B.4.4. Essais de pelabilité pour les écrans semi-conducteurs

CHIN H.H., WHITEHOUSE R.S., Cabot
Corp., Billerica, Etats-Unis

B.4.4. Peel test for semiconductive shields

CHIN H.H., WHITEHOUSE R.S., Cabot
Corp., Billerica, U.S.A.

Résumé

Actuellement, deux procédures de test sont utilisées pour déterminer les forces requises pour peler la gaine semi-conductrice de la couche d'isolation. Ces procédures sont respectivement basées sur des forces appliquées à des angles de 90 et de 180 degrés. Des résultats expérimentaux ont démontré que les forces requises différaient d'un angle à l'autre. Habituellement, les forces requises à 90 degrés sont supérieures à celles requises à 180 degrés. Une approche théorique sera introduite pour corréler les différences entre les résultats provenant des deux procédures. En utilisant le principe de la conservation de l'énergie, les forces de pelage peuvent être séparées en deux composantes à savoir, un travail d'adhérence (contribution de l'énergie de fracture) et une composante de fléchissement reliée à la rigidité de la couche sime-conductrice pelée. Des exemples seront donnés pour valider la théorie et la sensibilité des deux procédures de test.

Abstract

Currently two test procedures are being used to determine the peel force required to delaminate the semiconductive shield from the insulation layer. These are based on peel angles of 90° and 180°. Experimental results had shown different peel forces from these two peel angles. 90° usually resulted in higher peel force than 180°. A theoretical approach will be introduced to correlate differences between the two procedures. The peel force, using any energy balance equation, can be separated into two components, namely a work of adhesion (fracture energy contribution) and a bending component relating to the stiffness of the peeling semiconductive layer. Examples will be shown to validate the theory and sensitivity of the two test procedures.

Introduction

The power cables designed for medium to high voltage applications consist of a copper or aluminum core conductor, a layer of semiconductive shielding, a layer of insulation and a layer of semiconductive insulation shielding. The insulation layer is predominantly either crosslinked polyethylene or crosslinked ethylene propylene rubber (EPR). Generally the conductive layer contains carbon black and at least one ethylene copolymer containing vinyl acetate or an alkyl acrylate as comonomer. During the installation of the cable it is often necessary to make splices and terminal connections, this requires the clean delamination of the insulation shield layer from the insulation layer. Therefore a strippable semiconductive insulation shielding which can be easily stripped from the insulation layer will be desirable. This is often achieved by increasing the amount of polar comonomers, elastomers [1] or migratory additives [2,3]; all of which substantially increase the cost of the compound. However, a minimum strip force is required to maintain the mechanical integrity between the insulation layer and the semiconductive insulation; if the force is too low then loss of adhesion may result in water diffusing along the interface causing electrical breakdown.

The peel force [4] required to delaminate the semiconductive shield from the insulation layer has been an important factor for wire and cable industry. Because the size and geometry of the cables vary it is difficult to carry out comparative peel strength testing on actual cable construction. Prescreening of the peel force measured from a molded plaque test assembly will give a good indication about the final cable performance. The current study is focused on the two test procedures for measuring the peel force.

Traditionally a 180° test is employed in Europe [5] while a 90° test is used in US [6] for cable testing. The difference between the two test procedures are discussed here.

Experimental

Material

The insulation layer used in this evaluation were crosslinked polyethylene commercially available from Union Carbide (HFDE 4201 and HFDE 4202).

For the peel test data using different peel angles commercially available semiconductive compounds were used. The specific grades are noted later in the text.

For the theoretical validation test model formulation containing EVA resin and carbon black were used. The materials were compounded in a Banbury mixer together with antioxidant (0.5 %) and organic peroxide (1%); the organic peroxide was added at the end of the mixing cycle to minimize premature crosslinking.

Plaque

Individual plaques of both the insulation layer and insulation shield materials were prepared by compression molding the pelleted materials at 250°F (121°C); this temperature allowed smooth plaques to be formed without activation of the organic peroxide. The two layers were then laminated at 250°F (121°C) for 5 minutes to allow prewetting and then cured at 356°F (180°C) for 15 minutes. The dimension of the final plaque is 4" x 12" (100mm x 300mm). The insulation layer has a thickness of 0.039" (1mm) and the insulation shield has a thickness of 0.079" (2mm). Five strips of 0.5" x 12" (12.5mm x 300mm) were cut in the semiconductive layer, the insulation layer is not cut thus maintaining a more rigid strip substrate. The strips were debonded from the plaque. The peel force of