Recent Advances in Transmission Insulators
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Module No # 01
Lecture No # 05
Field experience of Ceramic/ Glass and Polymeric Insulators

Good morning we were discussing about the importance of the insulation coordination for the electrical equipment's which are used in the transmission and distribution systems. Further we were also discussing about the ceramic or porcelain and glass insulators for the service performance. Now we will discuss about the non-ceramic or the composite insulator which are all of recent origin and are being used from distribution glass to the very high voltage level up to ultra-voltage levels.

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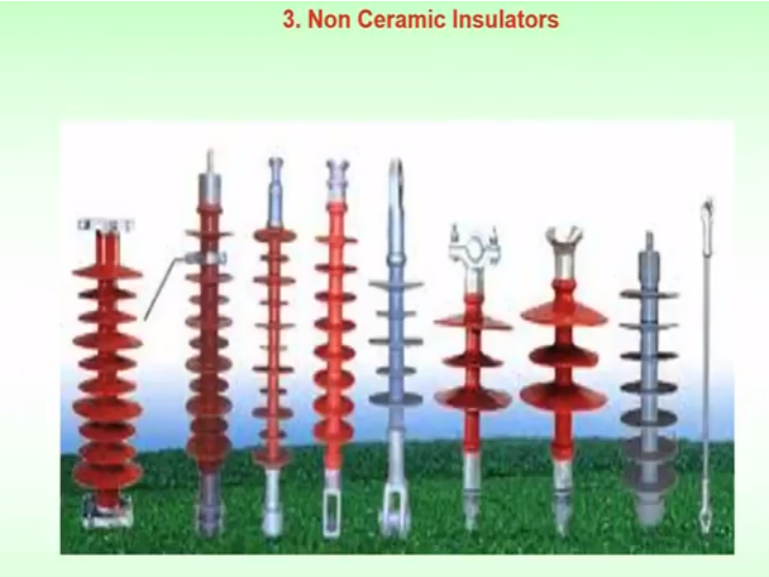

So this silicon rubber or polymeric or composite insulators are being manufactured from for different voltage levels and are being used railway traction transmission and also distribution purposes. So we have briefly looked into the composition the materials fixtures and the manufacturing of the porcelain polymeric insulators there are some issues as earlier discussed initially this polymer or composite insulator where of concern later on the technology has improved and still it needs to be improved.

Particularly in the maintenance aspects for the hotline maintenance of the insulators and there are groups which are being working towards this improve mental aspects and also trying to come up with the newer maintenance procedures for the EHP and UHP class which they do not exist presently.

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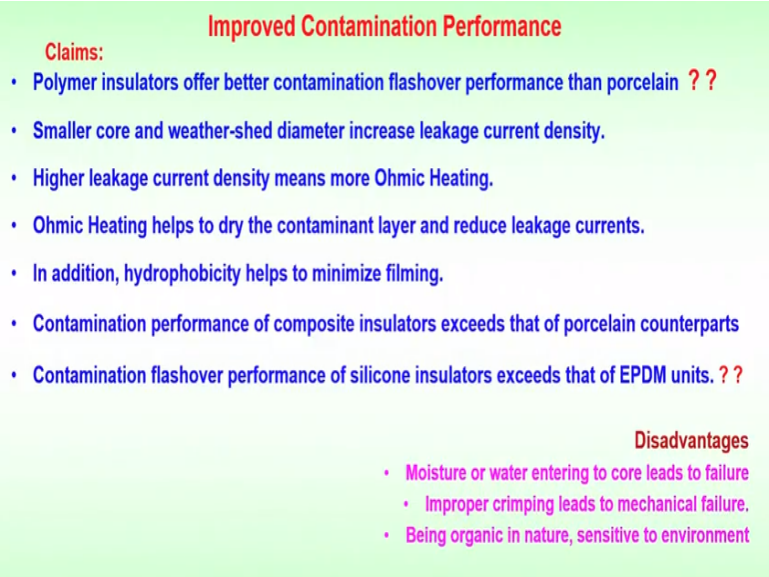

So polymer or composite insulators have some better advantages in compare to the porcelain or glass. We will look into the advantages of this insulators so polymeric or composite insulators of our better contamination flash over performance then porcelain insulators this is one of the important property where the utilities are much more comfortable in using this insulator during the polluted or contaminated conditions and zones where regular contamination or pollution flash over do occur.

So apart from that the polymer insulators have smaller core in comparison and whether shed diameters. So the petty coats are the shed dimensions of the porcelain or ceramic or glass or much bigger in size or bulk in size. So here the materials organic has mentioned they are lighter in weight and also the shed diameter is comparatively lesser in porcelain or the glass insulator. This increases the leakage current density so higher leakage current density means more Ohmic heating.

So this is one of the advantages so this ohmic heating helps to dry the contaminated layer and reduce the leakage current the reason is once the contaminating or the polluted layer on the

which is formed on the insulator surface becomes wet the conduction happens the surface gets conducted the leakage current flows because of the heating which is happening the lesser surface area when compared to the ceramic here the heating is more this helps to dry the contaminated surface.

Further once that surface dries then the leakage current the dry band or the formation of the dry area offers a high resistance and further reduced the leakage current flows. So this is one of the major advantages because of the hydrophobic in nature where the water repelling property of the polymer insulator has an advantage in compared to the earlier ceramic or porcelain insulators in addition hydrophobicity helps in minimizing the filming.

So there is property which repels the water droplets to form on the insulators surface so once this happens so there is no filming on the surface then minimizing the water filming also reduces the leakage current so the conduction is reduced. So this is the important property of the polymer or composite insulators as mentioned contamination performance of the composite insulator exceeds that of the porcelain this is what it has been noticed in the field literature also.

Filed conditions reports that the performance particular for contamination or pollution polymeric insulators of better performance in comparison to the earlier ceramic porcelain insulators So contamination performance of silicon or a composite is also exceeds the EPDM units where earlier version of silicon rubber.

So much better in case of pollution or contamination this phenomena is very important because as we discussed pollution or contamination is a very serious threat above extra high voltage that is 400 kilo volts and above contamination is plays a major role in the line design of EHP system. So property of the composite insulator of the better performance during the contamination or pollution is a major advantage and comparison to other type of insulating material.

So there are few disadvantages because of the reports or the service performance that has been available this majorly for the first generation or second generation of polymer insulators further lot of improvements have been taken in this regards so the disadvantages could be to

carefully look into the maintenance and also the manufacturing aspects procedures or the manufacturing protocols which have been followed to be carefully looked into.

In case the moisture or the water in case there is a damage to the insulating rubber on the surface polymeric insulators there could be a water entering into the core fiber glass core this could lead to value there are reports failures which are happened because of the moisture and formation of nitric acid and this nitric acid causing the brittle fraction to the fiber glass rod.

Further improper grumping particularly this as to carefully crimped into when the fiber glass rod is being crimped at the edges by the mechanical metallic or the end fitting. So this end fittings proper printing arrangements has to be done with the specified procedure and also the specified hydraulic pressure of this to be taken in to consideration.

The reason is during crimping even minor crack formation or over load because of the procedure which is being done could later on cause the insulator to shatter where this micro crack is may be a failure of this insulator or the fiber glass rod and the line could be thrown away. So this is a very important factor particularly during the manufacturing stage where it has to be taken into consideration and third limitation is because as mentioned the insulators polymer insulator has being organic in nature they are sensitive to environment.

So environment plays an important role for the overhead transmission system the line where it is passing and the climatic conditions of that area where the tower is situated insulars are placed. So this environment is paying a role we will further look into the various environmental parameter which could cause a series issues to the insulators in service.

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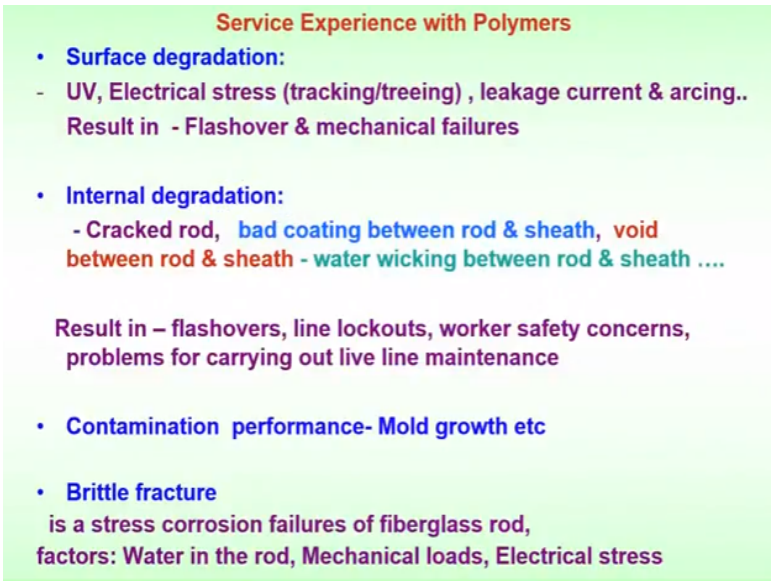

Through which experience or three decades since the initial composite insulator where used for the transmission systems now in several countries it is widely used even for the EHP and UHP range. So there are some experiences with the polymer over a period of time so initially there were few their initially there were failures notices because there were several issues.

So like surface degradation of the polymer surface the surface gets degraded the surface could be because of the ultra violet radiation from the sun over a the period of time the UV radiations from the corona control rings which are fixed on the either side of metallic fittings near the insulators this if it is not property placed or the corona control rings are not properly designed this could cause the discharge.

This corona dischargers continuously hitting the surface on the insulator over the period of time could cause the damage to the insulator a surface and this damage because of the moisture because of the pollution, because of fog or a snow entering into the surface could cause the nitric acid here again the failures have reported over a period of time similarly electrical stress because the insulators are continuously again electrical stress.

So these are (()) (11:26) attacking a tree so where in case the surface becomes hard or stiff the brittle in nature over a period of time the hydrophobicity property which we were discussing. This hydrophobicity property could be reduced over the period because of the

continuous hardening of the silicon rubber and this lead through the higher leakage current leading to the arching could be in case of the surface arching what we call (())(12:01) or partial arts this could be again due to the formation of the dry band and wet band on the surface because the surface may be continuously wet or partially wet.

So this small bands becomes due to rain or because of the fog conditions the surface which becomes partially wet and partially dry this in the arching known as the partial arch or (()) (12:31). This results depending upon the conditions the surface resistance offered so this dry band wet band formation followed by leakage current depending upon the surface condition could lead to flash over and sometimes mechanical failure also because of the fiber glass rod of failures.

So they could also be mechanical failures where the line could get detached some reports have indicated the mechanical failures because of the degradation. So similarly internal degradation this could happen because of the crack product i mentioned in the manufacturing stage or during the stringing there could be international damage this crack because of the end fitting the pressure micro structure there could be micro cracks which could have happening and this could develop over a period of time or this could be because of the coating between the rod and sheet before the silicon rubber material is molded on the fiber glass rod.

So the bad coating also could cause the internal degradation over a period of time or voids are small air pockets between rod and sheath over the period of time could again lead to the air pocket in discharge the charge build up also the failures happens because of installation becoming week at that junction where this small air pockets could break down and water entering into this places further could in case there is a micro structure damage to the fiber glass rod the acid is which is formed could contribute to the failure of the internal degradation between the rod and the sheath.

So this could again result in the flash overs the line lockouts or black outs or partial black outs what we call and also part from this it could also cause the worker safety concern as the problem for carrying out live line maintenance or not fully developed it is fully developed

for this insulators so this internal degradation could also cause series concerns to the safety aspects and also the utility engineers for the maintenance.

The important point as mentioned earlier and discussed earlier the contamination or pollution performance of this insulators in the field is a very important factor for design consideration and mentioning several times. So the contamination performance and dedicates have the insulator particularly at higher EHP and UHP ultra high voltage range. So this the we will be discussing in detail about the phenomena of the contamination the pollution how the flash over happens at abnormal conditions and what could be reasons for failures at working stresses.

During the climatic conditions or due to the area where the insulators are being used continuous fog or continuous mist which is on the insulator there could be there are reports over the mold growth over a period of time particularly cold places or cold countries or the places where the temperature are much below where this lines are being operated so there are contamination due to mole growth also.

And as mentioned above he brittle fracture again I am stressing this happens again the combination of reasons like where the fiber glass rod it could be because of the crimping issue during the manufacturing sage or during the operation the corona control rings or not properly designed or not properly placed the discharges which are coming out from the corona control rings continuously hitting the surface of the polymer insulator further beginning the insulation.

In case of the damage to the surface of the insulator the water or the moisture or the fog entering this junction over a period of this because the corona continuous corona there could be formation of nitric acid this nitric acid. This nitric acid again interaction with the rod could also both mechanical and electrical of us could see that there are failures reported for the brittleness or brittle fracture what it know.

So this has to be properly taken care and the maintenance as to be looked into for the fiber glass rod not to see that insulation on the surface eroded.

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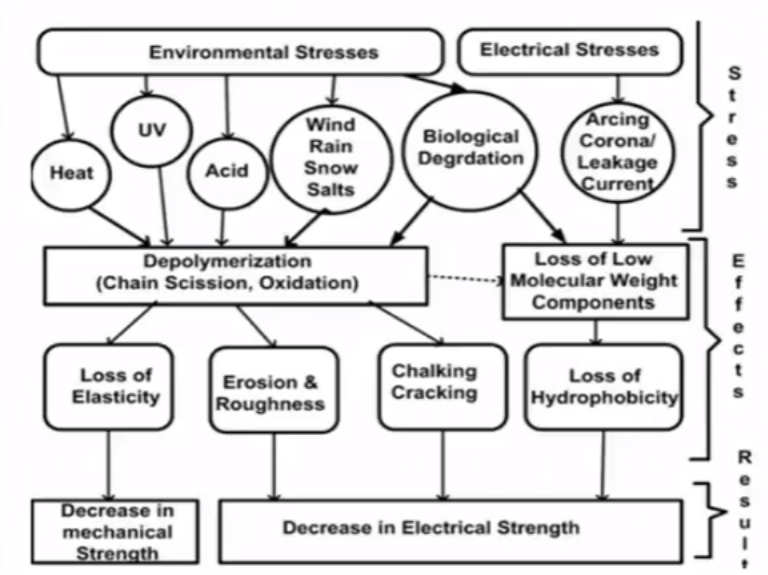

This gives the main information about how various stresses whatever we have discussed in detail about the polymer insulator or composite insulators being degraded how the failure could happen. So you can see that the various stresses which are shown this stresses could be because of environmental issues or could be the electrical stresses.

So environmental issues as discussed environmental stresses could be because of the temperature where the climatic condition of that area where transmission system is in place it could be of various temperature the insulators have to perform during the temperature. Ultra violet again as again I mentioned ultra violet could be from the there is ultra violet radiation from the sun in case of very high temperature the sun radiation could make the surface insulator brittle over a period of time or the ultra violet radiation which are being generated because of the corona control rings.

Improper design or the placement of corona control rings are not proper position now or during the over a period of time due to wind and due to the mechanical issues the corona control rings could have been shifted. So this again causes the placement of corona control rings could be because in case of the surface of the corona control ring could create a continuous corona in the surface where UV from the corona also could be generated and it could be in the surface.

Similarly there are instances where the acid could be acid rain which particular areas phase about this acidic component from the rain where on the insulator surface could create a hardness. And apart from that there are several industries which could be of chemical or which could of other insulator where acetic components which are being a sprayed on the surface over a period of time could cause the degradation in the long run.

Then other environmental factor being the wind again wind brings in lot of dust lot of pollutants to the surface. So over the period this settle and this pollution or contaminant builds up the surface in case there are some damages. So this pollutants may enter into the surface and slowly the degradation could happen. So wind again it depends whether the insulator string is in the which part of the then if it is because of the sand even the sand sometimes contains very high salts.

This salts again contains are spread on the surface could damage then rain also will head in the flash over of the insulators it could again cause the surface to become wet if it is heavy rain there is the complicating factor where the sheds are could be bridge is a reason where the alternate sheds are being designed as mentioned earlier. So rain again could make the surface wet conduct and the flash over could happen.

Similarly snow, fog, mist are more series as this settle over the surface the contaminants are already existing and this monsoon if the rains has no mist or fog could cause the surface become wet making the surface conduct and higher leakage current and depending upon the surface conditions formation of the dry bands wet bands because of this uneven spread of contaminants.

So here again the surface could degrade because of the conditions apart from this condition there is also reports like biological degradation as mentioned earlier this could be because of the mold growth in colder countries or places where continuous temperature is very low and mist or continuous places where receives lot of rain. Here the mold growth over a period of time could cause the degradation on the surface.

So the consequence of this environmental stresses various environmental stresses it could be the temperature either it could be heat or very low temperature also in have a problem

environmental stresses ultra violet radiations could be from again the sun or the ultra violet radiation from the corona of the hardware or the corona control rings of the insulator string conductors it should be because of the acid rain composition or it could be because of the in industries which are nearby to the transmission system.

So these stresses could cause the de-polymerization there could be change in breakage of the bonding of the material and oxidation could happen. So this de-polymerization what we called further could lead to loss of elasticity that is rubber property of the rubber could become brittle or it could become stiff this could again this could again lead to the mechanical property where mechanical issues where there is decrease in mechanical aspects.

So further erosion or roughness so roughness again of the material or material pilling of from the surface because of the continuous discharges or damages. And the choking or cracking because of the stiffness this could lead to the decrease in electrical strength because the creep age which is being designed could come down because of this issues where the surface resistance offered is very low and the material is damaged could cause of the electrical controller decrease in electrical strength.

So further this are the environmental issues so pertaining to the electrical stresses so electrical stresses as mentioned we have arching again on the surface because of the formation of the dry or wet bands this as mentioned over the period of time or during the monsoon condition or during the early morning conditions where the fog or mist is on the subjected on the insulator surfaces snow, mist this among with the pollutant contaminant starts conducting the surface because of the non-uniformity of this coating or the pollutants collected.

And also due to the wind conditions the surface becomes conducting in some portion and some portion does not conduct so where this dry band or wet band formation happen on the surface and small arching or partial arch do happen and sometimes because of the corona has mentioned a hardware which is being used could be from the conductors it could because of the insulators corona control rings fixed to the insulators or the glams or the metallic end fittings which are fixed to the insulator.

These generate corona if it is not properly deigned or properly placed further during the surface conducts and the leakage current flow so this continuous leakage current flow could hit up the surface and the degradation of the surface would happen where the loss of low molecular weight components could be observed over the period of time and further to this phenomena over the period there could be loss of hydrophobicity.

So as mentioned class of hydrophobicity again in case the water repelling property of the polymer composite insulator is lost where further the pollutants or the surface conditions due to wet because of fog or snow could slowly try to see that the entire surface gets conducted or the volume of the insulator surface gets conducting and the degradation happens in the entire insulator start conducting in the flash over could also happen.

So these are some of the electrical effects which could happen over a period of time here further will decrease the electrical strength. So you see the electrical stresses various environmental electrical stresses here and what are the effects from these things are given here and effects and the final result.

When you see the final result it could be the decrease or the insulation strength coming down the flash over could happen or if the mechanically it could become unstable where the insulator strength can be because of brittle factor or because of the rubber become it could peel of form the insulator surface. So these are very important or regular maintenance or these are concerned particularly and the request lot of maintenance for the polymeric or composite insulators.

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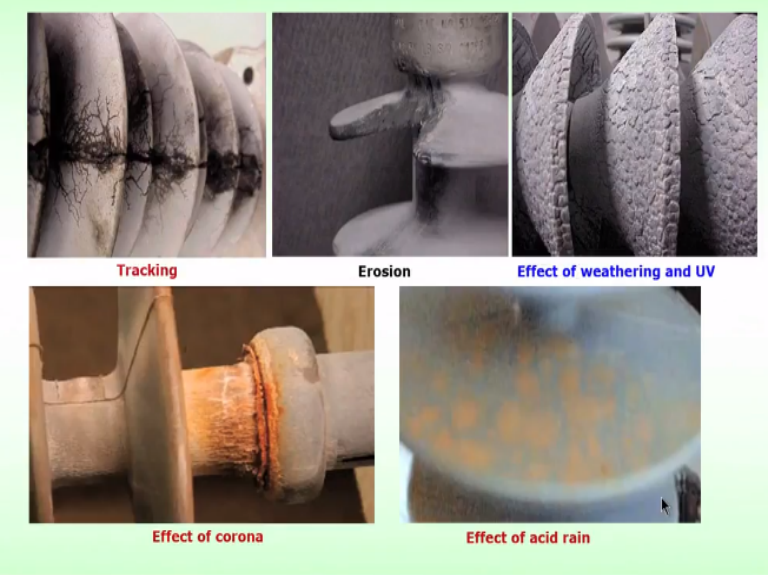

Some of the failures which have happen from the literature has been presented here these are not the present available information this could be over a period of time since the inception of this technology. So there are several failures or the problems which are being reported here it could be tracking you can see here the tracking of the insulator over the period of time this could be because of the continuous surface degradation where the electric arc or the current gets conducting and the flash over happening over the surface.

So this leads to the failure of the entire string and replacement is the second being the erosion you can see the material peeling of over a period of time this could happen because of several reasons as this could be the environmental issues it could be continuous failures because if the material becoming harder of the entire material is been peeled. So this surface erosion could happen because of reasons whether brings down the entire creep age distance then the flash over happens.

Then effect of weathering conditions again weathering conditions could be because of the sun because of the ultra violet radiation or because of the exposer to the corona control in over a period of time. You can see that the surface becoming stiffness the coming brittle and the entire surface becoming hydrophilic where it will be able to conduct and failure happens. This gives the effect of corona over the period of time you can see the metallic junction to the fiber glass rod.

So this is a very critical thing where it has to be taken care once there are micro structure damages as I mentioned so water or moisture or the mist or fog seeping in could only to the brittle fracture the corrosion happening near the metal and fitting is not healthy. So it has to be properly seen that coating of the metallic end fittings are done and it is been properly protected.

Similarly as discussed effect of acid as acid rain or the acidic components which are spread from the factories nearby to the transmission system could again lead to surface degradation over the period and this could damage the insulator in the fail.

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There are several again failures which were reported earlier it could be because of the hydrophobicity loss accumulation of dust the accumulation of dirt mold or because of it becomes dirt over a period of time. Similarly you have lost of hydrophobicity the sheds being mechanically weather where this shows again the hydrophilic nature where the water drop lets starts accumulating over the surface.

So this type of failures where noticed earlier in the stages now lot of technologies happening improvement the material aspect and also the manufacturing processes.

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So here you see the corrosion of end fittings this could lead to the failures of the post insulators or the suspension type of insulators. Similarly the de-bonding of the sheds so this again if it is not properly taken care during the manufacturing period this de-bonding of the sheds could lead to the failures to the period of time. So special case has to be looked taken into considerations there are failures in some of the countries where due to the gun shots where the failures happen to the fiber glass or the post insulators where it is damaged by the bullets it is spread.

Similarly as mentioned earlier you can see the small water or sorry air pockets which are during the manufacturing period. So this if it is left unnoticed over the electrical stress because of the environmental aspects these air pockets may damage or break this further lead to the water seepage or the moisture seepage inside could lead to the failures. So care has to be taken to see that no air pockets or the present air bubbles present on the surface of the insulators.

Similarly here there is a fiber glass rod exposure because over a period of time the pilling of material are taken place in both the places here. So this exposed due to the continuous stress or cracking or damage to the insulator surface.

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There are further reports about the hardware damages you can see here the corona control ring or end fitting which is fixed to the insulator surface degraded over the period and becomes highly corrosive and this leads to the failure of the insulators over the period of time. You can see again this failure of the corona ring due to the lightning surges or over a period of time in the service where failures have been noticed.

Again here there is a tracking or a surface erosion which is happened in both the cases this could results in the failure of the rod exposure.

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There are again failures due to several of this aspects because of the bird of because of the animals which have to be properly considered or to be taken care during the transportation or storage so here the insulators has you see many of the insulators surfaces are being chipped of either by bird or by rodents this cause the entire creep age to come down and the flash over or you cannot use the insulator for string use.

So be careful not only the manufacturing storage transportation also equal and protecting from the birds large animals is also causing concern to the utilities. So birds like chip the surface of the insulator but this could bring down the creep age and ultimate failures over the period of time. Similarly bird dropping this is again a very serious issue bird dropping on the insulator surface over a period time.

This is again the conductive fluid on the surface where the insulator starts conducting and the failure as been noticed because of bird droppings over a period of time or the bird droppings with the combination or the fog or mist could main surface conductive degrade over the surface. So several of this issue are also of series concern over the utilities in proper functioning of transmission network.

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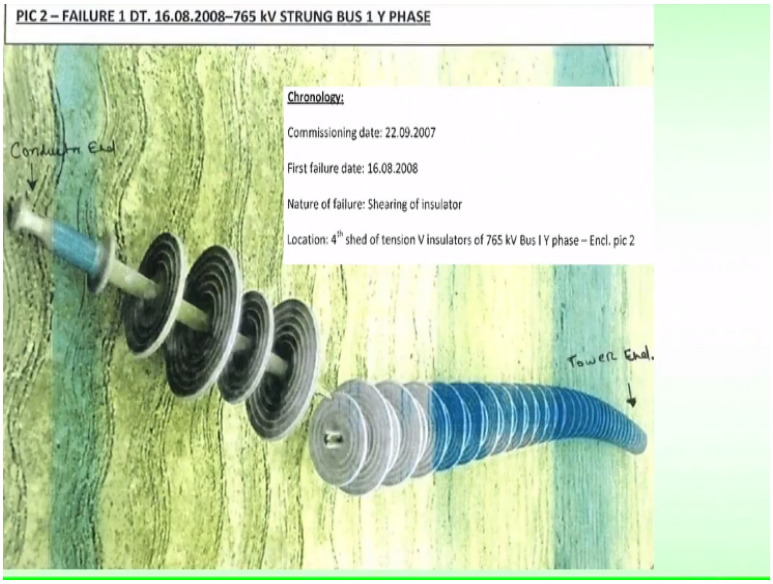

There are some failures even in the countries which are reported this could again would like to explain for the EHP insulators where the failures have happened at various junction you can see one of the failure is because of the brittle fractured happened after the fifth or fourth

shed here it has happened in the country. Similarly you can see the failure happened at the third insulation this is a polymeric insulator where it happened to the third insulator.

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So there are failures which have happened immediately after the stringing within a year or so this again is a very series concern so this was evaluated and this reason was due to the placement of the corona control ring the placement of the design of the corona control ring as I mentioned earlier is very important the corona discharges from the corona control rings over a period of time continuously which are impugning on the surfaces.

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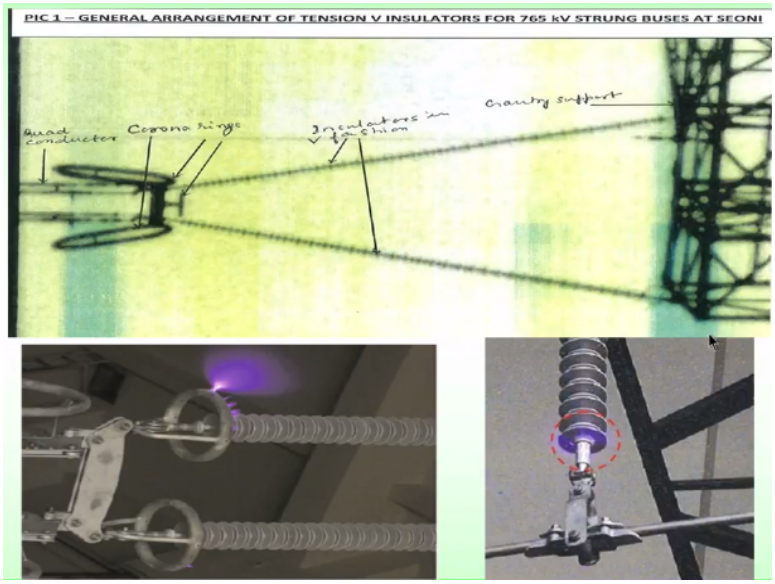

So this corona control ring causes the corona particularly at any instance and during the fore weather conditions this aggravate and where this entire insulation portion could damage the surface and as I mentioned in case of fiber class rod during the mechanical fixing of this end fittings if the micro structural damages are there this water seepage or the radiations because of this UV continuous corona could lead to the either the edition and where the line get detached.

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Comparison of features of Insulators

Insulator	Positive Attributes	Negative Attributes
Non Ceramic /Polymeric	Weight (60-90% reduction) Contamination withstand Low installed cost Impact strength Small profile/ Cost -? (1.5times - 1985-86 0.5times 1997-98)	Reduced strike distance Susceptible to aging Susceptible to arcing damage Brittle fracture possible Not easily inter changeable Limited Experience,Handling,Storing,Transporting Live line techniques to be developed
Porcelain/Ceramic	Performance quantified Long history of use	Weight Pin corrosion Post cascade failures Hidden defects "Fun" to shoot
RG Porcelain	Contamination withstand	Price Power loss
Glass	Spotting damaged units	Weight Attractive to vandals Negative perception - glass is fragile

So these are some of the practical failures which are being noticed in the field now coming to the comparison of the features of the insulators the comparison of all the three technologies non ceramic or the polymeric insulator the porcelain the glass and also the restive glazed coating of the ceramic or porcelain insulators. So this four when you compare you see the positive and both the negative advantages.

So in the positive we have better weight reduction that you can see around depending upon the voltage level the insulators string reduction comes down to 90% this is a very important for the utility people to work so the light weight it is very easy to string and advantages. So similarly there are advantages working with the pollution or a contaminated conditions. So the polymer insulators have better attributes in comparison to ceramic or the profile.

And as mentioned the low cost not the cost of the composite insulators is compared lower than ceramic or glass type of insulators and the profile the smaller profile comparison and it is

acetic in comparisons to the other technology. So some negative attributes reduced strike distance but this is again taken in to consideration in the technologies they are susceptible to again.

So as I said because of organic in nature the polymer or composite insulators or susceptible to aging degradation. Surface becoming brittle or surface becoming stiff hydrophobicity loss there could be fracture material becoming brittle fraction over a period of time so several of this attribute the lot of effects as been to see the material improvement aspects is being done.

And as technologies of not very old so limited experience particularly handling, storing and transportation. Apart from this life line technics have to be developed particularly for extra high voltage and ultrahigh voltage ranges. So where like ceramic or porcelain insulators that technology for live line washing or live line maintenance the tools the procedures have to be still developed.

So this is the one of the important aspects where people are trying to focus on this the porcelain or ceramic this performance is being quantified a long history of use more than 100 years the negative being the weight yes the comparison to the technology of polymer the weight is higher. Then pin corrosion failures are observed there are failures because of the post cascade failures. Some hidden efforts has been mentioned because of the ceramic insulators particularly the pin junction.

Because of the crack permission or the cement growth there are failures which could not be which cannot be absorbed by naked eye. And here again the places where vandalism both ceramic and glass insulator are there are failures or vandalism failures and lot of maintenance cost is filling to be considered at that places. So similarly there are improved version of resistive glaze the glaze resistive glaze coating on the porcelain they have also tried out particular to the contaminated or pollution conditions this have better performances compared to normal porcelain or the ceramic isolators.

But the question is the price for the coating and how long the coating exist and the loss of power because of the surface conditions. The several of factors again make to think for utilities to go type for the technologies. The glass as ceramic or porcelain it is better in comparison to see that spotted damages units could be easily known because of the transparence in nature.

Again it is similar to the ceramic or porcelain where the weight is one of the important criteria as the voltage level increase the number of insulator also increases the weight also increases the stringing is concerned particularly high altitude know to this area both porcelain and glass insulator stringing is a very difficult task. So this particular areas are attract to vandal so stone throwing and the gun shots could damage the bells of the insulators and being down the surface creep age of the string and failures.

So these are some of the comparison features of various technologies which are being adopted.

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So I put the slide it is a just to compare how people like to work in the area with the polymer insulator you can see the ceramic and polymer insulators. So the weight reduction is once of the criteria where people like to work in this area whereas stringing is very difficult in case of porcelain or the glass type of insulators. So look more esthetic in comparisons and lesser weight and maintenance could be of less when comparison to the ceramic or the porcelain glass insulators.

So with this we will end the glass I will be discussing about eh pollution or a contamination effect as I told you which is the series thread to the transmission insulators in the next class so thank you.