Pollution Performance of RTV Coated Insulators

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Abstract: ***Theincrease in power demand necessitates the usage of EHV and UHV transmission system. The growth of industries causes higher pollution level in the ambient condition on insulators. This increases the pollution severity of the site which results in pollution accumulation on the surface of Insulators. This causes flashover across insulator. Flashover across polluted insulators poses a serious threat to the reliability of the system and leads to system outages. There are many remedial measures to minimize the flashover of a porcelain insulator under pollution conditions. One such method is the application of hydrophobic coatings such as Room Temperature Vulcanizing Silicone Rubber on the surface of ceramic insulators. Laboratory testing of coated insulators has been carried out based on the solid layer method and by the inclined plane tests at constant voltage to evaluate the RTV coatings withstands capability against tracking and erosion. The performance of the coatings was assessed by monitoring the leakage current on the insulator surfaces. The applied voltage and leakage current were monitored throughout the tests. In order to optimize and economize the usage of RTV coatings various tests were performed and results are analyzed. It was possible to conclude from the test results that one fourth length of RTV coating is sufficient to withstand the pollution severity.***

Index Terms: ***RTV, Leakage current, Pollution, Scintillation.***

I. INTRODUCTION

Electrical power is an essential parameter for the overall development of a country. As the demand for electrical power is continuously increasing, it is observed that there is a steady growth in high voltage transmission lines for transmission of bulk power over long distances. As the level of transmission voltage is increased, switching and dynamic over-voltages and withstand ability of the insulator under polluted conditions are the most important factors, which determine the insulation level of the system. Under polluted conditions flash over occur across the insulator string leading to system outages which effects the reliability of the system. High reliability of the system is not only ensured by selecting appropriate insulation withstanding levels of various power components like power apparatus, insulators etc.., but it is also necessary to consider the pollution withstand levels of external insulation. RTV coating is one of the solution to combat pollution flashover on the existing insulator strings and insulators of related electrical equipment's like circuit breakers, switch gear, transformer, lightning arresters, support insulators, isolators etc.[1]. The coated material should have tracking and erosion property and should be able to withstand the pollution arc during scintillations [2]. Researchers have proposed several test methods to assess the ageing characteristics and to compare the performance of different RTV coatings [3][4]. In this paper Inclined plane test is carried out on glass plate substrate and on top surface of porcelain insulators for various lengths of RTV coatings. As RTV coating is costlier this research works helps us to optimize and economize the performance of RTV coatings on insulators.

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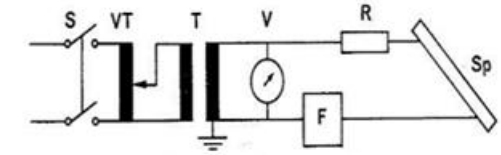
II. EXPERIMENTAL STUDY

1.1 Inclined Plane Test

In order to assess the RTV coated insulator tests were conducted on plane glass plate and RTV coated glass plate of various lengths.

This test helps for evaluation of RTV coated glass plate for various ambient conditions by measuring the surface current using liquid contaminant and inclined plane setup. Figure 1 shows the circuit diagram for Inclined plane test conducted as per IEC 60587 standards [5].



S — power supply switch
VT — variable ratio transformer
T — high-voltage transformer
R — series resistor
V — voltmeter
Sp — specimen
F — overcurrent device, fuse or relay

Fig. 1. Circuit diagram of inclined plane test

1.2 Experimental Setup & Test Procedure

The experimental setup for inclined plane test is as shown in Figure 2.The dripping setup is filled with 1% of NH_4Cl solution and the rate of flow is set according to the standards. The flow of the solution on the RTV coated glass plate is through the filter paper. The voltage is applied as per the standards for about 35 minutes. The surface leakage current of the RTV coated glass plate is monitored [6].

Fig. 2 Experimental Setup for Inclined Plane test

Inclined plane tests were conducted for RTV coated glass plate with removal of different lengths of RTV coating and without pollution layer. The Applied voltage and Flow rate for the tests, without removal of RTV coating to a length of 1/4th, 1/2, 3/4th and Full length removal under pollution were 6 drops per minute and 1.7 kV respectively. The leakage current measured during the Inclined plane test for various lengths of RTV coated glass plate are tabulated in Table I and shown in Figure 3.

Table-I: Leakage current for various lengths of RTV coated glass plate without pollution

TIME in Min	Fully coated RTV in mA	Full Removal of RTV in ma	Half Removal of RTV in mA	1/4 th Removal of RTV in mA	3/4 th Removal of RTV in mA
0	1.8	7.2	5	4.2	4.3
5	1.8	7.6	3.5	3.8	3.6
10	1.7	5.1	3.1	2.5	3.4
15	1.7	3.8	3.0	2.1	3.2
20	1.6	3.4	2.7	2.0	2.9
25	1.5	3.1	2.4	1.8	2.8
30	1.5	2.8	2	1.7	2.4
35	1.4	2.6	1.9	1.6	2.3

It can be seen from the Figure 3 that plane glass plate gives high leakage current compared to RTV coated glass plate. Even with RTV coated glass plate when RTV was removed has less leakage current value. Hence it is very clear that the difference between the currents of RTV Coating with removal of coatings for i.e., 1/4th, half, 3/4th and Full length, is less. From this it is very clear that coating can be applied on the insulators to an optimal length therefore cost of RTV can be reduced. As a safety measure the coating can be done for half the length of Glass plate.

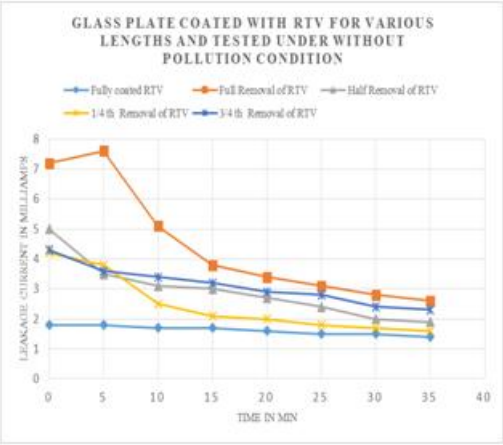


Fig .3. Leakage currents from inclined plane test conducted on glass plate coated with RTV for various lengths & tested under without pollution

The above procedure is repeated by removing the RTV coating of different lengths i.e., half, 1/4th, 3/4th, full and polluting the layer with the kaolin powder and salt. The Applied voltage and Flow rate for without removal, 1/4th, half, 3/4th and Full removal of RTV coating under pollution were 6 drops per minute and 1.7 kV respectively.The leakage current measured during the Inclined plane test for various lengths of RTV coated glass plate are tabulated in Table II .

Table-II: Leakage current for various lengths of RTV coated glass plate with pollution

TIME in Min	Fully coated RTV in mA	Full Removal of RTV in mA	Half Removal of RTV in mA	1/4th Removal of RTV in mA	3/4th Removal of RTV in mA
0	1.8	6.2	2.8	3.5	3.0
5	1.8	4.2	2.4	2.1	3.0
10	1.7	5.3	2.3	1.6	3.1
15	1.7	6.1	2.1	1.1	2.9
20	1.6	5.9	1.9	0.8	3
25	1.5	5.4	1.1	0.6	3.1
30	1.5	4.5	1.0	0.5	3.0
35	1.4	3.8	0.6	0.3	2.9

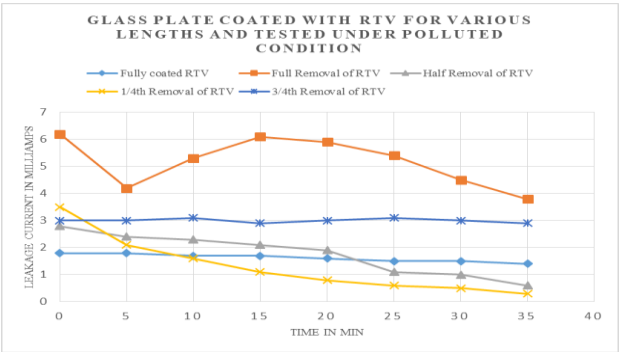


Fig .4.Leakage currents from inclined plane test conducted on glass plate coated with RTV for various lengths & tested under with pollution

Figure 4 shows that leakage current on polluted glass plate with RTV coating are generally high. This may be due to the fact that currents are flowing on polluted surface. The above graph shows the decrease in the leakage current in 1/4th pollution compared to other configurations like half, 3/4th . The sample without removal of RTV coating was drawing lesser current.

Figure 5 shows the RTV coated glass plate with 1/4th, 3/4th removal of RTV with pollution used for inclined plane test.

Fig . 5. RTV coated glass plate with 1/4th, 3/4th removal of RTV coating and Polluted

III. TEST ON RTV COATED CERAMIC INSULATOR

Ceramic insulators were subject to similar tests with and without RTV coatings, also for various lengths of RTV coatings after obtaining the

results from glass plate model [7]. Figure 6 shows the schematic diagram for testing insulators.

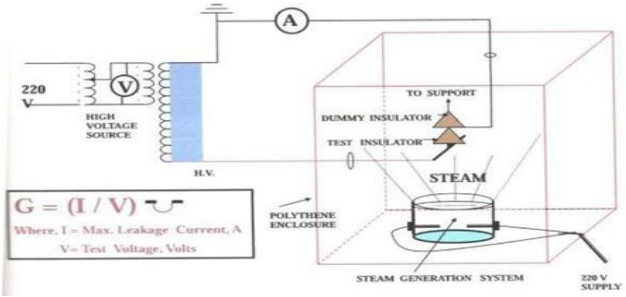


Fig.6. Schematic diagram showing the arrangements for test on insulators

Fig .7. Experimental setup for testing uncoated, RTV coated ceramic insulators

The experimental setup is as shown in Figure 7. Three insulators were subjected to test in which one of the insulator was uncoated, second one was RTV coated and third one was subjected to experiments for various lengths of RTV coatings on top surface. Tests on these insulators were carried out with and without pollution. Clean fog method of testing was adopted for the above experiments [8]. The pollution level was in medium range and surface conductivity was about 2.8 S/m. The water heater is switched onto generate fog and the input voltage (2.5kV) is applied as per BIS 60507 standards [9]. Leakage currents were monitored for every 5th minutes on uncoated, RTV coated ceramic insulators. The leakage current readings measured on uncoated and RTV coated Ceramic insulator tested under without pollution are tabulated in Table III and shown in Figure 8.

Table- III: Leakage current on Ceramic Insulator uncoated, RTV coated and tested without pollution

TIME (min.)	CERAMIC insulator uncoated (µA)	CERAMIC INSULATOR with RTV coated (µA)
0	60	40
5	40	30
10	40	30
15	50	40
20	50	40
25	50	40
30	40	40
35	50	40

When coated and uncoated insulators are not polluted then a small difference in the leakage current is observed from the above Figure 8.

In second set of experiment where RTV coating were removed for 1/4th of the top surface length and tested under without pollution [10]. The leakage current readings measured on uncoated, RTV coated, 1/4th removal of RTV coating on Ceramic insulator tested under without pollution are tabulated in Table IV and shown in Figure 9.

Table- IV: Leakage current on Ceramic insulators uncoated,RTVcoated, 1/4th length removal of RTV coating and tested without pollution

TIME (min.)	CERAMIC insulator uncoated (µA)	CERAMIC insulator with Fully coated RTV (µA)	TEST SAMPLE with 1/4th removal of RTV coating (µA)
0	50	40	40
5	40	40	30
10	40	40	30
15	40	40	40
20	20	10	10
25	20	10	10
30	30	40	40
35	20	20	20

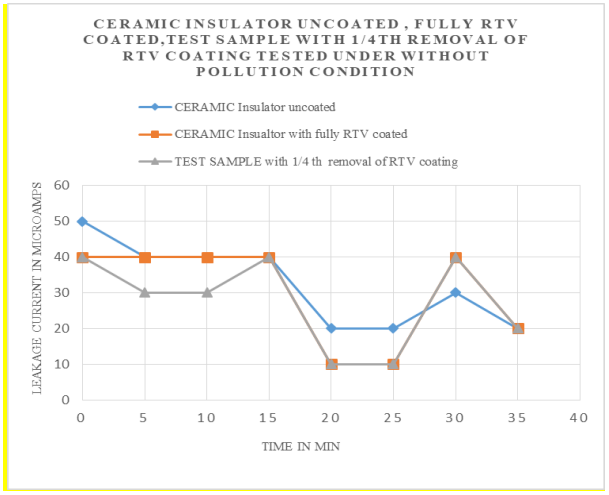


Fig.9. Leakage currents on ceramic insulators uncoated,RTVcoated,1/4th length removal of RTV coating tested without pollution

There is no much difference in leakage current between the insulators under unpolluted condition is observed from fig 9.

In third set of experiment where RTV coating were removed for 1/2 of the top surface length and tested under without pollution [11][12]. The leakage current readings measured on uncoated, RTV coated, 1/2 removal of RTV coating on Ceramic insulator tested under without pollution are tabulated in Table V and shown in Figure 10.

Table-V: Leakage current on ceramic insulators uncoated, RTV coated 1/2 length removal of RTV coating and tested without pollution

TIME (min.)	CERAMIC insulator uncoated (µA)	CERAMIC insulator with Fully coated RTV (µA)	TEST SAMPLE with 1/2 removal of RTV coating (µA)
0	4260	50	50
5	4140	50	50
10	4060	50	50
15	3900	50	50
20	3600	50	50
25	4100	50	50
30	3900	60	50
35	3600	60	50

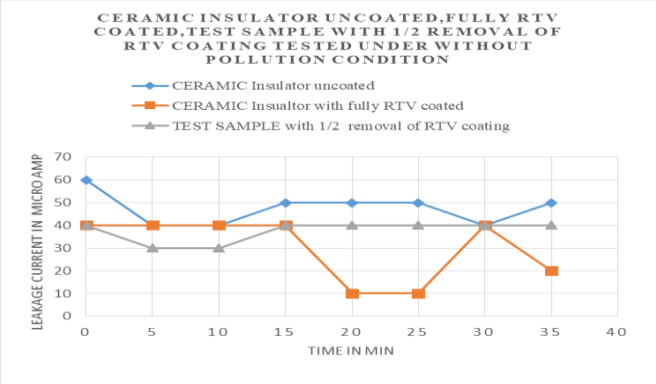


Fig. 10. Leakage currents on ceramic insulators uncoated, RTVcoated & 1/2 length removal of RTV coating tested without pollution

Figure 10 shows that same performance is obtained even when RTV coatings were removed for 1/2 of the top surface length.Experiment was also conducted on uncoated, RTV coated and RTV coating removed (1/2 of the top surface length) insulators with pollution [13]. The leakage current readings are tabulated and shown in Table VI and Figure 11.

Table-VI: Leakage current on ceramic insulators uncoated, RTV coated 1/2 length removal of RTV coating and tested with pollution

TIME (min.)	CERAMIC insulator uncoated (µA)	CERAMIC insulator with Fully coated RTV (µA)	TEST SAMPLE with 1/2 removal of RTV coating (µA)
0	40	40	40
5	30	40	30
10	50	40	30
15	20	40	40
20	40	10	10
25	50	10	10
30	60	40	40
35	30	20	20

Fig. 11 Leakage currents on ceramic insulators uncoated, RTVcoated& 1/2 length removal of RTV coating tested with pollution.

Figure 11 shows that there is very small difference between RTV coated and insulator with RTV coating removed (½ of the top surface length).It can also be observed that leakage current flowing through uncoated ceramic insulator is high compared to RTV coated and insulator with ½ length removal of RTV coating.Test was repeated on uncoated, RTV coated, 3/4th length removal of RTV coating on top surface of ceramic insulator with pollution [14] [15].The leakage current readings are tabulated and shown in Table VII and figure 12.

Table VII: Leakage current on ceramic insulators uncoated, rtv coated 3/4th length removal of rtv coating and tested with pollution

TIME (min.)	CERAMIC insulator uncoated (µA)	CERAMIC insulator with Fully coated RTV (µA)	TEST SAMPLE with 3/4th removal of RTV coating (µA)
0	1400	60	60
5	1420	60	60
10	1390	60	60
15	1030	60	60
20	1200	60	60
25	1120	60	60
30	1140	60	70
35	1120	90	90

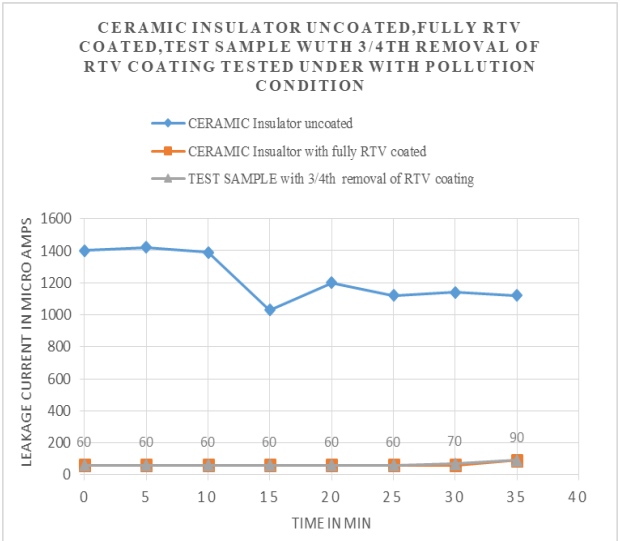


Fig. 12 Leakage currents on ceramic insulators uncoated, RTVcoated& 3/4th length removal of RTV coating tested with pollution

Figure 12 shows that uncoated insulator was drawing higher current than RTV coated insulators. Again there is no difference in performance of RTV coated insulator with 3/4thof top surface removed and fully coated insulator.

Figure 13 shows how RTV coating is removed for half, 3/4th length in insulator and polluted with Kaolin powder. These insulators were used for experimental study to know the performance of RTV coatings on Insulators for various lengths in polluted condition.

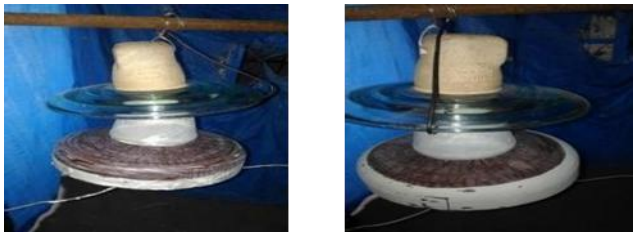


Fig. 13 Insulator with pollution and half, 3/4th removal of RTV coating

IV. RESULTS

Part A

Results of Inclined plane test on glass plate with RTV coating (with and without pollution)

a. Leakage current of 1/4th length of RTV removal and ½ length removal of RTV is less compared to fully coated RTV on glass plate insulator with pollution.

b. Leakage current of 1/4th length of RTV removal and ½ length removal of RTV is less compared to fully coated RTV on glass plate insulator without pollution.

Part B

Results of experimental study on insulator with RTV coating (with and without pollution)

a. A small difference in the leakage current is observed between uncoated and RTV coated insulators without pollution.

b. Leakage current on 1/4th length removal of RTV coating, 1/2 removal of RTV coating is less compared to uncoated and RTV coated insulator without pollution.

c. It is observed that uncoated insulator draws high leakage current in pollution condition. But Leakage current on 1/4th length removal of RTV coating, 1/2 removal of RTV coating is less compared to uncoated and RTV coated insulator with pollution.

V. CONCLUSION

Based on the experiments carried on glass plate and insulators with RTV coating (with and without pollution) following are the major conclusions

a. The results from inclined plane test carried out on glass plate for various lengths of RTV coating and tested for with and without pollution showed that 1/4th length of RTV coating carries lower surface current and performance is similar to fully RTV coated glass plate.

b. The results from inclined plane test carried on insulator for various lengths of RTV coating and tested for with and without pollution also showed that 1/4th length of RTV coating carries lower surface current and performance is similar to fully RTV coated insulator.

c. Tests carried out on both glass plate and insulator shows that 1/4th length of RTV coating is sufficient to withstand and perform similar to fully coated RTV.

The results of the above experiments are encouraging such that the cost on RTV coatings can be reduced effectively. This will help in reducing the line outages due to pollution flashover.

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