INVESTIGATION OF REMAINED WITHSTAND VOLTAGE LEVEL AND WATER TREE DEGRADATION ON AGED AND REMOVED XLPE CABLE

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ABSTRACT

In Japan, 77 kV class XLPE cables has been introduced into the power transmission system since almost 40 years ago, and some of them have been operated in the actual grid for around 30 years which is the same duration as the designed life time. The authors have been investigated the remained withstand voltage level on removed XLPE cables operated for around 30 years using the pre-breakdown discharge detection test. As a result, a water tree with needle shape can be a major cause of the degradation, and the deterioration characteristics of the electrical insulation are depicted.

KEYWORDS

XLPE cables, Water trees, Pre-breakdown discharge detection test, Aging, Electrical insulation.

INTRODUCTION

77kV class XLPE cables have been widely introduced in the power transmission system in Japan since 1960's[1], which have been introduced in urban underground transmission networks. As of the end of FY 2008, their circuit length is almost 7,000 km [2]. Thus their roles in the power transmission system have been more important ones.

Here, in order to maximize the operation efficiency of aged XLPE power cables, the electrical insulation performance of XLPE cables operated for around 30 years has to be investigated and their degradation cause has to be depicted. Thus, the authors have been investigating the electrical insulation performance and degradation cause of aged XLPE cables operated around 30 years, using pre-breakdown discharge detection test. This paper firstly introduces the testing technique, and then describes the electrical insulation performance and the degradation cause, which is a water tree, for the aged and removed XLPE cables. Finally, the degradation characteristics of the aged XLPE cable are depicted.

TESTING TECHNIQUE

A specimen is applied with ac high voltage with step-up method for the voltage withstand test and investigation on its electrical insulating performance. XLPE power cable is also applied with ac high voltage with step-up method, however, only breakdown path can be seen after the test and its cause such as a defect and a void can never be obtained. Here, the breakdown is followed by the precursor discharges, called a partial discharge (PD). Thus, if we can detect the occurrence of PD and shut down the applied voltage before the breakdown, the degradation cause can survive. Moreover, the applied voltage when the PD can be obtained is considered to be the same as the breakdown voltage, because the breakdown will occur immediately after the PD occurs.

The technique mentioned above is called "pre-breakdown discharge detection test" and was developed in 1980's [3]. We have adopted this technique for the aged and removed XLPE cable with its length of around 100 m. Fig. 1 shows the outer view of the pre-breakdown discharge detection test system introduced in CRIEPI. The ac high voltage source of the system can supply ac high voltage up to 450 kV, has a power capacity of 400 kVA, and initiate no corona up to 450 kV.

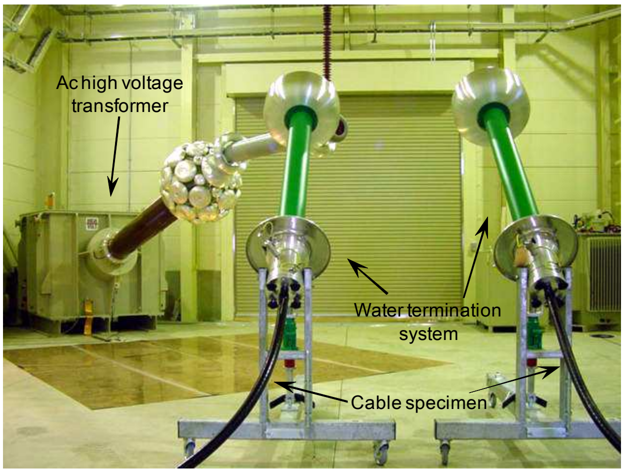

Fig. 1: Outer view of the pre-breakdown discharge detection test system

Fig. 2 shows the schematic diagram of the pre-breakdown discharge detection test system. The system has a high speed cutoff system to shut down the ac high voltage application immediately after receiving the shutdown control signal, within 50µs. So, if a PD can be detected and the control signal is sent to the high speed cutoff system, the applied ac high voltage may be shut down before the breakdown occurs, otherwise the breakdown occurs and the cause of the degradation is burned out.

Therefore, noise reduction in PD measurement is very important technique for the test. One countermeasure is to adopt a water termination system in order not to initiate any coronas at the cable terminations. The other is to adopt two sets of differential PD measuring systems. These systems can make reliability of PD measurement higher by means of eliminate the PD signals occurring in the cable insulation layer from signals including noises.

The test procedure is as followings; the shielding layer is firstly divided into 4 sections by removing copper shielding layer with 2 cm width and each section are connected with