PD Testing High Criticality MV Cables – Special Considerations and Case Studies

Sarajit **BANERJEE**, Shah **ANJUM**, Paul **SALVATORE;** Kinectrics Inc, Toronto, Ontario (Canada), sarajit.banerjee@kinectrics.com, shah.anjum@kinectrics.com, paul.salvatore@kinectrics.com
Jean-Francois **DRAPEAU;** JFD CableDiag, St-Bruno, Quebec (Canada, jfd.cablediag@gmail.com)

ABSTRACT

This paper will overview technical requirements and unique considerations in relation to performing diagnostic PD measurements on MV cables in specific contexts where high diagnostic accuracy is required. Examples of such applications include high-criticality circuits in distribution substation, generation plant and industrial applications. Given the strong technical, practical, and economic impacts of assessment outcomes in high-criticality contexts, a key differentiator in these applications is related to specific needs in terms of PD testing HV test sources, measurement instrumentation, and various execution methodologies which maximize PD diagnostic accuracy in terms of defect identification, discrimination, localization and condition assessment. Multiple informative, practical case studies will be discussed to illustrate the unique aspects of PD testing MV cables in high-criticality applications. The ultimate intent of the paper is to provide end-users engaged in the specification, procurement, or execution of MV cable PD field testing for high-criticality cables with an understanding of how to minimize the risk of '*False Positive*' (F+) and '*False Negative*' (F-) diagnostic results in such contexts.

KEYWORDS

Partial Discharge, Diagnostic Accuracy, Medium Voltage Cables, High Criticality

1. INTRODUCTION

Medium voltage cable circuits can range widely in terms of their criticality or relative 'importance' within a given cable population. The most straight-forward distinction is that in a high-criticality cable circuit, the consequences of an un-planned, in-service failure are significant. Although specifics will vary by application, key consequences can include significant outage impacts to large (or important) connected loads, risks to personnel or public safety, damage to critical connected infrastructure, lack of regulatory compliance, or degraded customer relations. Related economic consequences can include costs of lost generation or productivity, emergency outage labor and repair / replacement costs, or regulatory fines.

Medium voltage commissioning and maintenance testing is a widely adopted component of an asset management strategy for high-criticality cable systems, as described in publications such as CEATI #50/144 [1], EPRI 3002000557 [2], IEEE 400 [3] and ongoing activities in CIGRE WG B1.58.

Of the tests which are available, Partial Discharge (PD) is a crucial part of the condition assessment testing 'tool-box'. When executed in an accurate manner, PD testing can identify latent, localized 'dry' electrical discharges in a tested cable circuit, which may be present in a commissioning context (due to workmanship or installation related errors) or maintenance testing context (due to aging-related degradation). Such life-limiting defects can then be targeted for corrective actions, hence reducing the probability of in-service failures.

A key, non-trivial point in this statement is what constitutes an accurate test. Diagnostic accuracy in this context refers to the ability of a test to reflect the actual condition of a diagnosed piece of equipment. The main benefit of a high-accuracy approach is to lower the risk of 'false diagnostic' outcomes, namely:

- '*False Negatives' (F-'s),* which increase the risk of in-service failures following test due to defects being missed, and
- '*False Positives' (F+'s),* which increase the risk of unnecessary investment due to defects being incorrectly identified.

In terms of MV cable PD testing application, its diagnostic accuracy objectives have been described in another publication [4] as extending beyond strictly minimizing the risk of F+ and F-'s. Specifically, the testing also has to be executed in a manner which considers the functional objectives of Defect '**I**dentification,' '**D**iscrimination,' '**L**ocalization' and 'Condition **A**ssessment' ('IDLA'). In high-criticality cable applications as previously described, these various functional accuracy objectives play unique, crucial roles in maximizing safety and reliability and optimizing investment, as illustrated in Figure 1 below.

Figure 1: PD Testing Accuracy Objectives and Benefits

The publications [5] and [6] provide powerful examples of the practical, techno-economic user impact of applying high accuracy PD testing (amongst other tests) towards high-criticality applications. For example, [5] describes how high-accuracy testing primarily based around AC (50 / 60Hz) withstand and advanced PD testing has resulted in industry-low post-test / in-service failure rates around 0.08% in large populations of high-criticality 5, 8 and 15 kV circuits, hence maximizing safety and reliability. Furthermore, [6] illustrates how high-accuracy testing combined with a cable criticality-based risk-assessment process allowed for successfully deferring costly repairs / replacement in specific cases where cables exhibited anomalous diagnostic PD results, saving the utility $10M+ in one high-profile example alone.

Applying PD testing to high criticality MV cable systems constitutes the situation with the highest requirements in terms of diagnostic accuracy, and maximum potential cost-