HIGH PERFORMANCE MV CABLE SEMI-CONDUCTING SHIELDS

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ABSTRACT

Many patents have been issued and over 175 papers have been published on water treeing and water tree additive technology. Fewer papers have been published on conductor screen technology. High performance screens often employ acetylene carbon black which gives a smooth and ionically pure compound. In this paper we demonstrate that formulation plays a dominant role in determining the performance of power cable screens when compared to simply assessing smoothness and cleanliness of the compound. Time to failure and retained breakdown strength data on model and full size MV cores are presented.

High performance conductor screens (shields) with improved cleanliness and smoothness were introduced in the early 1980's. High performance screens often employ acetylene carbon black which gives a smooth and ionically pure compound. Smoothness controls electrical stress enhancement at the screen-insulation interface (Mayoux). Ionic cleanliness is a concern in MV cables due to water trees, although ions in ground water may also play a role (Shaw). Steady advancements in smoothness and cleanliness in semi-conductive shields and insulation compounds have been reported (Gao and Burns).

Extensive research has been done and over 175 papers have been written on water treeing in XLPE (Ross). TR-XLPE based on additive technology was introduced in the early 1980's in North America and was shown to be somewhat less sensitive to conductor shield cleanliness than earlier systems. Concurrently, co-polymer insulations were introduced in other regions of the world (primarily Europe) with similar success. Through the last two decades steady advancements in smoothness and cleanliness in semi-conductive screens and insulation compounds had been reported. Conductor screen formulation technology is usually not discussed however.

Several patents have been issued on conductor screen technology including patent #4,612,139 (use of polyethylene glycol, patent # 6,299,978B1 (polyolefin with ethylene vinyl acetate (vinyl alcohol) terpolymer), patent #6,291,772 (antioxidant that increases the accelerated test life of cable insulation), patent #6,491,849B1 (use of ethylene vinyl acetate and amide waxes) and patent #6,864,429 (carbon black with a specific range of properties). Formulation technology is usually not discussed as playing a major role.

However, in this paper we demonstrate that in reality, formulation actually plays a key role in a conductor shields performance.

While there have been reports demonstrating better performance with clean furnace blacks compared to acetylene black, most published results still show a correlation between carbon black ionic and sulfur content or screen smoothness and performance. In this paper we demonstrate that formulation plays a dominant role in determining the performance of power cable screens when compared to simply assessing smoothness and cleanliness.

Time to failure and retained breakdown strength data on model and full size MV cores are presented.

Figures 1 and **2** show the smoothness and ACLT performance of three experimental copolymer conductor screen compounds.

15 kV XLPE cores were tandem extruded on a laboratory CV line and placed on test. Carbon black 2 had the highest sulfur level and Formula 2 which incorporated it had the least smooth surface yet it had over twice the life on test as the commercial low sulfur conductor screen compound. These formulas contained a unique antioxidant system (additive A) that may have protected the screen insulation interface. In addition it is believed the unique morphology of carbon black 2 changed the properties of the screen insulation interface. Earlier work suggested that formulation additives may modify or protect the interface (Gao).

The last cable on figure 1 with an indicated life of 635 days also contained a unique base polymer. No samples failed after 635 days on test. The polymer was no longer available at that time so the test was discontinued.

Figure 1 Laser surface scan smoothness of conductor screen formulations