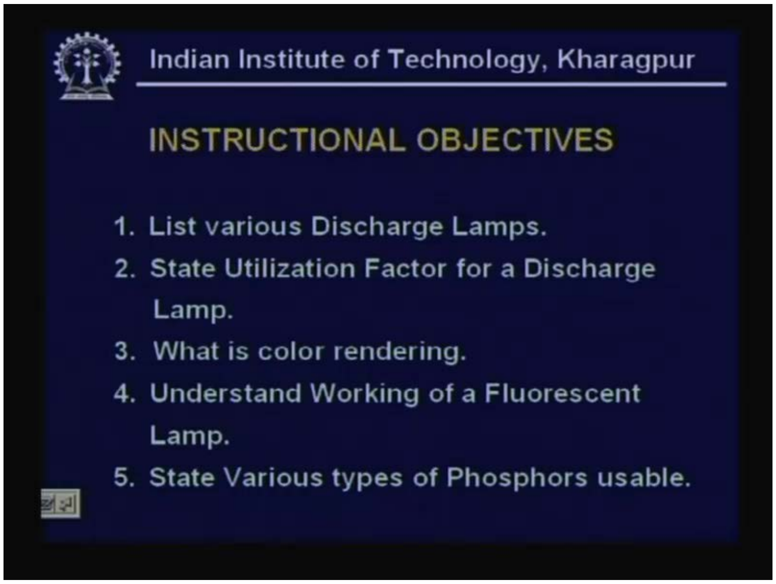
Illumination Engineering and Electric Utility Services
Prof. N.K. Kishore
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
Lecture No. # 9
Discharge Lamps – II

Welcome to the next lecture on illumination engineering and electric utility services. This is lesson 9 titled discharge lamps II is in continuation with the previous lecture on discharge lamps where we looked at various types of discharge lamps which essentially employ electro luminescence. Now, today we continue the discussion further and see what other forms of discharge lamps could be there. We had a look at the mercury vapour lamps and sodium vapour lamps and we also mentioned that there are neon vapour lamps. One central thing which was there to all these lamps was they had a line spectrum as against incandescent lamps.

(Refer Slide Time: 00:01:43 min)



So what are the instructional objectives for this lesson? They are ability to list various discharge lamps, state the utilization factor for a discharge lamp, in respect of the utilization factor we did look at in the last lecture that there is a relationship between the sensitivity of eye and the radiation ability. We saw there are certain radiation bands and when they are closer to the peak sensitivity of the eye, there is a higher utilization which is the case in case of a sodium vapour lamp whereas there are two distinct bands as far as mercury vapour goes in the low pressure zone where the sensitivity of the eye is very low, hardly any utilization and to some extent it improves when we go in for a high pressure mercury vapour lamps, this is the issue.

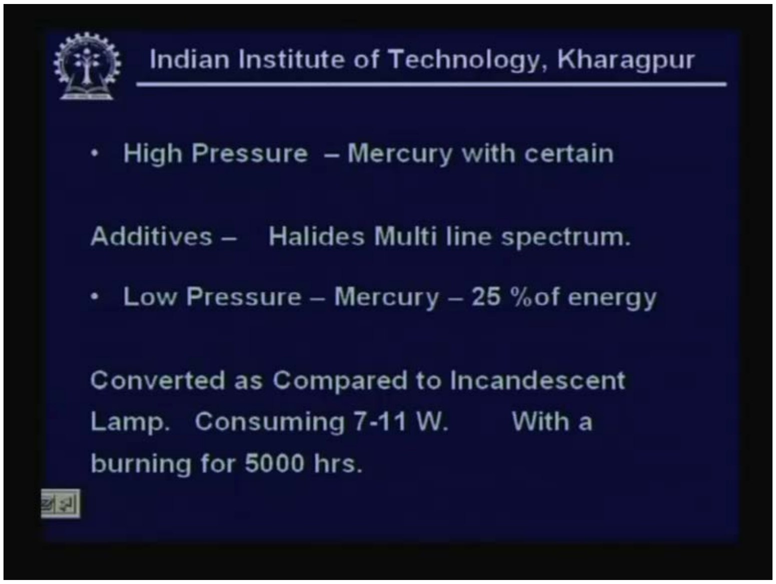
Now there is one aspect which we say ability of the lamps to reproduce the object colour which is a very important issue when choosing a particular lamp and that's what we call colour rendering and the next object is therefore is what is colour rendering. And as we said the mercury vapour lamp had two bands, one in the low pressure zone, the other in the high pressure zone.

And in fact we find that the low pressure zone falls in the zone which we call ultra violet, as recall that the light radiation can be thought of as a three distinct regions ultra violet, visible and infrared. Now the idea of a fluorescent lamp is to capture or employ the lamp radiating in that zone and with the help of suitable fluorescent materials reradiate in the visible zone. This is what is the phenomena of florescence. And of course in doing this the materials employed to do the process of florescence are called phosphors. So the last objective of the lecture therefore would be stating the various types of phosphors that can be used.

(Refer Slide Time: 00:04:03 min)

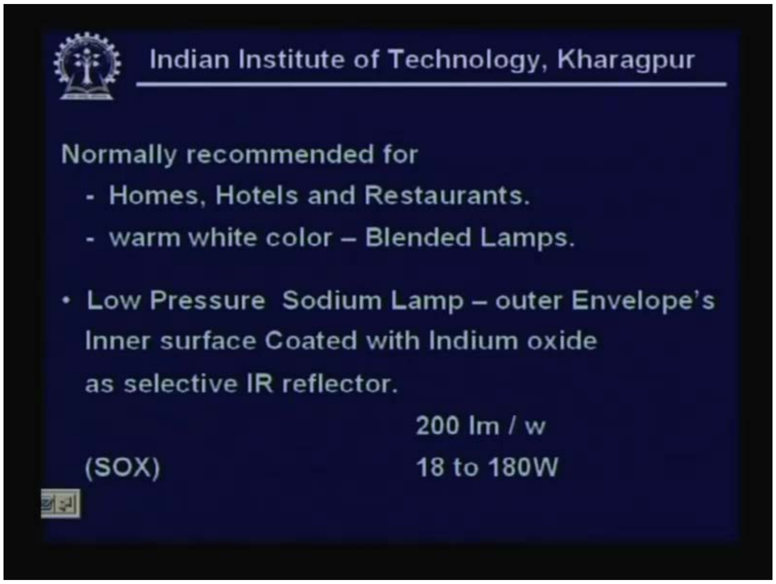
So continuing with the discharge lamps, we saw sodium lamps having their band spectrum located close to the peak of the, peak sensitivity of the eye are very favorably placed from the utilization point of view and we say that a sodium vapour lamp therefore is said to be having a high utilization factor. One important thing with all these lamps is that by one of the possible ways of emitting electrons could be electron electric field assisted emission could be thermionic emission that is by heating of the cathode or by impinging the photons one gets the gas vapour into a conducting mode and that radiates that's the issue. So in doing this we have an arc established and the arc needs to be maintained and arc colour depends on the type of the gas employed or the vapour employed whereas the intensity of radiation depends on the current level and therefore there are certain accessories required like starter, ballast etc. The low pressure mercury vapour lamp has a clear blue line spectrum whereas when low pressure sodium vapour lamp has clearly a monochrome a low orange thing.

(Refer Slide Time: 00:05:32 min)



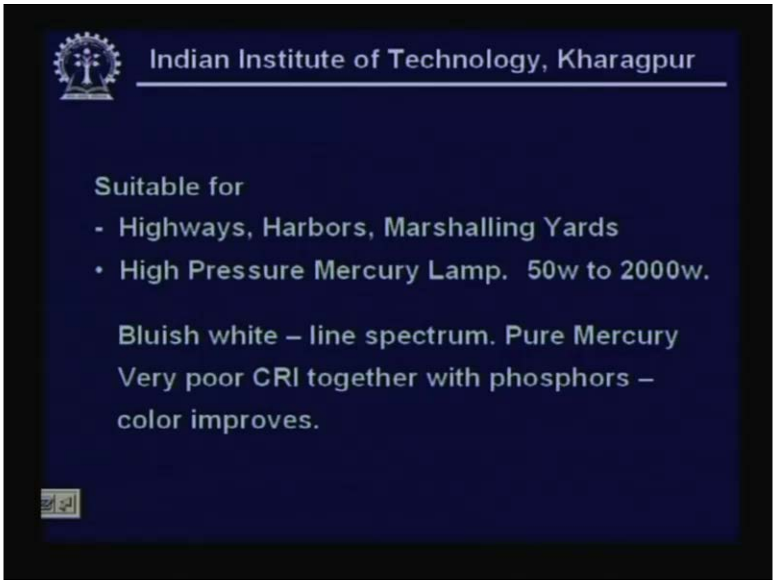
High pressure mercury with certain additives halides which are basically they could be bromides halides which improve the spectrum. They make it somewhat continuous and make it a little multiline I mean though not continuous spectrum like an incandescent lamp, it enables us getting some more lines in the visible zone and especially where the peak sensitivity is there. In fact if you see in a low pressure mercury only 25% of energy is converted as compared to an incandescent lamp but it consumes only about 7 to 11 watts. As against this is considering an equivalent incandescent lamp with a burning (Refer Slide Time: 00:06:26) of 5000 hours that's a very important issue. So energy consumption, this is as you can see it starts about 7 to 11 watts it's an equivalence between a 40 watt lamp and low pressure mercury vapour lamp.

(Refer Slide Time: 00:06:49 min)



Now one looks at using employing this. Normally such lamps are recommended for homes, hotels and restaurants. This gives a warm white colour and it can also be used to obtain blended colours, the blending of colours could be by combination of materials within the envelop or by employing suitable coloured glasses. You can in fact low pressure sodium lamp is again employed for selective applications like infrared reflections and these are available with certain oxide coatings inside. Now we did say apart from having any of the physical effects producing the radiation, it is the control which essentially ensures good lighting is obtained. In doing this the accessories play a role, apart from that the luminaire or the fixture which controls and there is a reflector. At times the envelope itself is used as a reflector and these low pressure sodium lamps which are employed may often be referred as SOX by some of the manufactures can radiate typically 200 lumens per watt of energy consumed with the lamps available anywhere from 18 to 180 watts. Remember the way to specify a lamp, all of us are familiar. I go to the market I say I want a 100 watt lamp, so if you want to say how you are going to specify a requirement for a lamp. First and foremost is the energy consumption, next comes the nature of the lamp.

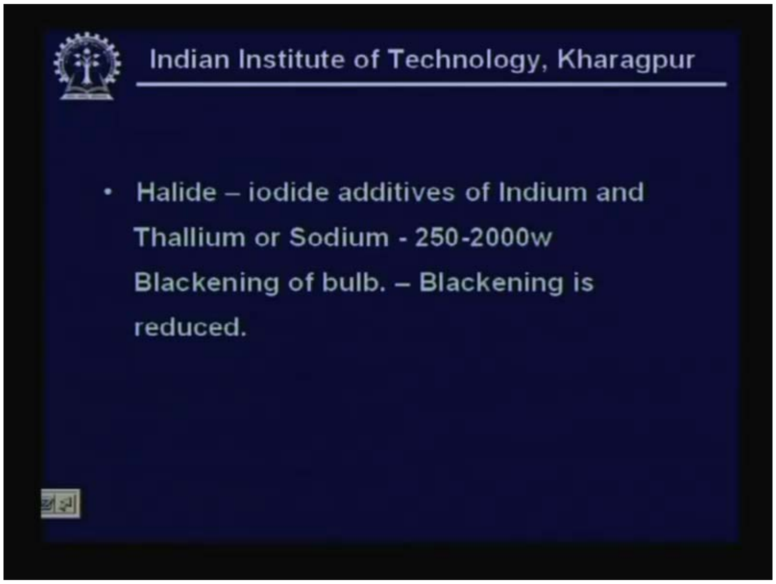
(Refer Slide Time: 00:08:50 min)



These are otherwise sodium vapour lamps are suitable for highways, harbor, marshalling yards and high pressure mercury lamps are also suitable in such areas. They are available from 50 watts to 2 kilo watts, they have bluish white line spectrum and colour rendering is bad and that is where some phosphors are employed to improve the colour rendering. In fact we see although the mercury vapour lamps can be used in such applications. We are finding that these days most high way application and industrial marshalling yards are essentially with the railway system, rail road's, harbors. There are such places also we are tending to replace with sodium vapour lamps essentially because of high utilization factor which we talked off. The utilization factor talks about we got that from the sensitivity I mean of the radiation which was obtained by considering the energy radiated from the lamp and the sensitivity of the eye which multiplied, we find that the line band available for sodium vapour is close to the peak yellow green zone and that's how characteristic yellowish orange colour we find for the sodium vapour.

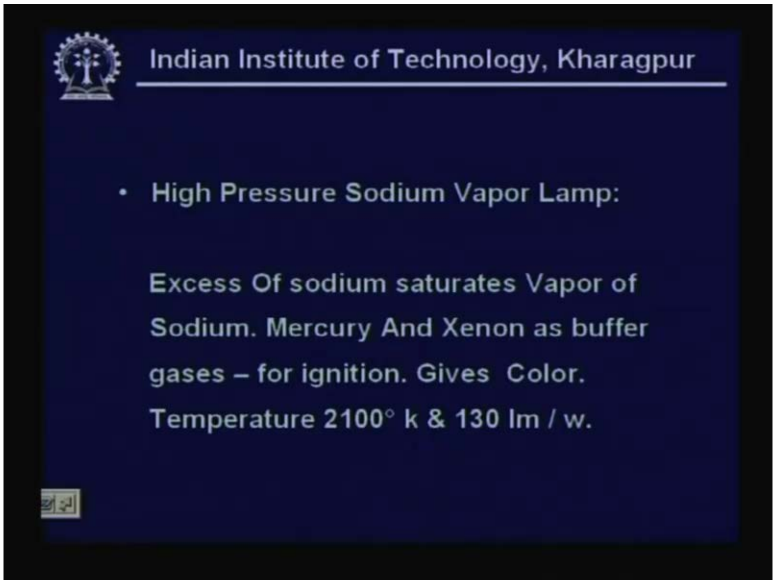
Now in all these applications we say colour rendering is bad. Colour rendering what mean as the name implies or the word means is the ability of a human beings to perceive the colour in its original sense and these lamps have very poor colour rendering. What we are trying to say is in case of a mercury vapour lamp, it is possible to improve the colour rendering by employing some phosphors. What happens? We saw that there are two zones of radiation, one is in the low wavelength corresponding to ultra violet and the other in the midway and therefore by employing this phosphors, we are enabling it to be moved reradiated and in the process we tend to get a band spectrum which is more continuous and as a result we have a better colour rendering, this is the issue.

(Refer Slide Time: 00:11:36 min)



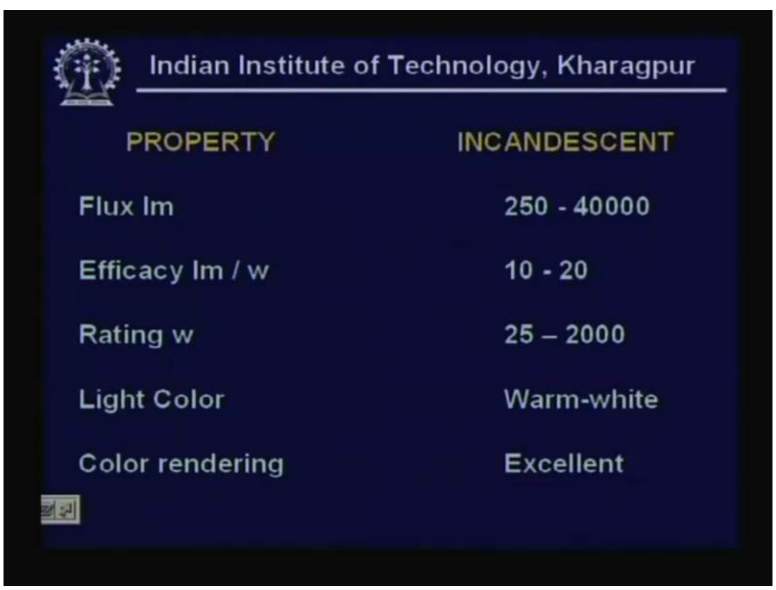
Remember there are two distinct line bands in case of a mercury vapour. Halides are also added sometimes, we said and in fact halides were employed even in the incandescent lamps we have seen that, they are halides of indium, thallium or sodium and these lamps in fact these days we have what are called as metal halides. Now these are basically high energy incandescent lamps which are used for flood lighting and we do find that there is a risk of blackening of the envelope because of evaporation of the filament and that's reduced if you have this halides because they react with the vapour that's available. And as a result absorb the heat and they get condensed and in the process they get redeposited in the filament. Why are we talking about the incandescent lamp in the lecture on discharge lamps? The reason is very simple because although we have categorized the lamps as incandescent and discharge lamps, in application we find we may go in for a combination of the thing. That is you have a mercury vapour and an incandescent lamp together in a particular fixture which can give you improve your colour rendering at the same time have low energy consumption and give an efficient light system that's the idea.

(Refer Slide Time: 00:13:13 min)



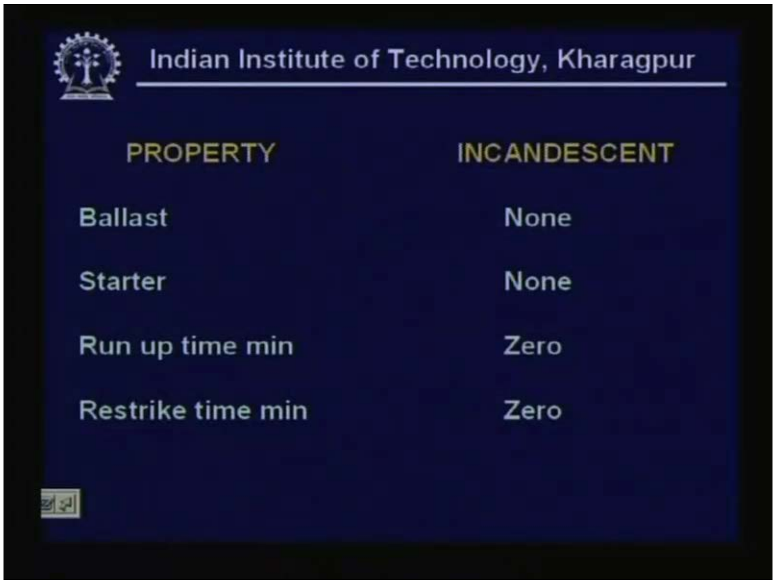
High pressure sodium vapour lamp has excess of sodium which saturated vapour sodium and sometimes to improve the colour, in fact here the mercury and xenon are used as buffer gases and they are also, remember all these discharge lamps need a starting gas which because of low ionization potential rare gases are used. Here, we are talking about xenon being used and this operates but as low I mean as good efficiency as 130 lumens per watt with colour temperature of the order of 200000 degree, 2100 Kelvin.

(Refer Slide Time: 00:13:53 min)



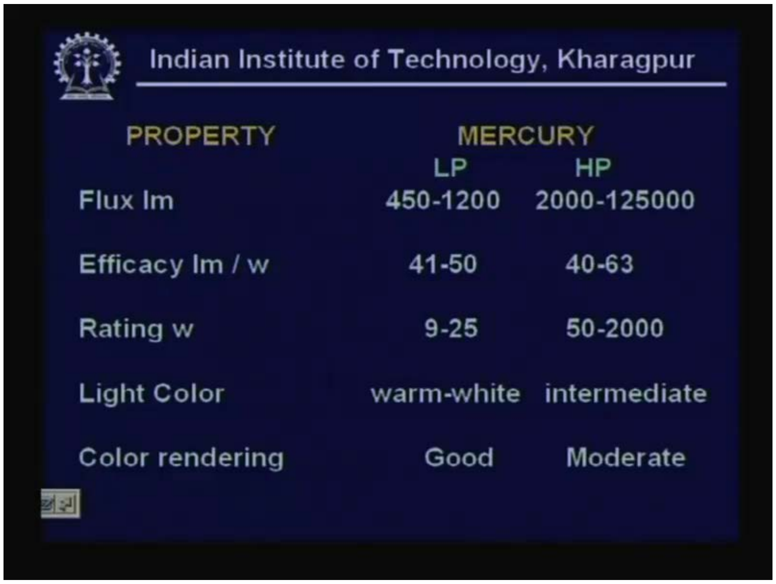
Having said so much we can look at the properties, various properties of the discharged lamps covered so far that is the sodium vapour lamp, mercury vapour lamp and the incandescent. We need to compare it with incandescent lamp for one simple reason that incandescent lamp gives a continuous spectrum which is very close to the natural light. The properties which we are trying to compare, the first and foremost is the light flux which we said is standardized as lumens. Then the next most important property as far as radiation goes is the efficacy that is lumen output per watt of the energy consumed. Thirdly the rating, we said we specify a lamp firstly by the wattage or the energy it consumes rather than the type then comes the thing. Next is the colour or the how the radiation has and the rendering of colour. Now the data for the incandescent lamp shows that you can have lamps with as low as 250 lumens to about 40000 lumens available in the market with as low as 10 lumens per watt to the highest possible being around 20 lumens per watt of energy consumed with 25 to 2000 watts, that is 25 watts we are all familiar 25 watts we use in our toilets or circulation areas where we need some background elimination but not intense tasks are not performed to 2 kilo watts. Colour radiation is warm white, I said a spectrum is continuous it spreads over entire visible zone it is close to the natural light therefore its warm white and hence we find the colour rendering is excellent. So that's qualitatively saying it's good in other words if you see a red colour thing it's truly red.

(Refer Slide Time: 00:16:20 min)



Ballast is what we said is an accessory employed in discharged lamps to essentially maintain the current. Remember we are operating systems on (Refer Slide Time: 00:16:28) voltage basis where there is need to increase the voltage and once the arc strikes, there is a constant current needs to be maintained independent of a small fluctuations in the voltage and that's possible by having a some kind of a reactive circuit in series and these reactive circuits is what we call ballast because it boost the voltage initially for the striking of the arc and then continues to maintain the current. There is no requirement for ballast in case of an incandescent lamp, there is no starter whatsoever and we have no run up time or because there is no arc or any, it's essentially heating of the filament and that radiates there is a zero run up time, zero re strike time. This strike time is what we call in case the arc quenches, there is a certain minimum time required for the whole process of radiation to begin from being an issue.

(Refer Slide Time: 00:17:29 min)



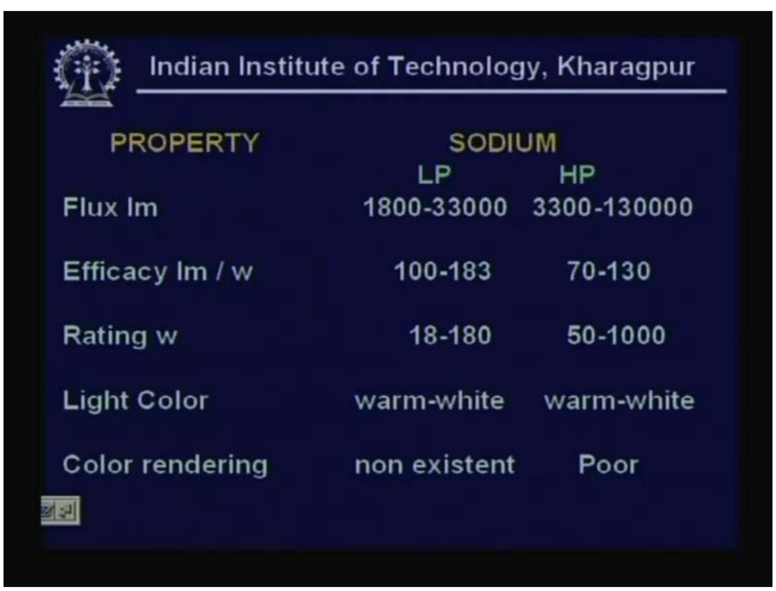
Let’s look at the mercury lamp. Here you have both low pressure and high pressure. See lumen wise the low pressure ranges from 450 to about 1200 lumens, its comparable to what you had in case of an incandescent lamp. So it’s quite possible that with certain additives like halides in the envelop and providing some phosphors, it may be good idea to get low pressure mercury vapour lamps to give comparable performance. If you look at the high pressure mercury vapour lamps they have some 2000 to about 125000 lumens. The efficacy wise they are comparable both low pressure and high pressure ranging from 40 to 50 lumens per watt, we have still not reached very high levels remember that. Ratings could be 9 to 25 watts as low pressure ones and 50 to 2 kilowatts is the high pressure one and colour that’s where a low pressure is reasonably in the warm white mode. And in fact some of us are familiar with these milky bulbs which we have been using at home, they fall under this category.

The intermediate range light colour ranges, colour is bluish green is the line which is predominant for the mercury thing. We said colour rendering is not so good is okay for low pressure or good it was not excellent, in case of incandescent it was excellent.

(Refer Slide Time: 00:19:14 min)

Now being a discharged lamp its needs a ballast, we have a ballast which is built in in case of a low pressure thing and in a high pressure thing we have it in the luminaire outside. As such it does not read as starter but there is a run up time for high pressure of about 3 minutes. There is strike time that is in case the arc quenches, it needs about 5 minutes for to restrike that’s what we have seen. They as far as low pressure thing, there is no run up time or restrike time that’s the process.

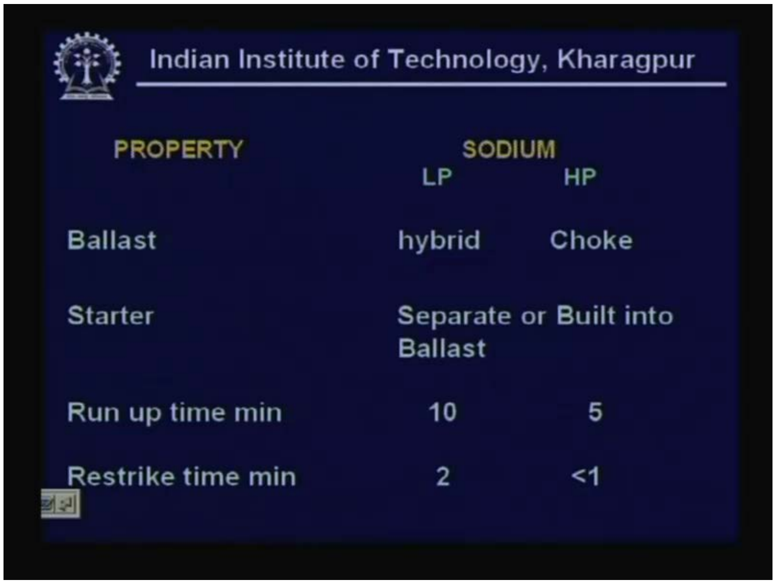
(Refer Slide Time: 00:19:50 min)



As against this if you look at the sodium, you see at low pressure itself the radiation levels are reasonably high, lumens ranging from 1800 to about 33000 and high pressure is from 3.3000 to

130000. That’s the kind of a flux that’s available with efficacies that’s where the issue is, very good efficacies 100 to 183. So for every watt of energy you consume, you are getting a reasonably good light output that’s the issue and you do have low pressure ones right from 20 watts to 200 watts and high pressure one’s going from 50.

(Refer Slide Time: 00:20:49 min)



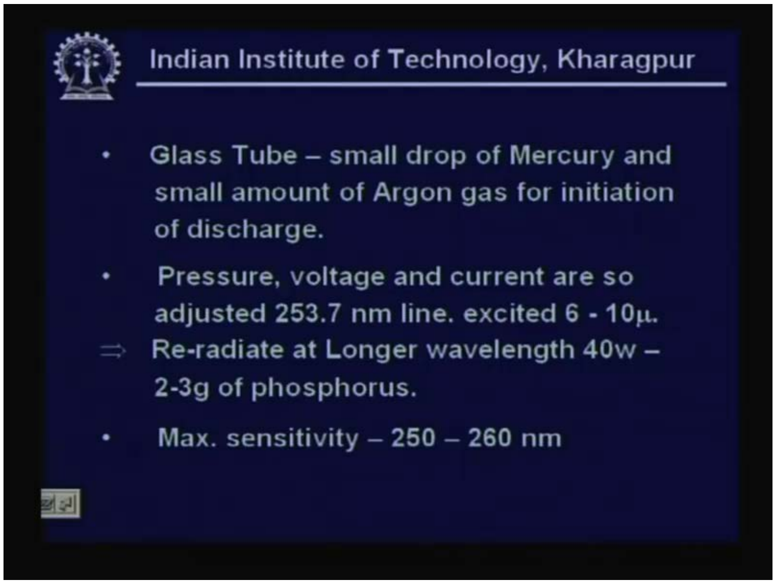
Now the light colour is something which is to be colour rendering is poor and all of them need a ballast which could be either built in or high separate, it could be a combination of L and C in case of a low pressure one. This starter could be built within the ballast. We do find they have a large run up time, in fact all of us have seen that the initiating process today we have run up time close to about 5 minutes, we could see the initiation is through you say neon gas which gives rise to a reddish light initially and subsequently we get the yellowish orange spectrum or light with the sodium vapour. The restrike time in case of a low pressure one is of 2 minutes whereas in a high pressure it is less than 1 minute.

(Refer Slide Time: 00:21:42 min)

Now having said this, we take up what are called as fluorescent lamps. Now fluorescent lamps as the name suggests employ florescence but they are still the discharged lamps themselves. Recall that the mercury vapour has two separate distinct bands, one in the uv region, the other in the visible region. Now the fluorescent lamp essentially takes care of converting that radiation available in the low wavelength of the uv region into visible zone by the process of florescence.

Let's see, if you have a luminescent powder providing the tubular vapour lamps, it in fact improves brilliancy of light, that's what we found from the mercury vapour lamps we did mention. So what we do is take a low pressure mercury vapour lamp, consider whose radiation is predominantly in ultra violet region, it's allowed to impinge on luminescent materials. As a result it reradiates longer wavelengths of visible spectrum, this we had defined right in the beginning as one of the processes used in the artificial lighting to produce radiation. This is absorbing the light at one wavelength and reradiating in the visible spectrum, that's what we are doing. So this is the process of fluorescence.

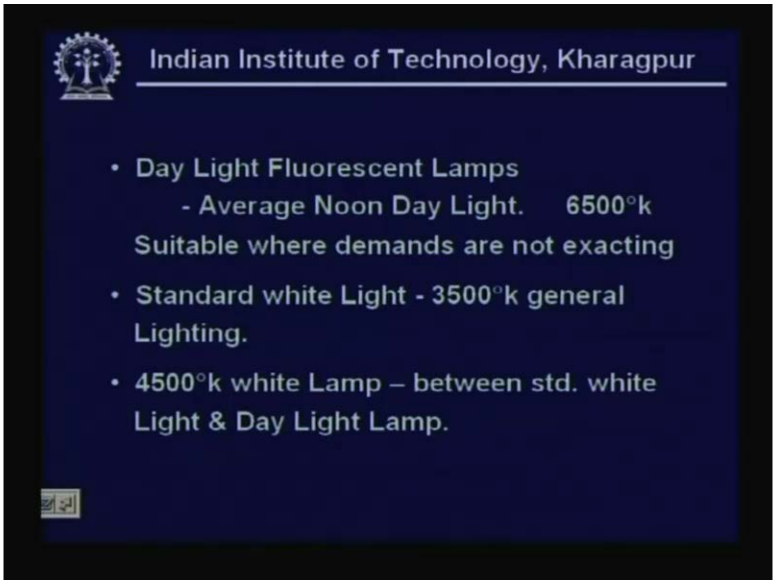
(Refer Slide Time: 00:23:35 min)



You have a glass tube with a some small drop of mercury and small amount of argon. Again why argon? Argon is necessary to vaporize your mercury to initiate the arc because it's still is an arc lamp or a discharge lamp. There the whole process is such that we control the pressure, voltage and current so that we have in the 253.7 nanometer line and then radiate at longer wavelength. A typical 40 watt fluorescent lamp will use about 2 to 3 grams of phosphors. We will see these what phosphors are.

Phosphors are nothing but this luminescent powders which we are talking about being coated within the envelope of the discharge tube. We will have to look at the various materials that can be used. A small amount, see the amount required 40 watt lamps are very commonly used this which all of us have been using in all our offices and homes, it's very commonly used. And we find that the maximum sensitivity of these. Now with respect to these phosphors one talks of sensitivity, sensitivity means the point on the wave spectrum where they absorb the light and then they reradiate of course the zone.

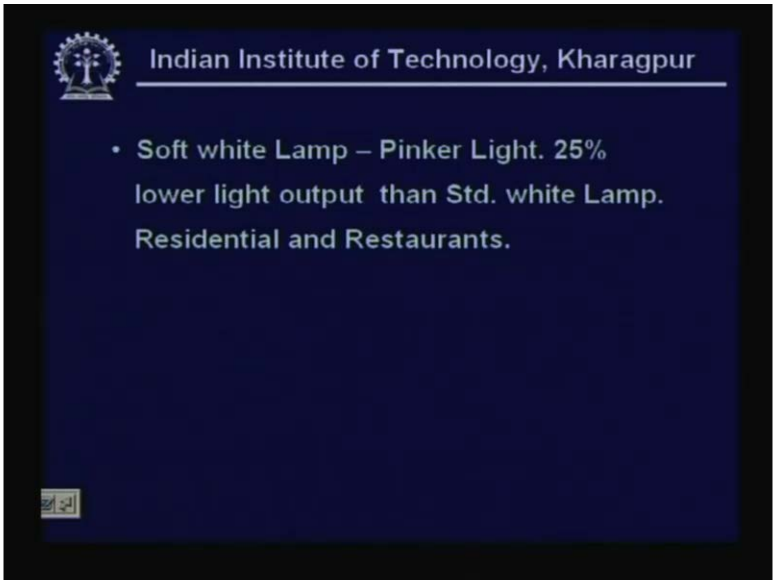
(Refer Slide Time: 00:25:21 min)



Keeping this in mind fluorescent lamps are available with different nomenclature and the first one is day light fluorescent lamps. In fact the idea is they are supposed to be having colour temperature corresponding to average noon day light hence they are called day light fluorescent lamps. Remember this is no longer a mercury vapour lamp in the earlier form, its though initial radiation is obtained by electro luminescence, it is the florescence which is giving you the ultimate output and hence it is giving a different kind of (Refer Slide Time: 00:26:06). You cannot say it's anymore what you called line spectrum. Now this is okay where the demands are not very exacting.

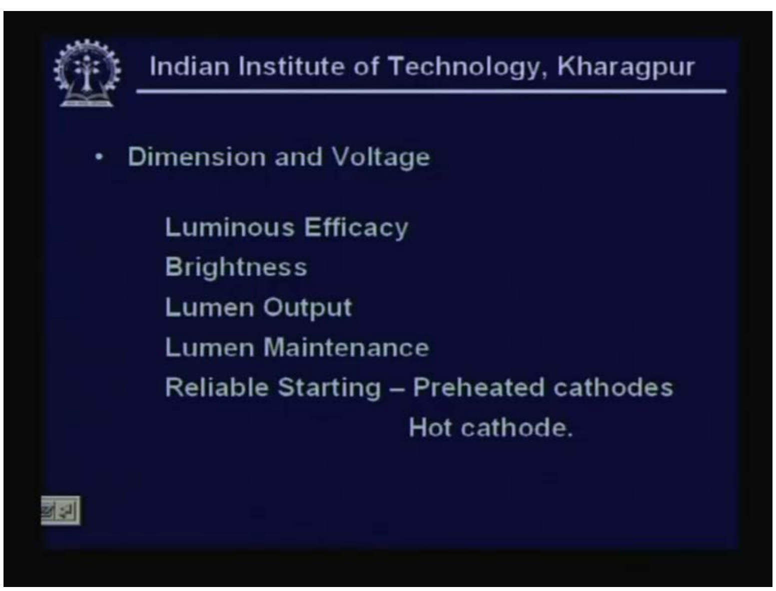
As against this we have a standard white light in fact most of us are using standard white light lamps very commonly which has a colour temperature of 3500 degree, this is employed for general lighting. Then there is a lamp which has a colour temperature between a standard white light and day light lamp which is around 4500 degree, in fact it is called 4500 k white lamp.

(Refer Slide Time: 00:26:48 min)



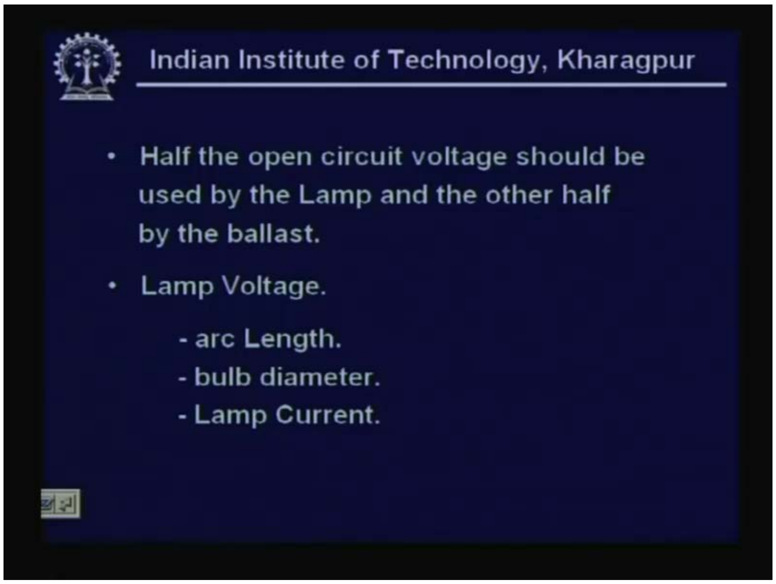
And you do have where the illumination levels are required or less having soft white lamps, this gives slightly pinkish because the output itself is 25% lower than the standard lamp and this is used where dim lighting is required. The application could be circulation areas in a residences, the corridor connecting various bed rooms, circulation areas in a hotel whereas hotel often times we have observed that hotels we tend to have dim lighting. The one advantage of that is you get the privacy you need. It’s a public place where many people are eating so you would like to have a private environment for the people with your colleagues or family.

(Refer Slide Time: 00:27:45 min)



So now on what factors does this depend? This depends on the dimension and voltage. The factors that come out are luminous efficacy is a very important thing. You have brightness lumen output in fact very important thing. Lumen maintenance is a another issue which we often times in analyzing or calculating, take it in terms of the maintenance factor because lumen output with age reduces. So, now for reliable starting we use preheated cathodes or hot cathodes, there are two categories. Preheated is prior to the arc discharge, it gets heated hot cathodes is continuous. Now the issue is we have already said although discharge lamps are radiating mostly by arc, they have two electrodes at the either end which depending on the cycle of the ac sign wave, each of them access cathode and hence each cathode is in turn heated by a filament which is similar to your incandescent lamp.

(Refer Slide Time: 00:28:58 min)

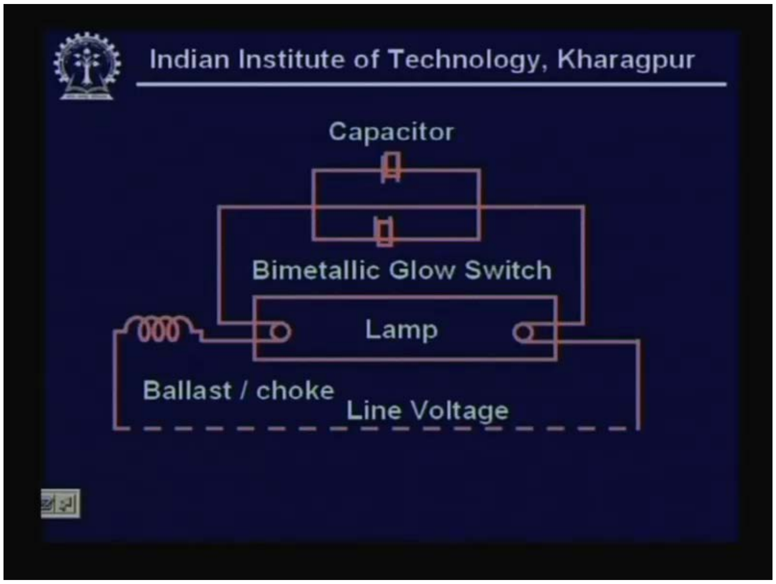


Now here what is done is if you have a certain open circuit voltage, we rate it such that the discharge occurs by using half the open circuit voltage. That is our lamps operate on 230 volts, so we expect around 110 and 120 volts to be the drop across the arc and the rest of the thing by the ballast, ballast you know ballast is required one to boost the voltage across the two electrodes so that there is a discharge. Lamp voltage of course depends on the arc length, bulb diameter and lamp current.

(Refer Slide Time: 00:29:44 min)

The hot cathode obviously can operate at lower voltages than the cold cathode. Cold cathodes, the basic disadvantage we did mention this cold cathode would mean the emission is essentially through electron emission and can have drops of the order of 70 to 100 volts at the cathode itself.

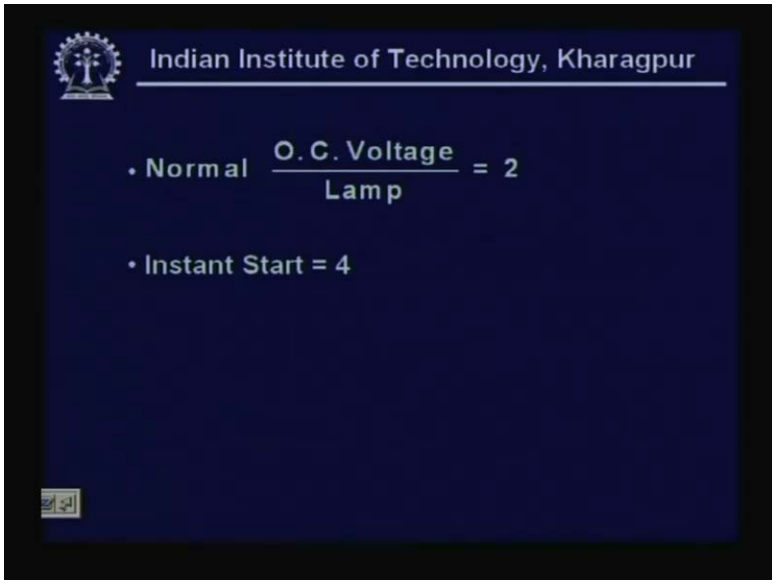
(Refer Slide Time: 00:30:05 min)



This diagram shows the complete functioning. We have the all the accessories shown. There is a glass envelope, it's a long tube where the lamp at either end there are two electrodes which are basically similar to your, what we found in the sodium vapour lamp or mercury vapour lamp. It shows the complete circuit diagram. This is the total line voltage applied across that ballast or choke which is known as which is predominantly electromagnetic off late we have been using electronic chokes which we will take up in later lecture on control devices for illumination system, we will look into the electronic ballast during that but suffice it to say in the circuit sense it's an inductance which helps in boosting the voltage initially to strike the arc and later on to be able to control the… There is a capacitor which in fact because of this inductor, it's bound to alter of the power factor and we know that all our systems should operate as close as possible to unity so that the conductor sizing for the input power supply becomes nominal. And there is a switch in fact initially the current flows through the choke, the left electrode and through that bimetallic switch which is also known as the glow switch to other electrode and thereby heats the two cathodes, two electrodes at each end and creates the vapourization. And since it's a bimetallic switch, there is a passage wave current, it heats and one of the, there is the differential expansion between the two metallic elements and the switch opens. And as a result there is a transient created. Remember if you have a RL circuit and you open there is a transient, current transient that builds a very large voltage across the two electrodes thereby strikes the arc.

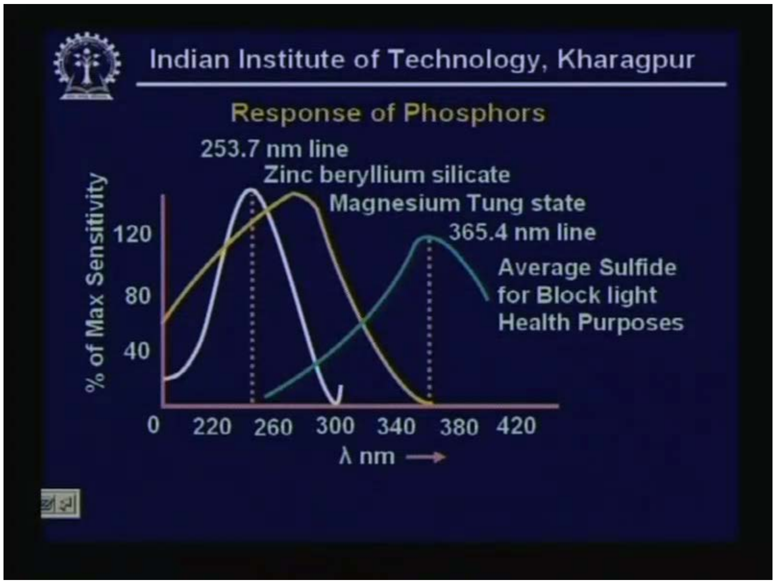
Once the arc is struck the inductance is in circuit and the circuit is the switch is out of the circuit and therefore at that time the capacitor comes into the circuit to ensure that the power factor is maintained.

(Refer Slide Time: 00:32:49 min)



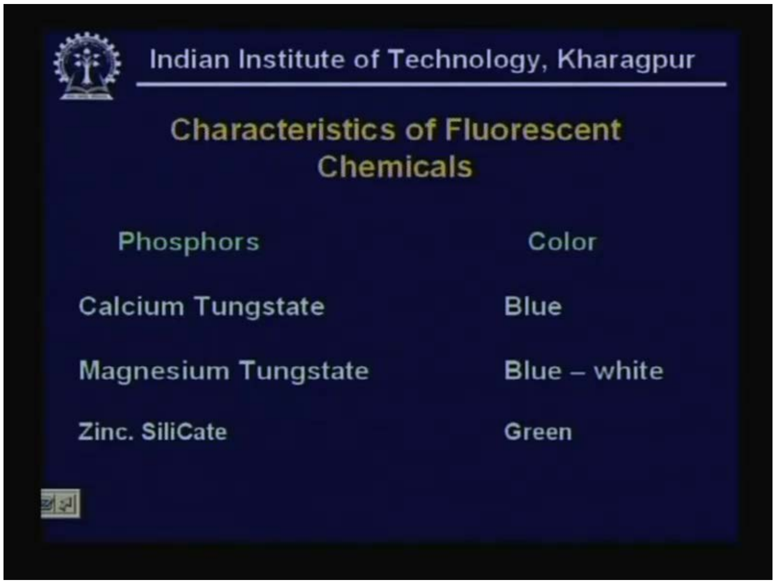
And as we said normally we try to have at least the arc drop or voltage drop across the lamp that is the only the arc tube to the open circuit voltage, total voltage supplied at least two but this we have seen when we switch on there is some amount of flickering that is because at times the required voltage by arc build up or even if it has build up an insufficient vapourization and the arc doesn't get established. So you do find that it may take few cycles that's why we can see the flickering of the lamp to be closed. So in order to have instant start, the design is done in such a way that this ratio is kept around four and then the lamps are called instant start. Here I must mention that these days in fact these lamps are available in more compact form with as low wattage as 18 watts or even lower and they are termed compact florescent lamps. Imagine having a glass envelope in which there is an arc tube along with its ballast starter and power fraction correction capacitor completely within this. So that's these are termed the compact florescent lamps and the beauty is that they are possible to be mounted in the conventional fixtures meant for the incandescent lamps. Now having looked at this, the one important issue is the material of the phosphor and we said phosphors are coated on the interior of the envelope, they absorb the light radiated in the UV region. So there is a certain sensitivity of this phosphors, they respond to a particular radiation and having responded they have an ability of radiating over a certain spectrum. This spectrum is what we want it to be in the visible zone.

(Refer Slide Time: 00:35:20 min)



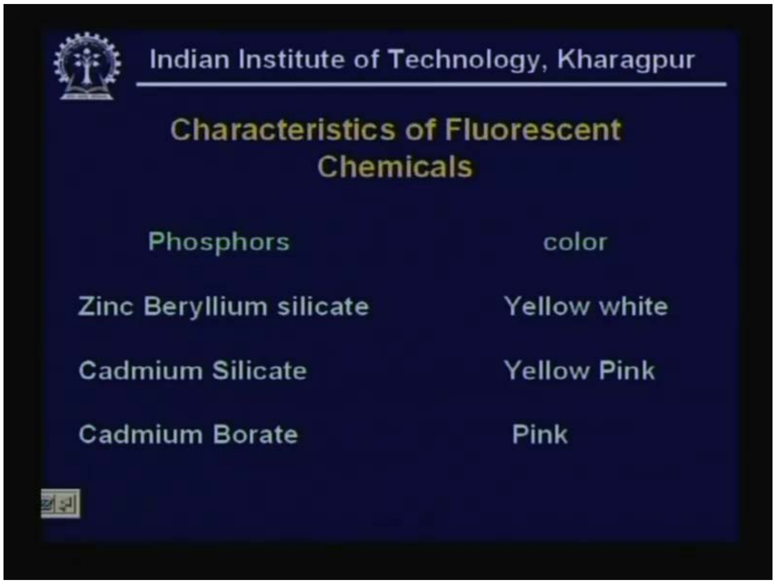
Now let's look at the picture which shows three different materials. The first curve shows has peak sensitivity around 253.7 nanometer line which is a zinc beryllium silicate. Now as against this we do have magnesium tungstate which is having a peak around 260, between 265 to 280 and the average sulfide which is normally used, the sulfides are very often used, these are special materials zinc beryllium silicate and magnesium tungstate. The average sulfide has around 364.54 nanometer line. Now in fact the help purposes we do use this light and it's called as a black light in that zone because if you don't make it visible by…

(Refer Slide Time: 00:36:27 min)



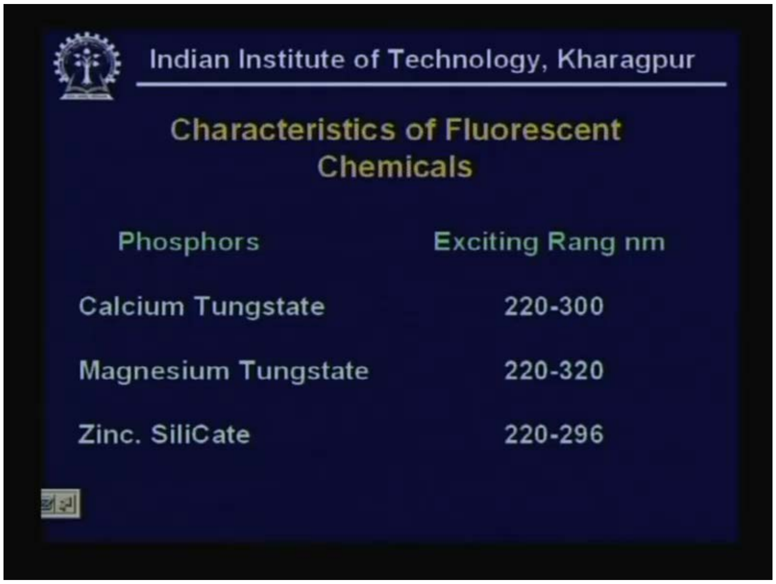
So let us look at the some of the chemicals that are employed, fluorescent chemicals we call them as phosphors. So we have phosphors versus the colour okay, calcium tungstate. When you talk of the colour, it's basically what we are trying to say is the radiation spectrum where it's going to be maximum calcium tungstate can be, after it goes into florescence may be termed to be blue magnesium tungstate will be blue white, zinc silicate is green.

(Refer Slide Time: 00:37:07 min)



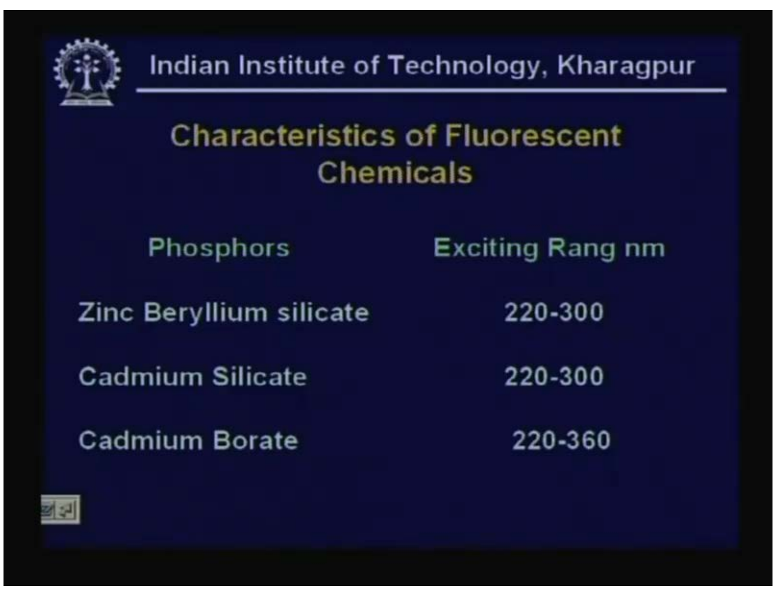
Green is good because it picks sensitivity of the eye yellow green, zinc beryllium silicate is yellow white may be we look for that cadmium silicate is yellow pink, cadmium borate all these materials have been used pink. This is the colour wise.

(Refer Slide Time: 00:37:23 min)



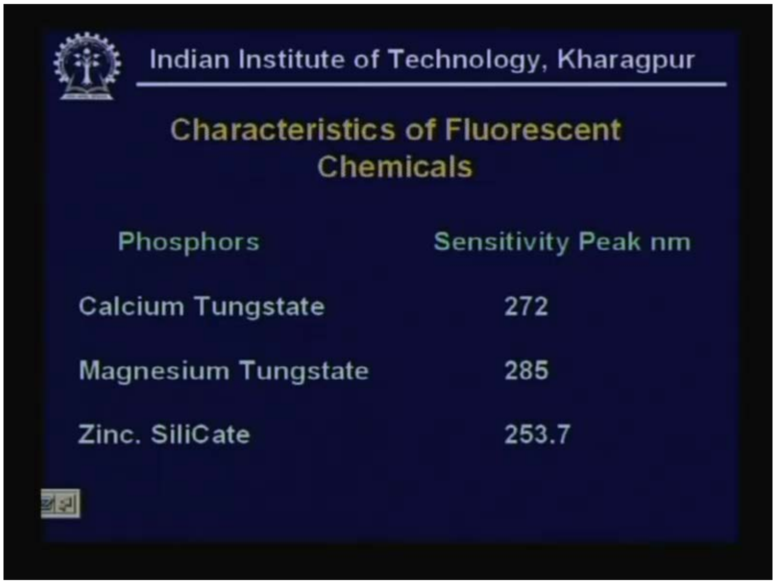
Now this is the range over which it can be excited, this is the range of excitation would mean. If the uv radiation is available this phosphor will respond and go into fluorescence. You could see the calcium tungstate is around 220 to 300 whereas magnesium tungstate is around 220 to 320 and zinc silicate is around 220 to 296.

(Refer Slide Time: 00:37:59 min)



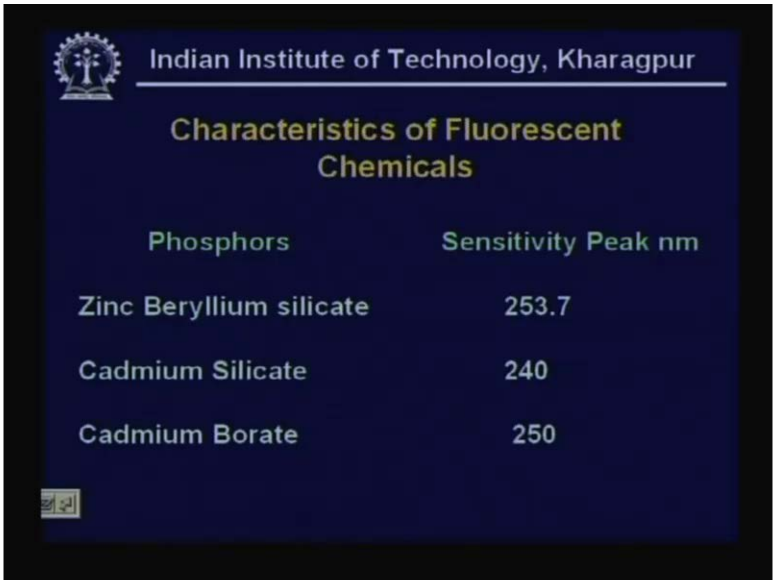
Going further zinc beryllium silicate is around 220 to 300. It has to be that way because it's below 300 is when we have the cadmium silicate around 220 to 300, cadmium borate 220 to 360.

(Refer Slide Time: 00:38:11 min)



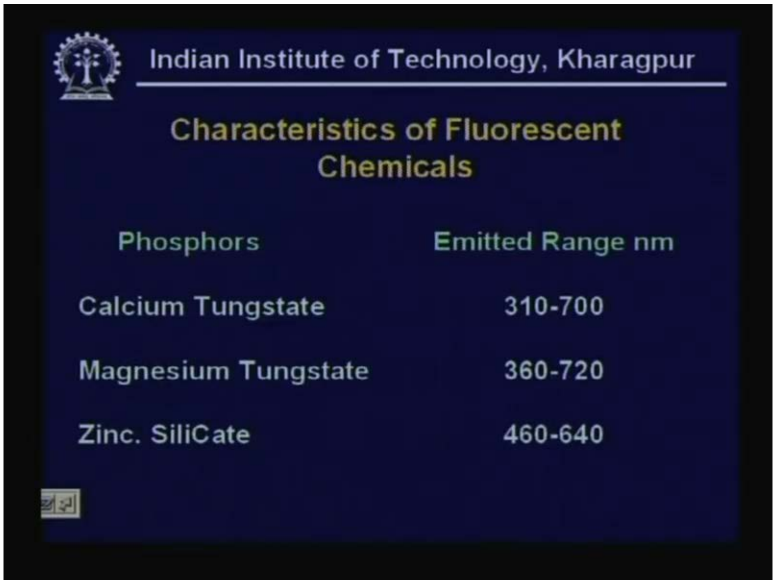
Then the next issue which comes is what is its peak sensitivity. We saw in that figure response curve there is a certain wave length at which it has a peak response or the fluorescence is a maximum. The calcium tungstate is known to have peak around 272 nanometers whereas magnesium tungstate around 285 and zinc silicate around 253.7.

(Refer Slide Time: 00:38:41 min)



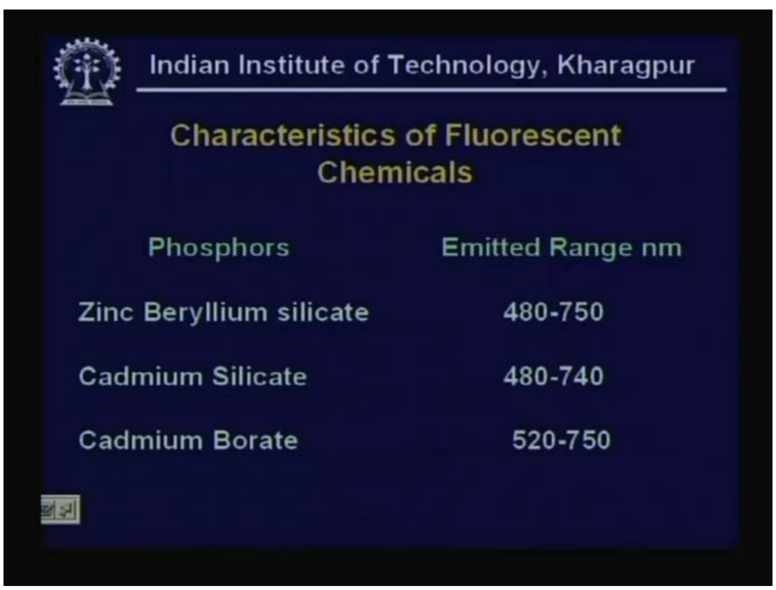
And zinc beryllium silicate around 253.7, cadmium silicate around 240 and cadmium borate around 250.

(Refer Slide Time: 00:38:52 min)



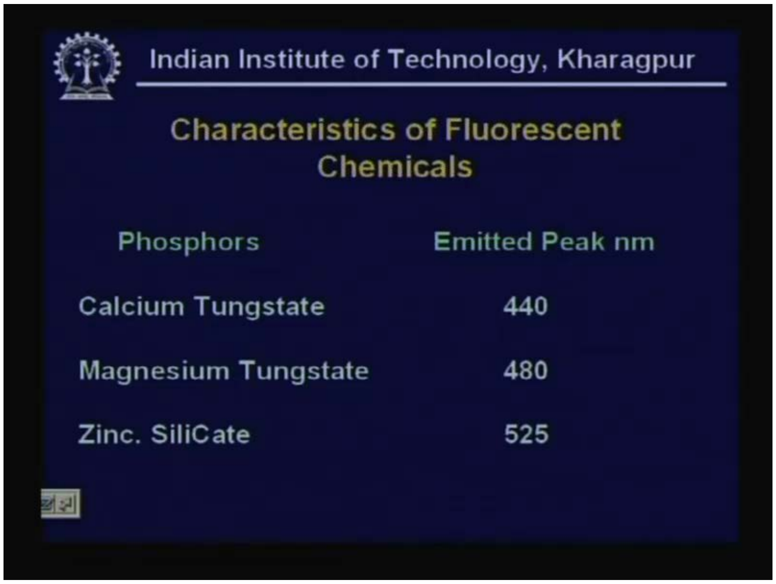
Continuing with the characteristics of this chemical, the range of emission this also equally important. After having absorbed the light, after going in the florescence what spectrum does it emit that's a very important. You see calcium tungstate; it's around 310 to 700 which mean it is covering the entire spectrum of visible zone. Magnesium tungstate is around 360 to 720 whereas zinc silicate is only between 460 to 640 that is an important issue to be kept in mind.

(Refer Slide Time: 00:39:27 min)



Zinc beryllium silicate is around 480 to 750, as cadmium silicate is as you see as we are going along down the table its shifting a bit to the right that's a very important thing to be kept in mind emitted range, cadmium borate is between 520 to 750.

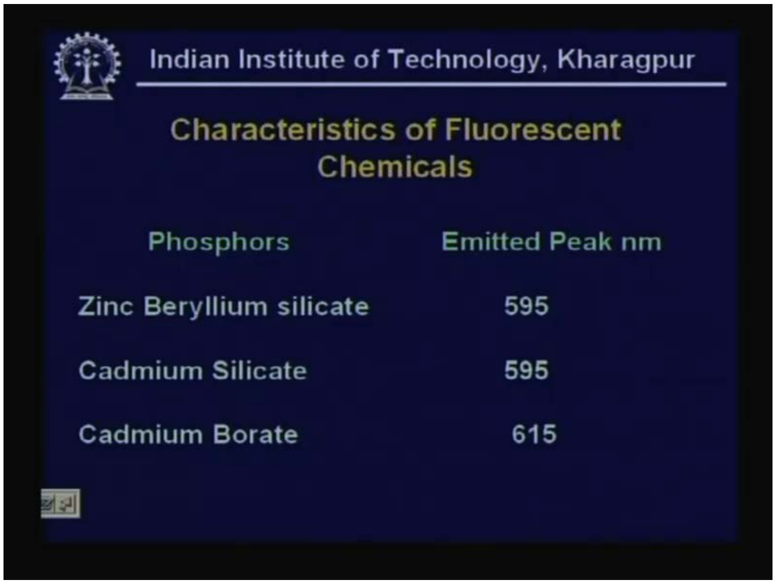
(Refer Slide Time: 00:39:50 min)



Now not we scanning this okay, it’s got a range but what is it that matters. It again matters that the radiation reradiated after fluorescence, where does it have peak? How does it compare with the sensitivity of eye, where is our eye sensitivity maximum? It’s around 550 nanometers, so that’s the ultimate thing which is going to decide the efficacy of the phosphor and usability of the phosphor. So you have to work towards creating the discharge around the sensitivity of this phosphor from the point of view of going into fluorescence.

Next look at the emitted range and see where the emitted peak is. If you look at the emitted peak, calcium tungstate though we saw that as we go down the table there is a shift towards the right in the spectrum but there is also a shift to the right towards the peak emitted, emitted peak that’s a very important. I look for in the close to the peak sensitivity of the human eye. Calcium tungstate has around 440, magnesium tungstate has around 480, zinc silicate around 525.

(Refer Slide Time: 00:41:18 min)



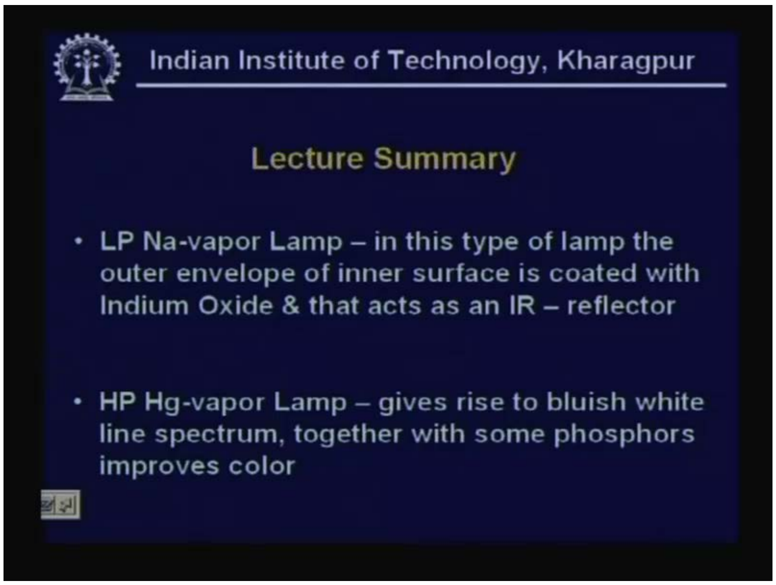
And you find zinc beryllium silicate 595, cadmium silicate at 595, cadmium borate at 615. So what do we see? If you look at the ultimately and you will find probably zinc silicate and zinc beryllium silicate, these are possibly the most commonly used phosphors are suitable because from the view, point of view of your high what you call emitted peak sensitivity close to your (Refer Slide Time: 00:42:02). So what we have looked at is that we do find as a whole there are two categories of discharge lamps that are possible, one you have a discharge, arc discharge and essentially work on the principle of electro luminescence and the band that is obtained is a line band and we have seen that normal gases that are employed are neon, mercury or sodium.

Now right in the beginning we said it is necessary that we have good efficacy. Efficacy of a lamp is talked in terms of the lumen output per watt consumed and its amply clear from the data observed that sodium vapour lamp scores over all other lamps from the point of view of luminous efficacy. However what did we find? We found that it has a very poor colour rendering. Often times colour rendering is not essential in areas like harbors, industrial establishments and probably on highways and streets. And that’s the reason why in those areas one could employ these lamps. However interior work calls for application of good colour rendering is required.

Colour rendering by definition we said is ability of perceiving the colour and its normal thing. Now the next thing is use of florescence. Fluorescence was trying to extrapolate or take the radiation at one frequency and absorb and reradiate. And what do we do? We use mercury vapour for this because we find the mercury vapour has two bands, one in the ultra violet zone and the other in the visible zone. We are trying to employ or use that region that’s available in the ultra violet region and this is done using fluorescence. Fluorescence calls for use of certain phosphors. When we talk of phosphors three parameters become very important, the one the sensitivity range that is the range of radiation when it impinges sends the phosphor into fluorescence. Two is the peak of this, that’s very important because you are having line spectrum, we design to have that line available so that the particular phosphor gets excited.

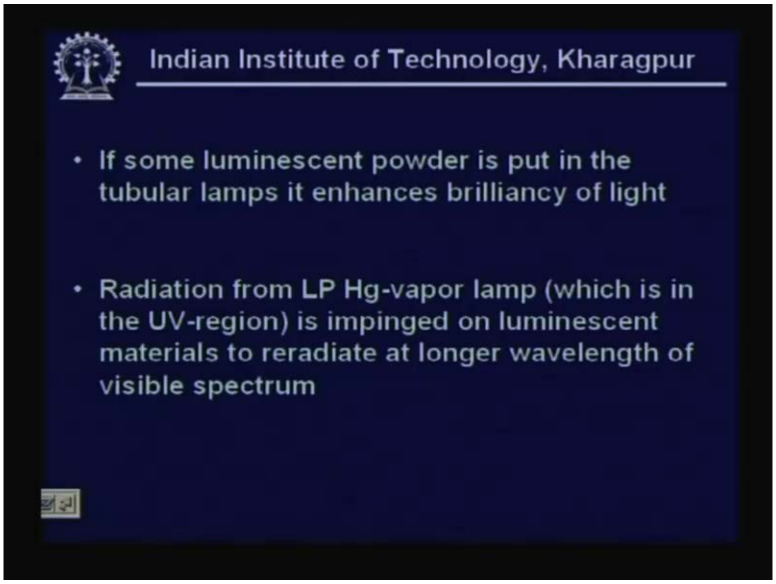
Well, after having it got existed, it is the emission that is important. Emission again has a range and fluorescence looks for emission in the visible zone and we saw among the materials that were used, zinc silicate and zinc beryllium silicate was having sensitive emission peaks close to the peak of the human eye sensitivity. That's what we had a look. Now all these being discharge lamps and they are depending on arc discharge and arc discharge calls for striking an arc between the two electrodes where the gas or vapour there. And therefore we have accessories associated with that, we had a look at that, we have seen that different lamps have different start up times and different restrike times, so that's the thing.

(Refer Slide Time: 00:46:12 min)



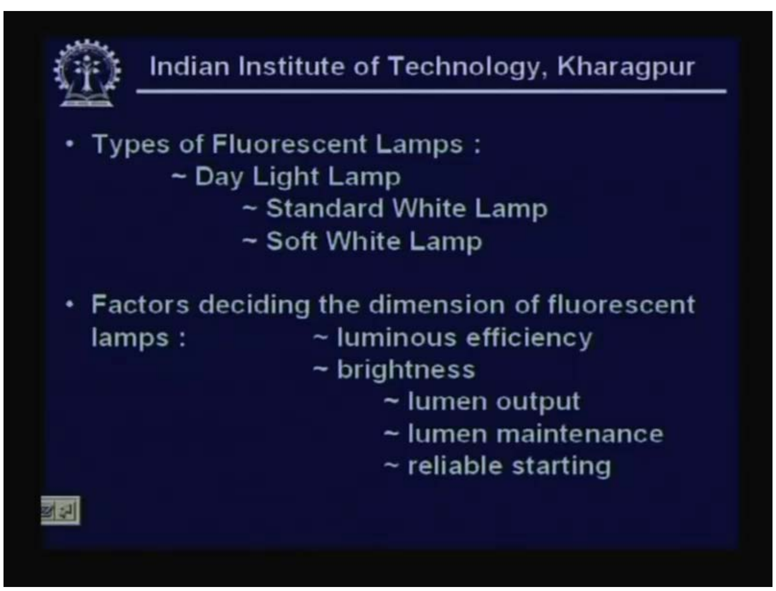
So one could say that the low pressure sodium vapour lamp sometimes we do use the indium oxide or halides are coated and that act as reflectors that's one thing. High pressure sodium mercury vapour gives bluish white line spectrum and sometimes in order to get good colour rendering, here again I must reradiate that colour rendering was little better than sodium vapour as far as mercury vapour goes. And therefore if energy is the issue or the power consumption is the issue, one could replace the incandescent lamp by a mercury vapour lamp because mercury vapour lamp does have what you call higher efficacy compared to the incandescent lamp.

(Refer Slide Time: 00:47:18 min)



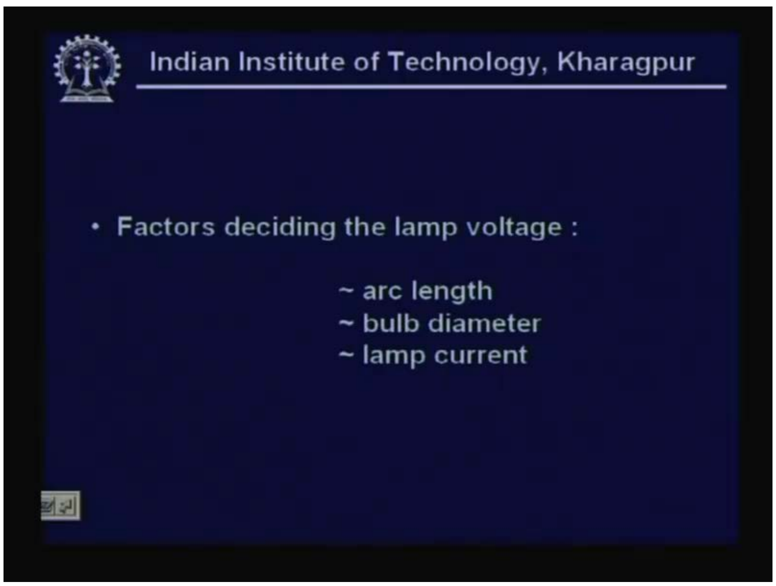
If some luminescent powder is put in the tubular lamp, it enhances the brilliancy of light that what we have seen. This is essentially considering a, what does it do? This powder is nothing but the phosphor that is converting the uv radiation into visible zone. This essentially is doing that radiation from low pressure mercury vapour lamp is allowed to reradiate at longer wavelengths. We have seen extensively how phosphors reacts, they have a peak sensitivity, there is a sensitivity band, emission peak and emission band keeping all this in mind, we found some of the phosphors that are used.

(Refer Slide Time: 00:48:02 min)



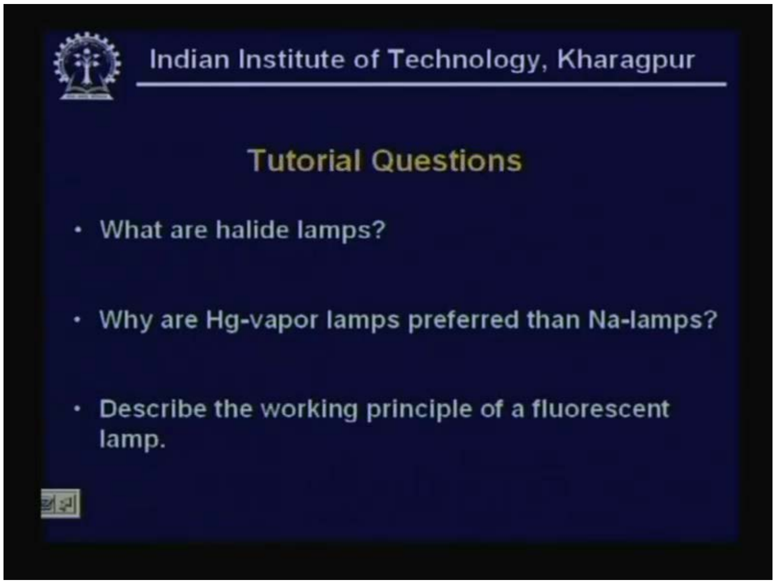
Now with this in mind, the fluorescent lamps which are quite often used that's what in fact we have enabled by going into fluorescent lamps. Utilization of mercury vapour discharge which had a low utilization factor when used otherwise compared to sodium vapour. But good colour rendering and that's how they have been in stay as far as the interior lighting goes. And they are categorized as day light lamp which has colour temperature close to noon temperature, noon sunlight. Standard white light and soft white lamp and the various ways of a fluorescent lamp dimensions of course there are two major dimensions, one is the length other is the diameter. We look into some of these issues in the next lecture where will also have a look how every watt of energy that goes in gets distributed in various forms. So it depends on the lumen maintenance and starting reliability of starting that's very important. Now starting depends on the, as we saw the voltage across the discharged tube and the total voltage that is the ratio we which we termed as the open circuit voltage to the lamp voltage. In fact we saw that it has to be around 4 to have an instant start lamp.

(Refer Slide Time: 00:49:37 min)



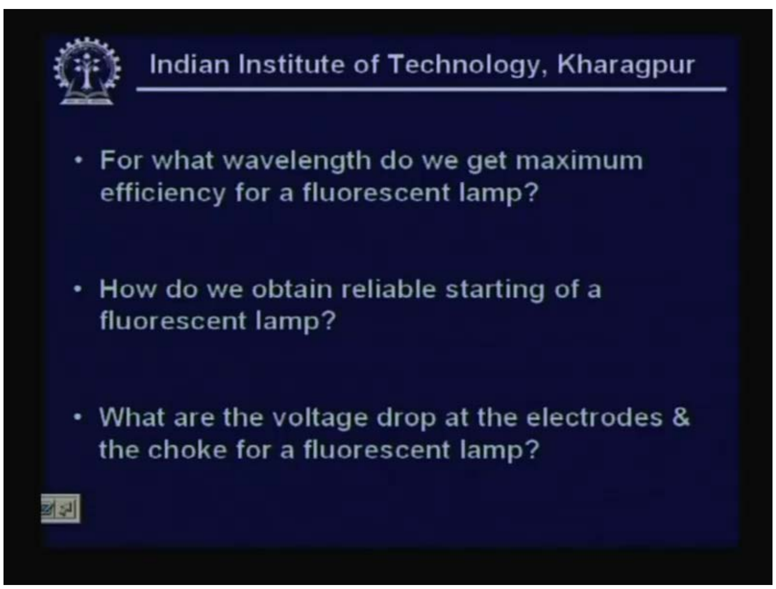
Lamp voltage of course we said bulb diameter, current and arc length decide so we are familiar with one inch dia tubes and we are also familiar with half inch dia and quarter inch dia which are coming these days called energy savers, okay. You remember that it is a discharge and the diameter has its own impact.

(Refer Slide Time: 00:50:10 min)



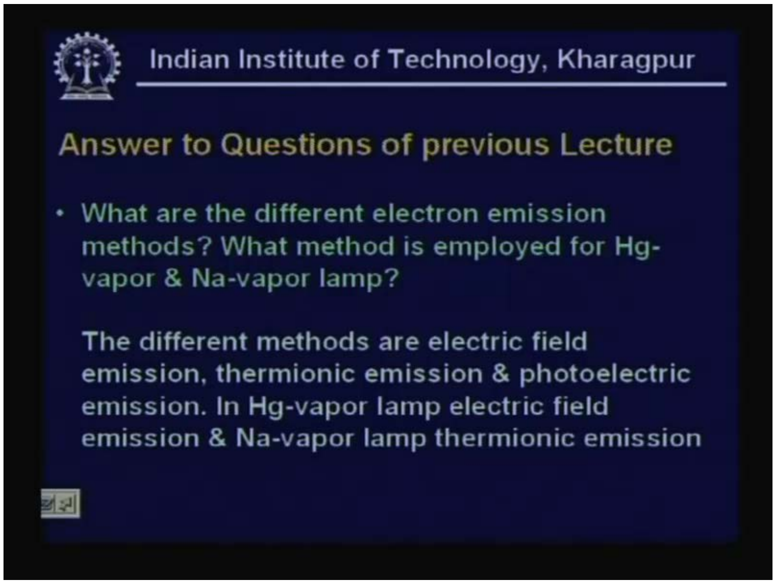
Having said this, some of the questions that may be answered here halide lamps, we have seen what halide lamps are, what kind of halides are used, why are mercury vapour lamps preferred than sodium lamps, describe the working principle of a fluorescent lamp.

(Refer Slide Time: 00:50:22 min)



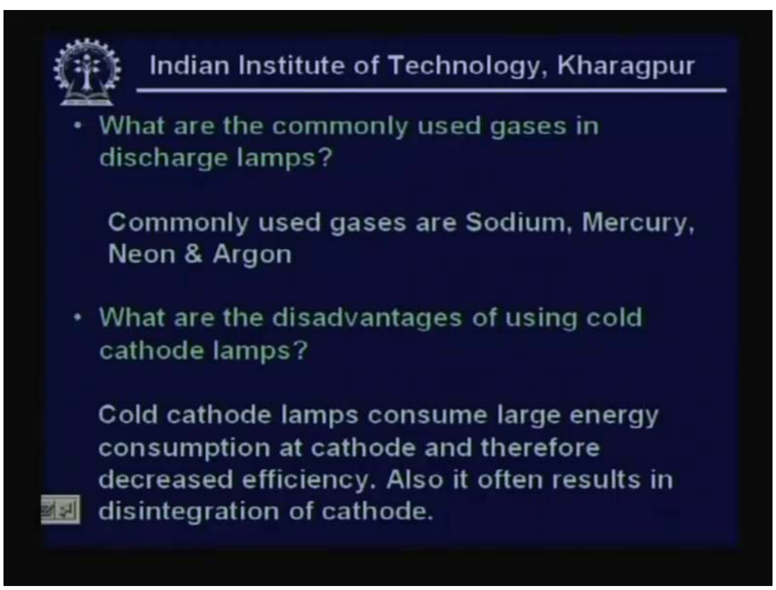
For what wavelength do we get maximum efficiency for a fluorescent lamp? How do we obtain reliable starting of a fluorescent lamp? What are the voltage drop at the electrodes and choke for a fluorescent? This is what the addresses basically the ratios that need to be maintained. Some of the answers to questions which we have already asked in a previous lecture on discharged lamps.

(Refer Slide Time: 00:50:47 min)



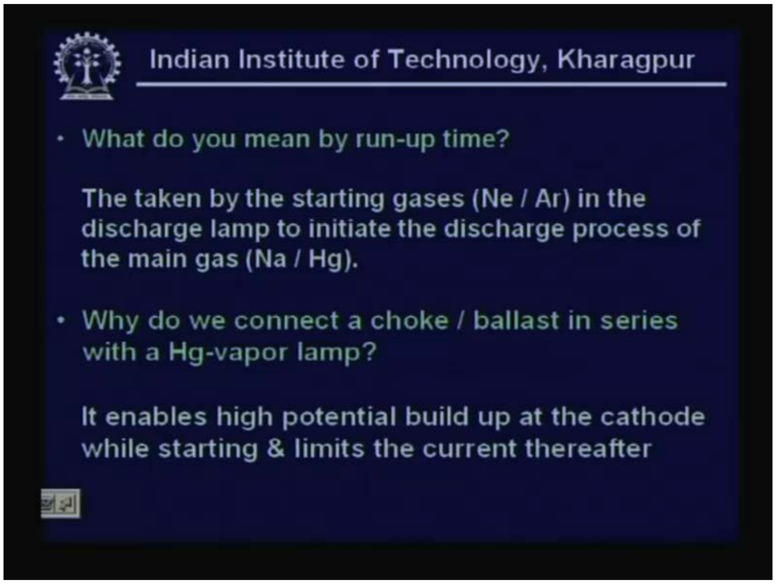
What are the different electron emission methods, what method is employed for mercury vapour and sodium vapour lamp? The different methods are electric field emission, thermionic emission and photoelectric emission. As already told electric field emission is by application of high field, thermionic is preheated and photoelectric is the (Refer Slide Time: 00:51:13). In mercury vapor lamp electric field emission and sodium vapour lamp thermionic emission is often used. That is normally low pressure mercury vapour lamps do not have any heated cathode.

(Refer Slide Time: 00:51:23 min)



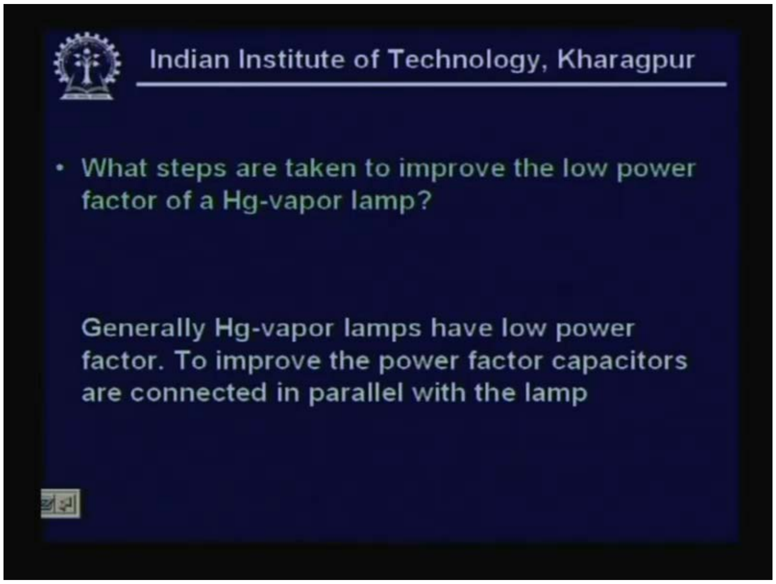
What are the commonly used gases in discharge lamps? Commonly used gases are sodium vapour, mercury vapour, neon and argon. Neon signs are often employed per as for display purposes, sign boards we have seen many in the shopping malls and it's quite often used characteristic red and of course other colours are obtained by a combination of gases or combination of envelops. What are the disadvantages of using a cold cathode lamps, cold cathodes, what are cold cathodes? Cold cathodes are those which employ field assistant emission and cold cathode lamps consume lot of energy and there is a large voltage drop that is the consumption at the cathode therefore decreased. It also leads to what we call disintegration of the cathode.

(Refer Slide Time: 00:52:17 min)



What do you mean by run up time? We have come across this run up time because the process after applying the voltage, there is certain finite time for the discharge to take place and the arc to be established. The time taken for the starting gas in the discharged lamp into the discharge process and transferring to the main gas this is what we call run up time. So this is we have seen in fact the run up time used to be very large for the lamps in the initial phase and these days we have high fast run up or less than 5 minutes. In fact we have studied that sodium and mercury vapour lamps did have large run up time of 20 minutes extra, these days we have them within 5 minutes. Why do we connect a choke or ballast in series with a mercury vapour lamp? It enables high potential build up that's what we said. Arcs need very a high voltage development that is done at the cathode while starting and (Refer Slide Time: 00:53:19) the current thereafter. This is possible because we know that if there is an inductive circuit, RL circuit you break or you create interruption in that current that builds a voltage transient and that helps the arc to build up.

(Refer Slide Time: 00:53:38 min)



What steps are taken to improve the low power factor of mercury vapour lamps? In fact generally mercury vapour lamps have low power factor, so why mercury vapour lamps even sodium lamps we can wherever there is power factor correction required we have a inbuilt capacitor. In fact we have seen the starter, cylindrical starter provided with the fluorescent lamps has this. What do you mean by principle line, what is the principle line for mercury vapour lamps? It's the wavelength of the lamp output spectrum which gives the maximum light output, for mercury lamp it is around 365 nanometers, this is the thing. Thank you.