DC Inclined-plane testing of silicone rubber formulations

Introduction
The inclined plane test for ‘tracking and erosion resistance’ of materials, IEC-60587, has become a routine tool for researchers developing high voltage outdoor insulation materials. The test is designed for ac applications and many laboratories have many years of experience with the technique. DC power systems are becoming more important and competitive in the market place. Often insulation systems designed for ac applications are utilised on dc systems. However, there is clear evidence of behavioural differences between identical materials under ac and dc stresses. An equivalent test to IEC-60587, has been developed and utilised for the dc case.

Leakage Current Analysis
Test information is displayed in real-time using a graphical user interface.

Log of sample performance made in each minute of a test.

Peak power & minimum surface resistance calculated as:

\[ R_{\text{peak}} = \frac{V_{\text{peak}}}{I_{\text{max}}} \]

Data is stored during the test and can be analysed in many ways as below:

Synchronised recordings of 3kHz LC waveform and 15fps colour video.

Time-frequency domain analysis using wavelet transform

Separation of low frequency and more dynamic aspects of the LC.

Tracking & Erosion Process
Contaminant, fed from the energised high voltage (HV) electrode, drips down the angled planar sample onto the low voltage (LV) electrode. Bridging of the two electrodes results in conduction and Joule heating of the contaminant, which slowly increases surface temperature. Dry band formation results in surface discharges that produce rapid localised heating. Discharges damage the surface by the decomposition of the filler material and at higher temperatures decomposition of SIR.

Surface Damage
At the end of a test for each test condition the surface condition is very different. A key characteristic of the positive tests was the extension of a non conductive but hydrophilic track between the electrodes. Under negative DC, this is prominent only in the bottom half of the sample. Mass loss due to erosion, and erosion depth during each test condition shows that positive DC conditions have the most severe damage.

Conclusions
The DC inclined plane test is very reproducible. The processes of material damage and electrical activity leading to tracking and erosion can vary with the conditions of testing. There are many further questions which remain to be investigated, but perhaps the most useful would link the conditions for deep sample erosion with arc properties under DC and AC.