Advances in UHV Transmission and Distribution
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Lecture – 15
Conductors used for EHV/UHV Transmission

Sir, you can start sir.

Thank you. So, the major components of transmission system in a tower we were discussing about the important components being the insulators which are very important for a transmission system.

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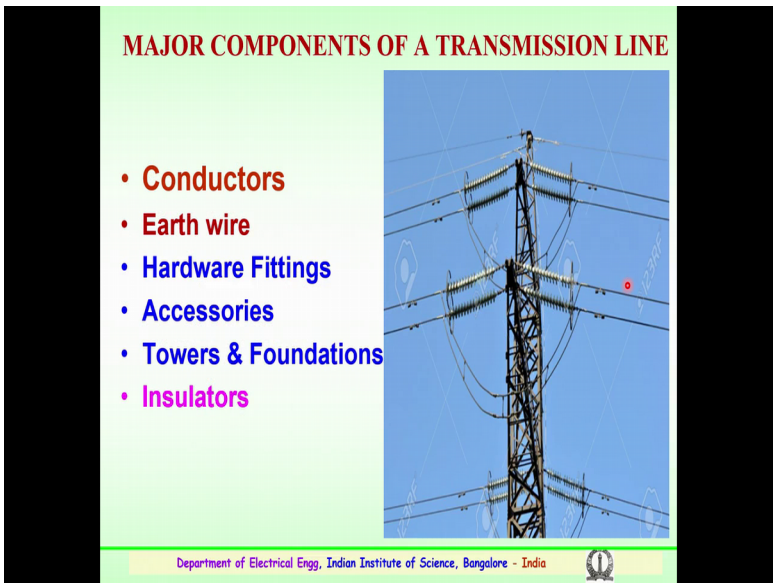

After the insulators the conductor is equally important. Then we have hardware fittings or accessories then the tower and it is foundation. So, we have discussed about the insulators which are used for EHV and UHV transmission. We will now look into the conductors that is the various type of conductors the important of conductors and earth wire earth wire ground wire which is being connected to the high voltage tower. Further we will be focusing on the hardware fittings hardware fittings generally comprise of the metal parts which are connected to the tower to the insulator.

So, these are your metal plates or corona control rings. Then we have vibration dampers, which are used for the reduction of the vibration cost due to wind and other sources. We

have other accessories like the clamps connectors and many of this which will be discussing about the task back. Further we will discuss about the various types of towers and the foundation requirements for the EHV and UHV transmission system.

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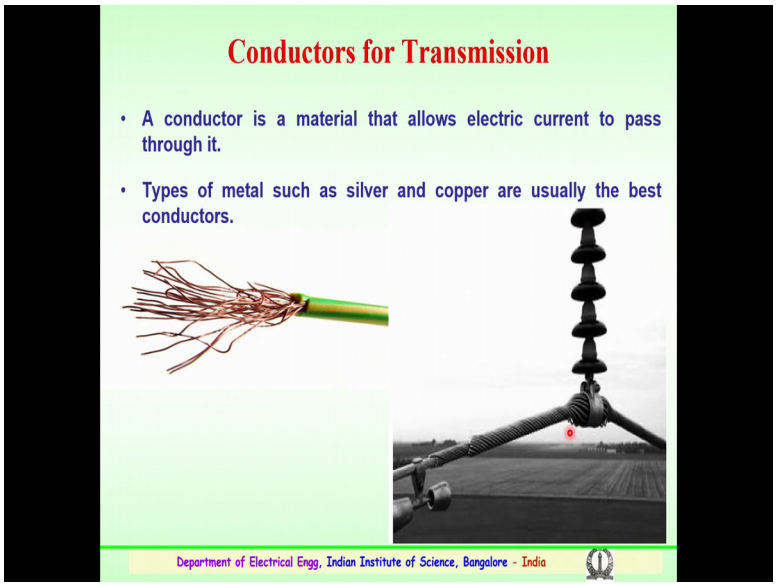

So, conductors for transmission system very important these are the conductors use for high voltage transmission connected to the insulator shrink. So, conductor is basically material that allows electric current pass through it. It is basic definition. Types of metal such as silver copper are usually the best conductors which are used for the electricity at the domestic and all also for the transmission and distribution systems. This is a typical conductor which is used for the domestic lighting purpose, and we will be focusing on the conductors various types of conductors, which are used for the extra high voltage ultra voltage transmission and distribution systems.

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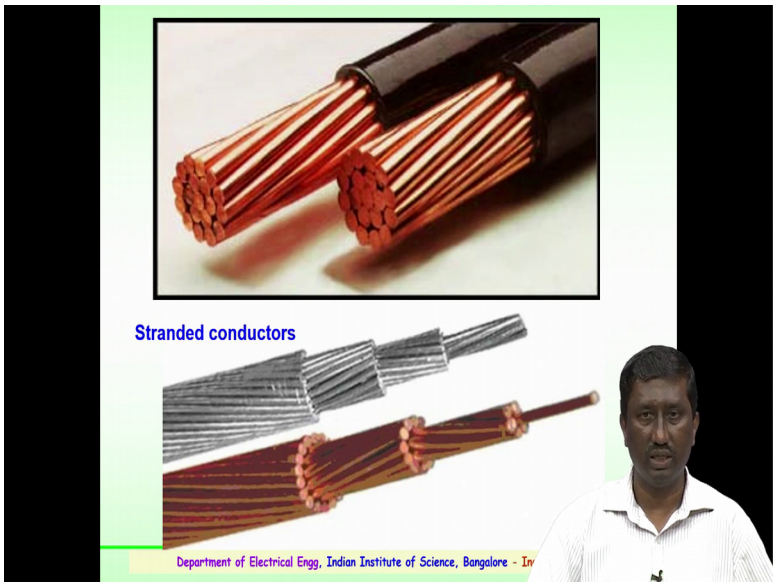

So, further this are the conductors with this stranded on known as a stranded conductors (Refer Time: 03:29) conductors importance of that why stranded is required we will look to that. So, various types of conductors depending upon the voltage a level and the current it has to carry. So, depend upon that the usages of conductors are being employed.

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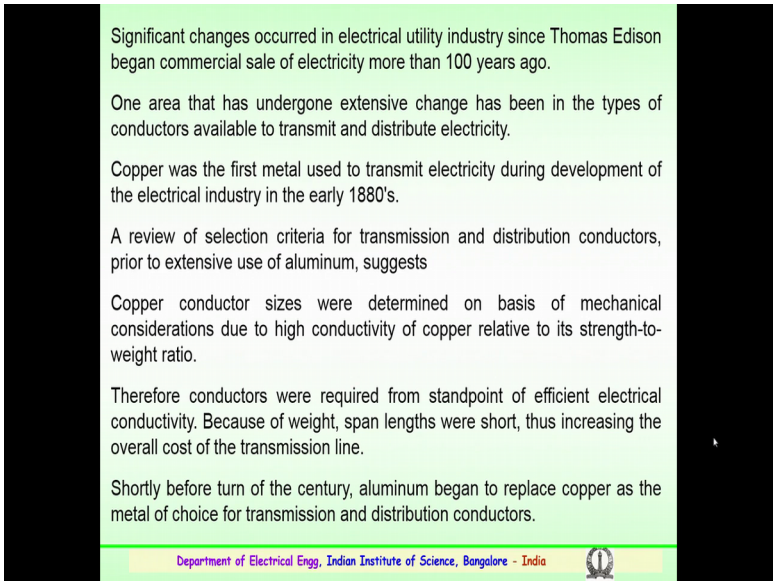

So, we know that significant changes have a occurred in the electrical utility industry. So, it is to be noted that significant changes have occurred in a electrical utility industry

since Thomas Alva Edison began commercial sale of electricity more than 100 to 120 years ago. The area one of the area that has undergone extensive changes robot changes have been in the type of conductors particularly for transmission and distribution of electricity. So, initially copper was the first martial used to transmit electricity particularly during development of electrical industry in the early 1880s.

So, late 1880s the copper was material which has been used later on a review of selection criteria particularly for transmission and distribution conductors to prior to extensive of aluminum, suggest that copper conductor sizes is were determined on basis of mechanical consideration due to high conductivity of copper and relative to it is strength to weighted ratio. So, that is the important a point to be noted here.

So, therefore, the conductors which were required from the standpoint of efficient electrical conductivity is a because of it is weight. This span length tower to tower distance incase if it is short thus increasing in the overall cost of a transmission incase of copper. So, shortly before a turn of the century conductor manufacturers and the utilities planned and started using to replace copper with the metal that is the aluminum which is the metal of choice for transmission and distribution industry.

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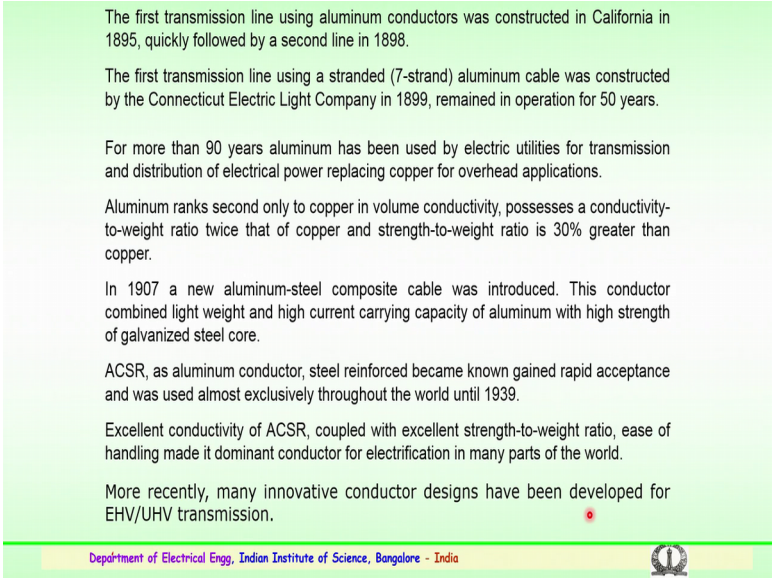

So, the first transmission line using aluminum conductors was constructed in California in the year 1895. So, later on quickly followed by many further to 1890s we had few more lines which were commission with the help of aluminum conductors. So, the first

transmission line using 7th strand that is the 7 conductor strand aluminum cable was used by they Connecticut electric light company in 1899 this remained in operation for almost 50 years.

So, more than 90 years aluminum has been preferred and has been used by the electrical utilities both for transmission and distribution of electric power by replacing copper for overhead applications. So, aluminum ranks second only to copper particularly volume conductivity, and possesses a conductivity to weight ratio twice that of copper and strength to weight ratio is 30 percent greater than copper.

So, these are the strength of the aluminum in comparison to the copper. So, 1907 new aluminum steel reinforced composite cable that is the conductor was introduced this conductor combined light weight. So, 1907 a new aluminum steel composite cable or conductor was introduced. This conductor combined both the light weight also it was able to high current of aluminum with high strength of galvanized steel core.

So, this was the introduction of the 1907 which is in was aluminum conductor steel reinforced as a aluminum conductor and steel reinforment reinforcement became known which gained rapid acceptance and was used particularly all almost throughout the world until 1939. So, with the excellent conductivity of aluminum conductor steel reinforcement which are having coupled with excellent strength to weight ratio. Ease of handling made the conductor that is ACSR conductor for electrification in many parts of the world and it was being used in many parts of the world.

However more recently a many innovative conductor designs have been also developed (Refer Time: 08:57) particularly for the extra high voltage ultra high voltage transmission which we will be focusing on this aspect changes in the design changes in the material aspect and various types of strands which are we used under dimension of the conductors which are being used for EHV UHV transmission system.

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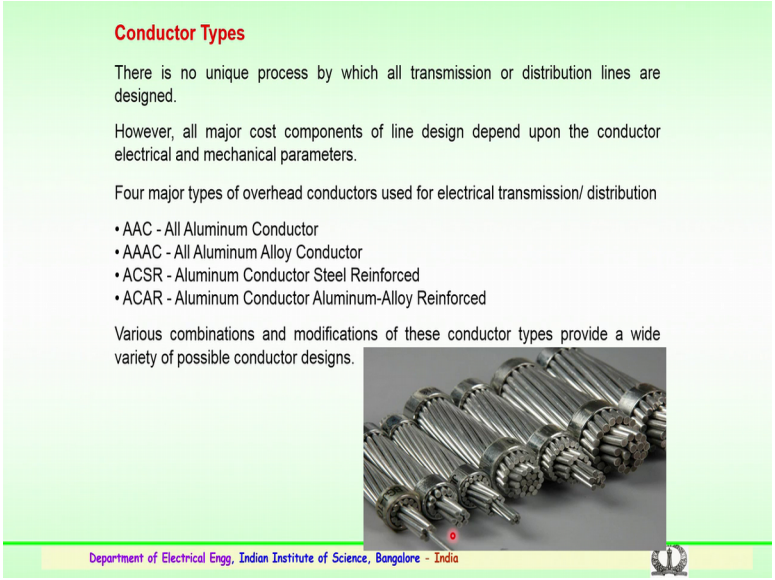

So, various kinds of or types of conductors are in use for a period of time. So, (Refer Time: 09:24) we can say that there is no unique process by which all transmission or distribution lines are designed; however, the major cost component of line design depends upon the conductor and it is electrical and mechanical parameters.

So, any conductor the major component in a line design depends on electrical and mechanical considerations. So, 4 major types of overhead conductors mainly used for the transmission and distribution for medium low voltage or high voltage system transmission are AAC that is all aluminum conductors the second AAAC that is all aluminum alloy conductors then ACSR is a aluminum conductor steel reinforced with the steel conductor in the middle and ACAR aluminum conductor aluminum alloy reinforced.

So, these are the 4 major types of overhead conductors which are in existence over period of time. So, with various combinations and modifications these conductors provide a wide variety of possible in the conductor designs. So, you can see here the various types of conductors from a low voltage or medium voltage level to the very high or EHV or UHV level conductor dimensions with the number of strands with the number of steel reinforcement defer depending upon the transmission voltages current the conductor is to carry; so both for distribution and for transmission systems.

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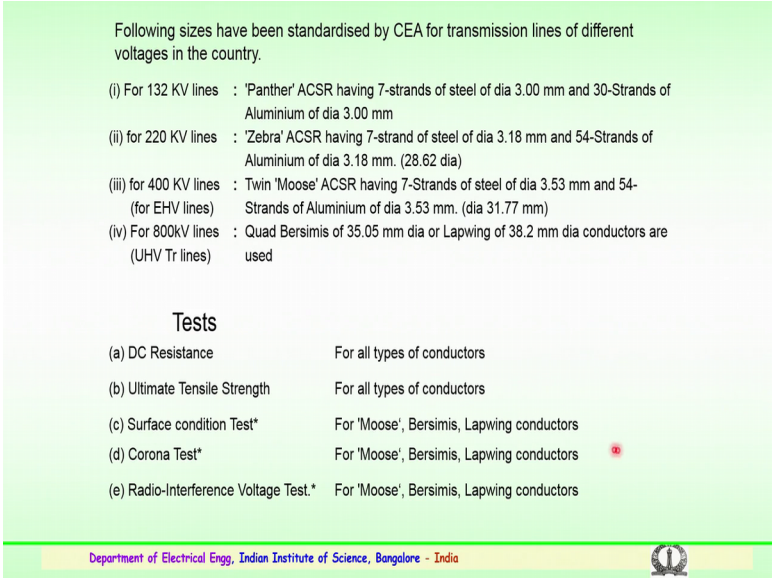

So, various sizes are being manufactured across the globe in India. The following sizes have been standardized by a central electricity authority of for transmission and distribution lines in the country. So, in general for transmission or lines of 132 KV system conductor normal clutter is a panther is a name of conductor of particular size which is of aluminum conductor steel reinforcement has 7 strands of steel in the middle for a mechanical strength of dia 3 mm it is surrounded by 30 strands of aluminum of dia 3 mm.

So, 7 strands in the middle similar to this in the medial it may be (Refer Time: 12:29) here 7 strands surrounded by aluminum conductors of 30 strands of dia 3 mm. This size of conductor is being used for hundred and 30 2 KV lines typically the overall dimension of the conductor could be 24 to 26 mm dia for 220 KV transmission lines zebra is the name of conductor for the particular size dimension of 28.6 2 dia conductor there is known as zebra aluminum conductor steel reinforcement has 7 strands of steel similar to panther of dia higher slightly higher then the previous that is 3.18 mm and contains 54 strands of aluminum of dia 3.18.

So, the total number of strands for 220 KV conductor which is of zebra (Refer Time: 13:30) has 54 strands outer conductors of aluminum and inner 7 strands of steel for 4 hundred KV that is were (Refer Time: 13:38) extra voltage transmission system normally at twin moose again twin moose is the name of the conductor twin is 2 bundle conductor

2 conductors of twin type aluminum conductor steel reinforcement having 7 strands of steel dia with 3.53 mm and 54 strands of aluminum dia 3.53.

So, overall dia of the line further moose conductor being 301.77 mm. So, for further EHV further UHV transmission lines conductors namely bersimis again name of the conductor or lapwing or bull. So, these are conductor being used for ultra high voltage transmission. Typically, the bersimis dia overall dia of that conductor 35.055 mm incase of bull it is 36 mm dia lapwing it is 38.2 mm dia conductors are used.

So, quad is the 4 bundle conductor twin is 2 bundle higher the voltage is you have quadruple bundle or 8 bundle which is octo bundle conductor. So, similarly depending upon on the voltage level and the current carrying capability they bundle numbers of conductors in a bundle are being used. So, these show the some of the test preliminarily test which are to be carry out essentially for the all types of for conductors.

So, DC resistance is normally carried out for all types of conductors' ultimately tensile strength. So, this is again mechanical with stand capability is conduct is carried out for all type of conductors. Then surface condition test is normally preferred to be carried out about 220 KV system or EHV or UHV lines. So, surface conductivity corona is radio interference voltage measurement surface of conductor is very important where the discharges should not affect transmission of the radios or television or any other communication networks. So, care has to be taken the conductors has to be smooth and (Refer Time: 16:05) it is free from the discharge when energyst.

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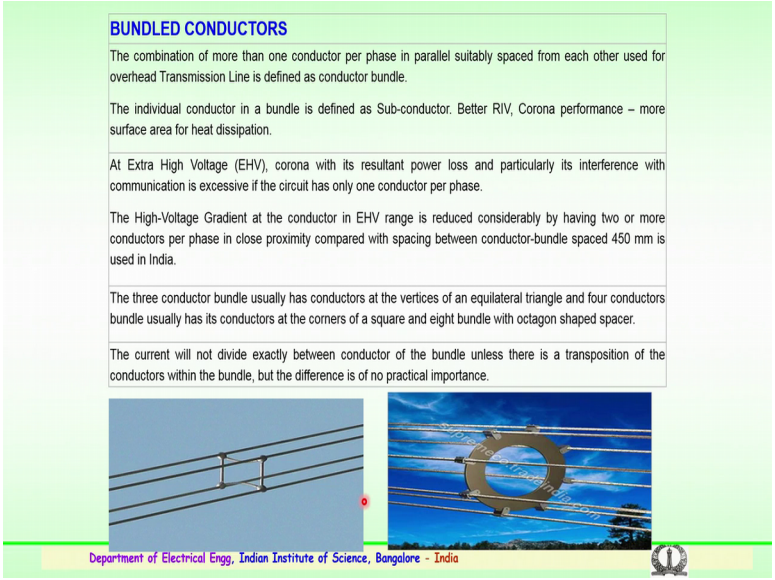

So, there is a bundle conductor what is the bundle conductor basically a bundling of the conductor or is a combination of more than one conductor per phase. So, we have initially discussed 2 1 twin conductors or a quadruple conductors or a type of conductors. So, this is the combination of more than one conductor per phase. So, when you see here this has a 4 conductors with suitable spacer. So, this suitable spacer is a quadruple spacer having a 4 conductors in a bundle. Similarly, you see here 8 conductors in bundle 8 conductors of same phase that is very important. So, the spacing between each conductor is 450 millimeters 45 centimeters which is typically employed in our county

So, the combination of more than one conductor per phase: so this conductor could be a single conductor or a twin or a triangle type of conductor 3 conductor are connected in the bundle or 4 conductor which is known as a quadruple arrangement, where 4 conductors are connected are in case of 6 or 8 or 12. So, depending upon the number of conductors the equalant spacer are used and the formation is made.

So, the individual conductor in a bundle is defined as sub conductors. So, these incase there are 4 conductors are each conductors is known as a sub conductor in that particular bundle. This is to see that the advantages is to see the conductors perform better in radio interference voltage or radio interference measurement (Refer Time: 18:02) a issues then corona performance because of the shielding effect corona performance is much better

going in for bundle conductors. And more surface area for heat dissipation that is one of the important a properties as higher the voltages this becomes advantages.

So, at EHV extra voltage an ultra voltage corona with it is are resulted power loss. And particularly interference with the communication is excessive if the circuit has only one conductor per phase. So, up to 132 KV typically single conductors employed. So, above 130 to KV more than 220 KV either twin for 400 KV 4 conductors or UHV either 4 6 or 12 conductors or normally used to counter the issues of radio interference corona a related a problems which could interfere with the communication circuits. So, the high voltage gradient at the conductor particularly in the extra high voltage a range is a reduced considerably by having 2 3 4 or more conductors per phase in close proximity compared with the spacing between conductor bundle and as mentioned the conductor bundle conductor spacing in a county is adopted as 450 millimeters or distance between any conductors is 40 450 millimeters that is the standard which is been adopted in the country.

The 3 conductor bund bundle if they are 3 conductors in a bundle, usually the (Refer Time: 19:52) has conductors at the vertices of a similar to an equilateral triangle and 4 conductor bundle has it is conductor at the corners as shown here is 1 2 3 4 like similar to a square arrangement with 450 mm (Refer Time: 20:12) design between 450 mm gap between each conductor. And it happens if it is more than 4 8 conductor you can see here this will have conductors spacing of 450 mm with a octagonal type of spacer amounted to support the 8 conductor bundle. So, the current will not divide exactly between the conductors of the bundle unless there is a transposition of the conductors within the bundle, but this difference is of not of much practical relevance.

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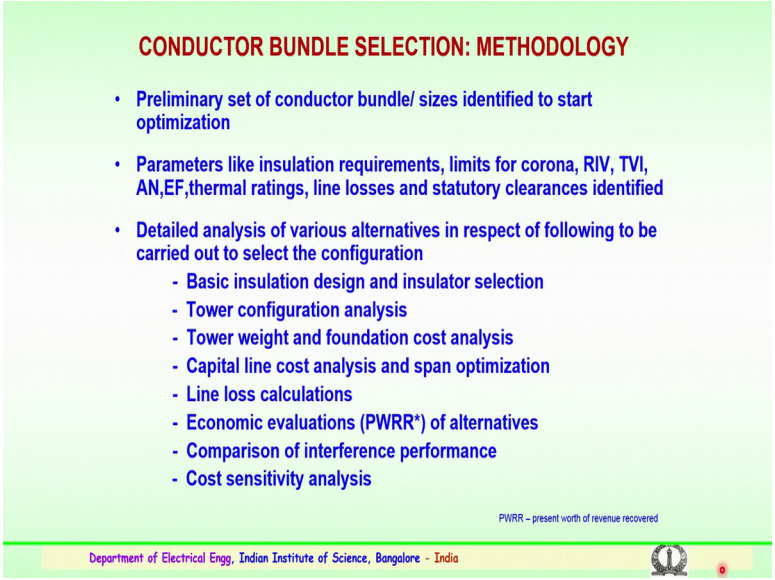

So, it could be not an important point to be considered. So, how the conductors are selected or the conductor bundles are selected. So, the methodology remains initially the preliminary a set of conductor bundles of various size of the conductors identified to start the optimization.

So important parameters like the insulation requirements for a particular voltage level; the limit is specified for the corona the radio interference voltage television interference they audible noise the electrical failed thermal ratings of the conductor the line losses because of the operation at that higher voltage levels, and the statutory clearances should be identified before the selection are made very important parameters for the choosing of the conductors.

So, further detailed analysis of various alternatives in respect to following should be carried out. So, that it would be helpful to select a particular configuration for the transmission or distribution system. So, the basic insulation design and the insulators selection has to be done, conductor size has to be identified what is the insulation level which it has to be used. Then tower configuration analysis watched what type of tower configuration is used for this voltage level where the conductor is being adopted. The tower weight and the foundation cost analysis have to be kept in during the estimation of the conductor bundle selection. And important being the capital line cost analysis and the span optimization of the conductors from the tower to tower the span which is being a

planned. Then line loss calculation again this depends on the voltage level where the conductors or being operated then economic evaluations.

So, economic evaluations or of alternatives that is PWRR. PWRR is the percent worth of revenue which is recovered to revenue to be recovered. Then comparison of interference performance have to be made and the cost sensitivity analysis. So, these are the important parameters or points to be taken into consideration while going in for selection of any conductor bundle for of suitable voltage levels.