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PRACTICAL ISSUES REGARDING THE USE OF DIELECTRIC MEASUREMENTS TO DIAGNOSE THE SERVICE HEALTH OF MV CABLES

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ABSTRACT

During the last decade, Very Low Frequency (VLF) testing for extruded distribution cables has gained interest among the North American utilities. The increasing interest is evidenced by recent research publications and discussions inside the expert community in which standards are being proposed and continuously discussed. While there is a general consensus as to the meaning of insulation dielectric properties, many open issues still remain for discussion in order to produce a more accurate evaluation. Consequently, this paper will discuss a number of the practical issues that arise when making these measurements at VLF on field aged and non-aged cables, particularly Tan δ measurements. The discussion is based on data from laboratory experiments and field testing.

KEYWORDS

Dissipation Factor, Tan δ, Diagnostics, and MV Cables.

INTRODUCTION

Medium voltage distribution cables and their accessories form a critical part of the power delivery system. Many of these systems employ insulations that have a relatively low permittivity and low dielectric losses. As the systems age the dielectric properties change such that they provide a very convenient way to monitor the degradation of the system insulation. In the majority of the cases, workers monitor the increase in dielectric loss which can be several orders of magnitude higher than when cables are new. This approach correlates well with the known mechanisms of degradation, namely the ingress of water (high permittivity and losses) and the subsequent growth of water trees [1].

During the last decade, Very Low Frequency (VLF) testing for extruded distribution cables has become very prominent among the North American utilities. The increasing interest is evidenced by recent research publications as [2] and [3], and discussions inside the expert community in which standards are being proposed and continuously discussed [4].

In practice it is convenient to measure the dielectric properties at VLF of 0.1 Hz as this both reduces the size and power requirements of the testing voltage source and increases the resolution of the measured value of the insulation losses [5]. While there is a general consensus as to the meaning of insulation dielectric properties, many open issues still remain regarding the definition of more accurate means of system evaluation. Therefore, this paper discusses a number of practical issues that arise when making these measurements at VLF on service aged cables, particularly dissipation factor (Tan δ) measurements. The discussion is based on data collected from laboratory experiments and field testing of MV cables.

The research presented here is part of the Cable Diagnostics Focus Initiative Project (CDFI) launched in February 2005 by the Georgia Institute of Technology through the National Electric Energy Testing Research and Applications Center (NEETRAC). The intent of the initiative is to provide cable diagnostic technology assessment and development via a series of projects designed by the NEETRAC and Georgia Tech research team with technical advice from the initiative participants. The CDFI project participants are formed by utilities, cable diagnostic providers, cable manufacturers, and other interested parties as the U.S. Department of Energy (DOE).

BASICS OF TAN δ MEASUREMENTS

Tan δ is a measure of the degree of real power dissipation in a dielectric material and therefore its losses. In the case of underground cables, this test measures the bulk losses rather than the losses resulting from a specific defect. Therefore, Tan δ measurements constitute a cable diagnostic technique that assesses the general condition of the cable system insulation. Tan δ can be applied to all cable types; however, when interpreting test results care must be taken with respect to the specific cable insulation material, installation conditions, and accessories.

When modeling, the cable insulation system is simply represented by an equivalent circuit that consists of two elements; a resistor and a capacitor [6], see Figure 1. When voltage is applied to the cable, the total current (I) will be the contributions of the capacitor current (I_C) and the resistor current (I_R). Tan δ is the ratio between the resistor current and the capacitor current. The angle δ is the angle between I and I_C when they are represented as phasors [7].

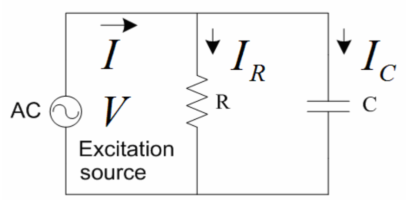

Figure 1: Equivalent circuit for Tan δ measurements

Factors which could influence the validity of the equivalent circuit are accessories condition or design, neutral condition and extent of degradation. Therefore, they can cause the Tan δ measurement to indicate a condition that is not correct for the whole system but this can be overcome by performing periodic testing at the same voltage levels while observing the general trend in dissipation factor values [7]. Additional factors not so easily handled include temperature,