Investigation on the tensile strength of silicone layers with different amount of graphite filler

Mirnes **AGANBEGOVIĆ**, Peter **WERLE**

Institute of Electric Power Systems (IfES), Division of High Voltage Engineering and Asset Management, Schering-Institute, Leibniz Universität Hannover, Callinstraße 25A, 30167 Hannover (Germany)

aganbegovic@ifes.uni-hannover.de, werle@ifes.uni-hannover.de

ABSTRACT

In this contribution the mechanical tensile strength and the elongation at break of differently doped silicone and layered silicone insulation were investigated. It is expected that the individual layers have different tensile strengths. For this purpose, test samples according to the standard DIN 53504:2017-03 (ISO 37) were prepared, which contain two silicone layers, one without fillers and the other made of the same base silicone, mixed with a specific amount of graphite powder. In order to compare the results with non-layered dielectrics, samples made from pure silicon and from graphite filled silicone were also tested.

KEYWORDS

Layered silicone dielectrics; Tensile strength; Elongation at break; Graphite filler; HVDC Cable.

INTRODUCTION

Silicone elastomers can be used as insulation material in various areas of energy transfer. They have a high dielectric field strength under alternating voltage stress (AC) and under direct voltage stress (DC). Silicones are also specified by a low electrical conductivity. It is known from the literature that silicone elastomers behave more robustly against partial discharge (PD) phenomena compared to cross-linked polyethylene (XLPE) and are less susceptible to polarization effects [1]. In order to improve or to control certain electrical properties of polymeric insulating materials, conductive particles (fillers) are blended into the insulating material. In order to maintain the dielectric strength of the insulation, only a part of the insulation could be filled with particles [2]. When used as a cable joint, termination or cable insulation, silicone elastomers are exposed to electrical as well as to thermal and mechanical stresses. However, the addition of conductive fillers not only changes the electrical properties of the silicone material but also has an effect on its thermal and mechanical properties. In earlier investigations, it has been seen that the addition of conductive particles into a silicone leads to embrittlement of the final product [2-3]. In order to investigate the influence of the conductive filler on the tensile properties of elastomers, samples with different amount of filler were prepared and tested and the results compared with the tensile properties of the layered dielectric. To produce samples according to the standard DIN 53504:2017-03 (ISO 37) [4], a sample cutter to stamp shouldered test bars was used.

TEST MATERIALS

The following sections discuss the materials used for these investigations and their specific properties. The base material is an addition-crosslinking silicone elastomer. The conductive filler is a finely grinded natural graphite.

Silicone elastomer

The used test medium is a RTV2 (room temperature vulcanizing) silicone rubber, which consists of two components, the base and the catalyst. After the two components are mixed together in a ratio 1:1 it vulcanizes at room temperature. Table 1 shows the main properties of the silicone [2].

Tab. 1: Properties of the used silicone elastomer

Colour	Translucent
Dissipation factor (at 20 °C and 50 Hz)	$25 \cdot 10^{-4}$
Permittivity (at 20 °C and 50 Hz)	≈ 2.4
Resistivity at 20 °C	$1.3 \cdot 10^{15}$ Ωm
Dielectric strength (at 20 °C and 50 Hz)	≈ 100 kV/mm
Temperature resistance in °C	-40 to +230
Vulcanization time at 23 °C in h	1.5
Kinematic viscosity in mm^2/s	7600
Hardness Shore A	43 ± 3
Density in g/cm^3	1.12

Both components of the silicone have a relatively low viscosity so that they can be mixed well and then poured into the appropriate mold. The processing time at 23 °C is about ten minutes. The curing of the silicone mixture usually lasts 1.5 hours at 23 °C [2]. At higher temperatures, it is accelerated, but slows down at lower temperatures.

Conductive filler

In order to variate the electric conductivity, a microscale graphite powder was used (see Figure 1). It is a finely grinded natural graphite with a carbon content of >99 % and a particle size of 4 to 6 microns. It is characterized by a degree of fineness of D50% [2].

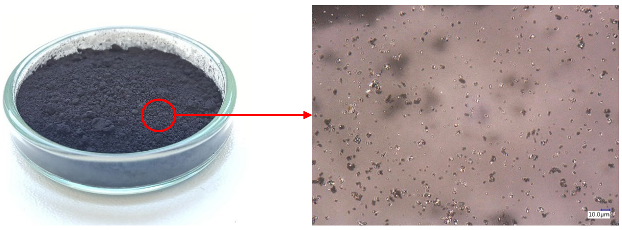

Fig. 1: Used graphite filler under microscope

In the right picture of Figure 3 it can be seen that the particles do not have a flake shape with pointed edges, but rather are roundish. This is advantageous when used under high voltages. Furthermore, it can be seen that the particles have a constant size and shape, which can be explained by the above mentioned degree of fineness.