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M2Po3B-06: Electrical Conductivity Measurements of Pressurized Gaseous Helium at 77 K

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Utilizing helium gas (GHe) as the coolant for advanced power devices including busbars, superconducting cables, motors, and generators are currently being developed for large scale electric transport applications. The power devices can have an operating temperature ranging from 30-110 K. To achieve this temperature range and to ensure sufficient cooling the GHe is typically pressurized up to 2.0 MPa to increase its density. Given the operating pressure of the helium and the dielectric designs of the power devices, the GHe typically becomes a composite insulation with a solid dielectric material such as Kapton, and polypropylene laminated paper (PPLP).

To enable DC electric field modelling to be conducted on GHe cooled power devices operating at cryogenic temperature, it is necessary to have the electrical conductivity of helium gas as well as the solid insulation material. Unlike relative permittivity (dielectric constant), the electric conductivity is a temperature dependent variable. As such, it is necessary to measure electrical conductivity at the desired temperature and pressure that GHe will be utilized for cryogenic application. As part of our previous work we have designed, fabricated, and verified an electrical conductivity measurement cell which enables measurements to be completed in a pressurized GHe environment. The experimental setup was developed in accordance with ASTM D257. As part of our previous research, we have measured the electrical conductivity of various lapped tape materials such of PPLP and Kapton in GHe at 77 K and 2.0 MPa, as well as in liquid nitrogen. As part of these measurements, we saw the coolant had a slight influence on the electrical conductivity measurement. As part of our continued work, we have explored the electrical conductivity of GHe at 77 K at four pressure level ranging from 0.5 –2.0 MPa (in step of 0.5 Mpa) as well as at two different electric field configurations (1 kV/mm and 0.5 kV/mm).

This paper provides an overview of the experimental setup to measure the electrical conductivity of GHe at 77 K for pressures ranging from 0.5 –2.0 MPa and summarizes the experimental results. Commentary is also provided on how these measurements can be implemented to enable DC electric field modelling to be completed for GHe cooled DC power devices at cryogenic temperatures.

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