



Contribution ID: 133 Contribution code: WED-PO2-616-13

Type: Poster

Varistor Insulation for HTS Magnets

Wednesday, 17 November 2021 10:30 (20 minutes)

A variable resistance thin dielectric insulation coating for REBCO tape HTS coils has been developed. This new type of insulation system switches between fully insulating and conducting, after an increase in inter turn voltage. Non-Insulated (NI), fully soldered, HTS coils have proven to be very reliable; NI coils are achieving high magnetic fields above 25 Tesla and are almost impossible to quench. Over-current operation simply redirects the excess current out of the superconducting tape, to flow radially through the coil then back to the power supply. The internal coil resistance can then run the current down when the power supply is switched off. The disadvantage with NI coils is, as the coil volume and inductance increases, the charging / discharging time can take many hours, even days. This is not compatible with magnet systems that need accurate and fast current to magnetic field control, such as accelerators or other systems. With the Varistor Insulation (VI) we aim to achieve both robust performances as seen in NI coils and fast ramping with controlled current to field transfer functions.

In this paper we present the electrical characterization of the insulation at room temperature and cryogenic temperatures, along with simulated magnet operation during ramping, normal operation and failure modes. We discuss other features of the VI insulation such as, application methods to provide thin layers, and alternative formulations to tune its properties. Its ability to act as a distributed quench heater when the voltage threshold is exceeded is also discussed. Finally, the application of the insulation material is documented during the construction of small test pancake coils.

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Session Classification: WED-PO2-616 Electrical Insulation for Magnets