NON-ELECTRIC DETECTION OF INTERNAL DISCHARGES IN HIGH-VOLTAGE CABLE ACCESSORIES

Klaus **VATERRODT**, Andreas **PETERSEN**, IPH Berlin GmbH, (Germany), vaterrodt@iph.de, petersen@iph.de
André **LEISTNER**, Polymerics GmbH, (Germany), al@polymerics.de
Thomas **GRÄF**, HTW Hochschule für Technik und Wirtschaft Berlin, (Germany), thomas.graef@htw-berlin.de

ABSTRACT

Partial discharges in high voltage equipment can degrade the quality of insulation over long periods of time. The evaluation of PD patterns can be used as a diagnostic tool to assess the condition of the insulation inside high-voltage cable accessories.

Non-electrical PD detection is completely immune to external electromagnetic interference, which is a great advantage in practical application and therefore an important part of current research and development. This paper discusses measurements and experimental results of PD detection in laboratory-made MV cable accessories with integrated new optical and acoustic fibre sensors compared to established electrical PD measurement techniques.

KEYWORDS

Partial discharges; non-electric PD detection; acoustic sensors; optical sensors; PD-monitoring;

INTRODUCTION

The rapid increase in electricity consumption in industrial centers and metropolises requires the use of more power cables in power grids. Especially in urban distribution networks, but also increasingly in transmission networks, there is an increased demand for cable systems. In recent years, extruded polymer high-voltage direct current (HVDC) cables have also been used in transmission grids, especially for connecting offshore wind farms. Temperature and electrical field strength dependent DC volume resistance of the polymeric insulation materials can lead to an electric field inversion within the cable and space charges can accumulate in areas of insulation with high electric field strength. It is well known that cable systems for AC cables used to connect two power cables or one power cable and one power device are critical components of a cable route. They operate in a harsh environment with distorted electrical fields, high temperatures, and mechanical stresses. A similar situation may exist for DC cable routes. Therefore, the functional safety of the accessories is also a central issue for the reliability of a DC cable transmission system.
In addition to electrical partial discharge (PD) measurement technology, the use of fiber-optic sensors (FOS) in combination with adapted detection units offers great application potential in equipment on high and medium voltage levels. Optical fibers offer a variety of advantages. They are made of insulating materials, are immune to electromagnetic interference, have a high sensitivity, are small and lightweight, cost-effective and can be used in harsh environments. For an optical sensor, it is essential to efficiently detect the emitted PD light close to its source. Therefore, the sensor should be integrated into the stress cone of cable assemblies without interfering with the electrical field and dielectric strength. This presupposes that the material must meet the thermal and mechanical requirements for high-voltage accessories. The optical signal is transported to a detection unit outside the accessory to convert the optical into an electrical signal. Then the electrical signal is transferred to e.g. a PD measurement system for display and evaluation.
The acoustical sensor can be mounted on the surface of a cable accessory. The sensor head is made of a single-mode optical glass fiber connected to an external detection unit for recording and evaluation of strain-induced changes of optical path length caused by thermo-acoustic emissions of PD events. The low attenuation of ultrasound by elastomers is in favour of such PD detection.
The aim of this contribution is to demonstrate the realization of the optical and acoustic measurement of partial discharges in laboratory manufactured MV cable accessories and to prove the possibility of manufacturing HV accessories with integrated optical and acoustic fibre sensors.

TEST SAMPLES

The specimens investigated for this paper consisted of laboratory-made slip-on terminations (Fig. 1) and cable joints (Fig. 2) in the voltage range of 12/20 kV. The accessories were prepared by placing a fluorescent silicone optical fiber (FSOF, Polymerics GmbH, Germany) in a mold of a cable accessory, filling the mold with a liquid transparent silicone (shore A hardness 38), and curing the silicone at high temperature. The optical sensor is a waveguide made from transparent silicones with a fluorescent core and a colorless cladding (diameter ca. 2 mm, length ca. 25 cm).

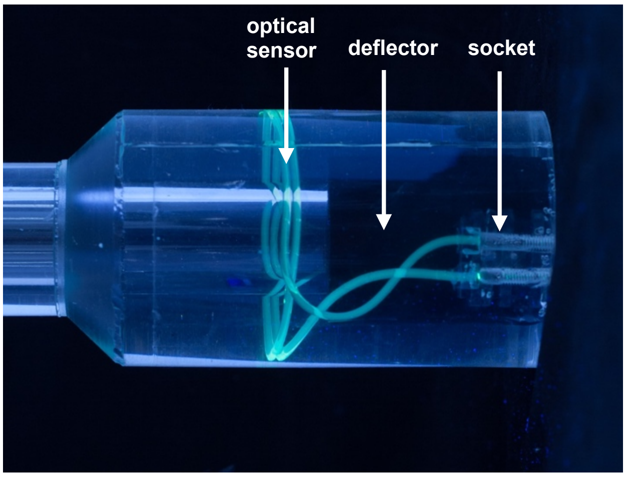

Fig. 1: Termination from transparent silicone (before coating) with embedded fluorescent silicone waveguide

The fluorescent dyes in the core of the waveguide are covalently bound to the silicone which prevents their migration and ensures long-term detection stability. Since the sensors have similar dielectric properties to the surrounding silicone, they do not disturb the electrical field and can