COMPOUNDING OF SEMICONDUCTIVES FOR HIGH VOLTAGE CABLES

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ABSTRACT

A key component of high, and very high voltage cable is the semiconductive layers; respectively the inner or conductor shield and the outer or insulation shield. The semiconductive extrudate must meet extremely well defined specifications with respect to pips or agglomerates and overall surface smoothness.

This presentation will detail the handling, feeding and compounding of conductive fillers into extrusion grade semiconductive compounds. It will compare the physical nature of these key raw materials and how this can lead to challenges in their incorporation in the polymer matrix.

Starting from stringently selected raw materials the quality determining step now lies in effective mixing of the ingredients, in particular the high level of pelleted carbon black. The energy input must be carefully controlled. The aim is to break down the carbon black to its primary aggregates and then to distribute the aggregates to the optimum degree (distributive mixing). An over mixing can lead to a decrease in conductivity due to undesirable break down of the primary aggregates.

Compounding techniques are therefore paramount in order to be able to meet these requirements.

KEYWORDS

Semiconductive, carbon black, compounding, dispersion, supersmooth.

INTRODUCTION

Both cable makers and end-user utilities are equally concerned about the expected life span of installed cable. Over the years significant improvements have been incorporated into cable design. Along with these technical advances greater demands are put on the performance of the cable. Cables today are installed in increasingly rough, hostile and costly (underground, undersea) environments.

In 1969 AEIC issued the first specification for polyethylene and XLPE insulated cable. Over the years this has been continually updated and new specifications introduced to ensure a very stringent and demanding set of criteria for power cable manufacture. Test requirements include physical, electrical and load cycling analyses. The semiconductive extrudate must meet extremely tight limits with respect to overall surface smoothness and the absence of lumps, pips or agglomerates against closely defined dimensions.

The quality of the semiconductive extrudate becomes of even greater importance as ever higher voltage rated cables are produced from polymeric compounds. The need for reduction of the insulation thickness to contend with the rising trend in voltage has been satisfactorily matched by improvements in cable manufacturing technology. The additional demands on the semiconductive are evident when typical thicknesses of conductor shield are compared with cable voltage, Table 1

Voltage (kV)	10	20	60	110	150	225	500
Shield (mm)	0.8	0.8	1.0	1.2	1.2	1.7	2.0

Table 1: Evolution of conductor shield thickness with voltage

Cable performance and cable integrity is dependent on all of the individual components that go to make up a cable. But specifically, and never more so as ever high voltage cables are produced from synthetic polymers, on the quality of the extrudate layers. These extrudate layers, predominantly applied in a single (triple extrusion) pass, are in intimate contact with each other and rely on zero interfacial imperfections for cable integrity.

Carbon black

Carbon black is one of the most versatile fillers used in plastics. It can be used to provide opacity, colour, UV protection, electrical conductivity, thermal conductivity and even reinforcement. In order to impart electrical properties to a polymer matrix typically carbon blacks from either the furnace process or the acetylene process are selected. Furnace blacks can be of petrochemical or carbochemical origin. Acetylene blacks, as the name implies, are produced from acetylene gas.

The smallest representative unit of carbon black is a particle. The properties of a given carbon black are related to the particle size and surface area of this primary unit. However carbon black does not exist as discrete particles. During the furnace manufacturing process the spherical carbon black particles permanently fuse together to form aggregates. A key property of the carbon black which controls its ultimate performance is the morphology of the primary aggregate. When many prime particles are fused together, usually with a high degree of branching or side chains, the resulting aggregate is described as having high structure. If the primary aggregate has relatively few prime particles the carbon black is described as having low structure, Fig1.