Cable System Commissioning Update

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ABSTRACT

In 2011, some of the authors presented a commissioning approach at the 8th International JICABLE Conference [1]. This paper is a follow-up describing performance of those cables and an additional 60,000 field cable assessments by Power Frequency Partial Discharge (PD) testing at utilities, renewable energy facilities and industrial sites. The performance of cable systems under various commissioning test techniques across the world will be presented. Test comparison case studies, defect dissection results, and performance data will be provided demonstrating the benefits of using industry factory quality standards in the field for maximum cable system reliability.

KEYWORDS

Partial Discharge, Improving grid reliability, Asset management, Extruded dielectric cable, Factory Quality Control, Failure modes of newly installed cables, Very Low Frequency (VLF), Online PD, Offline PD, Best practices, Tangent Delta

INTRODUCTION

Over the past decade, thousands of kilometers of medium voltage cable systems were installed at renewable energy facilities worldwide; there were more 35 kV cables installed during this period than in the previous 30 years. Similarly, electric utilities have installed millions of kilometers of underground cable within their transmission and distribution infrastructure. While the benefits of clean energy versus fossil fuels have long been debated, renewable energy is the fastest growing segment of new generation worldwide. In those 30 years, this industry has lost tens of millions of dollars in sustaining wind & solar sites because of ineffective design, poor construction procedures and inconclusive commissioning test practices. Electric utilities are not exempt to these issues either; they continue to experience outages from newly installed systems due to poor engineering design, insufficient training for installers and minimal or questionable commissioning practices.

Defects in cable systems have a serious impact on all energy suppliers as downtime impacts both the top and bottom lines in terms of outages, repair costs, unhappy customers and lost revenue. Recent surveys have concluded that the typical cost of failure at a wind site exceeds 100.000 € in repair and lost revenue, with approximately 15% of 3-phase collector systems having at least one substandard component requiring extensive repair actions. The statistics for new feeder and Underground Residential Distribution (URD) systems are comparable. Several utilities have documented that 1 of every 5 cables on newly installed feeder systems were found to have at least one sub-standard component (See Table 1 for acceptance criteria). This cost of failure is avoidable through field testing cable systems to the manufacturers' standards, during commissioning and planned maintenance outages.

While this sounds simple, complicating the issue of cable testing are the many cable test procedures available on the market, most of which fall short of the cable and accessory manufacturers' standards (see Table I). Cable and component manufacturers' factory quality control tests require 50/60 Hz Partial Discharge (PD) diagnostics – with better than 5 pico-Coulomb (pC) sensitivity. To achieve this sensitivity, manufacturers test their cable and accessories in electrically shielded rooms, free from construction, power system and/or other electrical noise. The technology to repeat these assessment test standards in the field is more challenging; however, it is available and has been used at over 350 renewable sites representing over 35 gigawatts of power generation worldwide. In fact, over 170.000, 5 kV to 500 kV class cable systems have been assessed in the field, at both renewable and utility sites, with a factory comparable PD test, demonstrating significant reliability improvements for both new and aged systems.

BACKGROUND

Power distribution systems can be categorized as either underground or overhead. Overhead systems are simpler to maintain than their underground counterparts, because they allow for visual inspection and physical access to all components. In contrast, underground cable systems are engineered as advanced products, designed and built to safely contain high levels of voltage stress within a few millimeters of insulation and to protect the components from corrosion and contamination once buried. This inherent concealment prevents visual inspection of these systems once they are put into service. Proactive and preventive management of underground cable systems is particularly challenging. There are many available cable assessment methods, but few are comprehensive enough to diagnose the precise health of each component in order to evaluate the assets useful life.

The renewable energy industry has gone through a major learning curve to improve the reliability of medium voltage cable systems. Collector cable systems for renewables commonly operate at 35 kV voltage class compared to their 5 kV- 25 kV class underground residential distribution (URD) counterpart utility systems. Renewable systems continually experience higher electric stress and higher loads making them more vulnerable to installation issues. Collector cable systems at solar and wind farms typically use underground cables to connect the wind turbines or solar arrays [Figure 1]. These generator arrays are connected in a daisy-chain configuration, saving cable costs, but resulting in a single-point of failure system, which trades cost effectiveness for greater risk. Until it is repaired, a single cable failure results in the loss of production from all upstream generators in the string. Additionally, installation contractors generally have less industry