Power System Engineering
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Lecture - 01
Over Line Insulators

So, welcome to this another course that is Power System Engineering. So, first we will start this one with that Overhead Line Insulators. Initially, particularly when we will cover like in your line insulator, so for in line insulators as well as the cables; initially some theories will be there. And after that and as usual a mathematical thing it will be described and supported by a good number of example. So for this course we will start with overhead insulators, right.

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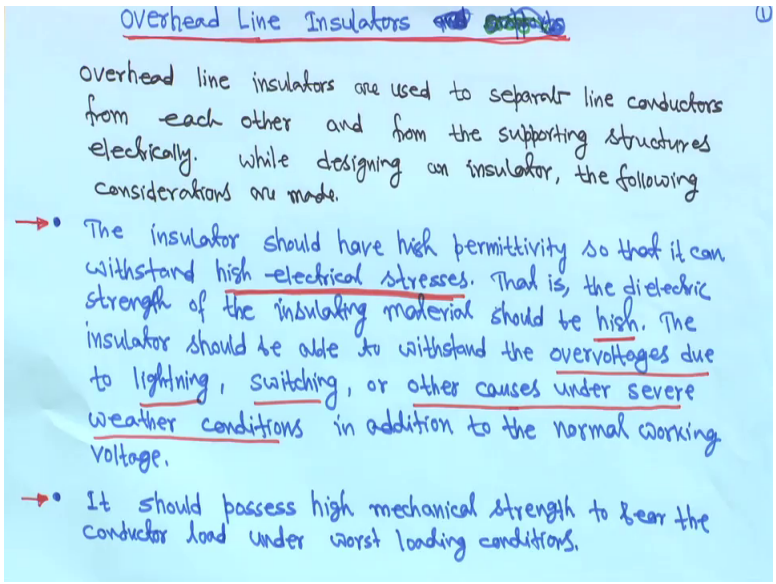

So, first an hour or so that only theories will be I mean regarding this insulators will be explained. So, first thing is that that generally that, overhead line insulators are used to separate the conductors from each other if you and from the supporting structures electrically. Now you have seen that transmission line or transmission the tau are with and transmission towers where we will find that insulators are there. So basically those high tension line right 66 kv or hour we will find those insulators are basically suspension type and any other thing up to 33 kv level or even 66 kv level pin type insulators generally they use.

So, first we will give that description of this type of insulators but it is a video lecture class, so all these things or something I have to skip and whatever the basic things we will try to understand. So, first thing is that overhead line insulators are used to separate the conductors from each other and from the supporting structure electrically right. While designing the insulator the following consideration are made. I mean whenever you choose insulator then some as some consideration I mean from the design point of view right you have to choose. First thing is insulator should have a high permittivity, so that it can withstand high electrical stresses, so insulated way or what you call insulator material whatever it will be used it must have a very high your permittivity, right.

And second thing is that dielectric strength of the insulating materials should be high, right so that means you have to design of course, later we will come we will see that porcelain are toughened glass got the very common thing but porcelain is mostly used but later we will come, right.

So the insulator should be able to withstand over voltages; due to lightning stroke that lightning is a phenomenon you know right due and switching or other causes under severe weather conditions. In addition to that your normal working voltage that will in insulator when it is designed it will it should be able to sustain that that the over voltages due to lightning stroke due to switching or other causes severe to severe other causes such as severe weather conditions say during windy storms right; and in addition to that normal working voltage.

Now it should also causes high mechanical strength to bear the conductor load under worse loading condition. If you look at the all the diagrams other things few I will show all the diagrams other thing cannot be shown in this video classes. But, if you look at that you know high tension line when you can see I mean on the road side or in the you know it is passing to the higher tension line if you see the different way of insulators are placed. So that means sometimes you can say vertically, sometimes you may say horizontal, and sometimes it is your v shape; we will come to that for a brief explanation.

So, it should possess high mechanical strength to bear the conductor load under worst loading condition. So, that means without insulator you cannot connect the your transmission line to the tower right that is that thing you have a tower that is the power

sometimes we call pole or towers and then cross arms will be there. So once this is your; in this another thing is that it needs to have a high resistance to temperature changes.

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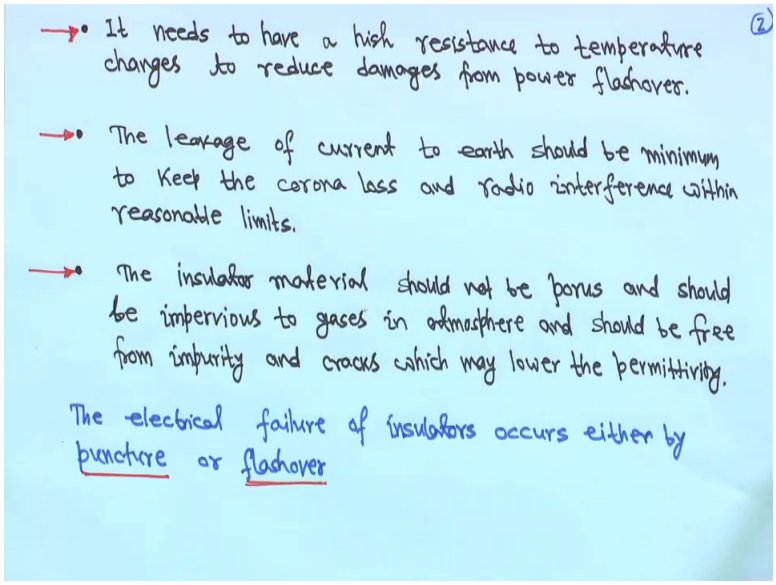

So, it has to have this thing your high your resistance to temperature changes to reduce damages from power flash over. This flash over is very common right and second thing is the leakage of current to earth should be minimum to keep the corona loss and radio interference within a reasonable limit this corona loss thing will come later you have a we will discuss corona loss also but later, so that will come after 3 or 4 chapters.

So, that means that leakage of current to earth should be minimum to keep the corona loss and radio interference within reasonable limits. Now another thing is the insulator material it should not be porous and should be impervious to gases in atmosphere and should be free from impurity and cracks which may lower the permittivity. That means, you have I mean you have to you have to choose the insulator insulated material; I mean insulated material in such a fashion such that it should not be porous and should be impervious of gases in atmosphere such that I mean where you are using in insulators. And if you know gaseous environment is there then it should say it should it should not be a spoil or damage right and should be free from impurity and cracks which may lower the permittivity there should not be any crack. So the electrical failure of insulator occurs either by puncture or flash over the puncture, if a puncture happens that means that means that electric that insulator will be totally damaged.

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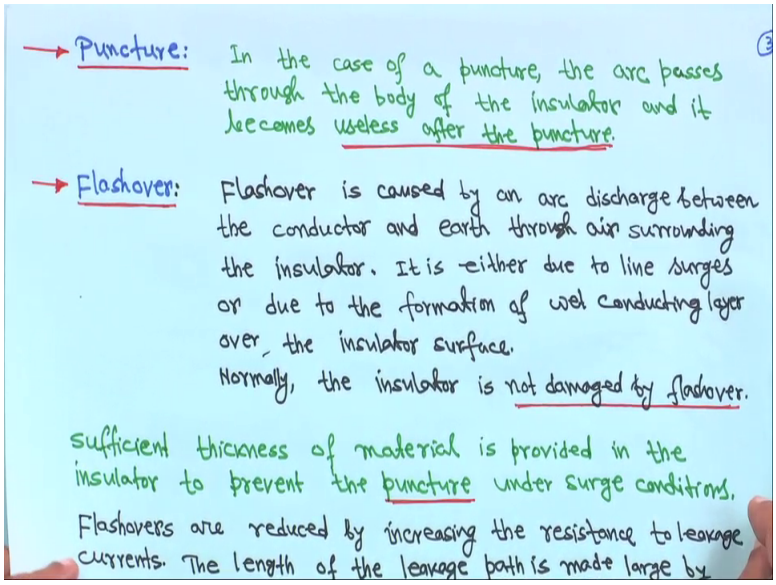

So that is why that your puncture case, In the case of a puncture the arc passes through the body of the insulator and it becomes useless after the puncture right if any arc forms and it passes through the body of the insulator then insulator will be totally damaged and you once puncture happens. Although that phenomena is very rare it happens I mean the probability of happening is very less, but still if it happens means that insulators is will be totally damaged right and then flash over is caused by an arc discharge between the conductor to an earth through air surrounding the in insulator. So this it is either due to line surges or due to the formation of wet conducting layer over the insulator surface.

Normally the insulator is not damaged by flash over, so in the flash over insulator we will not be damaged, because materials are designed meta materials are your made in such a fashion that flashover actually it does not spoil the insulator you might have you can see that it is in rainy season or other thing. Even if you even under tracks and line those insulators if it is there particularly I have also observed during rainy season other things some I mean flash over is going on but nothing will happen to the insulators. So that is why flash over if it happens so insulator will not be damaged, but puncture it is that means that arc will pass through the body of the insulator and it will be totally damaged I will give you some diagram of it right.

So, therefore the sufficient thickness of material is provided in the insulator to prevent the puncture under surge condition, there is a strong possibility that under the surge

condition that that insulator you are what you call may be a punch we got punctured. So it will sufficient thickness of insulin insulated material is used of course, these are all design thing design parameters rather.

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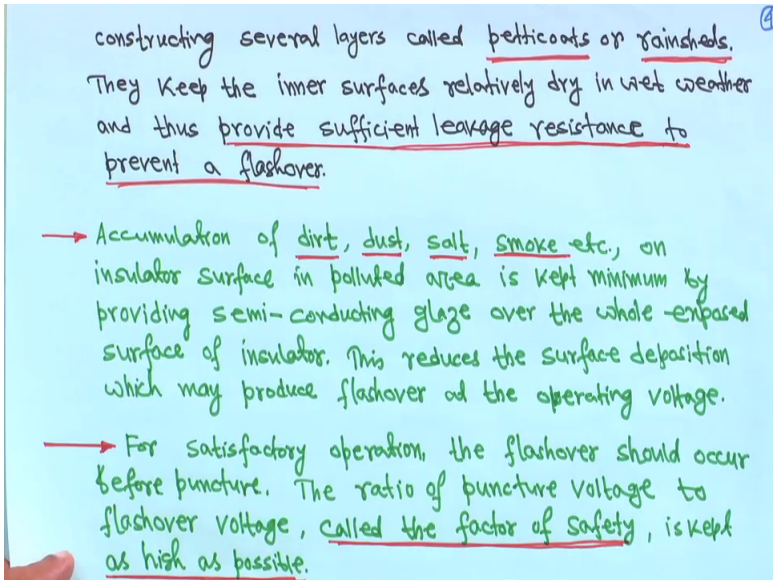

So, flash overs are reduced by increasing resistance to leakage currents that is the band the length the length of the leakage path is made large by construct your or what you call it may large by constructing several layers called petticoat or rain shed you might have seen insulator I repeat this one that flash over are reduced by increasing the resistance to leakage currents the length of the leakage path is made large by your constructor constructing several layers called petticoats or rain shed. You might have observe the insulator it is like a cap type of thing right I will give the diagram later on it is sometimes it is called petticoats or rain shed. That means it will inner portion will remain dry that is that your what to call the rain sheds are used they keep the inner surface relatively dry in a wet weather condition and thus provides sufficient leakage resistance to prevent a flash over.

So, that is that design thing, if you have if you have seen the insulator you will see that on the top it is a cap type of thing I will come to the diagram later right. So another thing these are all general thing, so accumulation of dirt then dust or salt or smoke etcetera on insulator surface in polluted area is kept maximum minimum right. By providing semiconducting glaze over the whole exposed surface of insulator if you look at the

insulator you will see the top portion actually glazing right, so just to that such that your accumulation of dirt dust or salt or smoke etcetera. I mean all these thing there will be no there will be deposition will be less on the surface of the on the top portion of the insulator that is why it is you will find it is a semiconducting glaze over the whole expose surface of the insulator.

But insulator made of porcelain and it is a very heavy even 1 unit you cannot very it is not easy to pull it by hand it is very is a very heavy thing right, this reduces the surface deposition which may produce flash over at the operating voltage. Now for satisfactory operation the flash over should occur before puncture right. This has to happen that the flash over must occur before the puncture, but puncture I told you it is very rare phenomena but if it happens insulator will get damaged. So ratio of the puncture voltage to flash over voltage called the factor of safety this is called factor of safety it is kept as high as possible that means puncture voltage should be much higher than the flash over voltage.

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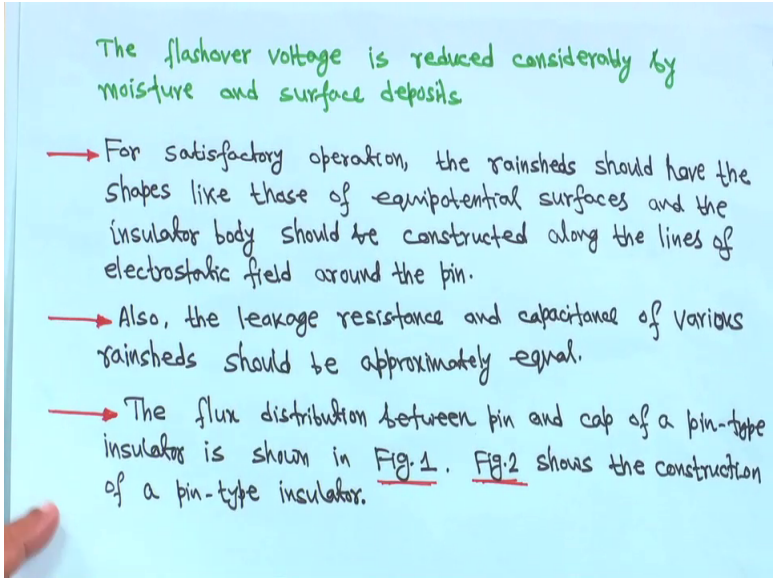

So, therefore the flash over voltage is reduced considerably by moisture and surface deposit for satisfactory operation the rain sheds should have the shapes like those of equipotential surfaces and the insulator bodies should be constructed along the lines of electrostatic field around the pin. I will come to that around the pin means pin insulator

right also the leakage resistance and capacitance of various rain sheds should be approximately equal.

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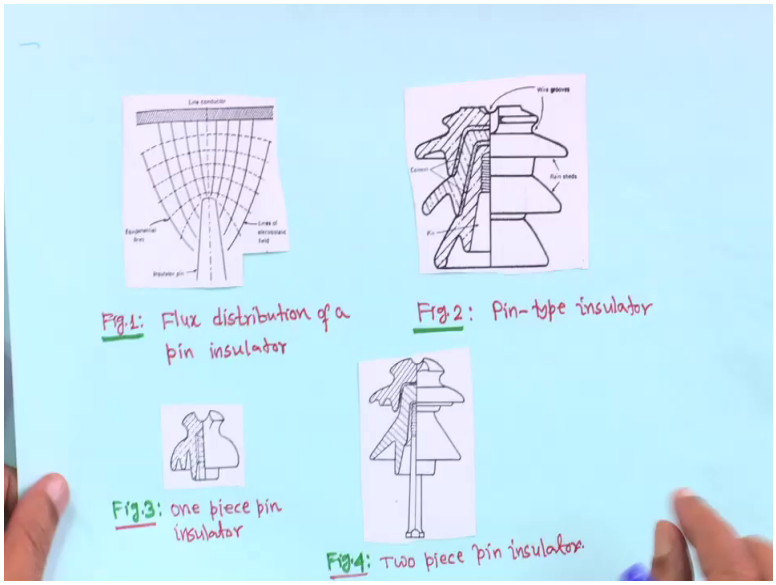

So, the flux distribution all these things, now actually before coming to the figure one this is actually a figure 2 I will come to that I have taken from a book then rather than hand drawing. So this is actually flux distribution of a pin insulator this is a pin actually. And this is through insulator pin and this is your lines of electrostatic field and this is equip pattern potential surface and conductor is connected suppose here. So this is your line conductor, so this is actually flux distribution of a pin insulator and this one that pin type insulator this is actually this one this one this one this is actually called rain shed.

So, upper portion your what you call that in inside of this that will be more or less dry and these are all cemented, but and this is actually pin this is actually pin this is a pair also 2 piece pin this is actually pin and this is actually screw this is screw I will come to that right. And this is 1, piece this is 2 piece and this is 3 piece insulator, I mean 3 sets are there or petticoats are there this 1 2 3 here also 1 2 and here also only 1 only 1 right I will come to that.

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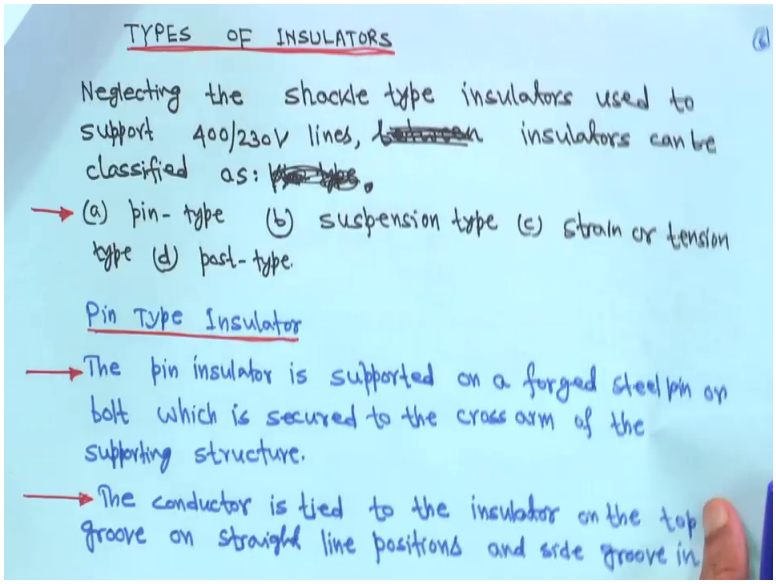

So, generally just hold on, so now the types of insulator, so neglecting the shackle type insulators used to support 400 230 volt you might have seen in front of your house or in your college that line insulators can be classified shackle type will not consider a small one right, either pin type b is also there suspension type and c is the strain or tension type and d is post type, so strain or tension type pin type suspension type. We will see how the how this are, so pin insulator is supported on a forged steel pin or bolt which is secured to the cross arm of the supporting structure. Actually, here this is this actually this is actually your pin right and what in inside the screw is there and this these two this is these are a cemented and it is your what you call.

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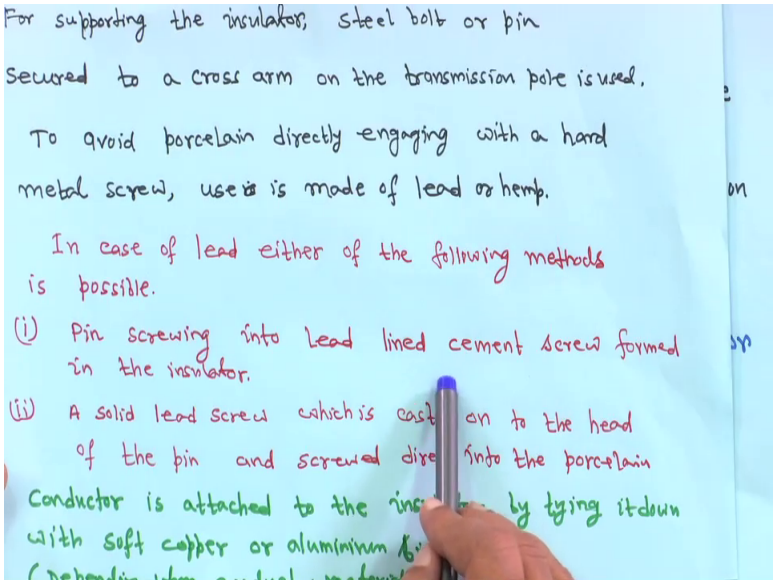

For supporting insulator here that steel bolt or pins secured to a cross arm on the transmission pole used right, in the transmission pole you have seen the tower and then the cross arm right, so cross arm of the transmission pole is used right to avoid porcelain directly engaging with a hard metal screw use is may or use is made of lead or hemp right. So this is actually your what you call to avoid emerging part with the hard metal screw use is made of lead or hemp, so this is actually you are not fully been seen but this is actually screw.

And these are cemented made so it will be such that actually that screw is tightened to the cross arm such that you are what you call it but it will not touch the insulating material porcelain will not be touched I will come to that. But that is why it is cemented and with a metal screws use is made of lead or hemp generally lead, right. In case of lead either of the following methods is possible one is pin screwing into lead lined cement screw formed in the insulator. So that is why it is that is why it is cemented it is cemented here it is shown cement right cement it is.

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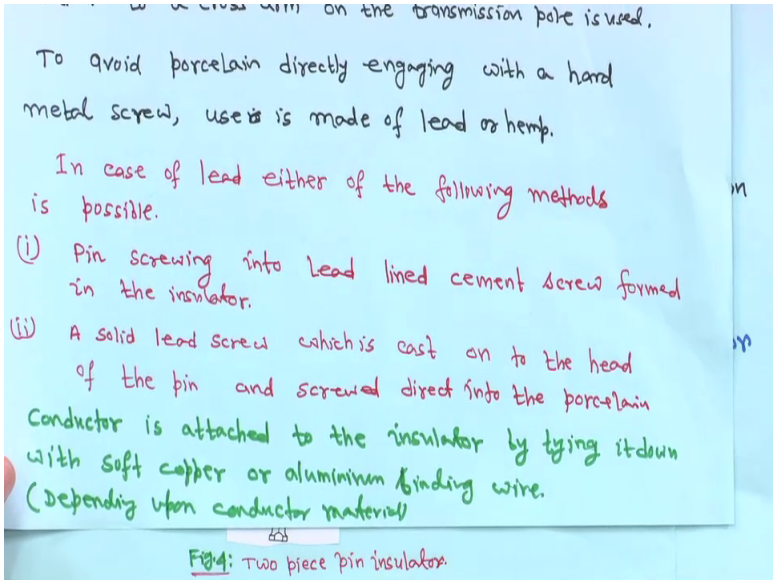

And this is pin, so pin screwing into lead line cement screw formed in the insulator, second another thing is a solid lead screw which is cast which is your cast on the head of the pin and screwed direct into the porcelain. So, anyway the conductor is attached to the insulator by tying it down with soft copper or aluminum binding wire depending upon conductor material. Actually here if these are the wire groups here right if conductor passing through it will be tapped suppose if it is a copper conductor then it will be tied with your what you call by the copper same copper conductor if it is aluminum then it will be tied with aluminum conductor so this is actually wire groups, so this is 1 2 3 this is 3 pin, this is one piece pin insulator and I mean general thumb rule is something like this that if voltage level is higher than number of insulate this thing will increase right number of insulator will increase, but in other way number of pieces will increase right, so if 1 2 3 so many are there and particularly for suspension type it is string.

And if it is only for low voltage level only your one piece generally thumb rule is that one piece means in general it is 11 k v then two piece peace means 22 k v, three pieces 33 k v like that, so this is two piece but philosophy everywhere it is remain same if it is one piece there 2 3 piece then you will see 2 cemented your cover is here, but if it is single one sorry 2 1. Then only one cemented thing is there right so that means, that means and that means pins screwing into lead line your cement screw formed in the insulator. So, this is actually your then pin type insulator and only thing about this pin type insulator is that if that for pin type insulator, if the your number of this rain shed

increase. I mean voltage level is increase it is cost become higher and higher although many cases it is restricted up to 66 k v, but up to 33 k v level it is cost is managed I mean the cost is not that high but if you try to use the your voltage level then cost of the pin type insulator will be higher right.

So, therefore the pin type insulator just is supported on a forged steel pin or bolt which is secured to the cross arm of the supporting structure, but any pole or tower you will see that supporting arm is there. So the conductor is tied to the insulator on the top group on straight line position and side group in angle position by annual binding wire of the same material or as conductor.

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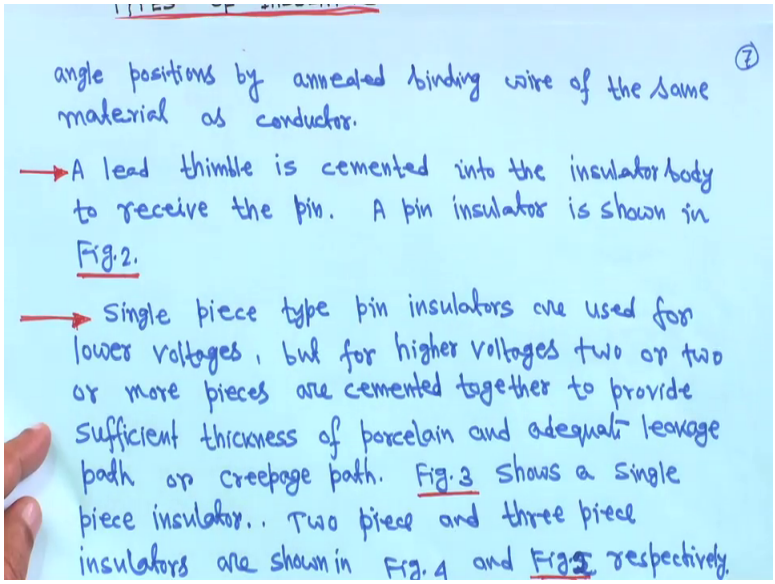

As I told this is the top group and this is the angle group. So, the way the conductor are tied right, but if the conductor is made up copper then it should by same conductor you have to tie and if it is a aluminum then same aluminum conductor you should use to tie it up right. So that means then a lead thimble I showed you is cemented into the insulator body to receive the pin a pin insulator is shown in figure 2 this is I told you this is a this is your what you call pin type insulator. So single piece type in insulators are used for lower voltages I showed you this diagram, that if you have a single piece then this one then this is for lower voltage level then for higher voltages to or two or more pieces are cemented together to provide sufficient thickness of porcelain and adequate leakage paths or creepage path.

So, figure 3 shows a single piece insulator two piece or three piece, so this is single piece insulator this is two piece insulator and this is figure 2 is the single your what you call that three piece insulators it have more if you want more than voltage level will be more right, so two piece and three piece insulator just I shown you in shown in figure 4 and this is figure 2 actually figure 2 right this is actually figure 2 right respectively.

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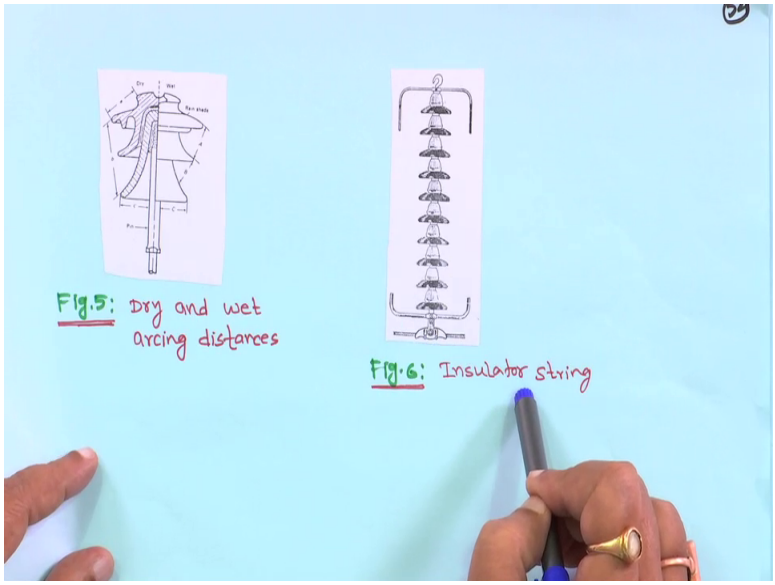

Now next is now another thing is for pin type insulator this one dry and wet arcing distance, so this side if you look into that do not see this one do not see this one that this side this is your this is dry. And this is your arcing distance this is your B and this is C and this side is wet this is wet portion this is rain shed this is A B and C this is your arcing distance.

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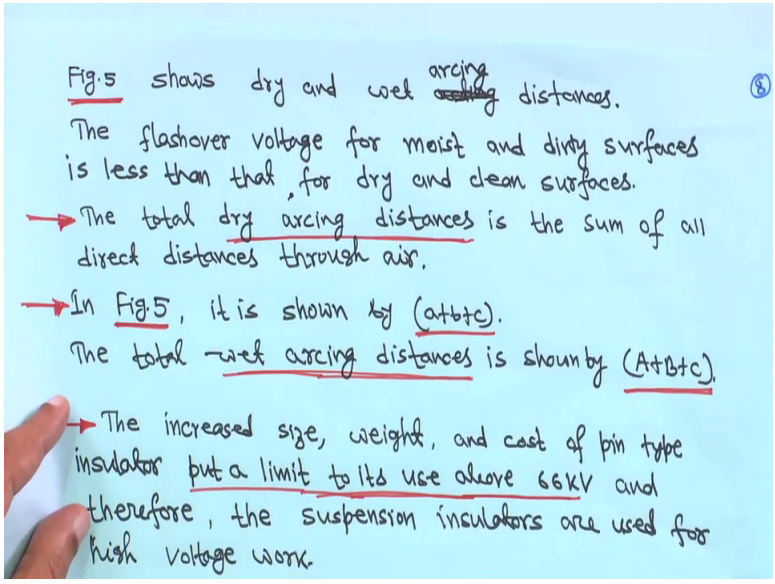

So, in this case figure 5 that is why it shows dry and wet arcing distances, the flash over voltage for moist and dirty surfaces is less than that of the dry and clean surfaces right. The total dry arcing distance is the sum of all direct distances through air. So, this is the total dry arcing distance this one is A this is B and this is your C this distance and this one and the total your what you call this distance is A plus B plus C this one your for wet arcing distance is this one this is a this is B and this is A plus B capital A plus capital B plus capital C, so the total wet arcing distance should be shown by capital A plus capital B plus capital C in this figure capital A plus capital B plus capital C.

So, the increased size wet and cost of pin type insulator put a limit to it is use above 66 k v, I have written above 66 k v is generally up to 33 k v you will find it is used and therefore, for some cases 66 k v. And therefore, the suspension insulator are used for a high voltage work then for high voltage line 66 k v or above you will find all the insulators are suspension type, that means so many pieces will be there before coming to suspension insulator this is that suspension insulator.

You will find any high tension transmission line. If you look at the tower you will find these are the this is the insulator stream then look so many pieces are there and conductor will be connected at the bottom this is such this is your vertical position horizontal position is also available, and as well as your connection will be different, and as well as your V connections are there so we will come one by one. So this is what you call that

insulator string together it call insulator string. So now we will come to this is the suspension insulator will come?

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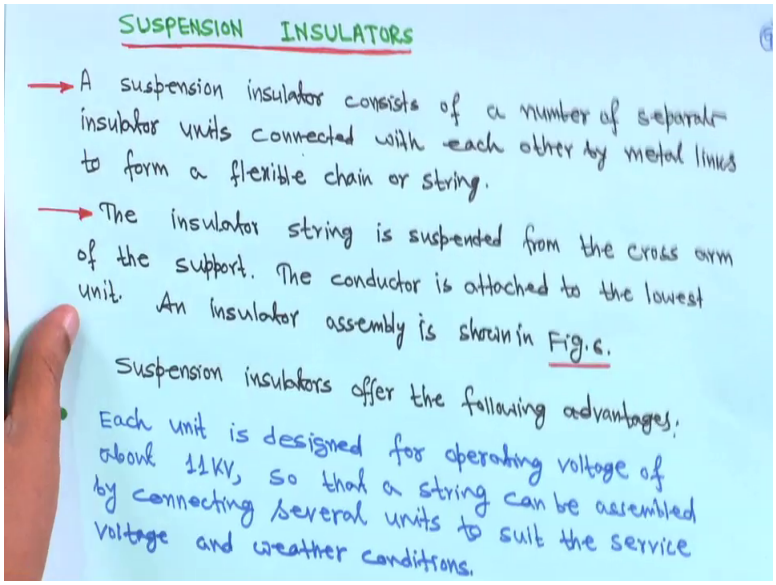

Now, this suspension insulator consists of a number of separate insulator units so each one is a separate insulated unit right ,connected with each other by metal links to from a flexible chain or string they all are connected with a metal link right with each other for a flexible chain it becomes a flexible chain or string right. And the insulator string is suspended from the cross arm of the support suppose you have that you have that this thing what you call that truck tower. And you have the cross arm and from the cross arm it is suspended these are suspended you might have observed in that a transmission tower right, so the conductor is attached to the lowest unit and insulator as a conductor will be it is getting conductor is connected at the bottom right and suspensions will offer the following advantages it has some advantages.

So at what are the advantages each unit is designed for operating voltage about 11 k v, so each unit I told you some thumb rule is there so each unit is about 11 k v, so that a string can be assembled by connecting several units to suit the service voltage and weather condition, so for example if I assume that 220 k v line so roughly your 22 pieces will be there which will form one string so that means it will be very heavy, right.

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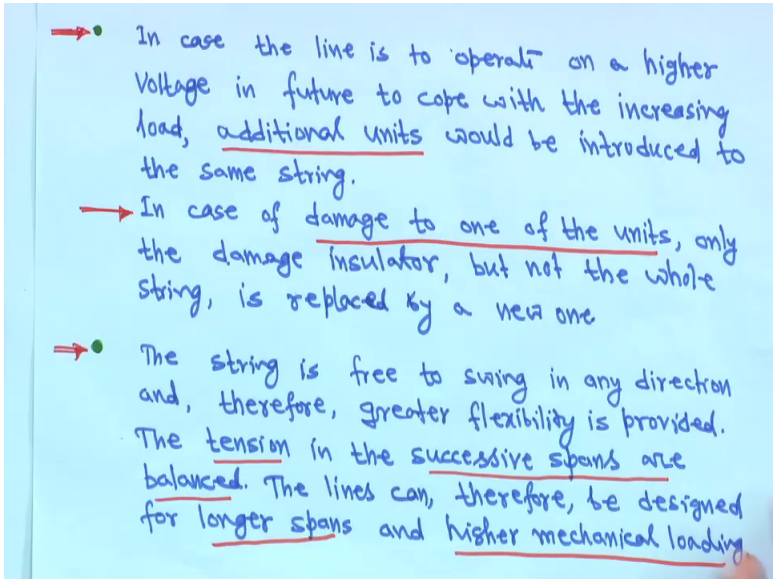

Second thing is in the case the line which operate on a higher voltage this is another advantage is there if the in case the line is to operate on a higher voltage in future to cope with the increasing load additional units should be introduced to the same string that means, suppose it was operating at 130 say 2 k v. Now we want to increase the voltage level. So in that case this that you are what you call that option is there you can connect more string with that I mean more pieces with that such that your voltage level can be increased right. So, that that option is there two additional unit should be introduced to the same string it is possible here it is possible.

Another thing is in case of damage to one of the units suppose if out of so many units suppose one unit is damaged right if one unit is damaged your then only the damaged insulator but not the whole string is replaced by a new one. That means if one unit is damaged that you can replace the damaged unit but not the whole string this is the another advantage for the suspension insulator. Now the string is free to swing in any direction. And therefore the greater flexibility is provided, so it can swing in any direction particularly during strong wind or storm right the tension in the successive spans are balanced the lines can therefore be designed for longer span and higher mechanical loading.

So, I mean this you are what you call that even if there is a your strong wind or storm whatsoever it will swing but it that distance between the two towers success it will be if

they design it from the how long it should be. And of course, another aspect is there the sag and tension of that that we will see later maybe may be it will be 4th chapter or 5th chapter sag and tension right, but those things therefore be or what to call the tension in the successive span are balanced, so the lines can therefore be designed for longer span and higher mechanical loading. So this is the advantages of your what you call the string insulator.

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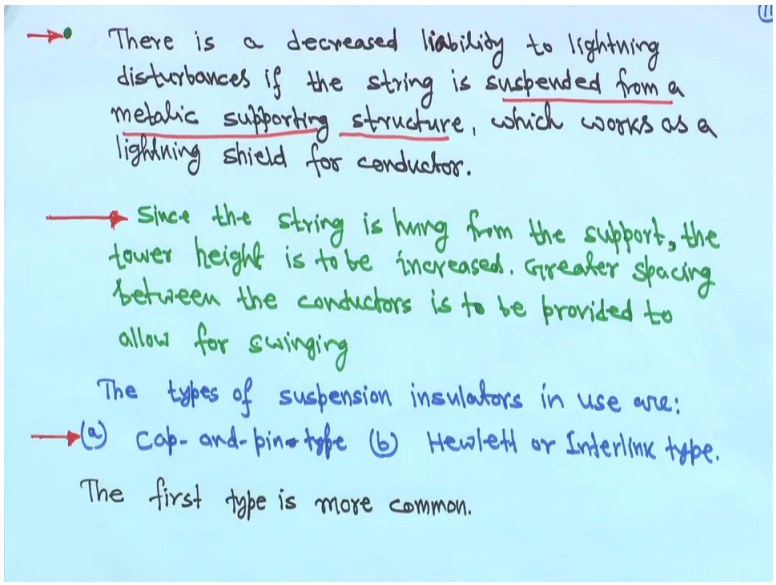

So, once this sorry this is a suspension type insulation and another thing is there is a decreased liability to lightning disturbances if the string is suspended from a metallic supporting structure which works as a lightning shield for conductor, so this is another advantage a great advantage actually there is a decreased liability to lightning disturbances. I mean if there is a lightning stroke on the tower say if the string is suspended from a metallic supporting structure which works as a lightning shield for conductor so this is another advantage.

Since the string is hung from the support the tower height is to be increased because this because the reason is, because high voltage line this insulator with so many pieces are there so it is very long and even 3 phase line. So that means that means for each phase there is for each phase and you know or what you call between your each corner for 3 phases 3 such insulators will be there at every tower right.

If it is a your what you call that your single conductor line so for in each space so such so that we string is hung from the support the tower height is to be increased this is true tower height will increase, greater spacing between the conductor is to be provided to allow that for swinging. So, there must be must be greater spacing between the phase conductors such that it will allow for swinging, during storm if you observe you will see it is to some extent it is swinging right. The types of suspension insulators in use are cap and pin type and second thing is Hewlett are inter link type these two type are there, the first type is more common that is cap and pin type is a more common this is actually your cap and pin type this is more common.

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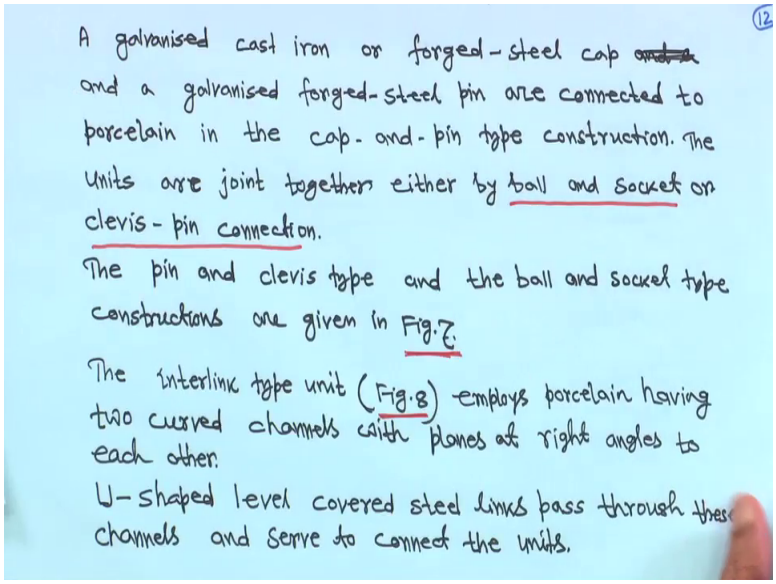

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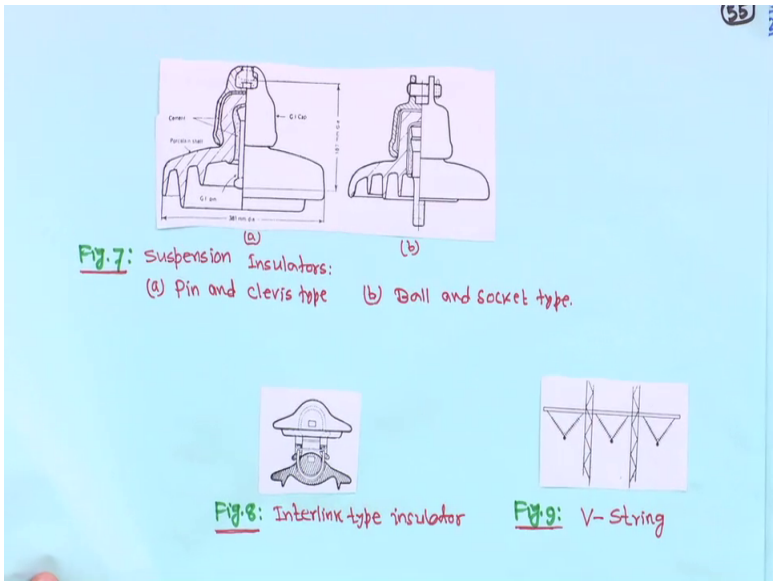

Then, so basically a galvanized cast iron or forged steel cap and a galvanized forged steel pin are connected to the porcelain the cap and pin type your construction, so the units are joined together either by a ball and socket or clevis pin connection this is that (Refer Time: 28:18) or suspension pin insulator this is a pin and clevis type, this is your the same as cement this is porcelain cell right this is the cap and this is ball and your socket type right.

So, the galvanized cast iron or forged steel cap this is the cap forged steel cap and a galvanized forged steel pin are connected your to the porcelain in the cap and pin type your construction, the units are joined together either by ball and socket or clevis pin your connection. The pin and clevis type and the ball and socket type connection are shown in figure your 7 a and your 7 b right, so it is 7 a it is pin and clevis type and it is the ball and socket type. Let us say there is a video class and if demonstration is required then one has to go to the substation so many open insulators are there I mean I do not like those were those who will take these courses maybe in your if you have a lab particularly high voltage lab you may have this insulator thing and there you can observe all these things must be there.

And second thing is the interlink type unit that is this figure this is actually interlink type insulator have a look just this one this one interlink type it implies porcelain having two curved channels with planes at right angles to each other you have this two curved your;

what you call that two curved channels and it is there is U shape here this is a u shape U shaped here. So U shaped level covers your steel links pass through these channels and serve to connect the units this U this U shape link is there right.

So, pass through these channels and serve to connect the units, so this is actually interlink type, but in what will happen that interlink type unit it implies porcelain having two curved channels are there. So there is insulating material between these curved channel it will be there will be highly electrical stress on this right. So that is another disadvantage of this one that between these two that insulator material will be there and it will be highly stressed.

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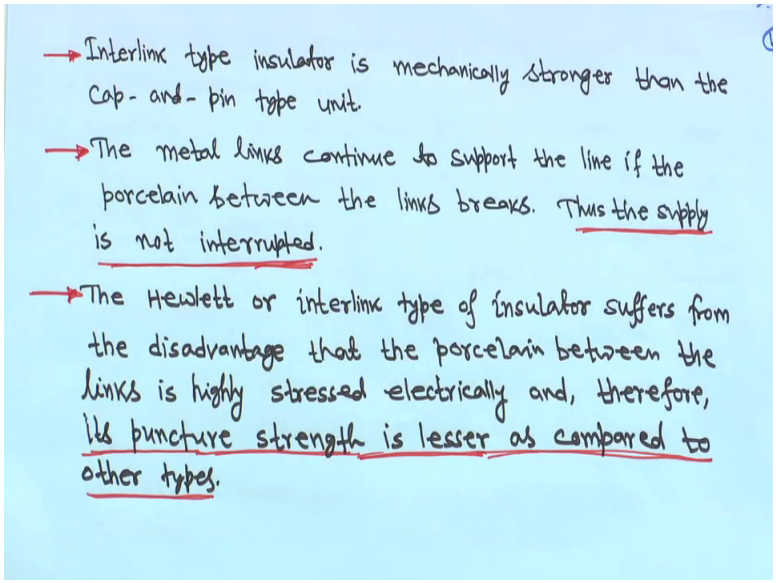

So, therefore, the interlink type insulator is mechanically stronger than the cap and pin type that is correct, but the metal links continue to support the line if the porcelain between the links breaks thus the supply is not interrupted. So, metal links actually continue to support the line if the porcelain between the links break. Thus, the supply is not interrupted this is some of the your advantages of this your what you call that this kind of insulator. But, inter link type of insulator suffers from the disadvantage that the porcelain between the link is highly stressed electrically. And therefore it is puncture strength is lesser as compared to other types. That mean, in between that in porcelain insulator is there will be highly electrical stress right. So that means the puncture strength is lesser as compared to other type of insulator.

So, these are your some kind of configuration of the insulator. And the metal links, and between each pieces that there will be metal link to support the line if the porcelain between the links break; if porcelain breaks also later you can replace, but question is that it will support the line right. So this is the advantage.

Thank you, we will come back again.