INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture-32
Air Distribution System-1

with
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I welcome you all in this course on refrigeration in air conditioning, today we will discuss on air distribution system, in a building not only I told you earlier and repeating again not only temperature and inside temperature or humidity, relative humidity are important but also the quality of air is important, air distribution is equally important, air distribution is equally important. You may have cold air but how to distribute this cold air into the entire building for small capacity systems like direct expansion package type of unit you can I mean the different type of air conditioning unit.

One is we normally use this split AC or window type of AC but, if the cooling load in a building is let us say 5 kilowatt so for 5 kilowatt you know what, it is not recommended or 6 kilowatt it is not recommended then you go for multiple units of window type AC instead of that a package type of system is recommended, a package type of system, package type of air conditioning system is a unit you can keep at the roof top and air will be circulated into in the entire house through ducting, though it is not in fashion but as far as the energy conservation point of view such type of arrangement should be made.

And ducting should be done in the house, nowadays very beautiful designer ducts are available in the market so, ducting can be done and air can be distributed in the different segments of house or a small building or a restaurant. Now if the cooling load is bore then we go for centralized air conditioning system in the central air conditioning system, in the basement of the building a roof is there where compressor is located and this compressor in fact in the vicinity of the compressor there is a evaporator also, in fact it is not the evaporator into the chiller so, in the chiller cooling water is chilled that is for the high capacity, suppose the capacity is 100 tons or 200 tons in that case chilled water type of system is used.

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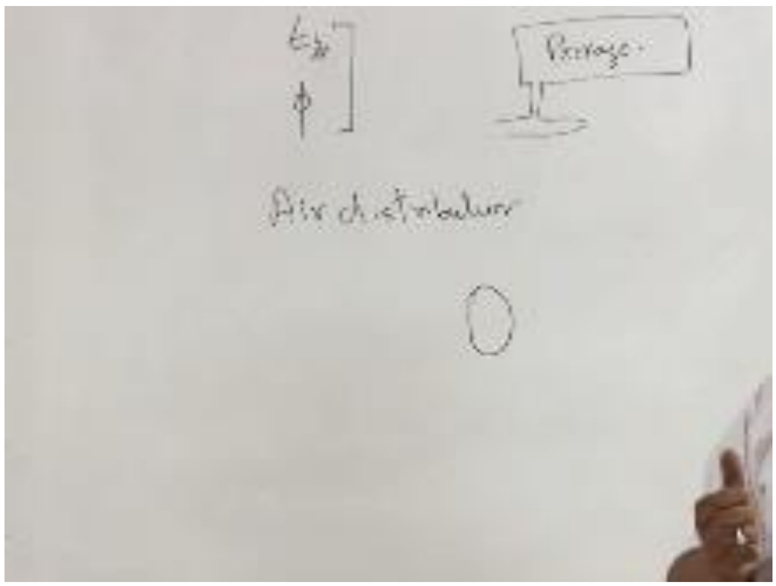

So we can go for a package unit, if the capacity is high we can go for a centralized cooling system where air will be centrally cooled in the in the building suppose the code load is 30 tons so, air will be centrally cooled and air will be circulated in the building, this is known as direct expansion type O system. Now if the load is high suppose, 250 tons now we want to have 250 tons of tons of refrigeration and I told you the thumb rule that 400 CFM per ton so, if I take 400 CFM per turn 400 CFM per turn so it is going to be 1 lakhs CFM.

1 lakhs CFM is approximately fifty thousand details percent I mean, I am just telling you how much bulk of air has to be handled by the system, now if this bulk of the air which is to be handled by the system has to be the movement for the movement of air we need blowers and big

size blowers they are known as AHU air handling units air handling units are I mean they consume a lot of energy, suppose there is a multi-storied building. So if normally on each floor or between or after alternate floor the air handling units are placed they are blowers they circulate air handling units are used for circulating air in the building.

Suppose the cooling capacity of air conditioning system is to 250 tons of refrigeration in that case we will be using around 215 to 400, 400 * 250 around 1 lakhs 10^5, 1 lakhs CFM shall be required it is going to be approximately equal to 47000 liters per second. In order to handle this type of fluid huge AHU’s will be required instead of doing that, instead of doing that chilled water is used chilled water is here as secondary refrigerant or chilled water takes heat from the building and this that this heat is subsequently transferred to the refrigerant in the centralized cooling system.

However if the capacity is low for example, 50 tons, 50 tons or 60 tons we can go for direct expansion type of system, in direct expansion type of system the air is cooled in the centralized school and it is circulated in the building for the circulation of air, air handling units are required, air handling units are nothing but fans and blowers which make circulation of air into the building, air circulation is not sufficient air diffusion is also important in the building.

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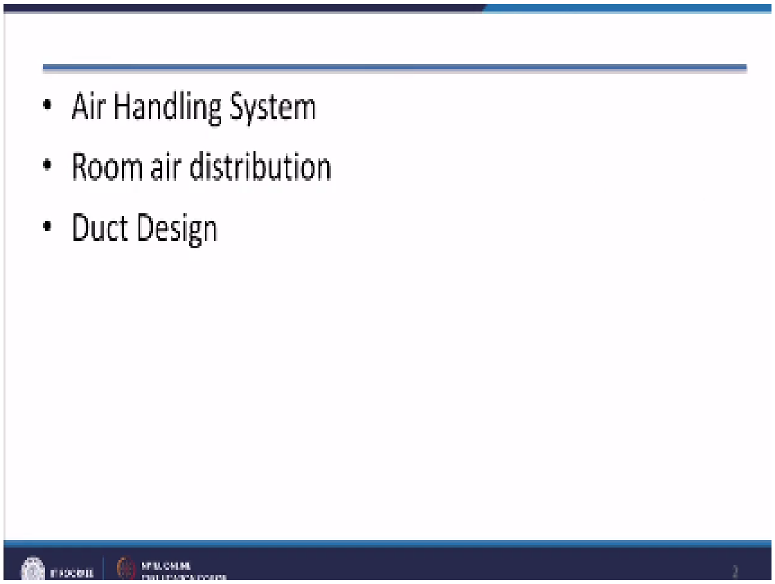

So we will take up first the air distribution in the building through the network of the net, so for the distribution of air in the building air handling units are required and for air handling units we need to have size of the duct, because if you take larger diameter duct the air velocity will be very less okay and it will attract more post if we take smaller size of the duct air velocity will be very high at the same time, pressure drop will be very high.

Suppose single duct, now we are by forgetting the duct there will be a pressure loss, the pressure losses in the bands and such type of a splits we'll discuss in subsequent lectures but definitely the solution equation you here in it will hold good, suppose cross section of this mean duct is 1 meter square and the split is 0.75 meter square and this is 0.25 meter square then velocity is let us say 15 meters per second so, discharge here 15 * 1 total discharge a1v1 or then suppose velocity is equal to 0.75 velocity here plus 0.25 velocity v2, this is v2 right.

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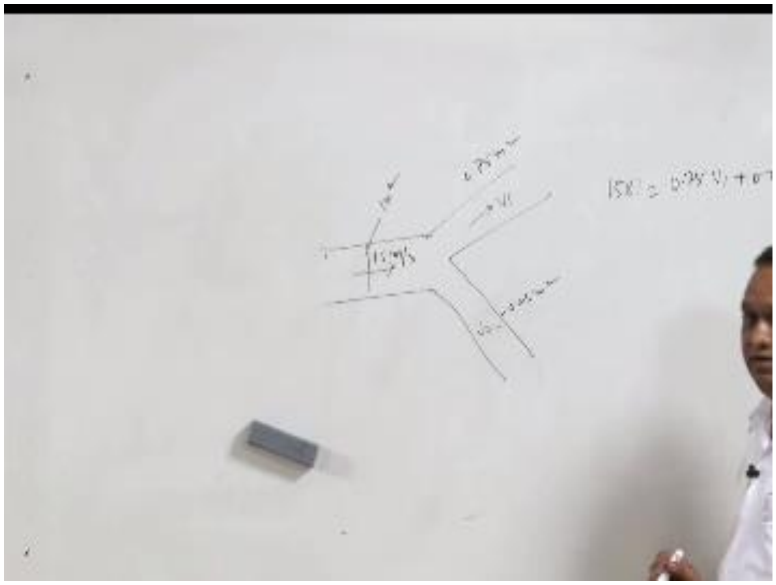

So I mean the all consideration of law of fluid mechanics are applicable here in the case of my duct design and definitely if it is m1 m2 and m3 then, m1 = m2 + m3 these processes are adiabatic processes so, there is no heat loss we can also use m1 h 1 = m 2 h 2 plus, but that will not be very useful here because we don't consider here normally in the distribution of air the heat transfer as well if, you want to if so if it is required it would be considered if it is required it will be considered.

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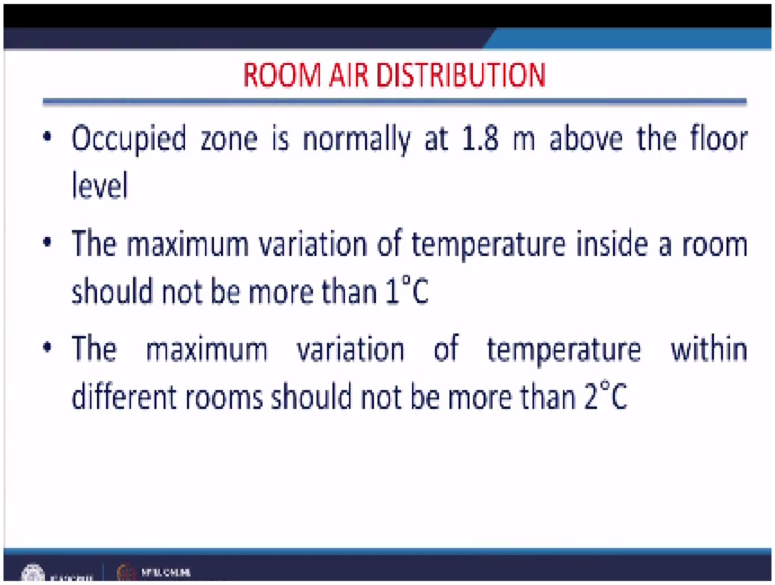

So this is these are the preliminaries in duct design, the room air distribution when the air enters the room occupied zone is normally considered 6 feet above the ground level. Now our focus remains or focus of steady normally remains upon 1 meter of 1.8 meters above the ground level and last two points i have already stated that in a the maximum variation inside a room should not be 1^0centigrade, so air should be distributed in a room in such a manner that the temperature differential in a room is not more than 1^0centigrade and temperature differential within a room with in differential different rooms should not be more than 2^0centigrade.

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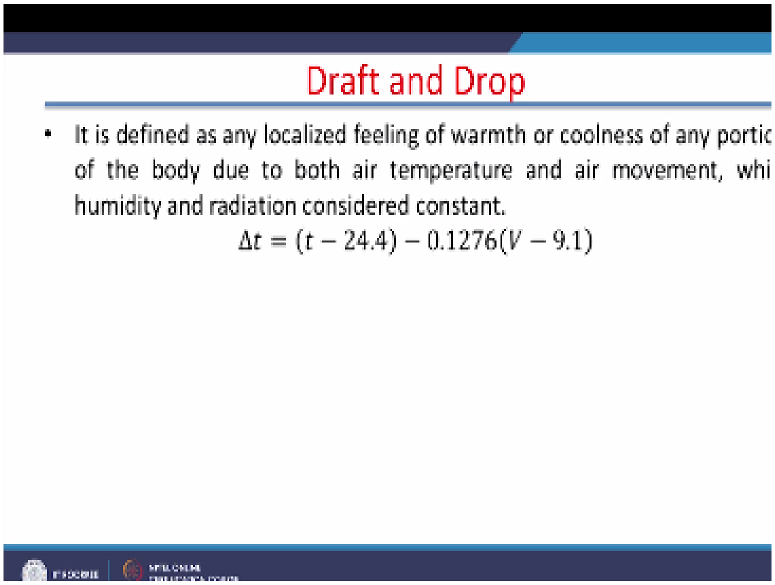

Draft I have already explained you, that is a localized feeling of warmth and coldness due to movement of 2 to both air and temperature, temperature and air movement while humidity remains constant. So draft I have already covered in the previous lecture drop is the vertical distance travelled by, a vertical distance travelled by the airstream suppose the airstream in a building is entering from this side so vertical distance covered by the airstream is known as drop for reaching to opposite wall so that is that is drop.

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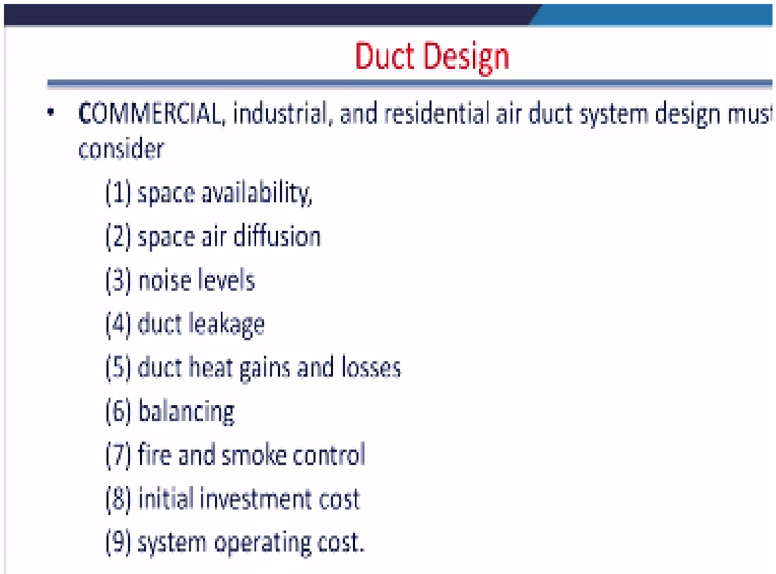

Now for designing a duct commercial, industrial and residential air duct system design must consider the following points available space, space here diffusion how much space is available for air distribution that is important, if space air diffusion noise level what is the noise level? Because, the noise level if we reduce the diameter of the duck because cost has to be taken also we, cost also has to be taken into account if you reduce the diameter of the duct the cost will reduce but at the same time velocity will increase that will subsequently lead to the friction pressure drop inside the duct.

So that is and on the other hand if he what if you maintain lower velocity that is also not recommended that very low velocity is maintained inside the duct in that case, size of the duct will increase and for load L velocity ducks other problems like stale air problem shall also becoming to the picture. So duct noise level, but that noise level I mean it is a criteria while designing a duct, duct leakage from duct takes place because the ducts are riveted and whatever state-of-the-art technology use some leakage will be there from the duct, it is it has to be confined to less than 10% of the total air discharge in the system.

Duct heat gain and losses so, ducts have to be insulated, because air which is moving the duct as you have seen in the load calculation literacy of the order of 13^0centigrade or 14 or 15^0 centigrade, if outside air is humid the condensation over duct surface will take place so, duct surface will come in contact with the outside humid air suppose outside air is 35^0 centigrade temperature and 70% relative humidity or 80% relative humidity the moment this air comes into this contact with the dust, because the dew point temperature for this air may be let us say 17^0 centigrade.

And I do not know the exact value but maybe if the say 17 degree centigrade and I do not know the exact value but maybe if the dew point temperature of outside air is more than the surface area of the surface temperature of the duct, condensation take place and this phenomena is known as sweating of the duct and this must be avoided, you must have seen in some of the buildings discolored walls in the vicinity of the duct that is due to sweating of the duct, the ducts were not properly insulated that is why when the humid air came into the context hot and humid air came into the contact with a duct subsequently the condensation took place and here the the water which was formed water vapor which was condensed on the duct surface subsequently it discolor the wall.

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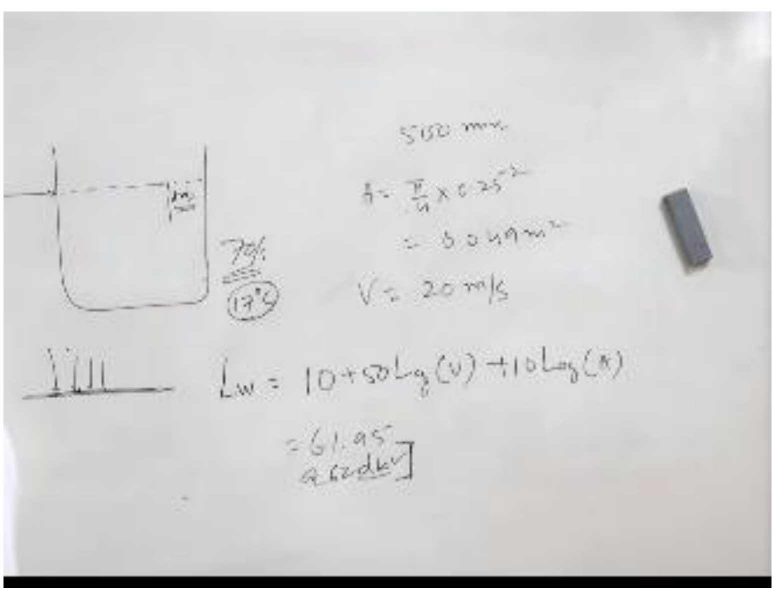

So if you must have observed such type of things in many of the buildings now balancing is important suppose air is supplied they are number of openings, there are number of openings and each opening certain amount of air has to be supplied if proper balancing is not done in that scale in this further area further openings fee may gets less air and the openings which are closer to the fan or a hu axis of air is supplied this is known as poor designing of air distribution system. If you are not getting the required amount of air at this openings that is known as imbalance in the system design fire and smoke control is immersed because.

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If there is a fire propagation in the building the fire the smoke propagates very fast through the duct initial investment costs I have told you the criteria for initial investment cost and system operating costs so eh use and all are to be used so that is the system operating costs now adduct noise level can be measured with the help of this is decibel power is 10 + 15 this is a very simple formula log of velocity plus 10 log of area suppose it duck is having a diameter of half meter 500mm duct 500 mm diameter circular duct so area is going to be PI / 4 x0.25^2 and that is going to be equal to $0.049m^2$, now area and then velocity duct velocity let us say 20 meters per second so noise level we can calculate as 10 + 50 x velocity is 20 +10 sorry 50 x log of velocity that is 20 + 10 x log of area that is 0.049 that is 61.95.

Approximately this is this is a log scale wicket okay let us take 62 decibel the 62 decibel noise is the nice which was somebody talks it is normal conversation so this is the voice of a sound level of the normal conversation so this much of sound shall be created because sound if sound level deduct is high in that case you may feel comfortable thermodynamically thermally you may be feeling comfortable but otherwise you will not be comfortable in that occupancy where noise level is very high.

So noise is one of the also is one of the criteria for designing the size of the adult because if we increase the velocity noise level will increase if we say here the area because velocity is remaining constant okay, so area cannot be justified here but if we are increasing the velocity for the same area if you are increasing velocity for the same area the noise well noise level will increase and if you increase area for the same velocity it means more air is flowing in that case also the noise level will increase.

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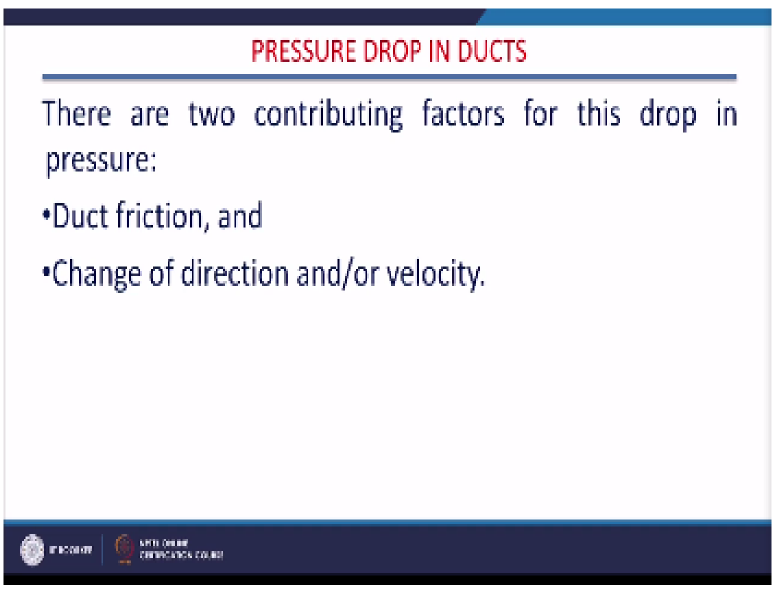

So pressure drop in adult can be contributed to do factors one is duck traction another is changing direction or velocity.

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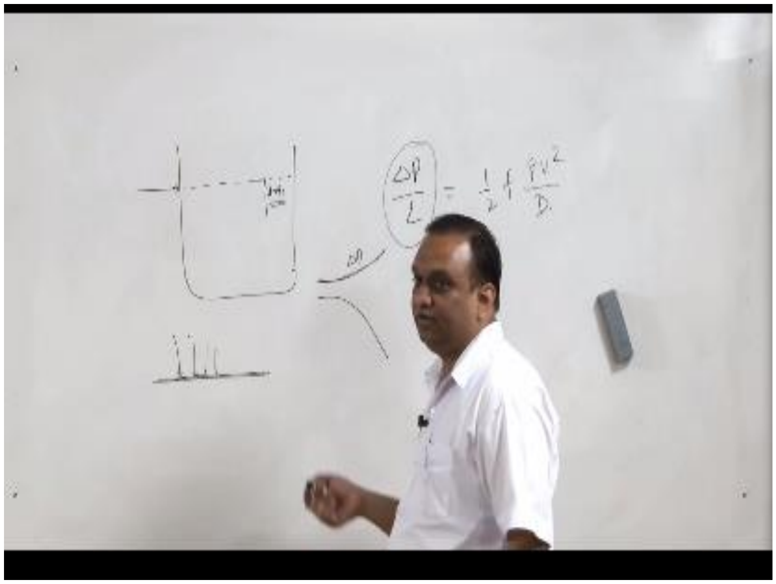

So that friction is $\Delta p / l = \frac{1}{2} F \rho v^2 / D$ this is duct diameter and this is the pressure drop per unit length and change in direction and velocity definitely there when there is a change in inertia pressure drop has to be there so if there is a change in the direction of the fluid pressure drop will be there or if there is a change in velocity I mean if the if there is increase in velocity there is going to be a pressure drop now this is a duck friction chart before I start that friction chart.

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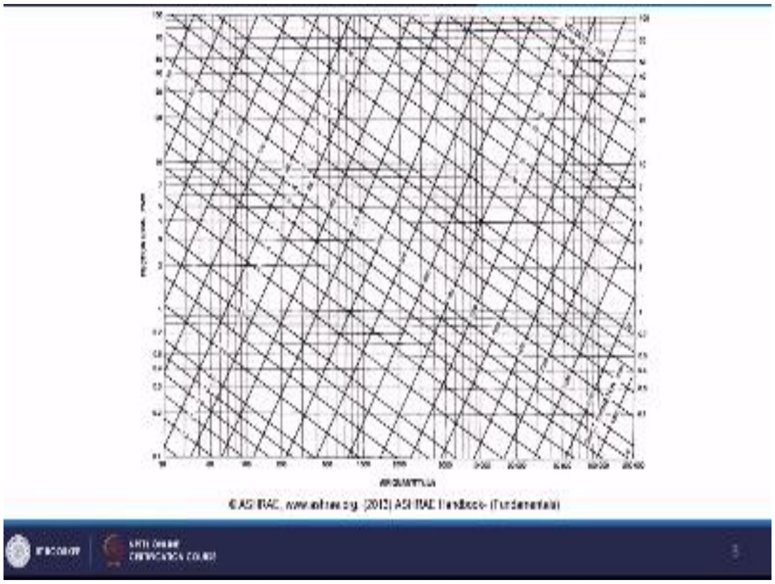

I will tell you because all the duct are not circular some of the duct are rectangular right now in those rectangular that is what we are going to do for those rectangular ducts if I want to take this chart because this chart is only for circular ducts suppose this is A and this is B so for a rectangular duct.

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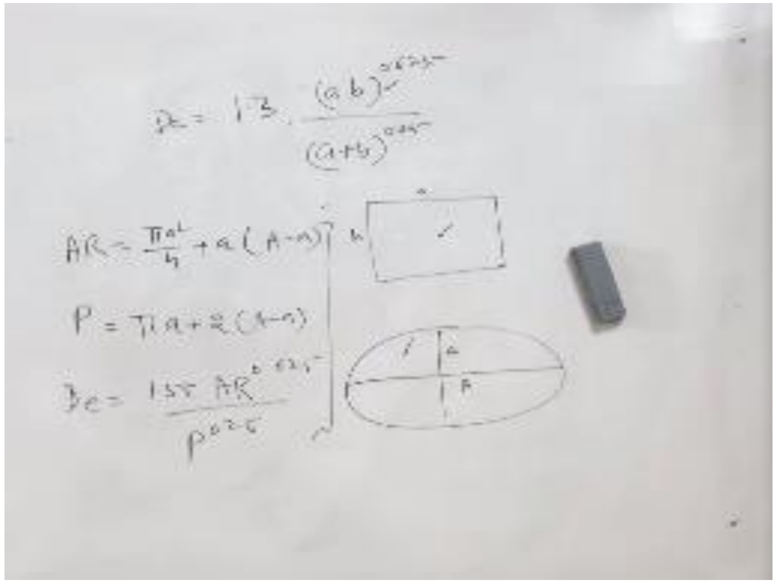

That the equivalent diameter is going to be 1.3 $A+B^{0.625}$/,sorry it is it was $AB^{0.625}$ / $A+B^{0.25,}$ so this is the diameter of equivalent diameter of the ducts which has a rectangular duct which has sides A and P A and B can be either of the side, so for this a b-side electoral adult this is going to be the equivalent diameter some of the ducts are over shape right, in oval shape duck suppose this is a major axis and this is minor axis then area of this is going to be π a^2/ 4 +A, a-a and P = π A + 2 a-a, and equal in diameter in this case is going to be1.55 $AR^{0.2625}$ / $p^{0.25}$.

So in both the cases whether it is a rectangular duct or a oval shape duct over share duct we have used these formulas we have taken area and this parameter function of parameter function of area here also function of area and function of parameter and we'll get the equivalent diameter so we can get equal in diameter for both the ducks whether it is a rectangular or square that or an over shill ducts.

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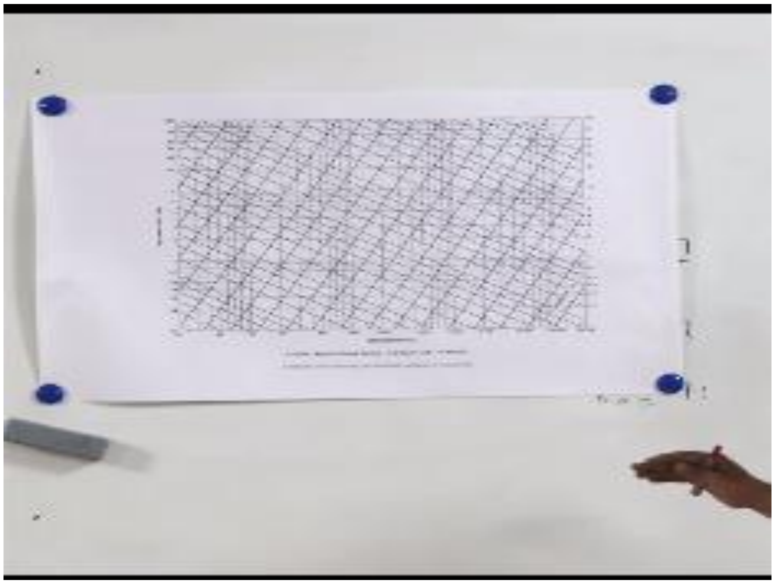

Now we will see a friction chart for around that this is the friction chart for a round duct on the x-axis on a log scale the air quantity is showed is starting from 20 liters per second to Lake liter per second it is on a log scale on a vertical axis or Y axis or ordinate friction losses in Pascal per meter friction losses in pas co δ P /l pastel per meter is given.

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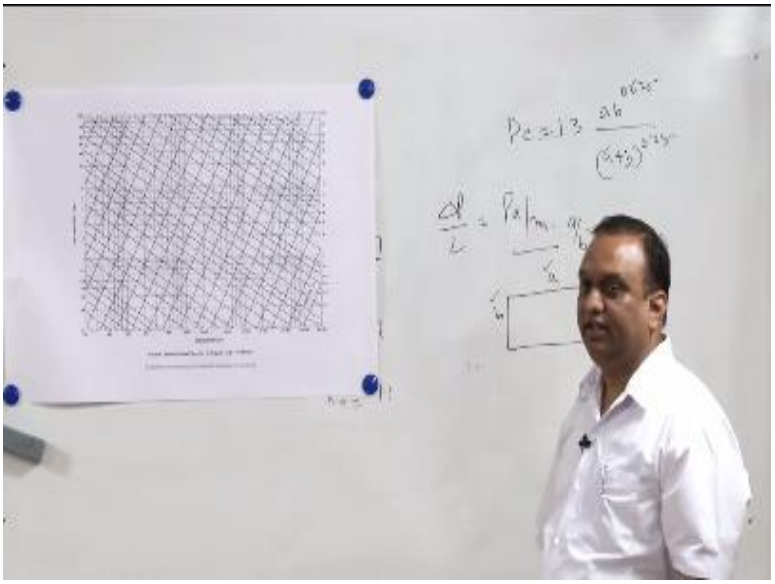

And these friction losses starting from 0 point 1Pascal meter to 100 Pascal meter 100Pascal meter is very high friction loss, similarly to length liters per second are also very high discharge rate so high where and the vertical lines here it means vertical lines in this chart vertical lines in this chart are from our for air quantity constant air quantity horizontal lines are the pressure constant pressure drop this chart is for friction chart for round ducts.

The density of air is assumed to be 1.2kg per meter cube and roughness of ducts surface J duck surface is 0.09millimeter this chart is taken from h Nabco fundamentals for 2013 now it has inclined lines these inclined lines these inclined lines are constant duct diameter line so this line is a constant diameter line now perpendicular to these lines again we have dark lines these lines are constant velocity lines.

Now with the help of this chart with the help of this chart the dimensions of that can be easily calculated suppose I will take one example suppose friction loss in my duct is one Pascal per meter so friction losses per one Pascal meter and discharge is 2,000 liters per second or friction losses let us say to Pascal per meter and discharge is 2,000 meters per second so in this case the duct diameter is going to be 500 millimeters, this is equivalent diameter if I want to have a rectangular duct I will have to use the equation for rectangular that that is a B and that equivalent diameter is equal to 1.3 $AB^{62.5}$ /$AB^{0.25}$.

And then if normally ratio or a B let us say if the A and B ratio is for that is a by B is 4 them using these two equations we can find the value of respective value of a and B for rectangular duct same exercise can be done for the oviduct, now here at this discharge this pressure the duct diameter is 500 if I increase the diameter of the duct for the same discharge, discharge is same if I increase the diameter of the duct from500 to 830 right in that case the frictional pressure drop will reduce to 0.6.

Simply by increasing the size of the duct if I further increase the size of the neck to 800sorry this is 630 not 830 degree 630, so 500 to 6 30 600 to 800 so if I further increase size to 800 the pressure drop per unit length will be reduced to point to so he starting from 500 millimeter ducked for friction draught to Pascal's per meter if I take 800 mm duck the pressure drop will be reduced to only 0.2Pascal's per meter.

So in the network of ducts they are going to be ducts of different lengths and different discharge forth for that network of the that we can find the diameter of individual duck using this chart in addition to that using the chart we can find the total pressure drop in the system which will help us in deciding the size of air handling unit rest of the things regarding the air distribution system will be covering in the next lecture that is all for today. Thank you very much.

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