AGEING OF SILICONE RUBBER INSULATORS UNDER HIGH VOLTAGE DIRECT CURRENT: PRELIMINARY RESULTS OF INCLINED PLANE TESTING

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Abstract: There are several High Voltage Direct Current (HVDC) schemes in existence, many of which have been traditionally insulated with glass insulator strings. Due to its hydrophobic nature, the later development of polymeric insulators provided better pollution performance. The performance, and in particular the ageing of polymeric insulators under HVDC stress, is an area that has not been researched as extensively as ac. Factors such as pollution catch and accumulation, material composition, space charge effects and line polarity have yet to be explicitly evaluated. This research focuses on the accelerated ageing of silicon rubber when subjected to dc stress, taking polarity into account. The results of inclined plane tests, as per IEC60587:2007, on silicone rubber are presented. The tests indicate that by using the standard ac guidelines, samples subjected to equivalent dc stress fail quicker than ac samples. It was observed that the positive dc showed higher levels of current than the negative tests, and the erosion is more severe. The negative dc test at 4.5kV showed severe erosion similar to the positive dc case, but the negative 6.3kV dc test ran for the full 6 hours with minimal erosion.

1 INTRODUCTION

It is hypothesised that the performance of the polymeric insulator material under dc stress, from a tracking, erosion and corona activity perspective, will be inferior for the dc case as compared to the respective ac scenario. This is possibly due to the aggressive nature of the dc stress and the fact that the dc voltage is non-cyclical in nature. In order to conduct the experiment, an inclined plane test (IPT) setup was utilised, shown in Figure 1.

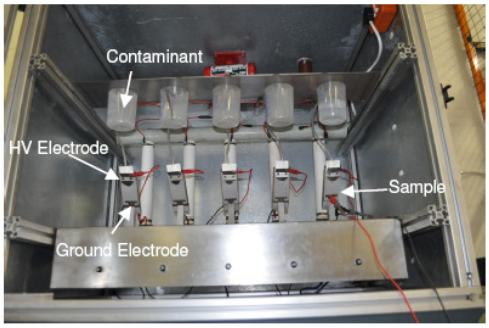

Figure 1: Inclined plane test (IPT) setup.

2 CONCLUSIONS AND RECOMMENDATIONS

Using the inclined plane test method and three test voltages, 4.5 kV rms for ac, 4.5 kV and 6.3 kV for both positive and negative dc the following results were obtained.

The samples of the ac test showed minimal erosion of negligible depth and ran for the full duration of 6 hours. The samples of the 4.5 kV positive dc ran for 95 minutes, while the 6.3 kV dc test ran for 58 minutes before being stopped. It is noticed that the average one-minute maximum currents for both the tests were similar and displayed high peak magnitudes as compared to the other tests. In both tests samples displayed severe erosion. This could possibly be attributed to the high peak current magnitudes observed.

The samples of the negative 4.5 kV dc test developed severe erosion after 20 minutes - less than the positive case. The average one-minute maximum current observed for this test was less than in the positive dc case.

The samples of the negative 6.3 kV case, which were expected to fail in a similar manner and time as the negative 4.5 kV test, ran for the full 6 hours and showed minimal erosion of negligible depth. The erosion appeared similar to the ac case, although the track marks were more distinct and showed greater surface blackening. This anomalous result needs further investigation. The rapid evaporation of contaminant prior to reaching the ground electrode, limits the current flowing on the surface of the sample. This would result in considerably less energy in the discharges and less damage to the insulation.

It is concluded that for the dc voltages investigated, especially the positive polarity, a stronger erosive effect on the silicone rubber material was observed. It is postulated in the negative dc case, the lower currents result in more damage, possibly due to the fact that the higher currents do not form stable arc roots at the ground electrode, and therefore do not initiate the severe erosion observed in the 4.5kV dc case. Further research is proposed to conduct further testing to evaluate the repeatability of the tests.