

# A STUDY ON THE INVESTIGATION OF SURFACE TRACKING IN POLYESTER INSULATORS

Ayten Kuntman

Mukden Uğur

Ahmet Merev

*e-mail: akuntman@istanbul.edu.tr e-mail: mugur@istanbul.edu.tr e-mail: merev@istanbul.edu.tr*  
*Istanbul University, Faculty of Engineering, Department of Electrical & Electronics Engineering, 34850, Avcılar,  
Istanbul, Turkey*

*Key words: Electrical materials, insulator, surface tracking*

## ABSTRACT

**In this study, the effects of longitudinal compressive and tensile stress, ultraviolet (UV) radiation and wind pressure from different positions with respect to the surface of the sample under test have been investigated in detail with the ASTM D2303 Inclined Plane Tracking Test method. The structure and topography of surface tracking patterns generated on the surface of polyester resin have been examined using fractal dimension model.**

## I. INTRODUCTION

Since the introduction of electricity in 19<sup>th</sup> century, there has been a growing demand for electrical energy. Higher voltages led the researchers to develop new types of insulators. Many natural insulators, which were widely used at the beginning of this century have been replaced by ceramic or porcelain materials [1]. Many of these suffer from low impact strength, brittleness, inflexibility, cracking during the manufacturing process, etc. New polymeric materials are advantages in such cases [2 - 4]. Polyester resin mixed with other materials is becoming to be used throughout the electrical industry. However as with other polymeric insulating materials under abnormal long term stress conditions it suffers from several breakdown mechanisms such as treeing, surface tracking or erosion. Electrical aging of insulators is associated with a wide variety of phenomena such as breakdown, discharges, treeing, electron interactions with charges, phonons, matters, etc. Several test methods have been developed to examine the performance of polymeric materials, however usually they exhibit too many random factors associated with them, which reduce their reliability.

In this study, by using the ASTM D2303 Inclined Plane Tracking Test method the effects of longitudinal compressive and tensile stress, ultraviolet (UV) radiation and wind pressure from different positions with respect to the surface of the sample under test have been investigated in detail [5 - 8]. The structure and topography

of surface tracking patterns generated on the surface of polyester resin have been examined using fractal dimension model.

## II. EXPERIMENTAL

All samples have been prepared by using polyester resin without any accelerator. The test samples with the dimensions of 100 mm\*55 mm\*9 mm were mounted at 45° to the horizontal of the test set-up [9]. All experiments were performed at 4 kV applied voltage and 0.36 ml/h contaminant flow rate.

## III. MATHEMATICAL ANALYSIS

Fractals can be described as geometric shapes that repeat their structure on ever finer scales [9 - 11]. Theoretically fractal object are infinitesimally sub-divisible in this way; each sub-set; however small, containing no less detail than the complete set, basically fractal dimension measures result and discussions. Several methods for estimating the fractal dimension of complex surfaces have been proposed. This work was performed by using capacity, correlation and information dimension methods.

### CAPACITY DIMENSION

Capacity dimension is used to calculate the fractal dimension of complicated shapes [11]. The basic idea of the capacity dimension is to cover the trajectory with equal square boxes till not any part of the pattern remains uncovered. All the boxes containing a part of the pattern are counted. Capacity dimension ( $D_{cap}$ ) was calculated using the following equation,

$$D_{cap} = \lim_{\epsilon \rightarrow 0} \frac{\ln N(\epsilon)}{\ln (1/\epsilon)} \quad (1)$$

where  $N(\epsilon)$  is the number of boxes,  $\epsilon$  is the side length of the box.

## IV. RESULTS AND DISCUSSION

In previously works, the structure and topography of surface of polyester resin using the international standard

procedure (ASTM D2303 inclined- plane Tracking test) have been studied and three factors effecting the lifetime of a polyester insulator have been investigated. [12], and than tracking patterns of this samples have been analysed by using Cellular Neural Networks [13, 14].

In this study three alternative mathematical algorithms have been used to establish the fractal dimensions of the tracking patterns as a function of UV, mechanical and wind effect. Those three algorithms mentioned above are static methods, which analyse the structure of surface tracking patterns. For each condition three different fractal dimensions have been calculated.

The dependence of capacity, information, correlation dimensions for various environmental factors such as ultraviolet adiation, compressive stress, tensile stress, wind effect and tensile stress + wind effect has been shown in Figure 1.

As it is shown in this Figure, fractal dimension values of polyester insulator were shown that the highest values were observed in straight air circulation + tensile stress case while the lowest ones were from ideal case.

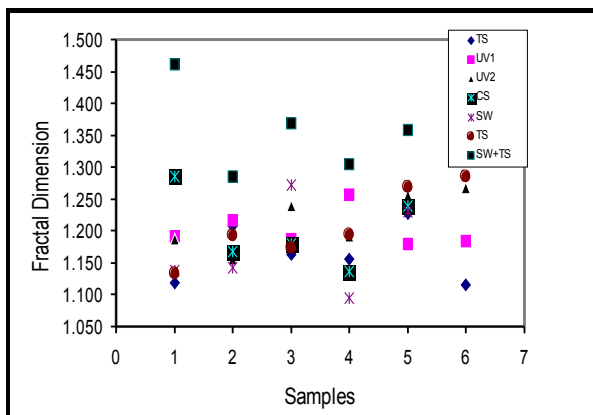


Figure 1. Change in capacity dimension due to the environmental conditions, RT: Room temperature, UV: ultraviolet radiation (1 Front side, 2 right side), CS: Compressive stress, SW: straight air circulation, TS: tensile stress, SW+TS: straight air circulation and tensile stress

## V. CONCLUSION

Fractal dimension method is intended to analyse the structure of surface tracking patterns in polyester outdoor insulator. In this study three alternative mathematical algorithms have been used to establish the fractal dimensions of the tracking patterns as a function of

environmental conditions. Results show that maximum distortion has been observed at straight air circulation and tensile stress. This results is found to be good agreement with experimental tracking initiation time.

## REFERENCES

1. B. Jubb, Current Overseas Practice with Transmission at 132 kV and Above, IEE Colloquium on a review of outdoor insulation materials, pp. 1.1-1.6, 1996.
2. A. Kuntman, T. Yilmaz, A. Güngör, B. M. Baysal, A New Polyimide Film for VLSI and its Electrical Characterization, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 5, pp. 296-300, 1998.
3. D. P. Augood, Dielectric Aging – Overview and Comment, Proceedings of 1978 IEEE International Symposium on EL, pp. 17-21, 1978.
4. H. R. Zeller, Breakdown and Prebreakdown Phenomena in Solid Dielectrics, Proceedings of 2<sup>nd</sup> International Conference on Conduction and breakdown in Solid Dielectrics, pp. 98-109, 1986.
5. Standard Test Methods for Liquid Contaminant, Inclined Plane Tracking and Erosion of Insulating Materials, ASTM D2303, pp. 258-270, 1983.
6. M. Kurtz, Comparison of Tracking Test Methods, Electrical Insulation, Vol. 6, No. 2, pp.76-81, 1971.
7. M. A. Sens, A. L. Tan, H. Gleizer, J. H. Mason, Factors Which Affect the Tracking resistance of polymeric insulating materials, EHV Tech, pp. 136-143, 1984.
8. J. F. Watson, J. H. Mason, A. C. Lynch, Assessing Materials for Use as Outdoor Insulation, ISH 3, pp.1-4, 1979.
9. ASTM D2303, Standard test method for liquid contaminant, inclined plane tracking and Erosion of Insulating Materials, Annual book of ASTM standards, Vol. 10.01, pp. 504-513, 1999.
10. K. Judd, A. I. Mees, Estimating Dimensions with confidence, IJBC, Vol. 1, No. 2, pp. 467-470, 1991.
11. B. B. Mandelbrot, The Fractal Geometry of nature, W. H. Freeman & Company, 1983.
12. M. Uğur, A. Kuntman, A. Merev, Investigation the Effect of Environmental Factors on the Performance of Polymeric Outdoor Insulation, Conference on Electrical Insulation and Dielectrics Phenomena, October 1999.
13. M. Uğur, O. N. Uçan, A. Kuntman, A. Özmen and A. Merev, Analysing the 2-D Surface Tracking Patterns by Using Cellular Neural Networks, Conference on Electrical Insulation and Dielectrics Phenomena, October 1999.
14. M. Uğur, B. R. Varlow, Analysing and Modelling the 2D surface tracking patterns of polymeric insulation

materials, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 5, No 6, pp. 824-828, 1998.