DEPENDENCY OF THE DISSIPATION FACTOR ON THE TEST-VOLTAGE AND THE AGEING STATUS OF MV PILC CABLES

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ABSTRACT

Diagnostic systems for the MV PILC cables are mostly based on measurements of the partial discharge (PD) levels. For some cables and for special applications either the dissipation factor tan(δ) or the dielectric response in form of the polarization and depolarization currents or the return voltages are measured. In this article, the attention will be directed to the interpretation of measured values of the dissipation factor and its dependency on the test-voltage and the cable age or ageing history. All presented results were determined using the so called ICAAS (Integrated Cable Accelerated Ageing System). The test field is made up of 57 selected samples and comprises different age groups, starting from new cables up to cable samples that have been in operation for 20, 40, 45 and 60 years. The measurements were accomplished under defined and monitored environmental conditions, using test voltages starting from 0.4 up to 2.2 times U_n. All measurements are based on the nominal network frequency of 50Hz to ensure realistic field, test and ageing conditions in the insulation material.

KEYWORDS

Cables, Diagnosis, Ageing, Dissipation Factor, Voltage dependency

INTRODUCTION

The power cables represent one of the biggest assets in our today's MV power networks. At the same time they represent a major source of the faults. In many metropolitan areas within Europe still PILC (Paper Isolated Lead Covered) cables are the backbone of the distribution systems, even they have been partially replaced since the 80th. Therefore, many of the PILC cables have already reached a critical stage, resulting in an increasing number of expected faults in the next decades. In order to predict the failures and to avoid consequences for the network operation, it is and will be even more important to have a reliable and accurate knowledge about the cable condition and its rest-lifetime. In this way, the further development of condition based investment and maintenance strategies is coming into the focus.

The cable condition can principally be estimated by an application of one of the diagnostic methods available on the market. Most of the systems are based on a single parameter like the partial discharge (PD) levels (inception voltage and intensity). Only some diagnostic companies already have an experience in the usage of the dissipation factor tan(δ) for selective cable types. Unfortunately, most of the test systems established on the market are designed and specialized for cross-linked polyethylene (XLPE), thermoplastic polyethylene (PE) and ethylene-propylene rubber (EPR) insulated cable systems. In order to deepen the knowledge about the ageing processes that happen in the PILC cables, an automated system for its artificial and accelerated ageing was developed and realized in the recent years. The functionality of the so called ICAAS will be briefly presented in the following paragraph. The test field is made up of 57 selected cable samples with a nominal voltage of 20kV and a length of 13 m. Most samples were taken out of field operation with a strongly differing operation history. The samples reach from new cables over 10 years old unused and stored cables to cable samples that have been in operation for 20, 40, 45 and up to 60 years. First measurements of the dissipation factor, the partial discharges, the return voltages and the polarization and depolarization currents had been done before the artificial ageing began [1-2]. Moreover, the environmental and electrical test parameters, like e.g. the temperatures and the applied voltages, etc. were varied in wider ranges and monitored, so that their influence on the diagnostic parameters can be analysed. The measured values are of the highest interest, as they can and will be used as references and key parameters for the interpretation of the natural ageing processes in field operation. Additionally the measurements will help to determine the ageing acceleration or the ageing factor artificially made in the ICAAS.

In this article some results out of more than 20.000 dissipation factor measurements will be presented. Therefore, the influence of the test voltage and the cable age on the tan(δ) values of selected cables and for selected temperatures will be presented and discussed.

ARTIFICIAL AGEING EXPERIMENT ON PILC CABLES

The cable insulation materials deteriorate with the time, first of all due to the physical and electrical fundamentals like the temperatures and the electrical field, the average load, load cycles, overload phases, overvoltage, etc. Further, the speed and acceleration of the ageing is affected by an increase of the humidity, impurities, in-homogeneities or contaminations in the insulation or impregnation and the cable laying conditions (laying temperature, curvature radius, staff experience, etc.). In the case of PILC cables there are also additional factors that can shorten the cable lifetime, which are a mass deficit/ drying-up (mass/oil) and a degradation of the cellulose.

By means of the intensive measurements and monitoring of the electrical and diagnostic properties of the cable insulation, a better understanding and rating of the influence of the ageing factors mentioned above could be reached. The wide age range of the PILC cable samples in the test field representing nearly a complete cable operational lifetime will help to understand the complex dependencies. Moreover, the parameter developments during the ageing process as well as a deep analysis of the dependencies on the electrical and environmental test conditions should approve the interpretation of the