Progressive changing of dielectric loss factor (tan-δ) of HVAC cables during type testing

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ABSTRACT

This paper focuses on the (progressive) changing of the dielectric loss factor (tan-δ) of the insulation material in HVAC cables due to temperature and/or the presence of applied voltage and a proposal to capture this through measurements.
During several type tests on EHV cable systems progressive increase in sheath temperature was observed. Investigations have shown that this was related to a progressive change in tan-δ. This deviation in sheath temperature or progressive change in tan-δ can be captured by performing tan-δ measurements as a function of temperature and voltage before and after the heating cycle voltage test.

KEYWORDS

Testing, HVAC, High Voltage.

INTRODUCTION

Dielectric losses in a high-voltage cable usually contribute only for a small (or even negligible) amount of energy when compared to the losses occurring in the conductor, while electric energy is transported over the connection. Losses dissipated in the insulation of the cable will increase the temperature of the insulation and will therefore lead to a lower ampacity for the conductor of the cable (thus limiting the possible amount of total transported energy).

The dielectric loss in a high-voltage cable can be assessed during type testing by measuring the dielectric loss factor (tan-δ). By measuring this dielectric loss factor, the amount of energy (losses) that is dissipated in the insulation material of the cable due to the alternating electric field can be calculated with the formula:

$$P_{loss} = U^2.\omega.C.\tan\text{-}\delta \qquad [1]$$

Materials with a high loss factor are not suitable as insulation material in high-voltage applications.

DETERMINATION OF THE CABLE CONDUCTOR TEMPERATURE

Purpose

For some tests, it is necessary to raise the cable conductor to a given temperature, typically 5 K to 10 K above the maximum allowed temperature in normal operation, while the cable is voltage energized, either at power frequency or under impulse conditions. It is therefore not possible to have access to the conductor to enable direct measurement of temperature.

In addition, the conductor temperature shall be maintained within a restricted range (5 K) since the ambient temperature may vary over a wider range.

Although a preliminary calibration for the cable under test or calculations can be satisfactory in the first place (i.e. Annex A, Method 2 of IEC 62067:2022), the variation of ambient conditions throughout the duration of the test may lead to deviations of the temperature of the conductor outside the required range.

Therefore, in order to be able to comply with the requirements of the standards, it is safer to use a method in which the conductor temperature can be monitored and controlled throughout the duration of the test (i.e. Annex A, Method 1 of IEC 62067:2022).

Calibration of the temperature of the main test loop

The purpose of method 1, is to determine the conductor temperature by direct measurement for a given current, within the temperature range required for the test.

The cable used for reference (hereafter called the reference cable) should be taken from the same length as the cable used for the main test loop.

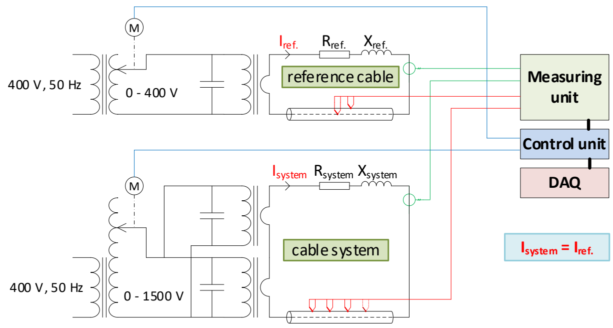

Fig.1: Diagram of the test setup for heating of cable system in accordance with method 1

Description of method 1 for heating of a cable system by using a reference cable

In this method, a reference cable identical to the cable used for the main test loop is heated with the same current value as the main test loop. The installation of cable and temperature sensors for both loops shall be as given in IEC 62067-2022, clause A.2.
The test arrangement shall be such that:

- the reference cable carries the same current as the main test loop at any time; small current changes are allowed in order to equalize the surface temperatures on the test cable and the reference cable.
- the reference cable is installed in such a way that mutual heating effects are avoided throughout the test.

A temperature sensor shall be mounted on or under the outer sheath of the main test loop at the hottest spot, usually in the middle of the length, in the same way as the temperature sensor is mounted on the hottest spot of the reference cable to check that the outer sheaths of both