Diagnostic Accuracy and Technical Considerations Influencing MV Cable Partial Discharge Measurements

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ABSTRACT

Partial discharge (PD) field-testing is being widely used to detect and reveal 'dry electrical' type defects in extruded medium voltage (MV) cable systems, covering varying application contexts (e.g., commissioning, post-repair assessment, maintenance), system criticality levels and asset management objectives. In terms of PD measurement systems intended for field MV cable system diagnostics, a wide range of commercial technical offerings exist amongst equipment vendors and service providers, involving different types of voltage sources and different levels of system complexity. This happens in a context of lack of standardization, and often a lack of understanding of the different factors that can influence the accuracy of PD measurements. Such factors can result in the very 'real' probability that the use of one MV cable PD measurement strategy / system versus another could lead to diagnostic inaccuracy, and ultimately different MV cable field PD assessment outcomes for the same test situation.

This paper intends to summarize and illustrates the importance of diagnostic accuracy and key technical considerations upon which MV cable field PD measurements are critically dependent. The objective is to assist non-expert end-users engaged in the specification, procurement, or execution of a MV cable PD field testing programs to understand their requirements, objectively evaluate options, and ultimately select the most appropriate PD testing strategy for their specific context.

KEYWORDS

Partial Discharges, Diagnostic Accuracy, Selection Considerations, Medium Voltage Cables

1. INTRODUCTION

The purpose of partial discharge (PD) testing is to identify the presence of latent, localized electrical discharges in the cable circuit, either within the insulation material, at the interface between a metallic and dielectric surface or at the interface between two dielectric surfaces. Such discharges are caused by the decomposition of air in voids / interfaces and ultimately lead to the degradation of the dielectric material. The degradation progresses through the insulation until reaching its surface and causing failure.

The types of defects identified by PD testing are commonly "dry-electrical" type defects at varying stages (i.e., latent, pre-failure to active, close to failure). Other mechanisms including thermal degradation, neutral degradation, and internal contamination can also cause PD activity at varying stages of degradation.

In a field context, the application of PD testing has traditionally been used for MV, HV and EHV cable commissioning purposes to reveal workmanship related defects in installed cable systems (including cables, terminations, and splices). Recently, it has also been applied to maintenance/aging management-type applications for older MV cable systems, across a wide range of system criticality levels. To support such activities, a wide range of commercial technical offerings exists amongst equipment vendors and service providers, ranging from black-box type approaches with proprietary algorithms used by service providers, to fully customizable and adaptable systems requiring high levels of expertise, to push-button type boxes that, in principle, can carry out measurements for unskilled users. This can represent a confusing array of options, with little guidance on how to objectively evaluate such options across a range of user contexts. This results in the very 'real' probability that the use of one MV cable PD measurement strategy / system versus another can lead to diagnostic inaccuracy, and ultimately different PD assessment outcomes for the same test situation.

To begin addressing these issues, this paper attempts to summarize and illustrate the importance of two fundamental topics of PD measurement strategy, which are:

1) Diagnostic Accuracy Considerations
2) Key technical considerations upon which MV cable field PD measurements are critically dependent, which can be grouped as:
    a) Test source / type of applied stress
    b) Measurement system characteristics (hardware)
    c) PD pulse discrimination and analysis strategies (software)
    d) PD localization strategies

2. MV CABLE DIAGNOSTIC ACCURACY (IDLA CONCEPT)

Diagnostic accuracy corresponds to the ability of a diagnostic test result to reflect the actual condition of a diagnosed piece of equipment. Accordingly, an accurate diagnostic result would assess a piece of equipment in good condition as "good" and would assess a piece of equipment in degraded or faulty condition as "bad". Accordingly, a fully accurate diagnostic is expected not to lead to any 'False Positive' or 'False Negative' assessment.

An end-user's need for diagnostic accuracy will vary according to testing context. For example, tolerance to diagnostic inaccuracy could range from 'low' to 'very low' tolerance in high criticality cable systems in nuclear generating plants to 'high' to 'very high' tolerance in situations such as MV distribution loops supplying local residential customers. In terms of testing purpose, an acceptance-based commissioning situation generally requires a higher diagnostic accuracy relative to an investigative maintenance testing situation, given that the former situation often includes external contractor involvement, warranty considerations, etc.

In the context specific to MV cable test system functionality, diagnostic accuracy can be evaluated in terms of the ability