JICABLE '99

B4.3

The effect of temperature on dielectric characteristics of XLPE

TANAKA T., TANAKA A., Tokyo Electric Power Co., Yokohama, Japan
SHIBATA T., HIROTSU K., Sumitomo Electric Ind. Ltd., Osaka, Japan

Résumé

Le mécanisme de détérioration de XLPE à température élevée a été étudié en se concentrant principalement sur le phénomène d'électroluminescence observé à l'aide d'échantillons modèles d'électrodes plates à aiguilles qui simulent la forte concentration électrique se formant autour des impurités de l'isolation des câbles. Le voltage initial de l'électroluminescence mesuré à température élevée résulte inférieur à celui mesuré à température ambiante. En outre, l'isolation entourant la pointe de l'électrode à aiguilles, une fois le voltage supprimé, a été analysée au radiospectroscope photo-électronique. Une oxydation importante a alors été détectée dans l'échantillon testé à température très élevée. Ces résultats portent à croire qu'une forte charge est injectée à température élevée et que l'oxydation de XLPE est favorisée par la température élevée.

Abstract

The deterioration mechanism of XLPE under high temperature is studied, focusing mainly on the electrical luminescence phenomenon observed in needle-plane electrode model samples, which simulate the high electrical concentration around impurities in cable insulation. As a result, the electrical luminescence inception voltage measured under high temperature is decreased compared with that measured at room temperature. Insulation around the needle electrode tip was analyzed with an X-ray photoelectron spectroscope after the application of voltage. As a result, much oxidization is detected in the sample tested under higher temperature. From these results, it is considered that larger charges are injected under high temperature, and the oxidation of XLPE is promoted.

1. INTRODUCTION

Insulation properties of cross-linked polyethylene (XLPE) cables have been improved by reducing defects such as voids, impurities and protrusions, through advances in manufacturing technologies. Long-term deterioration caused by these defects is an issue of serious concern[1][2][3], particularly at high electrical stress. On the other hand, there are reports describing a decrease in the dielectric characteristics of XLPE cable under high temperature. It is very important to understand the deterioration mechanism of XLPE under high temperature to improve the long-term reliability of XLPE cables.

This paper describes the results of studies on the deterioration of XLPE under high temperature, focusing mainly on the electrical luminescence phenomenon observed in the needle-plane electrode samples which simulate the regions of high electric field concentration. The electrical luminescence phenomena is generally known as a pre-breakdown phenomena prior to the inception of electrical trees[4][5]. The electrical luminescence component includes ultraviolet light which has enough energy to break C-C bonds of the polyethylene molecules. It is considered that the free radicals, generated at the time of molecular chain scission, promote the formation of oxides in the presence of oxygen. Moreover, to confirm the formation of oxides due to voltage application under high temperature, insulation around the needle electrode tip was cut out and analyzed with an X-ray photoelectron spectroscope (XPS).

2. EXPERIMENTS

2.1. Samples

Needle-plane electrode samples used in experiments are shown Fig.1. These samples simulate the impurities and protrusions that affect the performance of XLPE cable. As a high voltage electrode, a needle electrode of a 3 to 20 μm radius curvature is molded inside a XLPE sheet of 45X20X4 mm. A plane electrode is formed by coating with conductive paste on the opposite surface of the XLPE block. Hence, the electrode space is 3.0 mm. It is confirmed by an optical microscope that there is no gap at the interface between the tip of the needle electrode and the XLPE. The radius of the needle tip is measured with the optical microscope to an accuracy of ±0.1 μm. To avoid