Off-Line Diagnostic Measurements: Type of Measurement versus Insulation Weakness Targeted

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ABSTRACT

This paper intends to summarize some of the work performed by the three laboratories (EDF R&D, SINTEF and IREQ) in order to present a convergent approach of the use of available diagnostic tools.

KEYWORDS

Diagnostic, Medium voltage cables, Dielectric measurement, Tan delta, Partial Discharge, Off-Line.

INTRODUCTION

MV cable diagnostic methods have been widely used by utilities in order to help underground network asset management people to take the best possible replacement time decisions. EDF R&D, SINTEF and IREQ are laboratories that have been involved in evaluating diagnostic tools and editing guidelines for diagnostic methods and criteria to be used by national utilities networks, according to their specific needs. The aim of this paper is to provide an objective and clearer idea of what could be achieved with the different measurement methods used today in terms of identifying cable systems defects that limit the service life. The two main aspects of diagnostic applications, i.e. technical and economical, will be addressed. The technical challenge is to define which methods are best suited to reveal specific types of weakness targeted, e.g. for cases where those are known or "expected" (e.g. from service experience).

This paper proposes a vision of the available measurement techniques through the solution proposed to avoid technical difficulties encountered in real network.

OVERVIEW OF ONSITE APPLICABLE MEASUREMENTS

Characterization of cable section components

Theoretically, the best way to provide a correct assessment for an electrical network component is to have it characterized, first in a normal and healthy state, and then, at the different stages of possible degradation.

There are numerous ways in a lab to reach an electrical characterization of a component to define its behaviour under voltage, but few of them are really applicable for onsite measurements (e.g. techniques devoted to identify space charges).

We propose to consider here that the two principal ways to provide an electrical characterization compatible with onsite measurement are:

- Dielectric loss measurements
- Partial discharges measurements.

Dielectric Loss Measurement

Dielectric loss measurements aim specifically to provide an electrical characterization of the considered material. Thus a component could be considered as completely described when information is collected on the largest frequency spectra possible for all the stages of degradation due to different constraint applied (voltage, water penetration, thermal, mechanical, etc.)[1].

For MV cables, the most common way to characterize the condition of the insulation is to perform the dielectric loss assessment in terms of Tan Delta (imaginary part to real part of permittivity ratio, $\varepsilon''/\varepsilon'$). For such kind of measurements to be the most revealing, voltage dependence should be characterized. Also, if feasible, it would be far better to evaluate Tan Delta at different frequencies (i.e. perform "dielectric spectroscopy"). Such kind of assessment is illustrated in Fig 1.

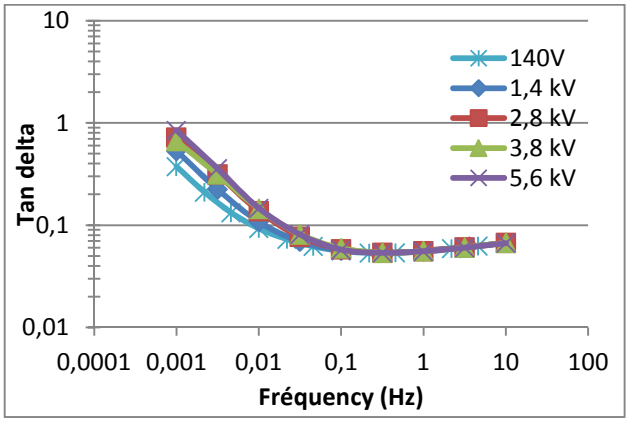

Fig. 1 :Voltage and frequency influence on the Tan Delta for a MV PVC insulated cable

Let us underline here that whatever the representation used, only two electrical parameters are really measured and interpreted: phase and modulus of the impedance. As other dielectric parameters needs relative accurate geometric information, only phase is exploited for onsite measurement through Tan Delta.

Partial Discharges Measurements

Partial discharges measurements have more to be considered to detect manifestation of electrical field impact to the specific component state (i.e. electrical characteristics).

Basically we can consider 2 types of situations for PD activity interpretation.