BROOKHAVEN NATIONAL LABORATORY

Superconducting Magnet Division
Magnet Note

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Topic: GSI

Title: GSI Cable Insulation Testing

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GSI Cable Insulation Testing

Peter Kirk, Jesse Schmalzle

Motive For Testing:

The hypot-compressive cable tests were designed to answer questions regarding the ability of the superconducting cable being used in the fast-ramp GSI magnets to maintain turn to turn electrical integrity under load while decreasing the amount of insulation on the minor edge of the conductor. These tests mirror the protocol used a decade ago for the SSC project. Using the SSC results as a reference point, the current tests were performed on three new configurations of insulation. A fourth group was tested as a baseline based on the older insulation scheme developed for SSC and employed in the RHIC collider.

The motive for the changing the current insulation scheme is based on the tendency of the magnets to quench during fast ramping. The potential for quenching arises from eddy currents within the conductor, which cause a local increase in temperature out of the superconducting temperature range. The conductor being used for GSI has been altered by the introduction of a stainless steel foil inside the cable itself. It is hoped that this foil will help dissipate the eddy currents. Furthermore, it is hoped that decreasing the amount of insulation on the minor edge of the keystone will increase the amount of convective heat transfer between the cable and the helium coolant. These tests show preliminary results concerning the integrity of the insulation methods chosen.

Experimental Setup:

The specimens being tested are shown in figure 1. After preparation, the cable samples were cured in pairs as indicated in figure 2. After curing, both ends are split open, and one end is stripped to allow for the electrical connections. The pairs are meant to simulate the interaction of adjacent cables inside the magnet. To simulate this phenomenon, a static voltage of 2 kV was applied to the adjacent cables. The cables were then placed inside a keystoned housing (BNL P/N 25-1153.01-4) and cycled within an Instron machine until failure. The cycles were as follows. Load the specimen to 5000 psi (34 MPa), and then relieve 50% pressure. Repeat this procedure at 5000 psi intervals until 15000 psi (103 MPa). At this point, cycle the load six times before raising the applied pressure to the next echelon. Repeat until six cycles at 50 kpsi (345 MPa) is reached, or else until failure of the specimen results. Figure 3 shows in detail the setup used for the experiment.

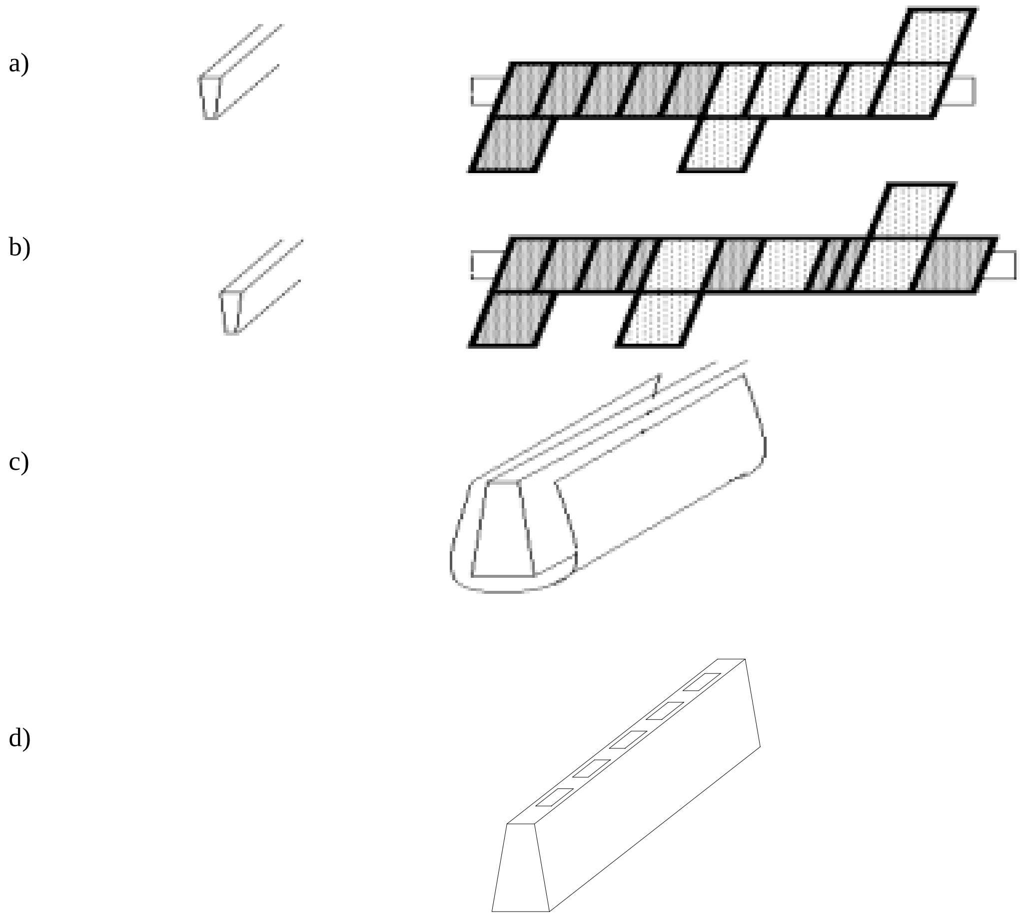

Figure 1: a) This shows the standard RHIC wrapping as used on the SSC. For the sake of these experiments, they were used as baseline. The wrapping consists of two layers of 50% overlapped kapton insulation. b) Like the previous model, the bottom layer is 50% overlapped kapton, yet the uppermost layer is a barberpole wrap, leaving a gap between adjacent strands. c) As shown, there is a wide piece of kapton insulation formed around the major edge of the conductor and trimmed flush to the minor edge. As in (b), the outer wrapping is a barberpole wrap. d) Standard RHIC wrap with laser cut slots on the minor edge. Slots ~.080 x .024 inches spaced ~.135 inches on center.

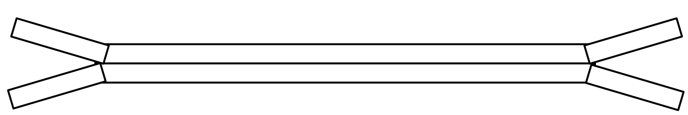

Figure 2: Above is shown two conductors cured together after wrapping. These conductors are cured under a compressive load and are typical for all the specimens tested. The ends are then separated to prevent arching, and one end has been stripped so as to allow for the addition of electrodes to apply the voltage.

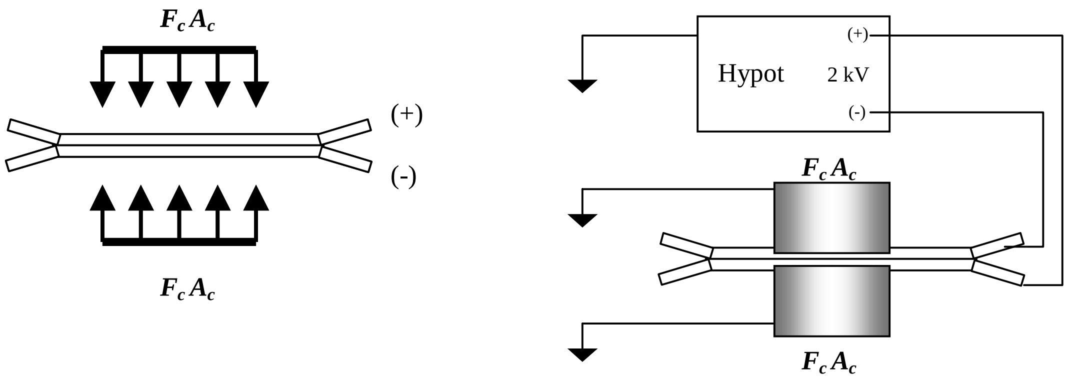

Figure 3: On the left, the specimen is undergoing cyclic compression over a finite area while under a variable loading. The housing has a complimentary keystone milled into, and it can be reasonably assumed that pressure is evenly distributed over the area, A_c. The right hand illustration is a schematic representation of the test stand. Shown is the specimen, the housing, the Hypot tester, and the wiring diagram employed. Omitted is the Instron machine in favor of an applied force, F_c.

<u>Results of Testing on Specimens</u>:

Figure 1 details the types of specimens used. Four specimens were made and tested for each of the first two categories, (a) and (b). Among these, all specimens passed the cyclic loading under 2 kV up to the limit of the Instron's capability, 50 kpsi (345 MPa). During the testing, all seemed stable, as reflected by no appreciable current flow through the Hypot tester. Furthermore, there were no indications, either visual or auditory, during the testing which would indicate a possible failure. Finally, visual inspection of the samples after each test did not seem to indicate any damage occurred.

Six samples of type (c) were made. They were grouped into three categories of two samples each. The categories reflected the amount of gap between the barberpole wrapping on the outer layer. Although it was thought that the gap spacing might influence the integrity of the cables, the empirical tests indicate that all specimens in this category failed uniformly. The specimens were not able to hold 2 kV without arching, so the amount of voltage applied to this group was decreased to 500 V. In each case, the cables were not able to withstand a force of 25 kpsi (172 MPa), and usually failed between 20-24 kpsi (138-165 MPa). The failure was apparent both by surges of current through the Hypot tester as well as visual and auditory clues.

Four samples of type (d) were tested. As sample type (c), they were not able to hold 2kV and were therefore tested with a 500V potential between turns. All samples passed the cyclic loading under 500V up to the limit of the Instron's capability, 50kpsi (345 MPa). Subsequently for each sample, the load was released and the potential was slowly increased until an arc between turns was detected. The shorts occurred between 900V and 1000V for all four samples.

Those Involved:
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