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Optical leakage current monitoring as a tool to assess the operating state of HVDC cables

Slide 1

Utilization of fiber optic (FO) for monitoring HV power cables has improved: increased range and complexity, broadened monitored parameters such as temperature, strain, and vibrations, however these parameters do not directly indicate the health of the dielectric of the cable. We strongly believe the implementation of leakage current monitoring is an important and complementary diagnostic tool for HVDC cable systems. .
Two key studies were performed by Company to support this claim: the investigation of the leakage current behavior with accelerated ageing during a type test, and the physicochemical and electrical characterization of XLPE samples taken from the same cables. A passive leak current sensor is developed by Company as a solution to monitor the leakage current of HVDC cable systems.

Slide 2

Leakage current monitoring coupled with periodic conductivity characterizations were performed during electrothermal stress application following CIGRE TB 852 Type Test protocol on a reduced scale cable with HVDC grade materials. The upper left figure summarizes the test protocol, which was extensively described in *[1]*. The bottom left graph shows the measured leakage current and dummy loop conductor temperature during a sequence of twelve 24h load cycles at negative voltage. On the right, only the first and last load cycles are shown to better highlight key features. Evolutions of leakage current throughout the stress application were seen such as current peaks and bumps with cable conductor temperature variations and plateau magnitude variations during stabilized high temperatures. We observe that the magnitude of the bumps increases with load cycles: from 0.14 μA to 0.38 μA, from the first to last cycle, respectively.

Slide 3

The graph shows the normalized leakage current plateau values (obtained by averaging the last 10 minutes of each plateau) of the 28 load cycles. The plateau values decreased during load cycle sequences; the magnitude of that decrease lessens at the following sequences. The leakage current values at the end of the sequences increase by 14% and 26% between the first and second, and first and last, respectively.
Characterization of XLPE samples taken from the cables used in the above study was performed in a complementary physicochemical and electrical study *[2]*. The results supported the leakage current evolution mechanisms and conductivity characterizations observed in type test. Peaks and bumps triggered by temperature variations were also observed in literature; they seem to be depending on the insulation formulation and its manufacturing process.

These results emphasis the importance of leakage current monitoring for cable systems under DC voltage as it expresses the health status of the dielectric. How can we monitor without altering the screen and ground impedance?

Slide 4

Supergrid Institute has been developing a FO current sensor to address the need for a DC dielectric monitoring system. The upper right graph shows the simulated leakage current values as a function of temperature for a 320 kV DC cable with 20 mm insulation thickness and nominal electric field of 16 kV/mm. For a few km between two screen grounding positions, the leakage current is expected to be in the order of a few mA. The current sensor sensor must hence be highly sensitive; we aimed a 0.1 mA sensibility. The sensor technology is based on a magneto-optical effect such that it is passive and exclusively made of nonmetallic materials. The sensor will not electrically interact with the HVDC cable system. The lower left picture shows the latest laboratory prototype. The lower right figure shows the results of a sensibility: currents down to 0.2 mA were measured.

In conclusion, we expect FO leakage current sensors to be used in the future in combination with temperature measurements for monitoring the dielectric state of the insulation of HVDC cable systems.

References

[1] L. Boyer, P. Daniel, and X. Festaz, "Current measurements on HVDC XLPE model cable during type test", presented at the International Conference on Dielectrics, Palermo, Italy, Jul. 2022

[2] M. Mourad, S. Haller, P. Daniel, S. Igelesias, L. Boyer, and M. Henriksen, "Study of the electrical properties of HVDC XLPE cable after type test", presented at the International Conference on Dielectrics, Palermo, Italy, Jul. 2022