Challenges of DC insulating systems for airborne applications

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INTRODUCTION:

- DC electrical systems can transfer more power than AC for same cable weight.
- Increased power demand leads to higher voltage
- For airplane applications 3 kV predicted in future [1]
- Behavior of solid DC insulation systems closely related to operating voltage and ambient conditions

MODELLING:

- Electrical conductivity of solid insulator under DC voltage is function of temperature and electric field strength.

$$\sigma_{ins} = F(T,E) = A\exp\left(\frac{-aq}{k_B T}\right)\frac{\sinh(B|E|)}{|E|} \quad [2]$$

- Electrical conductivity of air depends on several parameters. Two different constant values were used for the simulations ($3x10^{-15}$ and $8x10^{-15}$ S/m) [3]
- A power cable inside a duct was simulated (Tab. 1).

Radius conductor	5.25 mm
Insulator thickness	1.2 mm
Radius duct	8.45 mm

Table 1. Geometric characteristics of the cable and the duct.

RESULTS:

- |E| is very small and does not affect the value of σ_{ins}

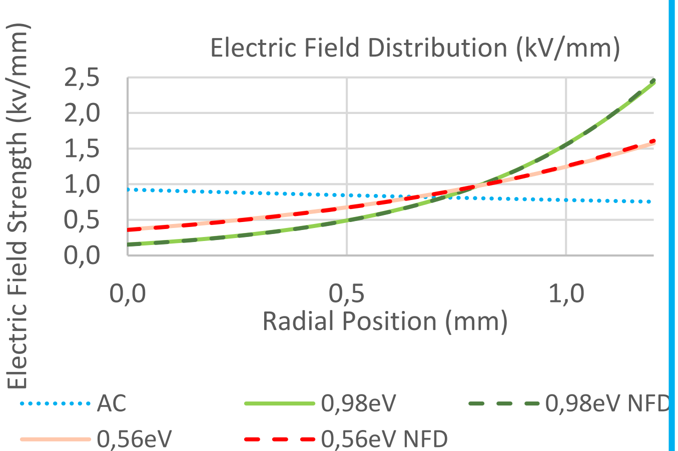

Figure 1. Electric field strength in the solid insulator of a shielded cable for two different types of XLPE (0.98eV & 0.56eV activation energy), with and without field dependency (NFD) on σ_{ins}.

- When using unshielded cables, electric field distribution in insulator and air changes over time (Fig 2)

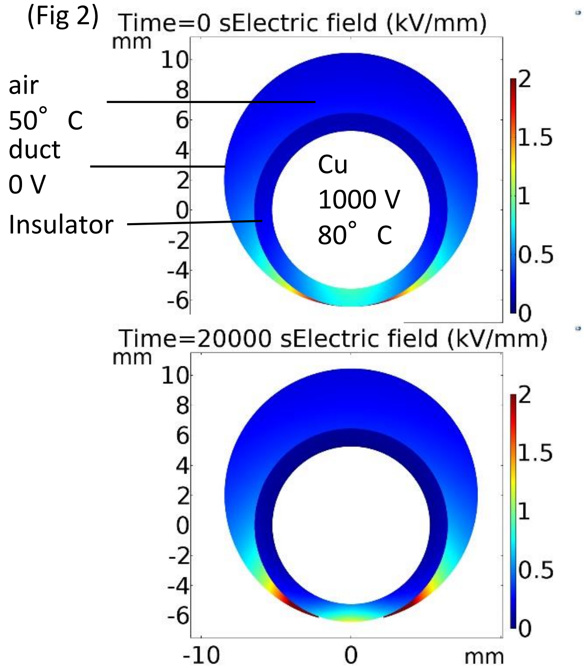

Figure 2. Cable in a grounded duct. The electric field distribution changes over time within both, the insulator and the air.

- Depending on operating and ambient conditions electric field strength has highest value in insulator or in air (Fig. 3)
- Smaller thermal gradients across insulator lead to more uniform distribution of |E| in the insulator

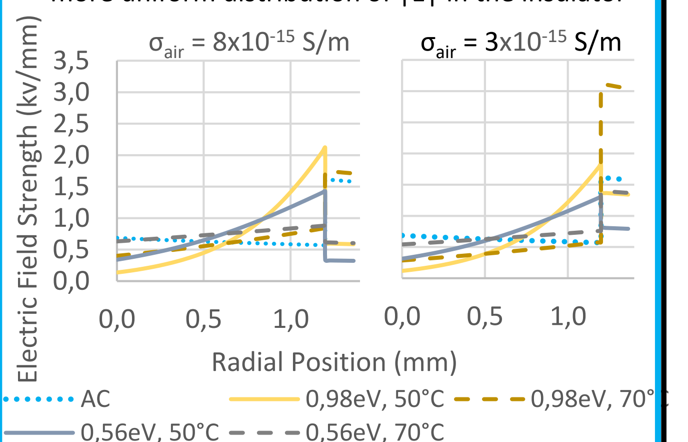

Figure 3. Electric field strength (across the black line in Fig. 1) for different insulator types, electrical conductivity and temperature of the ambient air.

CONCLUSIONS:

Insulating-material selection and good thermal design can reduce risk for electrical discharges in an insulated system under DC voltage.

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