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Intelligent Dip Test Method for Performance Analysis of Polymeric Coating Material

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Abstract: Porcelain and glass insulators are coated with Room temperature vulcanizing (RTV) silicone rubber coating due to its excellent leakage current suppression characteristics to overcome the pollution problem. The reliability of leakage current on various samples of the glass plate sample is studied and reported. In this study, the withstand capability of RTV coated insulators for pollution were evolved, and based on the experimental results long term aging performance of different RTV coated insulators was evaluated.

Keywords: *Aging, Dip test, Pollution*

1.1 Introduction

In general, insulators that are used in the transmission system are of ceramic. In substation ceramic insulators are widely used as suspension and post insulators The life span of ceramic insulators is more and they canwithstand both tensile and compressive stresses. Insulators, even after they get polluted, will not pose any problem till it absorbs moisture from the ambient condition. Once it becomes wet, leakage current starts flowing which causes dry band formation. Most of the voltage appears across a dry band which in turn causes scintillations (Partial Discharge). These scintillations are dynamic in nature can appear simultaneously at a different location on the insulator surface. If the number of scintillations at a given instant, crosses critical number, pollution flashover occurs. This pollution flashover is a serious problem for EHV, UHV AC, HVDC and UHVDC transmission system. Because of this reason, it interrupts the continuous power supply. Many solutions are there for combating the pollutionflashover.

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One of the methods of eliminating thepollution flashover is coating the ceramic insulator with hydrophobic material i.e.., RTV (Room Temperature Vulcanized Rubber) coatings on the insula- tors. This RTV coating is basically a silicon rubber coating which has good hydrophobic property [1]. Even though, there are advantages of RTV coating, problems are also there in using same [2]. Aging of RTV is one of the serious problems with the material and it is hindering the use of RTV coating on the insulators. The main objective of this work is to analyze the aging properties of RTV coated ceramic insulator. Further there is an ambiguity in carrying out the aging test on RTV coated ceramic insulator. Ageing test of RTV coating is necessary to evaluate the life of RTV coated insulator. Earlier the aging test procedure of polymer insulator itself was considered for RTV coated insulator. Initially, 1000hrs aging test was introduced in which, insulator was subjected to continuous application of salt fog along with voltage. Many tests were carried out in the laboratory by researchers and there were few failures. It was thought that this is not enough for evaluating the aging of RTV coated insulator. Therefore, this was modified to 5000 hours of the aging test. In 5000 hours of aging test, samples are subjected to various ambient conditions of humidity, UV, fog and rain in a cyclic manner while the voltage is applied continuously. Presently, these aging tests have been taken off and rotating wheel test has beenintroduced. In the present study dip tests has been devised in line with Rotating Wheel Test which can be an alternate to Rotating Wheel Test. This test is the presently ageing test for both polymer and RTV coated insulator. Inthis paper the results for aging performance of RTV coated material are presented. Further, the results of the test carried out to evaluate the length of RTV coatings required for withstanding the pollution are discussed.

1.2 Details of experimental setup for Dip Test

Glass Plate is coated with different lengths of RTV coatings are evaluated by dip test. Figure 1.1 shows the glass plate samples coated with different lengths of RTV coating. The distance between the electrode is 50mm[3].

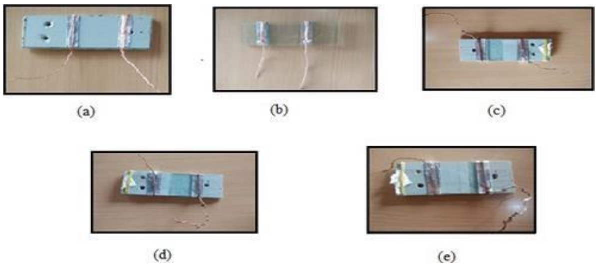

Fig 1.1 Glass Plate Test Samples used for Dip test (a) Full Length RTV Coated (b) Un- coated Glass plate (c) ½ Length RTV coated (d) 1/4th length RTV coated (e) 3/4th length RTV coated

The schematic diagram for carrying out the dip test is as shown in figure 1.2. A 230V supply is fed to 230/5KV, 1A transformer through a isolation trans- former. Voltage was measured using voltage divider circuit in series having a ratio of 1000:1 voltage. Current was measured by measuring the voltage across 1k resistance.

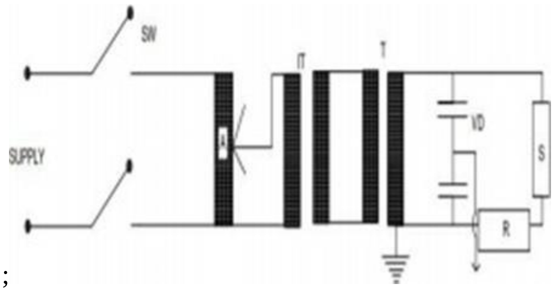

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Fig 1.2 Schematic diagram for Dip test

SW-switch,A-Auto Transformer IT-isolating Transformer, T-Transformer, S-sample, VD-voltagedivider, R-resistor

The ageing test in general accordance with IEC62730:2012, few modifications are considered toassess the performance of the RTV coated glass plate sample and also for 11kV insulator [4]. Each cycle inthis test has four positions as follows:

1. Dip Period
2. Drip Period
3. Energized Period
4. Cooling Period

1.2.1 DIP Test

A modified version of Rotating Wheel Dip Test has been used in this research work for the evaluation of RTV coated glass plate insulator [5]. In this test method samples are dipped for 40 sec and taken out for drip period of 40 sec. This is followed by voltage application of 40sec and cooling period of 40sec.

Fig 1.3 Experimental setup for Dip test

The experimental setup of Dip test (modified Rotating Wheel Dip Test) is as shown in figure 1.3 Five glass plate samples i.e. Uncoated, RTV fully coated, 3/4th RTV coated, 1/2 length RTV coated and 1/4th length RTV coated are considered for the test. A combination of two samples were subjected to testing. The test procedure is described in the following steps.

Step:1 Dip Period: Each combination of samples was initially dipped in salt solution in the test tank consisting of NaCl and water mixed at a salinity of 5g/L for 40seconds (The dip period was as per the requirement of rotating wheel test- IEC standard 61109/62217).

Step 2: Drip Period: Samples were placed for a drip period of 40 seconds.

Step 3: Energized period: A voltage of 2.5 kV was applied for 40 seconds. Step 4: Cooling period: Samples were allowed to cool for the next 40 seconds after application of voltage.

The same procedure was repeated for the next 50 cycles. The voltage across resistors and leakage current was measured to evaluate the leakage current.

1.2.1 Scintillation

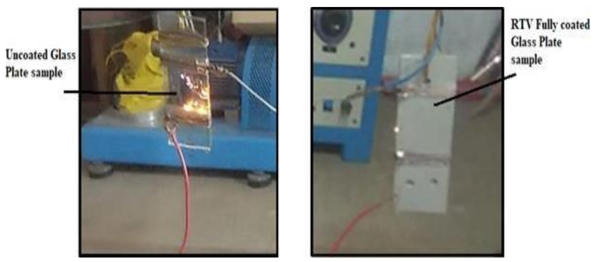

Fig 1.4 Scintillation

Test were carried out in a cyclic manner as described above. During the initial period of voltage application of 40 sec, scintillations were seen on the glass plate samples [6]. Figure 1.4 shows the scintillations on RTV coated glass plate samples.

1.3 Results Discussions

Results of the tests were conducted as per procedure described above for different combination of samples are given in the following section. When a voltage of 2.5kv is applied for 40 sec then leakage currents and voltages were monitored continuously on each glass plate sample [7].

Table 1.1 and figure 1.5 shows the leakage current measured on Full length RTV coated and Uncoated Glass plate sample during Dip test.

The same pattern of current was observed when Dip test is repeated on RTV fully coated and Uncoated Glass plate sample [8]. So, the leakage current values for different intervals of time are tabulated in Table 1.2 and Table 1.3 and shown in Figure 1.6 and Figure 1.7.

Table 1.1 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and Uncoated Glass Plate

Time (sec)	Uncoated Glass plate(mA)	Full length RTV coated GlassPlate(mA)
0	4.79	3.5
7	3.5	2.6
14	4.5	2.1
21	2.3	0.9
28	1.7	0.8
35	1	0.09

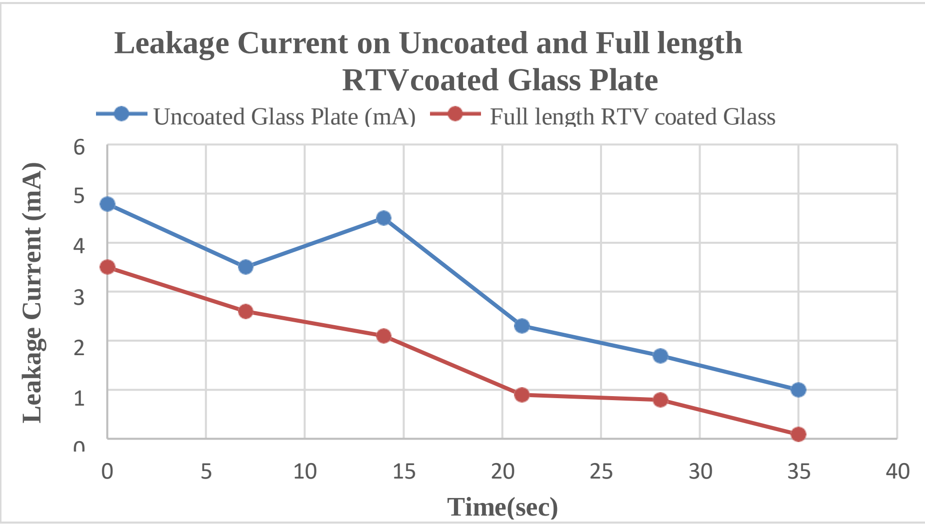

Fig. 1.5 Leakage current on Glass plate sample with RTV coating for full length and uncoated glass plate sample

Table 1.2 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and Uncoated Glass Plate

Time (sec)	Uncoated Glass plate(mA)	Full length RTV coated GlassPlate(mA)
0	11	5.5
7	5.2	5.1
14	1.2	0.7
21	1.1	0.2
28	0.1	0.07
35	0.008	0.06
42	0.005	0.01

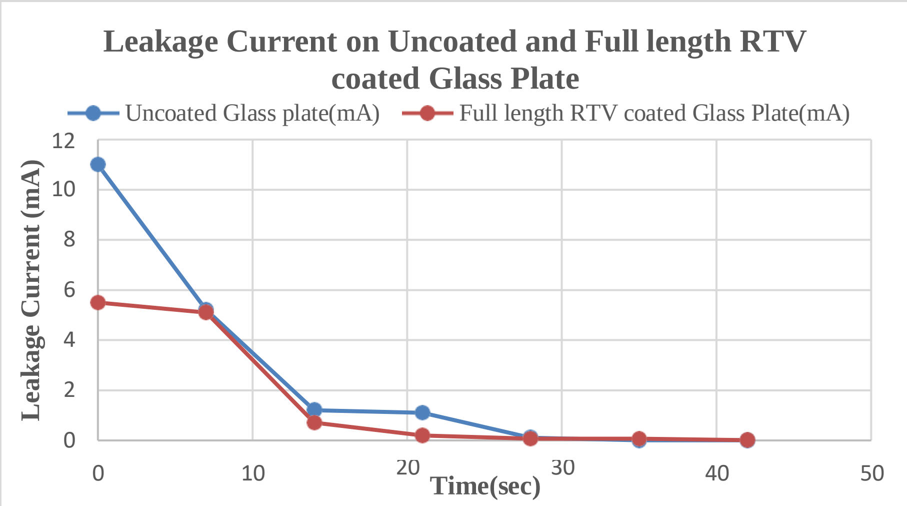

Fig. 1.6 Leakage current on Glass plate sample with RTV coating for full length and uncoated glass plate sample

Table 1.3 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and Uncoated Glass Plate

Time (sec)	Uncoated Glass plate(mA)	Full length RTV coated Glass Plate(mA)
0	9.6	3.3
7	6.41	2.7
14	9	1.2
21	0.117	0.003
28	0.427	0.026
35	0.138	0.0035
42	0.008	0.005
49	0.006	0.002

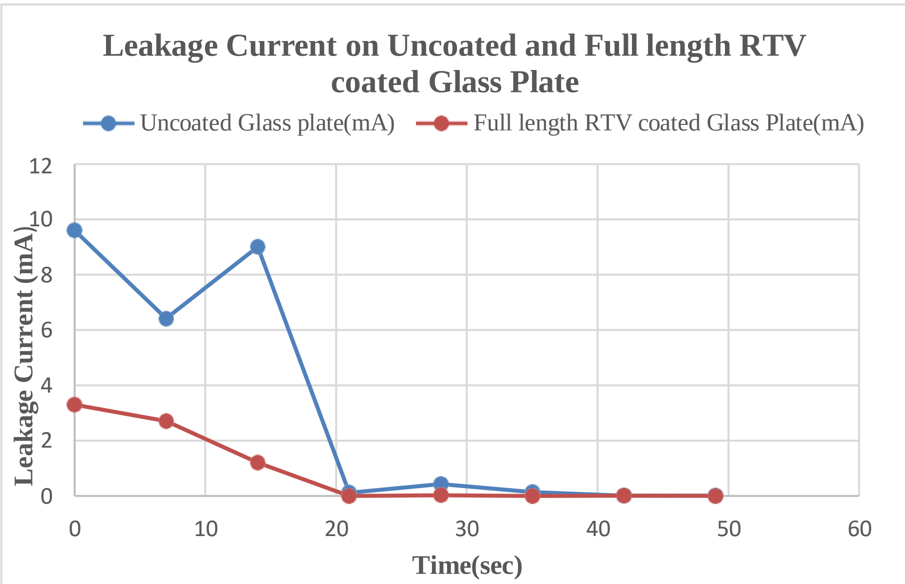

Fig 1.7 Leakage current on Glass plate sample with RTV coating for full length and uncoated glass plate sample

Hence it is observed that RTV fully coated glass plate sample carries less leakage current compare to uncoated glass plate sample. The repeated test on uncoated and fully coated glass plate shows that initial current during the dip test is high then the current reduces over a period of time however the current on fully coated glass plate is lesser than uncoated glass plate [9]. Further the test was also conducted on full length RTV coated and 3/4th length of RTV coated glass plate samples. Table 1.4 and figure 1.8 shows the leakage current measured for full length RTV coated and 3/4th length of RTV coated glass plate sample.

Table 1.4 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and 3/4th length of RTV coated Glass Plate

Time (sec)	Full length of RTV coated Glass plate (mA)	3/4th length RTV coated GlassPlate(mA)
0	17	12
7	4.77	3.2
14	3.5	2.1
21	3	1.8
28	2.1	1.6
35	1.8	1.2
42	1.5	1
49	1.2	0.05

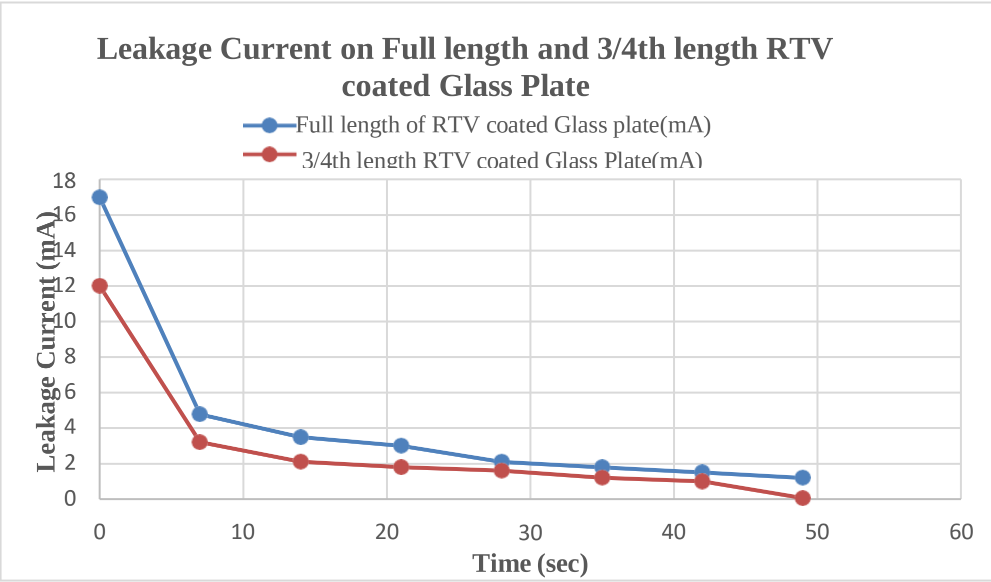

Fig 1.8 Leakage current on Glass plate sample with RTV coating for full length and 3/4th length coating

It can be seen that 3/4th RTV coated glass plate sample carries less leakage current compare to RTV fully coated glass plate sample. Further the test was conducted on full length RTV coated and ½ length RTV coated glass plate sample.

Table 1.5 and figure 1.9 shows the leakage current measured for full length RTV coated and 1/2 length of RTV coated glass plate sample.

Table 1.5 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and 1/2 length coated Glass Plate

Time (sec)	Full length RTV coated Glass plate (mA)	Half-length RTV coated Glass Plate(mA)
0	5.5	3.5

7	0.9	0.6
14	0.235	0.13
21	0.25	0.04
28	0.5	0.03
35	0.018	0.03
42	0.41	0.04
49	0.003	0.03
56	0.511	0.03

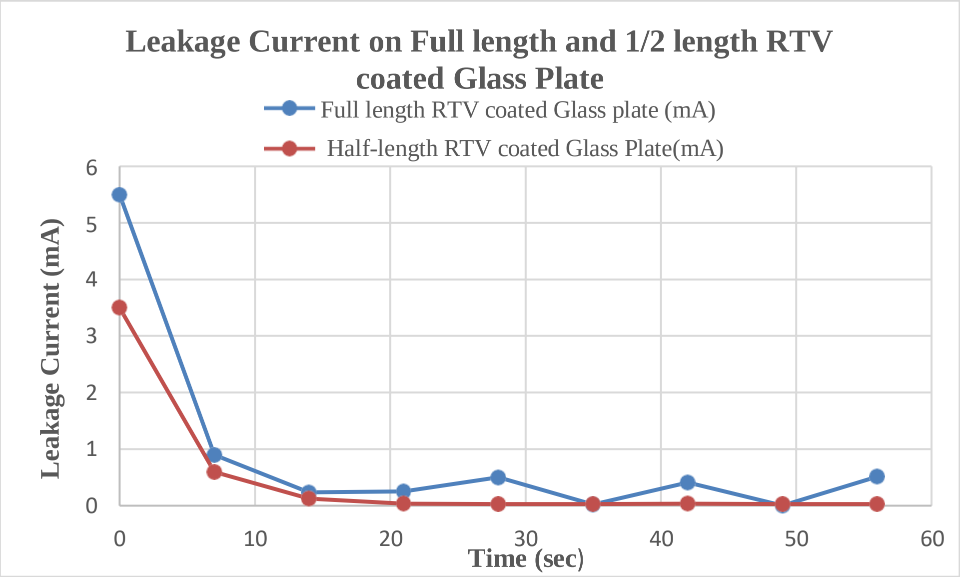

Fig 1.9 Leakage current from Dip test conducted on Glass plate sample with RTV coating for full length and 1/2 length coating

So, it can be seen that ½ length of RTV coated glass plate sample carries less leakage current compare to RTV fully coated glass plate sample. Lastly the test was conducted on full length of RTV coated and1/4th length of RTV coated glass plate sample. Table 1.6 and figure 1.10 shows the leakage current measured for full length RTV coated and 1/4th length of RTV coated glass plate sample.

It is clearly observed that 1/4th RTV coated glass plate sample carries less leakage current compare to RTV fully coated glass plate sample [10].

Table 1.6 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and 1/4th coated Glass Plate

Time (sec)	Full length RTV coated Glass plate (mA)	1/4th length RTV coated Glass Plate(mA)
0	19	18.4
7	9.25	5.03
14	0.073	0.206
21	0.025	0.026
28	0.022	0.009
35	0.016	0.006
42	0.019	0.003

49	0.007	0.007
56	0.511	0.03

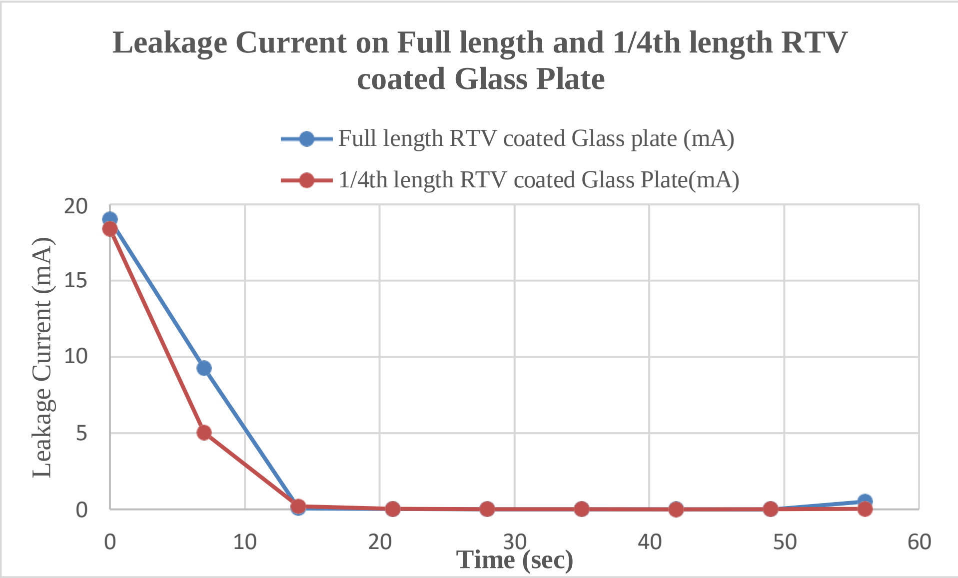

Fig 1.10 Leakage current from Dip test conducted on Glass plate sample with RTV coating for full length and 1/4th length coating

1.4 Test on 11kv Insulator

Dip test was conducted on two 11kvinsulator with one insulator uncoated and another insulator is half coated as shown in fig1.11. When voltage is applied to these insulators at different intervals then leakage current was measured as shown in table 1.8 andfigure 1.12.

Fig 1.11 Experimental setup for 11kV insulator

Table 1.7 Table Shows the values of Leakage Current versus Time for Full Length RTV Coated and Table Shows the Variation of Leakage Current versus Time for Uncoated and 1/2length RTV coated insulator

Time (sec)	Uncoated Insulator(mA)	1/2 Length RTV coated Insulator (mA)
0	0.098	0.033
7	0.092	.032
14	0.092	0.033
21	0.091	0.033
28	0.065	0.033
35	0.066	0.033

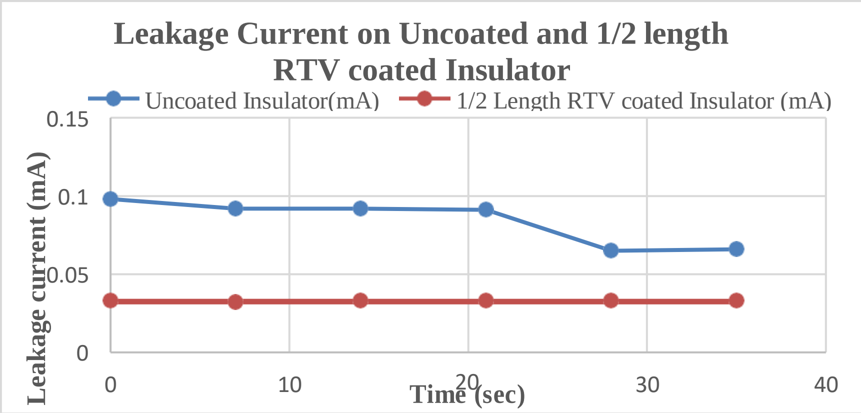

Fig 1.12 Leakage current on insulator with RTV coating for full length and uncoated insulator

1.5 Conclusion

Though the RTV coating is good for combating pollution but its cost is high. To reduce the cost of RTV coating, it is necessary to find the probable optimal length of RTV coating on the insulator to give good performance under pollution. The results obtained from the experiments carried out on 1/4th length of RTV coating gives lesser surface current and exhibits similar performance as RTV fully coated glass plate. Therefore, 1/4th length of RTV coating is enough to give similar performance as that of RTV fully coated glass plate. Hence for safety margin coating 1/2 of the length will be better.

The aging performance of RTV coated glass plate sample was good and remained hydrophobic after aging. Dip method of testing glass plate sample was easy and it can be preferred over rotating wheel tests. Dip test requires less investment than a rotating wheel test and less complexity. Dip test on porcelain insulators was also carried out for half coated and uncoated insulator. Half coated RTV insulator gives low surface current and shows better performance than uncoated insulator.

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