Building Services III
Lecture 7

Different Elements of Air Distribution Systems
Let us look at what are the different air distribution systems. While there is a lot of technology and engineering that goes behind cooling air, air conditioning systems are not complete without proper distribution of the cooled air to spaces that require air conditioning. Hence, air distribution systems are equally important components of efficient air conditioning. They consist of ducting that root cooled and air across the building to the spaces that require air conditioning. Grills and diffusers that disperse the cooled air in a planned manner to the air conditioned room, the return air ducts that recycle the cooled air and the fresh air intake dampers the fresh air required.

Ducting - ducts are usually galvanized aluminium sheets or stainless steel sheets shaped into rectangular boxes or round tubes. They are used to distribute the cooled air from the air handling unit uniformly throughout the building to be air conditioned. They started the AHU or the packaged air conditioner and travel to the spaces conditione carrying the cool air. There is also a growing trend to use round flexible hose ducting as branch connectors from the main duct to the diffuser outlets. We have looked extensively about the duct design, the specifications, the standards that have to be maintained, the aspect ratios that have to followed designing a duct, etc, in the previous unit. With that knowledge, let us take a look at a typical duct layout. Here, this air handling unit from where the main duct enters the space ideally over a common corridor and from the main duct, the secondary ducts are branched ducts, that enter the different spaces, conditioning all the faces of the room or of the building.

The next important component in this Air Distribution sytem is the Diffusers and Grills. The conditioned supply air arrives through the ducts and supplier diffusers and enter the conditioned space. Most diffusers are attached to the false ceiling and a variety of diffusers are available for different air spreading needs. For well distributed cooling, an air flow pattern needs to be created in the condition space. The design engineer takes care to separate the supply air diffusers and the return air grilles to prevent short circuiting of the air. Return air usually flows into the plenum or return-air box through grilles placed in the false ceiling. Basically diffusers are the ones that supply the conditioned air and the grills are the ones which take away the return air to the AHU.

Here, you can see a variety of grills and diffusers. The ones you would have commonly seen in many offices and many buildings are the square rectangular diffusers and the round diffusers and these type of grills are a common site in most of the commercial showrooms and shops.

Generally, they try to give a drop along the periphery of the room and mount these grills vertically on the face of the box. These rectangular diffusers are fixed onto the false ceiling in such a way that they directly throw the conditioned air to the space. These are other variations of the diffusers and grills. Now, let us look at return air. Why is return air gaining so much importance, what is its role?

Since a substantial amount of energy goes into cooling the air in the first place, it is a practice to recycle the air. Whatever air we take from the conditioned space is recycled till it is cooled and sent back to the AHU. The air is therefore brought back to the AHU or the packaged air conditioner using return air ducts. It is common to root that the air through the gap between the false ceiling and the main ceiling, a space that is referred to as the spleener. It is the desirable wherever possible to pass the supply air duct through the return air pleener because this works like a heat exchanger, thereby improving the energy efficiency of the plan. Sometimes the supply efficiency of the system of return air ducts boxing is employed to carry the return air instead of using the pleener where supply air ducts do not pass through the pleener, they are usually insulated so that the cool air does not pick up heat from the warmer surroundings. So if you have a closer look at this statement, you can see the return air meaning the air from the conditioned space is at a substantially lower temperature than the air outside or the fresh air. When it passes through the pleener where the supply air ducts are also present, it acts as a heat exchanger. When it is not possible, you have to go in for insulation of the supplier types. This is a typical arrangement or a picture depciting the air cycle. Here, you have the AHU or the Air handling unit, this is the supply air, the blower or fan, then the filters and mixed air. The outside air intake is here. It passes through the filters and goes through the AHU and from the AHU the conditioned air is supplied through the ducts.

Fresh Air Intake

Next, comes the fresh air intake. A certain volume of fresh outside air is sucked into the building near the AHU. This air is usually drawn in through a damper which is adjusted to allow the specified volume of air into the building. This keeps the air pressure within the building a little higher than the outside air pressure. This prevents dusty, moist or any undesirable external air from infiltrating into the building. This keeps the air pressure within the building a little higher than the outside air pressure. This prevents dusty, moist or any undesirable external air from infiltrating into the building. Why is fresh air important? Freshening the air - One of the most important factors in delivering comfort is the freshness of the conditioned air. If the same air was circulated over and over again it would become 'stale' and make the occupants very uncomfortable. Ideally an air conditioning system would induce plenty of fresh air into the air system. However, this outside air brings with it moisture and heat from outside.

This causes the heat load on the air conditioning system to go up thereby requiring a larger and consequently more expensive plant.

Substantial research has been done by ASHRAE to determine the optimum requirement of fresh air for different applications and the airconditioning engineer designs the plant accordingly. Usually the fresh air requirements are stipulated as cubic feet per minute (cfm) per person or minimum air changes per hour. A guide on recommended Fresh Air requirements are given below; the typical fresh air requirements are mentioned here. In apartments you need to give fresh air of one air change per hour. When it comes to stores it is once again one air change per hour. The highest air change is required at Bars, conference rooms and theatres. In hospitals it is necessary to not only bring in plenty of fresh air, but to also move the existing air more rapidly through the conditioned space to reduce the risk of infection. The following table indicates the number of fresh air changes required and the rate in which the entire air in the system is to be circulated. Inside a hospital, in an operation theatre, the room requires five fresh air changes per hour and the circulation air changes per hour is 25. So, you need the 25 times of circulation air changes of the same air, of the air that is inside. You need to give five air changes. One is to completely take out whatever air or volume that is inside the body and replacing it with completely fresh air. Like this, one has to do it 5 times per hour for the operating theatre. Similarly, for delivery room and trauma care, it is the same. In terms of the Recovery or the ICU, you need to do it 2 times. Before moving on, let us look at one aspect that has gained a lot of importance with regard to air conditioning and indoor air quality. It is called a sick building syndrome. Air conditions must do more than providing immediate comfort conditions, they must also be designed to prevent hidden negative effects on the occupants over a period of time. Indoor air quality is becoming an important concern and one hears the term 'Sick building syndrome' (SBS) frequently these days. The effects of IAQ are usually non specific symptoms rather than clearly defined illnesses. Symptoms attributed to IAQ problems include headache, nausea, shortness of breath, sinus congestion, cough, eye-nose and throat infection. The solution often lies in improvement of the air quality by introducing plenty of fresh clean air into the building and reducing the noise of air-flow and machinery.

Moving on, the next concept in this air conditioning system is; Filtration and filters. In other to clean the air, it is passed through filters that remove the air borne dust particles to ensure the delivery of clean air to the conditioned spaces. We have seen how important the quality of air is in the air conditioning system and filters play an important part in delivering good air quality. The filters keep the cooling coils from clogging thereby maintaining the efficiency of heat transfer. Without a good air filtration system, the diffusers in the rooms 'streak' and fluorescent lamps gather a film of dust that cuts illumination. Dust choked filters interfere with the performance of the air system. It is therefore very important to clean or replace the filters periodically. This is the common type of filter which we use in place of air conditioned systems. It is called the Pleated Panel type. Also called as Synthetic Media Extended Surface type filter. The pleated panel type filter consists of a porous fabric like material folded like an accordion to increase the surface area and fit into a frame. With that we come to the end of the components of an Air distribution system.

Noise and Noise Control

The noise and noise control in air conditioned systems. As we know the Air conditioning system involves a lot of machinery, motors, pumps, compressors, condensers. Naturally, when these machinery run, they tend to generate a lot of sound or noise. How do we mitigate its effects and how do we insulate or isolate the interior spaces from this sound. Sound is a result of vibration of air. When sound is unpleasant, it is referred to as noise. In an air conditioning system, sound emanates from the machinery such as fans, fan motors, compressors, pumps, air flow through ducts and diffusers, pipes and tubes, cooling tower fans. The solutions are; a) to reduce the original source of sound by using well designed equipment. b) enclose the source in acoustically insulated space and c) to absorb the sound using sound absorbing material. It is a practice to mount vibration producing machinery on anti-vibration mounts such as cork, rubber, springs and 'cushioned feet'. Plant rooms are acoustically insulated to prevent the machinery sound from permeating into the air conditioned space. That car fitted with sound attenuators which work somewhat like the mufflers in the exhaust pipe of a car, in addition acoustic insulation is used on some portions of the duct near the AHU discharge, where it is most prone to make noise.

Pipes are insulated from the walls it passes through, so that the vibrations are not passed into the structure. Cooling towers use Axial Fans that are a little more noisy than those using Centrifugal fans. In the induced draft cooling tower the sound is higher as the fan discharge side of the tower. It is desirable to arrange the fan discharge side in such a way that windows do not overlook it. Inside the conditioned space, some noise can make an entry through the diffusers. Carpets and curtains inside the space help them to dampen the sound. Locating the plant room properly will help reduce noise levels within the conditioned space. Here is an example of poor to the best positioning of the plant room;

In this layout if you take a closer look, they have first shown poor layout, a fair layout, better layout and then comes the best layout on the location of the plant room. Here, the plant room is located on the one end of the building without any surrounding buffer zones and without any proper insulation. The next fair layout, this property is sandwiched between an elevator and a staircase. This is slightly acceptable. Then comes the better layout where the plant room is separated between a staircase and a toilet. The best layout, it is located by maintenance spaces all around. The best layout because the plant room is surrounded on four sides by utility areas, therefore less sound is transmitted to human occupied areas.

Horizontal Air Distribution Systems

Next we move on to Horizontal air distribution systems. There are four types; the mixing system, the displacement system, the raised floor or the under floor air distribution system and finally the task and ambient system. In the mixing system, here is a graphic that shows how the cool air and the hot air move from the duct and into the interior space. In mixing ventilating systems, the air is supplied, through an outlet diffuser or grill at the ceiling or high on the sidewall. The flow from a typical ceiling diffuser has a velocity profile shown in the figure. It picks up velocity and as it goes, it hits the floor and goes back up and reaches the user. Mixing works well for cooling and can produce an even temperature throughout the space. This is the type of system we normally use in all types of spaces. When we use the same system for heating, it has a different effect. But there a few disadvantages in this system. The air velocity has to be low enough throughout the occupied area to avoid drafts. There is a tendency for inadequate air movement in some areas. Any pollutants in the space, can be spread throughout the space. This is because the pollutants are not filtered and they keep recirculating. Once, they go back and come again as a conditioned space, it spreads throughout the space and also to other rooms.

Next, is the Displacement system. Here, Displacement system aims to avoid mixing in the occupied zone. Air, a little cooler than the space, is introduced at a low velocity through large area diffusers in the wall close to the floor. This is the location where the large area diffusers are placed (in the picture). The air flows slowly and steadily across the space until it passes a warm object - a person or a piece of equipment. The warmth causes some of the air to rise up and out of the occupied zone, carrying pollutants and heat with it. Above the occupied zone, mixing occurs. Once the air picks up this warmth to rise out of the occupied zone, carrying the heat with it. Above the occupied zone, mixing occurs and the return outlet at the ceiling level draws some of the mixed air out of the space. This is where the mixed air is drawn. The air movement in the space separates into the lower displacement zone with a recirculation zone above. In a well-designed space, the recirculation zone is jus above the occupied zone. The objective of the system is to have the occupants and the equipment in a flow of clean air, with their own heat causing convection around them. This will lift their pollutants up, out of the occupied zone. In addition, the convection heat from surfaces and lights above the occupied zone do not affect the temperature in the occupied zone. As a result, the air leaving the room can be warmer than would be acceptable in the occupied zone.

Next, is the Underfloor Air Distribution system or the raised floor system. UFAD is supplied from a raised floor through numerous small floor grilles. Air, at 58-64 degree Fahrenheit is supplied to the cavity and discharges through the floor grilles. The floor grilles are designed to create mixing, so that the velocity below 50 fpm within 4 feet of the floor. You can think of the air as turbulent columns spread out above the 4-foot level to form a vertical displacement flow towards the ceiling. Return air is taken from the ceiling or high on the wall. The rising column of air takes contaminants with it, up and out of the breathing zone. In the picture, because of the draft or the displacement, the rising air picks up all the contaminants with it and moves above the breathing zone. This sweep-away action is considered more effective rather than mix-and-value. As a result, the ventilation requirements of ASHRAE standard 62.1 can be satisfied with 10% less outside air.

The advantages of this system are; Changing the layouts of partitions, electrical and communication cables are very easy, because in other layouts, the grilles and diffusers are all present on the ceiling and they are originally designed based on the office partitions and layouts. Once you start changing or moving things, they might not be very effective. Rather in this case, because of the floor mounted gates we can change the layout of the partitions and other items. For buildings with high 'churn' (frequent layout changes) this flexible way in itself, make the added cost of the floor economically justified. The flow of air across the concrete structural floor provides massive thermal storage. When the main supply duct and branches to the floor plenums are a part of a well-integrated architectural design, the air supply pressure drops can be very low, resulting in fan-horsepower savings. Less ventilation outside air can potentially be used.

The disadvantages are; A significant cost per square foot for the floor system supply, installation and maintenance. A tendency to require a greater floor to floor height, since space for lights and return air ducts are still required at ceiling level.

The final type will be the 'Task Ambient Conditioning system'. Here, with TAC, each occupant workstation is supplied with cooling air and a degree of control over this airflow, airflow direction and temperature as shown in the figure. Here, once again it is a raised floor system and the grilles are located in the partition or in the occupant's work station, thereby letting the occupant control the airflow himself or herself. In a typical arrangement, one or two supply air nozzles are mounted above the work surface. The occupant can easily alter the velocity or the direction of the flow. Temperature may be controlled by mixing room air into the supply air or by resistance or radiant electric heater controlled by the occupant. One specific advantage of the TAC for the occupant is the ability to modify the air speed.