Short magnet phone call July 17, 2012 RE: Spectrometer solenoid last training run which ended with a trip and an HTS lead circuit open. (A Blondel's notes, rev. D. Kaplan)

Next meeting next Tuesday 24 July 2012 17:00 UT = 13:00 EST (lunch break at the NUFACT meeting in Virginia http://mice.iit.edu/phonebridge.html
Access code: 5673390

with report on the following. (Alain to open an indico page for upload)

1. analysis of existing data to establish firmly the time line (Soren)

2. serial number and history of the said lead (at Wang, manufacturer) (Steve V)

3. examination of the lead once the magnet is warm (Steve V)

4. reflexion on how this magnet should be quenching (revisit – will next training start where we left it or regress?)

5. proposal for next steps (all)

a.o.b.

Notes of the meeting on July 17:

Steve V: Where we are: Started warming up magnet last week. Used the heaters to warm up faster, but only during day shift since undesirable to use them unattended. Very slow warm up otherwise. 1K/ 3hrs! Upon reaching 90K yesterday, decided to purge with N2, up to 1/10 atm. As of yesterday rate is 2.5K/hr → will be warm enough to open up Thursday morning.

What happened during training run: Low resistance showing in the E1 lead circuit when the current was steady. Voltage taps are connected at the ends of the HTS leads. Voltages recorded continually by Fast DAQ system; data now being reviewed by Heng Pan. Finding that this lead always looked slightly resistive, 80 micro-Ohms, but all other HTS leads show zero resistance. Bet by Mike Courthold is that HTS lead was damaged and slightly resistive all along. SV agrees this is most likely. This particular lead was used before in the history of the magnet.

DAQ system trip level was set to 100 mV so there was no trip due to DC operation.

Question: Can DAQ system show warning levels below the trip level? Steve thinks so and will ask the experts. Went up to 20 mV, implying about 5W dissipation in the HTS lead—well below what the first stage of the coolers can handle, so not noticeable on its own if at the warm end of the lead.

Voltage subsequently ramped up to 100mV level and tripped the circuit. This opens contactors, forcing current into bypass resistors.

Question by Bross about how long the quench took to develop—seems about 60 s. Soren studying the time development with Heng Pan, to understand if things are normal. It would seem at the moment that the HTS lead caused the quench. The quench protection system functioned nicely as designed. Slow pressure rise after the quench happened. This is as usual when there is heat deposition somewhere, but occurred much more slowly than during a normal quench.

Question: is quench protection adequate? (leads, coils)

Team is putting together a timeline summary to establish correlations between the various things.

After the trip, investigated the problem by cooling back down and powering the magnet at low current. E1 would not turn on but the other 4 coils were run up to 40 A with no problems

The the lead resistance is not caused by the magnetic field (which is at most 0.06-0.09 T)—it shows up already at very low current, and the voltage is linear with current, whereas it would be nonlinear if the field was having a significant effect.

Before failure, current held steady for 10 minutes and nothing changed, but then voltage across HTS lead started to increase, from 20 mV to 100 mV over 20 s.

Courthold: This raises doubt about the integrity of all the leads. Should they all be retested? Also suggests that 100 mV threshold should be lowered to 20 mV

Plan is to set the threshold above the noise but below 100 mV.

Question: Why did the QA miss the problem?

Best test bed for these leads is the magnet itself. Could we remeasure all the other leads and check the resistance? Could take the leads out and measure them independently to manufacturer specs. But leads are soldered in and removal would risk damage, to the leads and to neighboring components.

Do we have the pedigree data for these leads? Manufacturer tests and provides this for each lead. Will try to dig it up. (Leads were purchased by Wang, not by LBL.)

We know from temperature monitoring that the lead is cold enough. Worth mentioning soldering issue—difficult to be sure that the lead was not damaged by soldering. Manufacturer recommends clamped connection with indium interface.

Alan: How rigid are the interfaces? Leads don't take stress very well.

Connected stiffly at top but through compliant S-bends at bottom.

Should there be shunts protecting the leads, as in the AFC? Unnecessary due to contactors, which take leads out of circuit when trip occurs.

Soren: Prefers to analyse data for the behaviour of these leads and check that there is no sign of resistance developing. If not don't 'operate' so that we don't increase the risk by unsoldering valid HTS leads.

Issue of Power Ten power supplies that showed instabilities. They have been taken out of service for the training but will be needed at MICE. The Xantrex supplies are working fine, and are being used for training, but are no longer made. Can the Power Ten supplies be repaired? Difficult to duplicate the problem on the test bench since they work fine into a short circuit. (Magnet is a DC short circuit but with very large series inductance.) AMETEK has good models. A plan needs to be developed. May be similar problem for AFC since also using Power Ten supplies. Courthold recommends discussing with Chris White at Daresbury.

We need to open the magnet to understand what happened to the lead. In the previously damaged lead there were signs at the middle of the lead–location of damage will be a clue to how the lead failed.

Should new lead be QA tested? Difficult and risky. Would need to solder into test stand, unsolder, then resolder into magnet.

Ken: Do we solder the leads next time? (Or bolt them in? Does that require some R&D?). Answer: Not R&D, but indium also imperfect solution–can flow and degrade connection → solder them but as few times as possible. Then magnet can be checked for the resistance of the HTS leads when it is cold – painful but a good test to perform.