Approach to CBM Based on Recent Knowledge of Deterioration Process of Aged XLPE Cable Accessories

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ABSTRACT

HV XLPE cable has been used for approximately 50 years since its first introduction. Given that the design lifetime is from 30 to 40 years, application of appropriate measures by Condition Based Maintenance (CBM) for aged facilities is required. As for accessories, deterioration has become apparent in some products, but since various structures and materials are used, it is necessary to apply diagnostic methods that focus on individual deterioration modes. In this paper, two cases of deterioration modes experienced by TEPCO and its diagnostic techniques are presented. Furthermore, development of partial discharge measurement technique for improved accuracy is reported.

KEYWORDS

Taped joint; pre-fabricated termination; partial discharge measurement;

INTRODUCTION

HV XLPE cables have been installed in the area around Tokyo for about 50 years, and the current installed capacity has reached about 7,800 km. There are approximately 2,400 km (about 30%) that have exceeded their design life of 30 years. The challenge is to maintain reliability through appropriate maintenance for the large amount of aged equipment. In the past, maintenance was based on TBM, but in order to maintain both reliability and efficiency, a CBM approach has been introduced for maintenance.

In particular, degradation has become apparent in some accessories that have a variety of structures and materials used. Degradation is not uniform. It is necessary to elucidate the deterioration modes for each type of equipment and to apply appropriate diagnostic methods. This paper introduces examples of clarification of deterioration modes of equipment, development of diagnostic techniques, and their actual application based on our experience with equipment accidents.

The first case is a taped joint where deterioration due to oxidation of the insulation tape has been observed. A diagnostic method focusing on this deterioration mode has been developed and applied.

Secondly, we will present a case study of pre-fabricated terminations, where electrical breakdown has been occurring in recent years. We have observed a lot of degradation due to partial discharge (PD) related to deposits at the insulator interface. In response to this, we will introduce a diagnostic method using gas analysis, which has been increasingly applied in recent years.

Finally, we report on the progress of the development of advanced PD diagnostic technology. Incorporating real-time AI-based decision logic, noise removal through optimal filtering of data, and appropriate PD determination technology are being developed.

1. TAPED JOINT

Background

Taped joints (TJ) were applied in the early stages of the introduction of XLPE cables after the 1970s, and the proportion of aging equipment is high.

When we conducted a test to operate the TJ at high temperatures, we confirmed that the ethylene propylene rubber tape (EPR tape) oxidized and deteriorated due to the oxygen contained in the cable and insulation, and that it could break and lead to insulation breakdown [1].

Based on this experience, we focused on oxidation deterioration as a deterioration mode of TJ, and devised a life evaluation method based on this.

Investigation of lifetime evaluation by oxygen induction time [2]

a. Consideration method

The EPR tape used for the reinforcing insulator of the TJ was investigated.

The oxidative deterioration tendency of EPR was confirmed by volume resistivity and AC breakdown electric field as electrical properties, elongation as mechanical properties and oxygen induction time (OIT). A new EPR tape was oxidatively deteriorated at 180°C for 0-20 hours using a gear type aging tester. OIT, volume resistivity, AC breakdown field, and elongation were measured at 205°C for deteriorated samples taken out at arbitrary intervals.

b. Measurement results and examination results

Fig. 1 shows the changes in volume resistivity, AC breakdown field, and elongation. It can be confirmed that the electrical and mechanical properties of the tape deteriorate due to oxidative deterioration, leading to breakage and electrical breakdown. Fig. 2 shows the change in OIT over time and the change in volume resistivity characteristics side by side on the same graph.

From Fig. 2, it was found that the oxidation deterioration time and OIT (logarithmic display) show linearity even in the region where the volume resistivity does not change. Furthermore, the concept of EPR lifetime can be defined as the time at which the electrical properties begin to degrade. The OIT value at that time is the value at the end of the life of the EPR. Therefore, OIT is assumed to indicate the