# Time-evolution of Partial Discharge Characteristics of XLPE MV Cable Termination Defects

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# Abstract

Power cable terminations and joints experience high electrical stress due to the abrupt change in geometry of the cable; hence the insulation at these points is more prone to partial discharges and has been reported as the main root cause of power cable system failures. Electrical failure of the insulation is known to occur due to a phenomenon of Partial Discharges (PD). Modern practice (especially in higher voltage installations) entails installation of PD sensors at strategic locations during installation of electrical equipment such as cable joints and terminations. This enables continuous monitoring of PD events in the plant, and this is termed on-line PD diagnosis. However, with limited knowledge to interpret the meaning of certain PD changes during the service period, this practice remains limited. It is therefore the interest of the study to understand the time evolution behaviour of PD characteristics in order to discern the insulation condition or deteriorating stages.

The present study is on XLPE power cables, focusing on PD in artificial defects in the cable termination insulation that in most cases arise from poor workmanship. The power cables were subjected to accelerated ageing to emulate their ageing under service conditions. PD measurements were then conducted at periodic time intervals and characterized PD in terms of PD Inception Voltage (PDIV), maximum apparent PD magnitude ($Q_{max}$), Pulse Repetition Rate (PRR) and Phase-Resolved-Partial-Discharge-Pattern (PRPDP). The findings are that, $Q_{max}$, PRR and PDIV did not show any time-evolution trends unique to a defect, the general trends observed were that of a fairly constant PDIV with several fluctuations of a 5 kV band. $Q_{max}$ showed a decreasing trend over ageing time. The PRR decreased overall, with a pick up increase near the end of the tests. $Q_{max}$ and PRR were noted significantly fluctuative between 23% and 57% of the total ageing period, distinct characteristics were that, the tram line had the largest PRR which is expected since it is a flat cavity, and

the PRPDP appeared more skewed than other defects. The semicon feather had a PRPDP that seemed like a combination of a void discharge and corona discharge. The ring cut PRPDP was similar to that of the tram line except that it was not skewed. Furthermore, a capacitance PD model was constructed in Matlab® Simulink® to emulate experimental observed PD behaviour and therefore confirm the theory explaining the observed time-dependency of PD phenomena. Simulated void discharge PRPDP which corresponded with experimentally measured PRPDP were obtained for the unaged, moderately aged and severely aged cavity defect. The corona-surface discharge effect observed in the semicon PRPDP was also successfully emulated.

The study outcomes suggest that PD characteristics evolve over time, and that the behaviour of the observed trend is unique at different stages during ageing. The time evolution characteristics of PD are The PRPDP signatures did not change with time of ageing despite the variations in $Q_{max}$ and PRR. This means that, defect signatures obtained prior ageing or in-service operation of the cables can still serve as a good reference of identifying the nature of the defect at different ageing stages except in the event of PD evanescence. From the simulations, it was derived that the PD region surface conductivity as well as the geometry of the defect are the main contributing factors to the unique signatures observed at different stages and per defect.