Illumination Engineering and Electric Utility Services
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Lecture No. # 08
Discharge Lamps – I

Yeah, welcome to this next lecture on illumination engineering and electric utility service.

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This lesson 8 you started discharge lamps one, in fact we looked at the artificial sources in lesson 7 employing the phenomena of incandescence which essentially looks at the materials being at a higher temperature. And here today we move on from the physical process of incandescence to the next level that is electroluminescence and we look at the discharge lamps employing electroluminescence.

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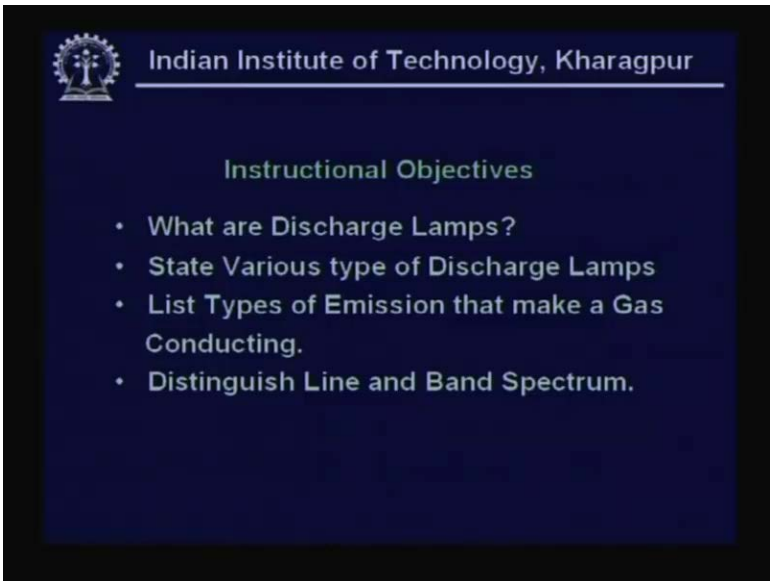

Though therefore the instructional objectives for this lecture would be what are discharge lamps, state various types of discharge lamps, list types of emissions that makes a gas conducting, distinguish line and band spectrum.

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So this is the issue that we are trying to use various physical processes, as already told in earlier lectures that one is the incandescent which we saw extensively in the last lesson employing tungsten filament. It has gone through several stages, in fact the Edison lamp was the incandescent lamp which depended on the filament material maintained at a certain temperature. Higher the temperature, higher was the radiation output however as already told any source we

employ should be able to give good efficacy. We define the light efficacy as the lumens per output of electrical energy because you remember that most of these lamps are being powered by the electrical energy and in fact tungsten filament and halide lamps which are in vogue these days come under the category of incandescence.

The next particular phenomena that is employed is luminescence or electroluminescence. And as already told it is the phenomena by which a radiation is obtained by creating a discharge in a gas or vapour by the application of electric field unlike the one in the incandescent where the filament material is heated. So, it could be at relatively lower temperatures. That's one of the reasons why the discharge lamp is more efficient compared to the incandescence source. In fact in going to the discharge lamps one may observe that there are certain radiations available which are not visible or they are in the zones where they are not normally visible, they can be made visible and that is the effect of fluorescence which is quite often used in our day today life. So we can see here we say that the combination of luminescence and fluorescence increase the efficiency. When we are talking about efficiency in a lighting system, we are talking in terms of the light output lumens per every watt of energy that is consumed. So it says increase efficiency of far beyond incandescence.

Now what is a discharge lamp? I am in fact in this lecture we are categorizing the lamps employing both electroluminescence or a luminescence and fluorescence both together under the category of discharge lamps. As we go along we see that fluorescent lamps are not any different from discharge lamps but the phenomena of obtaining visible light is different between the two. Discharge of electricity through a tube containing a conducting medium leading to electron flow. So essentially what you have, a large tube in which there is a gas which is ionized and made conducting. That's why we say it leads to a large electron flow. We know fundamentally any conduction is the process of electron flow and the field is applied and as already told of the three processes in fact incandescence is the one which produces light radiation output in terms of energy which is quite close to the natural light that is sun and a continuous spectrum is found whereas discharge lamps tend to give you a line spectrum or band spectrum. So this amounts to saying that in order to have a good radiation output, one needs to have a large number amount of electrons available. So all these lamps depend on electric discharge between two electrodes which are maintained, needless to mention as I have been stressing earlier also the electrodes (Refer Slide Time: 00:06:40) could be similar to your filament in an incandescent lamp.

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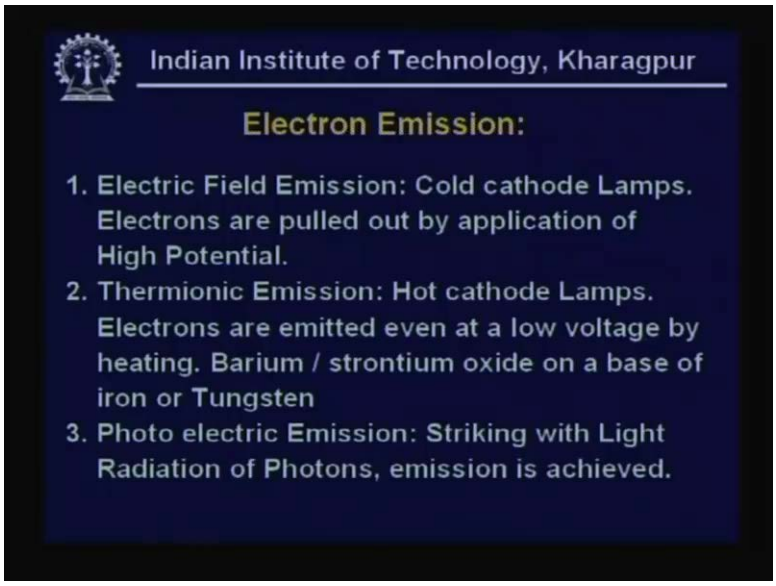

So, electron emission is fundamental to the whole process. Now how does this electron emission take place? This electron emission can take place through a variety of processes; in fact the first of these is what we call electric field emission that is emission of electrons sheerly by application of electric field. These are also called cold cathode lamps, in fact all of us who have gone through one course on electronics know that if you have a gas tube a two electrodes placed, one positive another negative we call the positive electrode as anode and negative electrode as cathode. It's the negative electrode which emits the electrons and thereby directed towards the positive electrode forming the conduction current in a gas tube. And the electric field emission essentially depends on the pulling out of electron by the application of high potential and since the cathode is not heated, the lamps employing electric field emission are termed cold cathode lamps, they need to operate at a high potential.

Another issue which often comes is the length of the discharge tube. Remember that once the arcs strikes anybody who has done a little bit of electrical engineering knows that arc is a sort of a constant current phenomena and therefore it has a tendency to have a reasonably small voltage drop and therefore it is you can find that if you have a cold emission, it has to be at higher potential and therefore length of discharge tube also becomes reasonably high. And remember that the length also gives an idea of the length of the source or the radiation output.

As opposed to cold cathode, we do have what's called as a hot cathode lamp which in fact uses thermionic emission and which has been the phrases of gas tubes working in as switches in the very beginning, in fact this electrons are emitted even at a low voltage by heating and invariably these electrodes or cathodes are made of barium or strontium oxide on a base of iron or tungsten. So we have electric field emission or cold cathode lamps, they need high potential and the hot cathode lamps or thermionic emission which can even operate at a reasonably lower voltages and there is yet another process by which one could do. That is by subjecting the cathode to photons, photoelectric emission striking light with light radiation of photons emission is achieved.

These are the three processes and in fact as already told to you the spectrum obtained from these discharge lamps is not continuous like an incandescent lamp and therefore is not very close to the natural sunlight and may not be all that good in sense of being able to observe the objects in the real sense. Remember when we are trying to get fine details may be necessary to get the complete picture that means there are other parameters that need to be included. However the discharge lamps have been applied initially in the street lighting and in the early days the street lights were basically operated in what was called a series mode. If a street had about 10 lamps, the idea would be these 10 lamps would be in a series connection that the entire voltage is dropped. So you could in fact 10 tubes together in series were operated at a single source, they could be operated at a high potential. Therefore you had what is called as a cold cathode scheme there whereas these days when you are operating most systems in fact when we talk of a system these days, we talk about operating a system at a particular voltage at a particular frequency that means we try to operate at a constant voltage mode therefore you may have to operate at a low voltages and therefore thermionic emission is more or less the order.

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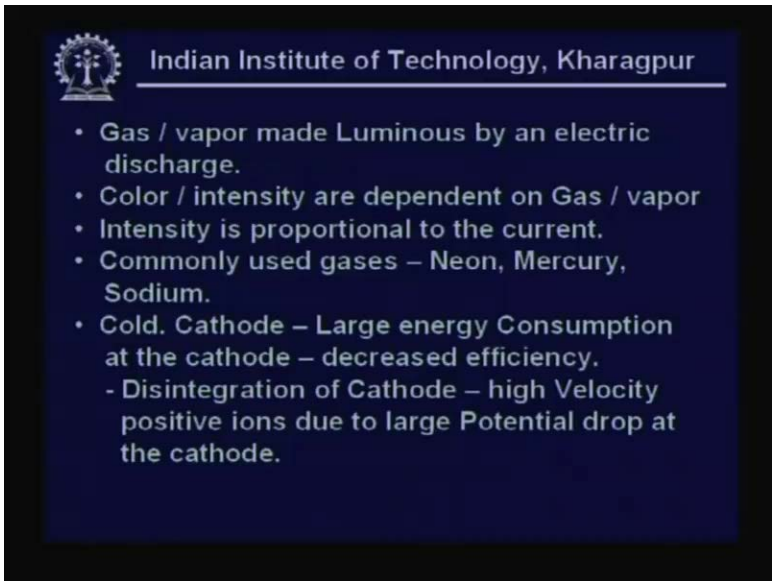

Now in these lamps what do we have? We have a gas or a metal vapour which is made luminous by an electric discharge. Now how does the discharge arise? After vapourization of the gas, it is by the conduction. Now the conduction could take place by the electronic emission which could be field assisted in the case of a or electric field emission which is the cold cathode kind of a thing or hot cathode thing where a thermionic emission of the heating of the filament does the trick. Now when we saw the incandescent lamp, it was more or less giving close to white light similar to the sunlight which was possible and continuous spectrum.

However when these gas vapours are made luminous, of course when we say incandescent lamp gives white light, we assume that the envelope or the bulb in which the filament is enclosed is transparent in nature. No doubt, in order to get various kinds of coloured lights these days several I mean coloured glasses are employed.

Now for a gas lamp therefore colour or intensity depends on the gas or vapour. It is the gas or the vapour that is employed decides the nature of the or the colour of the radiation. For instance when you have a neon lamp, neon gives rise to a red colour radiation. On the other hand if you had a helium, we will get pinkish or thing and mercury is known to give bluish colour and the sodium vapour which is quite often being used these days, sodium is a metal vapour in fact you have mercury or sodium which are metals which are essentially vapourized state you give. Now these are not normally gasses, mercury is a liquid, sodium is a solid which is vaporized. Now the intensity of the radiation is no doubt proportional to the current, now among the common gases that are used neon, mercury and sodium.

In fact we have observed neon being used extensively for the display purposes, sign boards, market places and certain important buildings. Mercury and sodium have been extensively used in fact they are used for street lighting and some large industrial lighting. As already told cold cathode is one which depends on application of the high voltage and emission, pulling out of the electrons from the cathode no doubt because of higher voltage application there is intense energy consumption at the cathode and as a result sometimes there is every likelihood of disintegration of the cathode. If there are high velocity positive ions and all this also leads to what we call the electrode drops or the potential drops at the cathode and this sometimes leads to blackening at the electrode tips. As we saw, we recall in the case of an incandescent lamp to do vapourisation of the filament material, the convection currents we could see the tungsten deposited especially in the, what we call vacuum lamps or type b lamps. The tungsten gets deposited on the top of the envelope and this could be taken care by introducing certain rare gas like argon.

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This blackening of cathode and therefore calls for long discharge tubes and so keeping this in mind we look at the mercury vapour lamps which are extensively, there are two categories of a discharge lamps which are of importance, one is mercury the other is sodium. Mercury in fact because it's got the radiation located around blue region. In fact light due to mercury vapour is bluish green and its deficient in red rays because of which the colour rendering is very poor.

Colour rendering we will understand when we go into another lecture, it means supposing I keep an object in an incandescent lamp which is normally red in colour I would observe that to be red. What we mean by a red colour object? It basically absorbs all other colours in the spectrum and reflects red colour radiation.

Now because of the nature of discharge lamp radiations being not a continuous one as in the case of an incandescent one, they tend to do not give good reproduction of the colour of the object. This is what we call by colour rendering and the colour rendering is talked in terms of a qualitative as well as quantitative indices which will be taken up at a later point in one of the lectures and therefore it's also known to distort colours. In a mercury vapour lamp we have at the oxide coated cathodes and we do use in fact it becomes necessary to avoid blackening and avoid long lengths for discharge tubes and to be able to operate at low voltages to employ thermionic emission.

As I told you the two processes that are possible are cold cathode and hot cathode and this can be taken care by having thermionic emission, we have tungsten wire filaments based on an electrodes which are made of strontium oxide or a barium oxide located at the opposite ends of a glass tube that's the philosophy. So we have two electrodes because remember that the supply or the electric supply is alternating in nature. So the two electrodes alternate as cathode and anode, this has to be borne in mind and thermionic emission needs heating of the cathode. This heating is obtained by a coiled tungsten wire which essentially is similar to the filament in an incandescent lamp. This is why in the last lesson we were stressing often that the understanding of an incandescent phenomena is very important and thermal radiation becomes fundamental to all kinds of sources that are employed.

So, what we see is a mercury vapour lamp is essentially a discharge lamp which contains a liquid mercury which is vaporized on application of the voltage and on application of the voltage apart from the field being created, there is a thermionic emission because of the heating of the filaments at either end. And as already said, this has got a characteristic bluish green colour and in fact this is a line kind of a thing. What is observed as the spectrum goes is that with the increase in pressure of the mercury vapour, the band or the peak radiation shifts from bluish green to yellow green. Yellow green is incidentally our sensitivity of the eye is at a maximum that is why high pressure mercury vapour lamps are preferred.

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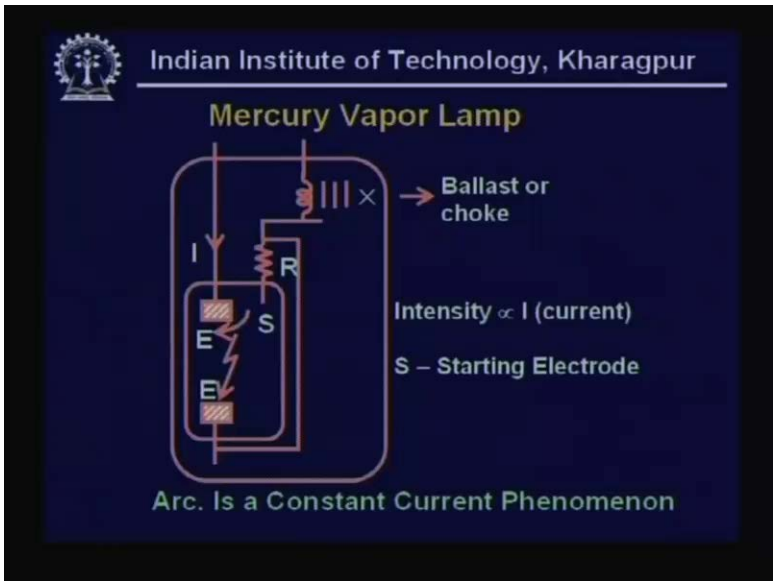

Now this show a picture of mercury vapour lamp. In principle though it says it's a mercury vapour lamp, this is the complete scheme of components available in any discharge lamp. What one says is there are two electrodes which are called the main electrodes. As already told they could be made of barium or strontium oxide on a tungsten base and along with they will be having coiled tungsten wire filaments which heats and release the electrons when a particular electrode acts as a this thing. Now remember mercury is in liquid state and therefore mercury is vapourised and the discharge takes place within the vapor. So we do have a starting electrode in the diagram given there S through which the current is controlled by a current controlled resistance and the other condition that's necessary for an arc to occur is the voltage being enhanced. This increase in voltage is obtained by the auxiliary which is often known as ballast or choke, ballast.

Why is it called ballast? It basically takes care of raising the potential across the two electrodes and subsequently it maintains a constant current across the arc, in fact the current remains more or less constant during the discharge process, the radiation is obtained. However as already told, our supplies are all constant voltage. So this difference in voltage acts as storing energy in that and ensures that constant current is maintained even though there are certain minor variations in the supply voltage. So, no matter what is the discharge tube all of them have these components.

So, you have two electrodes may be a starting electrode in fact we do find when we move on to sodium vapour lamp that to vaporize the sodium, we create a initiating process by having initiating gas as argon small amount of argon which has a low ionization potential which ionizes and thereby because of those ions, we have a secondary emission or ionization of the vaporisation of the sodium. And we have the ballast or an auxiliary, they are in the thing.

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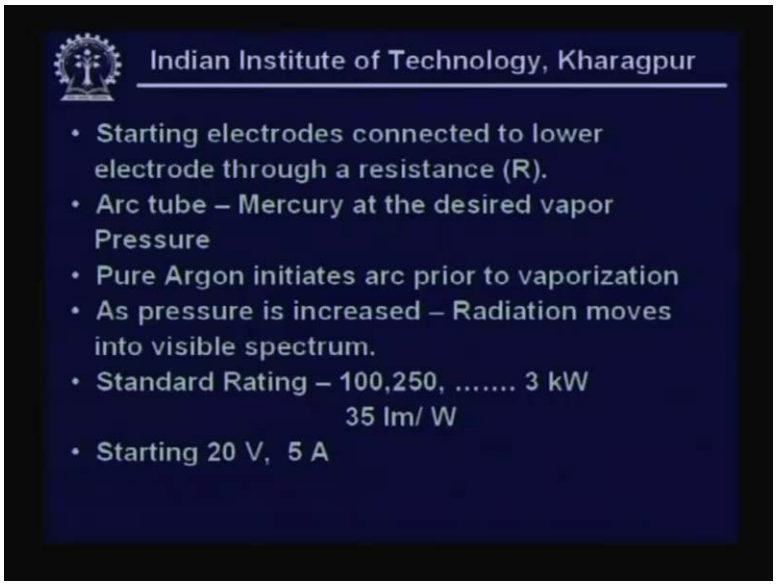

So, starting electrodes are connected. Initially there is a connection between the starting electrode and the lower electrode and so that is how mercury at the desired vapour pressure is already maintained. I have told that the mercury vapour in the liquid form at the desired vapour pressure is located in one corner of the tube and pure argon as told you they needs to be some way of initiating the vaporization process. This vaporization is obtained by having another gas which has got a low ionization potential. We have seen these used even in incandescent lamps and that had enabled in reducing the, what you call blackening of the lamps.

Now we find that as I told you this has got a line spectrum with bluish green, radiation colour improves because it moves to the central of the spectrum which is closer to the peak sensitivity of the human eye. If you look at the lamps that are available, we find that they are in the standard ratings of 100 watts, 250 watts and up to about 3 kilowatts. As already told most lamps are talked in terms of the wattage of the lamp and the voltage is more or less known to be constant, nominal voltage of most of our lamps has to be 220 volts which is the single phase supply which we use and this is the wattage. Once we know that this is the energy it consumes, depending on the nature of the lamp we know what is an efficacy and we can work out the light output. This mercury vapour lamps are known to give about 35 lumens per watt with a voltage as low as 20 volts across the electrodes and a current of about 5 amperes.

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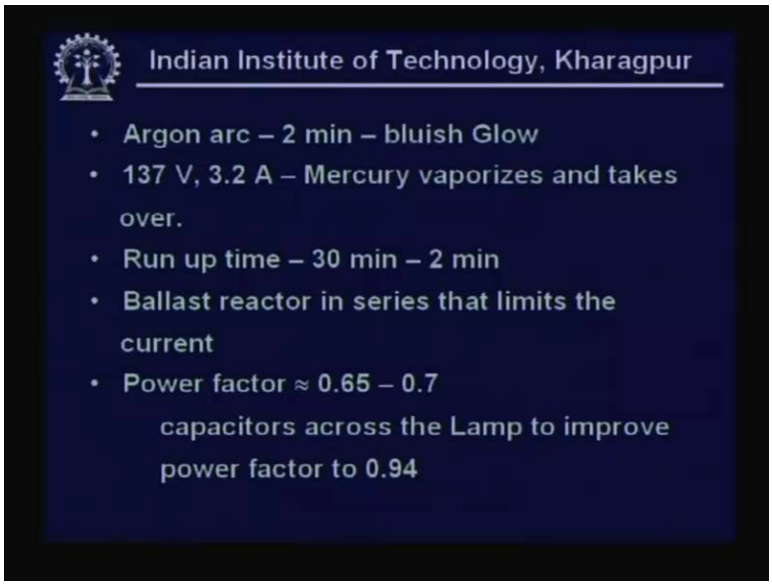

See initially the arc is basically because of the argon and this may last for about 2 minutes with a bluish glow and later on the mercury vaporizes and takes over. Now depending on the thing the early day mercury vapour lamps would have very large run up time, run up time is basically a time required from the time you switch on to the time when mercury takes over. This could be as high as 30 minutes but today we have powerful lamps which can pick up in no time that is in 2 minutes and the ballast reactor or the inductor we have shown, it's also called as choke, ballast nothing but a inductance coil often times air coat whereas we will find when we go to the fluorescent lamps which employ the fluorescence phenomena.

It must be mentioned that there are also kind of a discharge lamps only. They are again it is a mercury vapour and they limit the current and being inductive in nature, the power factor is low. We find the power factor is around 0.65 to 0.7 and often times capacitors are provided across to improve power factor. Let us recall the power factor essentially tells us how much reactive power is required from the system. Now if the power factor is low which meanings for the same power output, more reactive power is required number one which in turn translates as higher line currents. Higher line currents would mean higher cross section of the conductors or the wires that means not only higher cross section of the conductors and higher currents, it also means larger drop in the lines which means there is a danger of the lamp not lighting gap for a want of a required voltage. These are some of the issues one has to keep in mind.

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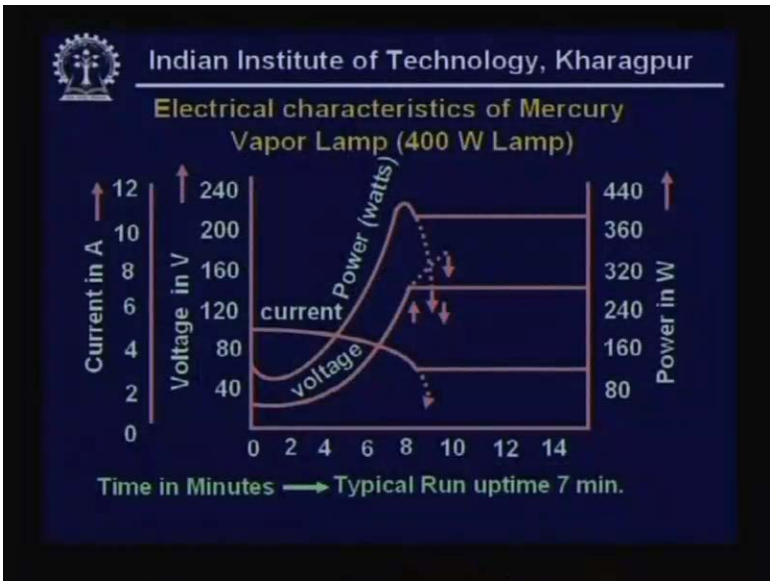

Now let us look at a typical 400 watt mercury vapour lamp characteristics, you can see typically the time in minutes is marked. As you can see the horizontal lines, there are 3 horizontal lines for the voltage current or power curve essentially show the steady operation. As can be seen in this particular lamp has about 7 to 8 minutes of run up time where the current builds up, the voltage takes over and maintains at the constant level of 120 volts drop across the thing and we see power consumption is around 400 watts.

Now these are the voltage current relationships. The three curves, you can see the current stabilizes around 5 amperes, this run up time is what we mean by the time, from the time you switch on to the time when the arc is established unless the arc current develops there is no radiation that period is the dark period. Then the other issue which is often taken care or needs to be taken care is should there be a power failure I mean should there be a power failure or you switch off the lamp. Now does it immediately restart or it has to start from cold condition, in fact most discharge lamps need to start from cold therefore there is what we call a restart time. If you look at the manufacturer's catalogs, you will find start uptime or run uptime and restart time.

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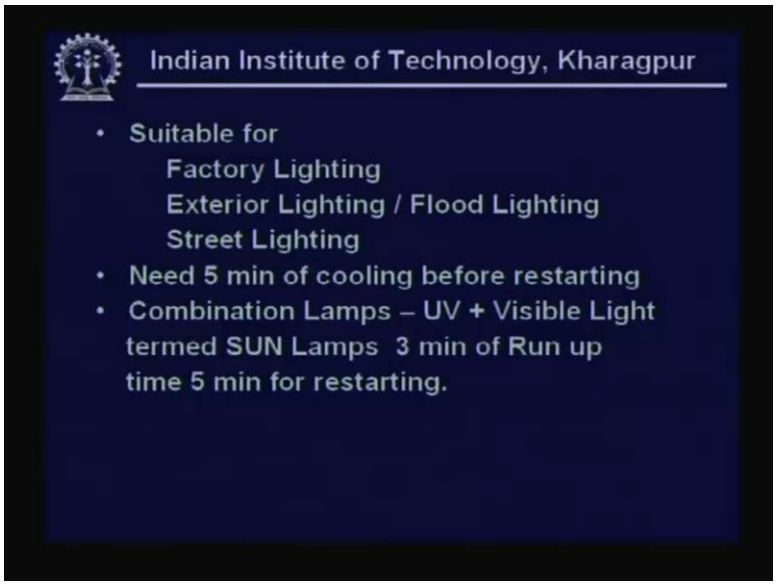

Stating, having said all this these lamps are quite suitable for factory lighting, exterior lighting, flood lighting or street lighting. When we say factory lighting, it's not suitable for all kinds of factories. The assumption here is this is a large scale factory where the large objects are being built where you really do not need good colour rendering, colour rendering is poor I said, street lighting, exterior lighting. And as already said they may need typically 5 minutes of cooling before restarting the whole process and its being found that this mercury vapour has one band spreading around the 500 to 570 nanometer spectral wavelength range and at another band of radiation located between 300 to 400.

Recall that the entire visible spectrum I mean entire light spectrum can be divided into three zones, 1 - the ultraviolet zone, 2 - the visible zone, 3 - the infrared zone. Now supposing we make the ultraviolet zone available for visible, converted into visible spectrum it would be quite useful for our applications and that is what is done in the fluorescent lamp but all of us are also aware that uv lights have been used for therapeutic effects. In fact most of us are using the water purification systems these days which are based on uv light and for therapeutic purposes, these watts available as combination lamps where uv plus visible light were put together and these were called sun lamps. They were used for therapeutic purposes and this assumes that the mercury radiates around the thing with the peak around 365 nanometers uv's region. Now this lamp does not have any material which uses fluorescence that's the difference between this sun lamp and the fluorescent lamp.

Fluorescent lamp what we call has some phosphors or a fluorescent material coating the interior of the glass envelope and thereby this radiation when it strikes there becomes visible. That is the process by which the light is absorbed at one wavelength and reradiated at another wavelength that's what we call fluorescence and in fact sun lamps are used for therapeutic purposes. So, we have seen that in essence a discharge lamps works on the principle of electric field emission and which is made conducting. The electric field emission could be using a cold cathode condition that is by sheer application of high voltage or hot cathode condition wherein you apply very high

I mean you heat the filament and thereby release the electron and make the vapourized gas or vapour conducting.

As already told the gases that are normally used is neon which is extensively used only for display science. Then the mercury vapour lamp we have seen which is often employed for exterior lighting or flood lighting. Now the requirement to move from incandescence to discharge lamps have been, one to be able to operate at a lower temperature and get higher radiation efficacy that's the very important genesis, remember that. The same kind of output from an incandescent lamp would call for immense temperature rise in the environment. Having said that about mercury vapour lamp, let's look at the sodium vapour lamp which is just as high pressure mercury vapour lamp, just as it's been in the high pressure mercury vapour lamp instead of mercury we have sodium.

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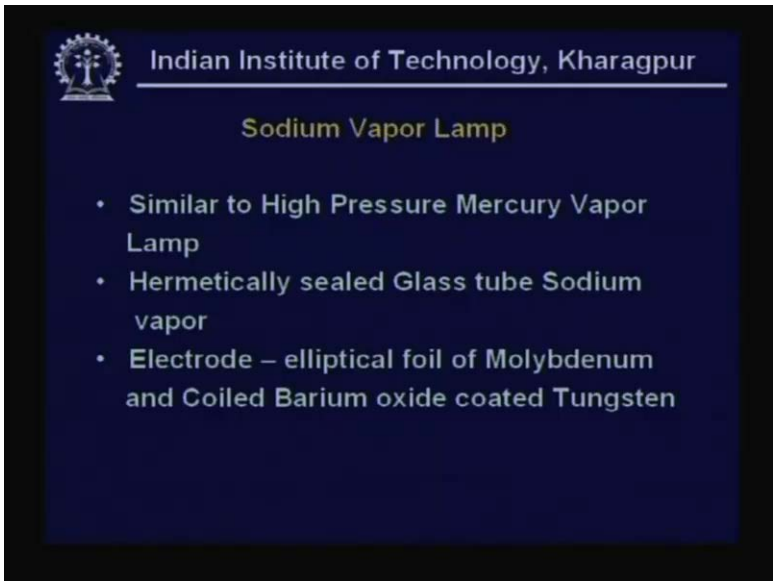

Mercury was in the liquid state, on the other hand sodium in a solid state which can get vaporized pretty easily. This is sealed, hermetically sealed in a glass tube just as it. Now here again we have two electrodes, one which can act as cathode and anode depending on the half cycle to which it is applied. These are made of elliptical foils of molybdenum and you have barium oxide coated tungsten on top of this on the base.

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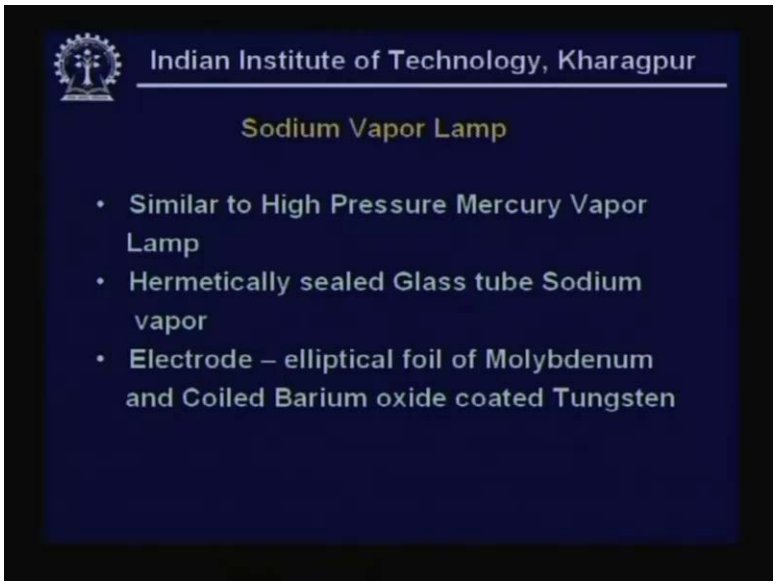

This is the electrode and so if you have recall the picture we saw of the discharge tube, one half cycle tungsten at the top acts as cathode, molybdenum at the bottom acts as anode that means each of the electrodes, each of the electrodes recall that they had a foil of molybdenum and barium oxide coated tungsten.

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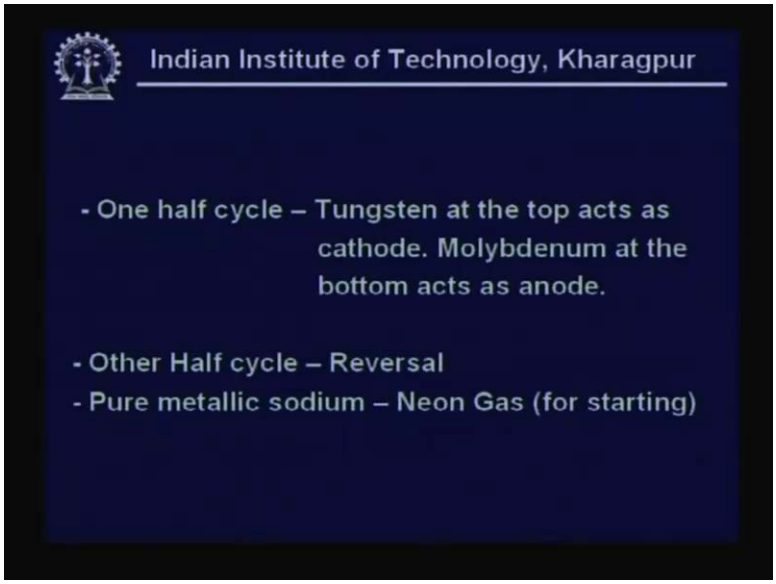

So the tungsten acts as the cathode and the molybdenum acts as anode. If the tungsten at the top acts as cathode in one half cycle, molybdenum at the bottom acts as anode and in the other half cycle the whole process reverses. The metallic sodium is placed and there is a starting gas in fact in the mercury vapour lamp, we had argon as the starting gas. Here we often have neon gas,

though the first who are been living in metros have seen when the street lights which are employing sodium vapour lamps are switched on, if you are happen to be there say in winter time around 530 types, you will observe the lamps glow reddish to begin with. This is because as already told to you, the characteristic colour associated with neon discharge is reddish and that is what is observed and we have already said the sodium has a characteristic colour of yellow.

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Now, this is not a cold cathode kind of an emission, it calls for a thermionic emission. A cold cathode emission is normally not adapted. The reason is very simple, you need a very high starting voltage number one. Number two, very high starting voltage, number two is there could be large potential drops at the electrode tips that is cathode or anode and this could be counterproductive in terms of the life of the discharge tube. And therefore the thermionic emission is more or less the order and therefore heaters are required to preheat the filament with and these heaters are part of the lamp. In fact we will know that the accessories required for a fluorescent lamp may be placed outside the lamp whereas most of the things are in built within the discharge lamp as far as mercury vapour lamp and sodium vapour lamps luminaire comes with complete housing where all the accessories can be provided. The point to be noted here is heaters are part of the lamp; it is in the gas envelope itself.

Now so it starts with a red colour because initially the neon vapour has a neon discharge takes place. Subsequently when the sodium vapour takes over, you find characteristic orangish yellow arc and in fact this being in the central region where the sensitivity of the eye is a maximum which has got a good application efficacy but remember this also gives a line spectra. These are the some of the issues to be kept in mind. Now let us look at some of the, let us look at the various sources we have seen and how their energy distributions can be considered and what sort of efficacy is there in terms of a light considering the response of eye.

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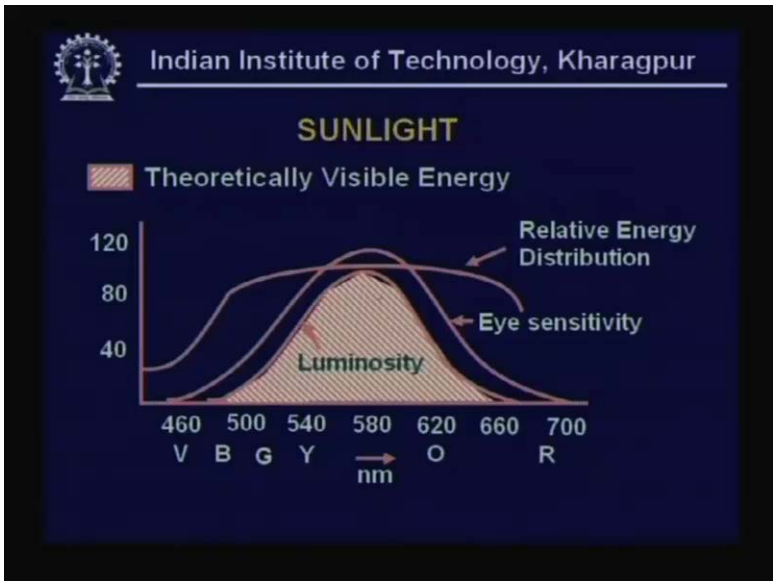

Let's look at the natural sunlight. We have three curves shown here. One is the relative energy distribution of the sunlight, it's marked in terms of percentage, the peak percentage corresponding to the maxima around yellow green zone. One could see carefully that it is that is more or less flat over the visible zone and on the other hand the response of eye is marked as eye sensitivity and there is a third curve which is hashed curve. In fact there is a legend which says the hashed region corresponds to the theoretically visible energy. This is the energy visible due to sunlight to the human eye. The eye sensitivity curve tells us the response of the eye to various colored lights due to the … So how does one obtain the luminosity of sunlight? This could be called the luminosity of sun light, one obtains by multiplying the relative energy distribution curve with the eye sensitivity curve and that is the thing.

So in principle the overall area is the idea of energy of the radiation that is made visible. So it's very clear that the most of energy that is available is continuous I mean you are able to see throughout the spectrum for this sunlight.

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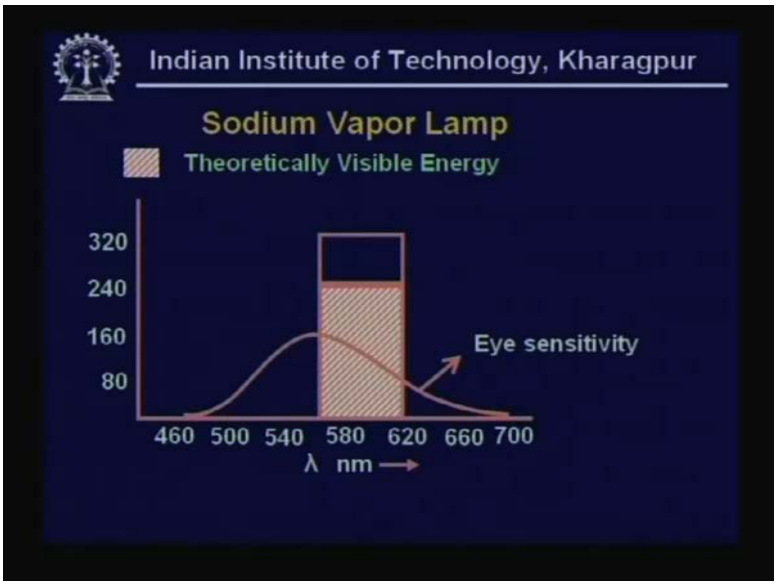

Now let at look at this for a sodium vapour lamp. The sodium vapour lamp what do we observe? In fact the eye sensitivity curve, bell shaped curve which we saw in the previous one is still there with a peak around 550 nanometers. Now what do we observe between 560 to about 610? you have a histogram, the bigger one corresponds to the total energy distribution due to sodium vapour lamp that means this is the region where the radiation due to a sodium vapour lamp exist and when you multiply this with the eye sensitivity curve, this results in considering the overall energy and on a comparative basis with the respect to the sunlight, the hash zone which shows the theoretically visible energy.

Now having got these two, one can talk in terms of the utilization of energy of a source. That is what is, we never talk of utilization of an energy of a source because more or less the entire spectrum is usable in case of a sunlight or an incandescent lamp but as regards the discharge lamps we talk in terms of that, you could observe that the very little portion of this sodium vapour radiation is not visible. This will become clear as we go along.

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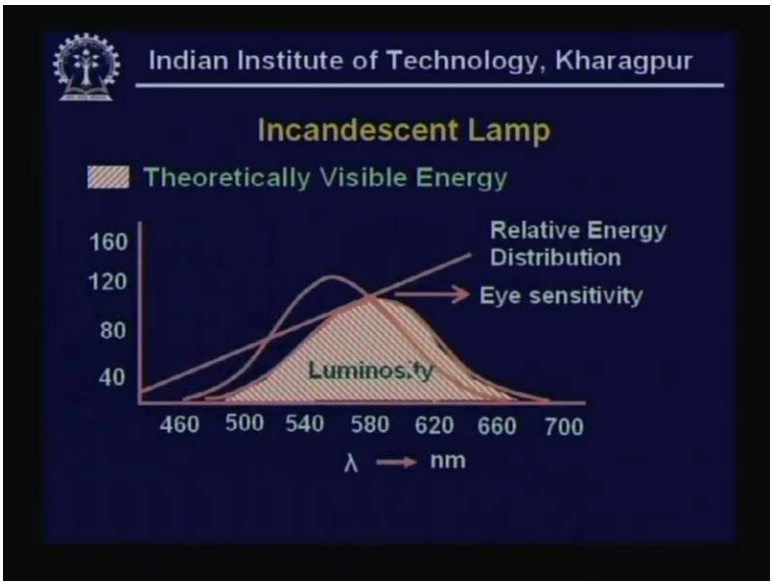

This is for the incandescent; we have seen the relative energy distribution. As can be seen higher the wavelength higher is the energy available eye sensitivity, so you find which is more or less visible energy is somewhat similar to what we obtain in the case of sunlight whereas the low pressure mercury vapour lamp has two bands, one in the uv zone.

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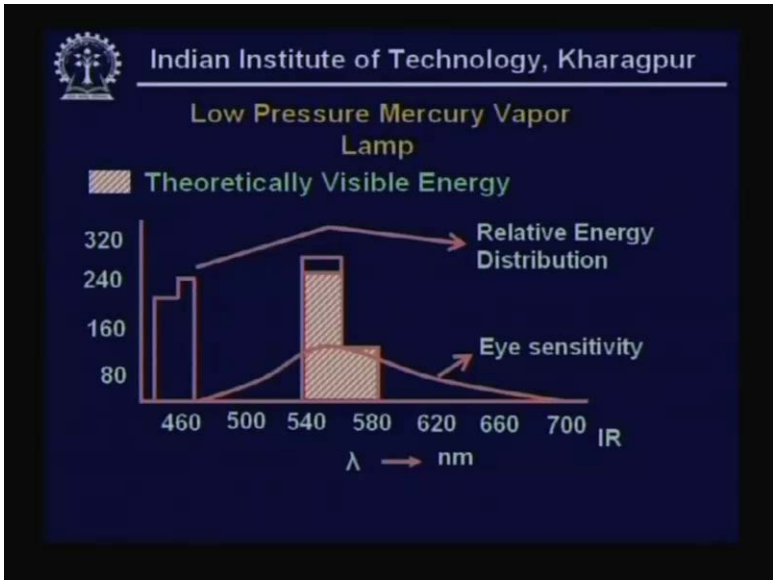

In fact that is why we were talking about the uv zone and the other in the blue yellow green region. And the eye sensitivity you know the previous curve, the bell shaped curve and seeing the whole thing we find that there is hardly any energy available radiation usable in the initial zone which is falling mainly in the uv spectrum whereas in the mid region we have, so this is

how one could talk of utilization of the energy radiation available. That is why we said the for the sodium vapour lamp we do have a very high level of utilization, very little energy is left unutilized.

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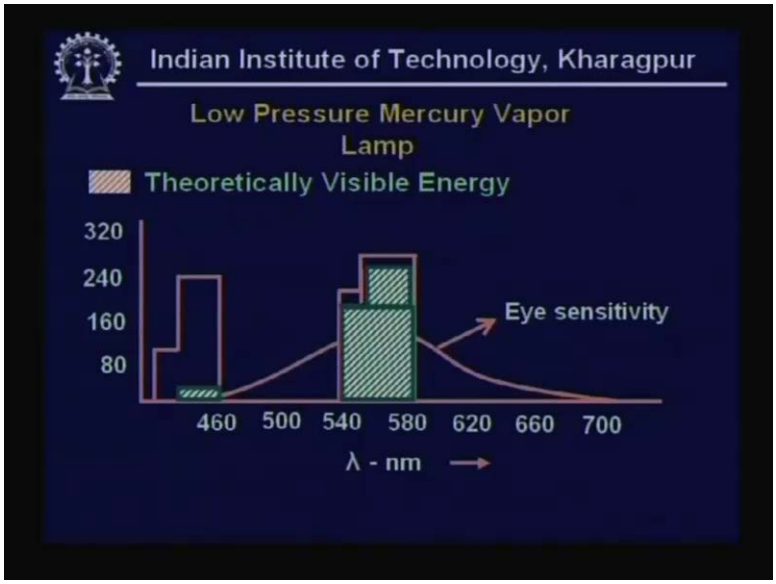

When you come to look at the high pressure mercury vapour lamp, we find on a comparative footing to the low pressure mercury vapour lamp is a little more in the, because it is shifted from a little bit more towards the central zone where the eye sensitivity is a maximum. So having said so much, what is it we have seen? We have seen that the discharge vapour lamps are no doubt having good efficiency in terms of light output but the utilization point of view of the two commonly employed discharge vapour lamps that is mercury and sodium, it is the sodium which has got a higher utilization factor and therefore it is fast replacing most such applications where mercury vapour was in vogue earlier.

Now all these lamps are employing the conduction through the vapour or gas and therefore it calls for vaporization and therefore they are requiring having a starting gas which was either neon or argon. Argon in the case of a mercury vapour and neon in the case of a sodium vapour. Now since arc discharge phenomena is a constant current phenomena, to maintain the current level with minor variations in the supply voltage there is a need to have some kind of a impedance in series to control this and that is obtained in the form of a ballast or a choke. Now the emission perceived could be cold cathode, hot cathode or photonic machine.

However we said cold cathode relies on very large voltage being applied and has large drops at the cathode or anode and known as electrode drops. Therefore not a very convenient thing and hot cathode is more or less common. And most of these the moment you say hot cathode, you have some kind of a filament which is heated by the passage of current. So these are the some of the accessories that are necessary.

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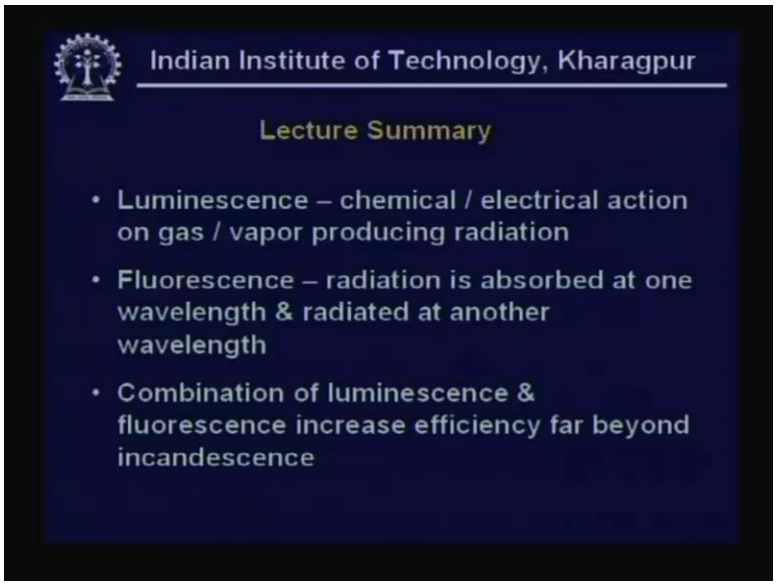

So in essence we observe that the luminescence is what is being used in all these discharge lamps, they have the electrical action on a gas or a vapour producing radiation. Now we saw the radiation has a certain colour, it's not a continuous spectrum as it was in the case of a natural sunlight or incandescent lamps. It produces a band spectrum or a line spectrum. Now the colour perceived depends on what? Depends on the material used. We saw that if you use a neon gas we get reddish, in fact to get other colors as already told even in case of an incandescent lamp which gives out clear white light is to have envelope, glass envelope which is made of different colors, the combination could give the required colour.

However since the spectrum is not continuous, the colour rendering is not good. Colour rendering is nothing but reproducing the colors of object, in totality colour rendering is very poor and colour distortion is high in this discharge lamps. Fluorescence is the radiation obtained at one wavelength and radiated at another wavelength. In fact this is what we observe that when we saw the spectral energy output on a mercury vapour lamp, we find that it has a band in the uv zone as well as a band in the mid spectrum.

Now we find that as such a discharge of the radiation is utilizing only 50% flows to 40 or 50% of the energy radiated available, as we know that our eyes are not sensitive to uv, ours eyes are having maximum sensitive around 550, 560 nanometers. This being the case, in fact fluorescence will be the topic of the next lecture which is nothing but again a discharge lamp allowed to radiate in the uv zone, we saw that both low pressure and high pressure mercury vapour lamps do radiate in that region. In fact that is where your sodium vapour lamp was scoring because its radiation is centrally located with the peak sensitivity of the human eye and therefore utilization factor is higher. Now the combination of luminescence and fluorescence gives much better efficiency, this is the reason why we say we get better efficiency. In fact when we look at the fluorescence, we will make a calculation of every watt that goes in how many watts are really used up in getting the useful radiation output so that will become more clearer then.

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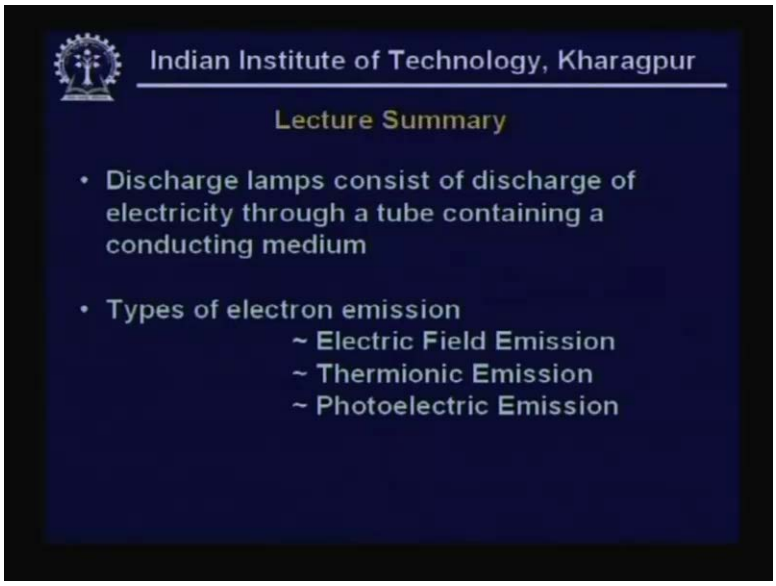

Further discharge lamps as already said is by the process of discharge of electricity through a tube containing conducting medium. This medium is either a gas or a vapourised metal, in case of mercury it was a liquid metal, in case of sodium it is a solid metal. Now types of electronic emission as already told could be electric field emission or the cold cathode emission which calls for application of a higher field, thermionic emission by heating or having a filament or a heater which heats the cathode and thereby gives photoelectric emission by striking electrons light on top of the thing.

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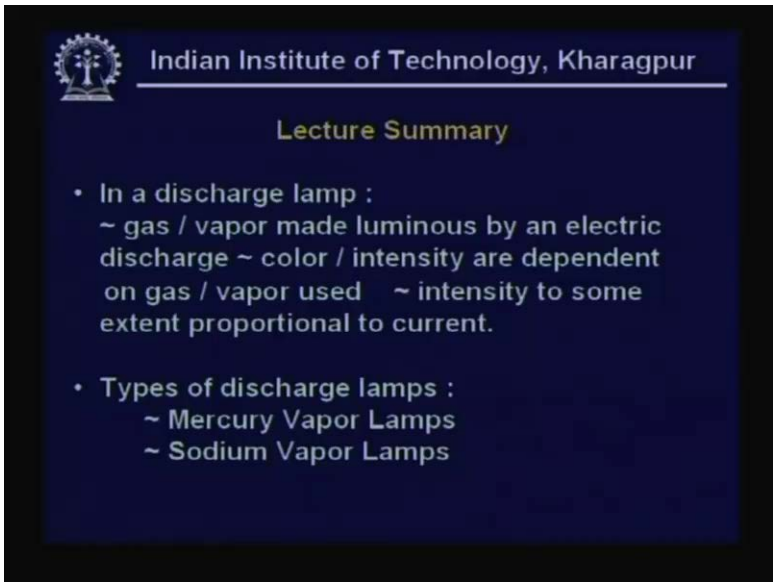

In a discharge lamp, now the gas or vapour becomes luminous and we already seen that the colour or intensity depend on the gas or vapour used. Now depending on the current you get the radiation intensity. Now remember the discharges in a mercury vapour are fine whereas discharges in neon or sodium vapour are continuous and thick. So the two commonly employed discharge lamps are mercury vapour lamps and sodium vapour lamps, in fact all of us have heard the term stone lamps very often.

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Now mercury vapour lamps as already said characteristic bluish green colour is what they give. As we have known that the gas vapour decides the type of colour. In a mercury vapour lamp a starting electrode is provided and typical run up time could be anywhere from 30 minutes 2 minutes I said here we are waiting 2 minutes because these day technology is available to start quickly.

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Gas at high pressure does improve the colour rendering because mercury vapour lamp radiation shifts to the mid spectrum, with sodium lamps a preheating heater is provided and as the initiating vapour is neon we get a red colour which turns to characteristic orange yellow colour.

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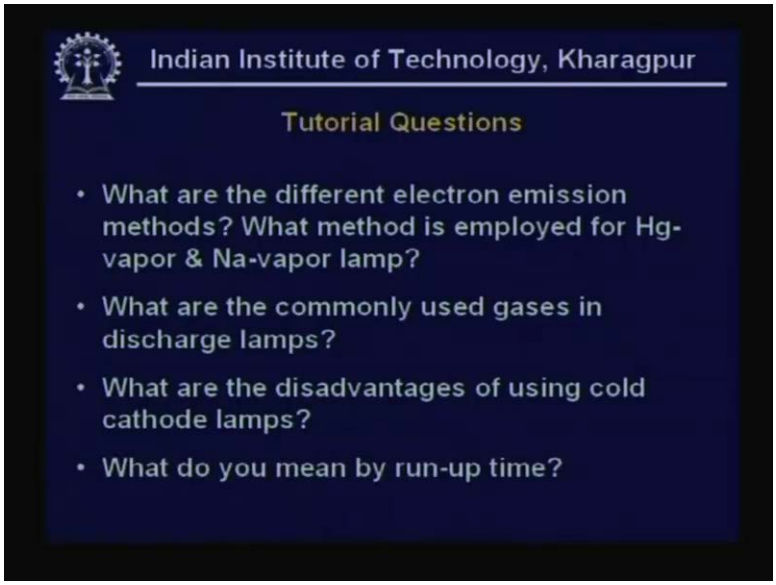

Some of the questions may be answered based on this lecture are what are the different electron emission method, what method is employed for mercury vapour and sodium vapour lamps, what are the commonly used gases in discharge lamps, what are the disadvantages of using cold cathode lamps, what do you mean by run up time.

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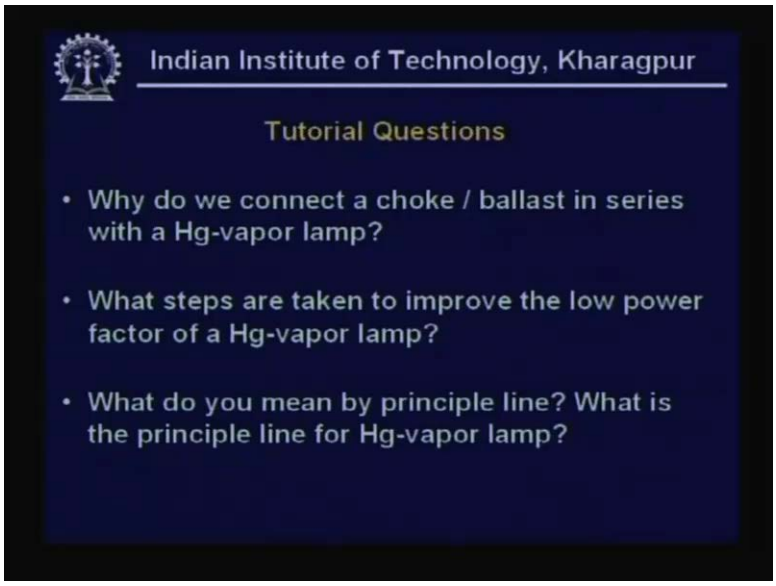

Continuing with the questions, why do we connect a choke or a ballast in series with a mercury vapour lamp, what steps are taken to improve the low power factor of a mercury vapour lamp, what do you mean the principle line, what is the principle line for mercury vapour lamp. The principle line…

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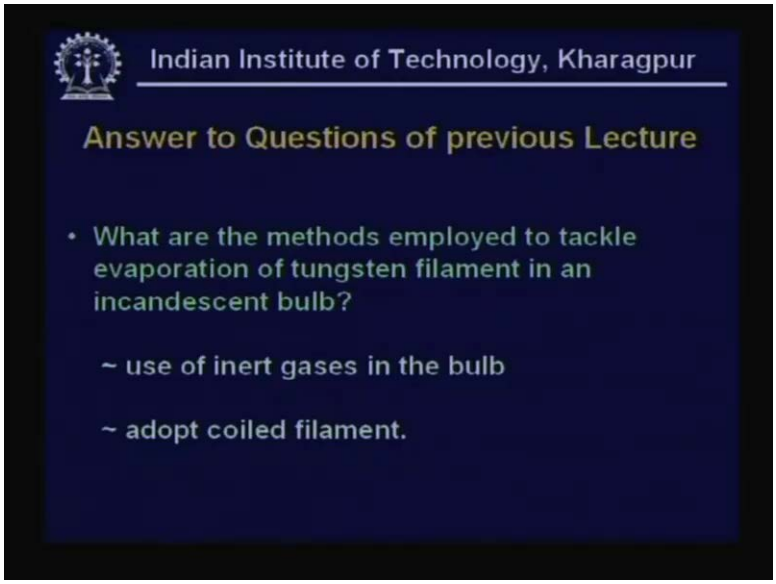

Some of the questions which were asked in the last lecture like what are the methods employed to tackle evaporation of tungsten filament in an incandescent lamp? Use of inert gases in the bulb, adopt coiled filament.

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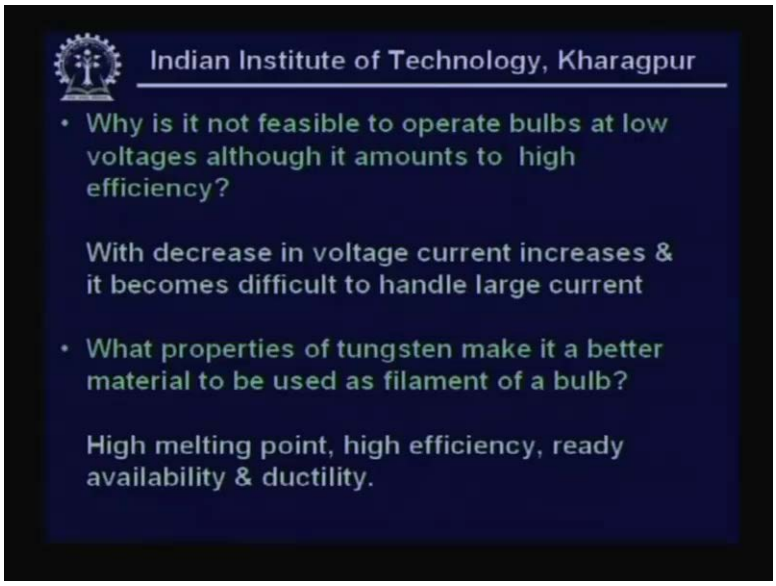

Why is it not feasible to operate bulbs at low voltages although it amounts to high efficiency? With decrease in voltage current increases and it becomes difficult to handle large currents. What properties of tungsten make it a better material to be used as a filament of a bulb? High melting point, high efficiency that is luminous efficacy, ready availability and ductility. Thank you.