Development of a new liquid antioxidant for stabilizing XLPE compounds or for direct peroxide injection (DPI) process.

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ABSTRACT

To satisfy the wire and cable markets increasing demands for improved performance and greater reliability, raw material suppliers must constantly innovate and develop new solutions. This is especially true for medium and high voltage cross-linked polyethylene (XLPE) cables where the trend for thinner wall insulation and thus improved dielectric properties, requires the use of extra clean materials, whether polymers or additives.

The need for greater performance and cleanliness also applies to the antioxidants used in these applications. The new liquid antioxidant developed by Addivant fulfills these requirements. The use of this new liquid antioxidant, which can be filtered prior to use, will allow enhanced levels of cleanliness and performance thus enabling greater reliability and extending the cable longevity in service.

This paper will present an overview of some of the technical data generated in the laboratory as well as some initial data generated from cables that have been produced by the so called DPI (Direct Peroxide Injection) process.

As a novel antioxidant, it shows significant stability and compatibility with commonly used peroxides. When pre-mixed with the peroxide before use in the cable manufacturing process, there are no signs of segregation, discoloration or premature cross-linking reactions occurring. The remarkably low freezing point that goes well below zero degrees Celsius, also allows greater handling and processing flexibility for cable producers.

Contrary to some of the other widely used antioxidants in XLPE compounds, it can be optimized to provide a balance between sufficient scorch protection and increased cross-linking speed. The new stabilization solution has very limited interaction with the peroxide during the cross-linking process. This enables the cable manufacturer to either marginally increase the CV line speed or to reduce the peroxide content hence providing increased productivity, cost savings and a reduction in the amount of peroxide cross-linking by-products that are generated.

KEYWORDS

DPI Process, Liquid Antioxidant, Filtration, Cleanliness, Peroxide Interaction, XLPE.

INTRODUCTION.

Antioxidants are added to essentially all polyethylene materials to inhibit the degradation caused by the oxidation that occurs during processing and use in service. This is also the case for XLPE insulated power cables where service temperatures are said to be 90°C with occasional local peaks in temperature up to 130 °C and are expected to last 40 years under these conditions. It is easily understood that to comply with such stringent conditions antioxidants have to be of an outstanding efficiency. Moreover, in order not to increase the insulation tan delta, their loading levels have to be exceptionally low when compared to any other cable additives. Typical loading levels range from about 0.18 % up to 0.5 % maximum. The mechanism by which an antioxidant operates inside a polyethylene matrix has been long demonstrated by the chemical industry [1] and won't be discussed in the present paper.

This paper will describe the development of a new liquid antioxidant system which was developed in response to the needs of the cable industry for an alternative liquid antioxidant for use in the DPI process. The following five areas of the development process will be discussed in more detail below:

Step One: Physical Properties
Step Two: Long Term Thermal Aging
Step Three: Cross-linking Kinetics and Peroxide Interaction
Step Four: Dielectric Considerations
Step Five: DPI Experience

Brief Overview of DPI Process

Regarding DPI, which stands for Direct Peroxide injection, the acronym doesn't really reflect the reality anymore. This is simply because, since the time it was first introduced, the concept has evolved as new technologies have been developed. Today, in many cable producers, the peroxide is not injected directly into the cable extruder but it is premixed with the un-stabilized LDPE base resin and liquid antioxidant very quickly in a "turbo-mixer" prior to being discharged into the extruder via a feed hopper. However, DPI has remained a generic name for these evolved processes.

The Direct Peroxide Injection Process (DPI) was developed in Europe in the mid 70's. It was originally intended for both LV and MV applications.

With time, the use of DPI in low voltage applications has been replaced by Silane cross-linking technology. However it has continued to grow in medium and high voltage applications.

Today it is claimed that the DPI process can be used up to at least 110 kV. Enhanced materials such as cleaner LDPE base resins, cleaner antioxidants and enhanced manufacturing processes could lead to the use of this process for even higher voltages.

The main reasons why cable makers adopted and further developed the DPI process were: