Institute of High Voltage Engineering and System Management
Graz University of Technology
Inffeldgasse 18, 8010 Graz, Austria

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Partial Discharge Behaviour of Oil Board Arrangements by the Installation of Fibre-Optic Technology for Monitoring

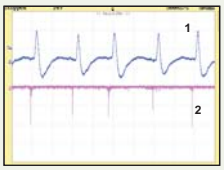
R. Schwarz, M. Muhr

Abstract:

Insulation condition monitoring of high voltage equipment is of significant importance in maintaining a safe and reliable electricity supply system. Important diagnostic methods are the partial discharge detection and the temperature measurement. For the measurements inside the equipment different fibre-optic technologies are in use.
By using fibre-optic technologies, it must be guarantee that the installation of fibre cables causes no additional disturbance inside the insulation system.

Basics:

Partial discharge (PD) detection - (breakdowns in partial regions of the insulating system) offers an distinguished possibility to characterize the properties of defects in insulation materials and is an indicator for insulation degradation.
An application area for fibre optic cables is the optical capture and transmission of PDs inside of lucent materials. The emitted light of PD impulses can be collected over the surface of an special fluorescent plastic fibre. Test results of investigations between a developed optical PD detection system using fibre-optic technology and the conventional PD measurements show a good correlation.

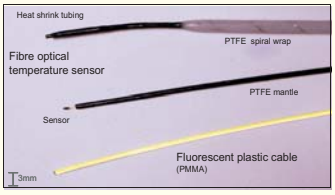


Comparison of electrical (1) and optical (2) measured PD impulses.

Temperature measurement - will identify potential problem areas (hot spots) that can lead to substantial equipment damage.
A punctual measurement by using a temperature-sensitive material in the head of the cable or a discrete temperature light converter with conventional data fibres are also possible. With special fibre optic cables the temperature distribution along the cable can be evaluated by the usage for example of the Raman effect.

Investigations:

The aim of the investigation is to carry out the PD-behaviour of different fibre optic cables implemented in an oil/board arrangement.
For the investigations different types of fibres are used:



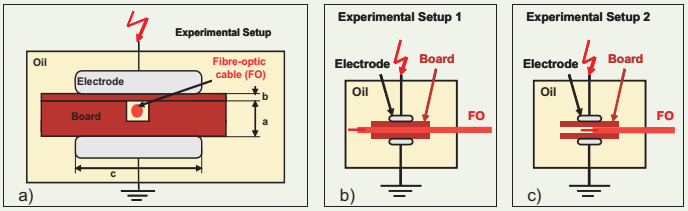
Investigated sensor types

Fluorescent plastic cable
Polymethylmethacrylat (PMMA) ∅=1mm, (one sample - "Fluor")

Fibre optical temperature sensor
Core material coated with Polytetrafluorethylen (PTFE), ∅=1.06mm, (three samples - "I÷III")
Optional reinforcement PTFE Spiral wrap, ∅=3.1mm, (three samples -"IV÷VI")

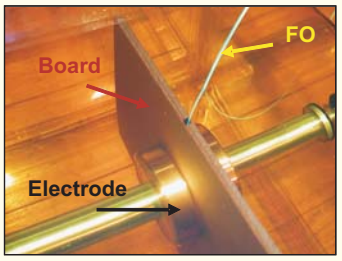
The *fluorescent plastic cable type* is the collector for optical PD-signals which collects the light flashs via the surface and transmits them from the core to the ends of the cable to a detection system.
The *fibre optical temperature sensor* is a commercial sensor for temperature measurement under oil. In the head of the sensor is a small temperature sensible material placed. Optional the fibre is reinforced with a spiral wrap of PTFE and the head sealed with a heat shrink tube.

Experimental setup



Schematic a) of the arrengement, b) Setup 1 - fibre-optic cable is completely in the board
c) Setup 2 - the fibre-optic cable ends within the board arrangement.

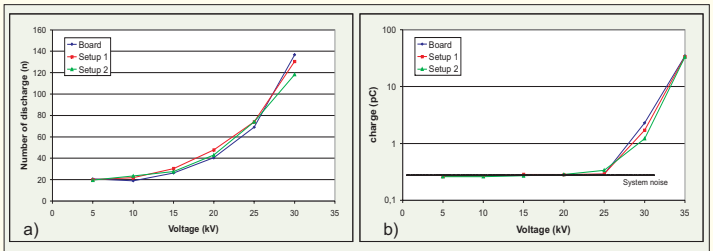
"Setup 1"
The fibre is located over the whole HV-electrode (full plugged in).
"Setup 2"
The head of the fibre is located in the centre of the HV-electrode (half plugged in).



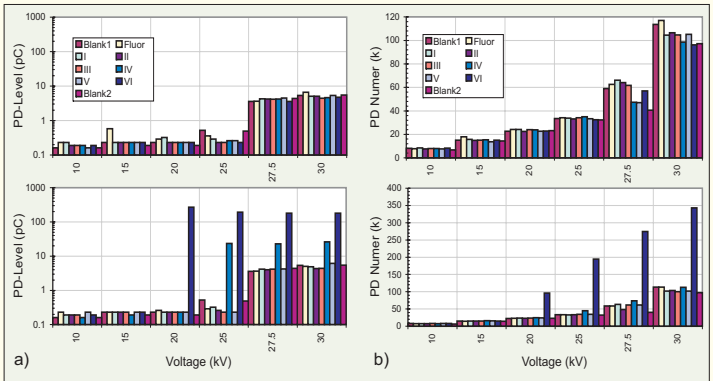
Oil-Board arrangement
- fibre-optic cable (FO)

Test Results:

The following pictures show the max. PD level and the number of partial discharge during a measuring time of 30s of the conventional PD measuring system according to IEC 60270.



PD behaviour - (Flour) - average value of 5 measurements,
a) Number of discharge versus voltage, b) max PD level versus voltage



PD behaviour - of the investigated fibres
a) max PD level versus voltage - upper diagram setup 1, lower diagram setup 2
b) Number of discharge versus voltage - upper diagram setup 1, lower diagram setup 2

The results of the measurement are similar by using a fluorescent fibre ("Fluor") and the fibre optical temperature sensors without protection spiral wrap ("I÷III"). A different behaviour show two of the three temperature sensors with protection spiral wraps. Sensors "IV" and "VI" feature different PD-pattern.This behaviour points to inclusion inside the fibre or air filled cavities inside the spiral wrap (the manual handling in the laboratory enabled not a vacuum impregnation of the sensors and so the existence of air inclusions in the spiral wrap cannot be excluded).

Conclusion:

First investigations with an oil-board-electrode arrangement show that a negligible influence by inserting the optical fibre into the slot (dielectric strength) is recognizable.
In some cases a small rise of the number of partial discharge was detectable, but it was approximately the same PD level in comparison to the blank reference arrangement.
The used protection spiral wrap made of PTFE is potential critical for air inclusion and needs a vacuum impregnation to avoid thereby caused PD's. Also for the thermo sensor head, a PD routine test is advisable before installation in a transformer.