TS-SSC 91-029
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February 12, 1991

Summary of DSA321 Quench Performance

DSA321 is the first Fermilab SSC model magnet with a 50mm aperture. During the course of testing it was quenched a total of 51 times which included one thermal cycle, at temperatures of 4.3, 4.2, 3.8 and 3.0K. 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 72 m/s at short sample in the straight sections. A map of the tap locations is given in Figure 1 for reference.

A	ADDED THESE DIMENSIONS	R.DIXON	11/15/90
B	FLIPPED COIL OVER TO PLACE LEADS IN THERE CORRECT LOCATIONS.	R.DIXON	12/06/90

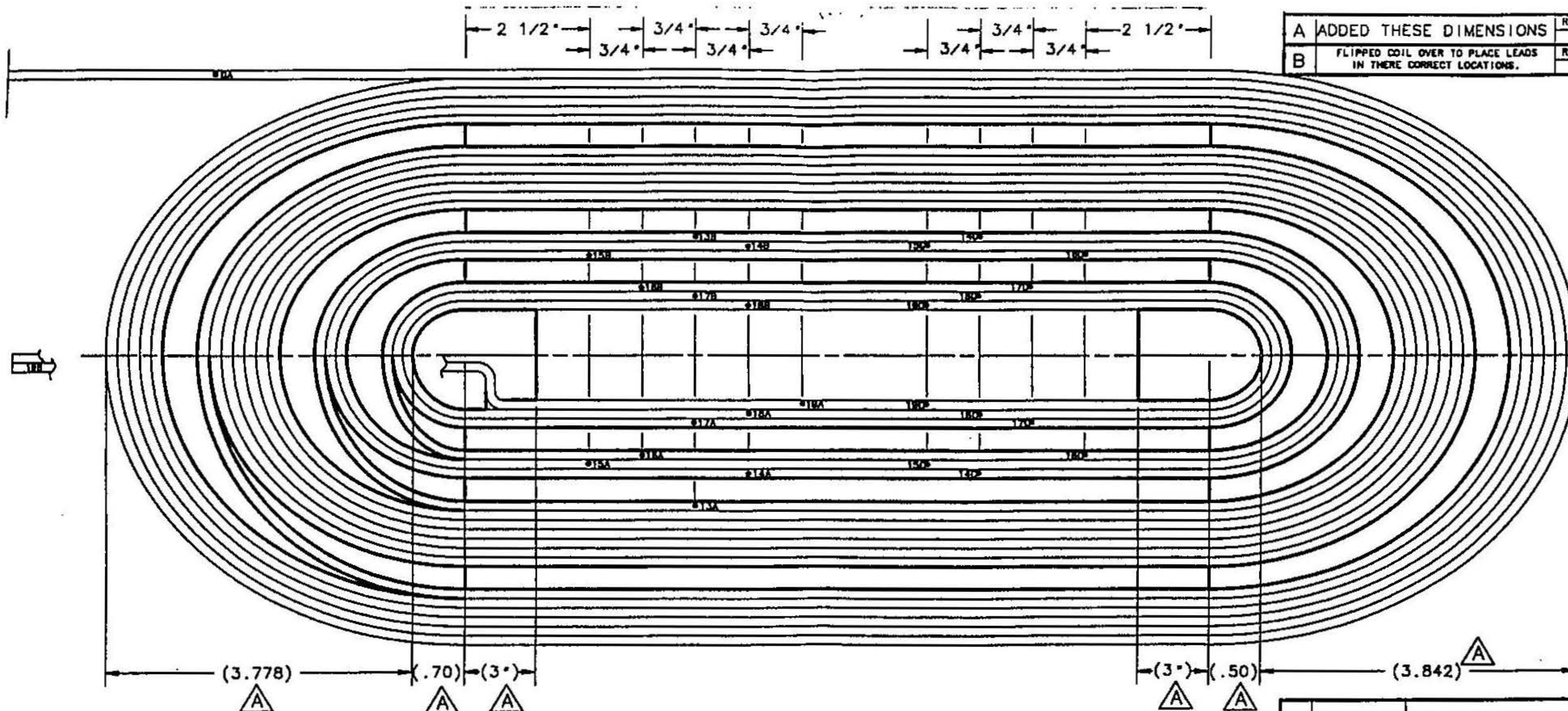


Fig. 1

NOTE:

1. VOLTAGE TAP WIRES FOR TAPS 0A, 19B, 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	

UNLESS OTHERWISE SPECIFIED: .XX ± .XXX ± ANGLES ±
1. BREAK ALL SHARP EDGES .03 MAX.
2. DO NOT SCALE DRAWING.
3. DIMENSIONING BASED UPON ANSI Y14.5M-1982
4. MAX. ALL MACH. SURFACES √

ORIGINATOR: STRAIT/KOSKA
DRAWN: R.DIXON 10/10/90
CHECKED:
APPROVED:
USED ON:
MATERIAL:

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

DSA3XX
VOLTAGE TAPS
INNER COIL

SCALE: NONE | FILMED: | DRAWING NUMBER: 0102-MB-263907 | REV. B

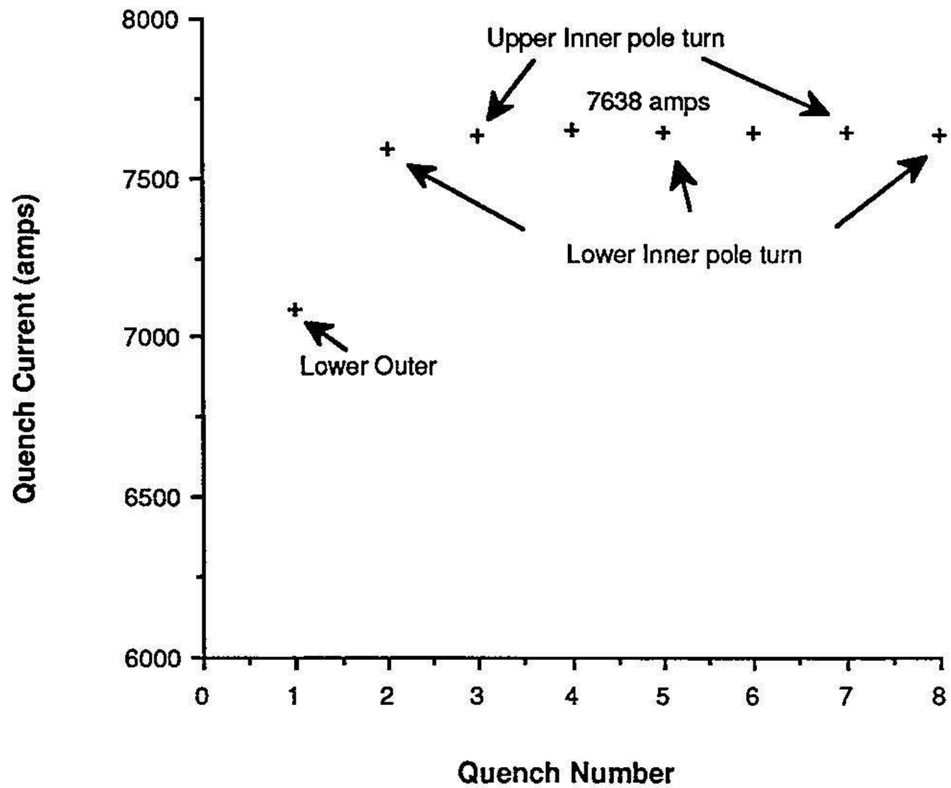
CREATED WITH I-DEAS 4.1 | USER NAME: SPUD

INCHES METRIC

Training Quenches

The first quench occured at 7088 amps in the lower outer coil, approximately -8 ms from the ramp splice. The subsequent quenches all appeared to be at or close to the short sample limit. The plateau quenches were in approximately the same longitudinal location in the pole turn, ramp splice side, of either the upper inner or lower inner coil. On the third quench the magnet reached a plateau of 7638 amps (see Fig. 2).

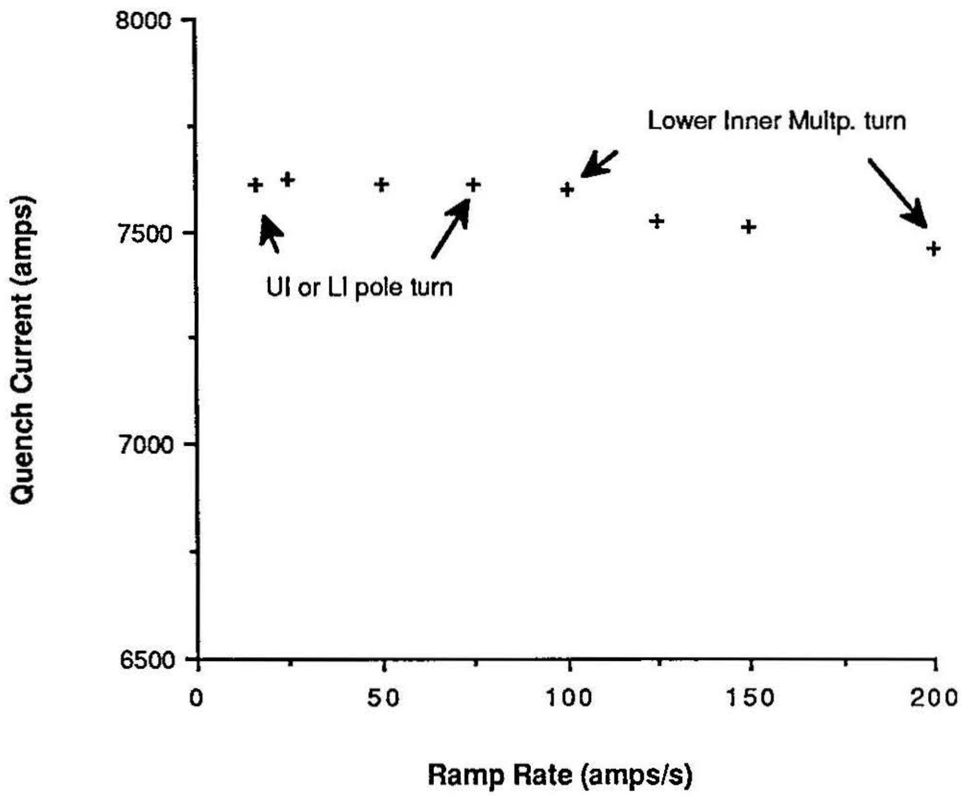
Fig. 2 DSA321 Training Behavior



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. The ramp rate dependence for this magnet is rather flat relative to the preceeding 40mm short magnets. Another curiosity is that the high ramp rate quenches occur in the multiple turn rather than in the ramp splice.

Fig. 3 DSA321 Ramp Rate Dependence



4.2K Studies

The magnet temperature was lowered to approximately 4.2K and quenched at a ramp rate of 16 amps/s. All quenches were at the standard plateau quench locations, either UI pole turn or LI pole turn, with an average of 7807 amps.

3.8K Studies

The magnet temperature was then lowered further to 3.8K. The magnet did not train. It was quenched 4 times with an average quench current of 8312 amps. All of the quenches occured in the same location as previous plateau quenches in the lower inner pole turn. The magnet was then warmed to room temperature for its first thermal cycle.

Quench History (After thermal cycle)

The magnet was recooled and the plateau currents at 4.3 and 4.2 K were reestablished.

4.3K Studies

It was quenched 5 times at 4.3K with an average quench current of 7609 amps. It exhibited no retraining. All quenches were standard plateau quenches located in either the upper inner or lower inner pole turn.

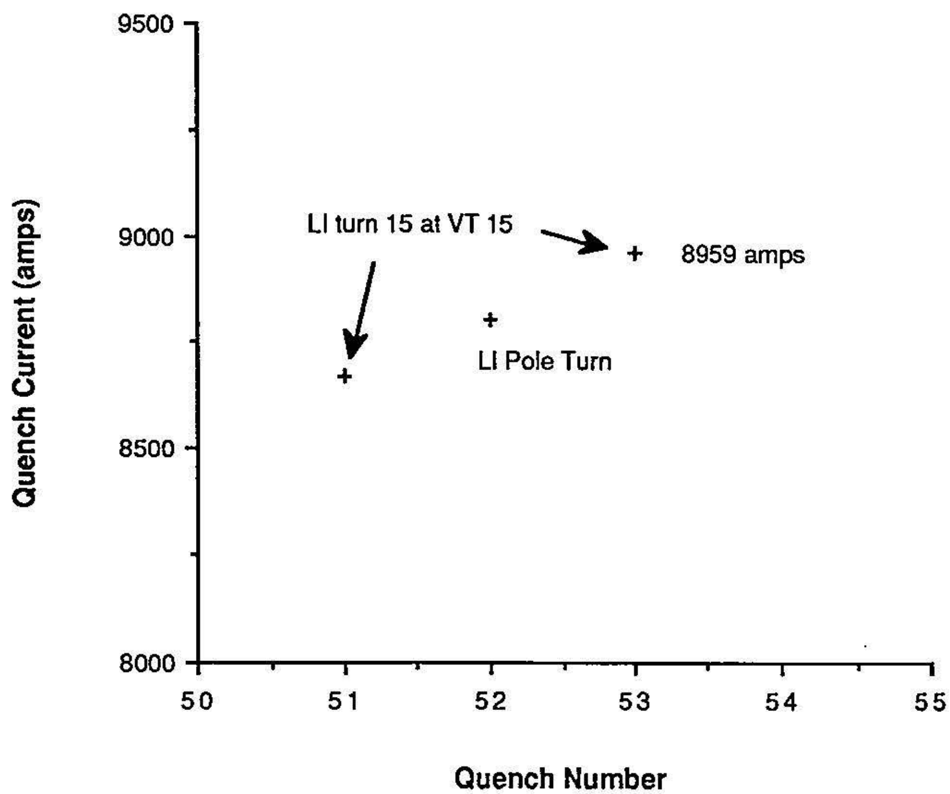
4.2K Studies

The magnet was then quenched 6 times at 4.2K. Again, all quenches occured in either the lower inner or upper inner pole turn with an average current of 7824 amps. It was also quenched a couple of times at 100 amps/s. Both quenches occured in the lower inner multiple turn. The average current was 7818 amps.

3.0 K Studies

Since the magnet had not shown any signs of retraining at temperatures down to 3.8K the temperature was lowered to approximately 3.0K. The first quench was at 8670 amps in turn 15 at voltage tap 15A. It reached 8802 amps on the second attempt where it quenched in the lower inner pole turn. The third and final quench was at 8959 amps located in turn 15 at voltage tap 15A.

Fig. 4 DSA321 Quench Current and Location at 3.0K



Quench Performance

The cable used to wind the inner coils was from reel SSC 3-I-00021. The short sample data, taken at Brookhaven, is given in Table 1. A comparison of magnet performance and predicted performance based on the short sample 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 Morgan-Sampson parameterization was used for the short sample based magnet performance predictions at temperatures of 4.2 and 4.3 K. The Green parameterization was used to extrapolate the magnet performance to low temperatures. The measured Iq at 4.3 was used as the normalization point for the Green extrapolation. The measured quench currents are taken from averages 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 SSC 3-I-00021.

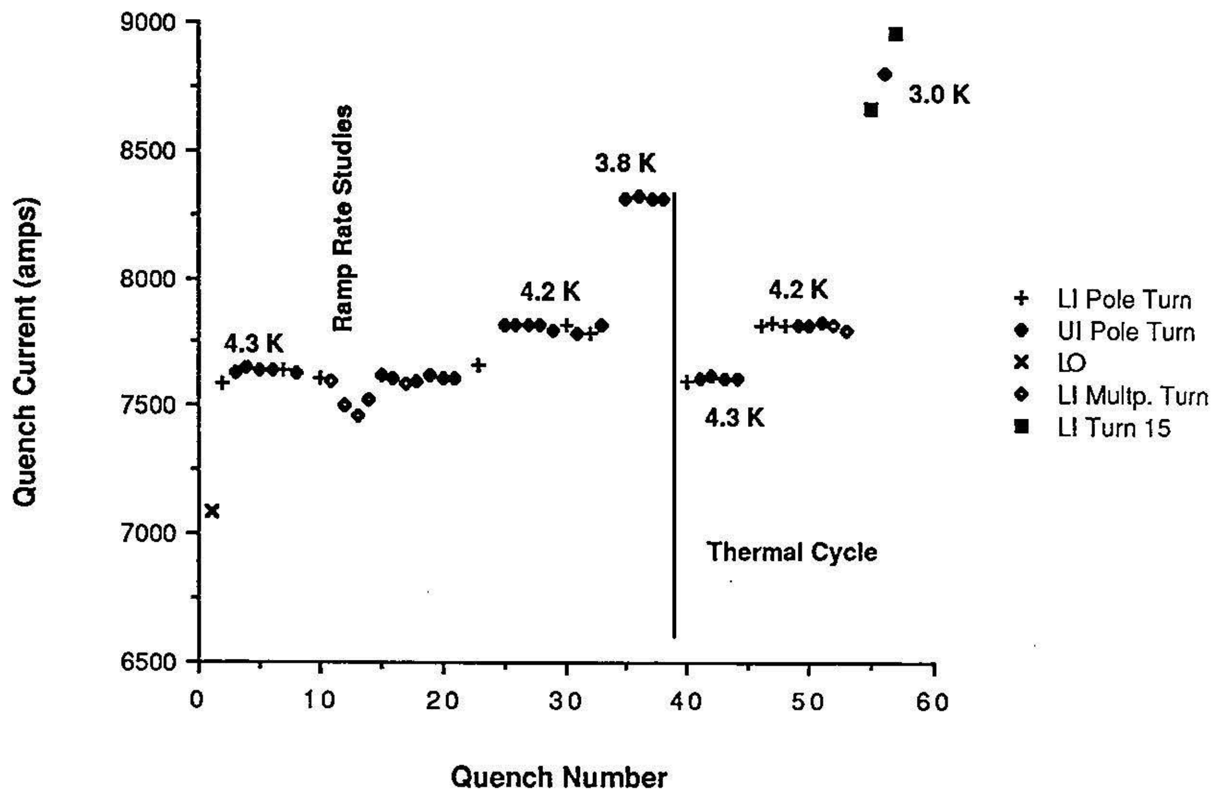
B (Tesla)	Ic (amps)	Jc (A/mm2)
7.0	11,024	1,815

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

Temperature	Measured Iq	Measured Iq (thermal cycle)	Predicted Iq Morgan-Sampson	Predicted Iq Green
4.3 K	7638 amps	7609	7485	
4.2	7807	7824	7622	7825
3.8	8312			8309
3.0	8959			9171

The quench history of DSA321 is summarized in Figure 5.

Fig. 5 DSA321 Quench summary



Quench File Summary
DSA321

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
	0	1012.	0.	0.0	0.0	U-L	0.0	0.000	-6.	UI	0.000	0.	4.22	4.18	4.18	760.	82.	
	1	1012.	0.	0.0	0.0	V-dI	0.0	0.000	-6.	UI	0.000	0.	4.22	4.19	4.18	761.	78.	
----4.3 K----																		
1	2	7088.	0.	0.0	0.0	U-L	0.0	-.012	-34.	UI	0.000	0.	4.35	4.31	4.30	853.	78.	LO -8ms from ramp splice
2	3	7593.	16.	0.0	0.0	U-L	0.0	-.011	-28.	LI	0.000	0.	4.36	4.31	4.30	860.	84.	LI pole turn, ramp splice side, 19A -19C -4.5 ms from tap 19A
3	4	7632.	16.	0.0	0.0	U-L	0.0	-.010	-26.	UI	0.000	0.	4.36	4.31	4.30	875.	80.	UI pole turn, ramp splice side, 19A - 19C -4.5 ms from tap 19A
4	5	7646.	16.	0.0	0.0	U-L	0.0	-.010	-26.	UI	0.000	0.	4.35	4.29	4.28	864.	80.	Same as 3
5	6	7642.	16.	0.0	0.0	U-L	0.0	-.010	-27.	UI	0.000	0.	4.36	4.31	4.30	879.	72.	Same as 3
6	7	7637.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.36	4.31	4.30	864.	93.	Same as 3
7	8	7637.	16.	0.0	0.0	U-L	0.0	-.012	-28.	LI	0.000	0.	4.34	4.30	4.29	861.	77.	Same as 2
8	9	7632.	16.	0.0	0.0	U-L	0.0	-.010	-27.	UI	0.000	0.	4.36	4.31	4.30	867.	86.	Same as 3
----Ramp Rate Studies----																		
9	10	7612.	50.	0.0	0.0	U-L	0.0	-.011	-26.	LI	0.000	0.	4.35	4.30	4.30	857.	86.	Same as 2
10	11	7597.	100.	0.0	0.0	U-L	0.0	-.007	-22.	LI	0.000	0.	4.38	4.35	4.31	878.	71.	LI Multp. turn
11	12	7509.	150.	0.0	0.0	U-L	0.0	-.010	-23.	LI	0.000	0.	4.33	4.28	4.27	853.	86.	Same as 10
12	13	7460.	200.	0.0	0.0	U-L	0.0	-.010	-25.	LI	0.000	0.	4.34	4.29	4.28	863.	86.	Same as 10
13	14	7524.	125.	0.0	0.0	U-L	0.0	-.010	-23.	LI	0.000	0.	4.35	4.30	4.29	864.	87.	Same as 10
14	15	7617.	75.	0.0	0.0	U-L	0.0	-.009	-27.	UI	0.000	0.	4.34	4.29	4.28	862.	84.	Same as 3
15	16	7607.	75.	0.0	0.0	U-L	0.0	-.006	-22.	LI	0.000	0.	4.36	4.34	4.30	865.	70.	Same as 3
16	17	7588.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.37	4.32	4.31	867.	76.	Same as 10
17	18	7602.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.36	4.32	4.31	866.	89.	Same as 3
18	19	7622.	25.	0.0	0.0	U-L	0.0	-.010	-27.	UI	0.000	0.	4.35	4.31	4.30	853.	83.	Same as 3
19	20	7607.	16.	0.0	0.0	U-L	0.0	-.010	-26.	UI	0.000	0.	4.35	4.31	4.30	856.	85.	Same as 3
20	21	7612.	16.	0.0	0.0	U-L	0.0	-.010	-26.	UI	0.000	0.	4.34	4.30	4.30	848.	85.	Same as 3
21	22	7656.	16.	0.0	0.0	U-L	0.0	-.012	-28.	LI	0.000	0.	4.35	4.31	4.30	853.	84.	Same as 2
----4.2 K----																		
22	23	7818.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.21	4.17	4.17	754.	80.	Same as 3
23	24	7818.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.22	4.18	4.17	755.	78.	Same as 3
24	25	7818.	16.	0.0	0.0	U-L	0.0	-.010	-26.	UI	0.000	0.	4.21	4.18	4.17	754.	80.	Same as 3
25	26	7818.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.21	4.18	4.17	754.	81.	Same as 3
26	27	7793.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	Not Recorded			758.	101.	Same as 3
27	28	7813.	16.	0.0	0.0	U-L	0.0	-.010	-27.	LI	0.000	0.	4.22	4.18	4.17	759.	82.	Same as 2
28	29	7788.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.23	4.18	4.18	762.	79.	Same as 3
29	30	7788.	16.	0.0	0.0	U-L	0.0	-.011	-27.	LI	0.000	0.	4.22	4.18	4.17	760.	83.	Same as 2
30	31	7813.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.20	4.17	4.16	747.	80.	Same as 3
----3.8 K----																		
31	32	8307.	16.	0.0	0.0	U-L	0.0	-.008	-25.	UI	0.000	0.	3.81	3.77	3.77	497.	100.	Same as 3
32	33	8317.	16.	0.0	0.0	U-L	0.0	-.007	-24.	UI	0.000	0.	3.82	3.79	3.77	503.	100.	Same as 3
33	34	8312.	16.	0.0	0.0	U-L	0.0	-.009	-24.	UI	0.000	0.	3.81	3.78	3.76	511.	100.	Same as 3
34	35	8312.	16.	0.0	0.0	U-L	0.0	-.008	-25.	UI	0.000	0.	3.80	3.76	3.75	496.	85.	Same as 3
----Thermal cycle 4.3 K----																		
35	36	7602.	0.	0.0	0.0	U-L	0.0	-.011	-28.	LI	0.000	0.	4.37	4.33	4.32	863.	90.	Same as 2
36	37	7607.	16.	0.0	0.0	U-L	0.0	-.010	-27.	UI	0.000	0.	4.37	4.32	4.31	859.	89.	Same as 3
37	38	7617.	16.	0.0	0.0	U-L	0.0	-.010	-27.	UI	0.000	0.	4.36	4.31	4.31	860.	73.	Same as 3
38	39	7607.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.36	4.32	4.31	866.	93.	Same as 3
39	40	7612.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.36	4.30	4.29	882.	92.	Same as 3
----4.2 K----																		
40	41	7818.	0.	0.0	0.0	U-L	0.0	-.011	-27.	LI	0.000	0.	4.22	4.18	4.18	755.	71.	Same as 2

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
41	42	7828.	16.	0.0	0.0	U-L	0.0	-.011	-27.	LI	0.000	0.	4.22	4.18	4.17	752.	85.	Same as 2
42	43	7823.	16.	0.0	0.0	U-L	0.0	-.011	-28.	LI	0.000	0.	4.22	4.18	4.17	752.	81.	Same as 2
43	44	7823.	16.	0.0	0.0	U-L	0.0	-.010	-26.	UI	0.000	0.	4.22	4.18	4.17	751.	85.	Same as 3
	45	121.	4.	0.0	0.0	Vtot	0.0	-.002	-1.	LI	0.000	0.	4.22	4.18	4.17	752.	80.	
	46	4753.	-100.	0.0	0.0	Vtot	0.0	0.000	-27.	UI	0.000	0.	4.22	4.17	4.17	752.	68.	
44	47	7823.	16.	0.0	0.0	U-L	0.0	-.009	-26.	UI	0.000	0.	4.22	4.18	4.17	750.	100.	Same as 3
	48	5037.	0.	0.0	0.0	Vtot	0.0	0.000	-29.	UI	0.000	0.	4.21	4.17	4.16	749.	80.	
45	49	7832.	16.	0.0	0.0	U-L	0.0	-.008	-26.	UI	0.000	0.	4.21	4.17	4.16	747.	65.	Same as 3
46	50	7823.	100.	0.0	0.0	U-L	0.0	-.004	-22.	LI	0.000	0.	4.21	4.16	4.16	743.	83.	Same as 10
	51	2074.	0.	0.0	0.0	U-L	0.0	0.000	-12.	UI	0.000	0.	4.20	4.16	4.15	741.	84.	
47	52	7793.	0.	0.0	0.0	U-L	0.0	-.005	-21.	LI	0.000	0.	4.21	4.16	4.15	741.	42.	Same as 10
48	53	7813.	100.	0.0	0.0	U-L	0.0	-.004	-21.	LI	0.000	0.	4.21	4.17	4.16	744.	17.	
---------Power Supply Studies---------																		
	54	302.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	LI	0.000	0.	0.00	0.00	0.00	0.	0.	
	55	302.	-16.	0.0	0.0	Vtot	0.0	0.000	6.	UO	0.000	0.	0.00	0.00	0.00	0.	0.	
	56	302.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	LI	0.000	0.	0.00	0.00	0.00	0.	0.	
	57	150.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	LI	0.000	0.	0.00	0.00	0.00	0.	0.	
	58	302.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	UI	0.000	0.	0.00	0.00	0.00	0.	0.	
	59	302.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	LI	0.000	0.	0.00	0.00	0.00	0.	0.	
	60	302.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	LI	0.000	0.	0.00	0.00	0.00	0.	0.	
---------3.0 K Studies ---------																		
49	61	8670.	0.	0.0	0.0	U-L	0.0	-.009	41.	LI	0.000	0.	3.01	2.99	3.00	174.	36.	LI turn 15 at VT 15A
	62	307.	0.	0.0	0.0	V-dI	0.0	0.000	-2.	LI	0.000	0.	3.07	3.06	3.07	192.	31.	
50	63	8802.	0.	0.0	0.0	U-L	0.0	-.006	37.	UI	0.000	0.	2.98	2.97	2.95	167.	29.	Same as 3
51	64	8959.	0.	0.0	0.0	U-L	0.0	-.008	47.	LI	0.000	0.	2.97	2.95	2.97	168.	32.	LI turn 15 at VT 15A
	65	106.	0.	0.0	0.0	Vtot	0.0	-.010	2.	UO	0.000	0.	4.22	4.18	3.48	755.	23.	

----- 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

NOTATION KEY

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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
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T(b)	Temperature at bottom of magnet
P	Dewar pressure (Torr)
LL	Liquid level (%)
Location	Quench or spot heater location

Distribution

R. Bossert
S. Delchamps
A. Devred
W. Koska
M. Lamm
P. Mantsch
G. Pewitt
J. Strait
J. Tompkins
M. Wake