Advances in UHV Transmission and Distribution
Prof. B Subba Reddy
Department of High Voltage Engg (Electrical Engineering)
Indian Institute of Science, Bangalore

Lecture – 02
Transmission system development, Important components of transmission system

Good morning, welcome. The transmission system is very important for the development of the any country. So, what the high voltage or extra high voltage transmission system, there are some issues pertaining to the development. And these issues and how the advancement have taken place we will be looking into this aspect.

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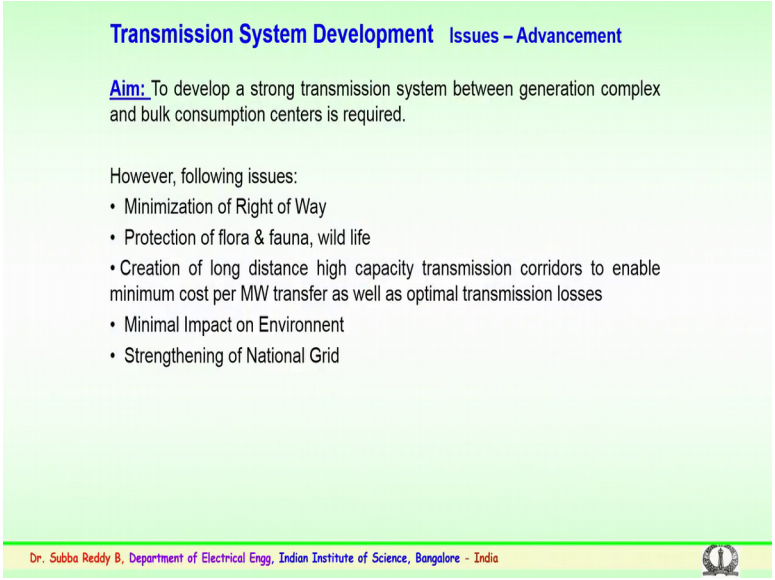

So, the main aim of the country is to develop a strong transmission system between generation complex or generating station and the bulk consumption centres. So, the bulk consumption centres maybe the industries or the domestic or agriculture requirement.

However, for the strong transmission system there are few issues which have to be looked into the first being the minimization of right of way. This is an important aspect. We will be looking into this aspect ahead of the course. The right of way is the minimum clearance to be maintained from the mid of the tower to either side.

So, later we look into the issues being protection of flora and fauna and wild life. So, when the transmission system is being constructed and long distance transmission, we

know that the transmission lines run over a long distance hundred of kilometres thousands of kilometres. So, it is likely to cross the forest where the flora fauna are likely to be affected including the wild life. So, this has to be properly taken care before going in for other strong transmission network.

Then further to this with a creation of high capacity transmission corridors, this will be helpful to enable to the minimum cost per megawatt transfer as well as optimal transmission losses. That is a main reason for going in for UHV transmission systems, apart from that as we looked into. So, protection of flora fauna and also because of the transmission system high voltage transmission system the impact to the environment should be minimal. This is being requirement where utility or the government when they are going in for a long distance transmission have to be there in mind. Then further strengthening of the national grid, this will be very helpful to control the entire grid through a single point system.

So, these are some of the issues which are to be addressed and what are the issues and how the advancements have been taken place by overcoming this we will be looking into.

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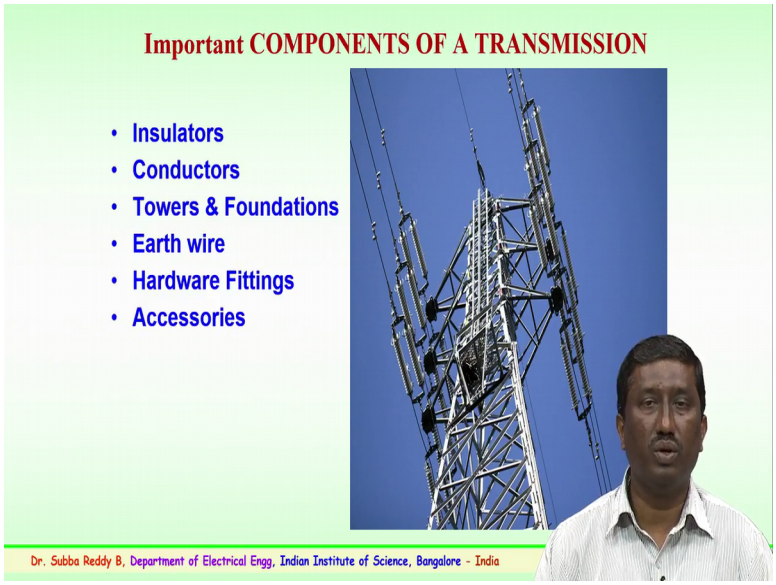

So, this shows the most important components of a transmission as network transmission system. Example is shown here a transmission tower, where the tower consist of are the following components which are very important. Insulators the first is the insulator.

Insulators has you can see here. There are various types of insulators which are being used for transmission this transmission again the insulators are of kept in arranged in a different configuration like the suspension attention quarter pole tension v suspension so on and so forth. So, what are the importance of this insulator.

So, insulators in important component of a transmission system; it performs duel function, one is it supports the tower mechanically and other it electrically isolates the conductor from the tower. So, this performs a dual function. Insulators are of mainly 3 types. Initially for last 100 years we have been using the ceramic or porcelain insulators, Europeans use glass insulators, then of recent origin polymer composite or silicon rubber insulators are being employed for the transmission network.

So, these are of recent origin. So, we will be looking into various types of insulators how they come into existence, what are the advancements in this insulator technology and what are the problems related to the insulator technology particularly using at extra high voltages and ultra-high voltages transmission systems. The second important component apart from the insulator is the conductor. The conductor is again a much more important component it transmits is the voltage from long distances hundreds of kilometres from generating to the transmission system.

So, various type of conductors is an existence. So, we will be focussing into the types of conductors, various materials which are being employed for the manufacturing of the conductors and the recent advances in the conductor technology. So, we also look in to the various types and the recent employed conductors.

The third being the much more important component that is the towers, so without towers the conductor's insulators cannot be used. So, the tower is one of the important component of a UHV or EHV transmission systems and the apart from towers the foundation what type of foundation is being used for the towers this again depends on the area where the tower is being erected, either it is in a healing area or in a normal plane conditions or a high altitude. So, the foundation also is a very important aspect which has to be taken care for the natural calamities. It may be because of higher winds it may be because of any natural calamities which are occurring.

So, towers and foundations are also the important components of a transmission system. So, next comes the earth wire or the ground wire. The earth wire of earth wire is shown

here. This is the earth wire which is connected to the top most portion of the tower in a EHV or UHV transmission tower. In case of lining this has to protect the equipment like the insulators shrinks and further the substation components. So, the earth wire or ground wires place an important role particularly during the lightning striking to the long high voltage transmission systems.

Then we have the hardware fittings hardware. Fittings consists of different and various types. Hardware fittings are used for insulators to connect to the tower. So, hardware fittings this is the UEO plates and UEO plates which are being connected. Apart from UEO plates we have a corona control rings. Then we have a several other components which are being used for shrinking the insulators to the tower. So, we will be looking into the hardware fittings what is the developmental aspects which has undergone for a period of time, and how the hardware fittings are being changed when it comes to the 765 KV 800 KV voltage levels that is the UHV voltage levels.

And final the important component is also the accessories, so various types of accessories which most of the engineering students would have not known, so the accessories are very important part of when a transmission system. So, some of the accessories are when you go to the near a near transmission system, you see a small components here this are nothing but the vibration dampers. So, similar to the vibration damper there is a specific which it controls the damping or oscillations that we will be looking into that. The importance of vibration damper and few accessories like mid span compression joint repairs lives T connectors many of these things these all fall under the accessories.

So, these are some of the important components of ultra high voltage transmission system. So, we will be looking into each component. And we will be looking into how the developments have been taken place over the period of time and what are the type of insulators conductors and different types of towers clearances which are being employed for the UHV and EHV transmission levels.

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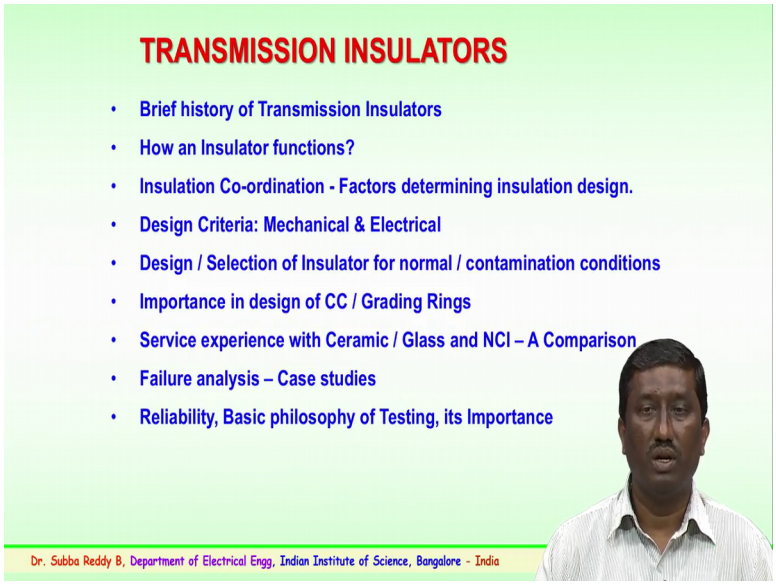

The first component being the transmission insulator we will briefly look into the history of the transmission insulator. How an insulator functions how the insulation coordination what are the factors which determine the insulation design for the transmission insulators, how importance is that then mechanical and electrical design criterias, which are to be adopted before the insulators are being used in the transmission system.

Then we will be looking into the design part or the selection of an insulator. Particularly for a normal condition or a contamination condition this again whether the transmission line is passing near the polluted zones or normal or heavy rain or heavy fog areas. So, depending upon the area where the transmission line is passing the selection of insulators is be done. We will have discussion on the selection and design aspect of the insulator of or various conditions.

So, how important is the design of CC is the control corona control rings or a grading rings. We will be having a look into that this is a very important aspect for the insulator shrink where this will be having multi functions. So, we will be discussing about this aspects, importance of the design of the corona control rings. And the service experience which ceramic or glass which has been used for which are been used for long more than hundred years in the transmission system. So, what are the experiences which have come across using the ceramic and glass? And we will be looking mainly into the non ceramic

insulators or a polymer or silicon rubber insulators which are very important and which are being of recent origin, and are being employed for the EHV and UHV transmission.

Finally, we will be comparing all the 3 technologies or of porcelain glass and ceramic insulator. And we will be looking in to some of the failure analysis of various type of this insulator, porcelain glass or non ceramic of few case studies which have been reported.

The important aspect of this transmission insulator is the reliability. The how reliable as an insulator should perform in field is very important. So, we will be looking into the reliability aspect, and we will also be touching into the basic philosophy of testing of these insulators before there being used in the field. So, it is importance will be looked into.

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So, how the history of transmission insulators: when we look basically the insulators grew out of the needs of telegraph industry. So, initially for power system the telegraph insulators were being employed somewhere in 1700s and early 1800s. So, early history centres around what today we consider very low DC voltages initially DC voltages where in existence initially. Gradually technical needs increased as high AC voltages grew with development of electric power industry across the globe.

So, during 1840s to 50s much before this insulator technology are grew. So, they use glass plates to insulate the telegraph lines, before the telegraph insulators are invented.

So, many trials with different materials like wood cement porcelain, beeswax, soaked rag, wrapped around the wire etcetera. So, several of these things we are tried out. Ultimately porcelain or ceramic and glass prevailed and they started using for the telegraphic needs.

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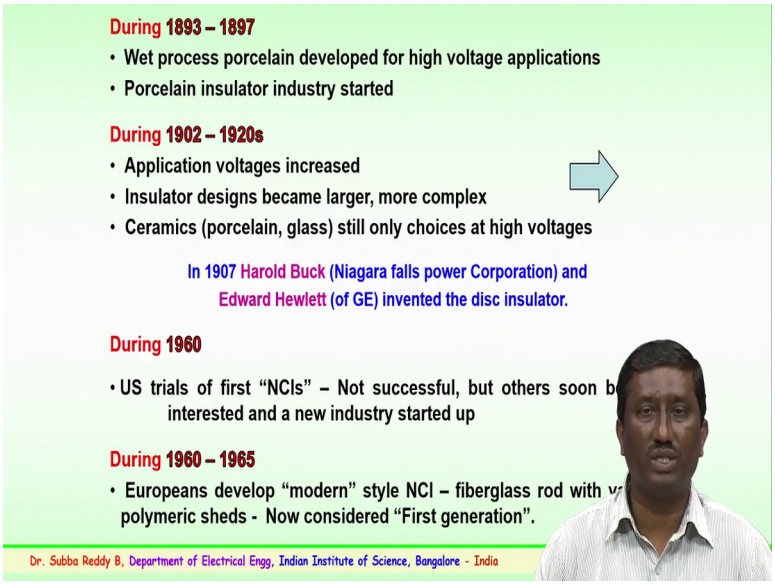

So, somewhere in 1893 the wet process porcelain was developed particularly for high voltage applications. Initially the telegraphic insulators where used up to 11 kilovolts. So, when the voltage level was increased for transmission system. So, the utilities face the flash over across this telegraphic insulator that is where in the technology have to be developed and the porcelain tech was developed for high voltages. So, the porcelain industry started growing during this period for the requirement of very high voltage applications.

So, applications of the voltages increase as I mentioned. So, insulators designs also became larger and much complex. So, ceramic that is a glass or porcelain are only choice of high voltages during that period. So, they were the technology was improved and voltage levels when has to when the voltage levels were higher. So, the designs have to be altered. So, it is in 1907 where mister Harold buck of Niagara Falls power corporation and Edward Hewlett of general electric invented the disc insulator which is of a day present technology insulator what we call.

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So, these are the earlier insulators which are used for telegraphic system, and what you see is the Edward Hewlett and Harold buck of Niagara Falls these are the people who are used the technology for other for developing the insulator technology.

During 1960s are the first non ceramic insulators that are polymers silicon rubber composite what we called the trial started in 1960s, but they were not successful initially because of the problems which they were facing. So, many companies try to start and some companies have to close down and this new industry also or parallelly looking into the ceramic insulators how improvemental aspect of the ceramic insulators.

So, during 1960s to 65 the Europeans develop modern non ceramic insulator with fibreglass rod technology which are considered of the first generation.

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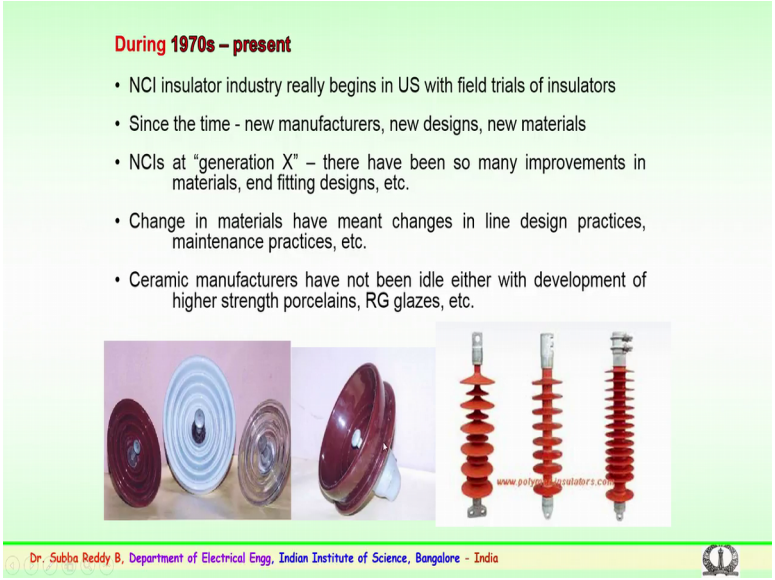

So, during 70s to the present the non ceramic insulator industry really begin with much better information much better field trials of the insulators, since then new manufacturers new designs new materials were incorporated new type of fillers were introduced into the compounds were in the non ceramic insulators, which are of present generation third have been available with various type of a filler materials embedded into the silicon rubber. So, the ceramic manufacturers parallelly, when the technology grew up for polymer or a silicon rubber, the ceramic manufactures have also not been idle. They also try to improve the development by using the high strength porcelain resistive glazes on the coating on the insulator surfaces and so on and so forth to sustain the technologies for the transmission system.

So, these are the various disc insulators which have been shown here. So, these are the ceramic insulators this again a ceramic insulator which is used with a higher capacitive length for a certain particular area. Then this is the glass type of insulator this is the antic fog insulator particularly for the areas where the transmission lines are possible high fog density locations. So, these are various types of polymer or a new type of composite or silicon rubber insulators which have been in use.

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A very quick look into the flow chart of the manufacturing process, for both the ceramic and the polymer will show you how much difficulty is to manufacturer porcelain or a ceramic insulator on the time period which takes place for the manufacture of the ceramic or a porcelain insulator.

So, you for a ceramic insulator to completely come out from the raw material to the final stage it take around 21 to 24 days, whereas the polymer insulator is so quick it can be done in a matter of 5 to 6 hours. So, that is one of the advancements which has been happening. So, we look how the porcelain or ceramic insulators are manufactured in a company or a industry. So, initially the raw materials which consist of the clay feldspar alumina etcetera are got, and they are grinded using the ball millings. And further this grinded material or the ball milling material is passed on for the sieving, where fur further of the sieving the material is kept in a suspension, where the water which is comprising of 1 part and 3 parts of the clay material which was used has to be removed.

So, this further after the multi stock sieving is sent after the water removal is sent for the shaping of the insulator. Here the shaping of insulator takes place depending upon the die sets which are being used either for transmission or for hollow post insulator or for a long rod insulator. This shaping of the material is being done, dewatering is being done again finally, the material which is kept in suspension mode is send it for this is again

demagnetization of sieving. Then it is in suspension dewatering then it goes to the shaping.

So, after the shaping it comes back to the shaping machines where the insulators are with the help of a die set or man or manufactured either for disc or for the hollow type of insulator. Then further the insulators which have been made or dried they are glazed depending upon the pigmentation on the colour requirement. These either hollow insulators or transmission insulators are glazed and further after the glazing this insulators are send for firing again the firing depends more than a 24 hours with the certain temperature. So, after the firing the sorting or a weeding out of the defectives are done. Further the testing of each and every insulator is being carried out for the porosity and many of the other tests which are being done at the factory.

So, after the testing the assembly of the insulator which connects both the pin and the cap: so initially it is only a ceramic or a porcelain shell. So, now, the assembly consist of a metal pin and a metal cap with the porcelain shell. So, further after the assembly, the insulator undergoes mechanical and electrical a test in the factory. So, again there have a routine testing for various mechanical and electrical parameters.

Finally, after the testing, the inspection physically inspection of the insulators is being done. It is a packed in a krait is and it is dispatched to the required utilities this is how the ceramic flow charts for manufacturing process.

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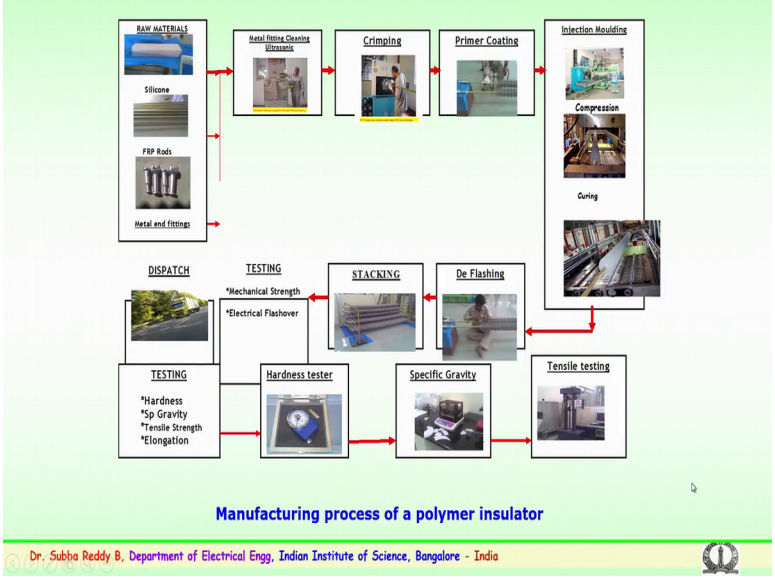

So, similarly when you look into the manufacturing process of a polymer that is the recent advanced material polymer material, which is being used for the high voltage transmission system. So, you can see the raw materials which are here. Raw materials may be of silicon rubber basically silicon rubber is added with filler. Then you have raw materials the fibber glass rods which are used what the core of the material then you have metal and fittings on both side of the insulator these are the basically raw materials.

Then the metal fittings is connect is done at the end of both the fibber glass rod. So, proper crimping has to be carried out after the crimping to the metal n fittings on the fibber glass rod a primer is coated on the fibber glass rod. Further with the help of injection moulding machine suitably under compression and curing this polymer material with the proper die set is being manufactured. It is later cured, after the curing de flashing of the insulator is done.

So, after the de flashing where it undergoes the extra material which is being present after the curing or the compression is being removed and either it is neatly stacked. Then after stacking it is send for the regular testing both again for mechanical and electrical testing. And the testing includes apart from a electrical and mechanical a hardness specific gravity tensile strength and elongation for the rubber. So, these are again chemical related test which are been carried out using hardness tester or a specific gravity meter or a tensile strength machines in the factory.

So, the entire process of a manufacturing of a polymer or a silicon rubber insulator happens anywhere between 4 to 5 hours. So, there it was for ceramic or porcelain used to take 24 a days. So, this is how the technology has improved and these are the recent insulators or of recent origin or organic in nature and are being used for the EHV and UHV transmission systems.

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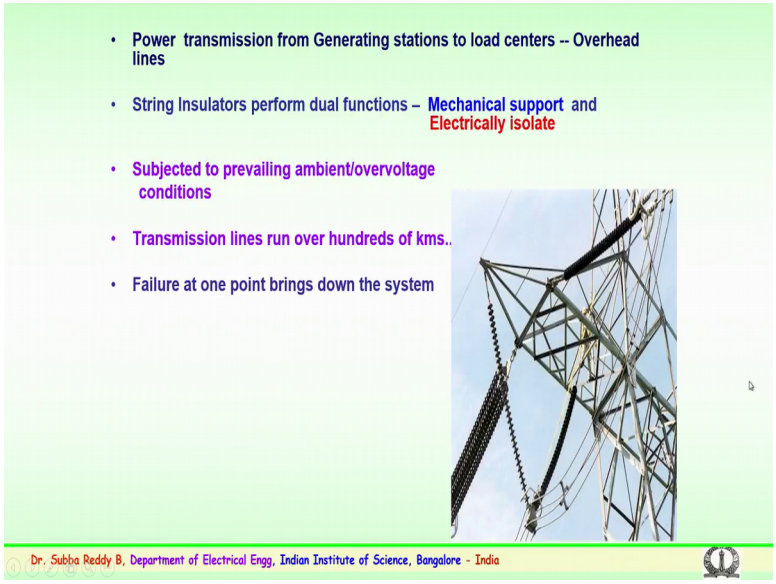

So, we have looked into the different type of insulators or which are being used over a period time. And we know that power transmission from the generating station to the load centres is by overhead transmission lines. So, as mentioned earlier the string insulators which are shown here perform dual functions. One is the mechanically support the tower high voltage tower and second is electrically isolate the conductor. These are the conductor these are the different spacers. So, these have to be electrically isolated from the tower as the conductors are at very high voltages.

So, during the transmission network in the system which it exist on a outdoor applications, on outdoor systems these insulator strings are subjected to prevailing ambient and overvoltage conditions. So, overvoltage we will be seeing that overvoltage is maybe because of the normal or frequency working or frequency voltages the overvoltages maybe because of the lightning aspects which are known as lightning surges or lightning impulses which are seen on the transmission system. Then switching surges or switching impulses which are seen on the transmission because of the opening and closing of the circuit breakers.

So, these have to be subject this will be subject to this type of conditions the insulators have to be stand in the field. So, transmission we know the transmission lines, run over a hundreds or thousands of kilometres from the generating to the load centres; so failure at any point in the network that is from the generating to the load centres. So, any point can

bring down the entire system. So, such is an importance of the insulator technology which is being used and it has to be seen that the failure does not happen in the transmission network.

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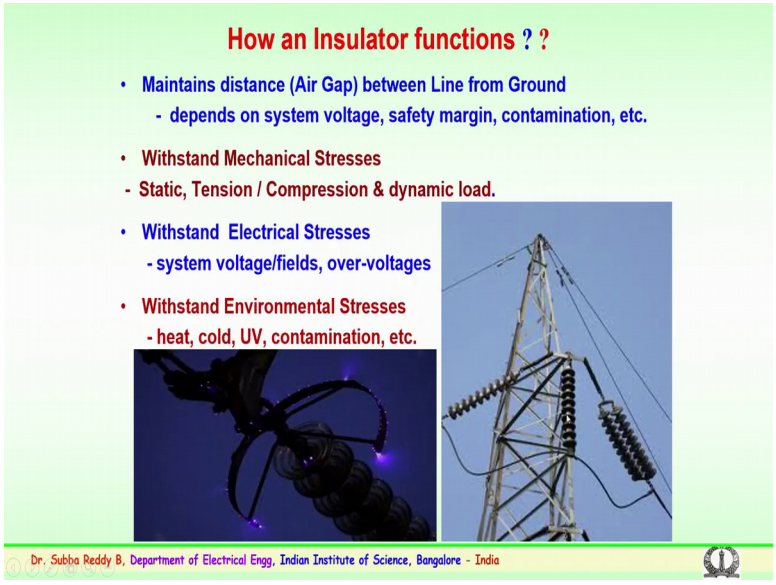

So, we looked into how the insulator functions. We saw that it is a important both for mechanical and electrical. Particularly it maintains the distance that is air gap between line and the ground. So, that voltage which is seen on the voltage on the conductor the minimum clearances has to be maintained from the ground to see that normal conditions or during the fog conditions or rain conditions or during the polluted conditions the flash work should not happen from the line to the ground. So, this again depends on the system voltage the safety margin which has been employed for the design the contamination levels are that area where the tower exists so on and so forth.

So, the insulator has to withstand mechanical stresses. Again mechanical stresses maybe of static in nature or tension compression or due to dynamic loading because of wind air because of any natural calamities which may happen. So, they have to withstand the dynamic and compression loads.

So, apart from this mechanical stresses insulators have to withstand electrical stresses. As mentioned the system voltages which is the normal working voltages and fields and over voltages. As I mentioned over voltages comprise of a lightning over voltages or

switching over voltages or sometimes for a short duration the power frequency over voltages.

Apart from mechanical and electrical stresses these insulator strings are to be withstand the environmental stresses like the temperature very high temperature areas where the transmission system is turreted. The second thing the cold areas like very high altitude where the temperature comes down drastically. So, this has to function in that environment and because of the ultra violet radiations particularly from the sun and also because sometimes the UV radiations happening because of the corona effect the corona effect is because on the hardware you can see this is the phenomena which occurs near the vicinity of the conductor where the air break down takes place and there are discharges Luminas discharges which are coming from the hardware if it is not properly designed.

And these discharges will are continuously heat the insulators either ceramic glass or porcelain. In case of ceramic not much of the issues, but in case of polymer these corona discharges which continuously heat the surface of the polymer insulators particularly which is organic in nature is likely to degrade it is surface lose it hydrophobicity over a period of time, and likely to see that the flash over or the degration further degradation which happens and insulator may give away.

So, this we will be discussing also when for the polymer insulator. So, these are all various environmental stresses the insulators have to withstand in service.