

Resistance of Silicone Rubber High Voltage Insulation to Leakage Current in Modified Inclined Plane Test

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Abstract- In this paper results of investigations of resistance to leakage currents of two different silicone rubbers subjected to a modified inclined plate test are presented. The modification of the experiment consisted in a change of the sample's inclination angle and in feeding a moistening solution to the upper surface of the sample. The main aim of the modification was to create laboratory test conditions as close to the ones observed in reality as possible.

I. INTRODUCTION

Inclined plane test is a well-known standard method of investigation of high voltage insulation materials such as for example laminates or resins which have application in high humidity conditions [1-6]. There are attempts to applying this test for estimate of silicone rubbers, which have hydrophobic properties. In this case a hydrophobic surface of silicone rubber require an artificial modification due to a drops of wetting agent which fall off from the surface.

In the standard method inclination of 45° cause fast flow of wetting agent which prevent wettable path formation and make impossible develop of leakage current.

Due to manufacture technology inclination of upper surfaces of insulator sheds is rather low. Results of inspections of insulators after a few years operating indicated that on the upper surfaces of insulator sheds pollution accumulation was observed. The presence of pollution favoured has developed of partial discharges, which cause of surface erosion.

For these reasons in the modified inclined plane test the upper surface of sample was wetted and the inclination of the samples was changed from 45° to 18° . Described conditions of the test comply with the operating conditions of upper surfaces of the sheds. The experimental setup is shown in Fig. 1.

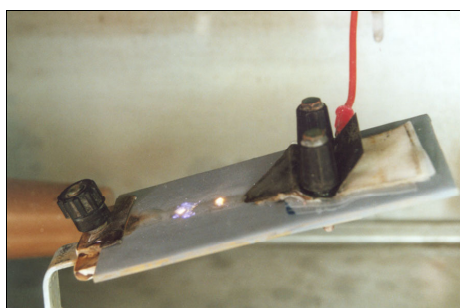


Figure 1. Experimental setup.

II. TEST SETUP AND OBJECT OF INVESTIGATIONS.

The object of the investigations were 3 and 5 mm thick clean samples of HTV silicone rubber and 0,4 mm thick also clean samples of RTV coating, all in the shape of 120x50 mm rectangles.

The test setup for investigating resistance to creeping currents (Fig. 2), described in standard IEC60587, was modified to feed an electrolyte solution at the sample's angle of inclination of 18° corresponding to the inclination of the upper surface of insulators sheds. According to standard [1], the sample should be fixed at an angle of 45° with its tested surface facing downwards. The solution was fed onto fixed layers of absorbent-paper and percolated down to the tested surface.

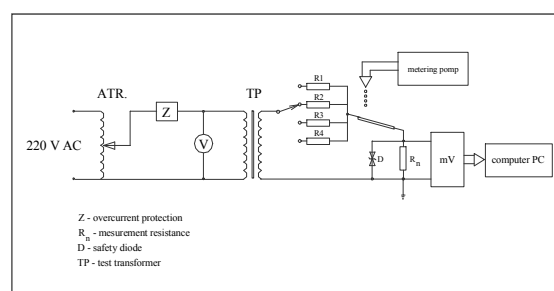


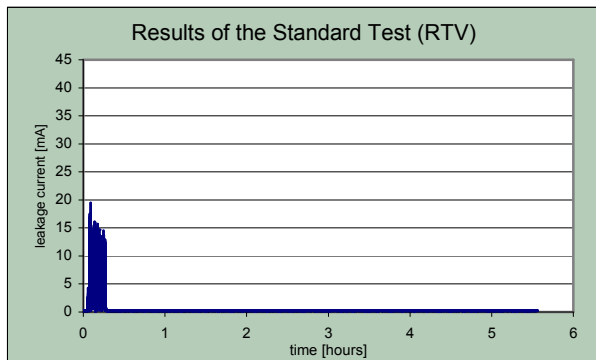
Figure 2. Circuit diagram.

A metering pump metered the wetting agent at a rate of 18 ml/hour. Ammonium chloride used as the wetting agent in the standard test was replaced with a saline solution whose conductivity was 1,5 mS/cm.

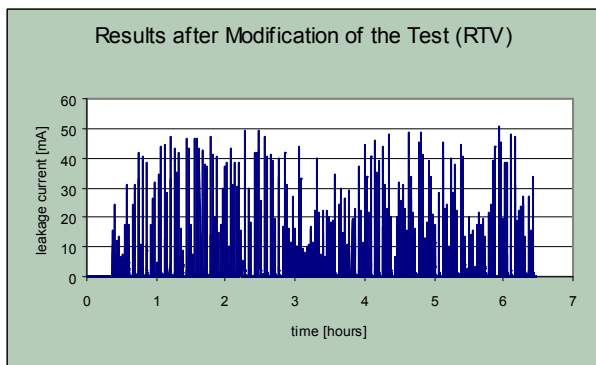
The electric stress was 0,8 kV/cm. During the test, the leakage current was recorded. A sample erosion of 0,2 mm or a recorded leakage current of 60 mA (a flashover could occur at a higher leakage current) was adopted as the end-of-test criterion [1]. If this current level was not reached within 6 hours of testing, the tested material was considered to have passed the test. Earlier investigations of the materials had shown that after 6 hours of the modified inclined plane test the criterion leakage current had not been reached and the differences between the two rubbers had been imperceptible. Therefore in the present investigations material erosion was adopted as the end-of-test criterion.

III. RESULTS OF INVESTIGATIONS

An analysis of the recorded leakage current on the clean HTV and RTV samples shows that the modified inclined plane test does not require special preparation of the surface of the tested materials except for periodic moistening (Fig. 3).



a)

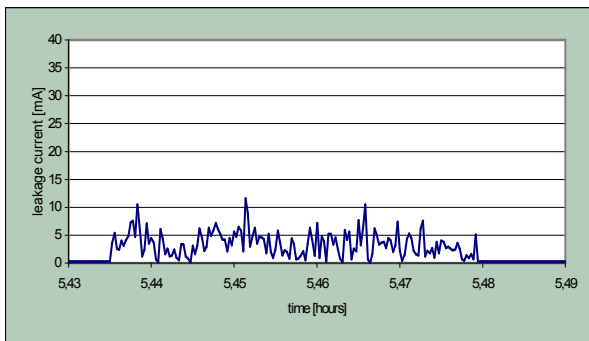


b)

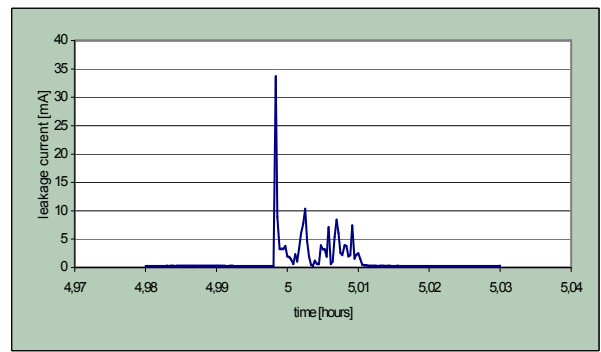
Figure 3. Leakage current versus aging time for RTV samples, a) the standard test, b) the test after modification.

In case of the standard test recorded leakage current value after a few minutes is very low, on a level almost zero. After modification leakage current contains a lot of high separate impulses that indicate on surface discharges occurrence. These results confirm legitimacy of test modification.

The shapes of the currents recorded for the RTV and HTV samples are different (Fig. 4).



a)



b)

Figure 4. Fragment of 3 minutes of leakage current measurements, a) leakage current versus ageing time for HTV sample, b) leakage current versus ageing time for RTV sample.

In case of RTV sample the recorded current has the form of separate current impulses with different amplitudes, decaying almost to zero.

In case of HTV sample current impulse ignition occurs periodically and they impulses do not decay but show a growing tendency. The maximum value of a current impulse for the RTV samples was almost 25 mA higher than for the HTV samples. The differences in the shape of leakage current indicate the active suppression of the current by the RTV rubber in the presence of moisture.

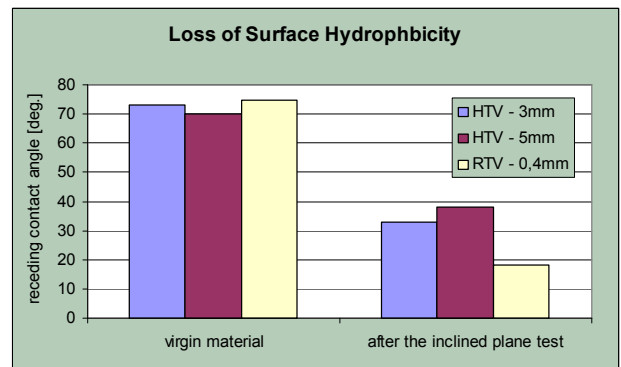
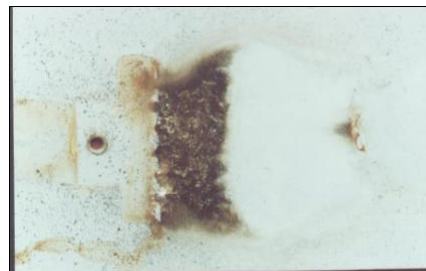


Figure 5. Loss of surface hydrophobicity after the test.

On the Fig. 5 loss of surface hydrophobicity after the test was showed. In case of 5mm thick HTV samples receding contact angle was equal almost 40 degree whereas the worse results were obtain for 0,4 mm thick RTV sample – almost 20 degree.



a)



b)

Figure 6. Surface erosion of tested samples,

- a) HTV sample after 53 hours,
- b) RTV sample after 36 hours.

The Fig. 6 presented pictures of both type of samples. In case of RTV material, test was interrupted after 36 hours because of deep surface erosion that uncovers the plastic base. For the HTV sample test was finished after 53 hours, the erosion was flat and uniform along the ground electrode.

Aging resistance in the modified inclined plane test was higher for the HTV material especially for 5mm thick samples in compare to the 0,4 mm thick RTV samples.

IV. CONCLUSIONS

- Silicone rubbers can be subjected directly to modified inclined plane test without necessity of increasing their surface wettabilities.

- Leakage currents on RTV coating were in the form of single impulses while in the case of HTV material from the beginning continuous currents were recorded. This indicate on the active suppression of the current by the RTV rubber in the presence of moisture.
- For RTV coating surface discharges caused local deep erosion while for HTV materials the erosion was flat and uniform along the ground electrode.
- Aging resistance in the modified inclined plane test was higher for the HTV material especially for thicker samples.

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