SPACE CHARGE MEASUREMENTS IN XLPE INSULATED MID-VOLTAGE CABLE: CORRELATION WITH CABLE PERFORMANCE

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ABSTRACT

*Three experimental mid-voltage XLPE cables, **C2**, **C3** and **C4**, rated respectively as 'good', 'very good' and 'bad' in perforation tests, are studied. All these cables have been systematically measured by PEA as produced and after being annealed at 90ºC and 120ºC up to 672 hours. Measured internal charge of cable **C4** at least doubles that of cables **C2** and **C3**. Evolution with annealing show as well differences in the reticulation process carried out during cable **C2** and **C3** preparation, which can explain why cable **C3** performs better than **C2** in perforation tests. Infrared spectroscopy measurements (IR) showed differences in components injected from the external semiconducting layer (SC) into the isolation during annealing. These results explain other observed differences in PEA measurements with regard of the SC type of each cable. To sum up, combination of PEA and IR measurements are a useful tool in understanding charge relaxation processes and XLPE cable performance.*

KEYWORDS

PEA, XLPE, cable, charge distribution, IR

INTRODUCTION

The presence of space charge in a dielectric material not only affects the value of its electric field and its conductive properties but also plays an important role in aging processes [1]. From an applied point of view, for midvoltage cable, the study of space charge formation and relaxation processes is especially interesting as they condition cable lifetime. Polyethylene (PE) is a linear semicrystalline non polar polymer that is used in such cable insulation. Some controversy arose in the past about the glass-transition temperature (T_g) of PE, but nowadays it is well established that it is below room temperature. This is a relevant fact in the study of the conduction processes of cable insulation because its working temperature (90ºC) is above room temperature and therefore, above T_g. Because of this, the conduction processes observed can be associated with free charge [2]. In industrial applications, PE is commonly crosslinked (XLPE) by the addition of some chemical additives (crosslinking agents) and heating it up to a temperature higher than 200ºC to produce a vulcanization reaction. This process introduce several crosslinking by products that influence materials conductive properties.

The development of new techniques for determining space charge profiles in insulators [3] has renewed the interest in the study of space charge in dielectric materials in recent years. These studies have shown that the formation of space charge profiles in crosslinked polyethylene (XLPE), used in cable insulation, is greatly influenced by several factors, including the crosslinking subproducts, antioxidants, oxidation of the material, temperature, electrode type, and other circumstances of the manufacturing process that must be taken into account.[4-6]

Previous works showed that cable semiconducting shields (SC) play an important role in charge trapping processes in XLPE [7]. The charge that arises was previously trapped in defects that diffuse from the SC layers. Infrared spectroscopy (IR) analysis showed that this diffusion of defects into the XLPE bulk takes place in a continuous way when the sample is annealed at temperatures above 80ºC. Diffused defects act as traps for the charge that is injected from the electrodes if a polarizing electric field is present.

In this work three experimental cables supplied by General Cable S.A., each one with quite different perforation test results, are systematically measured. The main goal to achieve is to obtain a correlation between cable characteristics and measured results. Following this purpose, several samples were annealed at T_a=90ºC and T_a=120ºC for different times t_a between 0 and 672 hours and the charge distribution profile and the diffusion of chemical components from the semiconducting external shield into the XLPE isolation, is measured.

EXPERIMENTAL

Samples

Cable samples were supplied by General Cable S.A. and consisted of a cylindrical insulating XLPE layer with 7 and 13 mm of inner and outer radii, respectively. The samples had two 1 mm thick semiconductor layers in contact with the inner and external surfaces of XLPE.

Three experimental cables (**C2**, **C3** and **C4**) were prepared using different 'PE-crosslinking agent' base resin (PE1, PE2) and different external semiconducting shields (SC1, SC2). Cables were evaluated by perforation tests at General Cable S.A., delivering quite different results. Table 1 summarize each cable properties.