TS-SSC 90-101
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December 10, 1990

Summary of DS0311 Quench Performance

DS0311 is a 1m Fermilab SSC model magnet with a 40mm aperture. It is also the last 1m magnet built with a horizontally split yoke. During the course of testing it was quenched a total of more than 80 times which included one thermal cycle, at temperatures of 4.3, 4.2 and 3.8K. This report is a chronological summary of test results including quench history, quench locations and ramp rate studies, followed by a comparsion of magnet performance with cable short sample.

Quench History (First testing cycle)

A summary of the quench data which includes quench currents, ramp rates, temperatures and quench locations is attached to the report. The quench summary sheet gives the quench times (locations) preceeded by a + (-) sign referring to the lead (non-lead) end side of the tap respectively. The quench propagation velocity was approximately 70 m/s at short sample in the straight sections. A map of the tap locations is given in Figure 1 for reference.

Training Quenches

The first quench occured in the lower outer coil during a strain gauge run at 6207 amps at a temperature of 4.3K. All ramp rates are at 16 A/s unless otherwise stated. The second training quench occured in the lower inner coil next to the second wedge. It was approximately -1 ms towards the non-lead end side of tap 10B. The magnet reached 6912 amps on the third quench which occured in the lower inner coil pole turn on the ramp splice side approximately +4 ms from tap 16C. This was the first quench at the location that would become characteristic for standard plateau quenches (SPQ's). The next quench occured in the same location at 6892 amps. The fifth quench dropped to 6636 amps and was located in the upper inner coil in the lead end turn. The subsequent five quenches were SPQ's with an average plateau current of 6890 amps. Figure 2 is a plot of the initial training behavior.

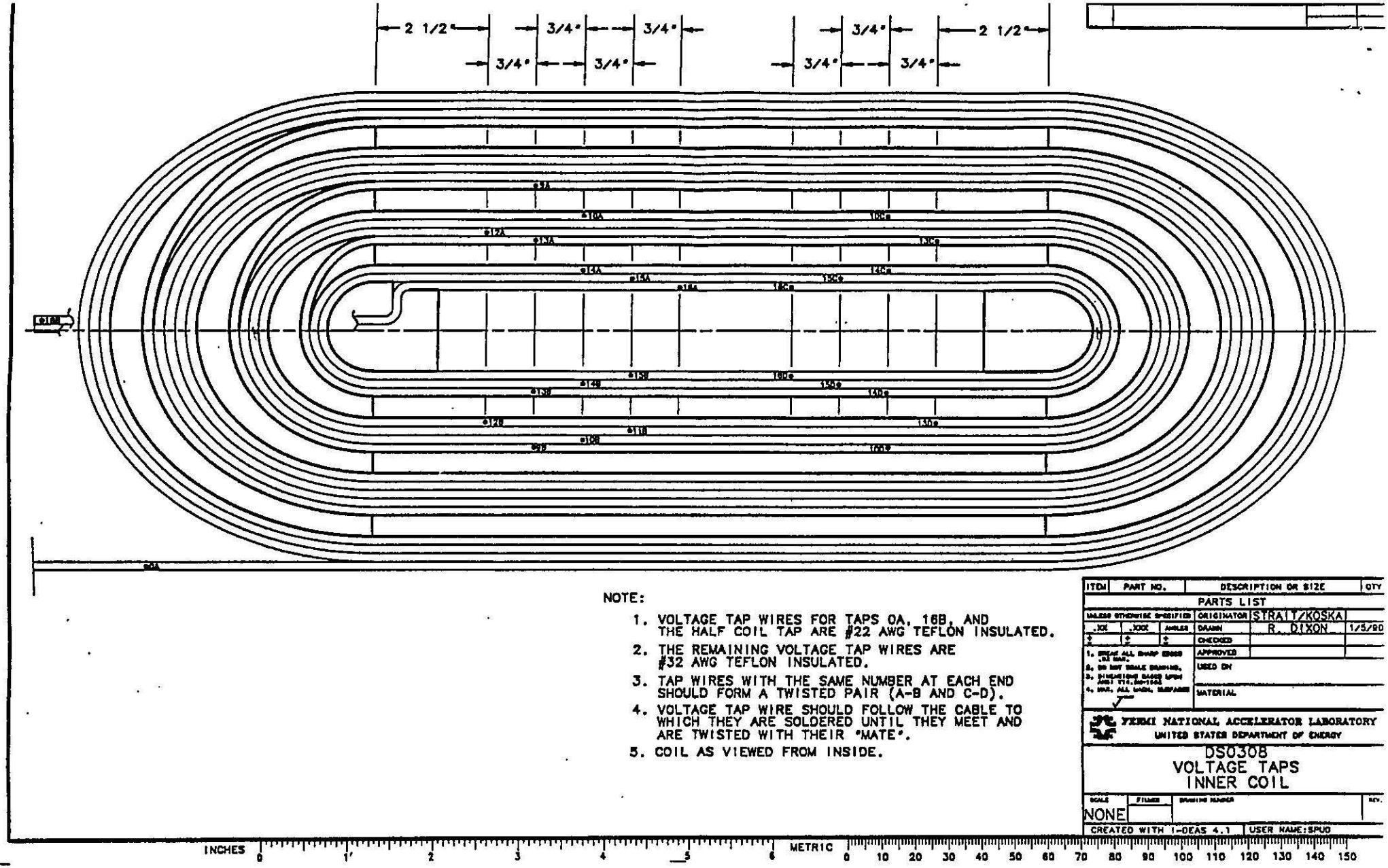
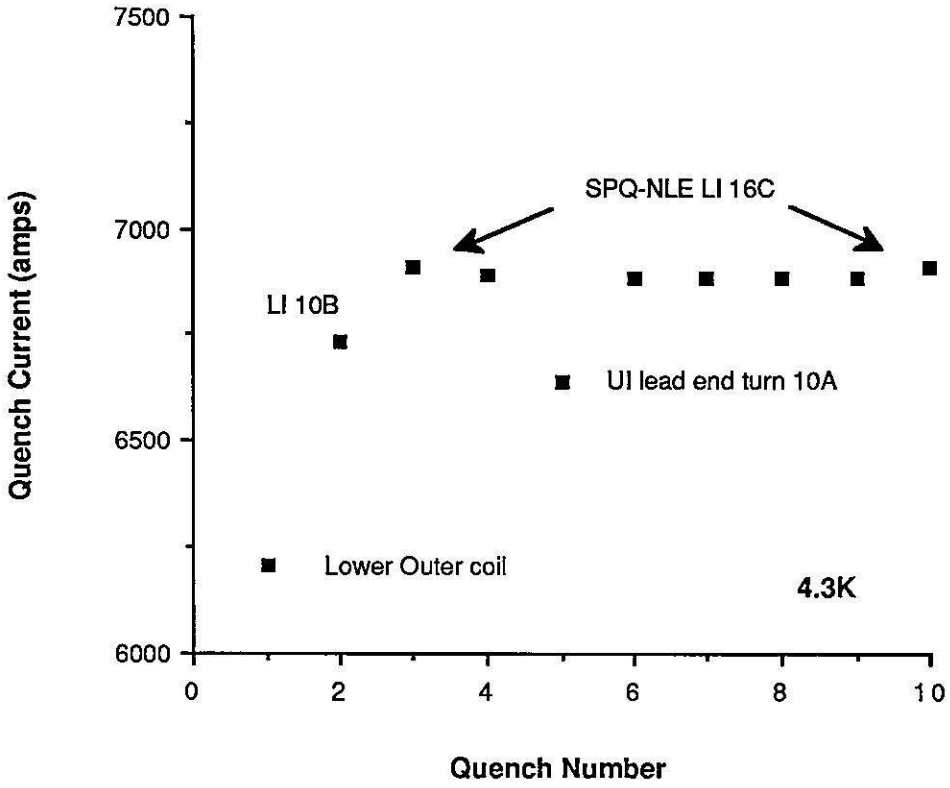

2 1/2"
3/4"
3/4"
3/4"
3/4"
3/4"
3/4"
2 1/2"
NOTE:
1. VOLTAGE TAP WIRES FOR TAPS 0A, 16B, AND THE HALF COIL TAP ARE #22 AWG TEFLON INSULATED.
2. THE REMAINING VOLTAGE TAP WIRES ARE #32 AWG TEFLON INSULATED.
3. TAP WIRES WITH THE SAME NUMBER AT EACH END SHOULD FORM A TWISTED PAIR (A-B AND C-D).
4. VOLTAGE TAP WIRE SHOULD FOLLOW THE CABLE TO WHICH THEY ARE SOLDERED UNTIL THEY MEET AND ARE TWISTED WITH THEIR "MATE".
5. COIL AS VIEWED FROM INSIDE.
ITEM
PART NO.
DESCRIPTION OR SIZE
QTY
PARTS LIST
ORIGINATOR
STRAIT/KOSKA
DRAWN
R. DIXON
1/5/90
CHECKED
APPROVED
USED ON
MATERIAL
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY
DS0308
VOLTAGE TAPS
INNER COIL
SCALE
NONE
CREATED WITH I-DEAS 4.1
USER NAME:SPUO
INCHES
0 1 2 3 4 5 6
METRIC
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Figure 1

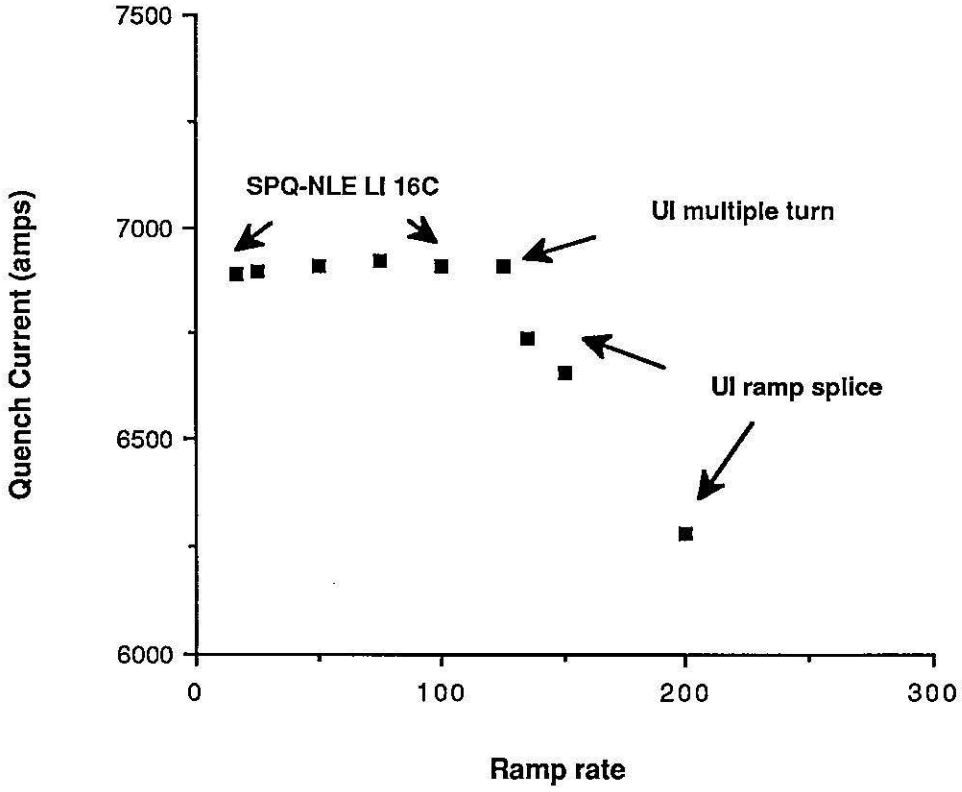
Figure 2. DS0311 Training Behavior



Ramp Rate Studies

The magnet was then quenched at a series of ramp rates ranging from the nominal 16 amps/s to 200 amps/s. A plot of quench current as a function of ramp rate is given in Figure 3. Measurements made at the same ramp rate were averaged. All quenches occuring from 16 amps/s to 100 amps/s were SPQ's with an average quench current of 6908 amps. At a ramp rate of 125 amps/s the quench current remained the same but the location moved to the upper inner multiple turn. Above 125 amps/s the quench current dropped with increasing current and all quenches occured in the upper inner ramp splice.

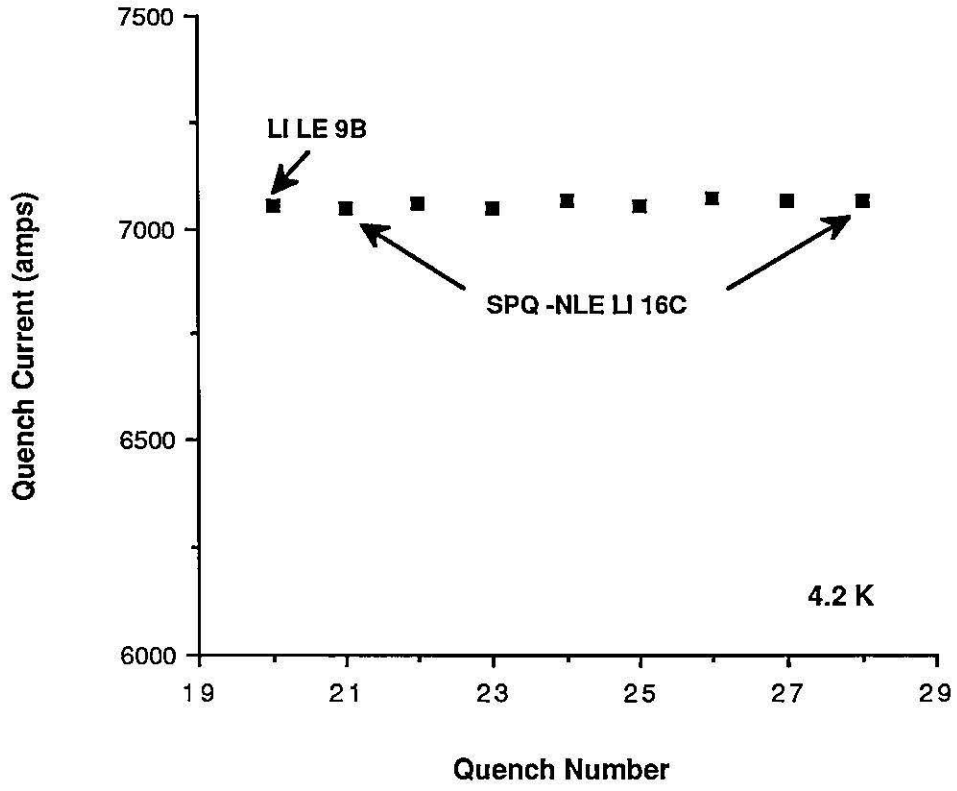
Figure 3. DS0311 Ramp Rate Dependence (first test cycle)



4.2K Studies

The magnet temperature was lowered to approximately 4.2K and quenched at a ramp rate of 16 amps/s. The first quench occured in the lower inner coil lead end in the vicinity of tap 9B at a current of 7054 amps. The following 8 quenches occured at the SPQ location with an average current of 7060 amps. The quench current and location data are plotted in Figure 4.

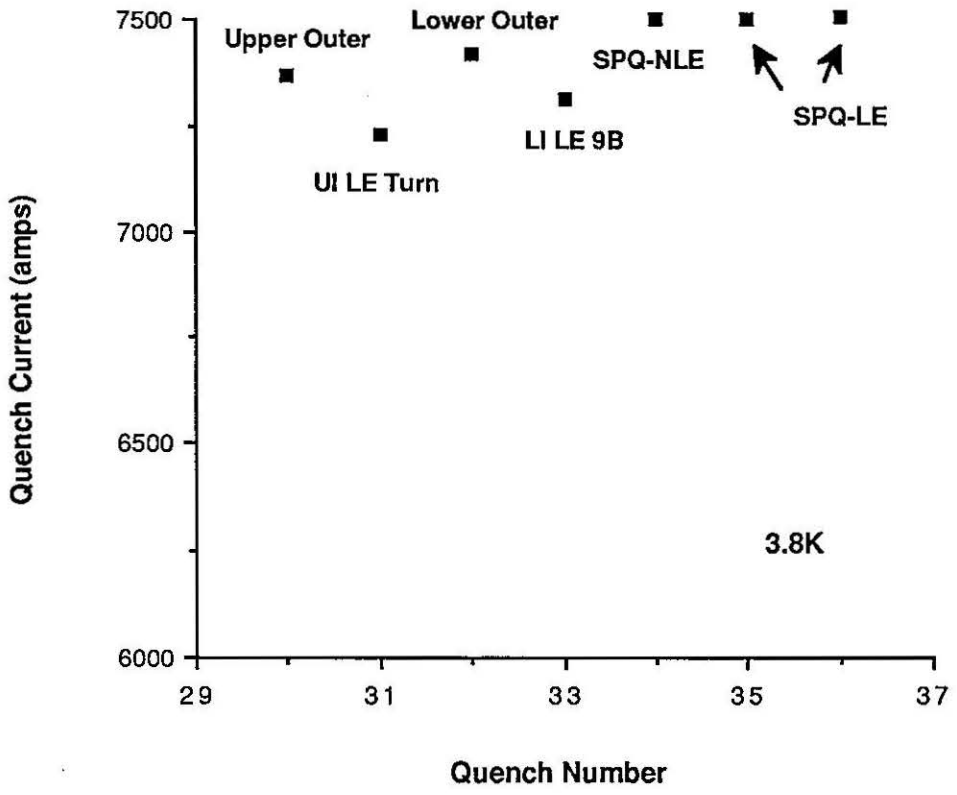
Figure 4. DS0311 quench current and location at 4.2K



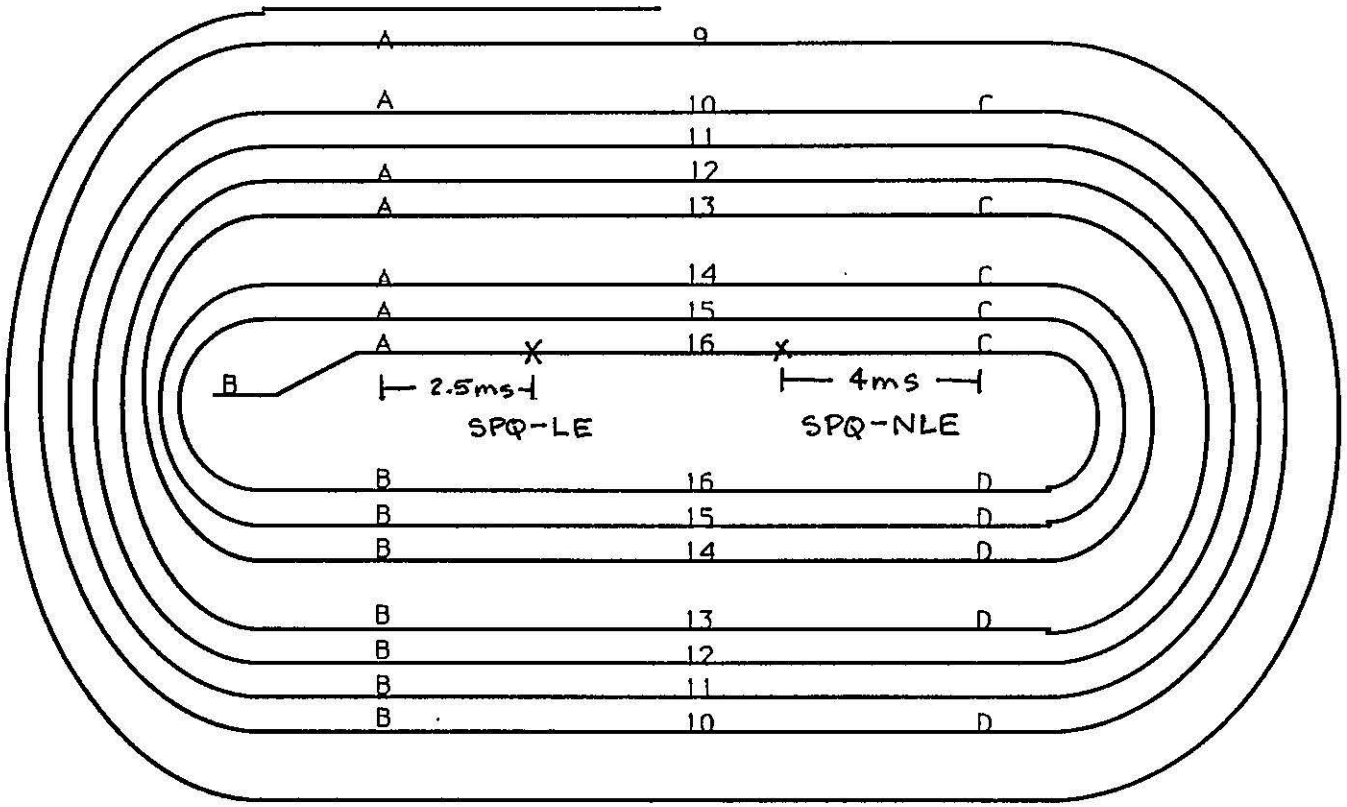
3.8K Studies

The magnet temperature was then lowered further to 3.8K. The magnet exhibited 4 training quenches before reaching a plateau of 7500 amps where it quenched at the SPQ location. The second and third plateau quenches occured in the lower inner pole turn on the ramp splice side, -2.5 ms from tap 16A. This location is toward the lead end from the SPQ location. It is the second location in the magnet which seems to be associated with plateau quenches. The two regions will be referred to as SPQ-NLE (non-lead end) and SPQ-LE (lead end). See Figure 5. The quench data are plotted in Figure 6.

Figure 6. DS0311 Quench Current and Location at 3.8K



Lower Left / Upper Right



Lower Right / Upper Left

Figure. 5 Location of SPQ-NLE and SPQ-LE quenches.

Quench History (After thermal cycle)

The magnet was warmed to room temperature and then recooled and all of the above tests were repeated.

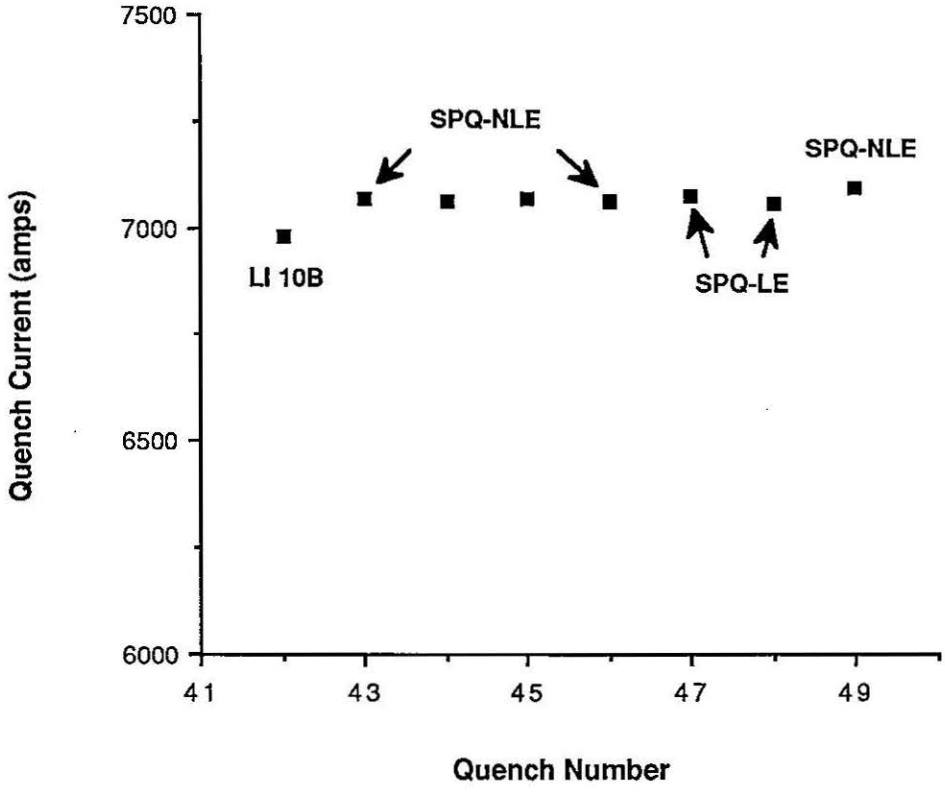
4.3K Studies

It was quenched 5 times at 4.3K with an average quench current of 6874 amps. It exhibited no retraining. All quenches were in the SPQ-NLE location.

4.2K Studies

The temperature was again lowered to 4.2K. The first quench occured at 6981 amps in the same location as the second training quench which was in the lower inner coil toward the non-lead end of tap 10B. The following 7 quenches had an average quench current of 7067 amps and were divided between the SPQ-LE location and the SPQ-NLE location (See Figure 7).

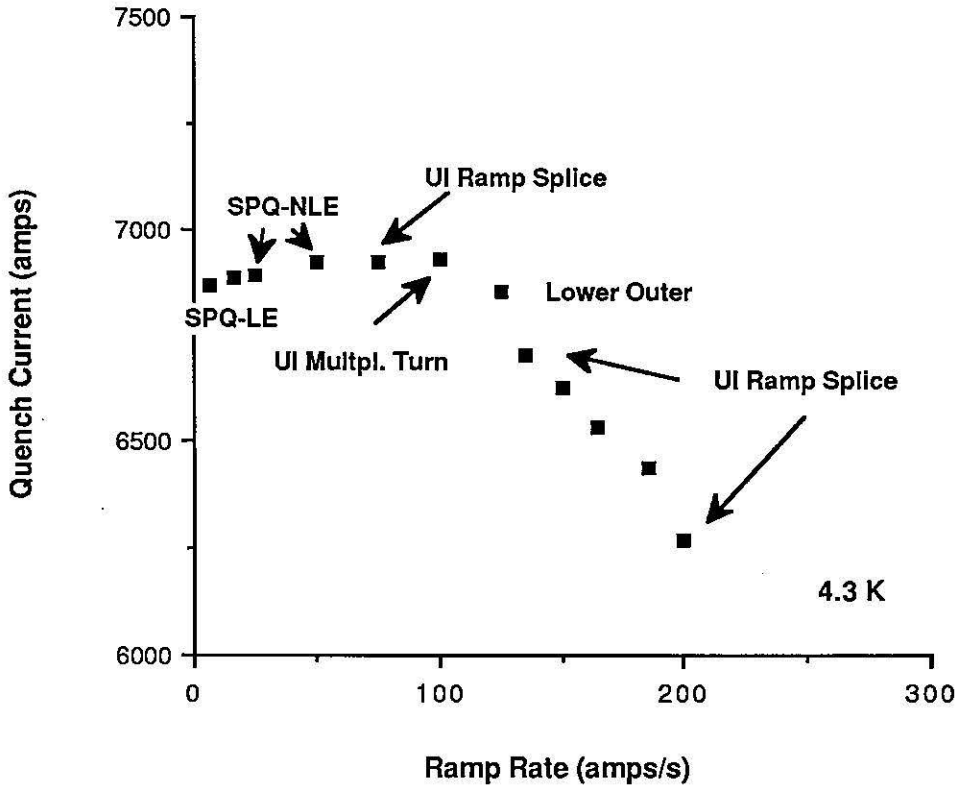
Figure 7. DS0311 Quench Current and Location (first thermal cycle)



Ramp Rate Studies at 4.3K

Ramp rate studies were repeated for ramp rates from 16 amps/s to 200 amps/s. The ramp rate resolution was increased inorder to investigate the quench behavior in the "knee" of the ramp rate curve. The quench locations were more scattered in these measurements than in the ramp rate study prior to the thermal cycle. Plots of quench behavior and location as a function of ramp rate are given in Figure 8.

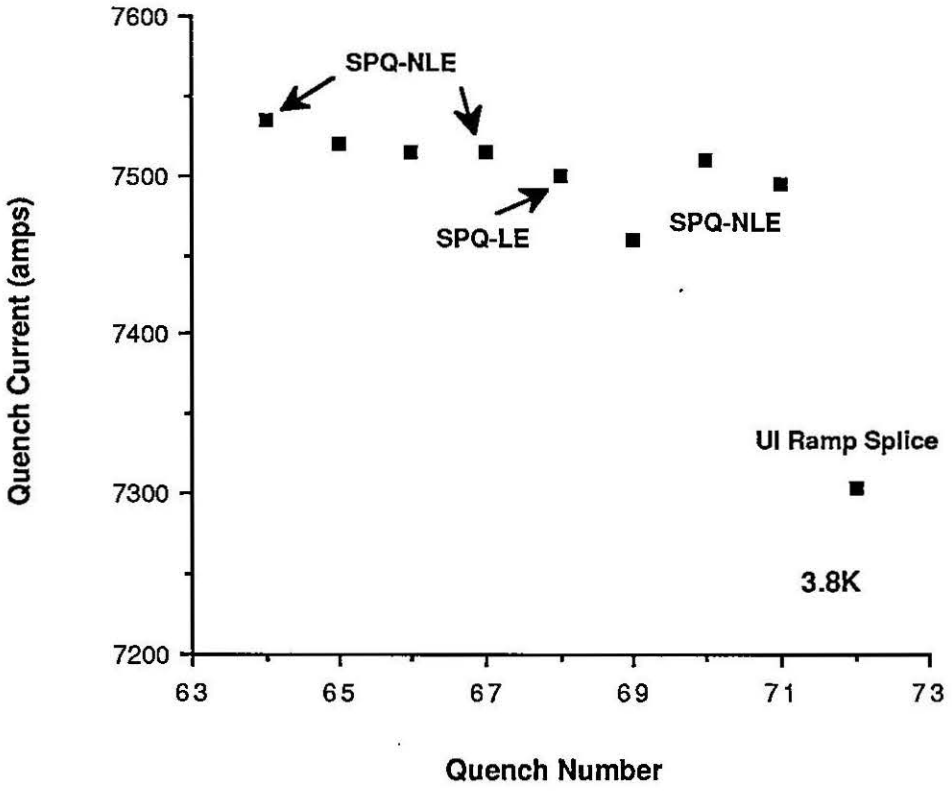
Figure 8. DS0311 Ramp Rate Dependence (After Thermal Cycle)



3.8K Studies

Nine quenches were recorded after dropping the magnet temperature to 3.8K. The locations were in the SPQ-NLE region with the exception of the 5th and 9th which were in the SPQ-LE region and the upper inner ramp splice respectively (Figure 9). With the exception of the last quench in the series, the magnet reached the same current as the plateau in the previous 3.8K run prior to the thermal cycle without retraining.

Figure 9. DS0311 Quench Current and Location at 3.8K (After Thermal Cycle)



4.2K Studies

The studies were then concluded by quenching the magnet 6 times at 4.2K. The first quench was a little higher than previous average quenches at 4.2, however the temperature data seem to indicate that the magnet was not fully warmed after the 3.8K runs. The quench locations were again a mix of SPQ-NLE and LE with an average current of 7053 amps (excluding the first point at lower temperature)

Quench Performance

The cable used to wind the inner coils was from reel SC12-00004. The short sample data, taken at Brookhaven, is given in Table 1. A comparison of magnet performance and predicted performance based on the short smaple data is shown in Table 2. Two programs, written by M. Kuchnir were used to make the predictions; one using the empirical Morgan-Sampson parameterization based on fits to measurements taken in the region around 4.2K and the other based on the parameterization of M. Green which is based on extrapolation along the J-B-T surface. The measured quench currents are taken from averages of SPQ's at 16 amps/s. The actual temperatures, taken from an average of the three thermometers placed at the top, middle and bottom of the magnet, are within 0.04K of the nominal values given in the table.

Table 1. Short sample data for cable SC12-00004.

B (Tesla)	Ic (amps)	Jc (A/mm^2)
5.0	11,628	2,458
5.6	10,269	2,170
6.0	9,362	1,979
7.0	7,097	1,500

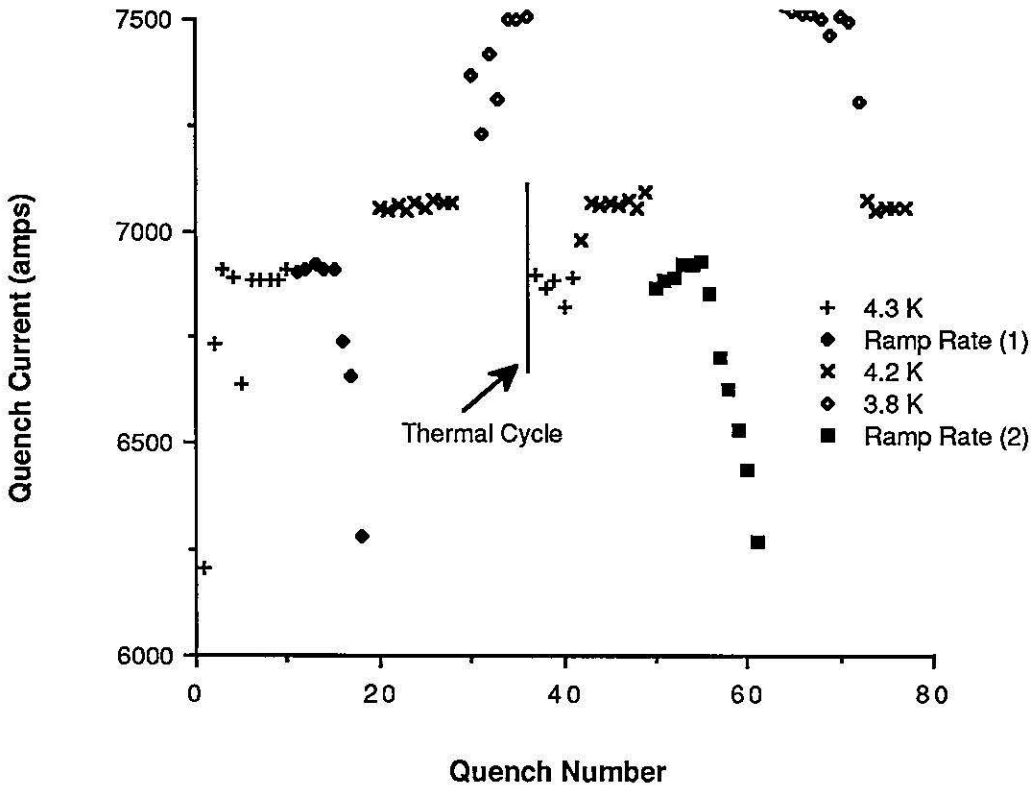
Table 2. Comparison of magnet quench current with predicted performance.

Temperature	Measured Iq	Measured Iq thermal cycle	Predicted Iq Morgan-Sampson	Green
4.3 K	6890 amps	6874 amps	6685 amps	7004 amps
4.2 K	7060	7067 7056*	6782	7120
3.8 K	7500	7483	7137	7571

*Second 4.2K run after thermal cycle

The quench history of DS0311 is summarized in Figure 10.

Figure 10. DS0311 Quench Summary



Quench File Summary
DS0311

Q#	File	I-m	Idot	I-t	Idot	QDC	MIITs	t-Q	V-max	Coil	t(H)	V(H)	T(t)	T(m)	T(b)	P	LL	Location/Comments
4.3K															<T> = 4.30K			
	0	9987.	0.	0.0	0.0	U-L	0.0	0.000	-6.	LI	0.000	0.	4.31	4.28	4.24	862.	80.	1000 Amp dump
	1	1027.	0.	0.0	0.0	U-L	0.0	0.000	-6.	LI	0.000	0.	4.32	4.28	4.27	864.	84.	1000 Amp dump
1	2	6207.	16.	0.0	0.0	U-L	0.0	-.014	-29.	LI	0.000	0.	4.32	4.28	4.27	856.	21.	Lower Outer Coil
2	3	6736.	16.	0.0	0.0	U-L	0.0	-.007	26.	LI	0.000	0.	4.33	4.30	4.28	860.	22.	LI -1ms from 10B
3	4	6912.	16.	0.0	0.0	U-L	0.0	-.007	18.	LI	0.000	0.	4.23	4.19	4.18	866.	27.	LI Inner pole turn, ramp splice side, +4ms from tap 16C
4	5	6892.	16.	0.0	0.0	U-L	0.0	-.007	19.	LI	0.000	0.	4.32	4.25	4.19	864.	23.	Same as Q#3
5	6	6636.	16.	0.0	0.0	U-L	0.0	-.008	20.	UI	0.000	0.	4.33	4.28	4.22	861.	24.	UI In the lead end turn +3ms from tap 10A
6	7	6887.	16.	0.0	0.0	U-L	0.0	-.008	23.	LI	0.000	0.	4.33	4.31	4.30	864.	66.	Same as Q#3
7	8	6883.	16.	0.0	0.0	U-L	0.0	-.007	22.	LI	0.000	0.	4.34	4.30	4.29	868.	74.	Same as Q#3
8	9	6887.	16.	0.0	0.0	U-L	0.0	-.008	23.	LI	0.000	0.	4.34	4.30	4.29	864.	75.	Same as Q#3
9	10	6883.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.33	4.30	4.28	865.	73.	Same as Q#3
10	11	6912.	16.	0.0	0.0	U-L	0.0	-.007	23.	LI	0.000	0.	4.34	4.30	4.29	882.	83.	Same as Q#3
Ramp Rate Studies																		
11	12	6892.	25.	0.0	0.0	U-L	0.0	-.008	22.	LI	0.000	0.	4.33	4.29	4.28	861.	71.	Same as Q#3
12	13	6902.	25.	0.0	0.0	U-L	0.0	-.008	21.	LI	0.000	0.	4.35	4.32	4.31	889.	63.	Same as Q#3
13	14	6907.	50.	0.0	0.0	U-L	0.0	-.007	22.	LI	0.000	0.	4.33	4.30	4.30	865.	58.	Same as Q#3
14	15	6922.	75.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.33	4.30	4.29	862.	62.	Same as Q#3
15	16	6912.	100.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.34	4.30	4.29	870.	74.	Same as Q#3
16	17	6907.	125.	0.0	0.0	U-L	0.0	-.005	18.	UI	0.000	0.	4.34	4.31	4.29	873.	71.	UI Multpl. Turn
17	18	6662.	150.	0.0	0.0	U-L	0.0	-.011	-20.	UI	0.000	0.	4.34	4.30	4.29	868.	76.	UI Ramp Splice +1ms from 16A
18	19	6285.	200.	0.0	0.0	U-L	0.0	-.013	-22.	UI	0.000	0.	4.33	4.30	4.29	859.	74.	UI Ramp Splice
19	20	6868.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.34	4.30	4.29	862.	86.	Same as Q#3
20	21	6741.	135.	0.0	0.0	U-L	0.0	-.011	-20.	UI	0.000	0.	4.33	4.29	4.28	871.	75.	UI Ramp Splice
4.2K															<T> = 4.16K			
21	22	7054.	16.	0.0	0.0	U-L	0.0	-.007	24.	LI	0.000	0.	4.19	4.15	4.14	752.	75.	LI Lead End at tap 9B
22	23	7049.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.19	4.15	4.14	752.	75.	Same as Q#3
23	24	7059.	16.	0.0	0.0	U-L	0.0	-.007	22.	LI	0.000	0.	4.18	4.15	4.14	750.	77.	Same as Q#3
24	25	7049.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.19	4.15	4.14	757.	66.	Same as Q#3
25	26	7064.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.18	4.15	4.14	749.	64.	Same as Q#3
26	27	7054.	16.	0.0	0.0	U-L	0.0	-.009	20.	LI	0.000	0.	4.20	4.16	4.15	756.	91.	Same as Q#3
27	28	7074.	16.	0.0	0.0	U-L	0.0	-.007	22.	LI	0.000	0.	4.18	4.14	4.13	747.	82.	Same as Q#3
28	29	7070.	16.	0.0	0.0	U-L	0.0	-.007	22.	LI	0.000	0.	4.18	4.15	4.14	749.	71.	No Data
29	30	7064.	16.	0.0	0.0	U-L	0.0	-.009	20.	LI	0.000	0.	4.18	4.15	4.14	749.	71.	Same as Q#3
3.8K															<T> = 3.77K			
30	31	7367.	16.	0.0	0.0	U-L	0.0	-.011	-27.	UI	0.000	0.	3.80	3.76	3.76	507.	80.	Upper Outer
31	32	7230.	16.	0.0	0.0	U-L	0.0	-.007	24.	UI	0.000	0.	3.81	3.78	3.77	511.	81.	UI +1ms from 10A, in the turn?
32	33	7421.	16.	0.0	0.0	U-L	0.0	-.009	-30.	LI	0.000	0.	3.80	3.77	3.76	505.	77.	Lower Outer
33	34	7309.	16.	0.0	0.0	U-L	0.0	-.007	27.	LI	0.000	0.	3.80	3.76	3.75	503.	77.	Same as Q#21
34	35	7500.	16.	0.0	0.0	U-L	0.0	-.006	24.	LI	0.000	0.	3.80	3.76	3.75	515.	69.	Same as Q#3
35	36	7500.	16.	0.0	0.0	U-L	0.0	-.008	22.	LI	0.000	0.	3.79	3.76	3.75	502.	68.	LI Inner pole turn, ramp splice side, -2.5ms from tap 16A
36	37	7504.	16.	0.0	0.0	U-L	0.0	-.008	24.	LI	0.000	0.	3.80	3.76	3.75	504.	78.	Same as Q#35
	38	3607.	0.	0.0	0.0	U-L	0.0	0.000	-21.	LI	0.000	0.	3.87	3.83	3.83	542.	94.	Test Aborted
Thermal Cycle																		
4.3K															<T> = 4.30K			
	39	1032.	0.	0.0	0.0	V-dI	0.0	0.000	1.	UI	0.000	0.	4.36	4.32	4.31	873.	88.	No quench
	40	1027.	0.	0.0	0.0	V-dI	0.0	0.000	-6.	LI	0.000	0.	4.36	4.31	4.30	885.	87.	No quench

37	41	6897.	0.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.34	4.30	4.29	860.	90.	Same as Q#3
38	42	6868.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.35	4.30	4.29	866.	90.	Same as Q#3
	43	3871.	0.	0.0	0.0	Vtot	0.0	0.000	-22.	LI	0.000	0.	4.35	4.31	4.30	867.	77.	No quench
39	44	6887.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.35	4.31	4.30	867.	77.	Same as Q#3
40	45	6824.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.35	4.31	4.30	867.	77.	Same as Q#3
41	46	6892.	16.	0.0	0.0	U-L	0.0	-.008	21.	LI	0.000	0.	4.35	4.30	4.29	865.	81.	Same as Q#3
----------4.2K---------- <T> = 4.16K																		
42	47	6981.	16.	0.0	0.0	U-L	0.0	-.006	24.	LI	0.000	0.	4.19	4.15	4.15	747.	85.	Same as Q#2
43	48	7064.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.19	4.15	4.14	746.	86.	Same as Q#3
44	49	7059.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.20	4.15	4.15	749.	90.	Same as Q#3
45	50	7064.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.19	4.16	4.15	748.	87.	Same as Q#3
46	51	7059.	16.	0.0	0.0	U-L	0.0	-.007	22.	LI	0.000	0.	4.20	4.15	4.15	750.	85.	Same as Q#3
47	52	7074.	16.	0.0	0.0	U-L	0.0	-.008	20.	LI	0.000	0.	4.19	4.15	4.14	746.	86.	Same as Q#35
48	53	7054.	16.	0.0	0.0	U-L	0.0	-.008	20.	LI	0.000	0.	4.20	4.16	4.15	754.	87.	Same as Q#35
49	54	7093.	16.	0.0	0.0	U-L	0.0	-.008	21.	LI	0.000	0.	4.19	4.15	4.14	746.	86.	Same as Q#3
----------Ramp Rate Studies 4.3K----------																		
50	55	6834.	16.	0.0	0.0	U-L	0.0	-.007	19.	LI	0.000	0.	4.35	4.31	4.30	873.	83.	Same as Q#35
51	56	6887.	16.	0.0	0.0	U-L	0.0	-.008	21.	LI	0.000	0.	4.36	4.32	4.30	876.	89.	Same as Q#35
52	57	6863.	6.	0.0	0.0	U-L	0.0	-.009	-19.	LI	0.000	0.	4.35	4.31	4.30	865.	84.	Same as Q#35
53	58	6892.	25.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.35	4.31	4.30	865.	79.	Same as Q#3
54	59	6922.	50.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.35	4.31	4.30	863.	75.	Same as Q#3
55	60	6922.	75.	0.0	0.0	U-L	0.0	-.006	-18.	UI	0.000	0.	4.34	4.29	4.28	870.	74.	UI Ramp Splice
56	61	6932.	100.	0.0	0.0	U-L	0.0	-.004	18.	UI	0.000	0.	4.35	4.31	4.30	862.	75.	UI Multpl. turn
	62	1311.	0.	0.0	0.0	Vtot	0.0	-.001	-7.	LI	0.000	0.	4.35	4.31	4.30	865.	82.	No Quench
57	63	6853.	125.	0.0	0.0	U-L	0.0	-.011	-30.	LI	0.000	0.	4.35	4.31	4.30	861.	87.	Lower Outer
58	64	6706.	135.	0.0	0.0	U-L	0.0	-.010	-19.	UI	0.000	0.	4.35	4.31	4.30	859.	77.	UI Ramp Splice
59	65	6628.	150.	0.0	0.0	U-L	0.0	-.011	-20.	UI	0.000	0.	4.35	4.31	4.30	861.	78.	Same
60	66	6535.	165.	0.0	0.0	U-L	0.0	-.012	-20.	UI	0.000	0.	4.35	4.31	4.30	862.	80.	Same
61	67	6437.	185.	0.0	0.0	U-L	0.0	-.012	-20.	UI	0.000	0.	4.36	4.32	4.30	878.	90.	Same
62	68	6271.	200.	0.0	0.0	U-L	0.0	-.013	-21.	UI	0.000	0.	4.34	4.29	4.28	869.	85.	Same
63	69	6853.	16.	0.0	0.0	U-L	0.0	-.007	19.	LI	0.000	0.	4.34	4.30	4.29	879.	81.	Same as Q#3
----------3.8K---------- <T> = 3.77K																		
64	70	7534.	16.	0.0	0.0	U-L	0.0	-.007	25.	LI	0.000	0.	3.80	3.76	3.75	497.	86.	Same as Q#3
65	71	7519.	16.	0.0	0.0	U-L	0.0	-.006	26.	LI	0.000	0.	3.80	3.77	3.76	503.	77.	Same as Q#3
66	72	7514.	16.	0.0	0.0	U-L	0.0	-.007	24.	LI	0.000	0.	3.80	3.77	3.77	501.	72.	Same as Q#3
67	73	7514.	16.	0.0	0.0	U-L	0.0	-.007	24.	LI	0.000	0.	3.80	3.77	3.75	506.	80.	Same as Q#3
68	74	7500.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	3.81	3.78	3.77	507.	92.	Same as Q#35
69	75	7460.	16.	0.0	0.0	U-L	0.0	-.006	22.	LI	0.000	0.	3.80	3.76	3.76	496.	92.	Same as Q#3
70	76	7509.	16.	0.0	0.0	U-L	0.0	-.006	23.	LI	0.000	0.	3.79	3.76	3.75	494.	88.	Same as Q#3
71	77	7495.	16.	0.0	0.0	U-L	0.0	-.006	24.	LI	0.000	0.	3.81	3.78	3.77	506.	93.	Same as Q#3
72	78	7304.	16.	0.0	0.0	U-L	0.0	-.006	21.	UI	0.000	0.	3.89	3.83	3.82	754.	79.	UI Ramp Splice
----------4.2K---------- <T> = 4.18K																		
73	79	7074.	16.	0.0	0.0	U-L	0.0	-.008	-22.	LI	0.000	0.	4.20	3.89	3.85	754.	88.	Same as Q#35
74	80	7049.	16.	0.0	0.0	U-L	0.0	-.008	-20.	LI	0.000	0.	4.20	4.15	3.93	753.	87.	Same as Q#35
75	81	7054.	16.	0.0	0.0	U-L	0.0	-.008	20.	LI	0.000	0.	4.20	4.16	4.01	753.	87.	Same as Q#3
76	82	7054.	16.	0.0	0.0	U-L	0.0	-.008	20.	LI	0.000	0.	4.20	4.16	4.01	753.	87.	Same as Q#35
77	83	7054.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.20	4.17	4.16	754.	87.	Same as Q#3
78	84	7054.	16.	0.0	0.0	U-L	0.0	-.007	21.	LI	0.000	0.	4.20	4.17	4.16	754.	87.	Same as Q#3
----------4.3K----------																		
79	85	6540.	165.	0.0	0.0	U-L	0.0	-.011	1.	UI	0.000	0.	4.34	4.30	4.29	860.	80.	UI Ramp Splice
80	86	6608.	165.	0.0	0.0	U-L	0.0	-.012	1.	UI	0.000	0.	4.33	4.29	4.29	849.	77.	UI Ramp Splice
----------4.2K----------																		
81	87	7015.	16.	0.0	0.0	U-L	0.0	-.007	20.	LI	0.000	0.	4.23	4.18	4.17	770.	86.	Same as Q#3

----- QSUMARY V03.13 -----

FORMAT:

```
  Q# File   I-m   Idot  I-t Idot  QDC MIITs  t-Q V-max Coil t(H) V(H) T(t) T(m) T(b)  P    LL    Location
----+----+------+----+----+----+----+----+-----+-----+---+-----+----+----+----+----+----+----+-+--------------------------
  A5,  I5,   F8.0,F5.0,F5.1,F5.1,  A5,F5.1, F6.3, F6.0, A4, F6.3,F5.0,F5.2,F5.2,F5.2,F5.0,F5.0,2X,A30
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NOTATION KEY

Q#	Quench number or Spot heater number (e.g. s4 is spot heater 4)
File	Quench file number
I-m	Main coil current at quench
Idot	Main coil dI/dt at quench
I-t	Trim coil current at quench
Idot	Trim coil dI/dt at quench
QDC	Name of quench detection circuit which tripped: 1) U-L Upper - Lower Coil 2) V-dI Magnet - Idot 3) SC L SC Pwr Leads - Idot 4) Vtot Magnet 5) Trim Trim Coil 6) Cu L Cu Pwr Leads - IR 7) GndI Ground Fault Monitor 8) Thru Through Bus - Idot
MIITs	Integral of (I**2)dt from t-Q to "infinity"
t-Q	Time first voltage appears in V(Upper) - V(Lower) (relative to quench detection time)
V-max	Maximum voltage across any quarter coil
Coil	Coil corresponding to V-max
t(H)	Protection heater firing time (relative to quench detection time); -.999 if heater did not fire
V(H)	Protection heater firing voltage; -999. if heater did not fire
T(t)	Temperature at top of magnet
T(m)	Temperature at middle of magnet
T(b)	Temperature at bottom of magnet
P	Dewar pressure (Torr)
LL	Liquid level (%)
Location	Quench or spot heater location

Distribution:

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