

§3. Study on Electrical Insulation Characteristics of Superfluid Helium

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A superconducting coil of LHD is exposed to various stresses, such as a thermal, electrical or mechanical one. The LHD coil should be stably operated even under these stresses. In this project, the authors studied electrical insulation under practical coil operation conditions. One of the most severe causes of insulation degradation in the pool cooling SC devices is a foreign particle intruding into its insulation space during fabrication and operation. This year, special efforts were made to clarify behavior of contaminant metallic particle under high electric field in superfluid liquid helium as well as normal liquid helium. Effects of the particle shape were investigated in detail using spherical and cylindrical particles as model contaminants. Data obtained in this project would be useful for electrical insulation design of LHD coils. Main results are summarized as follows.

- 1) The metallic particle repeatedly moved between the upper and the lower electrodes before the electrical breakdown took place under high electric field. This suggested that the electrical breakdown could be considerably influenced by the particle.
- 2) The particle generated gaseous bubbles and micro discharge when it collided with the electrodes. Detail observation revealed that the bubble formation was due to kinetic energy of moving particle rather than electrical discharge energy.
- 3) The breakdown voltage of liquid helium contaminated with cylindrical particles was lower than that with spherical ones over the whole pressure range (Fig. 1). This seemed to be attributed to higher field enhancement effect of cylindrical particles with sharp edges.
- 4) The breakdown voltage of normal liquid helium was mainly determined by the discharge onset electric field strength E_0 when the particle diameter was large and by the discharge propagation electric field strength E_p when the particle diameter was small (Fig. 2). On the other hand, the breakdown voltage of superfluid liquid helium did not show clear dependency on E_p and E_0 , and seemed to be influenced by the other factor such as preceding corona discharge.

Reference

- 1) Hara, M., Maeda, Y., Nakagawa, N., Suehiro, J., Yamada S.: "DC Breakdown Voltage Characteristics in the Presence of Metallic Particles in Saturated Liquid Helium", Proc. of 2005 IEEE ICDL, pp.373-376 (2005)
- 2) Nakagawa, N. Maeda Y., Suehiro, J., Hara, M., Yamada, S.: "Breakdown Voltage Characteristics in the

Presence of Metallic Needle-Particles in Saturated Liquid Helium", Annual meeting record of IEEJ (2005)

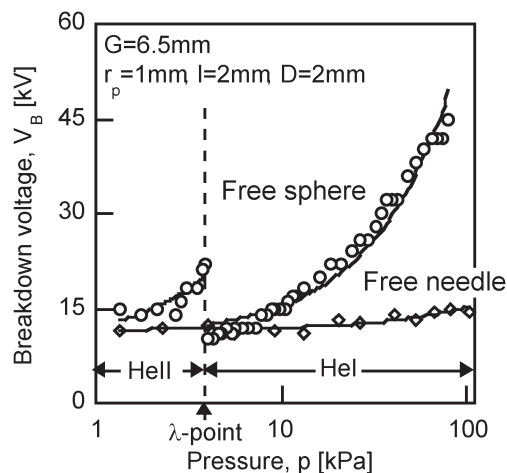


Fig. 1. Pressure dependency of the breakdown voltage of the liquid helium contaminated with a free spherical metallic particle or needle.

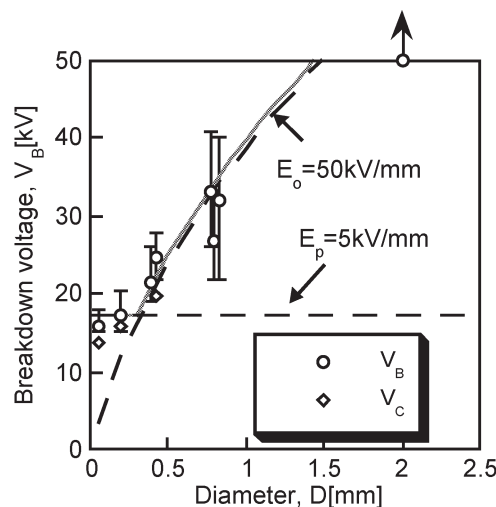


Fig. 2. Effects of needle tip diameter on the breakdown voltage (V_B) or corona onset voltage (V_C) of the normal liquid helium. E_0 : Discharge onset electric field, E_p : Discharge propagation electric field.