Can Cables Last 100 Years?

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ABSTRACT

How long can solid dielectric cables last? The authors and many in our industry over the last few decades, would say 30 to 40 years, but what does science and industry experience tell us? This presentation will explore the known primary drivers of activation energies sufficient to initiate deterioration at the molecular level and eventually yield more commonly known breakdown mechanisms. Which drivers are common place? Which drivers are rare or application specific? Can cable owners eliminate or reduce the risk of these drivers, and if so, what does science and industry experience tell about the future of cable longevity? Is 100 years possible?

KEYWORDS

Cable Life, 40-Year Life, Defects, Partial Discharge (PD), Failure, Electrical Trees, Water Trees, cable testing, cable diagnosis, cable injection

INTRODUCTION

Reliability of power cable systems is a critical topic for ensuring continuous electrical service and predictable maintenance and replacement cycles. A commonly held belief is that extruded dielectric insulated cable has a design life expectancy on the order of forty years and cable replacement scheduling is often based on this figure. In practice, when cable and accessories are free of manufacturing and installation defects, the authors have found, that cables under moderate service conditions can perform beyond 40 years but suggests the industry needs to identify 'stressors' and remove them proactively to achieve reliable performance beyond 100 years [1].

Utility Case Study

The cable reliability experience of a utility is shown in Figure 1. The left-hand y-axis and data in blue represent the number of circuit kilometers added per year with the cyclic nature of infrastructure expansion clearly visible. In contrast, the right-hand y-axis and data in red represents the number of 100s of cable failures of cable installed in the year indicated. This data shows, that the majority of cable failures experienced are on lengths installed prior to the 1980's. While the data in terms of absolute number of failures may be concerning, it needs to be remembered that cable life expectancy is a statistically built probability. Building on the 40-year life expectancy figure, in 1956 Jack Crowds states "Half the [cable] samples (in a test) would fail by the 40th year." [2] This concept, combined with data from the subject utility shows, even though there is a measurable cable failure rate of assets installed in the 1970's and earlier, there is a still a statistically significant population still in service and operating. According to many utilities surveyed, operating beyond the 40 year life is a practical necessity due to budgeting constraints scheduling, and resource availability; replacing all in-service cable by their 40th year is nearly impossible. Replacement programs spanning multiple decades means, cables are already in service beyond forty years and could potentially be in service for sixty or more years. Investigation of the mechanisms and conditions of failure is the first key to understanding how some cable systems are achieving this extended reliable performance and is the subject of this paper.

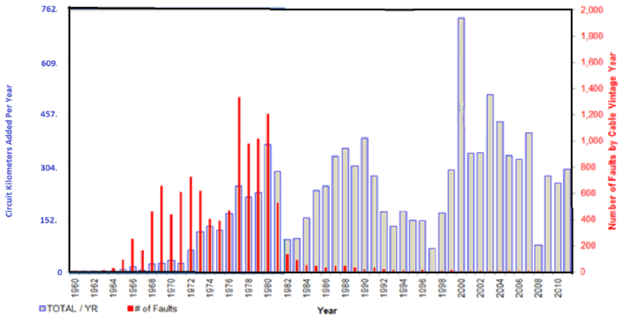

Figure 1: Utility study of cables installed and cables failed by vintage year.

High Voltage AC Breakdown Curves

Figure 2 shows the retained AC breakdown strength for three medium voltage cable populations with typical steady state service voltage stress represented by the blue horizontal line (~2kV/mm or ~50V/mil). In this case, cables were removed from service at intervals, and subjected to a high voltage time test to measure the AC breakdown strength. A common observation for this type of curve is, a significant drop in breakdown strength over the first 5 to 10 years of service life. In addition, the breakdown strength of the cable populations reaches a "perplexing equilibrium of at ~6U_0" (12kV/mm) after 10 years as noted by Nigel Hampton, et. al, in 2016 [3].

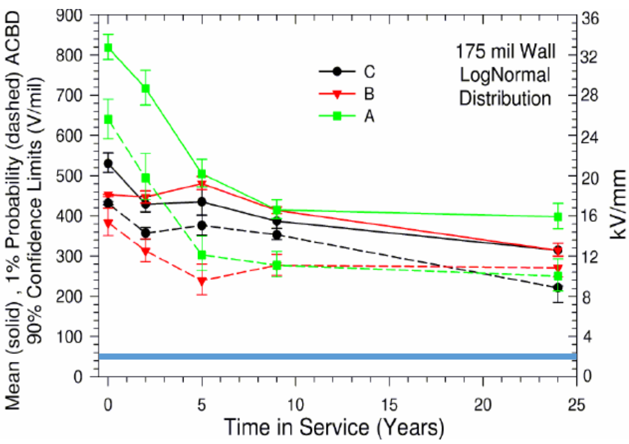

Figure 2: Mean AC Breakdown Strength of Field Aged Cables [4]