Recent Advances in Transmission Insulators

Prof.B. Subba Reddy
Department of Electrical Engineering
Indian Institute of Science – Bangalore

Module No # 01
Lecture No # 01
Introduction to Transmission and distribution Insulator

Good Morning, the topic of the discussion is a recent advances in a transmission insulators. So as we look into the before going into the topic we will look into the brief introduction about the development of power transmission in the country as well as globally.

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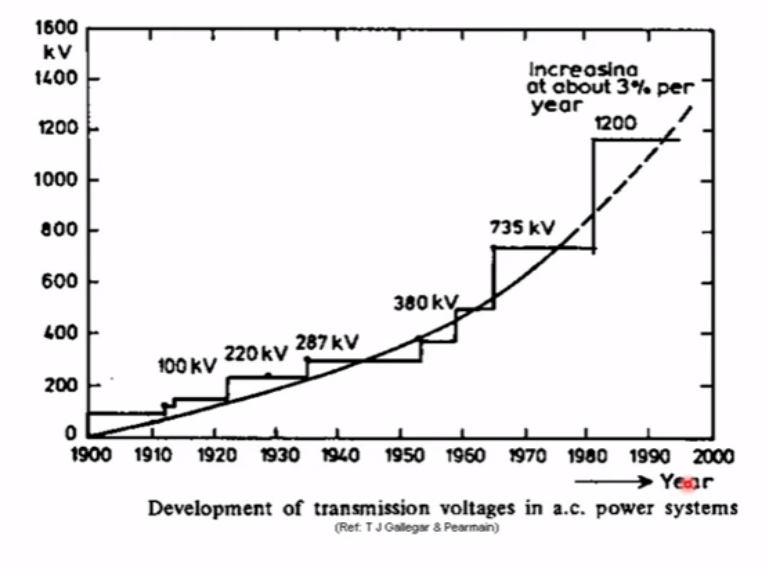

This graph shows you the growth or development of the power transmission across the globe where you see at an increasing about 3% per year. The voltage as the transmission voltage has been seen increasing since 1900. So presently we are in the country operating at 765 KV levels and at 1200 KV level experimentation is also in progress.

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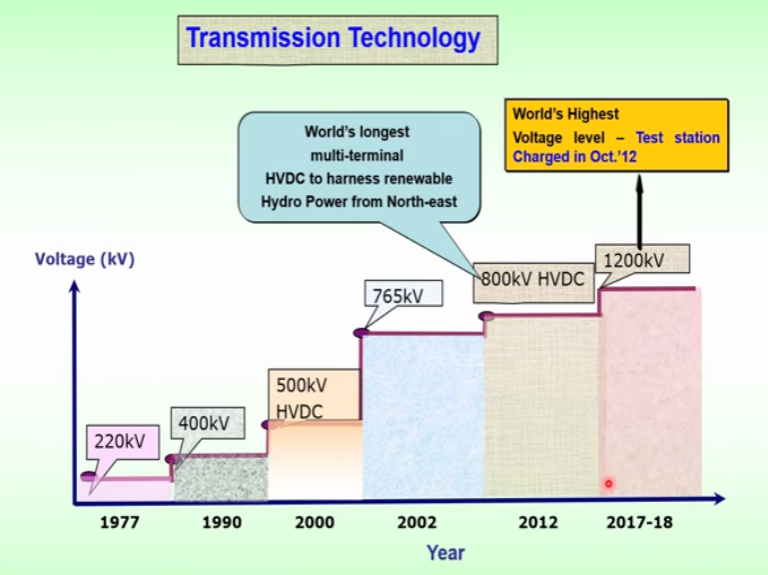

This is how the transmission technology which is developed in the country so this graph shows since 1977 where we were operating at 220 kilovolts gradually nineties we were operating about 400 KV further in 2000 we started using HVDC prior to that we were using HVDC but to an extent 2000 we started using 500 KC HVDC. HVDC is much more beneficial for long distance transmission where huge power can be transmitted over a long distances.

That is one of the major advantages of going in for HVDC presently in the country we have several lines which are operating at 500 KV and also at 800KV HVDC which is of world's longest multi terminal which has been in operation from Arunachal to Agra. So presently we are towards the AC side we are operating several 765 KV transmission lines HVDC we are at 800 KV transmission system is in operation.

And requirement of the power has been more and more that is the reason the 1200 KV lines are being planned and experimented station at (()) (02:32) Madhya Pradesh which is also the world largest voltage level at 1200 KV the operation or the experimental in the progress for last 5 to 6 years by various private manufactures, government organization and the public sector industry.

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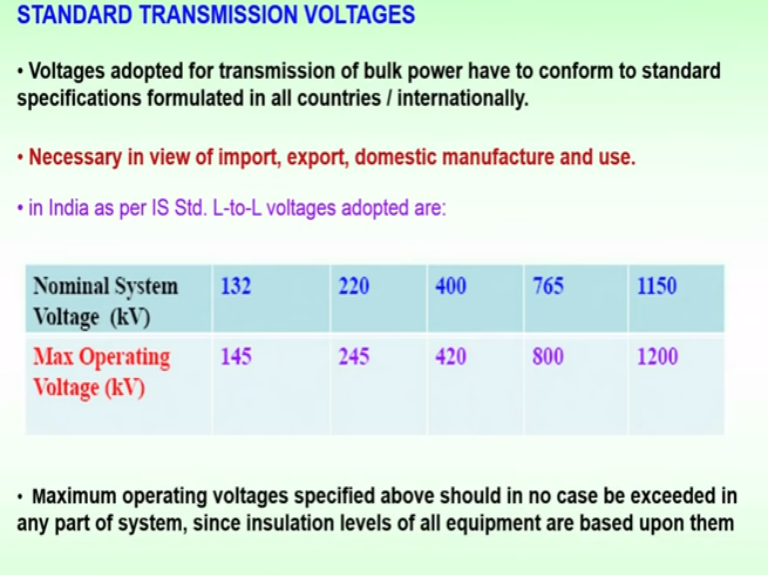

So the transmission when you look into the transmission standard operated voltages across the globe. So the voltages adopted for transmission particularly for bulk power have to confirm to the standard specifications for all the which are to be formatted in all the countries as this is very important because the manufacturers and the utilities will have to be following this standards which is a very necessary part particular in view of the export import and also useful for domestic manufacturers.

In India as per the Indian standards line to line voltages adopted or as the following we have nominal system voltages and also the maximum operating voltages. So the nominal operating voltages are shown for 132 KV the maximum operating being 145 kilovolts. Similarly for 220 it is 245 and for 400 KV it is 420 K kilovolts and for 765 it is 800 is the maximum operating voltage similarly for 1200 KV maximum voltage 1150 is the nominal system voltage.

So what does this give this maximum operating voltage specified here in no case that should exceed in any part of the system because the insulation levels are designed for any equipment for it could be the transmission components are substation equipment or any other operating at this voltages I have to adhere to this insulation levels and these designed is being based on these values.

So it is helpful for manufacturers as well as for the utility personnel to follow this standard voltage levels.

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Table-2.3 Power intensity in MW/meter at different voltage level.

Voltage	132 kV	220 kV	400 kV	765 kV	±500 kV	±800 kV (approx.)	1200 kV (approx.)
ROW Meters(M)	27	35	46	64	52	70	90
Capacity (MW)	Upto 70-80	Upto 160-170	Upto 600-700	Upto 2500-3000	Upto 2000-2500	Upto 6000-6400	Upto 6000-8000
MW/m	3	5	15	45	48	90	90

So when you look into the graph or chart here which is presented this gives a very clear idea of the power intensity in megawatt per meter for different voltage levels. This gives an idea like for 132 KV or system what should be the right off that is the towers the clearances from the midpoint of the tower to the either side. So the write off way per 132 kilovolts system is 27 meters and what could the capacity which it can transfer the power it is somewhere between to 70 to 80 watts.

So you can look into these as the voltage level increases the write off way is also increase the tower height is also increases and the capacity to transfer the power could also be much advantages in going for high voltages. So you see in our case of 765 KV system the write off way a minimum write off way required somewhere around 64 meter and the power transfer can be 2500 or 3000 megawatts this is the power which could be transmitted.

So but for the same voltage level when you look at + - 800 KV DC so the write off way and the power transfer capability for DC is much higher when compare to the AC level that is one of the advantage of going in for long distance transmission apart from several advantages. So you can transfer the bulk power anywhere between 6000 to 6500 megawatts in case of 800 KV systems and that is being the advantage.

So this gives us an idea the minimum write off way for a towers to be followed for a voltage levels and the capacity of the transfer of power which takes place at various voltage levels.

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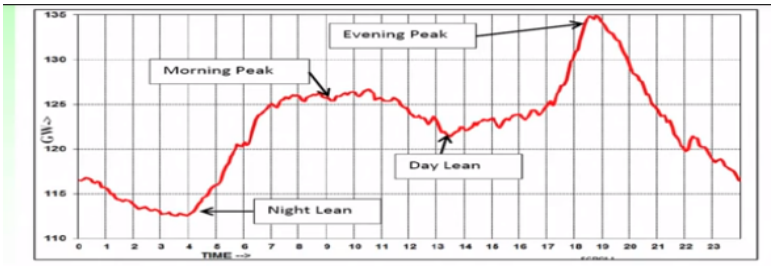

Figure 1: Typical All India Load Curve

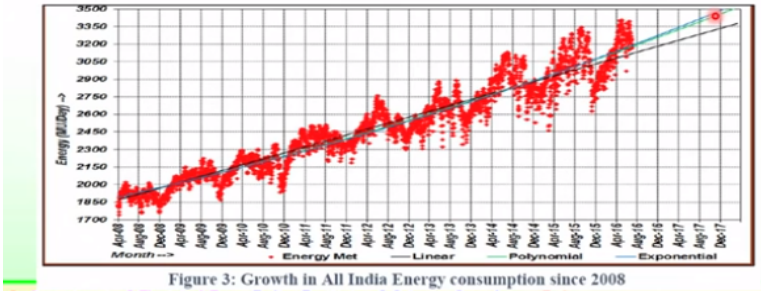

Figure 3: Growth in All India Energy consumption since 2008

This are very important information recent information the typical all India load curve. So how much is the power we are consuming in the country so this very clearly gives you the information where you can see the Y axis is being the Giga watts and X axis is being the time in a day the consumption if you take a typical way variation for the All India curve.

It shows in the morning there is decline and they starts arising after in the morning and it reaches a peak somewhere between 8 to 12 O clock or it could be this range where the morning peak occurs. Then there is a small change or the drop in the consumption and again after certain period of time there is a peak which is again says as evening peak which it should sub as a requirement and again steady lead comes down.

So this curve gives us an idea of Giga watt the consumption in the country and the average value in the country. So such huge amount of power is being consumed where we required somewhere around 136 Giga watts. The second graph here it shows the energy consumption how the growth as happening over the period of time in comparison from 2008 to the present you can see the energy in million units and in the Y axis and the energy which is shown towards the X axis how it is being increased or the time this is the times is the X axis and energy in millions units in the Y axis.

You can see that steadily there is an increasing in the energy growth consumption in the country so somewhere in December 2017 you can see the energy requirement is somewhere 3350 million units which we are presently being consuming so it is a very huge requirement of energy for various purposes.

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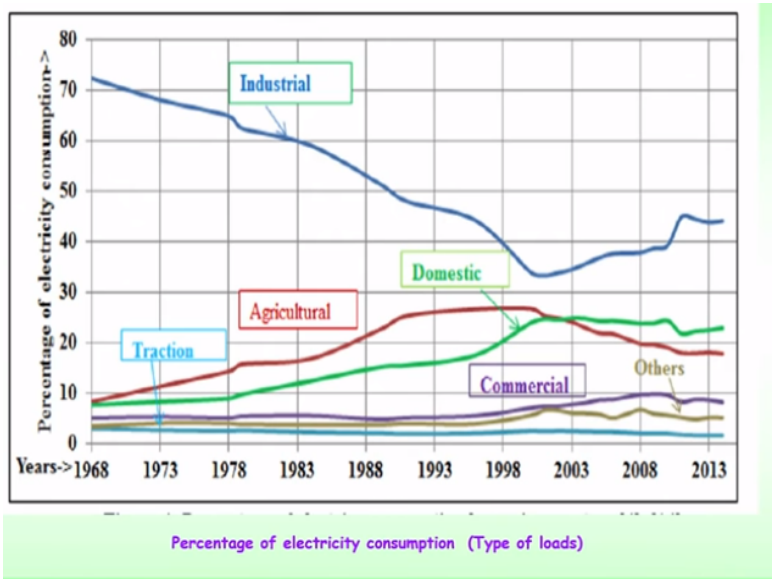

Percentage of electricity consumption (Type of loads)

So what are the purposes which the energy is being consumed so this is again a important graph where it shows you how the consumption over a period of time again you can see from 1960 up to 2013 how the percentage of electricity consumption. The Y axis shows you the percentage of electricity consumption so initially when you carefully look the major consumer is being the industries the other being the agriculture activity the domestic activity and the traction and commercial many other all requirements.

So this graph very clearly indicates over a period of time how the consumption or the percentages of electric consumption has been changing you carefully look initially the 70% of consumption was because of the industry level that has been steadily decreased and again there is a small increase at the present stage but whereas the agriculture activity initially it could be because many of the places where electricity was not reaching during the early 1960, 70.

So as electricity has been reaching the places so agriculture activity picked up and there is again consumption of agriculture activity going around somewhere between 20 to 25%. So then

domestic again domestic it depends upon the steady growth in domestic requirement of the consumption this is happening and here again it is anywhere between 20 and 25% of the consumption of electricity which is happening.

So traction you see almost it is study even those there are several requirements which anywhere metros as come up but the requirement of traction is almost looking to be steady somewhere around 2 to 3 % of the total consumption which is happening. So there are other factor other units which is also consumed this could be many other activities which electricity consumption is being carried out.

So this gives us broader information about the percentage of electricity consumption for various loads.

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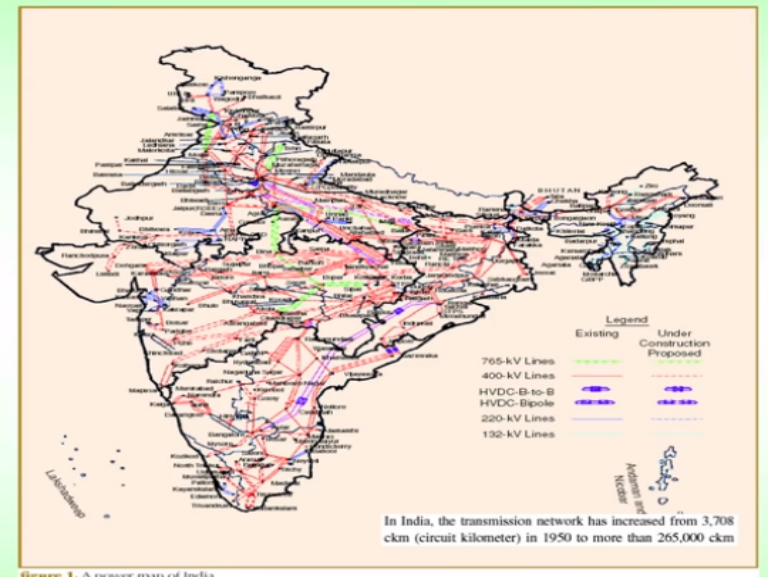

So very important information so now looking into the requirements when you have an entire country which is being linked and in India the transmission network has been suddenly growing over a period of time several initiatives by government of India has been taken up into see that the electricity reaches corners of the country. So and not only the electric reaching the last and it has to see that the generation points which are located depending upon the resource availability.

So this generation points to the load centers the transmission plays a very important part so this transmission has to be done over a very long distances. And the distances in case it exceeds a

certain limit of say 400 kilometers economically and technically it is much better to going to HVDC systems. So we are also having several HVDC or transmission lines in the country.

So the map gives an indication various transmission and network which is happening in the country and liver lines which are being also under construction or proposals are also been shown for voltage level starting from 132 KV to 765 KV ACE and also HVDC lines. So lot of initiatives from the government towards the power sector for the installation of liver lines and also up gradation of existing transmission lines is being taken up.

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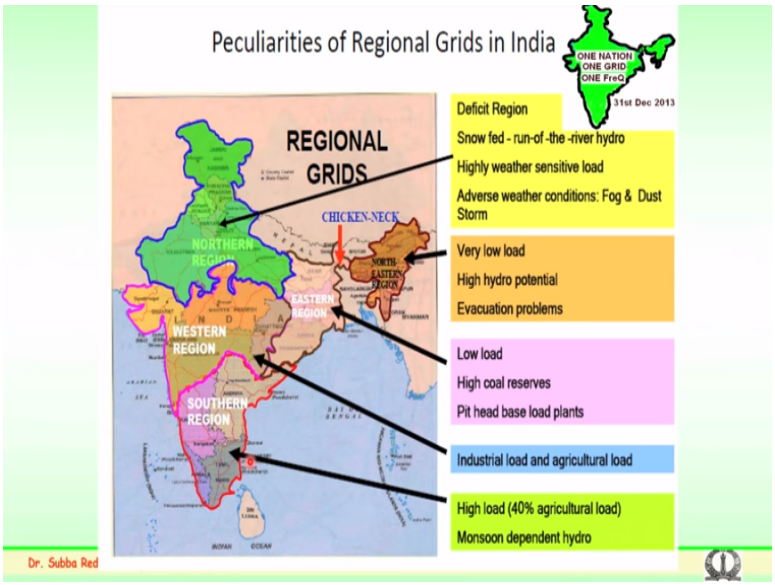

So very important information and the when you looked earlier about the entire nation the network which was spreading I mentioned about the availability of resources that place a very important role in setting up the generating units and later on the transmissions which happens through the transmission network here again the depends upon the transmission again it is mainly on the operation of the bridge we have in the country present into the single grid since the December 13 we have which we call as one nation one grid which operates at one frequencies.

But when we just look back we were operating at 5 regional grids then northern region, eastern region, western southern and north eastern region. These are the 5 grids which are being operated here when you look into that the peculiarities happening to be different for each region. So that is the reason we had to going for single grid which would be much helpful for entire operation of the country.

You can see the northern grid particularly we shows mainly the snow fled region here which is highly weather sensitive loads and also adverse weather conditions fog and dust or the storm or more during the monsoon and conditions there. In case of north eastern region very low load not many industries are available but very high hydro-potential so several reverse are there you have lot of hydro potential where you have generate hydro power in this north eastern region but there is an evacuation problem.

When you carefully look here small space which from north eastern towards the eastern region you have somewhere around to 24 to 25 kilometers is the small space or where you have so the evacuation from north east to the main grid is a really challenged to transfer the huge amount of power. So when you come back to eastern region again eastern region consist of low load and but this region as plenty of coal resource it could be in Jharkhand, Bihar and many of these states where these thermal generation is possible lot of coal resource are available abundantly.

So similarly the western region you see lot of industrial load and agriculture activity which is happening and Maharashtra, Madhya Pradesh or many of this aspects. And then the southern you can see there is a high load there is 40% of the agriculture load in the southern region and mainly the reverse which are available again it depends on the monsoon. So the hydro generation which is typically depends on the availability of the flow for the generation of hydro power. So that is the reason where we have resources at some particular places requirement major requirement at many other states.

So here the transmission system place an important role the generation stations there could be of thermal nuclear hydro or recently the wind and you know wills. So this generation as to reach to the load centers where typically transmission system comes into a play and the transmission system consisting of transmission conductors, the transmission towers and the transmission insulator the several of these things play a very important role here.

So we will be carefully looking into the important properties pertaining to insulation the outdoor insulation what are the type of insulators which are being used for the transmission. How are this manufactures what the design principles pertaining to this we will be looking into this aspect.

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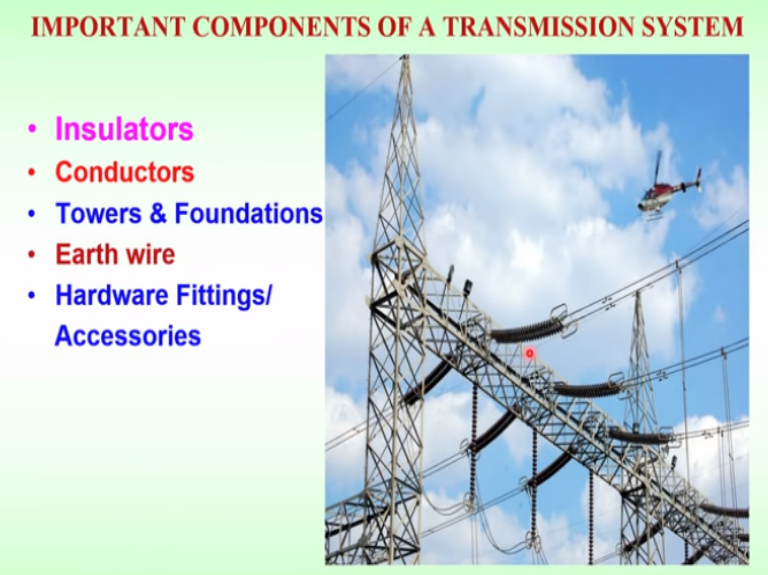

So these are the important components in the transmission system I have earlier mentioned about this aspect. So you have tower which depending upon the voltage level the tower is designed and you have the conductors here. Again the conductors up to 132 KV system could be a single conductor for 220 KV it could be a twin for 400 KV there could be 4 bundle conductor and above 400 KV 765 it could be 6 conductor or 8 conductor.

So that is how the conductor configuration is being done and you have an earth wire on the top of the towers which mainly used for the shielding purpose in case of lighting activity where the overall voltages should not develop and cause the problems related to transfer most of the substations or other equipment's which are placed. So you have earth wire or ground wire then you have hardware fittings.

Hardware fittings are basically the corona control rings it could be the dampers it could be the spacers. So several of these things constitute hardware fittings are accessories which are part of the transmission system and very important components. So each component in the transmission system is very important and equal amount of care and has to be taken in the proper design of these components.

So the tower the foundations depending upon where the location of the tower is also important so insulators which is are very important component of transmission system is to be discussed and this forms an important part of the transmission systems where we will be looking into the type

of insulator how this insulator design has been started being used what are the materials which are being used for the insulators for the overall transmission systems and what are the recent advances in this technology which are being adopted at a very high voltage levels.

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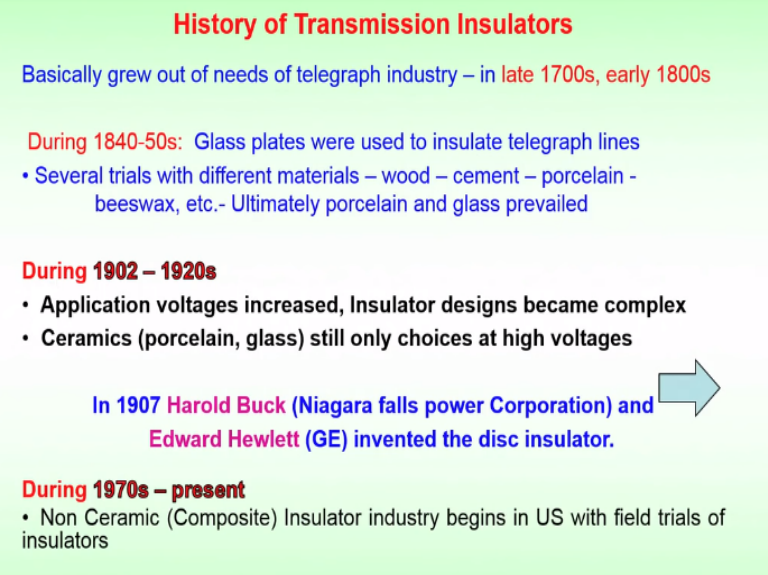

So when we look into the history of transmission insulators these insulators basically grew out of the needs of telegraph industry. So initially before the power industry the telegraph industry was in place these porcelain or initially the glass type of insulators which are known as the pin type of insulators where started being used in late 1700 and earlier 1800.

So during 1840's to 50's before the actually insulators where tried or designed the people were using the glass plates as an insulating materials for the telegraphic lines. So there where several trails with different materials initially people have tried out with would as insulting cement, porcelain, beeswax, lot of trail errors have been done. And ultimately it was found that porcelain and glass perform much better and then people thought about how porcelain and glass can be modified and these can be used for the insulation aspect.

So in a 1900 the early 1900 decade or two the 1900 or 1920's we saw the application of voltages increased the insulator design became complex. So when the voltage level started going higher so initially it was 11 KV then 66 the voltage levels started going up the insulator design became complex and insulator became an important part which are to be considered for proper design.

So here either porcelain or a glass or a ceramic what we called where the choice for the higher voltages and how these design came into the picture is very important. So lot of effort was done for to see that this insulters where tight and where this ceramic and glass insulators where initially invented by two important persons in 1907 one is the Harold Buck and of the Niagara falls corporation and the Edward Hewlett is the engineer was working in general electric.

So these two people were the responsible for the early design of ceramic insulators for high voltage a transmission. So before the several trails where carried out and finally the insulators which were used for the present day were modified version of this insulators which were designed by Harold Buck and Edward Hewlett. So later as a voltage levels grew up people felt that ceramic or glass were bulky and also required lot of effort in stinging.

So they thought that how to reduce the weight and what could be the material which could be used for the replacement of these. So somewhere in 70's people started trying it out several type of non ceramic glass type of insulators which are basically known as composite material or a polymeric type of insulators. So the industry both in US and Europe started using various composite materials in initially they started DPDM later on they started in silicon rubber with several additive filler and several of these things.

So this is how the liver technology of non-ceramic insulator or polymer insulators and started to come into the existence. So before going into the actual insulating part of the ceramic glass or polymer insulator we would discuss about how this insulators are manufactured. So we will see the ceramic insulators manufacturers of ceramic insulators and what are the important components which are required? What is the material which is required? What is the process which is adopted for the manufacturing of ceramic insulators and also the polymeric insulators. So today we will stop here thank you.