Comparison of the Detectability of PDs at an Artificial Surface Discharge Fault on a 20-kV-XLPE MV-Cable under AC, Damped AC, VLF-Sine, VLF-Rectangle and VLF-Cosine-Rectangle

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ABSTRACT

This paper discusses the impact of different test voltages on an artificial surface discharge failure in a cable system regarding the formation of partial discharges. Since the On-Site test voltages on the market vary in shape, form and frequency [1, 2, 3], it is of major interest, if the used test voltage may influence the occurrence of PDs in the cable system. Therefore, this investigation focuses on the comparison of different PD parameters under various voltage types and offers an insight into the performance of the used test voltage. The PD data, obtained at an artificial 20-kV-cable failure, will be evaluated in terms of number of PDs per period, fingerprints, amplitude distribution, and share of amplitude distribution. A comparison between the different test voltages helps to understand the formation of PDs at a surface discharge setup and shall enhance the acceptance of alternative test voltages.

KEYWORDS

Partial Discharges, Artificial Accessory Failure, On-Site Test Voltages, Damped AC, VLF-Sine, VLF-Rectangular, VLF-Cosine-Rectangular, PD detection

INTRODUCTION

Partial Discharge measurement is a key method for On-Site cable assessment as it helps to detect possible failures in the cable construction without the need of breaking down the cable during the test time [1]. Since a cable represents a strong capacitive load, testing at nominal continuous AC voltage at or above the operating voltage level would require a very powerful voltage source. Alternative test voltages, avoiding this reactive power problem gained more and more importance in the last decades. In previous investigations, the performance of alternative test voltages was investigated using artificial cable failures such as needle defects [4]. In focus of these evaluations were the PD-Inception at the needle tip and the breakdown potential of the used test voltages. However, since the PD measurement is widely accepted for On-Site tests, the test can be performed non-destructively, shifting the focus breakdown test to the measurement of PDs itself. Additionally, it is well known, that possible defects in a cable system can differ greatly, leading to defects, which can either breakdown fast or lead to PD which last for days and months [5]. It is of major interest, that On-Site test voltages are capable to generate a sufficient PD amount and amplitude at these failures for a detection and mapping of the PD origin.

For a comparison between different test voltage types, the PD characteristics such as PDIV (PD inception voltage) and PDEV (PD extinction voltage) offers a first insight into the differences of the initiated PD [6]. Also, these data are important for the evaluation of a cable system On-Site because they indicate whether PDs during normal operation are to be expected. Not only the PD characteristics such as PDIV and PDEX are important for in-field testing. The cable system represents a system with damping and dispersion for high frequency signals, and for a mapping and detection of the PD failure, the Time-Domain-Reflectometry method is required. The PD signal propagation on the cable is considered by measuring the first incoming impulse and the reflection of the PD impulse from the far end of the cable. Here the number and the amplitudes of the generated PD-Pulses is decisive. For this reason, this investigation will compare the different test voltage types by means of generated PD amplitude, number of generated PDs, fingerprints, phase angles, distribution of amplitudes and repetition rate [7]. All these parameters enable a comparison under reproducible test conditions and will help to choose an appropriate, alternative test voltage for diagnostic testing On-Site.

This investigation will be carried out at MV cable specimen with an artificial surface discharge arrangement create by omitting the field control element at one end of a 20-kV-XLPE medium voltage cable. This defect represents a failure mechanism in a cable accessory and can be investigated under reproducible conditions. The reproducibility of this failures was proven in previous investigations and this type of failure stated to be suitable for a performance evaluation of different test voltage types [6, 7].

For the comparison, the PDIV under the different test voltages will be compared against each other, as well as against continuous 50-Hz-AC. Achieving statistical accuracy is ensured by an adequate quantity of specimen. In the second part of this investigation specimen will face a fixed number of applied voltage periods of each test voltage to investigate the influence of applied voltage frequency, voltage type and voltage slope [8]. The comparison of the PDs will include the number of generated PDs, fingerprints, distribution of amplitudes and the relative, cumulative distribution of amplitudes. The investigation aims to provide a deep insight into PD formation and evaluate alternative test voltages for PD testing.

METHODOLOGY

Test samples – Artificial cable failure

In previous investigations, the artificial cable failure at a cable termination without field control element has been investigated in terms of PDIV, PDEV and PD behaviour at AC, DAC, 0,1-Hz-VLF-Sine and 0,1-Hz-VLF-Rectangular. The reproducibility and suitability of this artificial cable failure was proved and scattering of the measurement