High voltage outdoor terminations with integrated optical partial discharge measurement

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ABSTRACT

This paper presents the physical background behind the optical partial discharge detection technique as well as the solution of the integration into a 145 kV high voltage termination. The setup of an integrated optical fiber including its embedding into the stress cone and the appropriate high-voltage outdoor termination is explained. The paper concludes with the results of an integrated and operating optical partial discharge system and compares the gathered results with an electrical measurement which was done simultaneously.

KEYWORDS

Partial discharge measurement, optical partial discharge detection, silicone rubber, Fluorescence, stress cone

INTRODUCTION

High voltage cable accessories are expected to have a life time of more than 40 years without any failure [1]. To achieve this requirement, the insulation system and its performance must be regularly checked. Today's most commonly used diagnostic method to perform this task is the electrical partial discharge measurement. This technique is based on the measurement of electrical signals with very small amplitude. The disadvantage of this technique is that due to the small amplitude it is very sensitive against electrical noise caused by external electrical fields such as from transformers, overhead lines, etc.

As a result of this, the electrical partial discharge measurement in a noisy environment does not always allow a proper interpretation of the partial discharge measurement results and consequently an understanding of the condition of high voltage equipment is not possible.
A novel method in order to perform diagnosis of the insulation system is optical partial discharge detection [2]. This method does not work with the electrical signals which are caused in case of partial discharges but rather detects the optical signals which are coming up at the same time. Based on this different physical process, external electrical noise can be neglected which leads to a much better usability in the field.

LIMITS OF ELECTRICAL PARTIAL DISCHARGE MEASUREMENTS

Typically, the main origin for partial discharges in high-voltage cable systems are neither the power cables nor the cable accessories. Main contribution is coming from the installation so that the commissioning testing typically tests the installation quality. Only a partial discharge free commissioning test indicates that the installation was done properly and the cable system is able to meet the desired life time of 30+ years.

In case the installation was not proper and partial discharges are occuring, then they are typically found in the area of the stress control element because this is the region with the highest electrical stress (see figure 1).

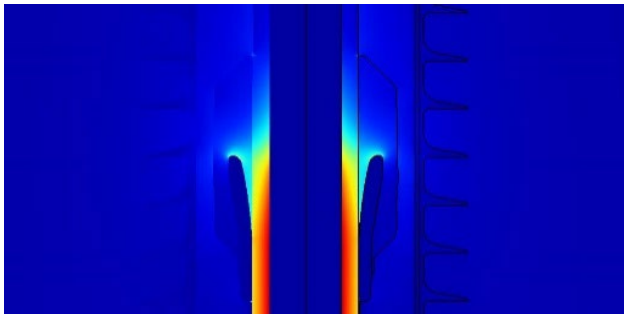

Fig. 1: electric field distribution inside of an outdoor termiantion

These partial discharges can have a small amplitude only and hence it is important to have a low noise to detect them correctly. Especially for commissioning testing, this is sometimes difficult because the to be measured cable line shows a very high noise level. The causes for this high noise level could often be found in following reasons:

- No screening existing
- Electrical interferences with other electrical equipment such as electronic converters
- In-coupling of partial discharges from other close by equipment
- Difficult grounding situation

Furthermore, very often these sources of noise cannot be switched off and affect the partial discharge measurement heavily e.g. the partial discharges from the stress control element are hidden by interferences. All these points lead to the fact that a correct partial discharge measurement in a noisy environment needs still the knowledge of experts. Unfortunately the decision about the condition of the cable line decides about big amount of money. Either the equipment is not accepted and big reparation costs are coming up or the cable system is failing because the partial discharge was not visible at the testing. This also involves high costs due to the cable work necessary after electrical breakdown. Hence a partial discharge technique at which the noise level is not influenced as easy as by electrical measurement would allow a better and easier statement of the cable system condition.

OPTICAL PARTIAL DISCHARGE MEASUREMENT

The optical partial discharge measurements uses the light which is emitted during the electrical discharge process. The light being caused at such a local breakdown depends on involved materials such as silicone, air, XLPE and other insulation materials. But most of the electrical discharges