Asset Management of MV Cables using Data Driven Health Indices for Water Treeing

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ABSTRACT

The underground distribution system makes up a significant portion of the distribution infrastructure (EEI) in the US. Most of the reported failures are associated with the accessories, which can easily (relative to the whole system) be addressed. However, the larger concern are the cables that; which as distributed devices, are more difficult and costly to address. This concern is amplified as cable from earlier generations still make up a large portion of the utility system. The main mode of failure, for EPR, HMWPE, WTRXLPE, and XLPE, is considered to be the conversion of water trees to electrical trees due to the modification of both the electrical strength and stress.

Luckily, water trees in EPR and PE-based insulations can be observed and measured thereby providing leading indicators to an Asset Management program so that appropriate actions may be taken. This work has developed a Health Index algorithm that is able to provide context to water tree studies and a data-driven (meta- data and water tree data) characterization.

KEYWORDS

Reliability, Water Trees, Health Indices, Extruded Cable

INTRODUCTION

The underground distribution system makes up approximately 18% - 24% of the distribution infrastructure (EEI) in the US [1]. This system is comprised of terminations / elbows, cable, and joints, which all contribute to the reported SAIDI and SAIFI data. The process of increasing the percentage of underground cables is seen as a way to improve reliability (Figure 1) [1, 2]. Most of the reported failures are associated with the accessories, which can easily (relative to the whole system) be addressed through replacement and diagnosis because they are discrete devices. However, the larger concern are cables [3, 4]; which as distributed devices, are more difficult and costly to address. This is especially concerning as cable from earlier generations still make up a large portion of the utility system.

Since the earliest days of extruded insulations and the discovery of water trees in PE (HMWPE, XLPE, and WTRXLPE) and EPR insulations, many utilities and laboratories have performed a large number of water tree inspections on extruded power cables returned from the field [5 – 15]. These examinations include both those which have failed in service and, very often, cohort lengths that have not failed. These studies were conducted in an effort to shed light on the processes that initiate and determine the rate of water tree growth. This work is influential as studies in 2004 and 2015 show that utility engineers place a premium on the cable reliability that they experience when determining which components to use on the systems that they design.

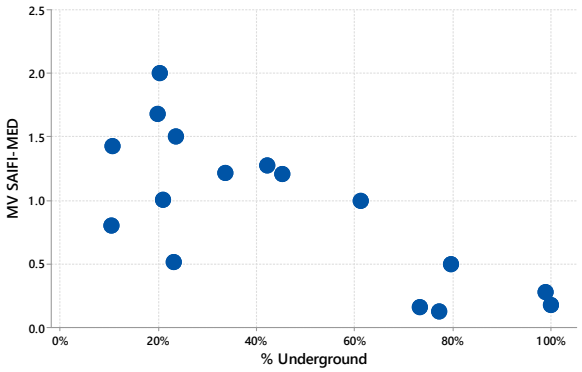

Figure 1 Impact of undergrounding on SAIFI – MED (Major Event Days) of selected countries

Generally, these studies are single or small group investigations and little consideration was given to consolidating the knowledge embedded in these analyses. Over the last few years, the authors have created a knowledge base from the many examinations (>450 investigations, 40 utilities, >5,000 trees) and used this repository to develop a fact-base (initial measured data and data developed more recently) to support the coming asset management challenges around the ageing cables within the distribution infrastructure. This is particularly useful for utilities

- Who proactively replace cables and wish to confirm that cables being extracted are near end of life
- Who extract samples upon failure and wish to assess the velocity of degradation and asset health

Health Indices are well suited to these tasks as they are commonly used to condense and summarize many quantitative and semi qualitative factors.

APPROACH

Sources of Data

Water tree inspections usually occur either after a service failure or to proactively identify potential tree formation.

- **After a service failure has occurred** – in these cases there is some level of damage around the failure site and invariably the initiator (often presumed to be the most stress enhancing water tree) is destroyed – thus the investigation focuses on the surrounding area whilst recognizing that the tree of most interest was already destroyed, and