Investigation of electrical and morphological properties of 10 kV XLPE cable insulation specimens

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ABSTRACT

The paper presents the investigation results for the specimens of commercially produced 10 kV XLPE cables manufactured at different plants, under different production conditions but on similar equipment with the use of the same materials. The investigation involved the analysis of the following: the morphology peculiarities by optical and thermal methods, the insulation system defect rate, the insulation resistance to electrical tree initiation. The results indicate that the minimum defect rate of the insulation system was observed in the specimens fabricated at moderate extrusion speeds and the maximum polyethylene insulation resistance to electrical tree initiation was observed in the specimens with a lower melting temperature.

KEYWORDS

Electrical insulation, cable quality, morphology, DSC, optical microscopy, electrical tree.

INTRODUCTION

Cable quality assurance requires constant efforts including those aimed at the development of new test methods and search of additional assessment criteria for cable product performance characteristics. The authors wish to draw attention to those cable insulation parameters and properties which, from their point of view, are of importance for reliable cable operation but are not widely used in terms of standard methods.

The work was aimed at the following:

- detection of differences in the specimens (by optical, thermal and electrical methods);
- interpretation of differences taking into account the technology peculiarities;
- interpretation of differences from the viewpoint of quality of the cable insulation.

The specimen quality was estimated using the following properties:

- insulation morphology;
- imperfection of the insulation system (dimensions of the foreign particles in the insulation, dimensions of the semicon protrusions);
- melting point;
- local dielectric strength (resistance to electrical tree initiation).

ESTIMATION OF THE INSULATION MORPHOLOGY

One of the essential conditions for reliable operation of the polyethylene insulation is its homogeneity. Numerous light microscope observations of insulation slices indicate that optically the insulation is practically always heterogeneous (**Fig. 1**).

Fig. 1. Large-scale structure of medium-voltage cable insulation.

If we look at the structure of a pure LDPE specimen molded in a laboratory environment we can see a classical picture (**Fig.2)**.

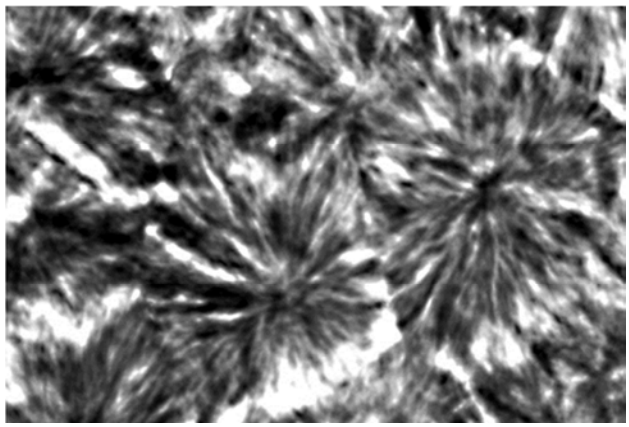

Fig. 2. Spherulite morphology of pure non-crosslinked LDPE. Frame width is 130 μm.

The material is composed of large spherulites the size of which reaches tens of micrometers. However cable insulating materials contain a number of additives providing cross-linkability, processibility and reliability; being processed in the continuous vulcanization line the materials are subjected to extrusion, cross-linking and cooling. The result is that their structure becomes multilevel and very much different from the one shown above.

Fig. 3 shows semimicroscopic morphology level where large structure elements, the so-called "clouds", and the area with primarily radial material orientation (the seam area) are visible.