A NOVEL TECHNIQUE OF INCLINED PLANE TRACKING AND EROSION TEST SUPER IMPOSED WITH UV RADIATION

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Abstract: This paper presents the result of experimental investigation carried out on Silicone rubber formulations with and without nano fillers. These formulations are evaluated employing Inclined plane tracking and erosion test as per IEC 60587 in addition to, UV irradiation stress on the sample. It is inferred that, inclusion of exposure to UV radiation in the IEC 60587 method aids in assessing the behaviour of silicone based formulations distinctly. Additives play a major role in the over all performance of a polymeric material than the base polymer itself. The intensity of UV radiation plays a dominant role in deteriorating the surface characteristics of the material. The performance of a polymeric material does not remain the same for different type of pollutants. The effect of nano Aluminium tri hydrate filler is found to reduce the leakage current only marginally, for the different filler percentages considered. A better performance could be achieved with inclusion of nano filler in reduced percentage. Incidentally, the inferences drawn appear to be useful to both CIGRE Working Group (WG D 1.14), presently active in standardisation of material aspect besides developing a testing methodology to assess polymeric material for outdoor insulation and also to International Electro technical Committee.

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1 INTRODUCTION

Polymeric materials, especially based on rubber and, Polydimethylsiloxane (SIR) are dominating among other housing materials such as ethylene-vinyl acetate (EVA) and ethylene-propylene-diene monomer (EPDM), for outdoor insulations. Although their usage is for over three decades, polymeric material standardisation is still being pursued by many Laboratories around the world.

Surface of the insulator housings are subjected to various stresses simultaneously in service including corona discharges from improper hardware design (metal end fittings and corona rings), missing corona rings, damaged or incorrectly installed corona rings, damaged end fittings or end fitting seal, split sheath due to weathering, carbonization of internal rod by internal discharges, improper design of insulator etc. The effect of corona discharges on polymeric materials are: oxidative cross-linking, formation of silanol hydroxyl groups which enhances oxygen content, release of ozone, UV emission, heat and formation of low molecular mass compounds [1,2,3,4,5].

By and large, the laboratory tests stipulated in IEC 60587 Standard simulates the conditions arising out of electrical discharges [6]. However, the effects of UV emissions caused by corona discharges are not taken into consideration. Literature survey also indicates that present IEC60587 standard needs up-gradation [7]. Even under ideal atmospheric conditions, the housing material is constantly exposed to UV radiations; nevertheless its presence exists during corona discharges. Evaluation of polymeric materials for a reliable future performance is still an elusive task. The intent of present investigation is an attempt to bring out evaluation considerations and its importance to ensure that the desired level of material performance is realized by the user

In the present investigation, the behaviour of SIR with different percentage of Aluminium Tri hydrate (ATH) is assessed using combined effect of UV and electrical discharges simulated as per IEC 60587. The performance of the SIR in presence of different pollutants is discussed. The effect of nano flame retardant additive in the base polymeric material, SIR is also brought out.

2 EXPERIMENTAL INVESTIGATION

Silicone rubber with Aluminium Tri Hydrate in different amounts, 80% to 120% in steps of 10% of base polymer SIR is evaluated employing inclined plane tracking and erosion test (IPTET) combined with UV irradiation stress. During IPTET a constant voltage of 4.5kV with 0.6ml/min rate of flow of contaminant is maintained throughout the test duration of six hours. The UV source is located at a distance of 0.14m from the centre of the sample mounted for IPTET so that, an irradiance of 72W/m^2 is imposed on the sample. UV meter,. Lutron make, UV-340 is used to arrive at the placement of the UV source. An UV lamp of OSRAM make, 300W is used as UV source in the present study. The lamp is designed to emit only UV ‘A’ radiations greater than 300nm wavelength as contained in the sunlight.

Further, the study is carried out using three types of pollutants namely Fly ash, coal dust and Hydrocarbon, generally seen near the thermal power stations, brick kilns and burnt agricultural fields respectively. SIR samples with different percentage of Aluminium Tri hydrate (ATH) are coated with these pollutants. The coating solution is prepared in one litre of distilled water with 40 grams of pollutant (fly-ash/ coal dust) to achieve a conductivity of 40 mS/cm. The sooth of Hydrocarbon is made to deposit on the sample by burning acetylene gas with a small amount of oxygen. The samples coated with these pollutants are subjected to IPTET+UV. Their performance is assessed on the basis of leakage current and resistance to tracking & erosion.

Some experiments are carried out to study the effect of nano fillers (ATH) in SIR. Four different formulations with same nano filler are evaluated with two different percentages of filler contents (50%, 60%).

3 RESULTS AND DISCUSSION

This section presents, typical results of different material formulations enumerated as A, B, C, D & E. The specimens designated A to E are subjected to IPTET as per standard IEC60587; in addition to UV exposure of intensity 72W/m^2, to assess its resistance to tracking and erosion. Figure 1 presents the photograph of samples after under going IPTET+UV with ATH content depicted. The leakage current was monitored intermittently during the entire test duration of six hours with a voltage application of 4.5kV and contaminant flow rate of 0.6mL/min.

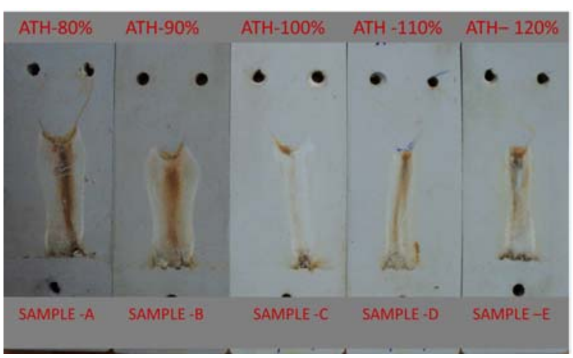

Figure 1: Photograph of samples A to E subjected to IPTET+UV

It is apparent from the above figure that, there is pronounced discolouration in samples with 80 % and 90% ATH. The least discolouration is seen in Sample C with 100% ATH. The discolouration is due to chemical reactions that have taken place on the surface during arcing in the presence of UV radiations. It is inferred that, quantity (percentage) of additive plays a significant role. However, the samples that underwent IPTET without UV showed lesser discolouration in comparison to the samples tested with IPTET+UV. There is no tracking but erosion is found to be slightly more in samples subjected to IPTET alone. This could be due to incomplete curing /polymerization which would have got completed during the tracking test, because of which the erosion could have been less in samples subjected to IPTET+UV. The depth of erosion is found to be more than 3mm for samples with 80%ATH subjected to IPTET alone. In samples B to E however, the depth of erosion is less than 0.5 mm

It is evident from the test results that the introduction of environmental stress (UV) seems to be more realistic and effective; in assessing the formulation distinctly for a completely cured /polymerized sample.

The variation in leakage current (LC) is observed to be within 35±10mA for all the samples subjected to IPTET and IPTET+UV. It appears that LC has to be monitored continuously to ascertain the maximum LC for IPTET and IPTET+UV tested samples.

Figure 2: Photograph of sample C with pollutants P1, P2, and P3

The sample C, subjected to IPTET+ UV exposure at irradiance 72W/m^2 with fly-ash (P1), hydrocarbon (P2) and coal dust (P3) pollutants exhibited varied behaviour. The deterioration in P1 appeared to be in the form of a filamentary track formation with slight carbonization along the tracked path. Discolouration noticed in P1 and surfacing of filler materials with slight pitting is observed in P3. Erosion is found to be slightly more in P3 in comparison to P1. The surfacing out of filler materials is more in P3 as compared to P1. Hence, it could be inferred that in the presence of fly ash, resistance of sample C is better. In sample C with P2, neither tracking nor erosion was observed. However, there is noticeable discolouration, in sample C -P2 when compared to sample C -P1 or sample C-P3.

Hence it can be inferred that a specific formulation does not perform identically when exposed to different types of pollutants. Thus in order to differentiate the different formulation's performance distinctly, it is necessary to have UV exposure combined during IPTET. A similar investigation conducted earlier revealed that the effect of UV at lower irradiance is predominant in the formulations considered [8]. Intuitively, it could be visualized that, higher irradiance dissipates more heat energy which gets either expelled in rapid evaporation of the contaminant during testing or in completing curing/polymerization process or both. Probably the entire heat energy at the higher irradiance does not totally get impinged on the sample, for it to cause erosion. However in case of lower irradiance, most of the heat energy from the radiation would have fallen on the sample to cause more erosion.

Typical results of samples N1 to N4 subjected to IPTET+UV with nano filler (ATH) are presented in Figure 3.

Figure 3: Photograph of samples with ATH nano filler subjected to IPTET+UV

In all the four formulations N1 to N4 with nano filler there is no tracking and erosion. However discolouration is noticed and these samples showed surface abrasion. The leakage current is noticed to flow, almost in the entire width of the sample. But the flow is narrower in case of samples A to E. The variation in over all leakage current (LC) is observed to be within 25±10mA for all the samples subjected to IPTET and IPTET+UV. It is inferred that, a similar or better performance could be achieved with nano filler present in a lesser percentage.

4 CONCLUSION

The formulation with equal amount of silicone and ATH is found to offer better resistance to tracking and erosion in comparison to other amounts of filler.

Leakage current needs to be monitored continuously.

Inclined plane tracking test combined with UV radiations aids in assessing distinctly, the behaviour of different artificially polluted polymeric materials.

The performance of a polymeric material does not remain the same for different type of pollutants.

Nano fillers in lesser quantity can achieve a better performance of a sample resulting in weight reduction of a final product.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

[1] R. J. Hollahan and L. G. Carlson, "Hydroxylation of polymethylsiloxane surfaces by oxidizing plasmas", Appl. Polymer Sci., Vol. 14, pp. 2499-2508, 1970.

[2] S. H. Kim, E. A. Cherney, R. Hackam and K. G. Rutherford, "Chemical changes at the surface of RTV silicone rubber coatings on insulators during dry-band arcing", IEEE Trans. Dielectr. Electr. Insul., Vol. 1, pp. 106-123, 1994.

[3] H. Hillborg and U. W. Gedde, "Hydrophobicity changes in silicone rubbers", IEEE Trans. Dielectr. Electr. Insul., Vol. 6, pp. 703-717, 1999.

[4] H. Hillborg, S. Karlsson and U. W. Gedde, "Characterisation of low molecular mass siloxanes extracted from crosslinked polydimethylsiloxanes exposed to corona discharges", Polymer, Vol. 42, pp. 8883-8889, Oct 2001.

[5] S. Kumagai and N. Yoshimura, "Hydrophobic transfer of RTV silicone rubber aged in single and multiple environmental stresses and the behaviour of LMW silicone fluid", IEEE Transactions on Power Delivery, Vol. 18, pp. 506-516,2003.

[6] Test Methods for Evaluating Resistance to Tracking and Erosion of Electrical Insulating Materials Used Under Severe Ambient Conditions, IEC 60587, 2007.

[7] Andrej Krivda, Lars E. Schmidt, Xavier Kornmann, Hossein Ghorbani, Ali Ghorbandaeipour and Maria Eriksson, " Inclined-Plane Tracking and Erosion Test According to the IEC 60587 Standard", IEEE Electrical Insulation Magazine, Vol. 25, No.6, pp.14-22, 2009.

[8] S.Ganga, N.Vasudev, V.Asai Thambi, R.Shivakumara Aradhya and A.Sudhindra "Impact Of Ultra Violet Radiation On An Artificially Polluted Silicone Rubber During Inclined Plane Tracking Test", Centenary Conference EE, IISC, Bangalore (under consideration)