TS-SSC 90-057

Fermilab

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TO: Distribution

FROM: F. Markley

SUBJECT: "New" Kapton Insulation

DuPont would like to set up a meeting here at Fermilab to present their data on the "new" Kapton insulation. They would like to meet with us for a presentation not to exceed 2 hours. They suggest September 17th, 18th, 20th, or 21st as possible dates for the meeting. I would appreciate it if you would contact me and let me know if you can/will attend, and what dates are best.

Jim Fravillig and Jim Oschner of DuPont were here on August 28th to discuss DuPont's "new" Kapton. Brookhaven has now built and tested a 1.5 meter magnet insulated with this material. It is designated DSO-201. The cable was insulated with two layers of half-lapped insulation. The first layer was 1 mil of amorphous unfilled Kapton with .3 mils of XMP1, polyimide thermoplastics insulation on the outside. The second layer was the same material, but with .3 mils of adhesive on both sides. DuPont called the material 130 CI-1 and 160 CI, respectively. The coil was molded at 4,400 psi and a peak temperature of 225°C. The molding cycle took 4 hours. The molded coils were collared at 10,000 psi. There was only a small (normal) loss of prestress after collaring. The modulus was about 1×10^6 psi which is about the same as they get for regular coils. There was a prestress loss of 5000 psi on cooldown to 4.2K, whereas regular coils experience only 3500 psi loss. This is assumed to be due to the higher expansion coefficients of unfilled Kapton compared to fiberglass-epoxy. Later coils will use a filled Kapton for the outer layer and the prestress loss is expected to be less. When the magnet was energized to full field, only about 500 psi of prestress remained. The field quality was "O.K.".

At 4.2K, there were 11 quenches all above the short sample current. Short samples quenched at 6800 Amps. There was no training curve; the magnet was then cooled to 3.6K and quenched several times. All were at currents greater than short sample and there was no training. On further cooldown to 3.3K, there were several quenches, the first at 7700 Amps and the rest at 7900 Amps (short sample was 7600 Amps). Brookhaven called the first quench a training quench.

Regular magnets usually quenched in the inner coil, but this one's quenches occurred equally between inner and outer coils. All quenches appeared to be in the same place within the coil. A flow rate of liquid helium thru the coil (how?) was measured and found to be 7 to 9 times slower than the rate thru regular coils. Oschner says that is what the theory of flowthru labyrinths would predict.

The magnet will be cut up to examine the insulation. Some coils were molded then cut up, and the turn-to-turn dielectric strength measured. Regular coils break down at 2000 V for the inner coil and 3000 V for the outer coil. The "new" Kapton insulated samples did not break down at 5000 V. (NOTE: there are 2 layers of Kapton being compared to one.) They say Kapton should be good for 6000 V/mil, so the lower breakdown voltage indicates some damage to the insulation.

Brookhaven has also made a second coil, DSO-202, of the same type but with .25 mils of adhesive instead of the .3 mils used in DSO-201. It is built but not yet cooled down. They will make 2 "breathable" coils, DSO-203 and DSO-204. The inner layer of insulation will be 1.2 mils of amorphous Kapton, 1/2 lapped, and the outer layer will be 2 mils of the same with .5 mils of XMRPI adhesive on one side and it will be gap-lapped to achieve "breathability". Since they now feel "breathability" is not necessary, their priority is to build magnets DSO-213 and DSO-214. Both will have 1 mil of amorphous Kapton with .25 mils of adhesive on the outside as the inner 1/2 lapped layer. The second layer of DSO-213 will be a 1/2 lapped layer of 1.8 mil filled amorphous Kapton with .2 mils of adhesive on both sides. DSO-214's second layer will be thinner, filled amorphous Kapton, which DuPont feels will be the optimum insulation system.

They will then build 4 more like DSO-214, and then some long ones. By October, DuPont plans to have material available for anyone who wants it. NOTE: Brookhaven does plan to build 2 magnets, DSO-205 and DSO-206, with regular Kapton coated with an epoxy adhesive (like our Low Beta quads). These would represent a lower cost and a lower temperature cure alternatives to the XMPI polyimide thermoplastics adhesive.

DuPont no longer emphasizes the cut-thrus resistance of the "new" Kapton. They now say that Brookhaven data corrected for their double ground short problem substantially agrees with my pressure to cause breakdown data, i.e., old and new Kaptons are about equal. They also claim that epoxy can crack and cause the crack to propagate thru Kapton in the long term, thus avoiding conflict with my data that this does not happen in the short term.

The new Kapton will cost substantially more, and the filled material is more brittle, and there is no case history to prove it's reliability, but they claim the following advantages:

1. Greater dielectric breakdown strength (due to replacing the epoxy fiberglass gap-lapped layer with a second layer of filled Kapton 1/2 lapped).

2. No shelf life limitations on the adhesive.

3. Over the long term, the coils are less sensitive to developing shorts through handling at room temperature. (Their belief that an epoxy crack can eventually propagate through the Kapton).

4. A shorter molding cycle since no residence time at maximum temperature is required. (But, it will probably take longer to reach 225°C versus 250°F)

5. Able to withstand higher molding and collaring pressures; again, due to 2 layers of Kapton versus one layer, plus epoxy fiberglass, making 50,000 psi possible versus 30,000 psi. (Greater than 50,000 psi is possible only if something is done to stop radical expansion of the cable under pressure, and this applies only to future high field coils.)

6. Better ability to mold to a specific size since there is only about .6 mils of a viscous adhesive versus 4 mils of epoxy fiberglass with greater fluidity during cure. (Unfortunately, this argument goes both ways since a greater amount of fluid material can compensate by thickness variations in the solid material.)

7. No training required. Based on one magnet only so far, and the theory is that the polyimide adhesive is less likely to crack and release enough energy to cause a quench.

NOTE: This is a report of the meeting with DuPont. I do not necessarily agree with their opinions, nor do I recommend the "new" Kapton to be used for the SSC.

Nomenclature:

DuPont's first three numbers are the total thickness in hundredths of mils; CI = amorphous Kapton, RCI = Al_2O_3, filled amorphous Kapton; and a number indicating adhesive on one side only instead of both sides; e.g., 125CI-1 and 180 RCI.

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