

Analysis of Ceramic and Non-Ceramic Insulator Under Different Levels of Salt Contamination

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Abstract: Transmission and distribution power network use insulator between line conductor and support structure. Most of the insulator is mounting in open air applications. So gradually contamination is deposited on the surface of insulator and reduce the voltage withstand capacity of insulator. This hampers the reliable operation of power network. Hence condition monitoring of insulator is needed in order to maintain smooth and uninterrupted power supply. Leakage current helps in determining meaningful information about contamination and flashover capacity of insulator. Considering the above mentioned fact an experimental setup has been made in the laboratory according to IEC 60507 for artificial pollution test on high voltage insulator. The effect of different level of salt contamination on 33KV porcelain and polymer insulator is being observed.

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

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. Various approaches are used to quantify the pollution severity and in order to predict flashover and surface degradation of outdoor insulators. We consider here conventional Equivalent Salt Deposit Density (ESDD) method for analysis of insulator under different salt contamination. In general silicone rubber material offers good hydrophobicity for a long time as compared to porcelain insulator. 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. 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 Insulator in both field and salt fog tests. We 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 analysis in order to understand the salt contamination effect on porcelain and silicone rubber insulator at different pollution levels.

2. EXPERIMENTAL SETUP

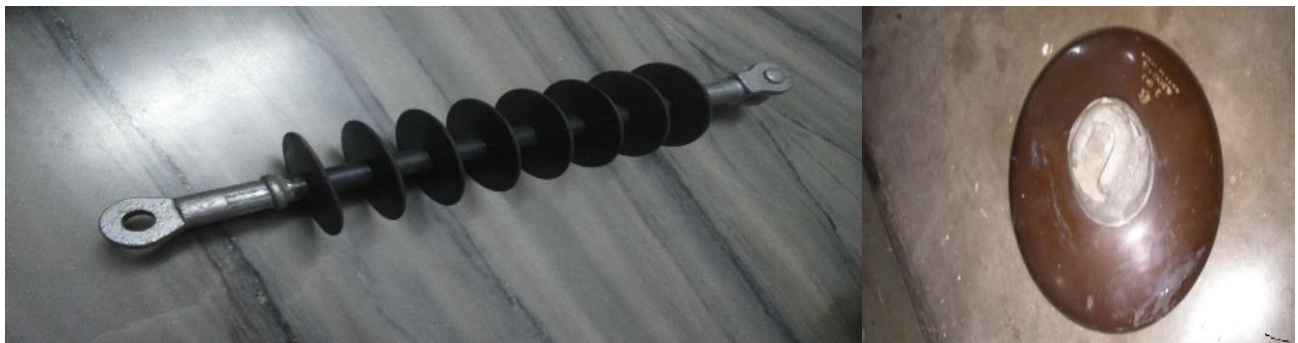


Fig.1 Image of disc type polymer and porcelain insulator



Fig 2 Image of Artificially Polluted polymer and porcelain insulator



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

A standard 33KV porcelain insulator and polymer insulator was used for the analysis of different salt contamination level. Figure 1 shows the test insulators that 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 Artificial 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 demonized 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).In experimental setup relative humidity inside the laboratory was measured using the wall-mount Hydrothermal instrument. Figure 3 shows 1.6 million volt impulse testing lab of JEC, Jabalpur where the test on insulator has been carried out. The test on polymer and porcelain insulator having same amount of levels of salt contamination the voltage was increased from 33KV up to breakdown occur and the waveform so obtain is analyzed in DIAS (Digital Impulse Analyzing System) which is connected to PC(Personal computer) for further analysis. At different contamination level impulse wave was applied across insulators and different breakdown voltage for different contamination level was observed.

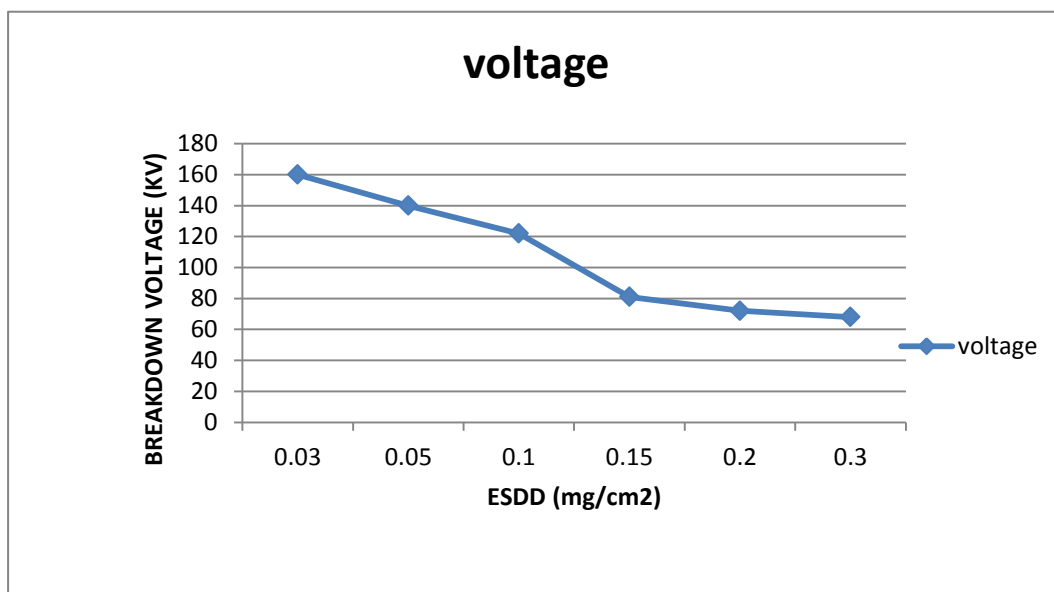
3. EXPERIMENT RESULT AND DISCUSSION

TABLE-1 FOR PORCELAIN INSULATOR

ESDD	Kaolin in gm	NaCl In gm	Distilled water in ml	Breakdown Voltage
0.03	1.5	5	50	160
0.05	2.5	10	50	140
0.10	3.75	25	50	122
0.15	6.25	50	50	81
0.20	8.75	75	50	72
0.30	13.75	100	50	68

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.

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. 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 so 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/cm².



Fig(a) Breakdown voltage vs ESDD at Porcelain insulator.

TABLE- 2 FOR POLYMER INSULATOR

ESDD	Kaolin in gm	NaCl In gm	Distilled water in ml	Breakdown Voltage
0.03	1.5	5	50	170
0.05	2.5	10	50	155
0.10	3.75	25	50	128
0.15	6.25	50	50	112
0.20	8.75	75	50	87
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.

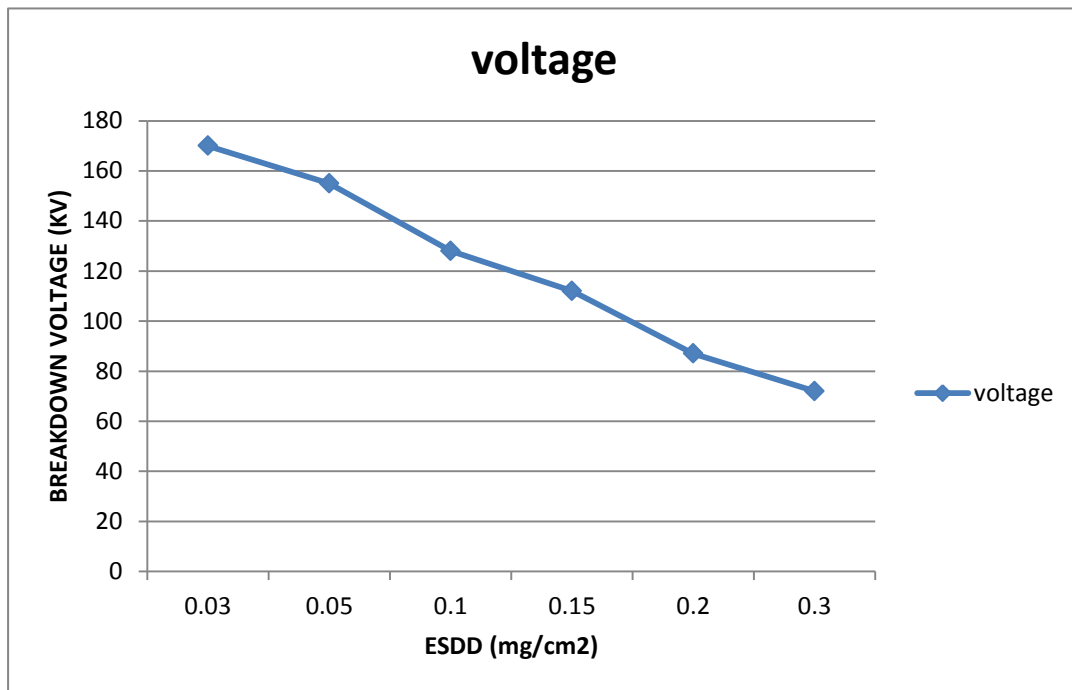


Fig (b). Breakdown voltage vs ESDD at Polymer insulator

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 nearby the coastal area by the action of the wind. From the above graph (a) it is observed that breakdown voltage of porcelain insulator decrease causing increase in leakage current with pollution level due to hydrophilic surface. Whereas in graph (b) in case of silicon rubber insulator breakdown voltage Increases causing decrease in leakage current due to hydrophobic surface of polymer insulator. Thus from above graphs the variation of breakdown voltage with different salt deposits density of porcelain and polymer insulator can easily be observed.

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. 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. Ppollution performance studies on silicone rubber and porcelain insulator has been carried out at different pollution levels. 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 contamination. They are subjected to conditions that depend on the place in which they are installed. These conditions can vary extensively from a place to another, depending on the characteristics of the region considered. These characteristics make possible that the level of insulation required can vary in a same line, due to the conditions of the pollution are different for all the line. The weather factors influence in a very important way on the growth of the pollution levels in a region. Usually the insulators show a significant change in their natural operation when they are exposed to severe environmental conditions. If, during the construction of an overhead electrical line, we do not keep in mind the pollution of the zone and we do not choose an adequate insulator, we will be obliged a greater maintenance work to prevent faults. This supposes an additional cost for the business.

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