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

Lecture – 04
Design/selection of insulators, Importance of grading/cc rings

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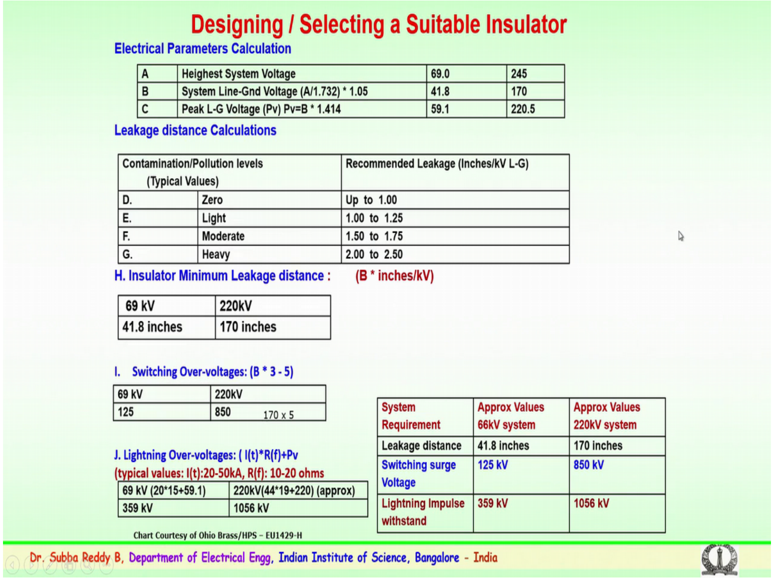

So we are looking at the design and selecting of a suitable insulator, so for 220 KV a system. As mentioned we have the following parameters which we have got the leakage distance being 170 inches. The switching surge or a switching impulse voltage will be 850 KV and the lightning impulse a withstand value will be 1056 KV. These are all for the dry conditions that is for the normal conditions, in a insulator strings are in the outdoor environment. That is without considering the rain fog or pollution conditions. In case of pollution rain or fog the wet flash over voltages or the wet switching surge lightning impulse and the values gets changed; so that we will be discussing.

So, this, whatever approximate values which we have are shown here for 220. Similarly, for 66 KV the table shows you in case a 66 KV the maximum system voltage will be 69 KV and the line to ground will be of around 41.8 and line to ground voltage the route will be 59.1. And here again for a 69 KV, if you take the insulator strings are operating at different environments we see leakage distance being at 41.8 and switching surge voltages 125 KV and lightning surge voltages being at 359 KV.

So, these are the 2 different values for different voltage level. Similarly, for a higher the voltages 400 KV 765 and higher voltages: similar a pattern will be follow with other considerations for the design aspect. So, just have looking in to the approximate a values the approximate values, which we have obtained for both the voltage levels are shown here the 66 and 220 KV. The leakage distance being 41.6 in case of 66 KV and 220 KV it is 170. Switching surge voltages being 125 KV in case of 66 and 850 and lightning impulses 359 and 1056, as I mentioned these values are for dry conditions.

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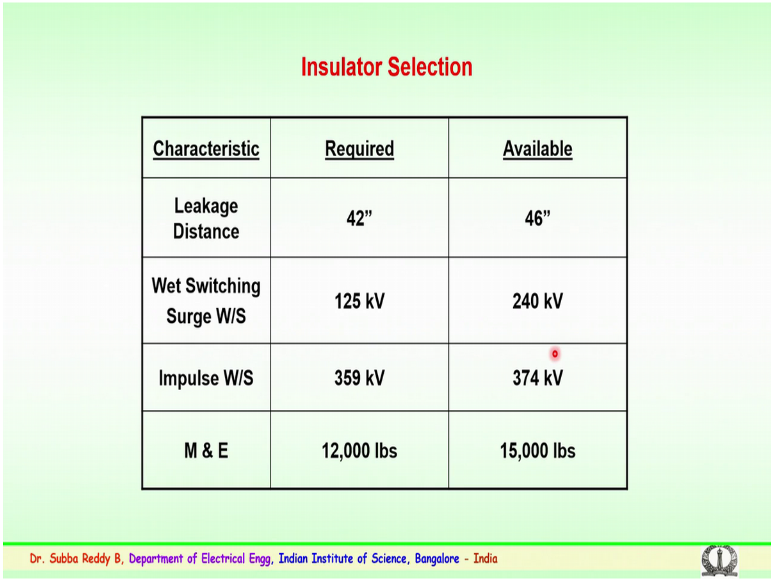

So, now the selection whatever we have a made or we have seen are from the data for the 66 KV. You know the leakage distance when you look the required is 42 inches. So, the available from the manufacture is 46 inches. So, which is higher than the required which we have try to estimate. Similarly, in case of a impulse a voltage levels, we have 125 KV and the available is 240 KV for a wet switching search and impulse withstand voltages the required is 359 as per our calculations the available is 374 KV. So, these voltage values by the manufacturers which are available are higher than the values which are been estimated. So, similarly for mechanical and electrical strengths, the mechanical strength requirement is 12,000 pounds whereas available mechanical strength with the insulator from the manufacture is 15000 pounds.

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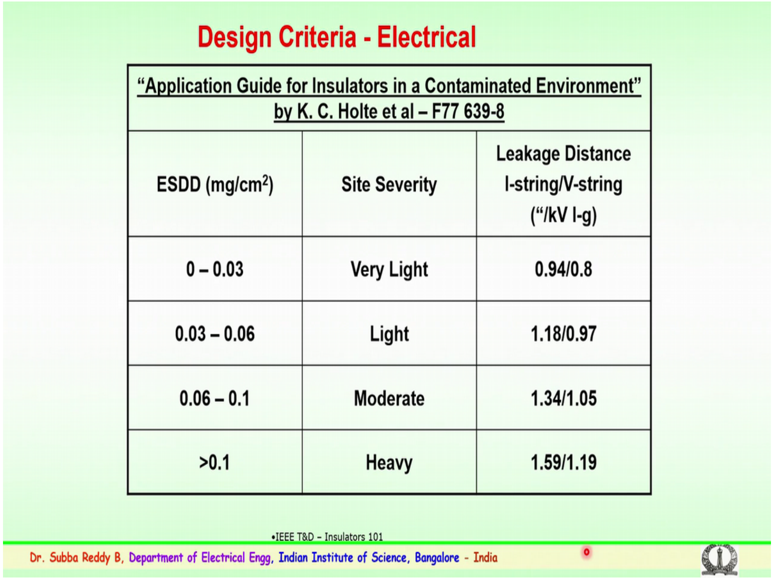

ESDD (mg/cm^2)	Site Severity	Leakage Distance I-string/V-string ("/kV l-g)
0 – 0.03	Very Light	0.94/0.8
0.03 – 0.06	Light	1.18/0.97
0.06 – 0.1	Moderate	1.34/1.05
>0.1	Heavy	1.59/1.19

So, various contaminated environments I was mentioning you in case of a wet or a polluted condition. So, polluted conditions are again divided into a various zones a like light medium heavy very heavy a very light and so on.

So, these areas where the insulator strings are to be used are being taken care particularly depending upon the area of the polluted zones. So, for this term known as ESDD: ESDD is equivalent salt deposit density. This is given in milligrams per a centimeter square. This equivalent salt deposit density a depending upon the site severity, I was telling the location where the insulator strings are to be connected or the towers, which are to be erected depends upon the leakage distance which is to be consider that is I is the suspension string I was mentioning you before a configuration of suspension string v being the v type of a string.

So, here it will be inches per KV, the values for line to ground voltages. So, you can see that ESDD is nothing but the equivalent salt deposit density on the surface, of the insulator how it is calculated. So, normally the insulator is allowed to be in the field for a certain period of time, based on the site severity whether the area is light moderate or heavy polluted zone. The insulator after period of time is taken out and the ceramic or a poly, porcelain portion except the cap and pin the contents or a contaminants which are spread on the only insulating surface are removed carefully with a known quantity of distilled water. And the connectivity is measured and this is how we see the equivalent salt as a deposit density on the surface of insulators.

So, based on this data we can say that the line which is being erected comes under pollution of light medium or heavy polluted zones. So, this is the application there is a application guide a particularly, how to be used during the insulation design. There are standard and also the international bodies which have the data for this.

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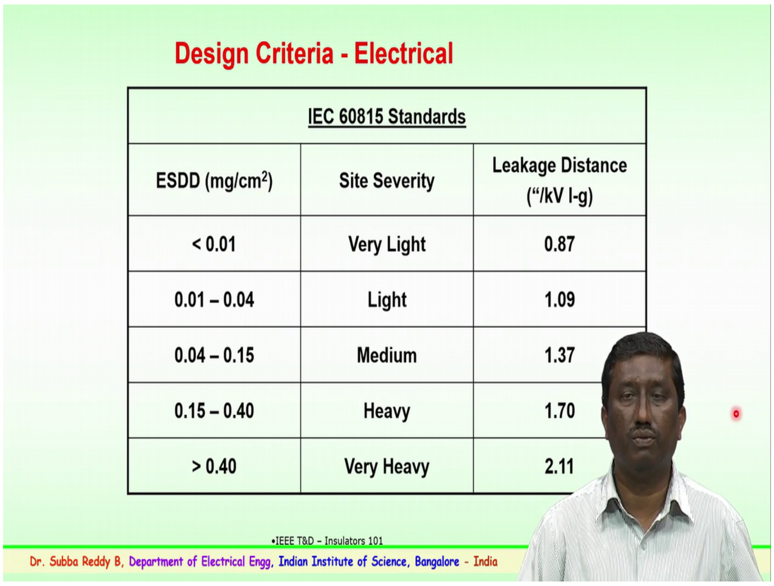

Similarly a important IEC international electro technical commission a standard 60815 which completely gives about the information on the polluted conditions the values which are to be used for the simulation in the laboratory for a particular KV voltage level is described in standard 60815 for various type of insulators depending upon the creep-age a length of the insulator how the insulator can perform in this conditions. So, the criteria has been given and various values as per the standard specified values of ESDD that is equivalent salt deposit density are to be used in case the laboratory verification or laboratory testing of this insulator for various a types of a insulators to be a tested.

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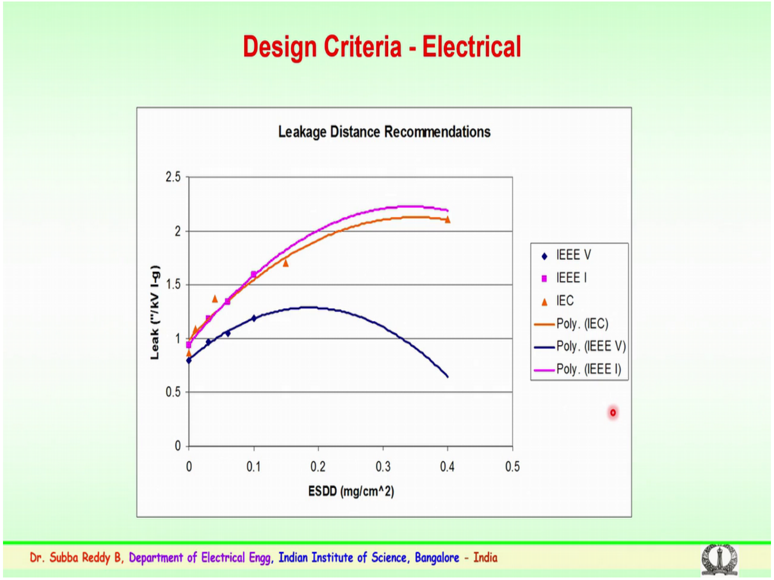

So, again the recommended leakage distances various a groups. This includes a IEEE international study groups and IEC is a electrical or international electro technical commission. Apart from there are several other standard bodies which converge and they look in to these requirements for various leakage distance and they have recommended. So, these are the curves which show for the recommendation of the leakage distances in each per KV, it is a line to ground verses the equivalent salt deposit density that is in milligrams per centimeter square.

The values have been defined for various pollution zones. So, both for ceramic glass and a polymeric a materials which have to be used for the laboratory evaluation for the verification or performance of a insulators.

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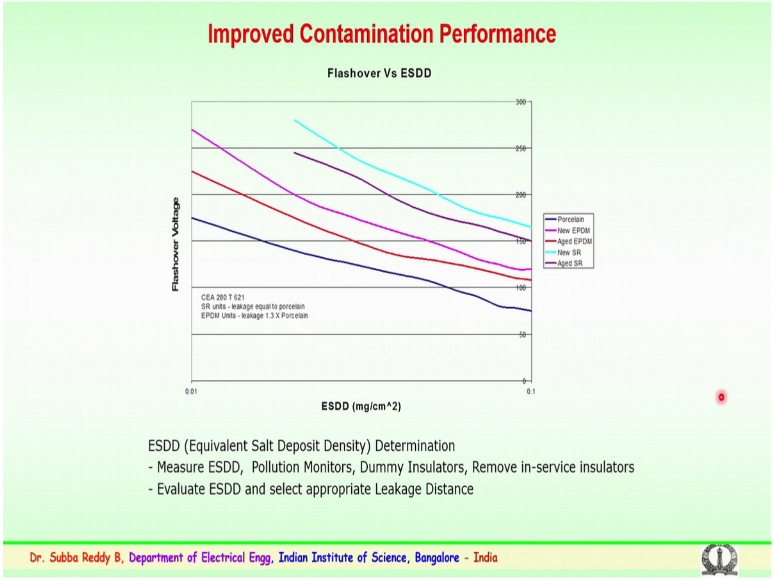

Then again this graph shows the improved contamination performance, mainly gives about the flash over verses the equivalent salt deposit density, the flash over voltage across the equivalent salt deposit density. The curves very clearly give you the idea which are been used for porcelain then EPDM and polymer insulator there is a new SRA silicon rubber insulator aged silicon rubber insulator, ethylene poly die monomer is the EPDM material which is being used for a the insulation purpose.

So, this gives you the improved contamination performance, the measure of a equivalent salts deposit density. How it is being used in the field with the help of the pollution monitors using a dummy insulators in service or removing a in service insulators a evaluation of the equivalent salt deposit density and selecting of the appropriate leakage distances to be used in that the areas so very important a graph which gives you the idea for the improved contamination performance.

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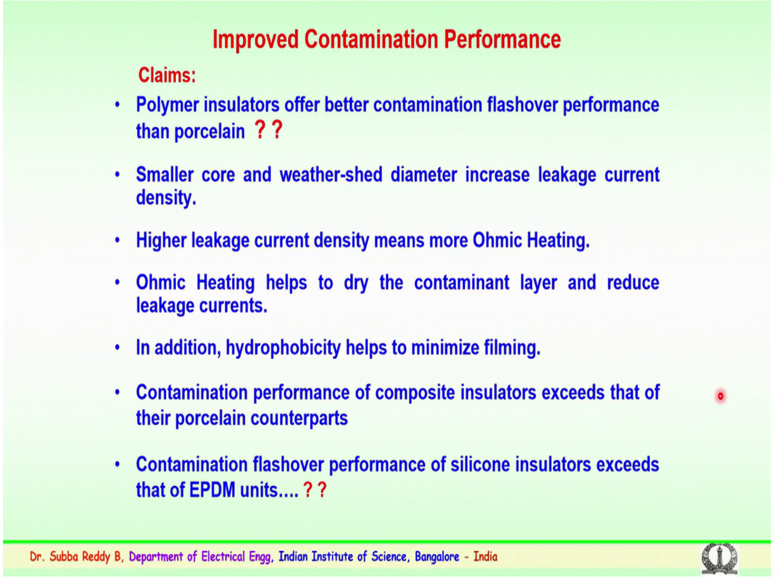

So, the contamination or the pollution performance of an insulator is a very important issue when you go for extra high voltage and ultra high voltage transmission I was mentioning. Now for last 100 years we were using the polymer porcelain or the ceramic insulators and glass insulators. Polymer insulators as I mentioning it was it is of the recent origin and a particularly they are organic in nature.

So, the polymer insulators presently what we have see after better contamination flashover performance then porcelain yes, but again the a performance has to be judged over a period of time these insulators being of a recent origin the field data available a for the longer performance or longer a time performance is not yet available. So, we have to see the performance over a period of time and then I conclude that a polymer insulator can offer better performance for a very long period of time. Yes short term performance they are performing good and are giving the better contamination flashover performance in comparison to the porcelain or glass type of a insulators.

The polymer insulators or silicon rubber or a composite insulator have a smaller core there is for the glass core and a weather shed diameter there is a petty coats which the molded on the farther glass or rod. This can increase the leakage current a density. So, it is a important comparison compared to the a porcelain, looks aesthetically much better than the earlier porcelain or a glass type of insulators a higher leakage. Current density what we were looking here a means a more ohmic heating. Again more ohmic heating helps to dry the contaminate layer and reduce the leakage current. So, this is a one of the very important aspect when using in for a polymer a type of insulator, where hydrophobicity the property of the surface of the polymer insulator try to repel the water and sees that it has better leakage current density and sees that the contamination layer and reducing of the leakage current which helps the better performance of the flashover particularly in pollution of a contaminated areas. In addition the polymer insulators hydrophobicity helps to minimize the filming.

Hydrophobicity is property of the surface of the material where it is tries to repel the water droplet us or the polluted droplet us which are being on the surface, particularly the water droplet us and sees that the filming formation on the surface is a reduced, and where the contaminants or the pollutants goes on accumulating it is reduced. That is one more advantage with the polymer type of insulator the contamination performance of a composite or a polymer or a silicon rubber insulator exceeds that of a their porcelain or a glass a counterparts which are being used for a long period of a time this is an important a point to be noted.

The next being the contamination flashover performance whether it exceeds that of the EPDM units again depending upon the number of years the insulators in service in comparison to the electric ethylene porcelain die monomer type of units which for the earlier version of the silicon rubber insulators are presently being used. The presently I have mentioned that being used or of a third generation. So, EPDM were earlier used a how much is better the time comparison is very important. This has to be properly verified in the laboratory from the field insulators and can be judged the performance of the silicon the information where the flashover performance could be better when comparison to the earlier EPDM units.

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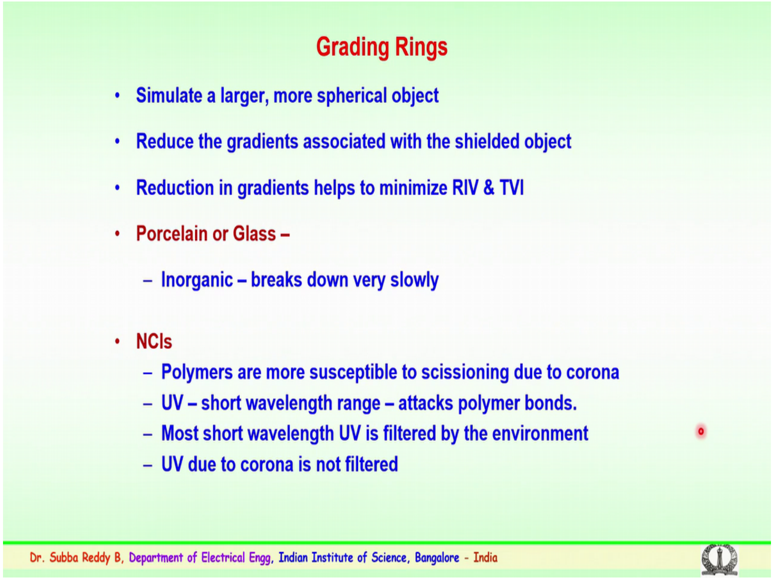

Next the grading rings as I was mentioning corona control rings, the grading rings, arching horns these are all the similar a names or a same hardware which are being used for proper grading that is a voltage distribution in case of a various insulator strings. So, this grading rings corona control rings are very important. This simulate a larger or more spherical object in case as the voltage level goes up the corona control rings of an spherical nature or a rectangular type which are being used in a long transmission insulators long transmission lines and high voltage and extra high voltage and ultra high voltage transmission for insulator strings. These help in a reducing the gradients particularly associated with the shielded object.

So, the insulator string is having hardware as I mentioned the yoke plate along with several accessories which are connected to the tower side and also to the line side. So, this have to be equally a reduced. So, that the insulator never sees stress in a particular region. So, the equal uniform distribution of voltage is to be maintained. And the higher gradients have to be reduced for this the grading rings or the corona control rings are employed for the transmission line insulator strings. So, reduction in gradients helps to minimize the RIV and TVI. RIV is a radio interference voltage and a TVI is television voltage interference.

So, we will be discussing about the radio interference voltage and TVI in future, when we come to the importance of this parameters. So, the gradients which in case if it is not reduced can lead to a discharges on from the particularly hardware on corona control or a grading rings. And these discharges which are of impulsive in nature will communicate through the conductors and to the neighboring areas where radio sides or a television could be affected because these are high impulse in nature and operated that voltage levels. So, radio interference voltage measurements which are carried in the laboratory see that the gradients are quite a lower and the discharges which are being from the hardware and grading rings do not interfere in radio interference as radio a circuitry or the television interferences causing interference to the radio on television sets. So, mentioning about the porcelain or glass these are inorganic and break down very slowly which are being used for last hundred years or so. Mechanically they are good on performance it has been judged over a period of time.

Now, the recent non ceramic insulators or polymer silicon rubber or composite a insulators, are more susceptible to seasoning due to corona. So, corona is again a phenomena which happens near the hardware, corona control rings particularly in vicinity of high voltage where the discharges on the year background takes place and the corona maybe initially audible then the visible discharges coming out from the hardware or a corona control a rings or a grading rings continuously influence on the surface of the particularly non ceramic insulator polymer insulators over a period of time, which in the intensity is more may cause the insulator surface to lose it hydrophobicity and likely over a period can reduce the surface property insulating properties. This how it happens due to the corona we will be also discussing about the effect of corona and the polymer insulators and how it could affect the insulation in future.

So, you next the UV ultra violet again these are short wavelength range this it may attack the polymer bonds on the silicon rubber or a polymer insulators. So, this ultra violet again maybe from the natural sun, during the day time, or due to the corona the effect of corona also causes the ultra violet radiations which may influence on the surface and attack the polymer bonds making the surface of the insulator less hydrophobic and where the surface may degrade over a period of time, and the insulation level could be reduced. So, the most short wavelength ultra violet is filtered by the environment, but the ultra violet us which is coming from the corona is not filtered and it may damage the surface. So, ultra violet due to corona is not filtered, this ultra violet and due to corona is from the hardware corona control rings or grading rings.

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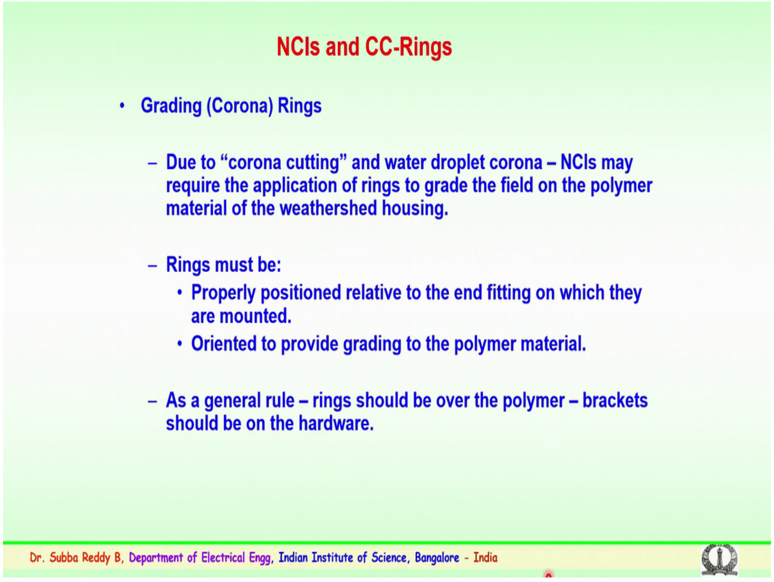

So, non ceramic insulators have a different corona control rings, which are designed not like the porcelain or a glass type of insulator. So, here the design of the grading rings or the corona control rings depends on a how the hardware end fittings of the non ceramic a insulators is designed and for the particular voltage level. So, due to corona cutting, what we call and also water droplet corona which this water droplet corona may happen because of the rain droplet us which settle on the surface of a polymer insulator. So, this are likely to develop a small discharges and later on corona discharges which slowly degrade the surface on the insulator and the hydrophobicity effect could be over a period of time it may lose the hydrophobicity characteristics later on the degradation of the insulator could happen.

So, the non ceramic insulators may require the application of the corona control or grading rings particularly to grade the field on the polymer material on the weathershed housing. So, this is very important in case proper design of corona control rings for the non ceramic or a polymer insulator is not done the material could the weathering on the particularly on the weather sheds petty coats or the weather shed of the material could lose the hydrophobicity over a period of time. With these corona rings must be or grading rings must be properly positioned. The positioning of the corona control rings is equally important with the design. So, not only the design place a role the positioning of the corona control ring alignment in the string is very important. So, that the end fitting on which they are mounted has to be properly mounted. Else there could be shift in the position and this where lead to higher corona discharges which may damage the surface of the polymer sheds.

So, the orientation positioning is to provide grading to the polymer material or a polymer insulator string. As a general rule the corona control rings or the grading ring which should be over the polymer brackets which should be on the hardware; so hard this brackets or accessories are provided on the insulator metal end fittings which are connected to the tower. So, they should be properly positioned properly mounted and properly oriented with the help of brackets on the hardware that is on the yoke or the connecting hardware to the tower and to the conductor side.

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So, what is a service experience which has been observed over a period of time? So, we will discuss about for both the ceramic and the polymer insulators which have served a transmission system for a period of time. What are the likely problems or issues which could happen in case of a polymer insulator or porcelain insulator or a glass insulator we will be discussing the particular issues in the field a related field use and so on.

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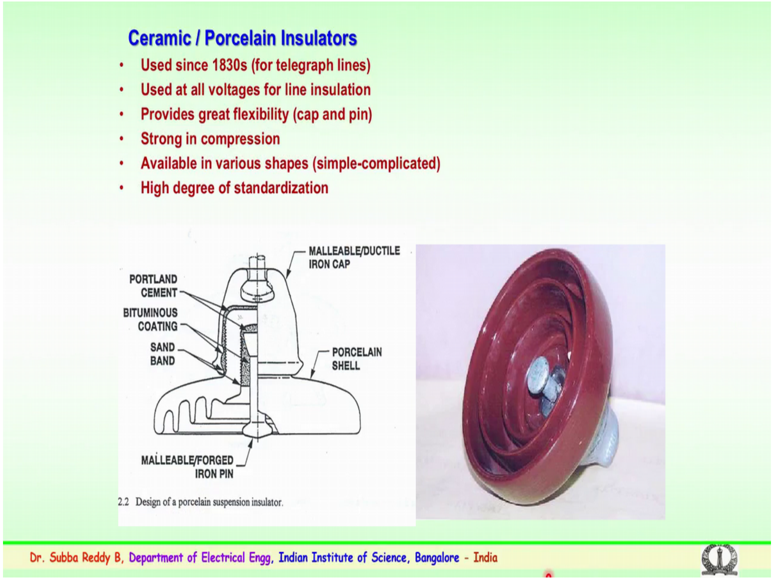

The ceramic or porcelain I was mentioning there more than hundred years old. Initially started off as telegraphic insulators for employed for the transmission very early stages, and presently the porcelain or a ceramic insulators are used for all voltages from a very low voltage to the ultra high voltage range up to 800 KV or even for the 1200 KV experimental lines in the polymer porcelain insulators are being used for the line insulation. These provide a porcelain insulator provide greater flexibility because have a cap and a pin arrangement this is the cap. This is a pin of the insulator this is the porcelain shell and these are the petty coats or sheds what we call. So, the cap and pin are connected are fixed to the porcelain shell with the help of a Portland cement and properly the gin coating is carried out to see the corrosion never happens in the field.

So, a schematic of the design of a porcelain suspension insulators is also shown here, where the porcelain shell is this form and the cap wherever the cap which you see is the malleable or a ductile iron material or which is fixed on the as a cap of the insulator. And we have a pin is again a malleable and forged iron pin; this is a iron both are iron cap and pin of the insulator. These are fixed with the help of a Portland cement with the bituminous coating here. So, you have initially a sand band particularly here to fix the pin. And also to fix the cap a sand band is coated fixed to the surface of the or porcelain disc later on with the help of the Portland cement, above the pin and a cap of the insulator are fixed leaving a small cushioning with here to the insulator. So, this is how the ceramic insulator is designed for the transmission system.

So, this as I mentioning a used for last 100 years and are there used for all voltages for any type of a line insulation, and they provide better flexibility because of this cap and pin arrangement. And they are strong in compression particularly because of the compressive loads because of the wind variation because of in the tension they are very good at compression that is one of the advantages of using the ceramic insulators, but they can take a better compressive load in comparison to other insulates. So, there available in various shapes again this shape it depends on where the area this insulator is being used either it is for a normal conditions that is a clear conditions or a polluted zones or the desert areas.

So, depending upon the areas the petty coats can be designed and the shapes can be made available. So, is very simple to make it and a complicated sometimes because you require a special a petty coat for a particular area in case there is a fog. So, the anti fog type of insulation has to be done and it has to be carried out with a high degree of a standardization including the material aspect and the process. So, this is how the porcelain or ceramic insulators are being serving the transmission utilities.

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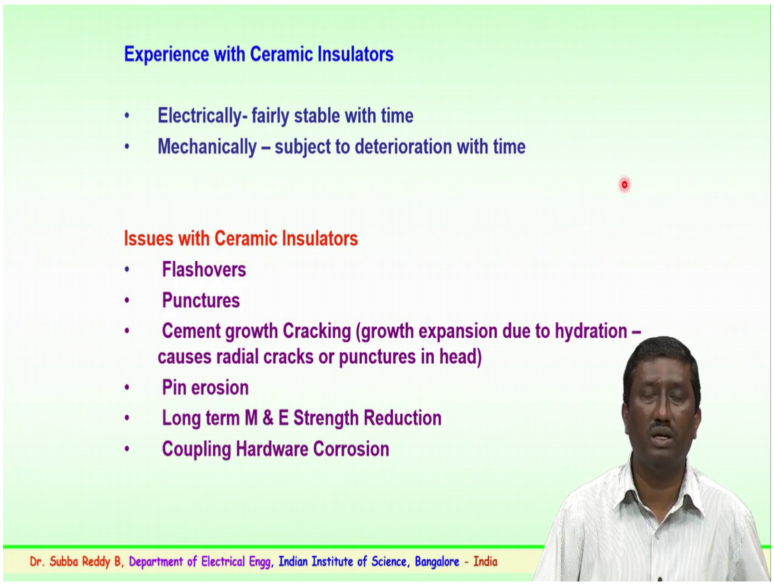

So, what is a experience with ceramic electrically over a period of time there is more than hundred years they have said. Electrically they are fairly stable with time over a period of time. Mechanically they are subject to deterioration with time. Mechanically they could happen is there may be cement issues here, the corrosion on the pin there could be a problem with a cap. So, this is a because of the mechanical load or because of the environmental factors the corrosion of the pin could happen and some of the cases where the cap and pin gets detach from the insulator leaves the line detach to the tower.