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Suitability of Open-Cell Foam as Electric Insulant for Superconducting Power Equipment

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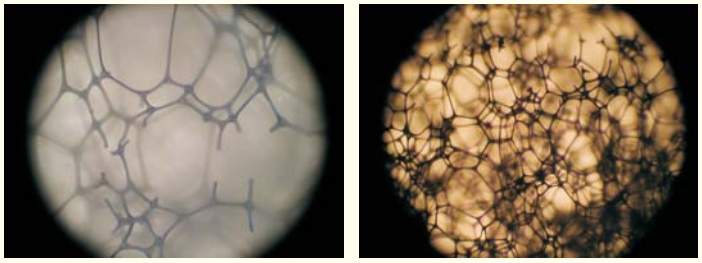
Abstract:

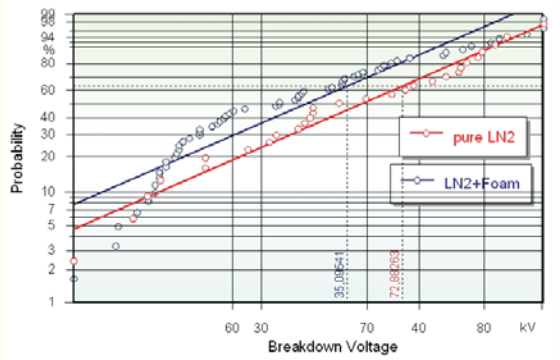
The suitability of an open-cell foam is investigated for the application as electric insulant in superconducting power equipment. The tested foam is made from melamine resin, a thermoset plastic from the aminoplastics group; it is a mechanical very flexible material with excellence compatibility to high and low temperature. It is produced with a three-dimensional filigree network structure formed from slender and hence readily thermo formable filaments. The impregnation with liquid nitrogen enables the application as electric insulating material. The main advantage of impregnated insulants is the very high life exponent, the self healing effect and the low relative permittivity, which has a positive effect on the load capacitance to reduce dielectric losses. The aim of these investigations was to test the aptitude of the liquid nitrogen impregnated open-cell foam with respect to the dielectric properties and the electric strength under different conditions. In this paper the results of permittivity measurements and ramp voltage tests were discussed and an outlook for future applications is given.

AC Breakdown Tests:



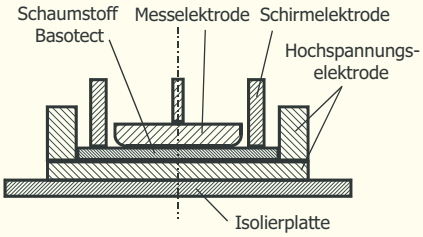
Open-cell foam from melamine resin (1:100 left, 1:40 right)

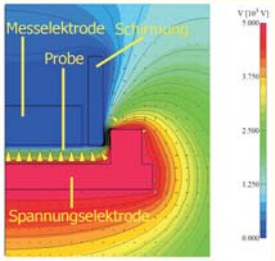
Test electrodes (left) and test vessel (right) for electric breakdown tests



Weibull Plot of AC Breakdown Tests

Relative Permittivity:

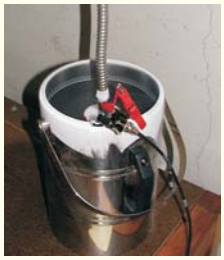




Electrode configuration (left) and field distribution (right) for relative permittivity measurement

$$r \quad \frac{C_{LN2}}{C_{vacuum}} \quad \frac{6{,}242\,pF}{4{,}509\,pF} \quad 1{,}384$$

Cable Model:



Cable model with open-cell foam as insulation medium (left) and test vessel

Conclusion:

The LN_2 impregnated foam showed excellent behaviour concerning the permittivity. The breakdown strength compared to pure LN_2 is about the half. This weak spot can be improved in the field design for a possible application.

The measurements on the cable model showed that an application as insulating medium for power equipment would be possible. The big benefit of the LN_2 impregnated open-cell foam is the very low relative permittivity and the combined function of electric insulating and thermal cooling. The very low value of the relative permittivity of approximately 1.8 or lower would open a wide field of applications in power engineering because the dielectric losses were minimal compared to conventional insulation systems. Beside the lower dielectric losses the capacitive load for power cables would also be lower. This would mean that less or no compensation reactors for long cable systems were necessary.

Future investigations should show the long time stability of the used materials. During the whole time of measurements (more than 9 month) at the open-cell foam no signs of tiredness could be found. The electrical and mechanical properties in dependence of load cycles should be demonstrated in a long term trial.

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