Advances in UHV Transmission and Distribution

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Lecture – 20
Selection/Design of clearances for HV towers

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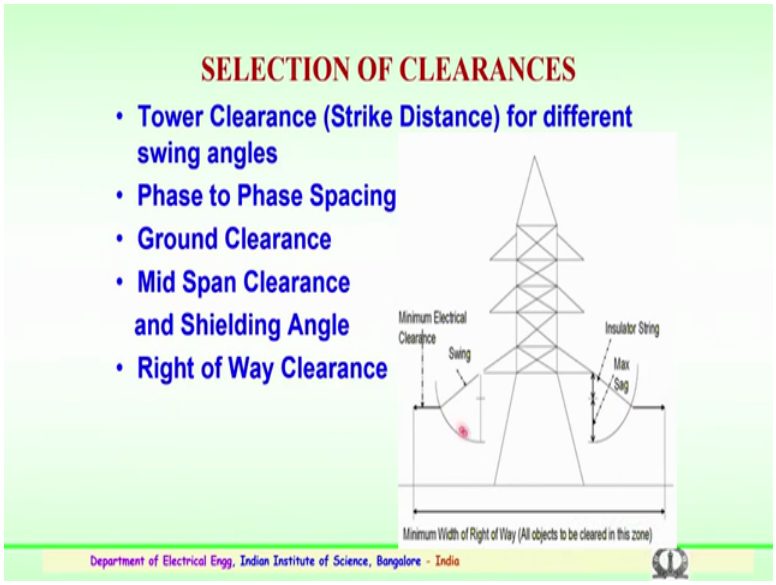

Now we will look into the clearances aspect and how the selections of clearances are being done for the towers. So, we see here the tower clearances; that is the strike distance; the strike distance for different swing angles. So, you can see the conductor the tower which as the three phases here r y b single circuit. Again r y b one more circuit. So, you have the final insulator string here as shown here the insulator string is here the conductor are here for the one of the phase in case of the wind there will be a swing. So, this swing angle and the point from the swing to the minimum clearances minimum electrical clearances again it depends on the voltage level of the transmission tower or the voltage level of the tower which is used for that particular transmission.

So, these minimum clearances; so, the total distance after the swing from here to the entire from both the sides of the tower with these entire distance is determined has the right of way what is the minimum clearances to be maintained for all the towers are depending upon any voltage levels. So, this right of ways very important that proper

clearances have to be maintained these has been considered including the sag or a swing because of the local wind effects.

So, selections based on the tower clearances minimum clearances from phase to phase each phase then again ground to phase then minimum ground clearances. So, so several of these factors have to we considered phase to phase spacing again as I mentioned this is one phase one phase. So, phase to phase spacing ground clearances is the conductors will be here this is the insulator string the control. So, this point from here to the ground connection this is the ground clearances. So, depends on the voltage level what voltage level is the minimum ground clearances have to be maintained. So, mid span clearance from here what is minimum and the shielding angles this is the angle which protects the minimum clearances and total right of way clearances.

So, total from the midpoint of the tower either side what is the minimum clearances estimated including the length of the insulator string is the swing angle and the total minimum electrical clearances have to be maintained. So, these have to be added for any voltages which are to be used in the transmission.

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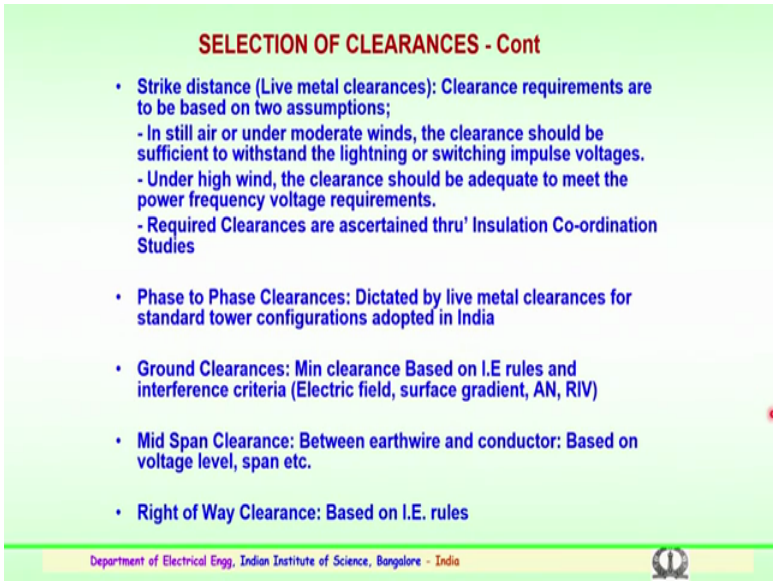

So, selection of clearances again we have also to look into the live metal parts which are being used for like the conductors the yoke plates the corona control rings the strike distance have to be maintained the proper clearance are requirements are to be based on the important assumption to important assumption in still air in the normal conditions

under moderate winds. So, the clearances should be sufficient to withstand the lightning or switching impulse voltages.

So, what about the designed or the estimated clearances including the metal part and the clearances to the phase to phase or to the tower in case of lightning activity or the switching activity it has to be able to withstand this surges under a moderate winds under high winds the clearances should be adequate also the mid power frequency voltage requirement so, normal power frequency over voltages which we were discussing. So, under heavy winds in case of heavy winds there will be swing which will be more than the normal case and that swing the clearances from the tower to the metal parts or phase to phase have to be seen that there should not be flash over for the power frequency voltages which the conductors are being which the conductors are loaded.

So, the required clearances are ascertained through the insulation coordinating studies so very important point which I normally trust earlier. So, insulation coordination is a very important criteria for the extra high voltage and ultrahigh voltage transmission where proper coordination in the insulation has to be carried out for lightning is switching or normal power frequency over voltages. So, that there will be no flash overs or no black outs because of the break down which could happen because of heavy winds or because of the fog or because of the contamination or because of the any other natural activity.

So, phase to phase clearances these are basically dictated by the level live metal clearances that are the live metal clearances may be corona control rings yoke plate the conductors. So, for the standard tower configurations have to be properly adopted as per the country as per which are been adopted for various voltage levels. So, minimum clearances have to be the considered before the towers are being in strung with the conductors.

So, then ground clearances what are the minimum clearances this should be based on the Indian electricity rules or international electricity rules and the interferences which are because of this conductors if the minimum clearances are not a maintain there could be interferences and higher electric field surface gradients and there could be audible noise radio interference so to see that the proper ground clearances or a minimum ground clearances have to be maintained for particular voltage level or for a particular conductor

size. So, that the electric field is reduced the gradients are reduced audible noise is reduced and radio interference and visible corona are reduced.

So, mid span clearances this is again between the top most portions of the tower the earth wire where it is connected and the conductor this is again based like this earth wire will be somewhere here this is the top most point where earth wire or the ground wire is completely connected from the earth wire to the phase third phase conductor. So, this; what is the minimum clearances to be adopted the phase to the earth wire very very important. So, that is what it is said here ground clearances minimum based on a this mid span clearances between earth wire and the conductor again based on the various voltage level what is the span of the tower to tower span length etcetera are very important while selection of the clearances have been made for a different voltage levels.

Then finally, the right of way very important which we discussed right of way is again is the total distance of with swing angle from this point to the other point of the tower which has to be maintained as per the Indian electricity rules or the international prescribed electricity rules for the higher voltage or ultrahigh voltage at transmission very important consideration and also plan to estimate the selections while a going in for the transmission or distribution system.

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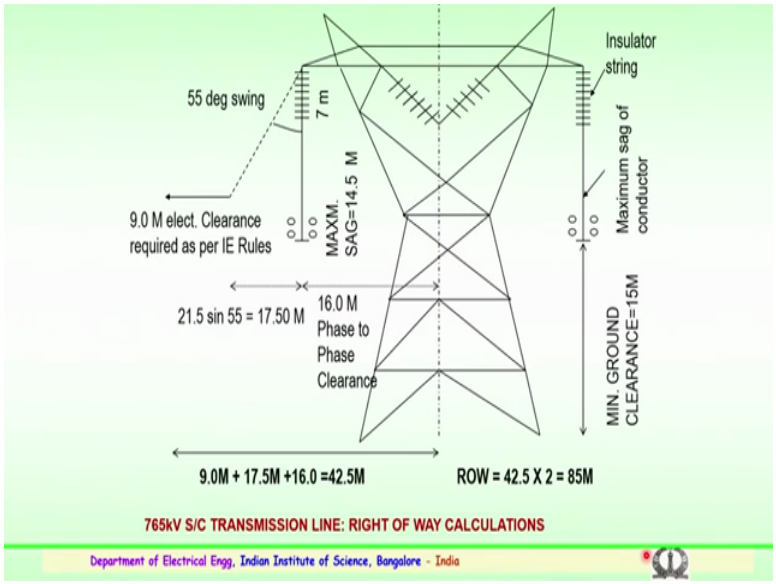

So, right of way very important, this gives briefly explanation for the 765 kV tower which is being considered how the right of way is a calculated or may estimated you can

consider this is the 765 kV tower typical tower which is being used for transmission system. So, the minimum ground clearances you can see these are the 4 quadruple conductors has a 4 conductors in a bundle constitute quadruple conductor.

So, this conductor will be a live par that is the 765 kV energized conductors the minimum clearances of the ground has to be maintained for 765 the minimum clearances for the ground is specified as 15 meters which is shown here then considering the maximum sag of the conductors this conductor the insulator string again depends upon how many insulator you used 35 in case of 210 kilonewtons or 40 in case of 120 kilonewton insulator string the length of the insulator string and the maximum sag of the conductor which is a considered is a distance from here.

So, once the insulator string with the conductor there is a movement you can see the because of the wind the sag are the swing of this insulator with the conductor happens this swing is considered as 55 degrees as swing is a maximum which is being considered. So, of the conductors and the insulator string now comes to this point this is typically for 765 kV considering 14.5 meters is the total length of the conductor sag and the insulator; insulator string itself is 7 meters and total the clearances up to this is 14.5 meters you can see here. So, this distance is entirely shifted to here because of the wind. So, from this you have a high voltage entire a 765 kV appears here. So, for that electrical clearance minimum clearance to either side is required is 9 meters.

So, from this 0.9 meter actual clearance have to be given here. So, this is the point where 9 meter plus the swing angle that is 21.5 degrees sin 55 is approximately 17.5 meters and the clearance from the suspension conductor to the tower this distance you can see this distances is 16 meters to the midpoint of the tower.

So, the one side of the right of ways calculated from the midpoint to the insulator string is the 16 meters and from the midpoint to the swing plus the electrical clearances this gives 17.5 meters. So, 17.0 up to this point: 17.5 meters plus 16 and 9 meter electrical clearances the total distance from the center of the tower to the clearances electrical clearances up to this junction will be 9 meters plus 17.5 plus 16. So, totally 42.5 meters is the distance of the center position of the in tower to one side. So, when you calculate the right of way this as to be equivalent to on the either side. So, total distance 45 into 42

into 42.5 into 2 is 85 meter minimum clearances or the minimum right of way is required for 765 kV transmission in tower.

So, this how the right of way is estimated for typical 765 SC is a single circuit transmission line. So, the right of way estimated to be 85 meters for 765 kV line.

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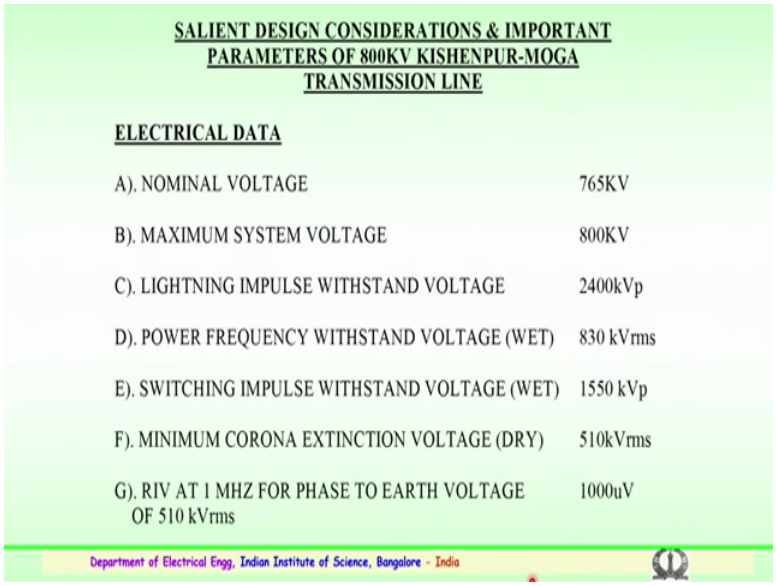

So, this some electrical data which when the country went in for the first transmission 800 kV transmission which was from the Punjab to Kashmir that is Kishenpur to Moga transmission line the first line which came in to operation in the country for nominal voltage of 765 the maximum system voltage being 800 kV the lightning impulse withstand voltage was designed to be 2400 kilo volts peak the power frequency with stand voltage wet conditions or rain conditions is 830 kilo volts r m s switching impulse voltage wet conditions 1550 kilo volts peak and the minimum corona extension voltage dry conditions to be measured at 575 10 kilo volts the corona should not appear up to 510 kV for 760 kV system, because the phase voltage will be 510 approximately.

Then the radio interference voltage add measure at one megahertz from phase to ground at 510 kV should not exceed 1000 micro volts that is 60 decibel micro volts micro 1 micro volt. So, this is very very important this is some of the technical details for the first transmission tower which have been erected in the country in 1996.

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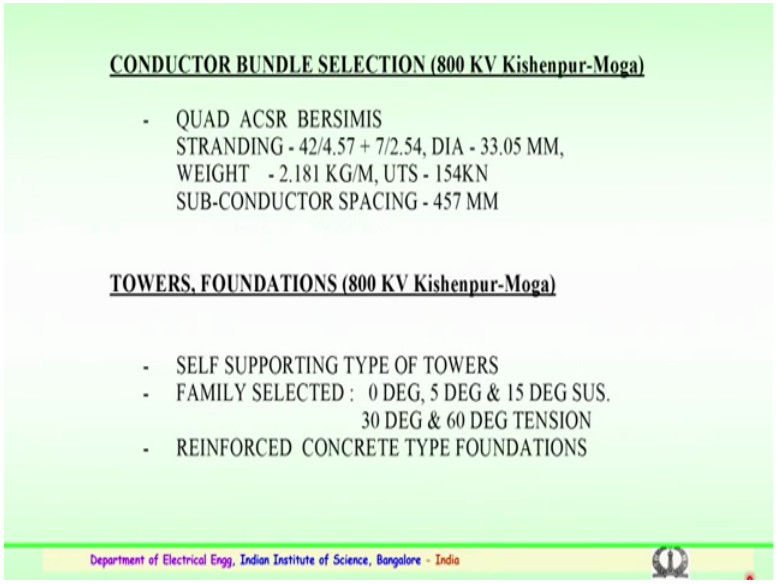

So, what was the conductors are used for the tower for this project that was quadruple ACSR AL; AL aluminum conductor steel reinforcement Bersimis was the conductor which as a diameter of 33.505 mm and it is the quadruple that is the 4 conductor in a bundle was used and the total weight being 2181 kg per meter and sub conductor spacing was 457 millimeter, this is a 45.7 centimeter was each conductor that is the 4 quad conductors each spaced in a corner of a similar to a square spacer.

So, this spacing was 457 mm. So, towers and foundations which were used for the first project where of self supporting type of towers and the selected of this tower family where 0 degrees 5 degrees the inclination and 15 degrees suspension type in case of tension, it was 30 degree and 30 degree selections were made and the foundation was reinforced concrete was used for all the towers for this first project.

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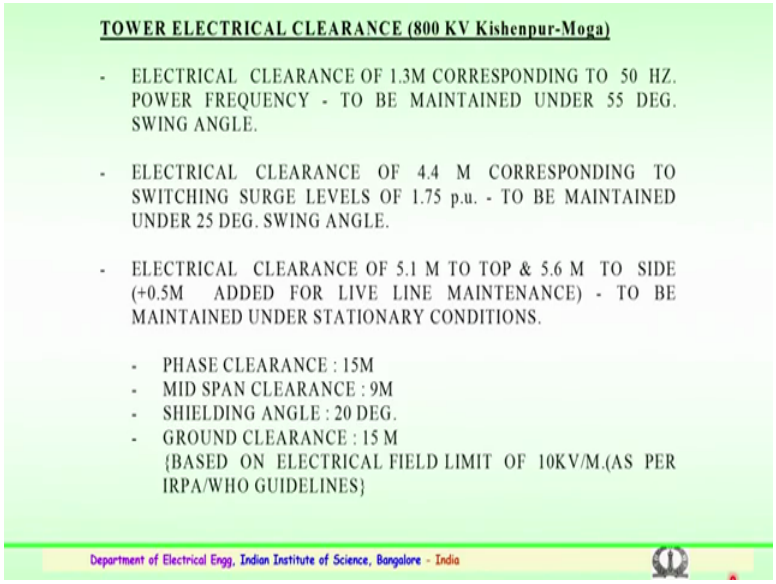

So, what are the electrical clearances minimum clearances which were adopted for the 800 kV towers very clearly it is given here? So, the electrical clearance of 1.3 meters which corresponds to the power frequency that is the 50 hertz which has to be maintained under 55 degree swing angle which we saw. So, the electrical clearance of 4.4 meters, this corresponds to the switching surge levels or switching impulse levels which are normally considered 1.75 per unit have to be maintained under 25 degree swing angle. So, the electrical clearances of 5.1 meter to top and 5.6 meter to the side added for live line maintenance in case the live line maintenance have to be carried out this extra clearance of 5.1 and 5.6 meters have been added for the clearances and for the maintenance aspects which are under the stationary conditions.

So, the phase total phase clearances adopted is 15 meters the mid span clearances is 9 meters the shielding angle is 20 degrees the ground clearance being 15 meters based on a electrical field limit it was considered 10 kV per meter as per the world health organization guidelines. So, this was the limit which was considered for the 800 kV towered configurations.

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So, what types of insulators were employed for the 800 kV? So, for suspension towers we have 2 types, one is the suspension arrangement analysis at the tension arrangement for suspension they have used 120 kilonewton for I string or a pilot string consisting of 2 into 40 that is the 40 insulators of parallely 2 double I that is the 2 I strings of a 40 number that is the 80 insulators, 40 parallel 40 and in for single suspension if it is the double suspension it is 2 into 40 which is the single suspension higher mechanical strength that is 210 kilonewton was used for V type of arrangement where V type of arrangement one arm of the insulator string consist of 35. So, there are total to an arm that is the V type of arrangement 35 and 35 in each arm of 210 kilonewtons.

So, in case for 5 degree double suspension were used 40 insulators similar to the first one and for double suspension both 160 kilonewton 210 kilonewton were used here again for suspension being double. So, we have used 2 VS. So, the both the sides 2 V in consisting of 35 into 2 that is 70; 70 on either side of the string. So, these are the for 15 degrees again double suspension mechanical strength consisting of 210 kilonewtons of insulators comprising of 4 into 35 were employed that is triple V. So, VVV; what you see it is used. So, for tension towers quadruple tension again 4 conductors in a bundle consisting of 210 kilonewtons were used for the project.

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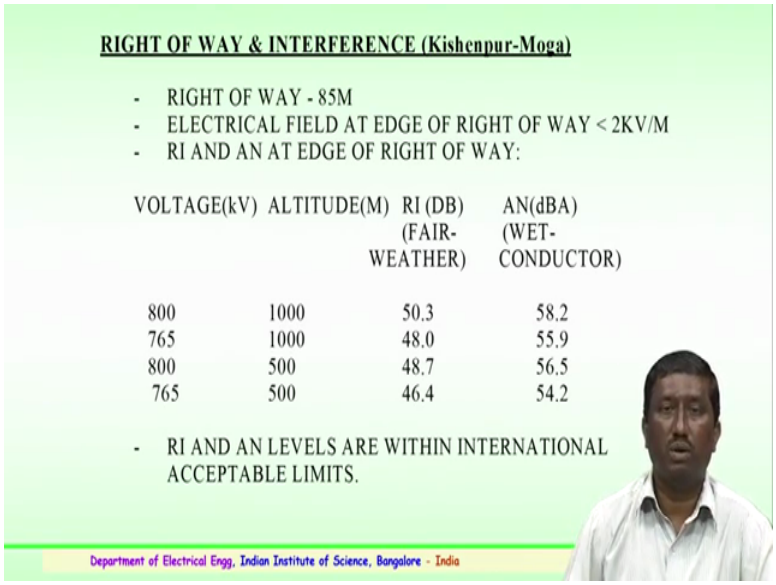

So, right of way for the project as a earlier shown and how it is a estimated was 85 meters and the electric field at the edge of the right of way was somewhere less than 2 kilo volts per meter is specified limit is 10 kilo volts as per estimated. So, it was less than 2 kilo volt per meter radio interference and audible noise at the edge of the right of tower again was considered and was verified and it was found to be the radio interference during fair weather that is the clean weather conditions gave a value somewhere from 46 to 50.3 depending upon the voltage level the voltage level was varied from 765 to 800 kV different altitudes we can see the altitude in meters.

So, here the value of the radio noise generated is much much lesser as per the stipulated the conditions of 60. So, it is 50 and in case of the wet conditions that are the fall weather or rain conditions you could again see it is a lesser than the prescribed limit of 60 decibels or 1000 micro volts. So, this 58.2 which is very very important and these are excepted values within the international acceptable limits. So, these are some of the values which are being used adopted in the first project which was commissioned 765 800 kV in the country.

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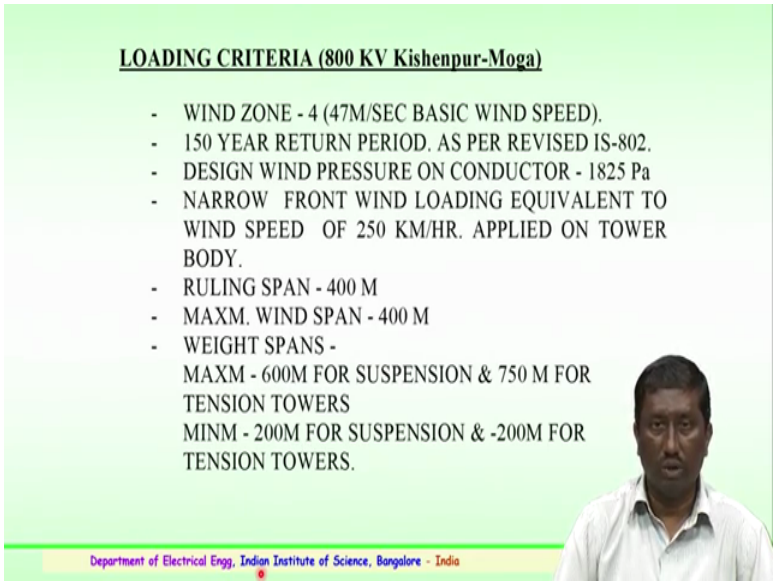

So, loading criteria how the mechanical loadings accept were considered. So, important was the wind zone basic winds speed was considered of 47 meters per second going and this data was obtained over period of 150 years as per the revised Indian standard 802. the design wind pressure on conductors were considered for various type of a loading front narrow and wind speed of 250 kilo meters per hour was employed and applied on the tower body for span maximum span ruling span of 400 meters.

That is the tower to tower distance is 400 meters and a maximum wind speed for the span was also considered and various suspension. And for a tension towers in the minimum clearances and the loading mechanical loading for both compression and tension related towers was estimated.