Gas Discharge in a Cavity – First Part of PD Measurement Process in Power Cable Systems

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ABSTRACT

This paper focuses on the initial stage of measuring partial discharge (PD) in a cable, which involves a gas discharge that occurs within a suitable cavity. It investigates how physical parameters associated with the cavity and cable construction affect the gas discharge within the cavity and the resulting charge magnitude due to PD activity. By analyzing these factors, the work aims to establish a framework for gaining a better understanding of the phenomenon detected by the PD measurement system and the severity of any defects present in the cable.

KEYWORDS

Cable Insulation, Cavity, 5-pC Sensitivity, Gas Discharge, Cavity, Partial Discharge (PD)

INTRODUCTION

Partial discharge (PD) is a phenomenon that occurs in the insulation of power cables and can lead to the deterioration and failure of the cable system. A variety of factors, including manufacturing defects, aging, mechanical stress and environmental conditions can result in cavities in different types of extruded insulation as well as liquid-impregnated dielectrics, which can cause PD activities. Therefore, detecting PD and interpreting the PD results are critical aspects of cable system maintenance and reliability.

Along with physical/dimensional tests and high-voltage time (proof) tests, a PD test has become a standard part of the toolbox used to identify such defects and to assure the reliability of power cable systems at the factory. PD tests are increasingly part of the suite of tests applied to new MV and HV / EHV systems in the field (commissioning test) and to assess the health of components in the field. International standardization activities have resulted in test protocols (test times and voltages) that guide in the process of determining the presence of discharges, usually in terms of the magnitude of the discharge (either in mV or a charge). In general, these guidelines are based on what is commonly practicable in the factory or the field for a wide range of accessories and components. Usually, the factory PD detection sensitivity of 5 pC or better is referenced in multiple power cable standards for the laboratory. Conversely, the field PD testing sensitivity is not defined and is determined based on the agreement between the cable manufacturer and the end user.

In practice, the effectiveness of PD detection relies on several critical factors. These include the characteristics of the discharge, the propagation of the signal from the discharge location to the detector, the detection system itself and the approach to interpreting the detected PD. Researchers have extensively discussed these factors in published literature. In this paper, a significant emphasis is placed on interpreting the magnitude of a discharge. Understanding the magnitude of PD is crucial in evaluating the severity of the discharge and determining appropriate measures to mitigate potential damage or failure.

Figure 1(a) presents the electric field distribution in a 15 kV cable with a conductor radius of 4.9 mm, insulation thickness of 4.2 mm, two cavities with a radius of 0.5 mm next to the conductor, and the outer radius of insulation, respectively. Figure 1(b) shows the significant local electric field enhancement in the cavity area, which may result in gas discharge in the cavity.

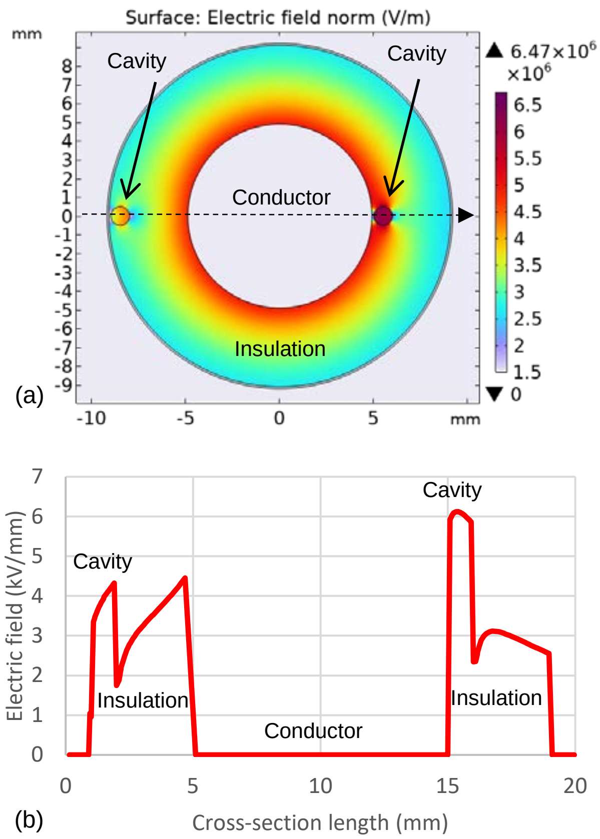

Figure 1. (a) Electric field distribution across the insulation of a 15 kV cable with two cavities with 0.5 mm radius next to the conductor and next to the outer radius of the insulation; (b) Variation of the electric field along the plotted cross-section line

This paper focuses on understanding the cavity type defect in the cable insulation and correlating the physical attributes of the cavity defects and measured PD magnitude. The study will illustrate the measured apparent charge magnitude as a function of defect size, position in