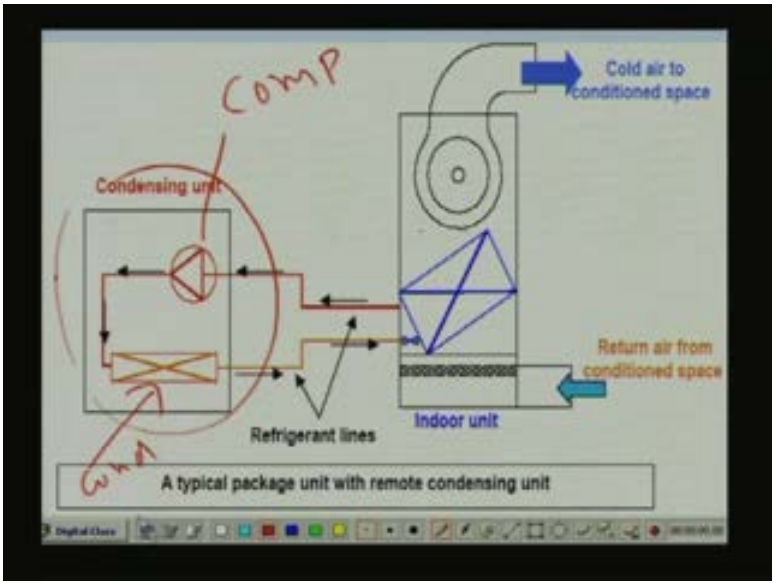

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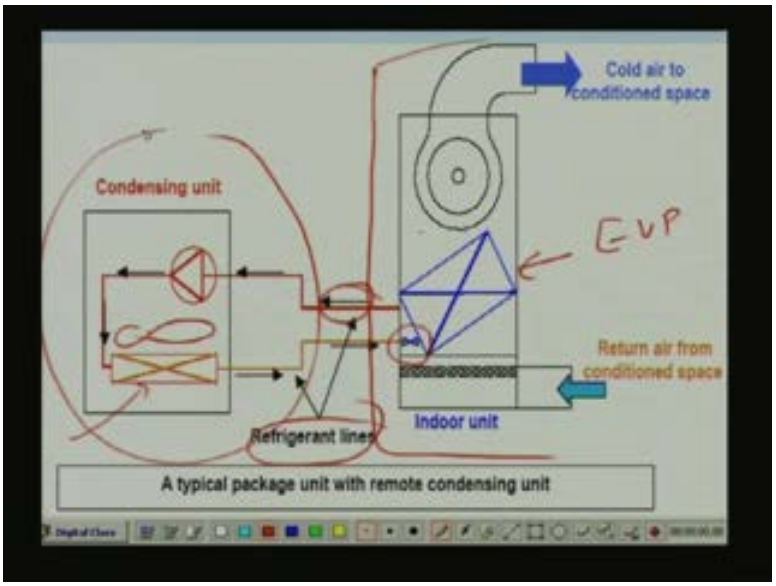

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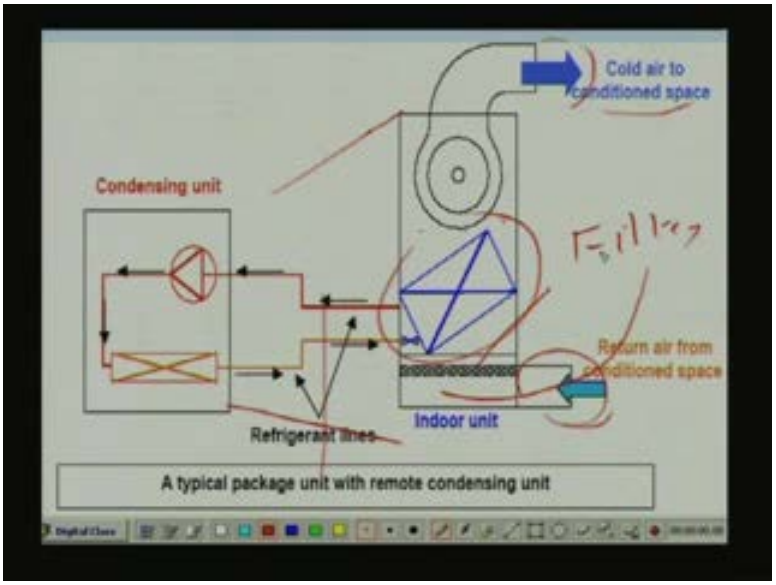

As I said window type room air conditioner is one important type of unitary system and these systems are available in capacities varying from about point three tone to about three tones and in the window type both evaporate and condensers are plate fin and tube type and forced air convection type coils okay. So let me show the schematic of a typical window type air conditioning system. As you can see that it consist of the four basic components the evaporator okay, condenser, compressor and the expansion device okay. In addition to this you have an evaporator fan for circulating the conditioned space air and you also have a condenser fan for circulating outdoor air over the condenser okay.

So two fans are there and generally both the fans are mounted on the same shaft and they are run by a single motor okay. So same motor runs both the fans and normally even though it is not shown here the evaporator and condenser are plate fin and tube type okay. So they are all finned tube type and it is not shown here again but normally you have a filter here okay. You have a filter here which filters the room air and circulates the clean air over the cooling coil and into the conditioned space okay. And normally since the name window type comes into picture because these units you can see that this a single unit okay is it comes as a single unit and these unit's are mounted generally in the windows okay. Sometimes if you do not have external, if you do not have any window for if there is any problem you can also make a hole in the window hole in the wall and you can mount it in the wall okay.

So one thing I must notice here is that it is it comes as a single package. So the outside of the wall must be the outdoor okay. That means you must have external walls or external windows to

mount these units okay. Now larger package units are available in capacities ranging from about five tones to up to about hundred tones okay. And the condensers in the larger systems could be either air cooled or water cooled so let me show a typical large package unit. So this is the typical package unit with remote condensing unit okay. So you have a condensing unit here the condensing unit consist of a compressor okay. And a condenser right normally the condenser is either a air cooled or water cooled okay.

This is air cooled or water cooled, if you are using an air cooled condenser you may have to have a blower for circulating the air and these are the refrigerant lines okay. This the line that comes on the condenser it goes to the expansion device here from the expansion device it goes to the evaporator okay. Where it takes the heat from the surrounding air and the vapor from the evaporator goes to the compressor it gets compressed and goes to the condenser and the refrigerant cycle continues. And this is the indoor unit that means this is kept inside the conditioned space where this can be whereas this can be kept outside okay, away from the indoor unit okay.

Of course if you are using a water cooled condenser it is not necessary to keep it away from the indoor unit you can in fact keep it along with the indoor unit the same thing can be in the same package with a distributor for separating out the indoor and outdoor units okay. And you can also see that you have limitate ducting here this is the connection for return air duct and this is connection for supply air duct okay. Return air from the conditioned space flows through the filter here okay then it gets cooled and dehumidified and then it enters into the conditioned space okay. The conditioned space here could be a single room or it could be a several rooms okay. But of course all these are controlled by a single thermostat okay. That means they serve only single zones right. So this a typical package unit and as I said larger systems are either constant air volume type or variable air volume type okay.

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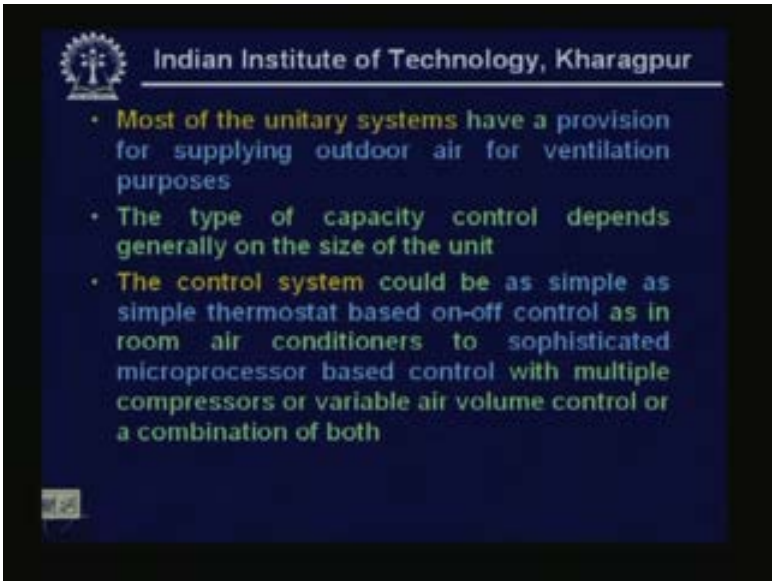

Most of the unitary systems have a provision for supplying outdoor air for ventilation purposes the type of capacity control depends generally on the size of the units and the control system could be as simple as simple thermostat based on off control as in room air conditioners to sophisticated micro processor based control with multiple compressors or variable air volume control or a combination of both okay. So the type of control system mainly depends upon the size of the system.

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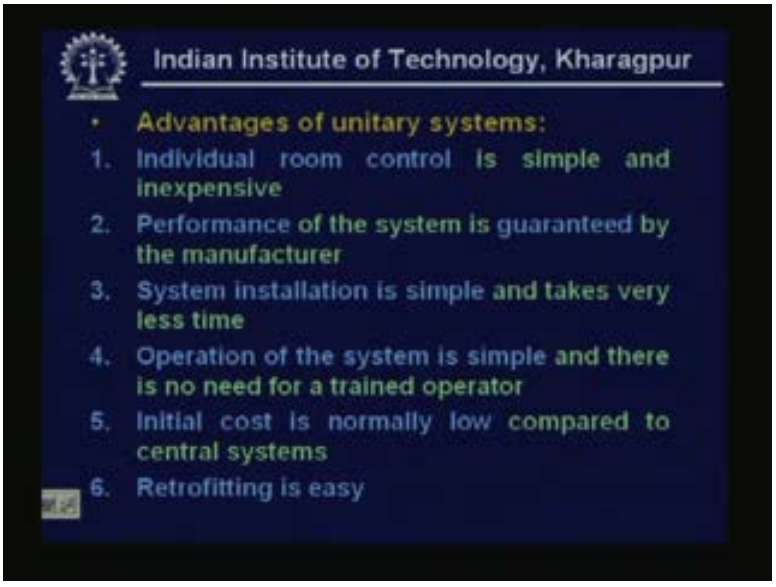

And what are the advantages of unitary systems individual room control is simple and inexpensive performance of the system is guaranteed by the manufacturer okay. So manufacturer gives the guarantee for the performance and system installation is very simple and it takes very

less time and operation of the system is simple and there is no need for a trained operator most of the time it is simply switching on and switching off okay. So you do not require a trained operator and initial cost is normally low compared to central system. So these are the advantages of this unitary package systems compared to the central systems central systems means all air systems all water systems air water systems etcetera. And retrofitting is easy okay. So you can easily fit these systems into existing buildings okay. Because they do not really require much space okay so as a result they can be used in existing buildings.

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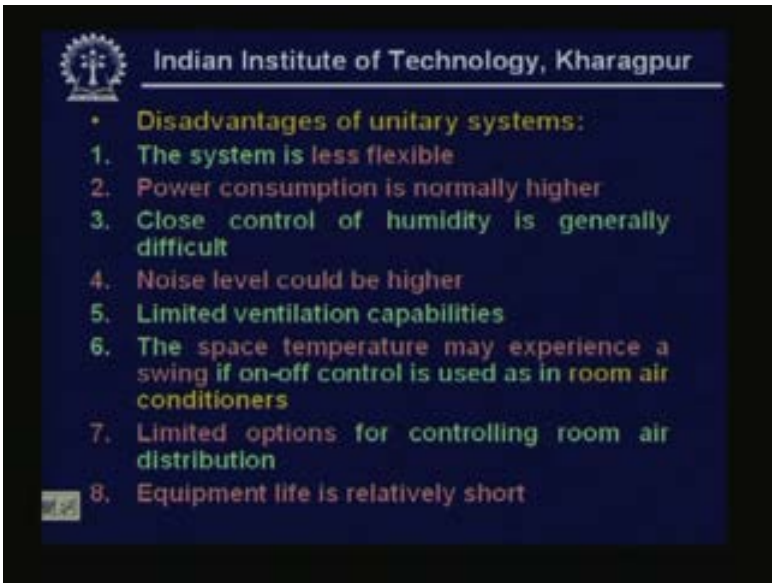

Now what are the disadvantages of unitary systems they have are several disadvantages the system is less flexible in terms of the air flow rate power consumption normally higher. That means the COP typical COP will be lower compared to the central systems and the total power consumption is also will be higher compared to the central systems and close control of humidity is generally difficult particularly in summer noise level could be higher. Because you have the mechanical elements close to the conditioned space. So you can have higher amount of noise and limited ventilation capabilities okay. You cannot provide large amount of ventilation using these systems and the space temperature may experience a swing if on off control is used as in room air conditioners okay. The swing could be as high as one to two degrees particularly in room air conditioners and limited options for controlling room air distribution okay. So you may not be able to get perfect room air distribution using these systems. So these are the disadvantages of unitary systems and equipment life is relatively short okay, compared to central systems.

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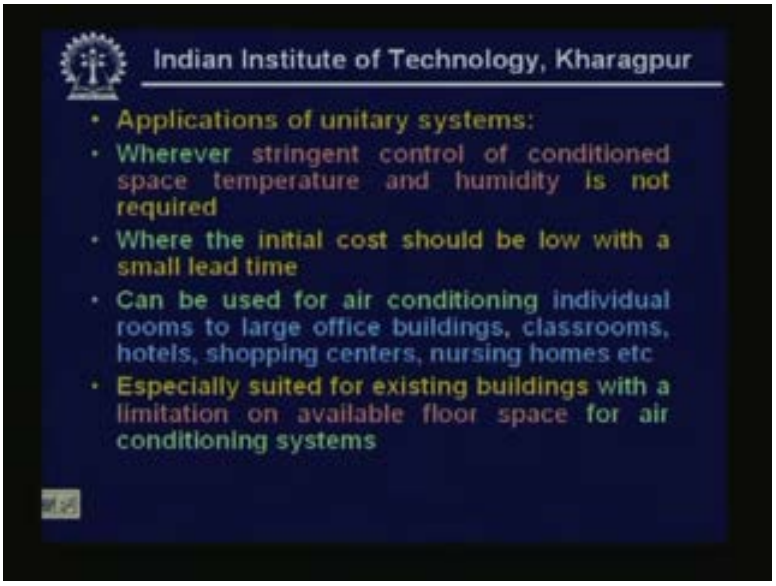

Now what are the applications of unitary systems okay. So unitary systems are used wherever stringent control of conditioned space temperature and humidity is not required. That means you are not very particular about maintaining a particular temperature and humidity inside the conditioned space okay. So there these are ideal for residential buildings etcetera. Where you don't really require very fine control and these systems are used where the initial cost should be low. That means if you want a system with very low initial cost then you should think of using unitary systems and also where you want to install the system quickly okay. That means the lead time is very small then you can install unitary systems and they can be used for air conditioning individual rooms okay.

To large office buildings class rooms hotels shopping centers nursing homes etcetera, okay. Depending upon the size you can as I said the available capacity varies from about point three tones to about all most hundred tones okay. So these systems can charted to a wide range of application starting from very small rooms where about point three tone may be sufficient tolarge office buildings etcetera, where you may require as high as about hundred tones okay. So these systems can offer to all these categories okay. So normally you do not have unitary systems above hundred tones above hundred tones you have to go for central systems. And these systems are especially suited for existing buildings with a limitation on available floor space for air conditioning systems okay. So at this moment at this point I stop this lecture I will continue this with a next lecture. Thank you.