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Partial discharge localization in gas pressure cable routes through double sided-synchronous-multi point-measurement

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ABSTRACT

Since the middle of the 20th century gas pressure cable systems rated at 110 kV ensure the supply of energy in larger cities all over the world. Many cable routes already exceeded the estimated life span of 40 years. In order to perform proper condition assessment different types of electrical as well as chemical and mechanical analysis methods are being applied.

The scope of this paper deals with a detection method that allows the localization of PD-events within an investigated cable route. To obtain a sufficient signal to noise ratio, despite high cable attenuation and cable lengths greater than 2 km, a redesigned measurement setup based on [1] as well as corresponding measurement data is presented.

KEYWORDS

On-site, partial discharge, locally distributed sensors, diagnostics.

INTRODUCTION

Although production ended in 2010 gas pressure cable systems are still key component in urban energy supply. The mass-paper insulated cables are located in pipes that feature an atmosphere of gaseous nitrogen under a pressure of 1.5 MPa Fig. 1.

The conductor (1) is wound with carbon paper (2) followed by the mass-impregnated paper insulation (3) with identification layer (4) and a field smoothing carbon paper layer (5) directly under the lead sheath (6). An additional paper layer (7) serves as padding between the sheath and a double-layer pressure protection made of tinned hard copper (8). Bitumen jute cords (9) also pad the individual strands against each other. Flat armor wires (10) reinforce and protect the cable when it's being installed the steel pipe (11) with PE coating (12).

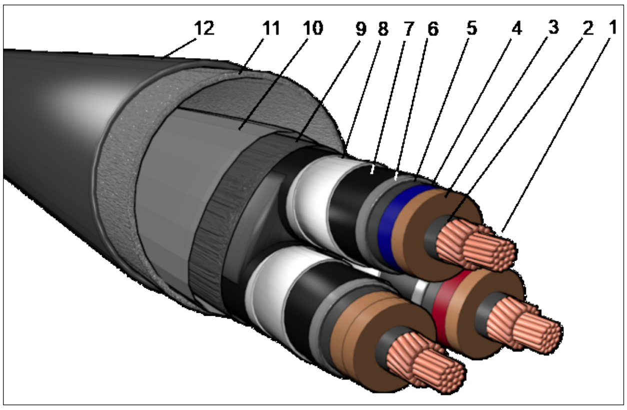

Fig. 1: model of an external gas pressure cable

In operation an increment of current load leads to temperature elevation in each strand's conductor. This causes the insulation temperature to rise as well. Simultaneously a decrease of the impregnation mass's viscosity occurs while the whole insulation compound starts to expand and applies pressure against the lead sheath. By lowering the load the cable's median temperature starts to recede again, given that the surrounding ground material provides a lower temperature. At the same time the impregnation mass and lead shields contract into original position due to force production through the external gas pressure in the pipe against them.

A lack of mentioned property would cause the shields and the insulation's paper parts to stay in expanded state while the liquid insulation would experience a thermally induced contraction. This would facilitate the likelihood of cavity formation with lowered breakdown voltage, partial discharges and finally accelerated aging of the insulation until breakdown as seen in Fig. 2.

Fig. 2: elec. breakdown of an external gas pressure cable strand due to preceding PD-events at 2*U_0

PULSE PROPAGATION PROPERTIES OF EXTERNAL GAS PRESSURE CABLES

Amongst other diagnostic methods on-site PD testing is a reliable way to check for installation insufficiencies or locally limited degrading cable sections. The strong attenuation of high frequency pulses along the cable causes a signal to disappear in the noise after several hundred meters when decoupled through ground.

In Fig. 3 a test charge is injected at the cable terminals. After reaching the first joint a reflection occurs due to the joint's slightly different wave impedance. The reflection's amplitude is measured after reaching the cable terminals. Fig. 4 shows the remaining signal amplitude as a function of covered distance. It shows that the test pulse amplitude