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Comparison of Breakdown Voltage of Ceramic and Non-Ceramic Insulator by the Effect of Different Levels of Salt Contamination

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Abstract: **This paper describes a comparison between a polymer and porcelain insulator subjected to salt polluted condition. Exposure test at laboratory was carried according to IEC 60507 out and flashover behavior of insulators at different contamination level was observed. The insulators were manufactured with same profile of the electrodes and had the same number of sheds to get result which were easy to compare. The influence of the different salt contamination level was observed for both porcelain and polymer insulator and a comparison was made between both insulators on the basis of the effect of similar type of salt contamination level for both insulators. Porcelain insulator surface is less hydrophobic as compared to polymer insulator surface.**

Keywords: **Porcelain insulator, Polymer insulator, Flashover voltage, Contamination level, Flashover characteristic.**

1. INTRODUCTION

The insulators exposed to coastal or marine environments, can become to be conductors due to the formation of a conductive layer on its surface. The insulators exposed to coastal or marine environments, can become to be conductors due to the formation of a conductive layer on its surface. This layer will be formed on account of the salted dew of the mornings in these zones close to the coasts. When dried with the heat produced in the same insulator or with the environment temperature, is going to deposit in the insulator the evaporated salt that had absorbed before. The particles placed in the insulators are not dangerous in dry weather but, the problem arises when the environmental weather is humid, rains, there is dew, fog then the layer can become conductor. The conductivity of this layer will depend on the kind of salt that form on it. The weather conditions vary considerably from the coastal areas to the interior areas and they play a very important role in the contaminants deposition rate and in the operation of the insulator. The problem of the pollution depends mainly on the environment. Also we must keep in mind the salt evaporated that is in the environment. By the action of the wind arrives at the insulators, being able to be placed in their surface. With the passage of time this layer will be thick enough to be dampened and to become conductor. The danger of the pollution will depend on the type of material and on the form of the surface. Also the sources of pollution must be investigated and the way of deposition of the pollution. The wind is the main bearer of the pollution, being others, the gravity and the electric fields. The pollution will depend also on the direction of the wind for a greater or smaller pollution of the insulators. The severity of the pollution in a location is quantified in terms of Equivalent Salt Deposit Density (ESDD) measure in units of NaCl mg/cm. This value of ESDD provides a base to do a classification of the severity of the pollution of the zone considered and will serve for knowing the value from which we have to do the maintenance of the insulator, that is to say to develop a politics of correct conservation. The marine pollution is located not only in the surrounding area of the coast, but also to considerable distances by the action of the wind.

In a power system, outdoor insulators play an important role in maintaining the reliability of the system. Ceramic insulators are widely used in power transmission and distribution lines since for a long time. In recent times, polymeric insulators are mostly preferred because of their superior insulation performance, in terms of contamination endurance compared with conventional ceramic insulators. When these insulators are installed near industrial, agricultural or coastal areas, airborne particles are deposited on these insulators and the pollution builds up gradually, which results in the flow of leakage current (LC) during wet weather conditions such as dew, fog or drizzle. The LC density is non-uniform over the insulator surface and in some areas sufficient heat is developed leading to the formation of dry bands. Voltage redistribution along the insulator causes high electric field intensity across dry bands leading to the formation of partial arcs. In the case of polymeric insulators, these partial arcs will lead to erosion and chemical Degradation of the insulating material. When the surface resistance is sufficiently low, these partial discharges will elongate along the insulator profile and may eventually cause insulator flashover. Inferring surface deterioration of polymeric insulators due to discharges is a complex process. Different approaches are used to quantify the pollution severity and in order to predict flashover and surface degradation of outdoor insulators. Here we use conventional Equivalent Salt Deposit Density (ESDD).In general silicone rubber material offers good hydrophobicity for a long time. The long term maintenance of the hydrophobicity is attributed due to its chemical stability and recovery phenomena resulting from diffusion of low molecular weight contents from bulk volume of the insulator to the surface of the material. Hydrophobic polymers are characterized by high electrical surface resistance which however decreases due to water absorption during aging and with increasing environmental temperature and contamination buildup. The phase angle between applied voltage and leakage current can be used as a measure of hydrophobicity (surface wetness), which will be a useful to diagnose the pollution severity and surface degradation of the insulator. For a given insulator, LC waveform evolution depends essentially on the changes occurring at the surface pollution layer and surface wetness of the insulator. Leakage current follows different patterns during the various stages involved in the development of flashover. We have analyzed the flashover voltage occurring at different salt contamination level at Impulse testing lab of JEC, Jabalpur and have compared the LC characteristics and aging of porcelain and polymeric insulator in salt fog tests. They have concluded that the time variations of cumulative charges and their component ratios were useful for estimating the conditions of ceramic and polymeric insulating surfaces. On this basis, the aim of the present work is to carry out laboratory experiments in order to understand the pollution severity of porcelain and silicone rubber insulator at different pollution levels.

2. EXPERIMENTAL SETUP

Fig.1 Image of disc type polymer and porcelain insulator

Fig.2 Image of Artificially Polluted polymer and porcelain insulator

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Fig.3 1.6 Million impulse voltage lab of JEC, Jabalpur where test at insulator under different level of contamination was performed

A standard 33KV porcelain insulator and polymer insulator was used for the analysis of different salt contamination level. Figure 1 shows the test insulator was suspended vertically inside the laboratory. The test voltage was 33 kVrms, 50 Hz. In the case of insulator, the high voltage was connected to the bottom pin and the metal fittings on the cap were connected to ground. Tests were conducted as per IEC 60507 Artifical pollution test on insulators. Before tests, the insulator surfaces were cleaned by washing with isopropyl alcohol and rinsing with distilled water, in order to remove any trace of dirt and grease. To reproduce saline pollution typical of coastal areas, a contamination layer consisting of particular quantity of NaCl and kaolin as specified in Table1 and Table 2 was mixed with deionized water and was applied to the surface of insulator as can be seen in Figure 2 showing artificially polluted porcelain and polymer insulator.

The concentration of NaCl salt was varied to give Equivalent Salt Deposit Density (ESDD) in mg/cm2 to 0.06 (lightly polluted), 0.08 (moderately polluted), 0.12 (heavily polluted) and 0.25 -0.60(very high pollution, which is not normally experienced in service) ESDD was taken according to IEC60507. In experimental setup relative humidity inside the laboratory was measured using the wall-mount Hygrothermal instrument. The research work was performed in 1.6 million volt impulse testing high voltage lab of JEC, Jabalpur Figure 3 showing the high voltage lab of JEC, Jabalpur. At different contamination level applied on insulators breakdown voltage was observed by applying different impulse voltage .Both the insulators having same quantity of ESDD was taken one by one by suspending insulator vertically with the help of support and connecting lower side of insulator to ground then impulse voltage was applied varying 33KV upto breakdown occur. Firstly porcelain insulator was considered and voltage was applied varying from 33KV in increasing steps 2KV each till breakdown occur the breakdown voltage so obtained was analyzed by DIAS(Digital Impulse Analyzing System) and the output of DIAS was connected to computer so that the output after testing so obtained can be stored for further analysis. Similar, process was performed for 33KV polymer insulator breakdown voltage was measured through DIAS (Digital impulse analyzing system) which was used in the present study and the waveform so obtained is stored in personal computer for further analysis. A DIAS system was used to visualize the waveforms. In this study, all the signals were captured and the data was stored in PC for further processing.

3. EXPERIMENT RESULT AND DISCUSSION

TABLE-1

FOR PORCELAIN INSULATOR

ESDD	Kaolin in gm	NaCl In gm	Distilled water in ml	Flashover Voltage
0.03	1.5	5	50	155
0.05	2.5	10	50	132
0.10	3.75	25	50	115
0.15	6.25	50	50	81
0.20	8.75	75	50	71
0.30	13.75	100	50	55

Table no. 1 show the result of breakdown voltage at different levels of salt contamination on porcelain insulator , table show the variation of voltage at different density of layer , and we can see that high density layer of coating give low breakdown voltage.

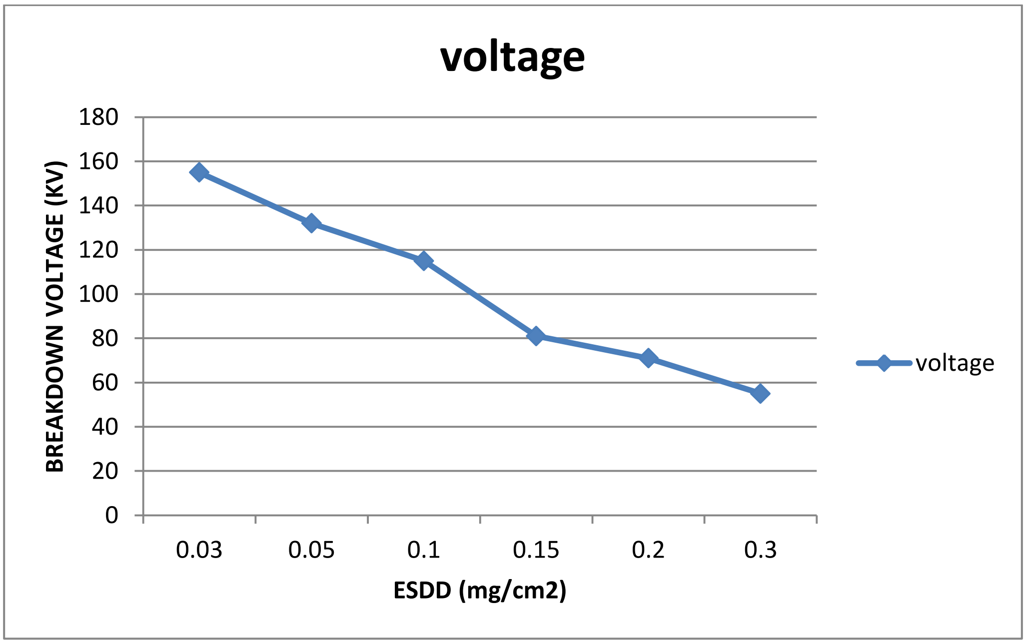

Fig.4 (a) Variation in Flashover Voltage w.r.t ESDD on Porcelain insulator

TABLE-2

FOR POLYMER INSULATOR

ESDD	Kaolin in gm	NaCl In gm	Distilled water in ml	Flashover Voltage
0.03	1.5	5	50	165
0.05	2.5	10	50	152
0.10	3.75	25	50	141
0.15	6.25	50	50	132
0.20	8.75	75	50	84
0.30	13.75	100	50	72

Table no. 2 show the result of breakdown voltage at different levels of salt contamination on polymer insulator , table show the variation of voltage at different density of layer , and we can see that high density layer of coating give low breakdown voltage

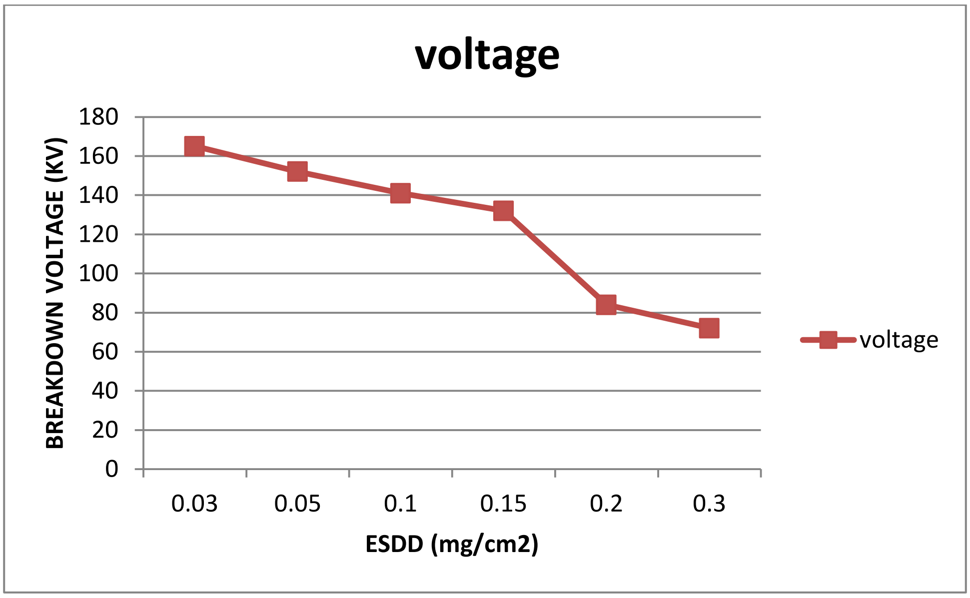

Fig.4 (b) Variation in Flashover Voltage w.r.t ESDD on Polymer insulator

Due to the different contamination layer the flashover voltage (leakage current) values differ, which are shown in the above tables.The insulators exposed to coastal or marine environments, can become to be conductors due to the formation of a conductive layer on its surface.The insulators exposed to coastal or marine environments, can become to be conductors due to the formation of a conductive layer on its surface. This layer will be formed on account of the salted dew of the mornings in these zones close to the coasts. When dried with the heat produced in the same insulator or with the environment temperature, is going to deposit in the insulator the evaporated salt that had absorbed before. The particles placed in the insulators are not dangerous in dry weather but, the problem arises when the environmental weather is humid, rains, there is dew, fog then the layer can become conductor. The conductivity of this layer will depend on the kind of salt that form on it. The weather conditions vary considerably from the coastal areas to the interior areas and they play a very important role in the contaminants deposition rate and in the operation of the insulator. The problem of the pollution depends mainly on the environment. Also we must keep in mind the salt evaporated that is in the environment. By the action of the wind arrives at the insulators, being able to be placed in their surface. With the passage of time this layer will be thick enough to be dampened and to become conductor. The danger of the pollution will depend on the type of material and on the form of the surfaces the sources of pollution must be investigated and the way of deposition of the pollution. The wind is the main bearer of the pollution, being others, the gravity and the electric fields. The pollution will depend also on the direction of the wind for a greater or smaller pollution of the insulators. The severity of the pollution in a location is quantified in terms of Equivalent Salt Deposit Density (ESDD) measure in units of NaCl mg/cm 2.

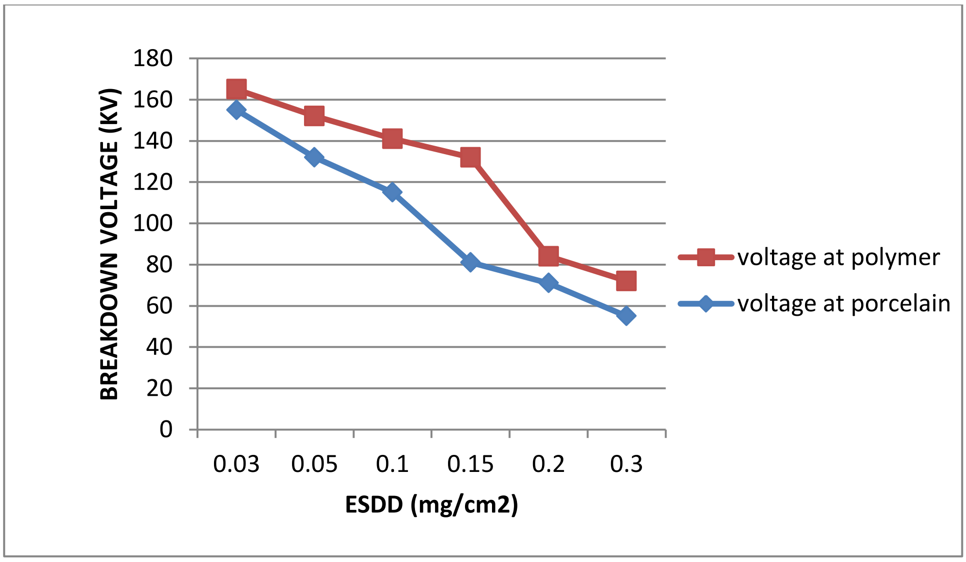

Fig.4 (c) Comparison of breakdown voltage w. r. t. ESDD on porcelain and polymer insulator.

This value of ESDD provides a base to do a classification of the severity of the pollution of the zone considered and will serve for knowing the value from which we have to do the maintenance of the insulator, that is to say to develop a politics of correct conservation. The marine pollution is located not only in the surrounding area of the coast, but also to considerable distances by the action of the wind. From the above fig 4(a) it is observed that flashover voltage of porcelain insulator decrease causing increase in leakage current with pollution level due to hydrophilic surface. Whereas in fig 4(b) in case of silicon rubber insulator flashover voltage Increases causing decrease in leakage current due to hydrophobic surface of polymer insulator. The combined effect of ESDD with respect to flashover of both porcelain and polymer is shown in fig 4(c). Thus from above graphs the variation of flashover voltage with different salt deposit density of porcelain and polymer insulator can easily be observed and both the insulators can be easily compared.

4. CONCLUSION

In this work, solid layer coastal region pollution seviourity experiments are conducted in laboratory is proposed to predict the pollution severity on the insulators. Results show that the characteristics of insulator depend on flashover voltage under different salt contamination level. The main objective of this paper is to predict the contamination flashover on the polluted insulator surface. Experimental results on porcelain and silicone rubber insulator are done to understand the pollution severity effect at different salt polluted condition on the insulators and to compare both the insulators. It was observed in the Impulse testing laboratory and variation of flashover voltage with different salt contamination level has been presented in this paper. Variations in flashover voltage with salt contamination level has been closely observed. Pollution performance studies on silicone rubber and porcelain insulator has been carried out at different pollution levels. According to obtained result it was observed that polymer insulator has high breakdown voltage at same level of salt contamination as compared to porcelain insulator .Applied voltage will be useful to predict the surface wetness, these preliminary lab results appear promising to predict the pollution severity of outdoor insulators at different salt contaminatination and comparison between both insulators will be helpful to predict which insulator to be useful to be used in salt contamination level.

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