DEVELOPMENT OF AN INNOVATIVE RESIDUAL-CHARGE MEASUREMENT TECHNIQUE FOR WATER-TREE DETERIORATED XLPE CABLE

Hiroyuki KON, VISCAS Corp., (JAPAN), hi-kon@viscas.com
Hideo TANAKA, VISCAS Corp., (JAPAN), h-tanaka@viscas.com
Toyoshi TSUKAMOTO, Tokyo Electric Power Co., (JAPAN), tsukamoto.toyoshi@tepco.co.jp
Hideaki SATO, Tokyo Electric Power Co., (JAPAN), Sato.Hideaki@tepco.co.jp
Koichi ONUKI, Tokyo Electric Power Co., (JAPAN), oonuki.kouichi@tepco.co.jp

ABSTRACT

Several diagnostic techniques for water-tree deteriorated XLPE power cable of 22-77kV class have been applied in JAPAN. Residual-charge measurement technique is one of them, and has been applied to 22/33kV-class XLPE power cables. In the conventional residual-charge technique, DC voltage application of -30kV for 22kV-class XLPE power cable is necessary for charge accumulation in water trees before following AC voltage application, however DC voltage is often restricted to be reduced to -10kV in some case. Therefore, we developed new residual-charge technique with cut-off AC voltage at phase angle 0 degree, which is the substitution for DC voltage application as pre-applied voltage. Electric charge accumulates in water tree during last AC half cycle, which is cut off at phase angle 0. In this paper effectiveness of this new technique in residual-charge measurement is presented, which has enabled to eliminate the some restriction in applying DC voltage. Some results of on-site tests are also presented.

KEYWORDS

residual charge, water tree, DC voltage, cut-off AC voltage

INTRODUCTION

It is well known that water-tree deterioration of XLPE power cable is one of the factors that decrease breakdown voltage. Therefore, several diagnostic techniques have been investigated in JAPAN. Residual-charge measurement technique, which was firstly developed in Central Research Institute of Electric Power Industry [1] and has been improved [2], is one of them.

In the conventional residual-charge measurement technique [1], total residual charge or residual charge per unit length (C/m etc.) is used as an index for determining the degree of water-tree deterioration.

Water tree degradation degree in not generally uniform in the whole length of each cable since surrounding condition of cable varies depending on the circumstances.

On the other hand, dielectric performance such as breakdown voltage strongly correlates to the longest (weakest) water tree. Therefore, accurate diagnosis is not possible by the conventional residual charge measurement technique, in which the total amount of residual-charge or residual charge per unit length are the index of diagnosis since they depend on the total amount of water trees.

Considering the above difficulty in diagnosis by using indexes which depend on the amount of residual charge, new residual-charge measurement technique has been developed [2]. In this technique, maximum electric field strength, at which residual charge is detected (Er), is used as the index of water-tree diagnosis. This index, released electric field strength, is measured as follows. (1) Step-like increased AC voltage is applied to the cable, (2) Residual charge is measured at each voltage step and (3) The maximum electric field at which residual charge is detected shall be Er. This is named as “step-like AC voltage application method”. It is reported that Er corresponds to the longest water tree and not to correspond to the number of water trees. Hence, diagnosis result is independent of the length of cable. The effectiveness of this technique has been also confirmed by on-site tests.

“Step-like AC voltage application method” is effective, but this technique also requires DC voltage application to accumulate charge in water trees before following AC voltage application as conventional ones. DC -30kV is usually applied to 22kV-class cables, but this DC voltage application is restricted to be reduced to -10kV in some case due to the GIS termination structure and so on. From this point of view, we have investigated the possibility of diagnosis with DC -10kV voltage application and have confirmed that it is possible in this case. However, detected charge signal becomes smaller than the case of DC -30kV. It may lead to a less reliability of diagnosis.

To eliminate this inconvenience due to DC -10kV application, we have developed the residual-charge technique without DC voltage application combined with “step-like AC voltage application method”. The remarkable feature of the new technique is that no DC voltage application is required throughout the whole measurement procedure including charge accumulation in water trees. In this technique, AC voltage cut off at phase angle of 0 degree is used for charge accumulation in water tree instead of DC voltage. This AC voltage is named as “cut-off AC voltage” in this paper. Cut-off AC voltage gives many advantages, not only the elimination of DC voltage application but also the reduction of total measurement time due to the substitution of 10 minutes DC voltage pre-application to 10 seconds cut-off AC voltage pre-application.