Invited Lecture

"Physical phenomena and challenges in electrical insulation for airborne applications"

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Jean Rivenc was born in Toulouse, France, in 1973. He received the Ph.D. degree in applied science from Paul Sabatier University, Toulouse, in 1998. During his Ph.D. studies, he worked on electrostatics, dielectrics, and electrical insulation, and was a Visiting Engineer at the Massachusetts Institute of Technology, Cambridge, MA, USA. From 1998 to 2013, he was an Engineer at Renault, Paris, France (automotive car makers), where he managed a team and a laboratory in the field of electrical and electronics systems reliability. He tested various systems with respect to physicochemical environment and hazards linked to electronics failures. Since 2013, he has been with Airbus Group, Toulouse, as a Research Engineer, in the field of electromagnetic compatibility, power electronics, and composite materials. He is currently eXpert in High Voltage, Partial discharges, Arc and Plasmas Technologies.

Synopsis

The purpose of the talk is to give an overview of physical phenomena and challenges in electric insulation systems for airborne applications.

First of all, the general context will be remembered. The embedded electric power is expected to significantly increase in future aircrafts. Whether in order to replace legacy hydraulic or pneumatic systems by electric ones, or for propulsion purposes, powers of several megawatts, or more, will be needed. In order to manage this increase, while limiting the mass and volume of electric conductors, there is a need to increase the voltage. Targeted values are around 1000V, both with DC (Direct Current) and AC PWM (Alternative Current, with Pulse Width Modulation) networks. With this level of electric voltages and field, many physical phenomena occur and must be withstood: partial discharges and surface discharges, space charge, electrical insulation aging… A high electric stress is therefore applied to electrical insulation. In order to avoid equipment and systems failures, it is of prime importance to master these phenomena. They have been studied, and their effects have been well controlled, for many years in some industrial sectors like electric grid distribution.

The situation, however, is different in aeronautics. Compared to other industries, our business is probably the one which concentrates highest constraints for electric insulation: high temperatures up to 200°C, low pressures up to 100 mbars, and strong needs of compactness and lightness, which requires low thickness insulation and, therefore, high electric fields. Moreover, materials, which are used for the electrical insulation, are different compared to grid business: unfortunately, well-known materials like PE, PET, PEN are not used in aeronautics, but instead materials like fluoropolymers, epoxy, silicon, or PPS, for which much less literature is available. For these reasons, the transition to higher voltages in airborne applications is a real challenge.

In order to make a lively and didactic presentation, concrete examples will be presented. Examples of questions, which will be discussed during the presentation, are: how to design a partial-discharge-free cable? How to test a complex equipment, like a converter, with respect to partial discharges? How to determine creepage distances at high altitude? Is there a need to take the space charge phenomenon into account in sizing of the electric insulation system, or can it be neglected? What is the aging effect on dielectric performances, and how to demonstrate that no electrical insulation failure will occur for a 30 years' application?

We will try to bring - at least partially - answers to these questions, to share our vision on how to manage the electrical insulation and to give perspectives in order to design a safe and reliable insulation system for airborne applications.