

# Using the Electrical Field Analysis for Assessment of the Influence of Paper Insulation on Discharge Initiation in Oil

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## Abstract

**Introduction:** Conclusions about the influence of paper insulation on the mechanism of electrical discharge initiation in mineral oil may be drawn mainly on the basis of laboratory experimental studies [1, 2]. However in some cases, these conclusions may be supported by other methods like electrical field analysis basing on FEM [3-5]. Determination of electrical field distribution and maximum values of electrical field stress in the vicinity of model electrode setups with paper insulation and without it may be helpful in the deduction about the initiation mechanisms in model paper-oil insulation setup. Comparison of the results of simulating works with previously obtained results of experimental works, especially in the field of measured times to initiation, may confirm a hypothesis about "weak points" included in oil, which are responsible for initiation processes [5].

**Use of COMSOL Multiphysics®:** COMSOL Multiphysics® was used for the simulation of electrical field distribution in the model electrode setups previously investigated in the experimental laboratory tests. One of these setups, with bare HV electrode, is presented in Figure 1. Both simulating systems consist of HV electrode (in first case with paper insulation and in second without insulation but with outer geometric dimensions as the insulated one), grounded electrode with insulating plate placed on it and free oil space.

**Results:** Example of the results of electrical field distribution obtained for bare HV electrode setup is presented in Figure 2. Because the most important area, form discharge initiation point of view, is the area around the HV electrode, the electrical field distribution in this area was taken into account and presented on the picture.

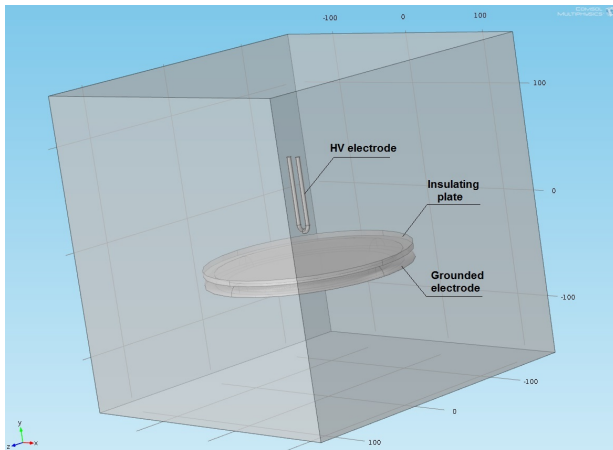
**Conclusion:** During experimental works the hypothesis that the source of "weak points" of paper-oil model electrode setup is oil, not the surface of metal or insulation wrapping, was formulated [2]. This hypothesis relied on the identity of times to discharge initiation measured in the same field condition for insulated HV electrode and bare HV electrode having the same outer dimensions as the insulated one. Testing conditions were related to the well known the most stressed oil volume law [6]. According to this law, the same oil volume being under electrical field higher than 90% of maximum value, may be statistically the source of the similar number of "weak points" in the paper-oil insulation setup [5, 6]. Thus, for both considered model electrode

setups, if the maximum electrical field stress is similar, similar is the most stressed oil volume. So, the similar number of "weak points" may be included in this volume. Therefore, obtained on the basis of the experimental works identity of times to initiation, seems to be explainable. Calculations performed using FEM in COMSOL Multiphysics® confirmed the established hypothesis because the maximum values for both cases were almost the same (0.4 MV/cm for insulated HV electrode and 0.42 MV/cm for bare HV electrode). Because the obtained values of maximum electrical field stress are in accordance with theory of electrical discharge initiation in mineral oil [7], it may be recognized to be correct.

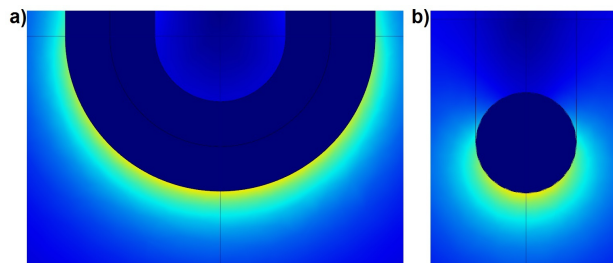
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## Figures used in the abstract



**Figure 1:** Geometric model of setup with bare HV electrode



**Figure 2:** Magnified fragment of calculated electrical field distribution for setup with bare HV electrode: a) x-y axis, b) y-z axis