Close and Return

Partial discharge, predictive cable testing experience and lessons learned

REDER W., Ultra Power Technologies Inc., Minneapolis, USA

ABSTRACT

This paper reviews lessons learned while testing over 2,450 km (over 1,500 miles) of underground cable throughout the USA from March 1998 through March 1999 using 60Hz ac as the voltage excitation source. The technology, developed at the University of Connecticut, has been extensively described in past publications.

Testing is done by gradually increasing voltage across an isolated cable until a partial discharge (PD) is detected. The voltage where PD is first detected is referred to as PD inception voltage (PDIV). The maximum test voltage is typically 3.0 p.u. However, if PD occurs at a lower voltage, then the recommended practice is to raise voltage in two 3kV steps above the first PDIV. The dwell time at each PDIV level is two to three seconds to avoid further deterioration on extruded cables.

This paper reviews typical report results and overall findings during a one-year test period. It also discusses the testability of different types of cable and presents several important case studies, demonstrating the lessons that can be gained from PD testing.

RÉSUMÉ

Ce rapport propose une revue des expériences et leçons acquises à la suite de tests et diagnostics menés aux états unies entre Mars 1998 et Mars 1999, sur plus de 2450 KM de câbles enterrés. Les tests sont effectués à la fréquence industrielle de 60 HZ. La méthode, mise au point à l'université de Connecticut, a fait l'objet de multiples publications.

Le test est effectué sur des câbles isolés, auxquels est appliquée une tension que l'on augmente progressivement jusqu'à l'apparition des premières décharges. La tension à laquelle les premières décharges sont détectées est connue sous le nom de TADP (Tension d'Apparition des Décharges Partielles). La tension maximale du test est de l'ordre de 3 U_0 ; toutefois, si des DP apparaissent à un niveau plus bas, il est recommandé d'augmenter ce niveau par pas de 3 KV au dessus de la TADP. Le temps d'application de ces valeurs de la tension ne dépassent guère 2 ou 3 secondes, ceci par soucis d'éviter toute dégradation ultérieure des câbles.

Ce papier expose les relevés typiques et une quête étoffée sur les résultats obtenus durant une année entière de tests. Il discute aussi de la faisabilité des tests sur différents types de câbles et présente diverses études sur des cas très intéressants, mettant

PARTIAL DISCHARGE REPORTING

Following one week of testing, where typically 50–60 cable segments are analyzed, a report is generated which summarizes the results. Recommendations to repair, monitor or do nothing to the problematic PD locations are based on the PDIV level and the where the PD originates.

Testing reports identify the length of the cables tested, location of splices, and identification of PDs in the cable and/or accessories. Results are given for each cable segment as shown in the simplified graph below. The length and location of the splices are shown on the horizontal axis. The PDIV level of the PDs are represented on the vertical axis. The type, location and severity of the detected PDs can be interpreted from the symbols on the graph. In Fig. 1, on a cable segment 2,055 feet long or 626 meters, there is a PD in a splice on A phase that occurred at 1.3 p.u., and a cable discharge on the same phase occurring at 2.0 p.u. Note the most severe PDIV is located higher on the graph. The report summarizes PD's by severity. In addition, to facilitate construction repairs, cables are also prioritized based upon the most severity of PDs identified.

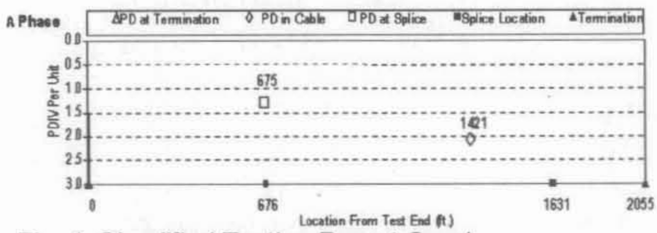

Fig. 1: Simplified Testing Report Graph

ESTABLISHING RECOMMENDATIONS LEVELS

Recommendations for various inception voltages, based on whether they are detected in cable insulation or in accessories, are shown below in Fig. 2. The recommendations have been formulated from the testing results to date and continue to be refined with experience. Since there are an infinite number of dependencies, which may induce a PD location to fail, an exact time-to-failure recommendation is not possible. Each utility should mold the recommendations based upon system protection, reliability concerns, frequency of local transients, and other factors that accelerate PD growth.

These recommendations were initially established based upon the time-to-failure after the detection of a PD. In the past year, many cables with PDs requiring "*Immediate*" repair, have failed at correlating PD locations if proactive measures where not taken. On the other hand, splices and terminations in the "*Immediate*" recommendation level have been more