D.3.1. Localisation de décharges partielles comme outil d'exploitation

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Résumé

En tant qu'outil de diagnostic pour le réseau de câble Moyenne Tension de plus de 1,5 million de km installé aux USA, un système d'instruments de localisation de décharges partielles (DP) a été développé et essayé dans des conditions réelles, ses trois composants sont un détecteur de DP, un localisateur de position et un "pointeur" pour la position exacte. Cet article donne une brève description de l'instrumentation et de ses caractéristiques essentielles, il donne aussi les résultats de plusieurs essais menés dans des conditions réelles, mettant l'accent sur les résultats d'un essai récent effectué sur des câbles vieillis en service dans un environnement particulièrement bruyant. Des essais de claquage ont confirmé que les câbles détériorés par les arborescences d'eau comportent peu de points faibles discrets ou rassemblés qui coincident avec les endroits défectueux et que, après retrait de ces liaisons faibles les câbles présentent une rigidité diélectrique relativement élevée.

D.3.1. Partial discharge location as a cable operating tool

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Abstract

As an operating diagnostic tool for the more than 1.5 million km long aging medium voltage cable system in the U.S.A., a partial discharge (PD) location instrumentation system has been developed and tested under field conditions. Its three components are a PD estimator, a position locator and a PD site pointer. This paper provides a brief description of the instrumentation and its salient attributes. It also reports on the results of several tests conducted under actual field conditions, emphasizing the results of a recent test performed on field aged cables in a particularly noisy environment. Voltage breakdown tests verified that water-tree deteriorated cables have few discrete or clustered weak spots which coincide with the failure sites and that, after removal of these weak links, the cables assume a relatively high dielectric strength.

Introduction

In the United States, more than 1.5 million kilometers of medium voltage extruded dielectric cable costing over 100 billion dollars have been installed since approximately 1963. A significant portion of this system is affected with water trees, a defect which is known to cause premature failures in service [1]. This system is estimated to require an annual expenditure of 4-6 billion dollars to meet the needs for replacements and additions. To remedy the problems associated with in-service cable failures, the U.S. utility industry has resorted to either replacing or rehabilitating, by dielectric fluid injection, cables perceived to have reached the end of their economic life. The criteria utilized for these actions have been invariably based on two or more consecutive failures in the same circuit, occasionally supported by additional laboratory tests on adjacent cable lengths. These actions are predicated on partial statistical events which do not necessarily reflect the actual condition of cables. The recent exposure of the utility business to open competition has provided a new impetus for increasing reliability and cutting cost. The traditional approach of counting failures no longer satisfies these requirements.

Since 1985, the University of Connecticut has been developing, on behalf of a group of electric utilities, a cable diagnostic system based on partial discharge (PD) location. A number of publications cover various technical aspects of the instrument [2, 3, 4, 5] which is also briefly described in this paper. Several tests under simulated and actual field conditions have been successfully completed. A recent study conducted on behalf of a major utility company was performed on several lengths of 15 kV cables removed from service. The PD location test was followed by ac breakdown tests to determine the weak spots in the cables. The paper provides a detailed account of these tests, and attempts to formulate procedures for utilizing the instrument as an effective distribution cable operating tool.

The Instrumentation System

The pinpoint location of a PD site on a direct-buried cable is accomplished in three steps. In an initial step, the site is estimated, as a percent of total cable length, by means of an **estimator** designed on the principle of reflectometry. In a second operation, the position of this site along the cable is determined from measurements performed along the surface of the cable trench by means of a **position locator**. In a final operation, a trench is dug in the ground at the position indicated in the previous step, exposing 2-3 m long portion of the cable, and the exact PD site is revealed by means of the **PD pointer**. The three instrument sub-systems, illustrated in Figure 1, will be described in some detail.

Estimator

The cable is excited by a variable voltage source capable of producing repeated partial discharges in cable defects. Although the excitation source utilized in the tests reported in this paper was a 60 Hz alternating voltage transformer, other excitation modes are possible. For instance, at the University of Connecticut, a successfully used method based on alternating polarity dc-biased ac voltage (APDAC) reduced the voltage and kVA ratings of the ac transformer needed to about 50% and 25%, respectively, of its original values. The estimator is capacitively coupled to one end, A, of the cable, AB, under test through a high pass filter. The signals are amplified, digitized and processed through a number of