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Electrical Characterization of Polymeric Insulators Using HVAC Tests

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Abstract: This paper presents experimental work conducted on polymeric insulators. The inclined plane test IEC-60587 method using to determine the characterization of polymeric (HTV Silicone rubber and silicone rubber) insulating materials. The constant voltage method used for testing. Testing under AC, positive DC and negative DC voltages are according to standard. The comparative performance of the two materials and the effect of different voltage application ware investigated. In Silicone rubber material showed more erosion comparable to the HTV silicone Rubber. Mass loss reduction is found by calculating the weight difference of samples before and after IPTET. After the experiment compare the mass loss reduction of both materials at different voltage level condition.

Keywords: HTV Silicone rubber, Silicone rubber, tracking, erosion, IEC 60587, Inclined plane test.

I. INTRODUCTION

The bulk of power delivery from generating plant to load centers is transported by overhead lines. The transmission line conductors not only have to be physically connected to the support structures, but also electrically isolated from the support structures. The insulator used to perform the dual function of support and electrical isolation. The most important factor that determines the physical dimensions of outdoor insulators is their performance under pollution conditions. Depending on the pollution severity and the wetting conditions of the site, outdoor insulators need to have sufficient surface leakage length to ensure that dry band formation and surface arcing is minimized. The ceramic insulators, made of porcelain and glass, show good performance and resist environmental aging. In addition to high mechanical strength, they provide excellent resistance to material degradation caused by electrical stress and discharge activities.

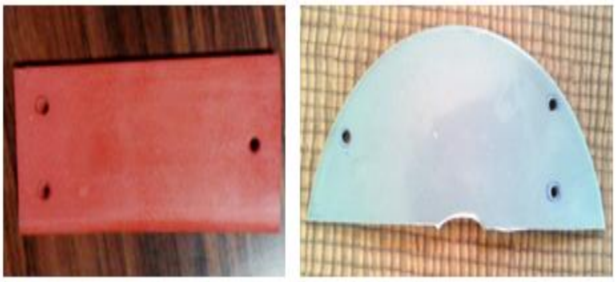
However, they suffer from having hydrophilic surface properties, which means that water can easily form a continuous conductive film along the cree-page path, thus allowing high surface leakage currents to flow on their wetted surfaces. Such currents cause dry bands at areas of high current density and lower wetting rates, which eventually cause surface arcing and frequently complete flashover of the insulator.

For this reason, various internationally standardized test methods have been developed in order to test polymeric insulator materials regarding their ability to resist a number of environmental aging and degradation factors. One of these test methods is the Inclined Plane Test (IPT) method outlined in the International IEC 60587 standard [1]. The standard test includes testing by AC voltage only and a similar test for DC voltage has not yet been standardized. Moreno and Gorur [2] performed inclined plane tests on polymeric housing materials, using the AC method and a modified apparatus to do DC tests.

Recently, polymer insulators have been introduced and widely used at distribution voltage levels due to their better pollution performance. Currently, insulators made of polymeric materials are often called composite insulators. Non-ceramic insulators, such as silicone rubber, offer several advantages over porcelain insulators. They have excellent hydrophobic surface propertiesunder wet conditions, this property helps to minimize the leakage current and the probability of dry band formation.

II. EXPERIMENTAL DETAILS

A. MATERIALS



(A) (B)
Figure 1 (A) HTV Silicone rubber (B) Silicone rubber

The silicone rubber sample of ATH-filled and HTV silicone rubber were used as test samples. Test samples of approximate dimensions 150 x 50 mm and 5 mm thickness. Equivalent AC, +DC and –DC voltage levels were applied as per IEC standard. [1].

B. INCLINED PLANE TEST

The incline plane test method IEC-60587 use for surface tracking analysis. A schematic circuit of the inclined plane test apparatus is shown in Figure 2. As the test is carried out at high voltages, the preferred test voltages are 2.5 kV, 3.5 kV and 4.5 kV [1]. The sample is mounted

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to a flat surface on the underside. The insulator samples mounted on a stand, which inclined at an angle of 45° with the test surface facing downward. The material surface is artificially polluted with a liquid contaminant consisting of NH_4Cl, and non-ionic wetting agent Triton X-100.

Figure 4 45° Inclined plane test

This contaminant has a (0.1 % ± 0.002 %) by the mass of NH4Cl (ammonium chloride) analytical quality, and (0.02% ± 0.002%) by mass of isooctylphenoxypolyethoxyethanol (a non-ionic wetting agent) in distilled or de-ionized water [1]. The contaminant flow rate is set according to the voltage level [1].

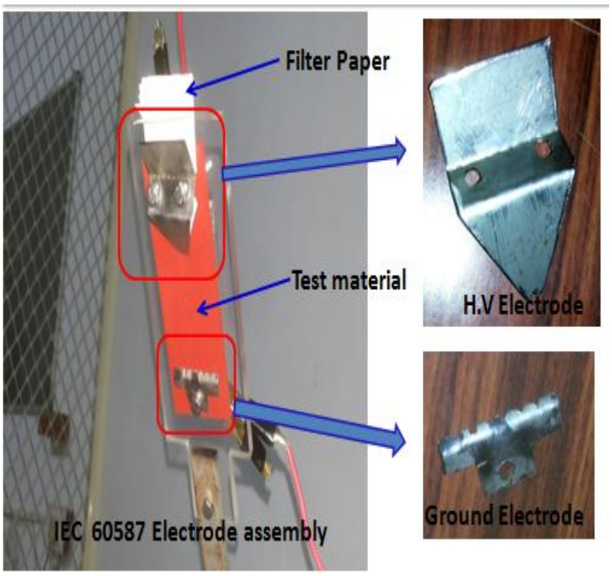

Figure 2 IEC 60587 electrode configuration

All electrodes, fixtures and assembly elements associated with the electrodes, such as screws, are made of stainless steel. The electrodes are made of one mm thick sheet of stainless steel. All the dimensions are as per IEC 60587 standard. The schematic of the electrodes are shown in Figures 2 Top electrode, in Figure shows the high voltage electrode. It has a quill hole in its nose for contaminant flow. The bottom electrode is called ground electrode. It is broader to arrest the contaminant flow from the top electrode. The high voltage electrodes for the inclined plane test were fabricated as per IEC standard 60587. The electrodes are carefully fabricated to avoid any sharp edges.

Figure 3 Mounting support

The present IEC standard specifies a mounting support for soft polymeric samples as shown in Figure 1. When using the IEC support we noticed that soft samples bent in the middle, and liquid solution dripped down to the water collecting tank before reaching the ground electrode [7]. The proposed support has two additional thin ribs for a better mechanical support, while at the same time still not affecting cooling of the samples by air, see Figure 3.

C. AC TEST

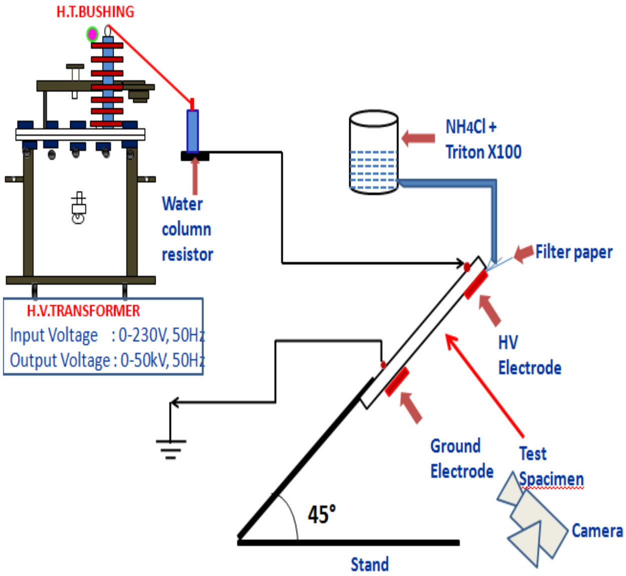

Figure 4 Schematic diagram of inclined plane AC test

The schematic diagram is given in figure1. A 230V / 50 KV step-up transformer is used to generate the required test voltage. As per standard two AC test methods use, the constant tracking voltage method and the stepwise tracking voltage method in this experiment the constant tracking voltage method was used for evaluation of material. A water column resistor is placed in series with the test sample in order to reduce current, which is used as a current limiting resistor.

The control panel is suitably designed keeping, all the necessary, safety points in view. The control panel has the provision to read A.C. Input and timer to study the withstand voltage test. The emergency push button switch has been provided in the control panel. This can be used at the time of any emergency, such as burning of rectifier, divider, or any fumes, etc. Coming out of the control panel or the transformer.

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Figure 6 Control panel

Figure 7 H.V. Transformer

It is a setup, oil cooled mobile transformer. It has primary winding as the low voltage winding and secondary as the high voltage winding. The high voltage end of the winding is brought out through the bushing and starting lead of the secondary winding is grounded firmly.

Specification:

- Input voltage :- 0 – 230V, 50Hz
- Output voltage :- 0 – 50KV, 50Hz
- Secondary current :- 50mA
- Type of cooling :- oil cooled.

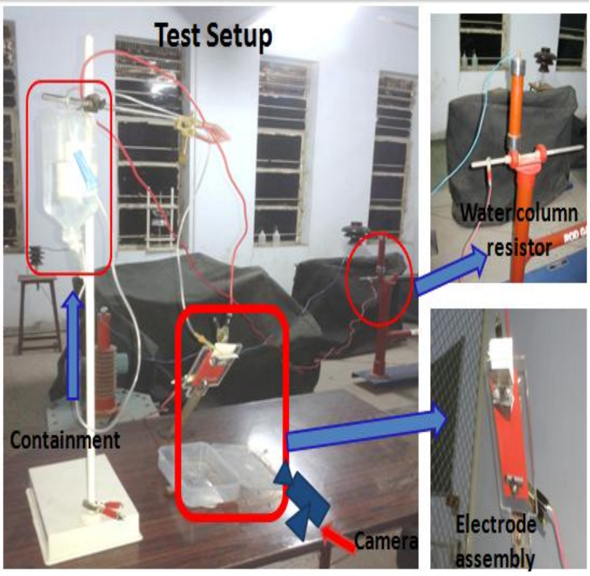

Figure 8 Actual Experimental setup

The actual experimental setup shown in figure 8. The contaminant was filled with medical bottle and flow rate is adjusted through medical needle Nobe. The supply gives to H.V electrode through a water column resistor which is shown in figure. The electrode assembly was mounted on inclined stand, and tracking process was recorded through video camera put in front of the test assembly.

III. RESULTS

All The arcing processes develop during a test which is observed by a video camera. In this figure we can show the effect of different voltage applied on the same material. The visual observation shows the lowest arcing during AC voltage application and maximum arcing during 4.5kV AC.

A. AC TEST

In the ac test 3.5 kV and 4.5 kV ware applied to the both sample silicone rubber and HTV silicone rubber. Discharge activity was noted on voltage application, shown in Table1. After approximately 45 minutes of energization, it was observed that 'track' marks were clearly visible in the sample. It is clearly seen in the figure that erosion under AC is less after 3 hours of voltage application. As shown in the figure 5 the HTV silicone rubber material developed only minor erosion during ac test. The silicone rubber material showed more erosion compare to the HTV silicone rubber.

HTV Silicone rubber

3.5 kV 4.5 kV

Silicone rubber

3.5 kV 4.5 kV

Figure 9 Visual appearance of sample at end of tests

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Table 1 Experiments carried out

Sample	Voltage (kV)	Flow rate	Time
HTV	3.5	0.30 ml/min	3 hr.
HTV	4.5	0.60 ml/min	1.5 hr.
SiR	3.5	0.30 ml/min	3 hr.
SiR	4.5	0.60 ml/min	3 hr.

Figures In mass loss measurement, we can analyze the effect of voltage level and voltage type on both insulating materials. So we can compare the both materials HTV silicone rubber and silicone rubber. After the measurement, we can show the mass loss in silicone rubber material is more comparable to the HTV silicone rubber. HTV silicone rubber has higher tracking and erosion resistance.

Table 2 Mass loss reduction

Sample	Voltage(kV)	Mass loss
HTV	3.5	NA
HTV	4.5	NA
SiR	3.5	0.0019
SiR	4.5	0.0389

IV. CONCLUSION

From the tracking and erosion test using HVAC, it is observed that in HTV silicone rubber no erosion occurred after applying voltage duration of 3 hours. But in silicone rubber material little erosion occurred. So we can say that the tracking and erosion resistance is good in HTV silicone rubber. After the mass loss measurement, we conclude that the mass loss reduction is higher in silicone rubber material.

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