INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE
Refrigeration and Air-conditioning

Lecture-28
Design Conditions

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Hello I welcome you all in this course on reflection in air conditioning today we will discuss the design conditions because a when an air conditioning system has to be designed we have to fix the design conditions air conditioning is used for variety of applications starting from human comfort commercial applications air conditioning is used in the shopping malls commercial areas warehouses preservation of foods cold storage laboratories with there are many applications of air conditioning system.

But we cannot fix universal design condition for all the systems but in the most of the systems now ambient temperature for somewhere especially in India the for designing the system the summertime ambient temperature is considered to be 43.2 °C that is a standard value second thing is load calculations we'll be discussing in the subsequent lectures but suppose we have load on a building suppose load in a building is coming 100 tonnes or should we go for a 100 ton refrigeration system or a 100 under air-conditioning system that is the point because.

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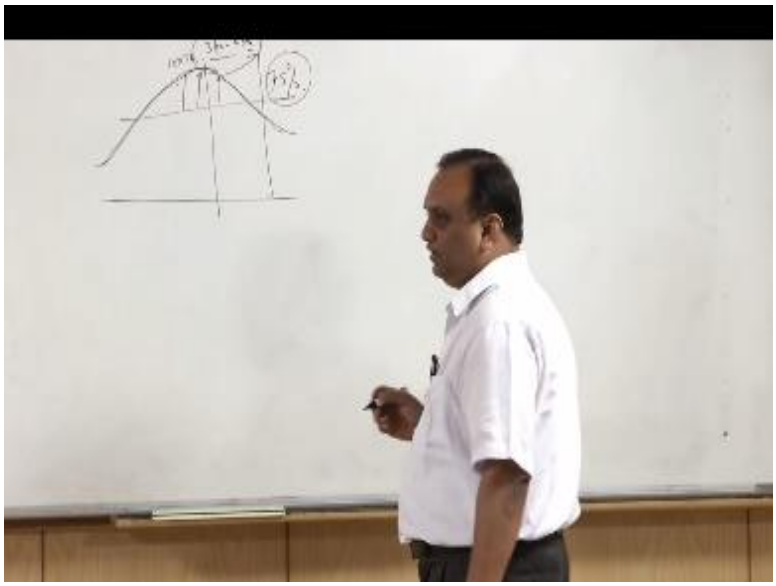

If we choose the air-conditioning system with the peak load because load on AC will vary load on AC will vary throughout the day and the maximum load will be between3 p.m. to 4 p.m. right so normally it is like this so the peak load is 100 tons of refrigeration but the issue is if I go for 100 ton machine my machine will be underutilized throughout the day except this period if I take 50 percent of this load when I 50 tons of machine then the 50 tons of machine this is 100tons suppose this is 100 ton cliff load if I take 50 ton.

Then my machine will be over stress and that will cause maintenance power if the machine is overloaded that will call for maintenance of the machine so that is why when we design an air conditioning system first of all we calculate load in the building maximum load in the building and capacity of the machine is desired close to the 75percent load of the building because we have to see this redness of this curve also but in any case it is approximately75 percent of the peak load in the building.

For the air conditioning in the cold storage it is interesting to know that for different foodstuff there is a different preservation temperature for example we take potatoes, potatoes have to be stored around 3 to 4 °C temperature.

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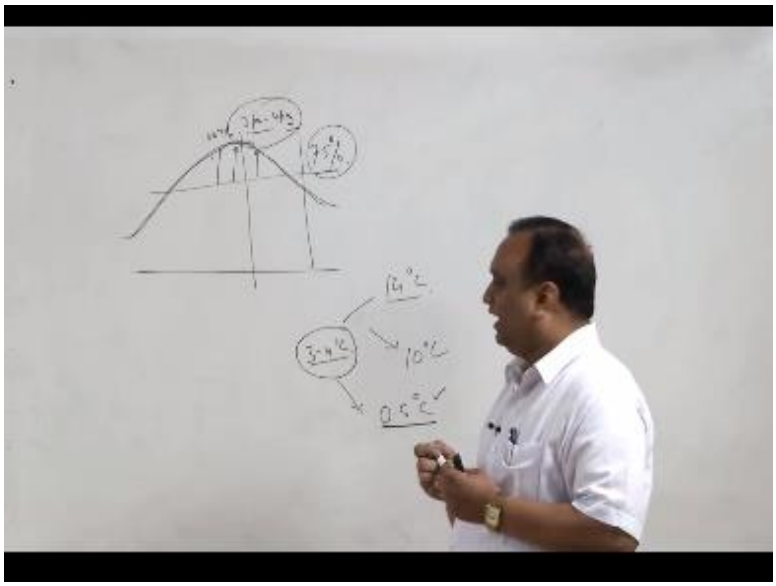

But normally they are restored at 0 °C that is not advisable because this preservation temperature is the optimum temperature where the ripening effect in the foodstuff is minimum bananas 40°Cwe do not have to keep bananas in refrigerator another example I will give you bang goes mangoes also around 10 degree centigrade milk, milk is 05.5° so this is very close to 0 °C approximately 0.05 0.5°C.

So if you look at the ashtray handbook of refrigeration you will find preservation temperature of all foodstuff and all food stuff for the sake of froze I should not be kept into the refrigeration so for every foodstuff here is a specific temperature for preservation and it should be kept at that temperature only so now regarding the design condition in air-conditioning system I have already told you then, the outside design condition temperature of air is normally considered for summer air conditioning for the 3.2°C.

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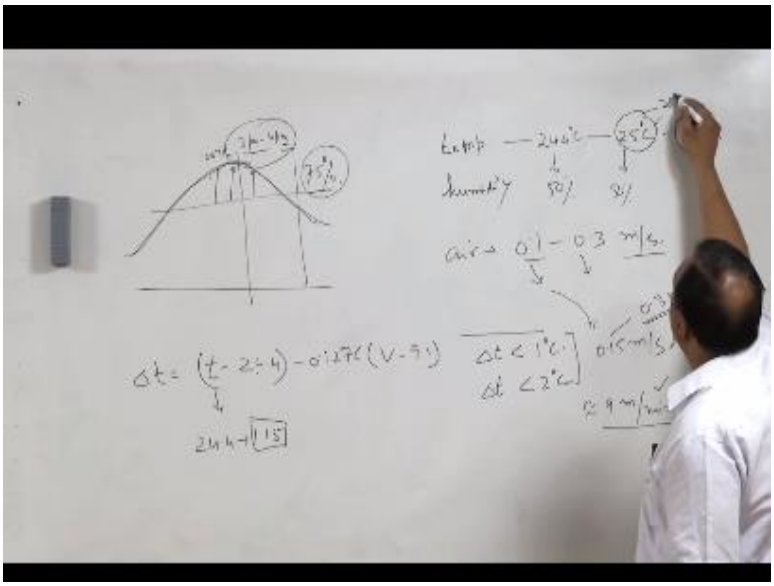

Inside design inside design there are two things temperature and humidity ideal case we say that temperature has to be 24.4°C but in India we continue with 25°C if you look at the psychometric chart it is indicated as 24 °C we go for 25°C because in our country they are conditioning now till date the air conditioning means cooling of the air and cooling from outside air is 40 43 °C if you are pulling up to 25°C we are saving some amount of energy in fact even if the temperature of a room in the summer season is maintained at 27 °C it should work provided.

There is a proper movement of air in the room so humidity is also important humidity here it is 50% here also we assume that humidity should be 50 % but it can it is this is the issue with the humidity also it is not always possible to maintain 50 % humidity so it is maintained in a particular range now while I was talking about this 27 °C even if we maintain 27 °C temperature with proper movement of air you will feel quite comfortable.

Air movement air movement is also important in the occupancy the air movement normally it is 0.12 0.3 meters per second if you exceed 0.3 meter per second then the movement of air shall also become uncomfortable for you so it has to be lower than 0.3 meter per second and but has to be more than 0.1meter per second otherwise if the proper air movement is not there in the

movement in the room or in the building certain pockets will be created in the room and high temperature differential will be formed in the room in the room for.

For the purpose of air conditioning the temperature difference between 2points in the room should be less than 1°C if it is a house in the entire house the temperature difference should be less than 2°C in any part of the house now air movement ideally our moment is 0.15meter per second it turns out to be approximately 9 meters per minute yes it is 9 meters per minute right.
So if proper air movement is maintained in the room we can go up to 27°C there is a concept of draft.

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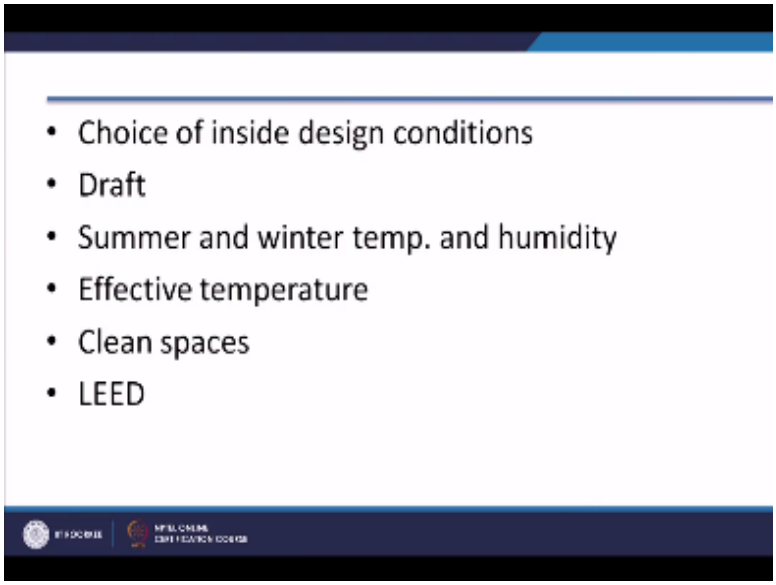

There is the equation for draft temperature difference that is Δ T that is equal to t -24 0.24-0.1276 V minus 9. Now this equation if velocity is doubled I mean 9 meter per minute if I double the velocity I make it 0.3 meters per second then for same draft feeling then 9* 0.1276 this T can be 24.4+1.15 so we can go temperature by higher by1.15 °C if this T is 25°C so 26.15°C or 26.5°C we can go up to if we increase the velocity from 0.152 0.15 to 0.3 m/s.

This is the upper limit so deaf comfortably, comfortably because this temperature sprint if I even if the temperature is 26 °C in the room you will not feel uncomfortable so we can easily go up to 27 stressing 27 °C I'm stressing out 27 °C because if you maintain 27 °C temperature in a room outside temperature is let us say 40, 40 °C.

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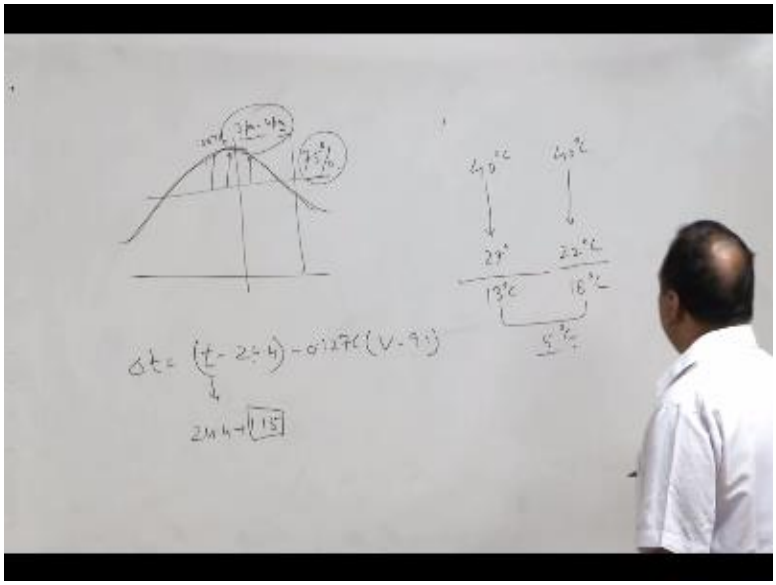

And you are reducing temperature in a room to 27 °C that is 13 °C reduction in the temperature in another case 40 °C nowadays I have seen the people normally maintaining the temperature of the room 22 °C and then it becomes 18 °C so now 13 to 18there is a difference of 5 °C and I mean I mean 30%approximately 30% more energy is consumed in maintaining this temperature and it is not advisable a thermodynamically it is not advisable, advisable to sit in a boardroom of a company in a 22 °C wearing a warm suit or wearing a suit so clothing is important.

Especially in Japan what people are doing even in the corporate meeting they are going with a light clothing, clothing makes a lot of difference that we'll cover in subsequent lectures how the clothing of an individual affects the temperature in the room I mean if you go for the light clothing you can the higher temperature in the room will give the same order of comfort now we

have already discussed the draft now in summer air conditioning the outside temperature suppose air conditioning is done in the desert area outside temperature is 40 ° 45°C humidity is 10 %.

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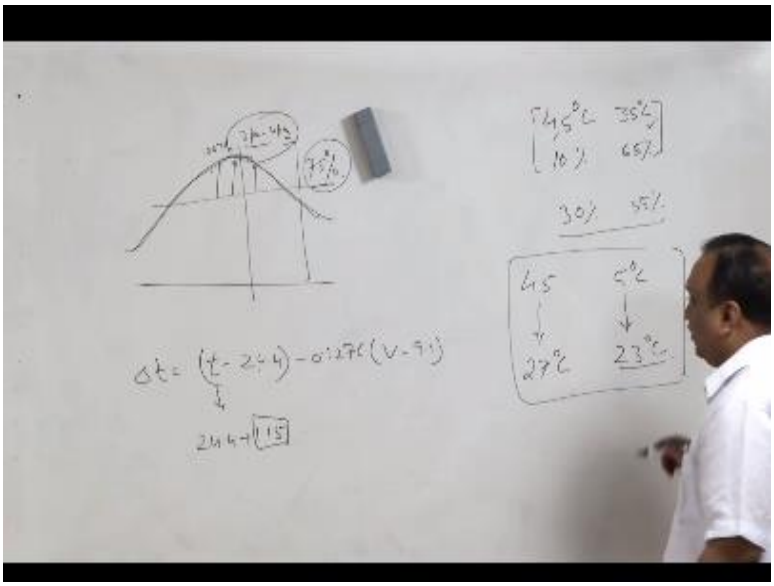

You need not go up to 50% of relative humidity even 30 to 40 % relative humidity will serve the purpose on the sea side if there is a coastal climate the temperature is 35°C humidity is 60 % or 65% that is quite uncomfortable those who live in the coastal area they can feel this is more uncomfortable than this in dry weather in dry weather suppose you are standing under a shade it is a big relief but if the humidity is high though the temperature is low by10 °C.

This weather makes you very, very uncomfortable anyway so 35 65 we can reduce the or humidity to 60 or 55 % it will do we need not go up to 50 % see we see with the temperature suppose outside temperature is 45 I think 27 is okay but if the outside temperature is 5 °C in cold in the winter outside temperature is 5 °C in that case I think inside temperature you can maintain 23 °C so this is these are the measures to save energy because a good design of a system is especially in the air conditioning system which saves energy because there is a lot of stress on energy saving in the air-conditioning system.

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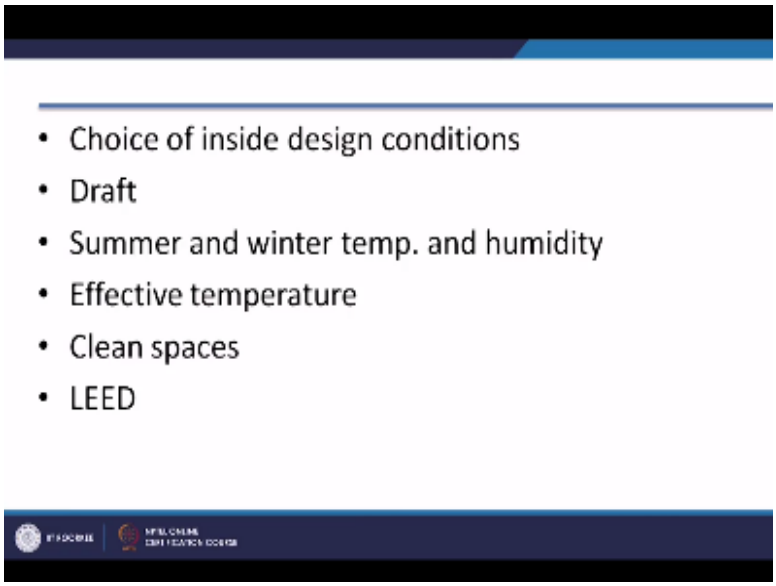

Now second thing is if you go for the small capacity type of system like split international split air conditioners are good I mean aesthetically also they are good but they don't have any provision for fresh air so this has to be kept in mind I have seen in the buildings instead of putting a 20 ton units they are put a split a AC's that is not advisable because split AC is not made for such type of applications and it is not an energy efficient system also if you are putting there is 10 split AC of 20 ton capacity.

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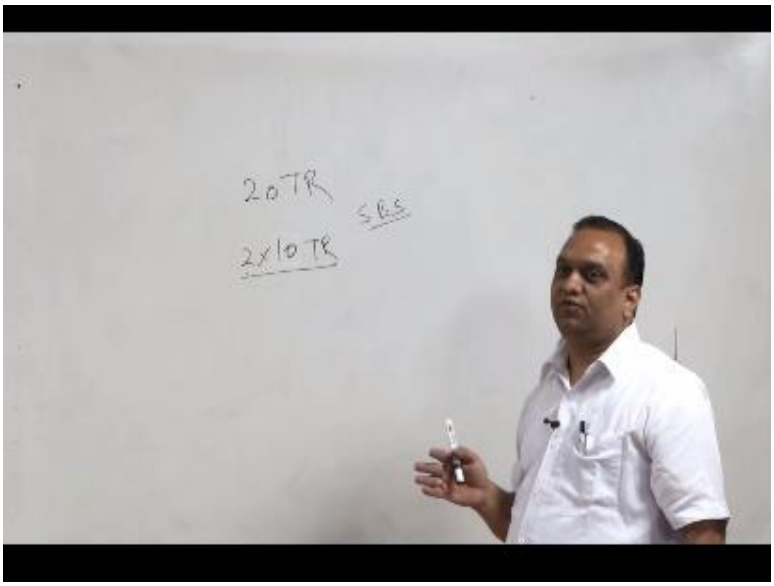

For a 20 ton requirement you are putting 10 AC's of 2 tons each this arrangement is first of all is not very energy-efficient system second thing is in this type of system there is no provision for fresh air supply these ACs are our manufacturer our proposed for small capacity cooling in a small capacity chronic means residential cooling in residential cooling through infiltration only it through infiltration itself you get or a lot of outside air inside the building right this is not possible sometimes in the commercial buildings and then again in the building sick building syndrome appears.

I have already explained you what is sick building syndrome signaling syndrome is the is a syndrome when you enter the building you feel sick and you feel sick because the quality of air in the building is not maintained effective temperature effective temperature.

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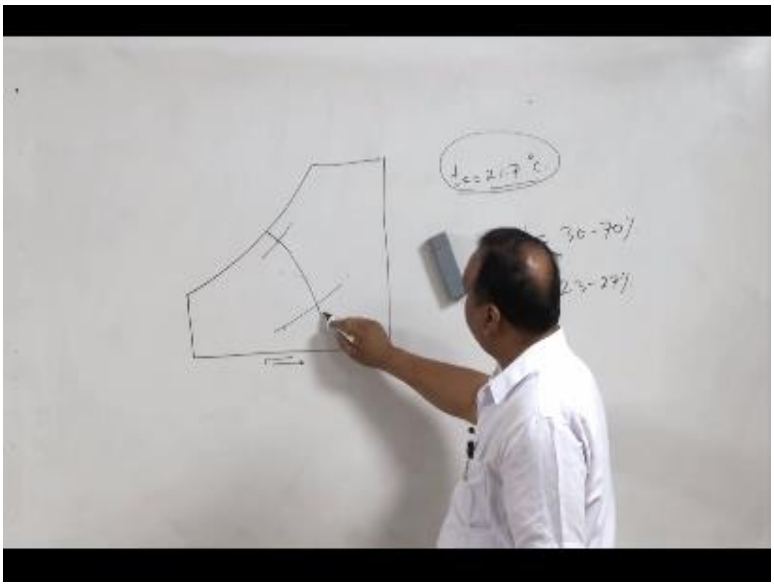

Of let us say 201.7 degree centigrade what is effective, effective temperature is the temperature of saturated vapor temperature of saturated vapor at which you get the same comfort feeling as you get in the case of twenty four point four degree centigrade and fifty percent RH and that temperature is 21 point seven degree centigrade and if you follow the effective temperature line it is like this if temperature is high effective constant comfort line this is this is this one if the dry bulb temperature is high you can go for lower relative humidity if the dry bulb temperature is low

If even if the humidity is high it will give you state of comfort I am NOT able to draw the with the proper intonation it is like this so if for the high dry bulb temperature you can go for lower relative humidity for lower rival temperature one can go for higher humidity and for designing an air conditioned conditioning system depending upon the outside condition we can take the range of relative humidity as 30 to 70 percent and temperature in a range of 23 to 27 percent but this condition with this should lie on this curve effective temperature curve.

3d space now for designing a system we do not have to maintain the temperature and humidity at the same time we have to maintain the cleanliness of the air also it should be free from the

pollutants so filters are provided and cleanliness I cannot simply say that this air is clean and this care is not clean it cannot be said in the simple and straight forward manner so the cleanliness, cleanliness of this piece is classified it is classified I will say it is a plus thousand the class.

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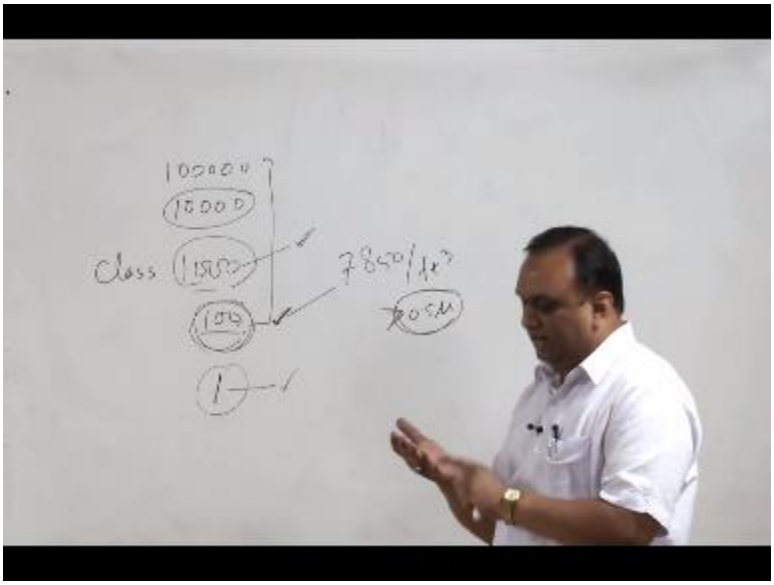

Class thousand air plus 100 air class10,000 air class one Lake here like this now what does this class mean for example suppose there are 50 particles per cubic feet of size greater than 0.5micron greater than size of the particle is greater than 0.5 micron the N number of particles is 50 per meter cube it is class hundred if it is 850 then it is class thousand if it is 7850 then it is class 10,000 now for the surgery room for the medical applications for the surgery room class thousand is recommended there is class one also your mobile chips mobile chips are manufactured in class one no particle has dimensions greater than 0.5 microns.

So it is free from any particle of this size and human occupancy is not allowed the moment you enter this room the class will change even for class 100 special type of suits are there one has to wear those suits before entering the class hundred environment otherwise the class of the environment will change so in order to this maintain so in addition to the temperature humidity the air movement and the cleanliness of air has to be maintained inside the building.

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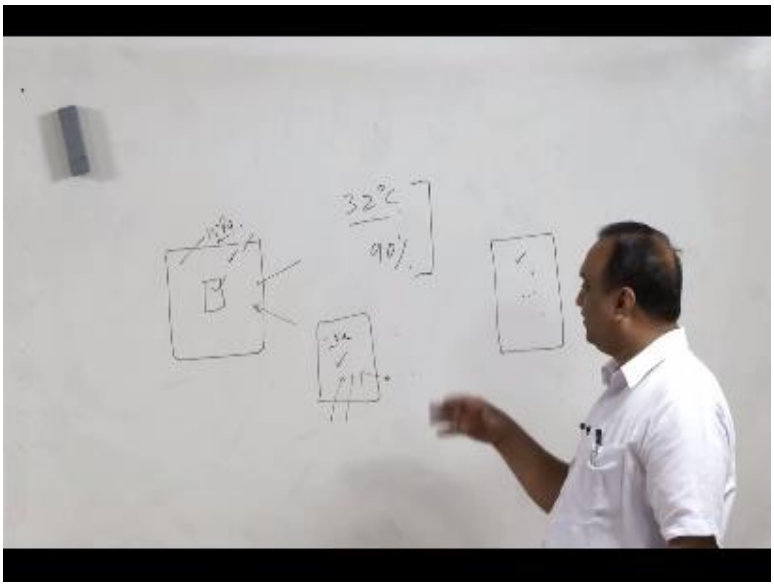

Now for medical applications special type of design conditions are there for medical applications for example there is a word for burn patient word for burn patient should have 32 degree centigrade temperature it those who burn patient should be kept on high temperature and humidity should be very high 90% you might not like to stay in this environment but burn patient should be kept in this environment so for medical applications for Hospital air conditioning very special type of arrangements have to be made.

For example there is a room where a patient is suffering from some contagious disease or immune suppression suppose a patient is suffering from AID She should not get infection or outside air should not enter this room what should we door another example on either extreme suppose in a desert there is a communication box it has a lot of electronics equipment and this box has to be dust free how to maintain this box thus free in, in dust environment how to maintain this room free from outside air the simple solution is.

These chamber shave to be positively pressurized we can positively pressurize a chamber up to 15Pascal by providing the excess air it is a centralized DC system excess air is supplied in the room and it is positively pressurized so that outside air does not enter the room and patient gets

infected another room another patient is suffering from some contagious disease so the people surrounding this room should not get any in any infection from this patient in this case negative pressure is maintained in this room and negative pressure is maintained is this room.

So the outside air can enter this room but inside here will not leave this room so this is how the air conditioning is done to those Hospital in air conditioning is very critical somebody should not or any patient should not get infection from some other patient so the isolation rooms and openings a special type of air conditioning is provided in hospitals anyway we have already completed the clean spaces now the buildings there is a lead design of the building yes lead you must part of this internship in energy and environment design lead.

And you must have heard that in Hyderabad or in Georgia or many other places on Bangalore they have LEED certified plated platinum building gold belaying silver building so these buildings.

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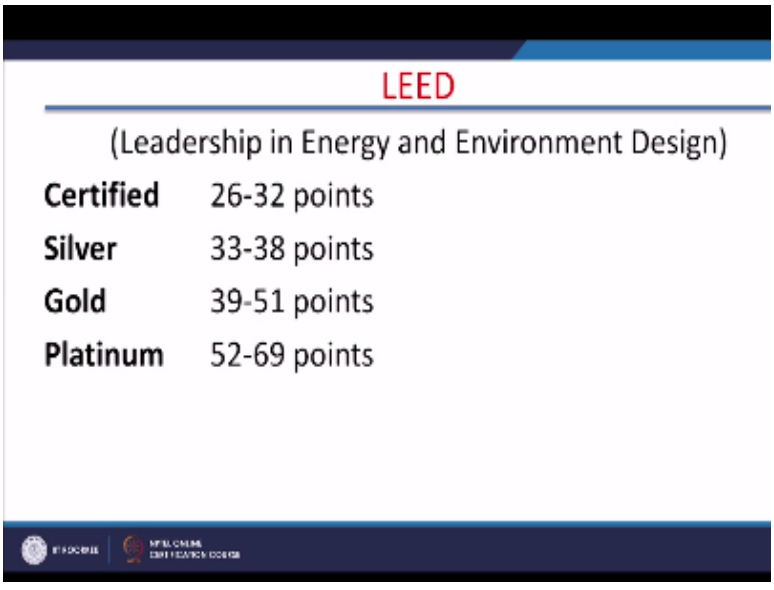

Are lead compliant buildings and LEED is a point system and for different activities there are certain points and for example there is a sustainable site for that it is there 14 points water efficiency you are not using potable water for gardening purpose.

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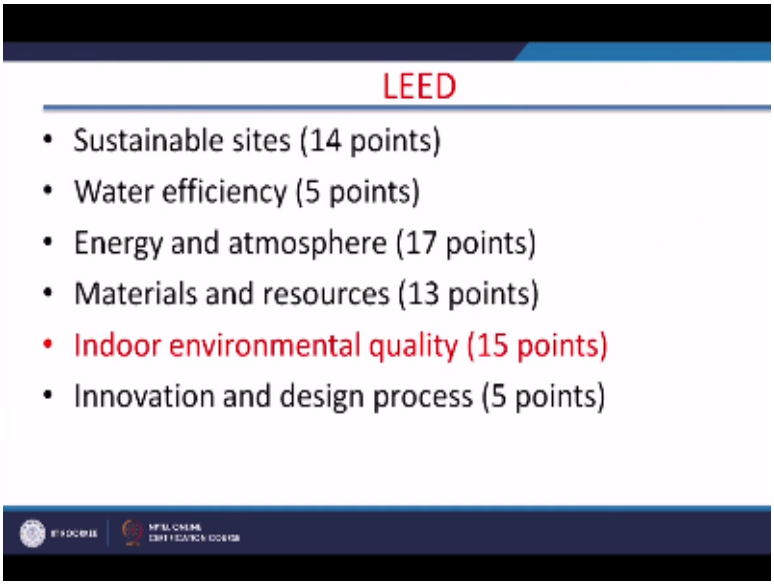

And there are many points on this that is water efficiency how efficiently the water is being used energy and atmosphere material and resources there thirteen point of material and resources indoor environment quality the 15 points are kept for this the next to the energy is another and environment quality and innovation and design process how you are using the local material how innovative you are in your design so all these point together they form 60.60, 69points and if any building else between50 to 69 points it is called a platinum building now sustainable sites there are certain sub points also.

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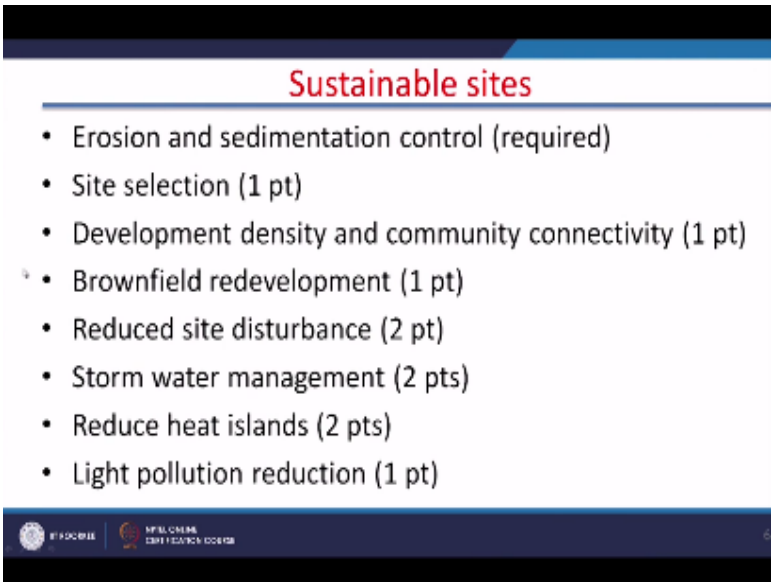

I will read them one by one quickly erosion and sedimentation control site selection development density and community connectivity, connectivity is also important because we are talking about the sustainable sites brown field development reduced size, size disturbance store water management reduce heat island light pollution light is also a pollution in urban pollution light pollution is, is also notice if the places are over eliminated that is not desired because in earlier days.

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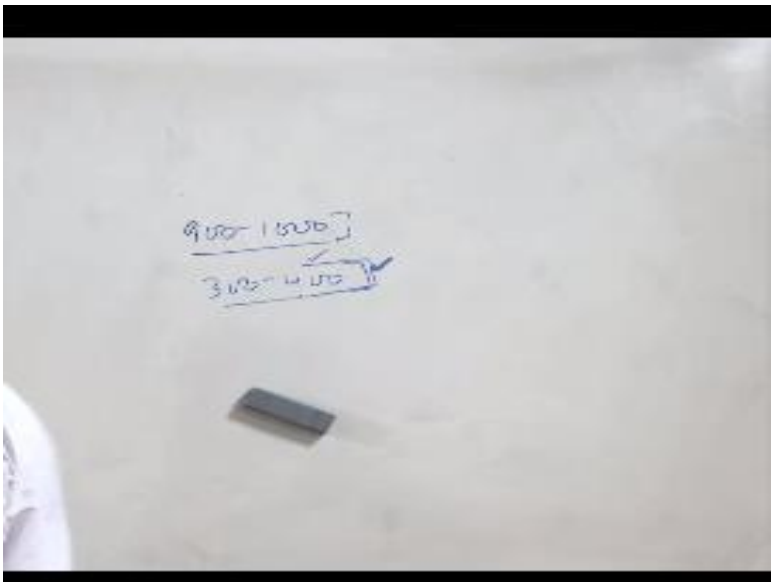

And over in liberated places they consume more energy also in earlier days in a room in a normal reading room the illumination was recommended around 900 mm lux nowadays it is reduced to 300 to 400because most of the time we are working on the computer and fine print outs are available so 300 to 400 Lux of light is sufficient for, for the office of its occupancy so this is how the energy can be saved and water efficiency water efficient landscaping.

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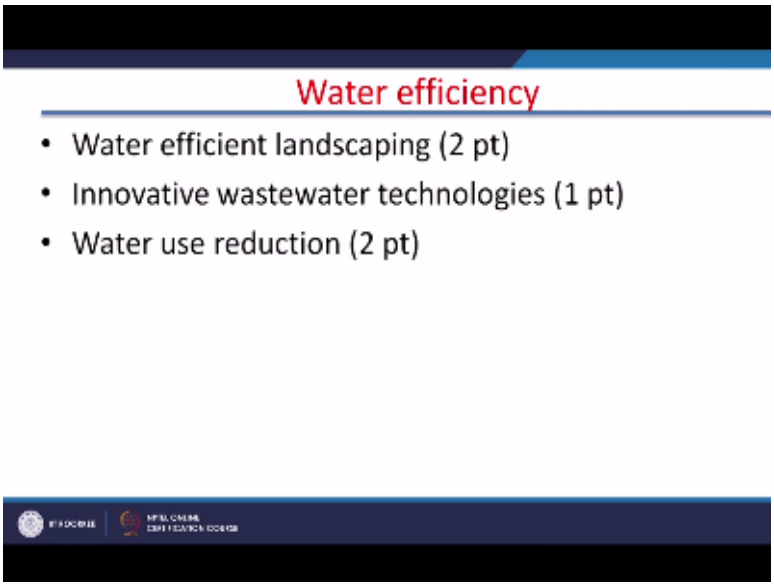

Water is used reduction is also it carries two points then energy and atmosphere.

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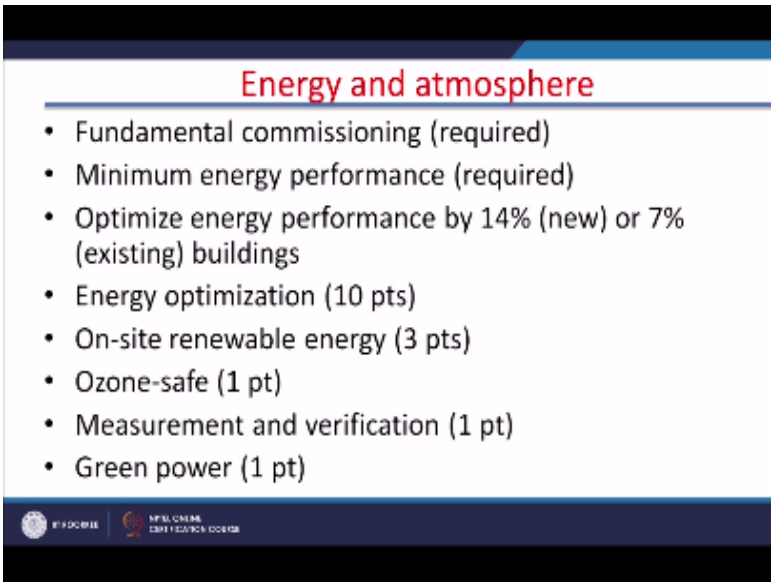

If you are using some ozone safe flutes or zone safe technology that also earns one point and green power is also given one point so there are many, many points in this and these accumulated points tons the building into this classification this is certified silver gold and platinum right and after the lead there are certain general design guidelines there thumb rules I mean they so the system cannot be designed using thumb rule thumb rules are just for cross verification we should do our analytical calculations and compare our results with these thumb rules and values are if venues are very close to each other.

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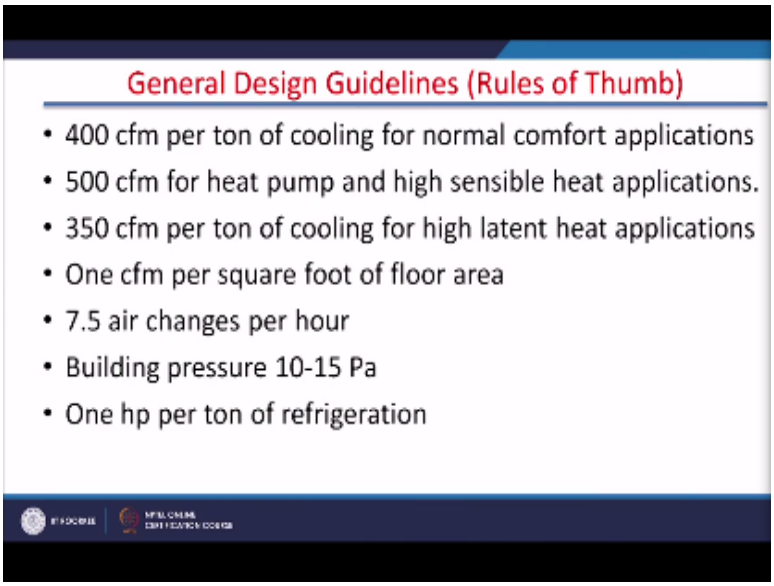

Then we say we develop a confidence in our design for example per ton of cooling400 CFM should be there but if you look at the split a/c or window AC if you look even if 110 or 1.5 Tennessee this requirement is not met but it does not mean their design is faulty so it is a rough estimate that in a centralized especially this is for centralized air conditioning system the 400 CFM per ton of cooling for normal comfort application 500 CFM for heating purpose three hundred CFM where latent heat is high for example kitchens, restaurants, dance floors, gymnasium.

Where I will explain later on how they contribute more latent heat because there a repose in the kitchen or in the restaurant so latent heat addition is high so 350CFM one CFM per square foot of floor area so if this is a room of 10 feet by10 feet so approximately 100 CFM should be circulation in the room normally if10 feet by 10 feet we are using one ton of AC then not, not 400 CFM into the window AC then it is going to be two hundred CFM 150 to 200 CFM but in any case it is more than one CFM per square foot of floor area.

So they are thumb rules so we don't have to design this is a bear in mind the width thumb loose we don't have to design the system but this is the values which are getting after designs they can

be cross verified for example 7.5 air changes per hour in a building should be done but normally in a building in a commercial building 7 to6 to 8 air changes are normally ensured building pressure 10 to 15 pasta that is pressure for pressurized building thermostatic expansion super heat should be in a range of 4 point 5 to 6 purposes.

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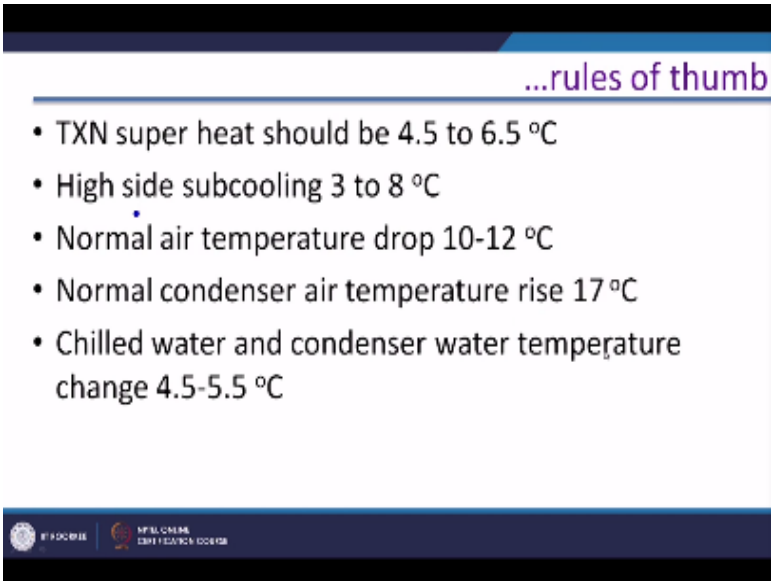

For expansion wall sub cooling before entering the expansion device 3 to 8°C normal air temperature drop 10 to 12 °C normal condenser air temperature rise because the air takes away the temperature from the condense of 17°C chilled water temperature rise or fall in a range of 4.5 to 5 5.5°C they are simply the rule of thumbs and but the value should hover around these, these values so this is all for indoor and outdoor design conditions more on indoor design conditions we'll be discussing on the subsequent lectures this is all for today now in the next lecture we will take up the cooling load calculations.

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