Fermilab

TS-SSC 91-019
1/29/91

To: Distribution

From: Jim Strait

Subject: DC0304 strip heater to ground short

During post-yoking electrical checks the strip heater in quadrant II (upper left as viewed from the lead end) failed hi-pot to ground at approximately 1.5 kV. All other hi-pots passed, however, including coil to ground, with the strip heaters held at ground, at 5 kV. Ohmmeter measurements showed the heater to have a resistance of approximately 250 Ω to ground.

A set of four-wire resistance measurements were made to determine the location of the short. A Hewlett-Packard current source and Fluke DMM on the hi-pot cart were used for the measurements. A current of 0.1 A was passed through the heater from the return end of the magnet and returned through an external lead. The heater in quadrant I was used to make a voltage measurement connection to the heater at the lead end. The arrangement is shown in Figure 1. The measured voltages are shown in Table I. The heater resistance of 2.67 Ω agrees well with the value in the Traveller and the sum of the resistances from the two ends to ground equals the total resistance to within 1 mΩ (better than 1 part in 2000), indicating that there is only one short to ground.

Table I
Heater Resistance Measurements
I = 0.1 A

Segment	Voltage
Lead End to Return End	266.7 mV
Lead End to Ground	263.3 mV
Return End to Ground	-3.3 mV

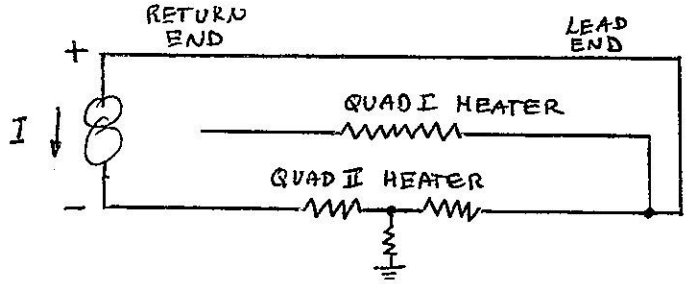

Figure 1

The strip heaters are made of copper coated stainless steel with periodic high resistance points at which the copper coating is absent and the stainless is cut into a zig-zag pattern. Therefore the resistance is far from uniform along the length of the heater and the location cannot be derived by simple ratios of resistances from Table I. The resistance per unit length was measured on a heater removed from an earlier coil. This heater has a total resistance, measured with the same equipment, of 2.70 Ω. This equals the resistance of the heater in DC0304 within about 1% and the difference may be within the uncertainty of the measurement. (Separate measurements of each heater over the course of an hour varied by about ±1 mV, presumably due to small drifts in the current source.) The heater on the bench has the first high resistance spot beginning 41 inches from the end and the resistance to just before the high resistance spot is 63 mΩ. This gives a resistance per unit length of 1.54 mΩ/inch. The heater on the bench bears the imprint of the collars of the magnet in which it was used. The resistance from the end of the heater to the beginning of the collar imprints (21 inches) is 32 mΩ, essentially equal to the resistance of the DC0304 heater to the ground short.

Using the measured resistance to the shorted point of 33 mΩ and assuming that the DC0304 heater has the same resistance as the heater on the bench, the short is 21.5" from the end of the heater. The heater extends 10 inches beyond the end cap of the end clamp, the end clamp is 8 inches long, and the heater makes an approximately 0.5 inch "jog" just inside the end cap to go from the radius of the slots in the end plate for the heaters to the outer radius of the outer coil. Thus the short appears to be approximately 3 inches into the collared coil and is not in a location such that it can be easily repaired.

The heater is shorted only to ground and the insulation between all heaters and the coil passes the hi-pot test. Only two heaters are required for magnet quench protection; the others are included only as spares. Thus it is recommended that assembly of this magnet continue and that the presence of the shorted heater be noted so that it will not be used.

Distribution:
DC0304 Traveller,
R. Bossert, J. Carson, S. Delchamps, S. Gourlay, W. Koska, M. Lamm,
P. Mantsch, E.G. Pewitt, D. Smith M. Wake