Fermilab

Revision for $\bar{p}$ Note #354

Description for Non-Magnetic Tests Made on SQC Magnets

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Description of non-magnetic tests made on SQC Magnets
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Collected in this document is a list of the existing mechanical and electrical tests made on Tev I small quadrupole magnets. The information is supplied by Don Zedonis for the coils and by Mike O'Boyle for the steel. The information about the end pack stacking was supplied by Leo Ray.

Coil Tests

In the list below, "coil segments" refers to each separate winding. Each quadrant has four coil segments, which are a 3/4 turn winding, a 5/6 turn winding, a 7 turn winding, and an 8 turn winding. At several steps along production the copper turns are inspected for nicks, burrs, gouges, rough edges, etc. All the L & Q measurements listed below are made at 1000 Hz with a bridge (either a Hewlett Packard Universal Bridge 4260A or a Wayne Kerr Automatic Bridge B605). The R measurements are made with a Biddle digital low resistance ohmmeter (Cat. # 247000). Since the vacuum tube is never present for any of these, its effect does not appear.

1. After winding, the coil segment is pressurized to 150 psig with helium and a sniff test is made with a mass spectrometer type leak detector with the segment bagged. The number of joints in the coil segment is noted at this point.

2. Temporary water fittings are soldered on and the water flow rate is measured through the coil segment with a pressure drop of 200 psi.

3. A hydrostatic test is done with 1000 psig applied for 30 minutes.

4. After taping each conductor, the coil segment is clamped together temporarily and a measurement of L, Q, & R are made. A 20 microfarad capacitor charged to 100 volts is discharged through the coil segment and the ringing is viewed on an oscilliscope.

5. After ground wrapping of a coil segment, measurement of L, Q, & R and ringing are repeated.

6. After oven curing of the insulating tape and removal of the coil segment from the curing

fixture, L, Q, & R are measured and a ring test is made. The mechanical inspection exemplified by sheet #1 is made for the 7 & 8 turn coil segments. The coil segment is then typically stored on a shelf.

7. When needed for insertion into a half-core the coil segments are rechecked with a L, Q, & R measurement and a ring test. The ringing photographs are compared for each similar coil segment for each quadrant of the magnet.

8. The coil segments are glued into the half-cores and some mechanical checks are made (see sheets #2 and #3). Those on sheet #2 check the spacing between the 8 turn coils in the two quadrants and the clearance of the innermost turn of the 8 turn coil from a flat bar laid across the half-core. The former has a specification of 8.024 +/- 0.060 inches and the latter is specified as 0.019 (+ 0.019 / - 0.020).

9. With the coil segments in place in the half-cores, L, Q, & R measurements and ringing tests are made for each segment. The quadrants are inter-compared.

10. Temporary half-core connections of coil segments are made and L, Q & R measurements and ringing are done.

11. Hi-potting of coil segments that touch each other is done (see sheet #4). Temporary connections are made and the entire half-core coil is hi-potted to the steel.

12. After the half-cores are assembled together and clamped, the coil segments are connected by quadrant and flow checks of each quadrant are made at 200 psig differential pressure.

13. A hydrostatic test at 1000 psig for 30 minutes is made for each coil quadrant.

14. In the full magnet, ringing tests and L, Q, & R measurements are made for the lower, upper, and full coil.

15. A hi-pot measurement is made from the full coil to the steel. This is the only data sheet where a maximum current is specified (5 microamperes).

All hi-pot measurements are made at 1000 DC volts. A change to 3000 volts is to be instituted immediately for the hi-pot of coils to steel.

End Packs

The end packs are made up from type A or type B laminations--or a mixture of both (the type designation designates the direction of taper across the steel). The laminations are measured as a group at either side and at the top to judge thickness differences. Small shims are inserted at the sides during stacking as necessary to keep the thickness within tolerance (the tops are typically thicker than the sides for the laminations). During the stacking process epoxy is applied to the faces of the laminations and the end pack is oven cured after stacking (the earlier procedure was to try to cure the epoxy at room temperature).

After oven curing the end packs are measured in order to find a good side for machining to shape the ends to the desired contour. The end pack is laid down on a surface plate. A feeler gage is used to check flatness at points shown as A through H on sheet #5. Any measurement of greater than 0.005 inches out of flatness indicates a bad side. Perpendicularity is then measured with a precision right angle and feeler gages at points A & D. A measurement of greater than 0.002" indicates a bad side. Perpendicularity measurements are continued at points E, F, G and H. The tolerance is 0.008". Perpendicularity is measured at the pole tips at three places on each tip--again with a tolerance of 0.008". Finally, a dial gage on a stand is run over the surface of the end pack. The amount of variation is noted. The tolerance for the variation is 0.020".

End packs that fail the measurement on both sides are put aside. Those with perpendicularity good at points A & D on sheet #5 are sent out to be ground flat. They return to be remeasured using the process described above before machining is done to shape the end pack for pole shaping and coil fit.

Half Cores

During stacking of the half cores, the length of the stack is checked at the sides and connecting yoke by comparison with a bar of the proper length. Some selection is made of laminations used in order to get the lengths

equal to the nominal length +/- 0.030 while under a pressure of 10000 +/- psig on the three hydralic cylinders (two pressing on the sides and one pressing on the connecting yoke).

The half cores are placed with their parting planes down on a surface plate. As shown on sheet #6 the lengths are measured at several locations and perpendicularity is measured at several locations. The parting edge flatness is measured at each 3 inch lamination pack at the outside edge. The sheet shows the specificaions for length, flatness, and perpendicularity. The sheet is somewhat out of date; the 0.801 +/- 0.002 specification for the pole gaps is no longer used, for example.

Full core measurements

An attempt is made to match half cores in length and a pair is clamped together with the specified torque on each bolt. The parting edge gaps and pole gaps are measured at each 3" lamination pack--as shown on sheet #7. Averages of the pole gap measurements are made for each pole (but without the end pack pole gap values). Typically the left and right gap averages agree to better than 0.0005 inches; the same is true of the top and bottom gap averages. Weld bead (on the top or bottom welds) is applied or removed as necessary to make all the averages agree to 0.0005 inches or better. This process of adjusting the weld thickness can take place even with a coil present in the core, if it is deemed necessary to maintain production schedules. The pole gap measurements can still be made with the coil present (although there is difficulty now that a bead of epoxy is put in place just next to the inner layer of the 8 turn coil).

Diagonal Pole to Pole Measurements

G. Michelassi has designed a fixture that can make accurate measurement of the two pole tip to pole tip dimensions on the 45 degree diagonals. The purpose of the fixture was to make mechanical measurements on quads for the situation where the coil was in place (the fixture was a response to the early quads that had mechanical difficulties & did not have their welds corrected as described above). The existence of this fixture makes it possible to consider making 45 degree diagonal pole to pole measurements routinely, but it appears that the measurements already being made with gage blocks between poles suffice. They also have the virtue of being much more interpretable in

terms of gradient quality at large distances away from the magnetic center (as compared to gradient at the center).

Appendix I

Between Dec. 16 and Jan. 10 several tests had been revised. The test on half cores shown on sheet # 6 measures parting edge flatness as shown and core lengths. Perpendicularity is no longer measured at the end packs. The total core tests shown on sheet 7 are now always done with the coil present. The coils are glued in the half cores and the full core is assembled always with the coil present. This implies that the parting plane gaps are only measured at the outside edges.

Capacitance C between coil and steel is now being measured at 1000 Hz (with the Wayne-Kerr bridge)--along with dissipation factor D. Hi-potting is done at 3000 volts now for the final hi-pot of coil to steel.

Another possibility for making end packs will exist for the debuncher and accumulator small quadrupoles. This will be to machine ("nibble") the laminations and then stack them. They can be distinguished by the drawing number that is stamped into the outer face of the end pack.