INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture – 39
Indoor Environment Health - 2

with
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Hello, I welcome you all in this course on refrigeration and air conditioning today we will continue our discussions on indoor environment health today we will discuss the ventilation.

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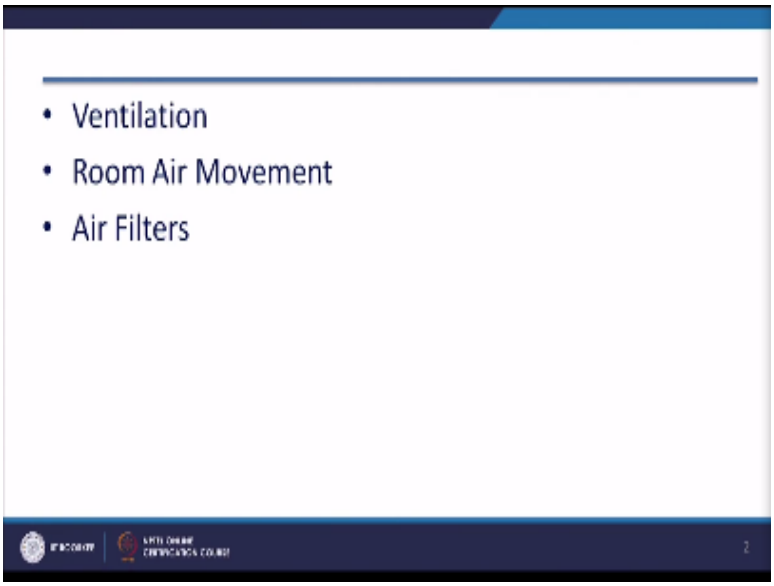

Room air movement and we will discuss about the air filters as well now in ventilation there are two types of ventilation one is natural ventilation.

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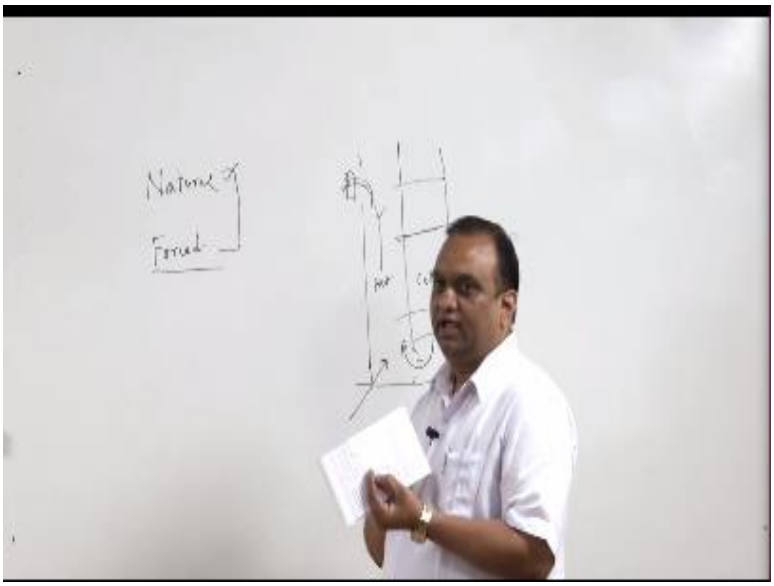

Natural ventilation and forced ventilation forced ventilation right, now in natural ventilation no external energy is required yes we discussed earlier due to stack effect in the building when inside is open seas hot outside is cold especially in the nights because in the light outside is colder than inside of course if you are not is sleeping in an air-conditioned environment naturally in any building inside environment is hotter than the outside environment.

In that case what happens the air can flow in from the bottom of the building and can leave from the top right, so this is called night ventilation otherwise in natural ventilation the ventilation in the building takes place in a without any consumption of energy or in natural manner it can be through the flow of air over the building envelope in that case also the ventilation will take place and ventilation natural ventilation can maintain the required amount of air is required for maintaining the indoor environment health.

In case of mild weather if the weather is mild or the climate is mild in that case even natural ventilation can provide good indoor environment health but in case of extreme climates one has to go for force ventilation systems and force ventilation system is definitely you are fixing some fan or either at the exit or at the inlet so either induced draft will be created in the building or the

force draft will be created in the building and that is known as forced ventilation. Now flow in the room flow of air inside the room is also important flow and dispersion of air inside the room.

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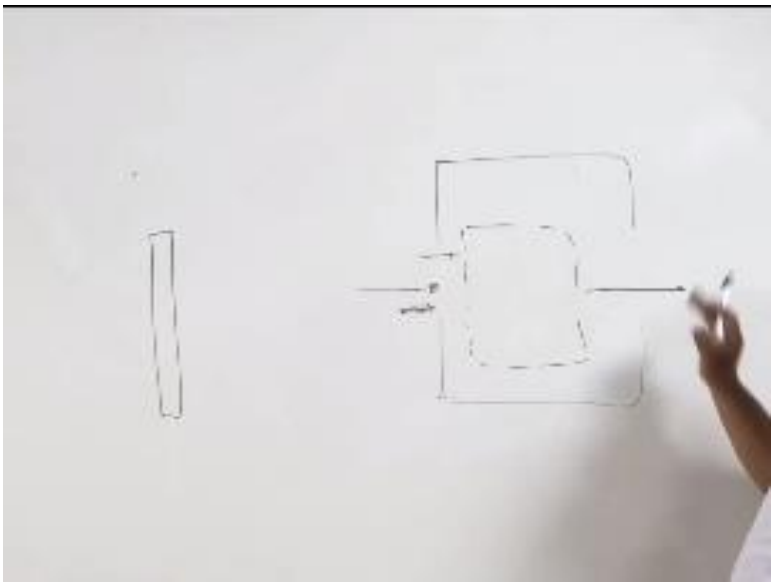

Suppose there is a room and air is entering from this side from any point from this side and when air is flowing in the room then it will also take F because low pressure may be created here so air from the surrounding of this jet shall be mixed with this air this is known as entrained flow or flow entrainment and this mixing will definitely affect the properties of this air that is known as entry in flow, another type of ventilation is displacement ventilation in displacement ventilation the new air enters from this side and it displaces entire air in the room from the other side or here in this room is play displaced.

And in ideal casein ideal case it should be a piston effect it is something like a piston is moving in this direction and displacing the air that is the ideal case but it does not happen in actual practice but most of the player is display 90% or 80% of the air is displaced and there are displacement devices displacement ventilation devices are available in market okay, and if the air is coming to the room through these devices there is a parallel flow stream and providing a prosthetic effect it displaces air inside the room.

So there are two types of flows in a room one is entrainment flow another is displacement flow and this flow is all waste controlled by the fence in the Fen we all know there is a fen total pressure FTP.

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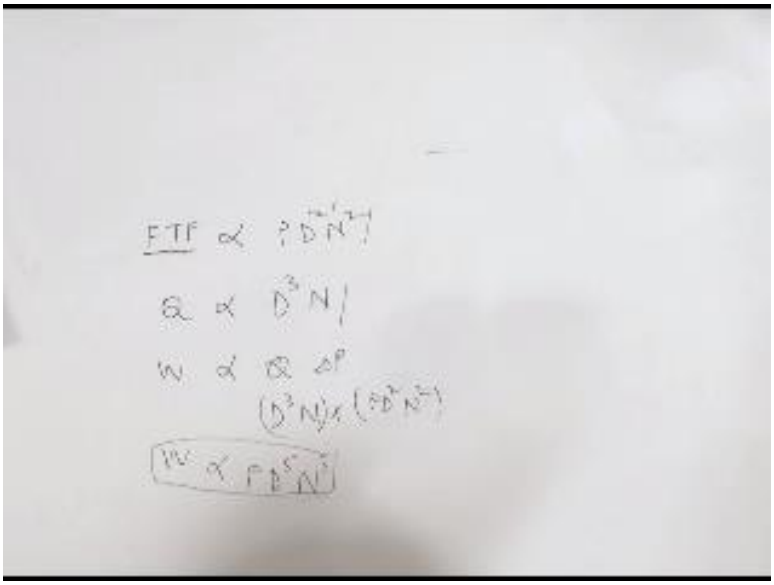

An FTP is proportional to $\rho d^2 n^2$ d is the diameter of the fan and is the RPM so suppose if we change the Rpm of the fan the total pressure fan total pressure will reduce square root of this it is not directly proportional. Similarly discharge how it is going to affect the discharge is so if I reduce the RPM the discharge will be proportionally reduced or if I increase the RPM this charge will be proportionately increase pressure will increase in square of the RPM so rise in pressure fen total pressure will be sharper percentage rise in Fen total pressure will be sharper than the percentage rise in discharge and power consumed by the fan is proportional to Q δ P.

So it is going to be D^3 N x ρd^2 N^2 and so the energy consumed by the fan is proportional to ρB^5 N^3, so you can imagine when we suppose we increase we increase by some percentage the RPM of the fan the variation in flow rate will be linear then this is going to be a sort of square of this square of RPM and this is of the cube of the power consumption will be cubic of RPM this

information is required because offer there is a there is variation in fan rpm due to variety of reasons.

And second thing is in normally in the fence suppose there is a centrifugal fen in a centrifugal fan normally backward vane type of fence are used because if there is a flow variation in the flow power consumption will not be very significant enhancement in power consumption will not be significant and efficiency of the backward flow vein flow type of backward vane type of centrifugal fan is approximately 80%.

So efficiency is also high and if you deviate from optimum design conditions the change in other parameters is not significant so that is why most of the cases in centrifugal fens the backward vane type of system is used until unless very high pressure ratio is required if very high pressure ratio is required then that case forward rate type of fence are used when we talk about ventilation rate becomes important because we have to quantify the ventilation how much ventilation is taking place.

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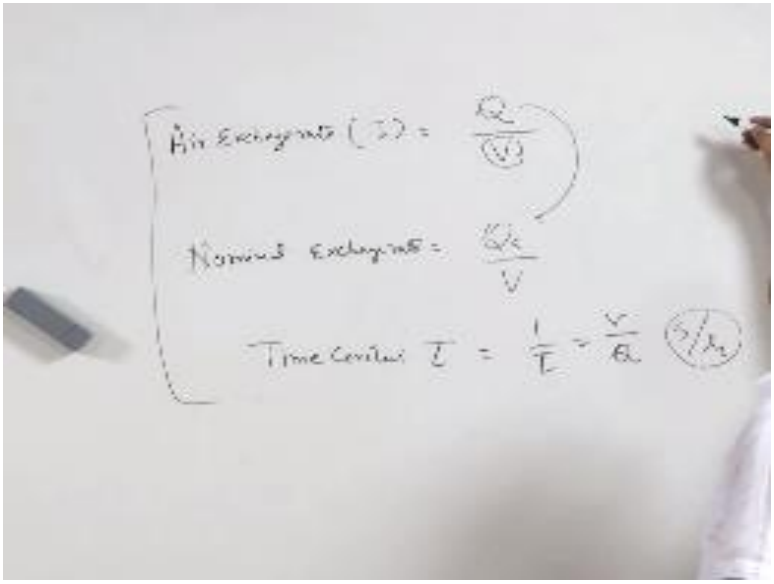

So in order to quantify the ventilation there is a term air exchange rate air exchange rate is denoted by I is equal to air entering to the room ventilation air entering to the room per hour divided by the volume of the room it means per hour or per second I mean it is a time unit so how much volumes of the air head how much volumes of the air have a enter the room in form of wind direction right and another term is nominal exchange rate in nominal exchange rate totally air is not considered but total outside air is considered.

That is known as nominal exchange rate after that comes the time constant is denoted by τ = inverse of I or V / Q and the unit can be second or our whatever unit we are using that is going to be the time constant, so these are certain things which quantifies the ventilation in the building now ventilation in a health care unit because indoor environment health in health care unit is very important, so if proper ventilation is not maintained in a health care unit in that case severe infection can be caught by the patients and sometimes it can be fatal also.

You must have heard or you must have read in the newspaper many of the patients died due to post-surgery infections.

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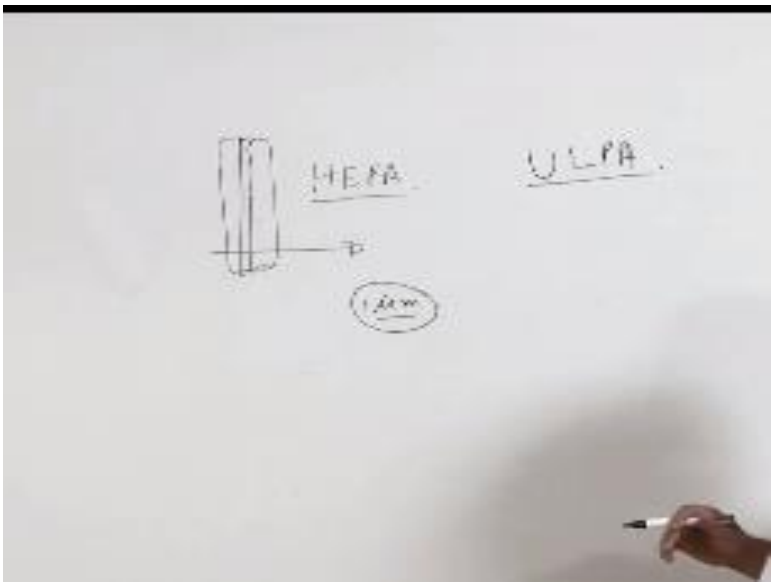

Now in a health care unit some filters are provided mainly infection takes place through bacteria or virus in health care units so they are certain filters are provided one of the filter is HEPA high efficiency particulate air filter if we use three layers of this filter if you use three layers of the filter even we can prevent the entry of the bacteria in the confined space normally the bacteria size is approximately 1 micron and that is the movement of this bacteria is prevented by HEPA filters.

So they are commonly used in the bypass surgery room or the surgery where which is which is very prone to the infection now another type of filter is used is ULPA ultra low particulate air filters, so these filters are hired filters and they are they are proposed to used in the health care units in a surgical group air exchange rate has to be high air exchange rate has to be maintained in the intensive care unit of the hospital where are surgical room of the hospital.

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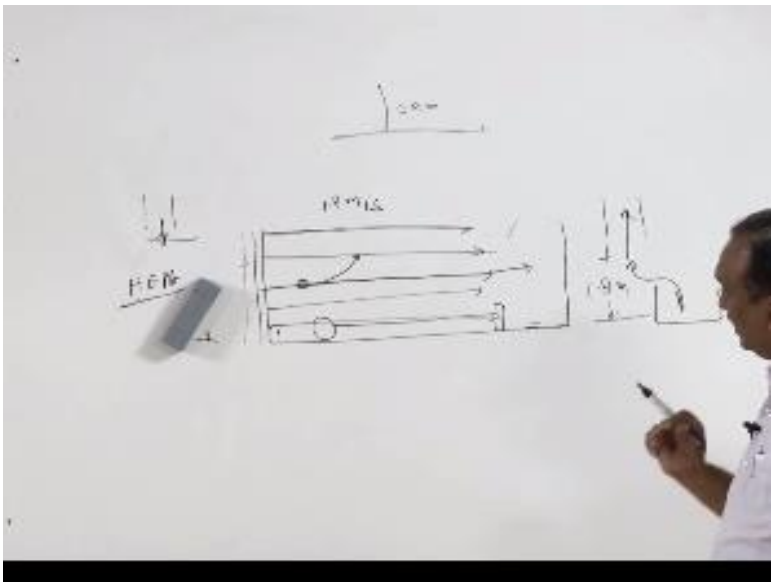

Where bypass surgery or critical surgery takes place laminar flow benches are used. In laminar flow benches the patient is laid and air comes from one side and the flow of air is laminar flow and this laminar flow passes over the body of the patient the flow the velocity is quite high it can go up to let us say 1.8 meter per second and on this side there is a layer of high-efficiency particulate air filters so all the air which is coming to the lemon laminar flow bench is coming through a HEAP filter.

Now the property of laminar flow is that there is no cross transfer of the movement from one layer to the another layer suppose when virus or bacteria is in at in one layer it will continue to be in that layer it will not spread in the room and it will pass from other side now these type of batches are used for preventing post-surgery and during surgery infections in the patient in addition to this the exhaust and Inlet if the hospital has to be taken care of exhaust of air to the atmosphere and Inlet of air for the air-conditioning purpose.

There should not be any waste disposal site close to the inlet because this may contaminate the air for this reason it is always recommended that inlet should be approximately 1.8 liter over the ground level and if in later at the rooftop it should be approximately 0.9 meters above the roof

level in addition to this in hospitals personal ventilation is also provided in general wards or it is also the personal ventilation is suppose patient is lying on the bed the fresh air will come from the pillows and it will envelope the face of the patient, so this envelope is created throughout the on the face of the patient with the fresh air and which is definitely on a slightly higher pressure, so that outside air is not inhale by the patient, this is known as personal ventilation and it is becoming very popular in hospitals even in offices.

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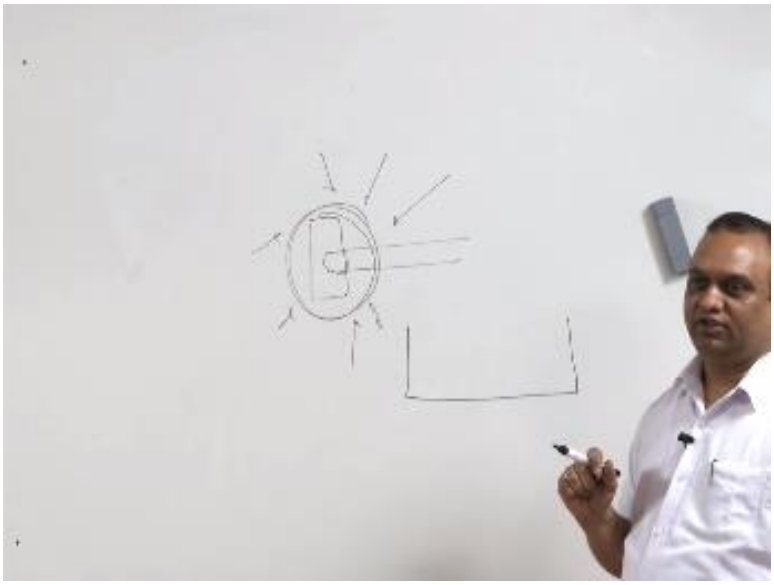

In some of the countries in offices, offices are normally use find normally there is a big hall in the companies and where our cubicles and people are sitting in the cubicles so, instead of cooling the entire hall the individual is provided some fresh air or individual is surrounded by the fresh air and that is known as personal ventilation and this type of ventilation is becoming very popular because, it is cost-effective less air the quality of the less air has to be maintained and it is easy to operate so but these things are done only to maintain the indoor environment health.

And therefore ventilation is very critical if proper ventilation is done definitely the good quality of environment, the indoor environment can be maintained one more ventilation type of ventilation which is I mean frequently be used that is ventilation in the tunnels because

nowadays with the development of the countries or development in our country more and more tunnels are being dug for the rapid transportation or for metro transportation the ventilation of these tunnels is critical, we cannot pu a fan here or something fan here or fan at certain intervals.

Now in these tunnels shafts are provided their openings they are known as shafts and with these shafts in these shafts fans are provided either to supply air to the tunnel or takeaway air from the tunnel and these shafts are provided after a certain interval in the tunnels sometimes through the supply shaft a ducting is also done up to a certain extent so, that the air is uniformly spread if tunnel is we're not very long jet fans are used, jets and fans are the fence which throw the jet of the air with very high velocity.

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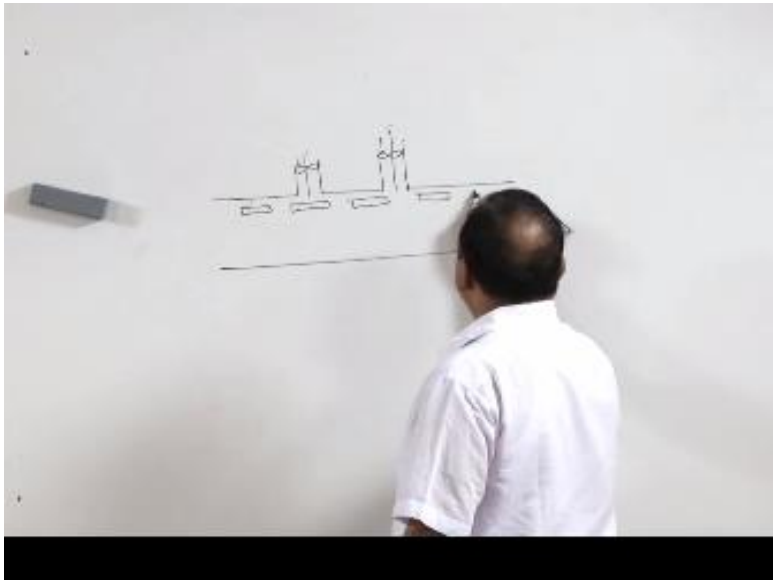

So jet fans you must have seen in the parking's of shopping malls where these jet fans are provided these function of these jet fan is to remove the smoke in case of emergency. So in case of emergency these jet fans can be used for removing the smoke as well so here the function of the jet fan is in this case is only the circulation of air. So nowadays tunnel ventilation is also becoming popular but first and the foremost thing in indoor environment health is filters.

Some of the filters we have already discussed, now there are certain type of filters which can be classified as, classification of the filters shape, shape of the filter it can be in the form of a panel it can be in the form of a extended surface, so as per the shape of the filter they can be classified coating of them the filter coating mean it is a dry type filter or some viscous coating, sometimes viscous coating is done in order to remove the particles, viscous type or dry type filters operating life once through once use or I mean use and throw type or the disposable type or disposable or it is a recyclable or renewable.

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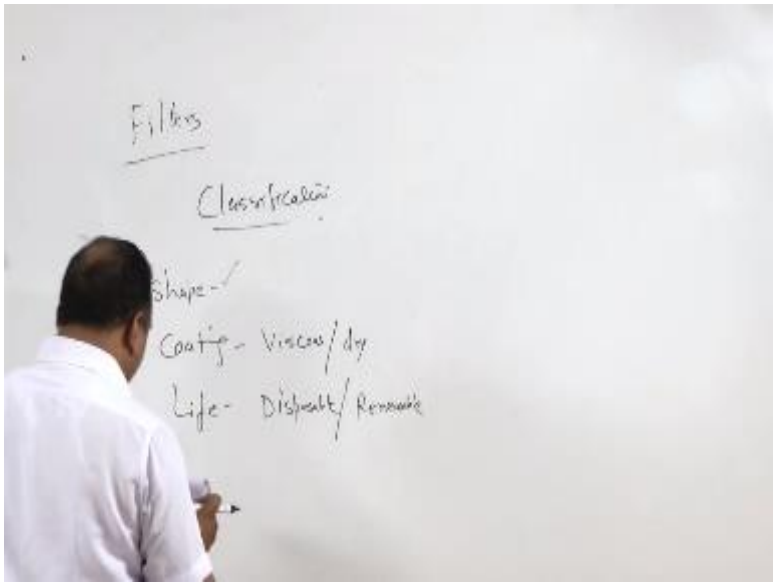

And efficiency of the filter, high efficiency, low efficiency and medium efficiency this is how the filters are classified and mechanism is first is direct interception I mean the air stream is coming to the filter, direct interception of the air and air goes out particles will be retained here but sometimes results of these filters are misleading or nowadays it is not used but not much used because if some of the particles are heavy then percentage-wise you can say this much a percent of dust or contaminated we have filtered through using this filter but, in actual practice most of the small particles will pass through this filter and it will not be that effective.

So that is what is direct interception type of filters, now types of filters, now types of filters there are dry type of filters the pressure drop across the drive-by filter is 1 to 10 to 60 Pascal and with this pressure drop the filter surface remains dry, another type of filter is viscous filter, in viscous filter viscous coating is made on the filter surface and thus particles this they stick to the viscous coating on the viscous filter third type is automatic type of filter, in automatic type of filter there are two rollers and when the air is passing over the filter the roller skeeps are moving and after a particular time the part of the this filter which is coming into the air we were just coming into the contact with the air it keeps on changing.

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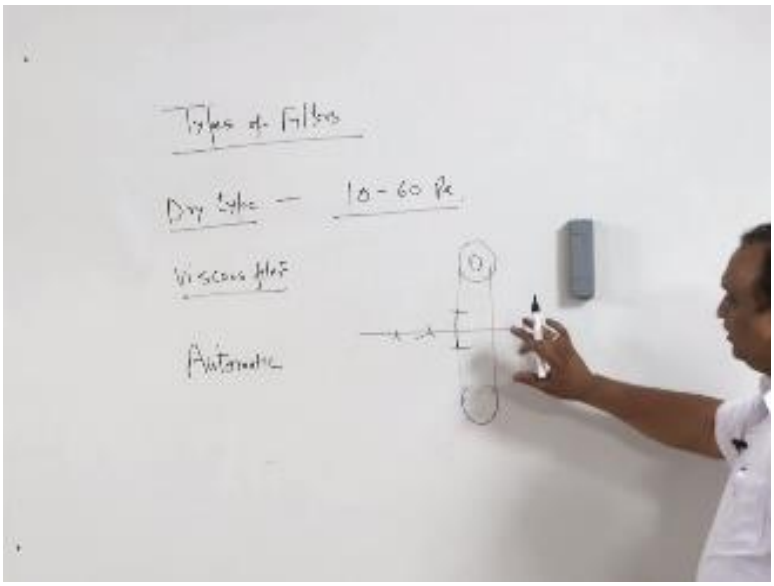

So automatic type of filters, in automatic type of filters the effectiveness of filtering is more because every time after a certain time interval this, this filter the part of the filter will be shifted because these rollers are moving with a certain velocity and that is why we get a better quality of filtering in this type of automotive, automatic filters. Ultra violet filters are also there ultraviolet, ultraviolet filters are used for barrel by aerosols because by it by aerosols are almost on the same size normally ultraviolet rays are used for killing the bacteria's.

So these types of filters are this can be also used for filtering another type of filter is adsorption filter. Now, absorption there is a difference between absorption and adsorption, absorption means the absorption of solvent in the solute that is absorption refrigeration you must have we have discussed namely discussed. Now adsorption is absorption only on the surface solute does not enter inside it remains only on the surface like if you dip it chalk in ink, the ink will remain if you break the chalk inside will remain white ink will be strained only or ink will be straining only outside the chalk.

so this is adsorption process now it is becoming very popular and with the help of activated carbon, activated carbons are used for adsorption filters, wet filters are also their wet filters they are like scrubbers and washers is covers and washes but the wet filters are not recommended for the solid particles right so facade otherwise red filters and scrubbers, scrubbers and air washers. They are wet filters are using for cleaning the air.

Now testing method the testing method is first is just spot test testing methods, now first is dust spot test, in dust spot test this is the testing of filters, so if there is a filter and air is blown over the filter on upstream side and downstream side, on the upstream side and downstream side on the filter cloth the strains are seen whether, if they are optically analyzed, if there is an improvement in the strains I mean these strains are lesser, it means the particles have been filtered from with from this filter and this that shows and through this process we can find the efficiency of a filter.

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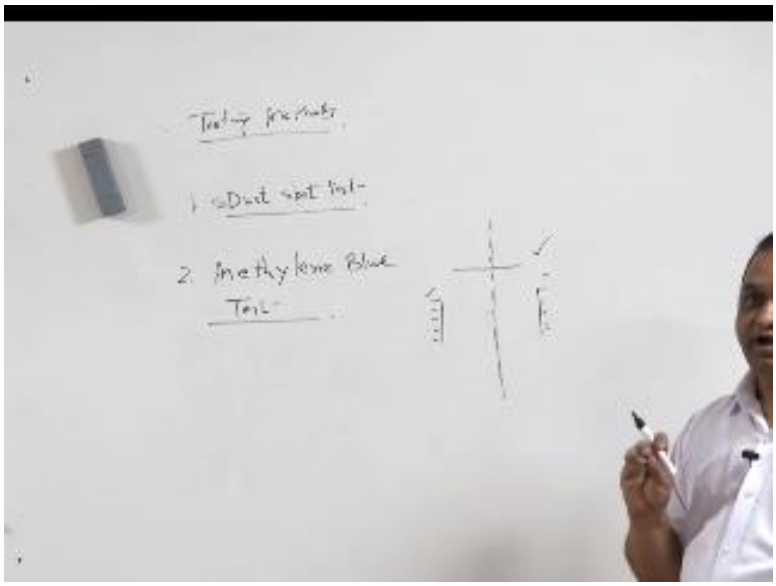

Another test which is very popular is ethylene blue test, ethylene blue has particles which are in size and shape very close to the particles of dust which are very, which are very close to the particles of dust so may three blue is part passed over the filters and filtering of ethylene blue particles is noted and that is how the efficiency or effectiveness of a filter is decided. That is all for the testing government testing method of filters so, in order to maintain and the indoor environment health choice of proper filter is very important.

So if the proper appropriate filter should be used in order to endure a health environment that is first thing and the second thing is proper ventilation should be there in the room or in the occupancy and in order to have proper ventilation and proper diffusion of air not only ventilation diffusion is the distribution of air in the room so there should be a proper diffusion also in the room with the help of these tools the indoor air environment health can be maintained this is all for today, thank you very much.

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Acknowledgement

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