BROOKHAVEN NATIONAL LABORATORY

Superconducting Magnet Division

Magnet Note

Author: J. Escallier

Date: February 22, 2002

Topic No: 617-33 (AM-MD-318)

Topic: Common Coil Design

Title: Assembly Techniques For Common Coil Magnet Cassettes.

M. Anerella
A. Blake
J. Cozzolino
J. Escallier
G. Ganetis
M. Garber
A. Ghosh
R. Gupta
H. Hahn
M. Harrison
J. Herrera
A. Jain
P. Joshi
S. Kahn
W. Louie
J. Muratore
S. Ozaki
B. Parker
S. Peggs
F. Pilat
S. Plate
C. Porretto
W. Sampson
J. Schmalzle
J. Sondericker
S. Tepikian
R. Thomas
D. Trbojevic
P. Wanderer
J. Wei
T. Wild
E. Willen

Superconducting Magnet Division
Magnet Note
John Escallier

Assembly Techniques For Common Coil Magnet Cassettes.

The ten turn common coil program is a rapid turnaround development program instituted for the quick learning of methods and designs needed for building a high field, brittle conductor pancake style coil.

Coil winding

When winding the ten turn coils, the delicate nature of the reacted conductors forces the use of very low winding tensions. As a result, it is not possible to use tension to hold the conductor next to the bobbin where the straight section meets the turn. Clamps could be used, but must be removed at every turn. Removing clamps allows the conductor to bow out, causing a high cable tension.

We have developed a method of holding each turn in place using a filament type Kevlar string. Each turn is bound to the inner pole piece; allowing each Kevlar string to hold only one turn of the coil. This prevents a buildup of forces needed to hold the coil in place; eliminates the continual removal and replacement of holding clamps, and provides control of end fluff when the coil is clamped into it's final dimension within the impregnation/curing fixture.

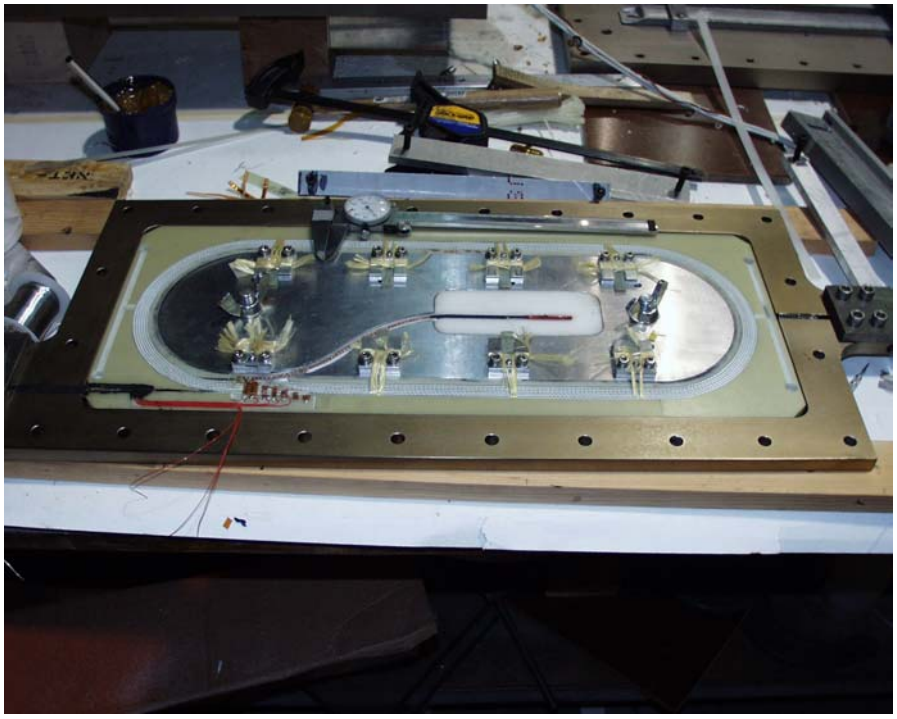

Figure 1 Kevlar clamp setup, coil locked into fixturing

Coil impregnation mold design

Initial mold tooling required the use of mold release for preventing adhesion of the epoxy to the sides of the mold. The release agent is Frekote, a waxy coating which prevents bonding. The Frekote worked as expected, preventing adhesion, but also entered into the glass cloth side pieces of the coil cassette. This caused occasional epoxy free areas on the surface, as the wax prevented full epoxy penetration.

The second option tried was a Teflon tape, with silicone adhesive on one side. This worked also, but tends to trap air between the mold sides and the tape. Under vacuum, these air pockets expand, causing areas of cratering, where the epoxy was starved out. An interim solution to this was to use a "wallpaper removal tool" to make many holes in the tape. This allowed trapped air to be pulled out from behind the tape.

The third solution is to treat the surfaces of the tooling with the "Magnaplate" process. This is a heat treatment chemical process which imparts a surface on the metals that epoxy does not stick to. Because of the high temperature of this coating process, aluminum tooling was unacceptable. The aluminum plate material tested was unable to maintain flatness through the coating process, even with annealing and machining beforehand. The tooling sent for coating was steel.

Figure 2 Mold side plate with magnaplate coating

For impregnation, it was decided to tip the coil with tooling at an angle, allowing gravity to assist in the removal of any outgassing products during the impregnation. The epoxy is introduced at the lowest point of the coil, while the outlet is the highest point. To prevent a large epoxy spru from curing next to the delicate coil, the top mold plate has four holes, two at each end of the coil. The epoxy is introduced to the coil assembly at a blank location of the G-10 end piece. Channels are cut in the G-10, routing the epoxy directly to the center tip of the coil. Similar channeling is located on the other end of the coil structure. This allows control over the cross section dimensions of the epoxy where it contacts the coil tip, and allows disassembly of the structure without the possibility of compromising the coil when the spru is broken.

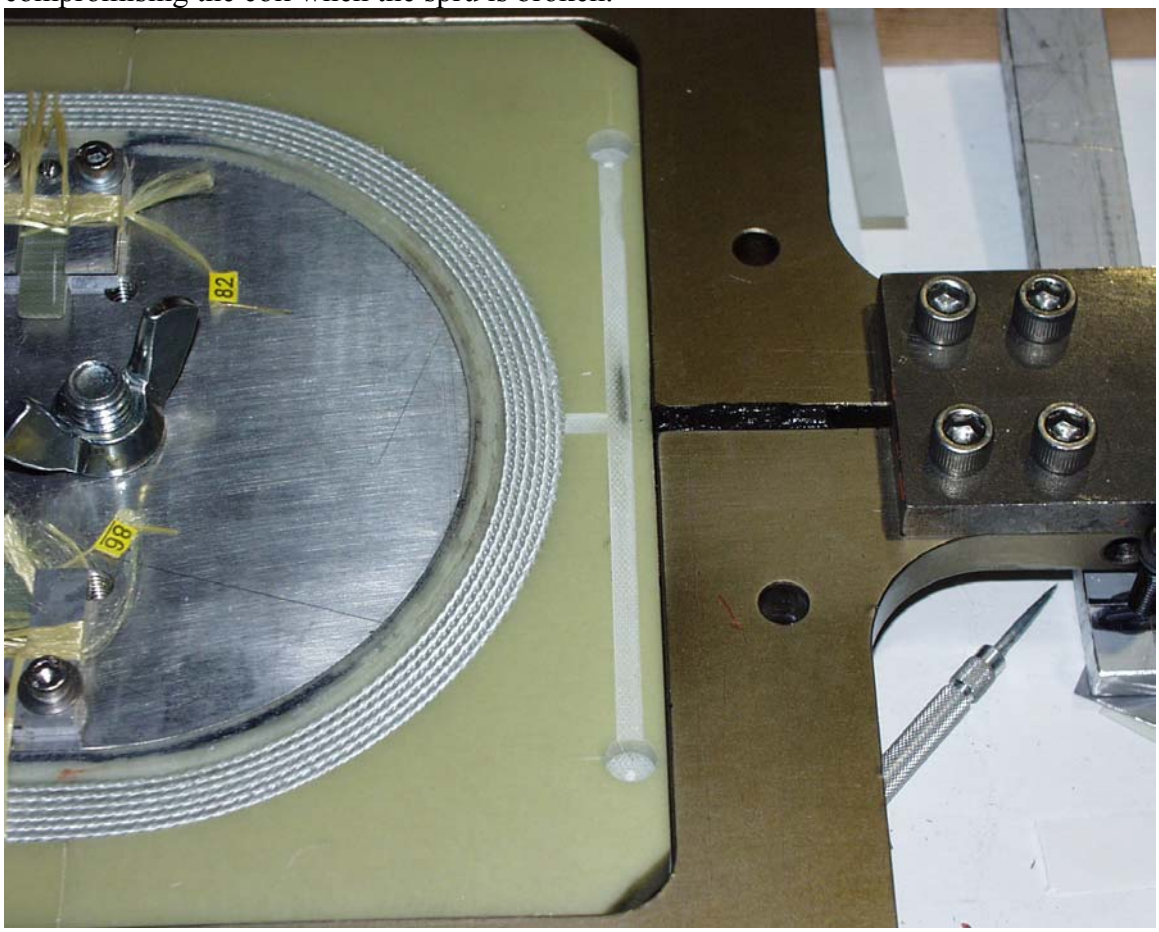

Figure 3 coil G-10 end piece showing epoxy path

Voltage taps

Voltage taps were used every turn, and at the lead in and out, a total of 12 taps per coil. Initial taps were of #32awg tefzel coated wire. Each tap is soldered to the conductor on the edge after winding, and was initially routed to the center of the coil bobbin. Care is

taken to limit the height of the solder joint, and an additional layer of glass cloth is on the tap side, with the tap path cut out of the cloth providing relief for the wires. A final cloth is placed over the coil, giving a continuous glass layer to the coil side.

When the Kevlar string clamp method was used for coil winding, it was found that the conductor packing prevented using the standard method of soldering the wire to the cable. A method was developed using 1 mil thick copper ribbon, and soldering the ribbon across the cable while the coil is being wound. When the coil is complete, the copper ribbons are dressed to the side of the coil, and wires are soldered outside of the coil area. The G-10 side pieces of the cassette are machined to allow routing of the v tap wires.

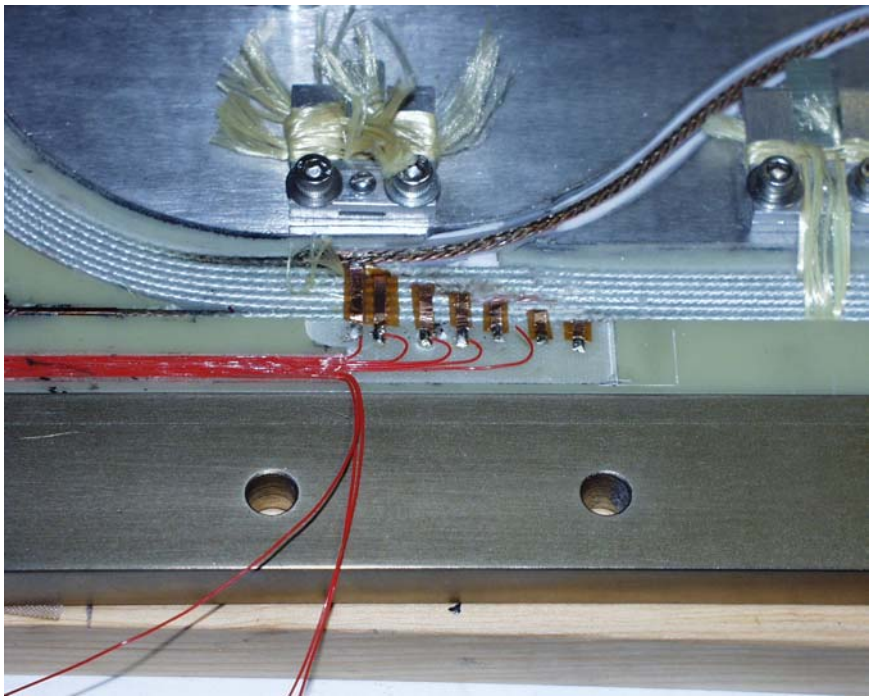

Figure 4 Voltage taps being soldered in G-10 channel

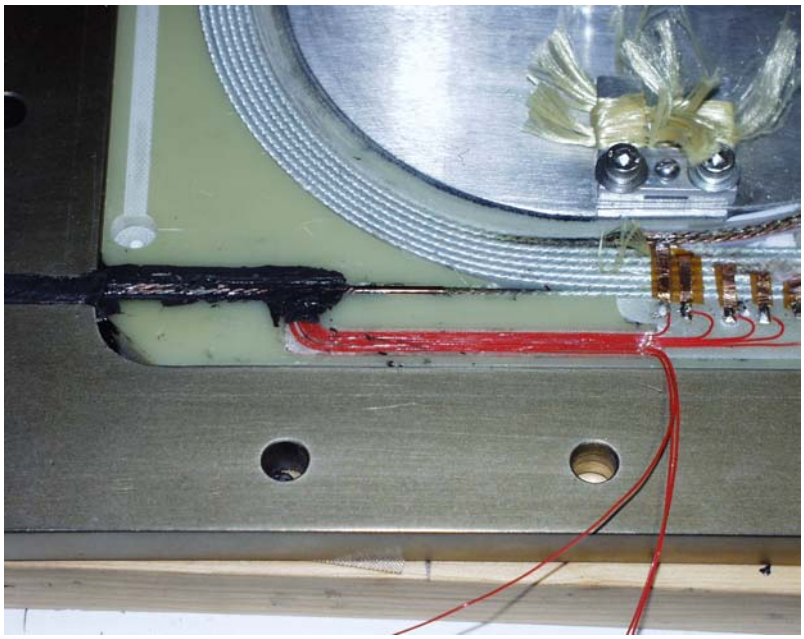

Figure 5 Voltage tap wire placement for exiting coil

Vacuum bag fixturing

Under development at present is the use of a flexible membrane sealing technique known as vacuum bagging. A prototype curing table was constructed, and several successful trial impregnations were performed. The best features of the bag technique are the ability to remove all mold sealing issues, and the ability to modify the magnet design without major mold tooling reworks or replacement. Additional work is underway to further reduce the amount of geometry specific tooling required for any coil design.

Figure 6 Vacuum bag table with membrane

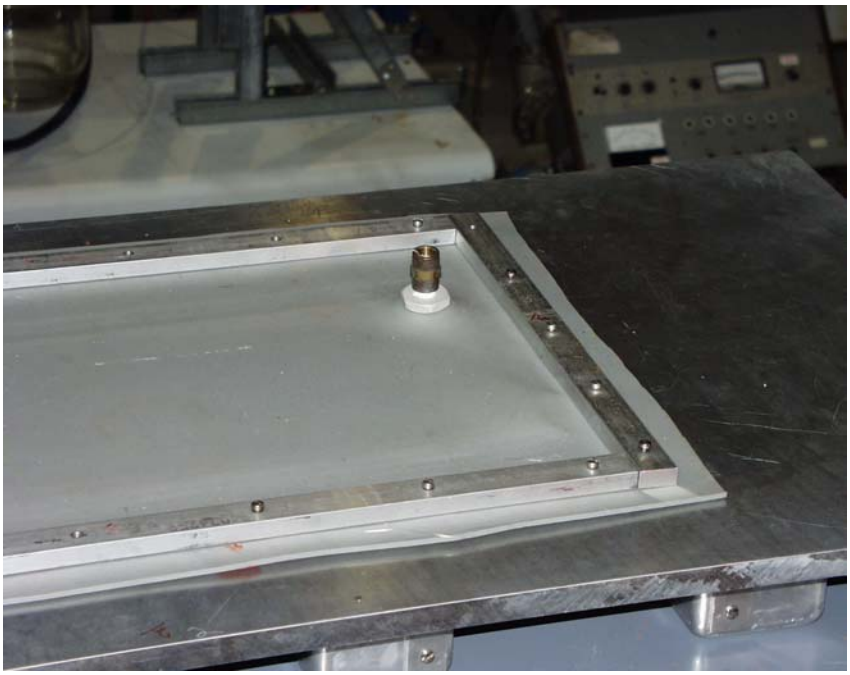

Figure 7Vacuum bag table membrane exit port