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A.6.2. Essais sous tension continue des câbles à isolation polyéthylène réticulé

PARPAL JL., GUDDEMI C., AMYOT N.,
DAVID E., IREQ, Varennes, Canada

A.6.2. DC Testing of XLPE insulation

PARPAL JL., GUDDEMI C., AMYOT N.,
DAVID E., IREQ, Varennes, Canada

Résumé

Les essais sous tension continue après pose, réparation ou pour des fins de maintenance, ont pour but de déterminer tout changement des propriétés diélectriques de l'isolation des câbles souterrains. Afin de déterminer l'influence de la tension continue sur la durée de vie de l'isolation polyéthylène soumise à la tension alternative, nous avons préparé des échantillons en forme de gobelets qui étaient réticulés avec une ou deux électrodes semi-conductrices. La moitié des échantillons a été soumise à la tension continue pendant le vieillissement sous tension alternative. Le temps de vie a été mesuré en environnement sec ou humide à la température de la pièce. L'effet de la tension continue sur la durée de vie et la longueur des arbres d'eau, sous tension alternative, est discuté. Des résultats préliminaires sur la sensibilité de la tension continue et du 0,1 Hz à détecter un défaut artificiel sont présentés.

Abstract

DC testing is used extensively to verify the dielectric integrity of underground cables after laying of materials, repair or maintenance. Although DC testing is very simple and inexpensive (small size equipment test), there is some concern that it potentially affects the life-time of polymeric insulation. In order to evaluate the influence of DC testing on the life-time of XLPE insulation under AC stress, extruded cup-shaped polyethylene samples crosslinked with one or two semiconductors were prepared. Half of the samples were subjected to periodic DC tests during the AC aging. The time-to-breakdown was measured on these samples in wet and dry environments at room temperature. The effect of DC conditioning on AC time-to-breakdown and water-tree lengths are discussed. Preliminary results on the sensitivity of DC and VLF tests to detect similar defects are also presented.

Introduction

The DC test was inherited from paper-oil-insulated underground distribution cable techniques where it is very efficient. However, its sensitivity for detecting defects in polymeric insulation is limited, as shown by numerous studies on the subject [1-4]. Furthermore, many utility engineers are concerned about whether DC testing is detrimental to the polymeric insulation of the cables and joints to the point where the life expectancy of these materials is reduced. The debate between the pro and cons of DC testing on polymeric insulation has been raging for many years but there are very few reported studies to help determine wether this test should be eliminated and replaced by low-frequency (0.1 Hz) or oscillating-wave testing.

A study by Faremo *et al.* [5] revealed that the application of a DC voltage to new or aged XLPE cables (12 or 24 kV, 9-10 years in service, presence of water trees) has no effect on the AC breakdown voltage. Also, these authors suggested that a failure during application of the DC voltage could reduce the AC breakdown voltage of the rest of the cable insulation. Schädlich *et al.* [6] reported similar results when they tested 10-m lengths of 20-kV XLPE cables that had been in service for up to 17 years. To our knowledge, it is only the study of Srinivas *et al.* [7,8] that has suggested that the application of DC voltage on cables with water trees reduces their life-time.

In order to assess the influence of DC on the life-time of XLPE insulation under AC stress, laboratory samples made of extruded cup-shaped polyethylene crosslinked with one or two semiconductors were tested with either artificial defects (protrusions and holes) or water trees. Half were subjected to periodic DC tests during the AC aging and the time-to-breakdown was measured in a wet or dry environment at room temperature. The effect of DC conditioning on AC time-to-breakdown and water-tree length is discussed.

Furthermore, a comparative study between AC, DC and VLF was performed on some samples with moulding defects or protrusion at the semiconductor interface in order to evaluate the sensitivity of these tests to detect such defects. The relative breakdown values (E_{BD}/E_0) for each test are presented.

Experimental

The study was performed on XLPE and TR-XLPE samples using semiconductors as electrodes to reproduce the cable structure and a uniform electric field. The cup-shaped samples were prepared by the Industrial Materials Institute (IMI) of Canada. They were moulded with commercial polyethylene pellets by an industrial process. The semiconductors were first extruded in a ribbon (5 mm × 0.5 mm) then disks were cut with diameters corresponding to the inner and outer dimensions of the polyethylene samples [9]. The semicon disks were then crosslinked with the moulded polyethylene cups at 180°C under 7 atm of nitrogen for 15 min. The typical gel fraction and density of the samples were respectively 82% and 0.9182 g/cm^3 A maximum of 40 samples were crosslinked at the same time.

Two types of IMI samples were prepared: one with inner and outer semiconductors (Figure 1a), which served mainly for the study of samples with defects under dry conditions, the second with only an external semiconductor (Figure 1b) for wet aging. The major defects were protrusions (0.4 - 0.5 mm) and holes (0.5 - 0.8 mm) for the first type and water trees for the second.

A screening test was performed on each sample prior to the aging test, which removed 40% of the total population (application of 25 kV AC for 1 min). In addition, some samples failed very soon after the aging test began, leaving about 50% of the total number of IMI samples to be aged under AC voltage. For each population of samples, half were subjected to AC voltage only, while the others were exposed to AC and periodic DC voltages. The aging conditions differed for the different populations of samples as shown in Tables 1 and 2.