# Reliability Assessment of Insulation Systems for 1200V Electric Traction Motors

## Research project

The project will focus on the reliability of 1200V electric traction motors, with a specific emphasis on the challenges associated with using oil spray for cooling. Oil, often a hydrocarbon, is subject to high temperatures during operation, which can lead to the release of hydrocarbons in a gaseous phase. A significant example is methane, which has an ionization potential of 12.6 eV, lower than that of hydrogen (15.4 eV). This characteristic can contribute to a reduction in the partial discharge inception voltage (PDIV), increasing the risk of insulation breakdown.

Additionally, the presence of suspended metallic particles in the oil presents an additional risk factor for insulation reliability. This contamination is a realistic possibility, as oil is commonly used not only for cooling but also as a lubricant for the gearbox. The accumulation of conductive particles may further reduce the PDIV.

Moreover, exposure of the oil to high temperatures can cause it to become more acidic and lead to the formation of solid byproducts, factors that could negatively impact the overall system performance. Given the complexity of these interactions and the lack of established literature on the subject, a thorough investigation of all these aspects is necessary to ensure the reliability and safety of 1200V electric motors in traction applications.

The ADR activities aim to develop innovative methodologies to study these complex phenomena, with the objective of gaining a thorough understanding of the variables that influence insulation reliability in 1200V electric motors.

In the initial phase, an investigation will be conducted to study the influence of volatile hydrocarbons derived from oil vapors on PDIV. To carry out this study, a simple electrode system will be designed within a controlled atmosphere, allowing the effect of oil vapors on PDIV to be observed, simulating typical operational conditions in the laboratory.

Subsequently, the impact of oil aging on PDIV will be studied: experiments will be conducted by spraying both new and aged oil on an electrode system that represents the

insulation system of an automotive motor, evaluating differences in dielectric and insulation behavior.

Finally, the study will conclude by replicating the experiment with the addition of micrometric particles suspended in the oil to examine the influence of metallic contamination on PDIV reduction. These experiments represent an essential step toward the characterization and mitigation of degradation phenomena, contributing to the definition of safer operational parameters for electric traction systems.

## Research plan

1. M0-M2: Understanding intent of the project, literature review, and training to use the different instruments needed to carry out the research activity.
2. M2-M4: Develop a test setup for testing the PDIV of a simplified electrode system (e.g., point/plane electrode system) with and without fumes released by an oil used for cooling and lubrication (Automatic Transmission Fluid, ATF).
3. M4-M6: testing the impact of the fumes released by an heated ATF on the PDIV of the test setup developed in #2.
4. M7-M9: development of an insulation model representative of 1200 V electrical machines for transport electrification.
5. M9-M10: effect of oil aging on the PDIV of the test setup developed in #4
6. M10-M12: effect of metal particles suspended in oil on the PDIV of the test setup developed in #4.