DS0309 TEST PLAN

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Test Objectives

DS0309 is the second complete C358D cross section magnet built at Fermilab. Its room temperature prestress (6/8.6 kpsi in the inner/outer coil) is substantially higher than DS0308 and therefore it is the first that is considered to represent a properly assembled magnet. The test objectives are to make the "standard" measurements of magnet performance (quench, mechanical and harmonics through two thermal cycles). This is the first magnet with steel collars and substantial preload that has the ground insulation directly against the laminations. A "mini-life test" of 500 excitations is planned to stress the insulation. DS0309 is instrumented with 55 voltage taps, 8 active and 6 compensating collar pack strain gages, and 8 active and 2 compensating "bullet" strain gages. The voltage taps fully instrument both the inner and outer coil portions of the "ramp-splice", inner turns 10 and 13-16 and partially instrument turns 11 and 12.

Test Plan

1) Measure harmonics at room temperature with the magnet mounted in the dewar.
   a) Power the magnet with +10 A and monitor the voltage across the magnet. In the tests below turn off the power supply and let the magnet cool if the voltage exceeds the initial value by more than 5%.
   b) Power the magnet at +10 A. Locate the ends of the magnet relative to the tape measure on the probe mounting fixture by moving the probe vertically and identifying the points at which the dipole field is 1/2 its central value. Define the magnet center to be half way between the two end points.
   c) Measure harmonics as a function of position. At each position record data with I = +10 A and I = -10 A. Take data at the following positions relative to the center of the magnet (positive is towards the lead end, i.e. up): -16", -14", -12", -10", -8", -6", 0", +6", +8", +10", +12", +14", +16".

2) Cool to 4.2 K monitoring all thermometers and strain gages at a 10 minute logging interval. Magnet operating temperature for all tests should be 4.35 K (850 Torr or 16.5 psia) unless otherwise specified.

3) Protect magnet with a 30 mΩ dump resistor. Delay dump firing 50 msec after quench detection (but phase back power supply promptly). Evacuate the warm bore tube.

4) Check safety circuit balances:
   a) Saw-tooth ramps between 100 and 200 A at 50 A/sec.
   b) Manual trip from 1000 A.

5) Set data logger sampling frequencies and pre-quench windows:
   a) Data loggers 1 and 2: 2 kHz and 25% pre-quench.
   b) Data loggers 2 and 4: 5 kHz and 50% pre-quench.

6) Take strain gage runs, one file per current loop, using the following sequence of currents:

0 A *		
2200 A		
3100 A *		
3800 A		
4400 A *		
4900 A	Limit of run #1	
5400 A *		
5800 A	Limit or run #2	
6200 A *	Limit or run #3	
6600 A	Limit of run #4	
7000 A *		
7300 A		

Use a ramp rate of 16 A/sec. Take data at all currents on the way up and at the currents marked "*" on the way down. Make runs to the following currents or until the magnet quenches: 4900 A, 5800 A, 6200 A, 6600 A.

7) Train the magnet until 4 plateau quenches have occurred. Ramp at 16 A/sec to quench. Do not do more than 15 quenches. The predicted short sample limit current as a function of temperature is:

3.8 K	7383 A
3.8 K	7190 A
4.0 K	6978 A
4.2 K	6749 A
4.35 K	6567 A

8) Take a strain gage run to I_{quench} - 100 A if this current is more than 200 A above the highest current run taken before training.

9) Bring the warm bore tube to room temperature, insert the harmonic probe and establish the flow of room temperature purge gas. Quench the magnet twice to establish I_{quench} under these conditions.

10) Measure harmonics at 4.2 K.
  a) Power the magnet with 2000 A. Locate the ends of the magnet relative to the tape measure on the probe mounting fixture by moving the probe vertically and identifying the points at which the dipole field is 1/2 its central value. Define the magnet center to be half way between the two end points.
  b) Ramp the magnet to quench at 16 A/sec.
  c) Ramp the magnet at 12 A/sec to 6500 A or I_{quench} - 200 A, whichever is lower, hold at flattop for 2 minutes, ramp down at -12 A/sec to 110 A, hold for 2 minutes, ramp at 6 A/sec to 5000 A. (If I_{quench} < 5500 A, the final ramp should be to I_{quench} - 500 A.)
  d) Measure harmonics as a function of position at 5000 A (or I_{quench} - 500 A). Take data at the following positions relative to the center of the magnet (positive is towards the lead end, i.e. up): z = -16", -14", -12", -10", -8", -6", 0", +6", +8", +10", +12", +14", +16".

e) Ramp the magnet to 5500 A (or I_{quench} - 200 A), then back to 5000 A (or I_{quench} - 500 A). Measure harmonics as a function of position at z = -16", -14", -12", -10", -8", -6", 0", +6", +8", +10", +12", +14", +16".

f) Position the harmonic probe at the center of the magnet and measure the harmonics as a function of current: Ramp the magnet from 5000 A down to 110 A, then to I_{quench} - 200 A, back to 110 A, then to 1000 A, all at 16 A/sec. Record data every 6 seconds (approximately every 100 A) starting from 500 A on the first down ramp until 1000 A on the second up ramp.

11) Remove the harmonic probe and evacuate the warm bore.

12) Ramp value studies:

a) Ramp to quench at 16, 25, 50, 75, 100, 125, 150, 200 A/sec.

b) Ramp to 6500 A at 16 A/sec, then ramp <u>down</u> from 6500 A to 4000 A at 100, 200, 300, 400, A/sec.

13) Quench the magnet at 3.8 K until 3 quenches have occurred on plateau or a total of 10 quenches have been taken, whichever occurs first. Use a 16 A/sec ramp rate.

14) Take a strain gage run at 3.8 K to I_{quench} - 100 A if this current is at least 200 A higher than the highest strain gage run at 4.35 K.

15) Warm the magnet to within 10 K of the pretest temperature, then re-cool to 4.2 K. Record data from strain gages and thermometers every 10 minutes during the thermal cycle.

16) Repeat steps 3-9 and 10 c-f, from the first thermal cycle, except in steps 10d and 10e record data only at the center of the magnet.

17) Determine the largest ramp rate (from step 12) at which the magnet will reliably reach 6500 A at 4.2 K. (Interpolate between the quench currents at 4.35 K and 3.8 K). At this ramp rate, ramp the magnet 500 times between 2000 A and 6500 A at 4.2 K.

18) Take a strain gage run to the same maximum current as in step 8. Operate the magnet at 4.35 K for this run.

19) This is an "optional" test sequence which may be done if time permits.

a) From the ramp rate study (step 12) choose a ramp rate well above the "knee" for which the quench current is at least 300 A below the low ramp rate value. Ramp the magnet to quench at this ramp rate to verify the quench current.

b) Perform a series of ramp cycles between 100 A and progressively higher peak currents. Each ramp cycle consists of an up ramp, at the rate chosen in step 19a, from 100 A to the peak current, a 20 second flattop at that current, a down ramp to 100 A at the chosen ramp rate and a 10 second dwell at 100 A. Five successive ramp cycles should be preformed to the same peak current before increasing the peak current. The first 5 ramps should be to 200 A below the quench current found in step 19a, the next 5 should be to 175 A below the quench current, and so on. Continue this sequence until the magnet quenches. (This procedure will require the use of the table driven ramp function.)

c) Perform 50 ramp cycles to the last current at which all 5 cycles were completed without quenching (25 A below the quench current in step 19b).

20) Warm to room temperature. Monitor all strain gages and thermometers at 10 minute logging interval until $T > 100$ K, then at 30 minute intervals. Continue to monitor until the magnet is within 5 K of its pretest temperature.