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MAKING REMAINING LIFE PREDICTIONS FOR POWER CABLES USING RELIABILITY ANALYSES

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ABSTRACT

Most underground cable owners would like to know what the probability is for failure of a given cable asset as a function of material type, function type, age of the asset, geotechnical environment, and other factors, when we know past failure distributions, predominant failure mechanisms, and other attributes. While most underground electric utilities have collected voluminous data that could guide them into better buried cable management in the future, the use of suitable reliability analyses in their asset management programs have been beyond their reach. Often the replacement and rehabilitation decisions have been based on simple rules of thumb rather than either good science or statistical analyses even when tremendous amount of resources and time are expended on benefiting from the use of state-of-the-art cable assessment techniques. When utility engineers struggle to convince the public, shareholders, and the legislators the dire need for increased rate of investments into buried cable assets, it is our obligation to engage the most suitable analytical tools to make the best use of past failure data and available cable infrastructure capex funds. This paper provides a methodology on how sound reliability analysis tools can be used in such management decisions to maintain and operate our underground cables better.

KEYWORDS

Cables, asset management, reliability analyses

INTRODUCTION

Globally we have spent many trillions of dollars into valuable underground cable infrastructure over the past century. We are continuing to spend large budgets on in-situ condition assessment of existing underground cables and on forensic examination. Often, component materials forming these underground assets are also tested resulting in enormous funds being spent for calibration of data collected from other testing techniques, yet little attention has been paid on using proper statistical analyses of all of this data. Most industries outside of cable engineering have progressed much farther in the use of more advanced data analyses over the past 50 years. The most important question to ask ourselves is what is the probability of failure of a given cable as a function of certain attributes such as

- type of component materials in the cable
- type of function?
- age distribution of the asset?
- type of environment?
- break history?
- predominant failure mechanisms?

How do we allocate future funding to get the most optimum return from the current assets, given the limited resources we have for asset management?

STEPS IN RELIABILITY ANALYSES

It is not possible to rely only on the analytical tools known to engineers who have practiced design engineering, condition assessment, and asset management for cables to complete the remaining life predictions. One has to use tools from other industries in performing such reliability studies. The appropriate steps in proper reliability analyses toward remaining life prediction for underground cables shall contain as a minimum:

- Collect and organize track record data.
- Select a statistical distribution that best fits the lifetime data on hand.
- Estimate the defining parameters that fit the statistical distribution chosen to represent the lifetime data, for example using regression studies.
- Make better predictions than rules of thumb on estimates of the life's attributes:

- reliability or representative life of the cable?
- probability of failure for a chosen life span?
- which component material lasts longer?
- under what site and operating conditions?

PROBABILITY DISTRIBUTIONS

The Weibull probability density functions (PDFs) can be used to characterize past failure records of cable or component materials, if sufficient data indicate that one or both of these PDFs would approximate the past failure behavior of the buried assets.

The 3-Parameter Weibull PDF is represented by the following equation:

$$f(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} \quad (1)$$

Where β is shape parameter
η is scale parameter
γ is location parameter
t is time
f (t) is PDF.

The cumulative distribution function (CDF), F(t), or unreliability function and the reliability function, R(t) can be obtained from f(t) as follows: