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Effect of UV-Rays and Salt Contamination on 33kV Silicon Composite Insulators

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Abstract: *Outdoor polymer insulators are exposing to different contaminated conditions and environmental factors like UV rays for a long time. These will degrade the insulator performance and decrease the life span. However, the surface of insulating material, such as silicone (Si) rubber will lost its hydrophobic nature due to these severe environmental conditions. Long term performance analysis of polymer insulators is essential to estimate the life expectancy. In this paper, experimental investigation is carried out on 33kV silicone composite insulators under salt contamination and UV ray's exposure. Insulator performance is analyzed by measuring leakage current and breakdown voltage for a certain interval of time up to 185days. Test results are compared between virgin insulators and contaminated insulators. Compared to virgin sample average leakage current is increased up to 77.19% for sample 1 and 71.79% for sample 2. Average breakdown voltage decreased to 45.61% for sample 1 and 41.66% for sample 2. These results help to estimate the life span of polymer insulator for long run.*

Keywords: *Polymer composite Insulator, UltraViolet(UV)rays, Salt pollution, Leakage Current(LC), Breakdown Voltage (BDV)*

I. Introduction

Outdoor polymer insulators are exposed to different electrical and mechanical stresses. In addition to these stresses, insulators will be operated in highly inconstant atmospheric conditions. Due to these environmental factors like UV irradiation and different pollution contaminations like salt, fog, urea and cement etc., degradation and aging of insulator takes place and results to flashover. Now a day's polymer material like silicone (Si) rubber is commonly used due to its hydrophobic nature [1]. This nature helps to increase breakdown strength of the insulator. Severe atmospheric conditions and several pollution contaminations result to loss of hydrophobicity.

Transmission lines near seashore will have severe salt pollution in the atmosphere. This pollution shows severe impact on insulator performance. To analyze this performance, laboratory tests like artificial salt fog test is standardized for porcelain insulators but for polymer insulators it is under considerations as per IEC 62217-2012 recent publication [5]. In addition to salt pollution, UV rays from sun will also degrade the insulator. Due to these severe atmospheric conditions life span of polymer insulators is becoming low. Hence, long term performance analysis is must to determine the life expectancy of polymer insulators.

Reference [1] has compared field exposure test results and laboratory test results. By using these comparisons, polymer insulator performance under salt contamination is evaluated. Xingliang Jiang [2] have studied and evaluated artificial contaminated flashover performance of glass and porcelain insulators. Artificial salt fog test was carried out [3] on both RTV coated ceramic insulator and HTV silicone rubber insulator. Test results are compared for both type of insulators and proved silicone rubber insulators are better than RTV coated ceramic insulator

In this paper, experimental investigation is carried out on 33kV silicone composite insulators under salt contamination and UV ray's exposure. Insulator performance is analyzed by measuring leakage current and breakdown voltage for a certain interval of time up to 185days. Test results are compared between virgin insulators and contaminated insulators.

II. Sample Preparation And Experimental Setup

A. Test Sample

Polymer insulators consist of three components. They are core, weather sheds and metal fittings [4]. Core is made of FRP rod sheathed with weather sheds and housing made of silicone (Si) rubber. End fittings are attached to core by crimping polymer (Si) composite insulator components are shown in fig1.Two insulators are used for experimental evaluation.

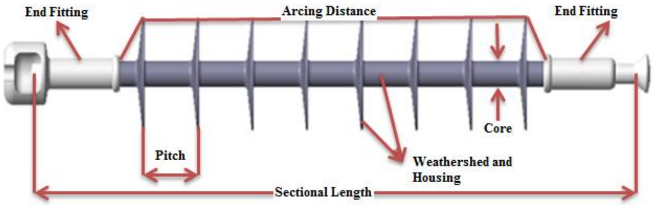

Fig.1 Polymer insulator [4]

Table-I Test Samples Dimensions

Insulator type	Polymer(Si) Composite Insulator
Sectional Length (mm)	510 $\pm$ 18.75
Dry Arcing Distance (mm)	380 $\pm$ 15.50
Creepage Distance (mm)	910 $\pm$ 28.75
Specific Creepage Distance(mm/kV)	25 $\pm$ 2.50
Core Diameter(mm)	21 $\pm$ 2.34
Pitch (mm)	45$\pm$ 3.30
Pollution Range	Medium

IEC 61109[4] is a standard for polymer suspension and tension insulator. Before the test arrangement, all virgin sample dimensions are measured to confirm with IEC 61109 standards. Dimensions are tabulated in table. I. Sample dimensions and their tolerance values are confirmed with IEC 61109. After measuring dimensions, all insulators are cleaned with de-mineralized water to remove dust.

B. Experimental Setup

After cleaning, test sample is arranged in suspension mode and energized as per the circuit diagram shown in fig.2.

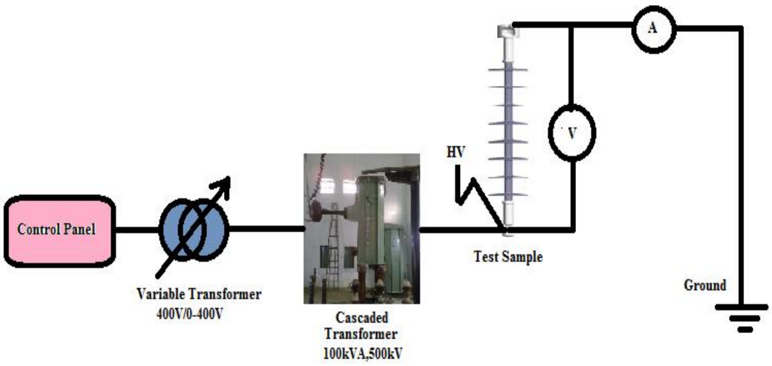

Fig.2 Experimental Setup

After making connections, power frequency voltage are applied to the sample in steps up to BDV is reached. At each step leakage current is measured and tabulated .Test results are given in table II.

Table-II Virgin Sample Test Results

S.No	***Applied Voltage (kV)***	***Sample1***	***Sample2***
		Leakage Current (µA)	***Leakage Current (µA)***
1	20	16.3	17.3
2	40	32.9	33.6
3	60	55.2	52.2
4	80	86.6	80.9
5	100	123.6	108.6
BDV (kV)		166	170

III. Samples Under Salt Contamination And UV Rays

To determine the long term performance of insulator under salt contamination and UV rays, virgin samples are continuously exposed to artificial salt pollution and artificial UV rays. Salt water is taken from sea and pollution is applied on insulator by spaying method as shown in fig.3.

Fig.3 Artificial Salt Contamination by spaying method

After spraying salt water, insulators are exposed to artificial UV rays by using UV lamps as shown in fig.4.

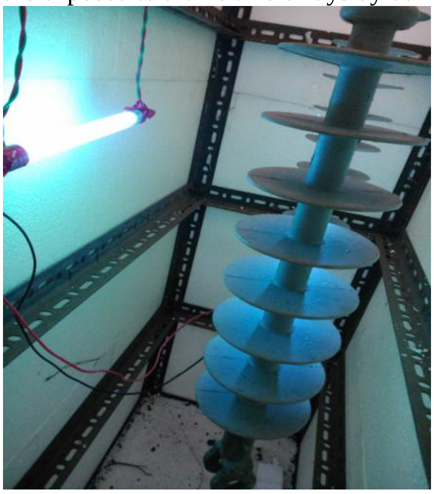

Fig.4 Insulators under UV Irradiation

The above procedure is repeated for everyday 24 hours. Leakage current and breakdown voltages are measured for certain intervals of time up to 185 days.

IV. Measurement of LC and BDV ON contaminated test samples

C. Sample1

After 15 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 5.14% and BDV decreased to 1.84%. LC results are shown in fig.5.

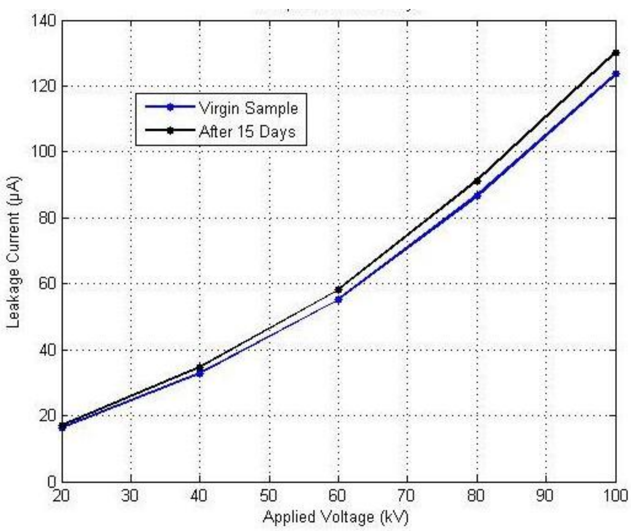

Fig.5 Sample-1 LC measurement after 15Days

After 30 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 7.97% and BDV decreased to 3.10%. LC results are shown in fig.6.

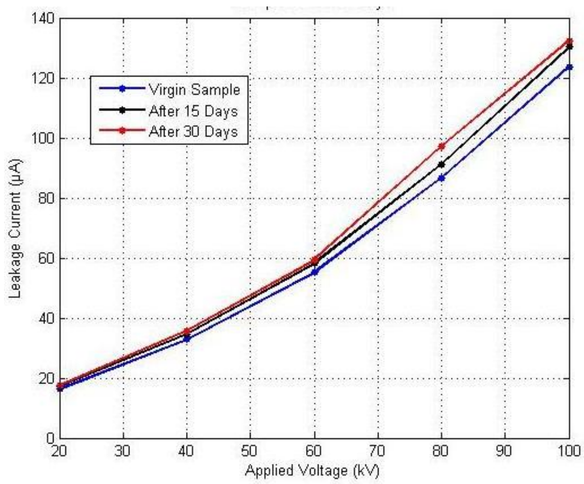

Fig.6 Sample-1 LC measurement after 30Days

After 45 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 10.95% and BDV decreased to 7.10%. LC results are shown in fig.7.

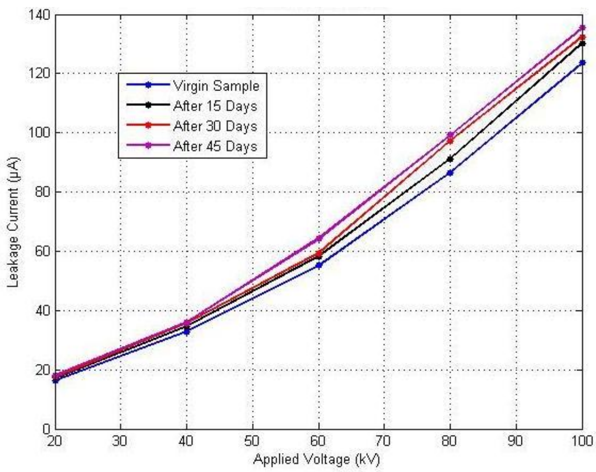

Fig.7 Sample-1 LC measurement after 45Days

After 60 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 16.41% and BDV decreased to 18.57%. LC results are shown in fig.8.

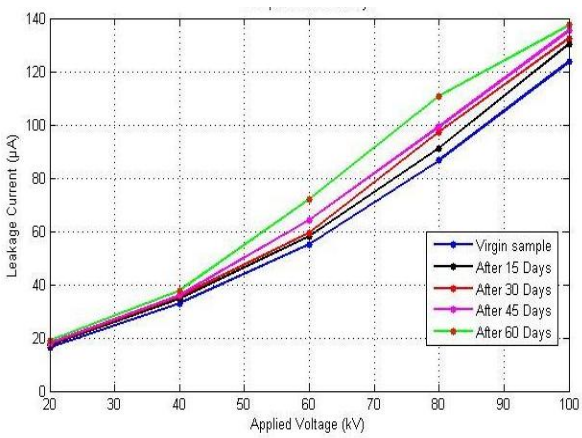

Fig.8 Sample-1 LC measurement after 60Days

After 75 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 23.39% and BDV decreased to 22.96%. LC results are shown in fig.9.

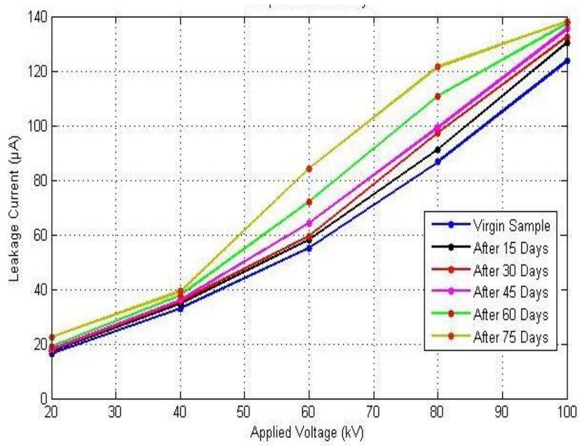

Fig.9 Sample-1 LC measurement after 75Days

After 105 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 48.27% and BDV decreased to 32.80%. LC results are shown in fig.10.

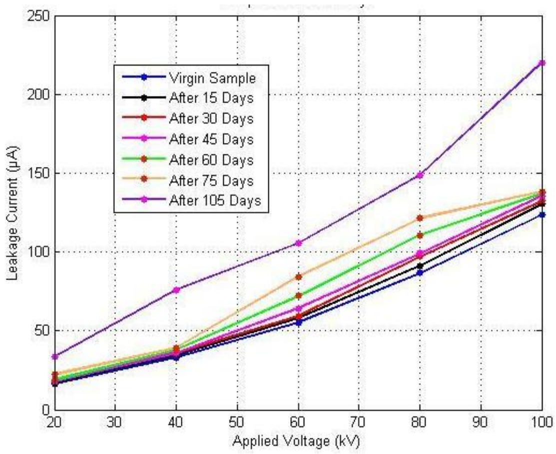

Fig.10 Sample-1 LC measurement after 105Days

After 135 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 72.65% and BDV decreased to 38.33%. LC results are shown in fig.11.

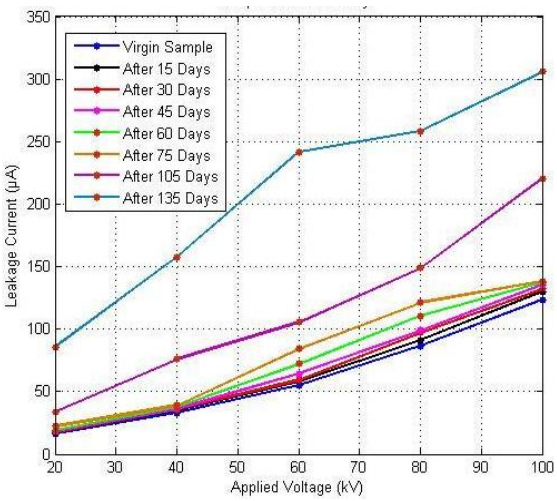

Fig.11 Sample-1 LC measurement after 135Days

After 150 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 73.99% and BDV decreased to 39.50%. LC results are shown in fig.12.

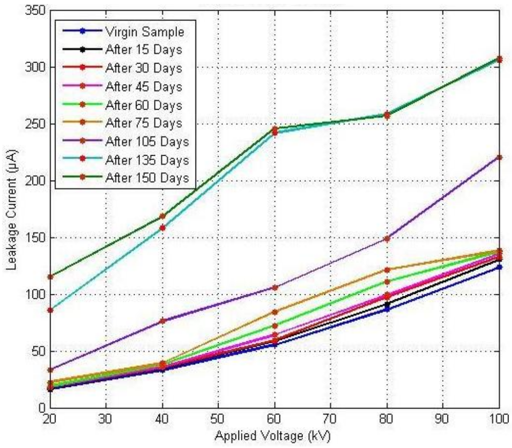

Fig.12 Sample-1 LC measurement after 150Days

After 165 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 74.67% and BDV decreased to 44.35%. LC results are shown in fig.13.

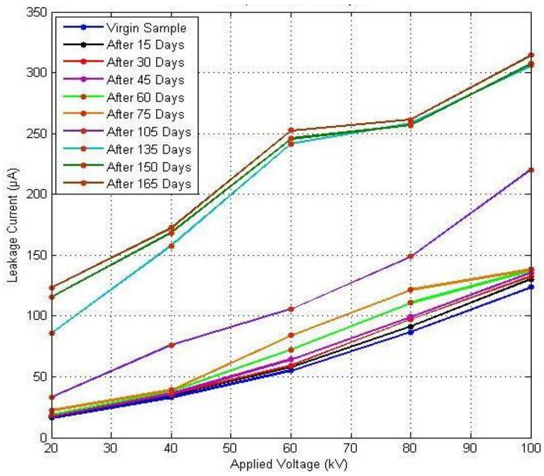

Fig.13 Sample-1 LC measurement after 165Days

After 185 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 77.19% and BDV decreased to 45.61%. LC results are shown in fig.14.

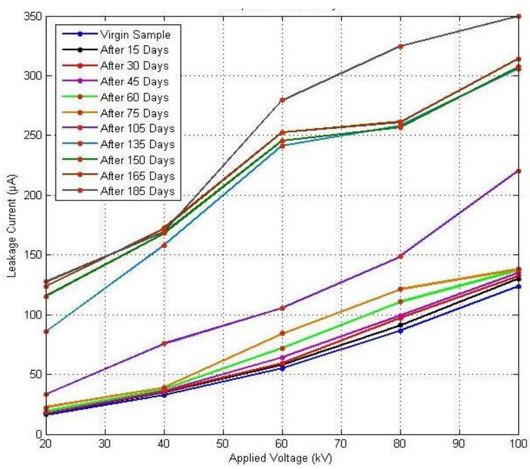

Fig.14 Sample-1 LC measurement after 185Days

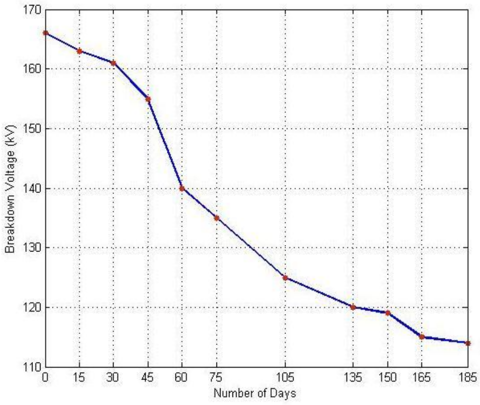

Fig.15 Sample-1 Number of Days Vs BDV

When the degree of pollution increases, breakdown strength of the test sample decreased as shown in fig.15.

D. Sample2:

After 15 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 5.67% and BDV decreased to 6.25%. LC results are shown in fig.16.

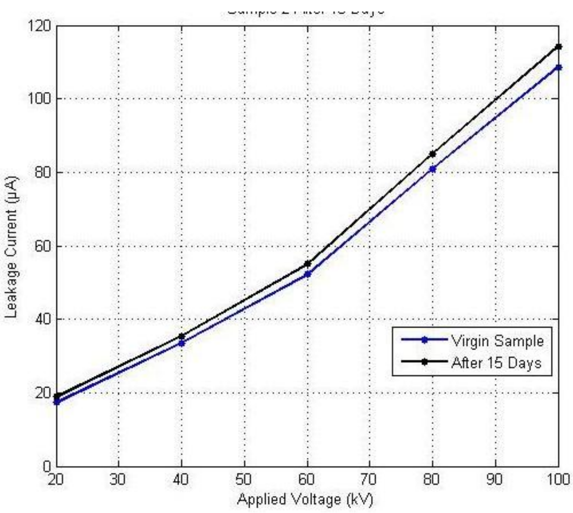

Fig.16 Sample-2 LC measurements after 15Days

After 30 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 7.97% and BDV decreased to 3.10%. LC results are shown in fig.17.

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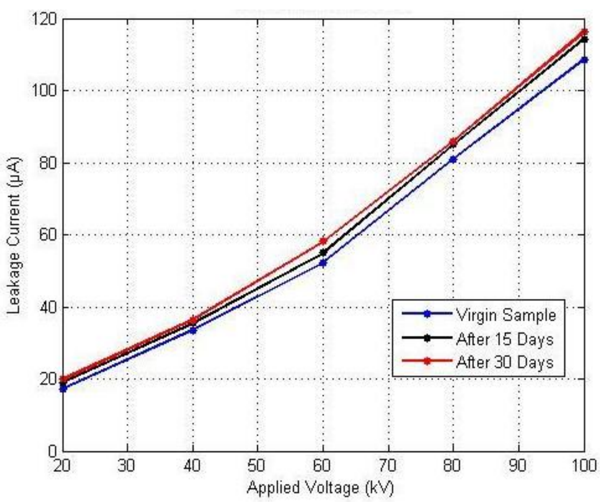

Fig.17 Sample-2 LC measurements after 30Days

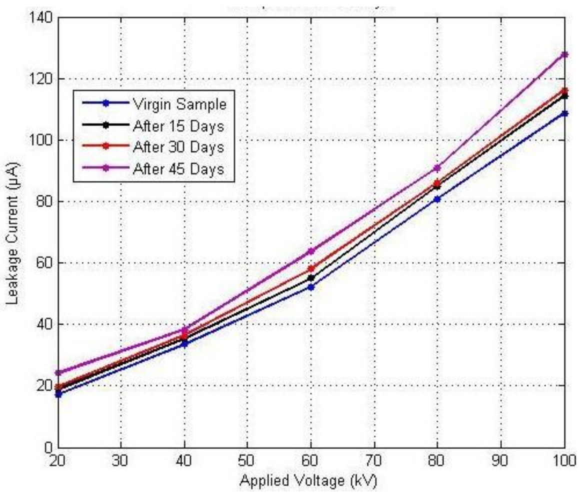

Fig.18 Sample-2 LC measurements after 45Days

After 45 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 16.94% and BDV decreased to 7.59%. LC results are shown in fig.18. Again after 60 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 38.44% and BDV decreased to 17.24%. LC results are shown in fig.19.

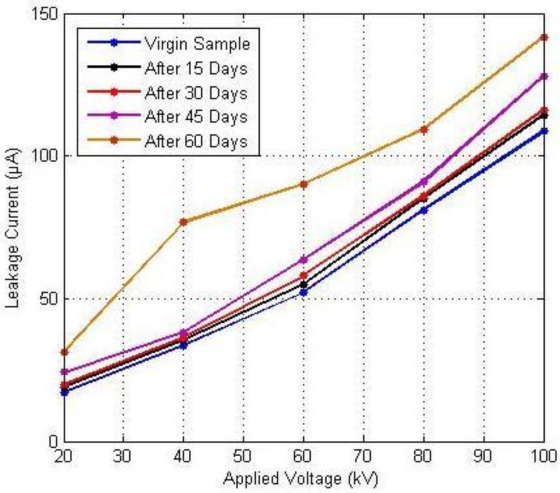

Fig.19 Sample-2 LC measurements after 60Days

After 75 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 53.69% and BDV decreased to 30.77%. LC results are shown in fig.20.

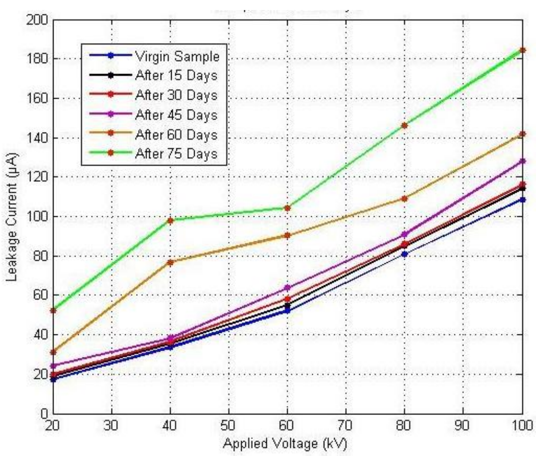

Fig.20 Sample-2 LC measurements after 75Days

After 105 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 62.53% and BDV decreased to 32.81%. LC results are shown in fig.21.

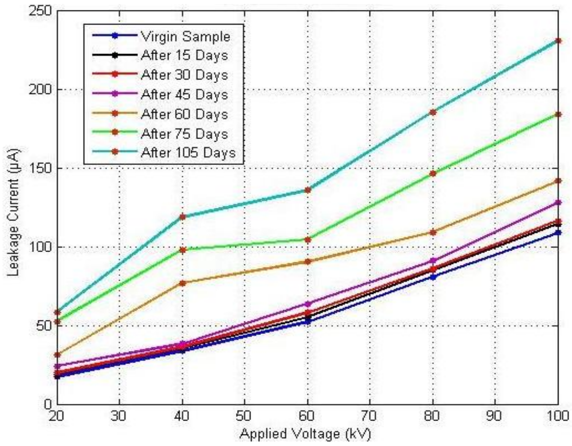

Fig.21 Sample-2 LC measurements after 105 Days

After 135 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 65.85% and BDV decreased to 36%. LC results are shown in fig.22.

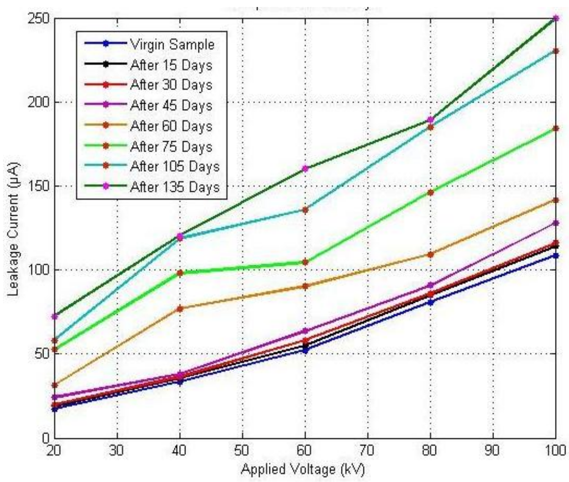

Fig.22 Sample-2 LC measurements after 135 Days

After 150 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 67.19% and BDV decreased to 39.34%. LC results are shown in fig.23.

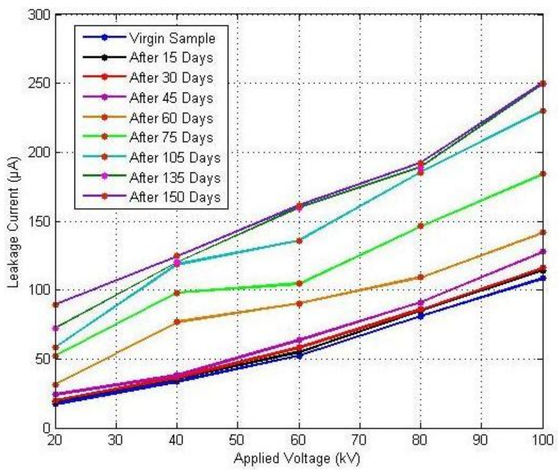

Fig.23 Sample-2 LC measurements after 150 Days

After 165 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 67.69% and BDV decreased to 40.49%. LC results are shown in fig.24.

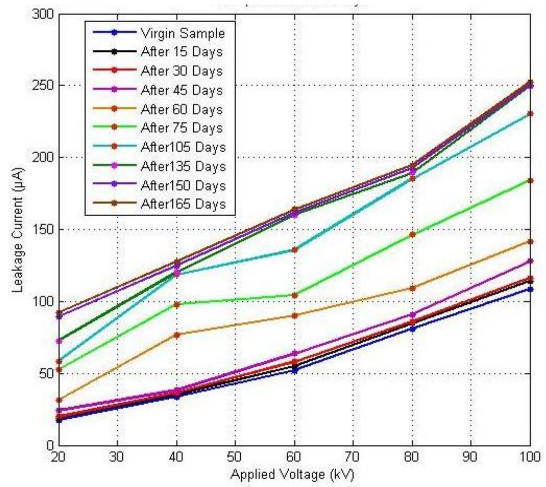

Fig.24 Sample-2 LC measurements after 165 Days

After 185 days of contamination, LC and BDV are measured. When compared to virgin sample results, average LC is increased to 71.79% and BDV decreased to 41.66%. LC results are shown in fig.25.

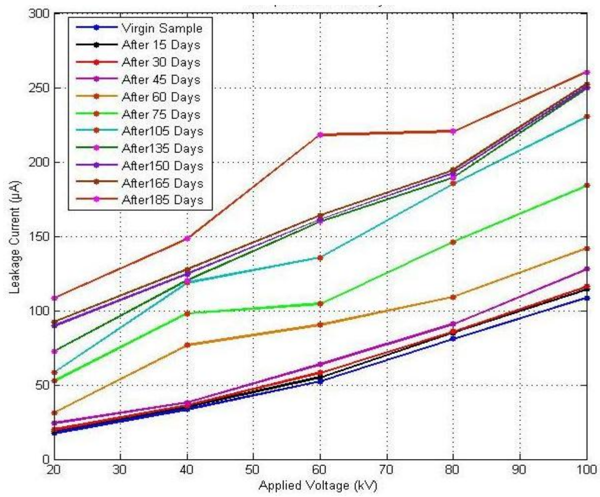

Fig.25 Sample-2 LC measurements after 185 Days

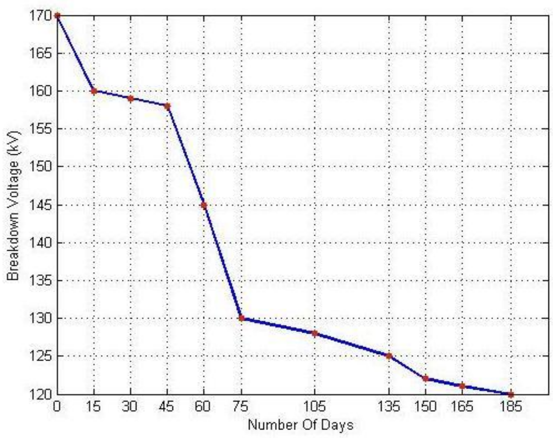

Fig.26 Sample-2 Number of days Vs BDV

When the degree of pollution increases, breakdown strength of the test sample decreased as shown in fig.26

V. Conclusion

Polymer insulator will expose to different variable atmospheric conditions. Due to these severe conditions degradation of insulator takes place and results to flashover. Polymer insulators will give better results under contaminated conditions but ageing occurs after a long period. Hence, long term performance analysis is must. In this paper long term performance analysis is carried out on 33kV polymer insulator under salt contamination and UV rays.LC and BDV are measured for regular intervals up to 185 days. Results proved that as the degree of contamination is high more will be the UV rays effect. Test results are compared between virgin insulators and contaminated insulators. Compared to virgin sample average leakage current is increased up to 77.19% for sample 1 and 71.79% for sample 2. Average breakdown voltage decreased to 45.61% for sample 1 and 41.66% for sample 2.

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