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Performance of silicone rubber materials under high voltage direct current using the inclined plane test

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Abstract

There are many HVDC schemes around the world operating at various voltage levels ranging from ±200kV to ±800kV dc. The choice of insulator types and level of insulation varies with voltage levels and environmental conditions through which the substations and transmission lines traverse.

As in the case for ac lines, polymeric insulators were introduced on dc lines with a view to improved pollution performance and reduction of damage from vandalism. Another possible reason is that, generally, the price for a full dc glass string is higher than that of a similar voltage polymeric insulator unit.

Polymeric insulators, comprising of silicone rubber (SiR) material filled with alumina trihydrate (ATH), have the ability of maintaining and transferring their hydrophobic property to the pollution layer that may collect on the surface, which gives them their superior pollution performance. A concern regarding the use of polymeric insulators is the ageing of the SiR material, which when stressed under certain ambient conditions may temporarily lose its hydrophobic property. During this period local discharge activity (corona discharges or surface leakage current flow) may lead to tracking on the surface and even erosion of the material. With sustained activity this may eventually lead to permanent degradation of the material and allow moisture ingress to the fiber glass core of the insulator. The combination of moisture ingress and the high electric fields may ultimately lead to failure of the insulator by mechanisms such as brittle fracture, flash-under, etc. as seen in various cases reported on ac lines.

The performance, and in particular the ageing of polymeric insulators under HVDC stress, is an area that has not been researched as extensively as for HVAC stress. 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, and the materials analyses on the 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. This dissertation presents the results of electrical testing, and analyses of the materials after degradation using known chemical analysis techniques.