Assessment of Overheating in XLPE MV Cable Joints by Partial Discharge Measurements

Espen **EBERG**, Sverre **HVIDSTEN**; SINTEF Energy Research, Trondheim, Norway,
espen.eberg@sintef.no , sverre.hvidsten@sintef.no
Kristina **BERGSET**; - The Norwegian University of Science and Technology (NTNU), Dept. of Electric Power Engineering, Trondheim, Norway, kristina.bergset@gmail.com

ABSTRACT

Partial discharge (PD) measurements have been performed on service aged XLPE joints. Partial discharge activity was measured at voltages up to 12 kV at 0.1 Hz and at 50 Hz. At 0.1 Hz the PD inception voltage was found to be above service voltage, whereas it was below at 50 Hz. Weibull analysis shows significant differences in charge magnitude distributions, and suggests that different PD sources, or sites, are excited at 0.1 Hz and 50 Hz. Dissection showed that the joints had suffered from excessive thermal degradation during service caused by bad metallic ground screen connections.

KEYWORDS

Condition assessment, partial discharge, medium voltage, distribution grid, power cable

INTRODUCTION

In Norway, more than 140.000 km of MV distribution cable is installed, equipped with over 100.000 joints and terminations. More than 40% of this quantity was installed during the 80s and 90s, and are thus reaching their expected lifetime. With an increased focus on utilization of the ampacity, the reliability of supply and asset management in general, robust and precise condition assessment of the installed distribution network becomes crucial.

A large number of MV joints suffer from overheating, likely caused by high contact resistance in the metallic connections in the joint. These bad connections can lead to local temperatures significantly above 90^{o}C in the joint. This can strongly increase the conductivity and permittivity of the stress grading material in the cable accessory [1], or in more severe cases lead to faults short time after installation [2].

The significance of partial discharges (PD) on the lifetime of cables and accessories has long been recognized [3]. On site, off-line diagnostic measurements are usually performed at other frequencies than the power frequency (50/60 Hz), using portable sources with very low frequencies (VLF) in the range 0.1-1 Hz [4] or oscillating wave source with frequencies in from tens of hertz to a few kilohertz [5, 6]. The question is whether this difference in voltage shapes and frequencies cause different PD characteristics than those appearing at service conditions. Several studies using artificial cavities in XLPE insulation [7] and other polymers [8-10] show that there is an influence of frequency on parameters such as charge magnitude, charge-phase relation, number of PDs per cycle. Measurements on cables and accessories with artificial defects, on the other hand, generally show an overall good agreement in characteristics between 50 Hz and other frequencies [11, 12].

Cable accessories are more complicated geometries compared to model samples, involving dielectric interfaces between different insulating polymers (e.g. XLPE, EPR, silicone rubber) and field-grading materials. Numerical calculations of voltage potential distribution along stress-grading materials have shown that the distribution is altered when the frequency is changed [13]. Stress grading with voltage-dependent conductivity and permittivity causes the potential to distribute longer away from the insulation screen (ground) termination when the frequency is reduced. The local electric field close to any defect is thus dependent on the applied frequency and the axial position close to the field grading tube. An artificial void under a stress cone in a MV termination showed increased PDIV for 0.1 Hz compared to 50 Hz [14]. Also, Mauseth *et al.* [15] found higher discharge rates (PDs/period) at low frequencies for thermally laboratory aged EPR joints.

Basic quantities such as inception voltage (PDIV) and charge magnitude (Q) are often used as evaluation criteria of the insulation system, based on acceptance limits. These basic quantities do not give any information about the root cause, and thus little information about the severity of PD. PD is a complex stochastic process, which leads to statistical variations in the measured quantities [16]. Different computing strategies taking into account the statistical nature of PD have been proposed in order to identify/correlate PD signals to the PD source and discriminate PD signals from each other and noise [17-19]. E.g. it has been shown that PD sources can be discriminated and identified by means of the shape parameters in mixed-Weibull distributions [20, 21]. This could provide a simple and intuitive method for investigating changes in PD characteristics at different frequencies and voltage waveforms.

In this work a 24 kV XLPE service aged joint has been removed from service and subjected to PD measurements at 0.1 Hz and 50 Hz. To our knowledge few studies have investigated the frequency dependency of PD in service aged cables and accessories, and thus motivates this work. The aim is to provide more robust evaluation criteria for condition assessment with PD measurements using test samples taken from service. In order to achieve this statistical analysis is applied to the PD data, with subsequent microscopy examination to examine the root cause of the discharges.