

Evaluation on Practical Application of the Gas Analysis Technique for XLPE Cable Terminations

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ABSTRACT

The authors applied the diagnosis method of abnormality based on the concentration of acetylene gas inside aged 77 kV XLPE cable terminations on 762 samples of actual cable lines. This method contributes to the prevention of insulation breakdown of cable lines. In addition, six samples of 77 kV XLPE cable terminations were removed and subjected to a breakdown voltage test. It was confirmed that the breakdown voltage values of the samples had been reduced by half compared to the original values. These results suggest that the use of this method is suitable for investigating the degree of internal degradation.

KEYWORDS

XLPE cable termination, Diagnosis method of abnormality, Gas analysis method, Acetylene gas concentration, Partial discharge, Partial discharge initiative voltage, Breakdown voltage

1. INTRODUCTION

Partial discharge (hereafter referred to as PD) occurs in cables, joints or terminations of aged XLPE cable lines as a precursor to insulation breakdown due to degradation. Therefore, continuous monitoring by PD measurement is effective in preventing insulation breakdown of cable lines. ⁽¹⁾⁽²⁾⁽³⁾ In recent years, the quality of XLPE cables manufactured in factories has improved significantly. On the other hand, the assembly work for the termination is carried out on-site during construction, where the dust environment is inferior to that in the factory. Therefore, the termination is considered a weak point of XLPE cable lines.

In order to investigate the diagnosis method of abnormality in XLPE cable terminations, the authors measured the acetylene gas concentration in terminations of 77kV XLPE cable lines installed in many locations in Japan where internal gas sampling is possible, and removed and disassembled such terminations to investigate the degree

of degradation inside the terminations. As a result, a correlation between the detected acetylene gas concentration and the degree of degradation of the terminations was confirmed, and the diagnosis method of abnormality based on the acetylene gas concentration inside the terminations (hereinafter referred to as the GA method) began to be applied to actual 77kV XLPE cable terminations in FY2010 ⁽⁴⁾⁽⁵⁾⁽⁶⁾.

This paper describes the results of the diagnosis method of abnormality using the GA method for 762 samples of 77 kV XLPE terminations on actual cable lines from FY2010 to FY2021. The paper also describes the results of evaluating the relationship between the concentration of acetylene gas and the insulation characteristics of the terminations by removing six samples of 77 kV XLPE cable terminations with high concentrations of acetylene gas from the site and performing PD measurements and breakdown voltage tests at commercial frequency.

2. OVERVIEW OF THE GA METHOD FOR 77KV XLPE CABLE TERMINATIONS

Figure 1 shows an outline of a 77kV XLPE cable termination. Insulating materials such as epoxy resin insulation and pre-molded rubber (ethylene-propylene rubber) are used for the electrical insulation of the cable termination. The interface in the termination is composed of epoxy resin insulation and pre-molded rubber, and pre-molded rubber and XLPE insulation. Silicone oil is applied to the surface of the insulating materials in order to improve the insulation performance, resulting in silicone oil remaining at the interface. When a high electric field in XLPE cables and pre-molded rubbers is applied to the silicone oil, voids and other defects form at the interface due to solidification of the silicone oil.

PD occurred in these voids, resulting in the generation of acetylene gas and other gases. Although the amount of acetylene gas generated is reduced by various chemical reactions, such as reactions with the copper part of the protection casing, some of the gas accumulates inside the protection casing of the termination. Since the generation of acetylene gas requires a large amount of energy, such as PD, the detection of acetylene gas indicates that PD is occurring within the termination.

Figure 2 shows a schematic diagram of the relationship between the concentration of acetylene gas and the degradation inside the terminations. Figure 3 shows photographs of the degradation in the terminations (after sampling and disassembly). There is a positive correlation between the progression on the degree of degradation and the increase in acetylene gas concentration. If high concentrations of acetylene gas are detected, black products and discharge erosion marks are expected to appear at the interface within the termination, leading to concerns about degradation of the termination's insulation

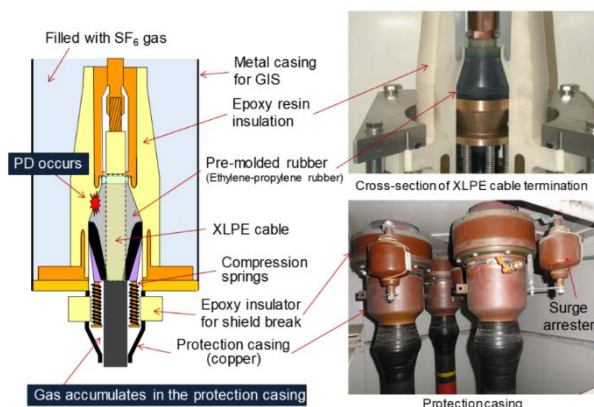


Fig. 1: Outline of the XLPE cable termination