C9.1

High performance conductor shields for HV/EHV solid dielectric power cables

REID C. G., Union Carbide Corporation, Somerset, USA

Résumé

L'écran semi-conducteur extrudé sur âme est un composant important des câbles HT/THT à isolant sec, et affecte le rendement global du câble durant le processus de vieillissement. Les composés semi-conducteurs conçus spécifiquement pour ces applications offrent un interfacial poli de qualité supérieure, ne comportent aucune impureté ionique, et demeurent chimiquement inertes durant tout le processus de vieillissement électrothermique. Toutes ces propriétés se retrouvent combinées dans les écrans sur conducteur à base de noir d'acétylène, fabriqués à l'aide d'une haute technologie de compoundage et de polymères adaptés à une exposition prolongée à la chaleur. De nombreux essai, les comparant aux composés pour écrans sur conducteur conventionnels à base de suie, ont permis de démontrer que le rendement supérieur des câbles était attribuable à ces caractéristiques clés. Des essais sur des échantillons de laboratoire, des modèles de câbles types et des câbles de grandeur réelle sont présentés.

Abstract

The extruded semiconductive conductor shield is a critical component of HV/EHV solid dielectric cables and affects the overall cable performance during the aging process. Semiconductive compounds designed specifically for these applications have superior interfacial smoothness, an absence of ionic impurities, and exhibit chemical inertness during the electro-thermal aging process. The combination of these properties is found in acetylene black-based conductor shields prepared with advanced compounding technology, polymers with suitable rheology, and formulation technology for long term heat exposure. These key characteristics are shown to be responsible for improved cable performance properties in several different tests compared to conventional furnace carbon black-based conductor shield compounds. Tests on laboratory samples, model cable designs, and full size cables are presented.

Introduction

Extrudable semiconductive materials are a critical component of a solid dielectric insulated power cable. The primary purpose of the resistive shield is to ensure uniform electric field potential at the interface between the conductive and dielectric components of the cable design. However, several factors can cause the field to be non-uniform at the electrical interface, leading to the electrical degradation of the primary dielectric layer.

Over the last forty years, the primary goal of research and development efforts on materials used for solid dielectric insulation systems of power cable has been to increase the useful life of the cable within reasonable cost. Improvements of several orders of magnitude have been made to the quality of materials (semiconductive shields, insulation, and jacketing) cable design, and cable manufacturing. These factors, in turn have provided for improved reliability of underground power transmission and distribution with solid dielectric cable designs.

The importance of the semiconductive layer to the overall cable performance is a factor that cannot be neglected by the cable design engineer due to the abundant evidence that improved quality products have resulted in improved life of cables in laboratory testing [1].

There are two broad classes of semiconductive shields for power cable (ie, semicons) which are currently in industrial use. *Conventional* semicons are those manufactured from conductive grades of furnace process carbon black. *Supersmooth* semicons are manufactured with acetylene black and are used especially for use on HV and EHV cables. Supersmooth semicons exhibit significantly improved smoothness, cleanliness, and purity, relative to conventional semicons.

Supersmooth semicons were commercially introduced in North America from Japan around 1985, and commercial scale production of supersmooth semiconductive compounds in the United States was initiated in 1990. The result of this technological advantage in the United States and Canada is that nearly 50% of MV, and 100% of HV and EHV cables, are now made with supersmooth conductor shields. Supersmooth compounds were also introduced into Europe around 1985 and are used in many HV/EHV cable constructions. By the end of 1998, over 15 k-tons of acetylene black-based supersmooth semiconductive material has been produced in the United States and utilized for the worldwide production of cables from 5 to 500kV. This quantity is enough to produce over 1 million km of 50 mm^2 conductor with an 0.4 mm shield, or over 100,000 km of 1000 mm^2 conductor with a 1.0 mm shield.

Materials

For this paper, several semiconductive products were tested, as shown in Table 1. The polymers used for the