TS-SSC 92-052

TEST RESULTS OF DSA329, 50 mm APERTURE MODEL DIPOLE

Tariq S. Jaffery
Fermi National Accelerator Laboratory
MSIM at BNL
April 7, 1992

Executive Summary of April 7, 1992 MSIM (BNL)

TEST RESULTS OF FERMILAB 50 mm APERTURE, 1.5 m LONG MODEL DIPOLE

Tariq S. Jaffery

DSA329 is the sixth, Fermilab built 50 mm aperture short dipole that was cold tested in Lab2 (superconducting magnet test facility at Fermilab). This magnet has gone through two thermal cycles. The magnet showed some training and all the plateau quenches were in the multiple turns with one voltage tap for quench information. As part of the standard procedure, after coOldown, to study the mechanical behavior of the magnet six strain gage runs were made at 4.35 K to different currents. During a strain gage run to high currents the magnet quenched in the upper outer coil at 7672 A. All the quenches with low ramp rates (4,6,16,25 A/s), which preceded flattop at high current had a higher quench current and were in the straight section of the lower inner coil near the lead end (ramp splice side).

DSA329 PLATEAU CURRENTS

# quenches	27Qs	27 Qs
TEMP (K)	TC1	TC2
4.2	7847 A	7842A
4.35	7704 A	7690A .
3.8	----	8364 A

The quench current ramp rate dependence of this magnet is somewhat similar to DSA328 and DSA326. All high ramp rate quenches were in the multipleturn (non pole turn) of the inner coil which is not very well instrumented with voltage taps. The cold harmonics measurement data shows b2=1.27 and b4=0.1 units at1 cm. The magnet ends were preloaded to ~ 280 lb per bullet. The lead end screws were also torqued to achieve the same preload. AC loss measurements made on this magnet shows that the hysteresis loss is similar to what we we have seen on previous short dipoles (81 J).

The magnet was quenched four times at 3.0 K, with the highest quench current of 8926 A. We did not try to plateau the magnet at this current and could not do any strain measurement at this temperature.

Distribution: FNAL S. Delchamps, M. Lamm, M. Wake
SSCL J. Jayakumar, V. Kovachev, G. Snitchler

TEST RESULTS OF DSA329
50 mm APERTURE, SHORT MODEL DIPOLE

I. INTRODUCTION

II. MECHANICAL BEHAVIOR

III. QUENCH BEHAVIOR

IV. AC LOSS

DSA329

-> VERTICALLY SPLIT YOKE

-> ALUMINUM END CAN/G-10 CR11 COLLETS

-> KAPTON ONLY(NO GLASS TAPE) INSULATION ON THE WEDGES

-> ROOM TEMPERATURE COLLAR STRESS

INNER =68 MPa (~10 kpsi) OUTER=38 MPa (~5.5kpsi)

-> END PRELOAD =~1.1 kN/per Bullet

-> VOLTAGE TAPS

SHIMMING

MAGNET	INNER COIL	OUTER COIL
	(mils of Kapton)	
DSA321	0.	0.
DSA323	0.	0.
DSA324	+5.	+5.
DSA326	0.	0.
DSA101	0. (G-10)	-10. +2. (Kaptontape with adhesive)
DSA102	+8. (G-10)	-5. + +2. (Kaptontape with adhesive)
DSA328	+3.8	-5.
DSA329	+4.0	--- (Kaptontape on wedges)

PRESTRESS CHANGE WITH COOLDOWN
1.5 m Long , 50 mm Aperture
SSC Model Dipoles Tested at Fermilab

Magnet	Coil Stress Change (MPa) Inner Coil	Coil Stress Change (MPa) Outer Coil	End Force Change (kN)
DSA321	-19	-14	-1
DSA323	-30	-10	0
DSA324	-33	- 8	1
DSA326 (TC1)	-34	-25	4.8
DSA326 (TC2)	-37	-23	5
DSA326 (TC3)	-36	-22	-2.5
DSA101 (TC1)	-35	-22	---
DSA102 (TC1)	-49	-18	---
DSA328 (TC1)	-36	-8.5	6.6
DSA329 (TC1)	-34	-16	1.4
DSA329 (TC2)	-35	-17	1.0

DSA329

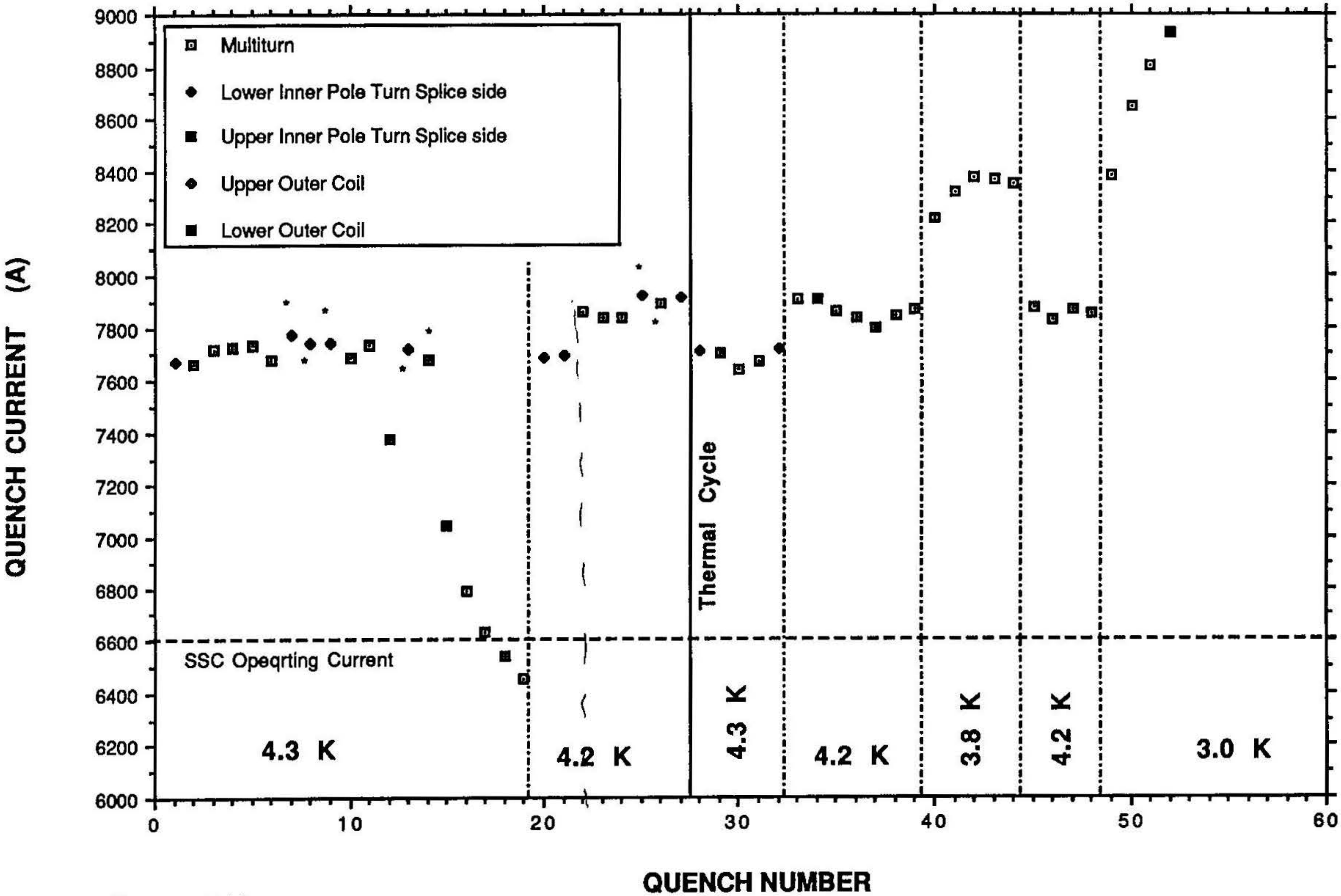
CABLES:	INNER	OUTER
UP	SSC-3-S-00026	SSC-4-I-00040
LO	SSC-3-S-00026	SSC-4-I-00040

PREDICTED Iq at 4.35 K =

PLATEAU CURRENTS:

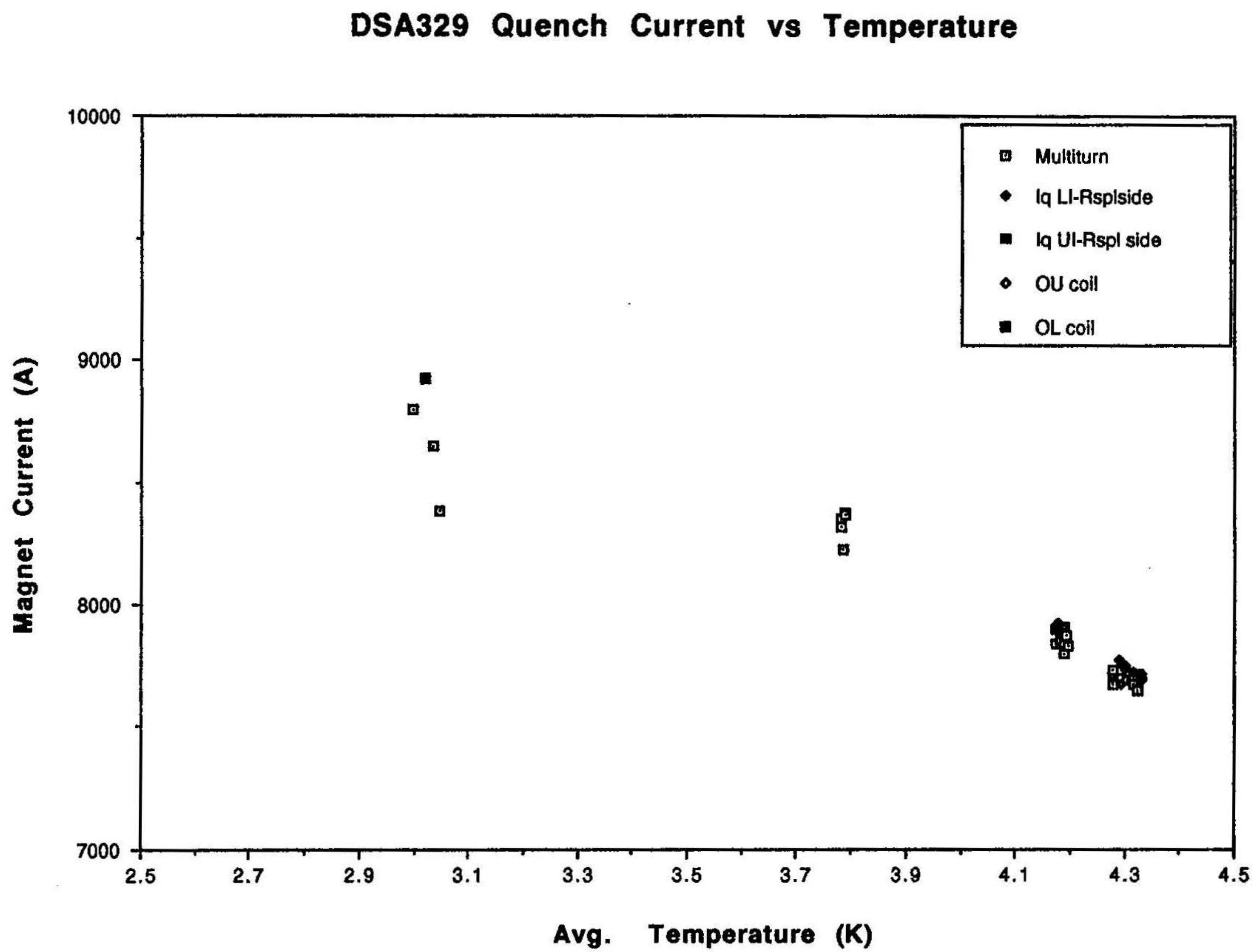
	TC1 (27 quenches)	TC2 (27 quenches)
4.3 K	= 7704	7674
4.2 K	= 7847	7842
3.8 K	= ----	8364

DSA328 QUENCH HISTORY
(Fermilab built 50 mm, 1.5 m long SSC dipole)

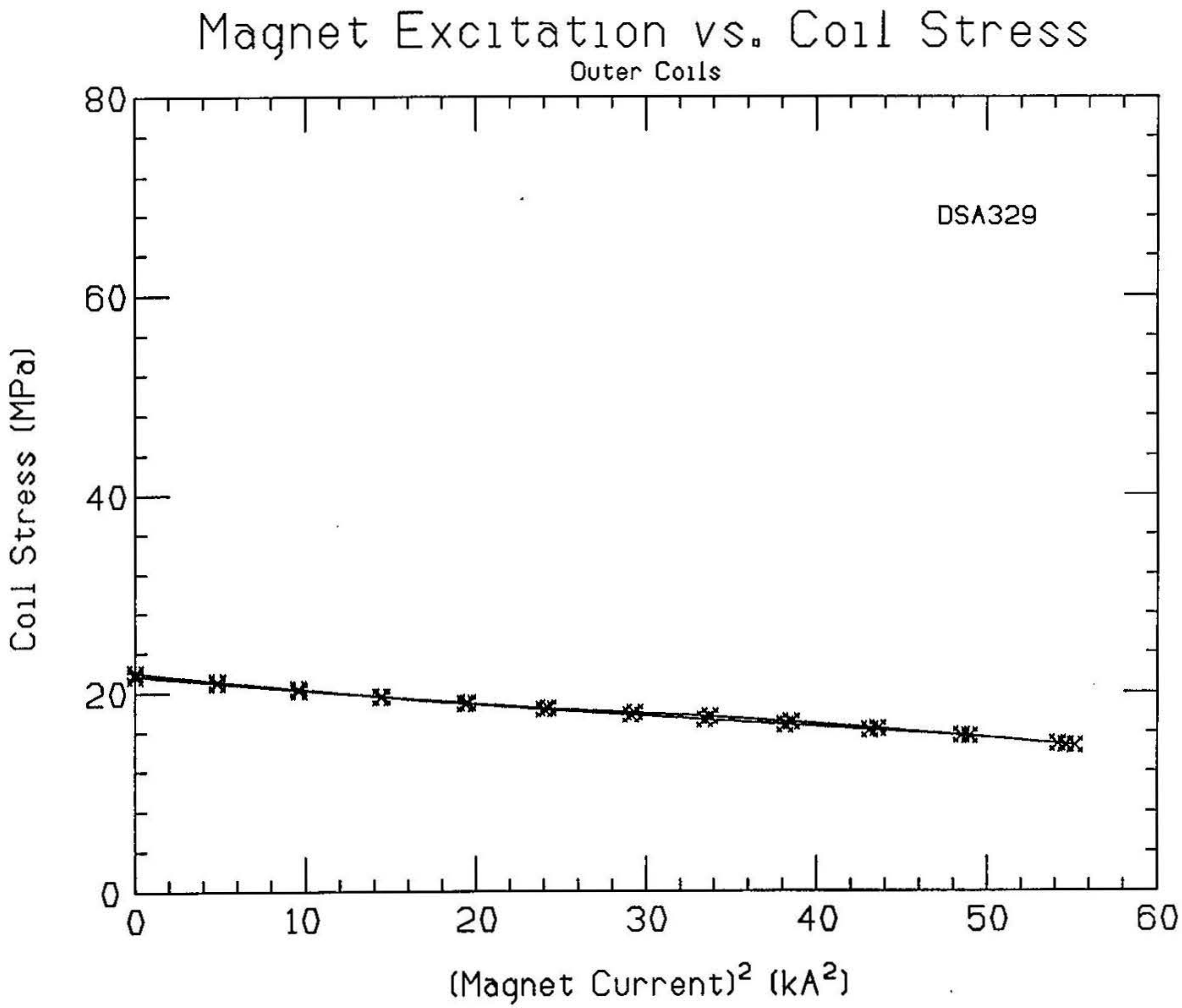


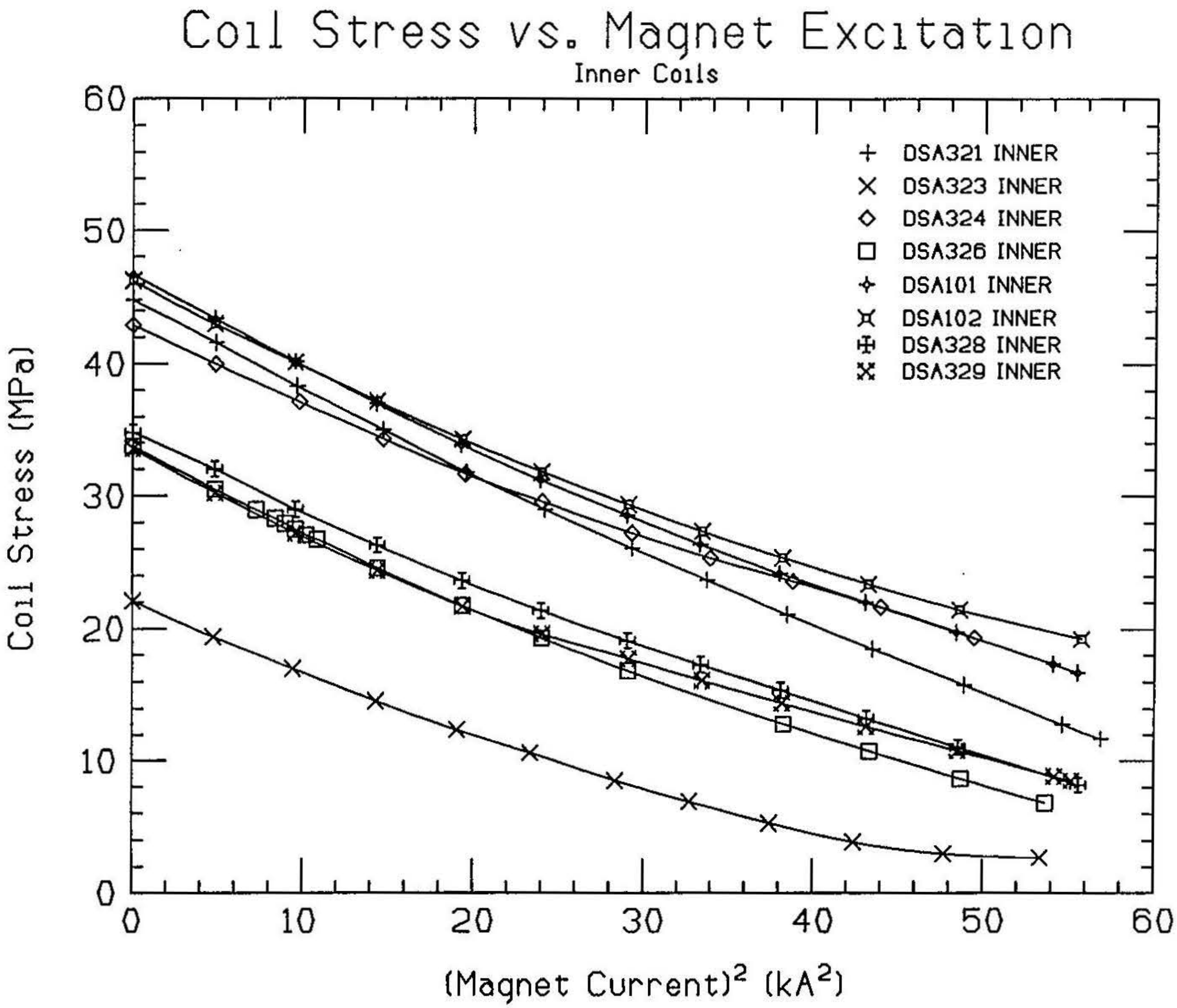
* 10 min Flattop at 7 kA

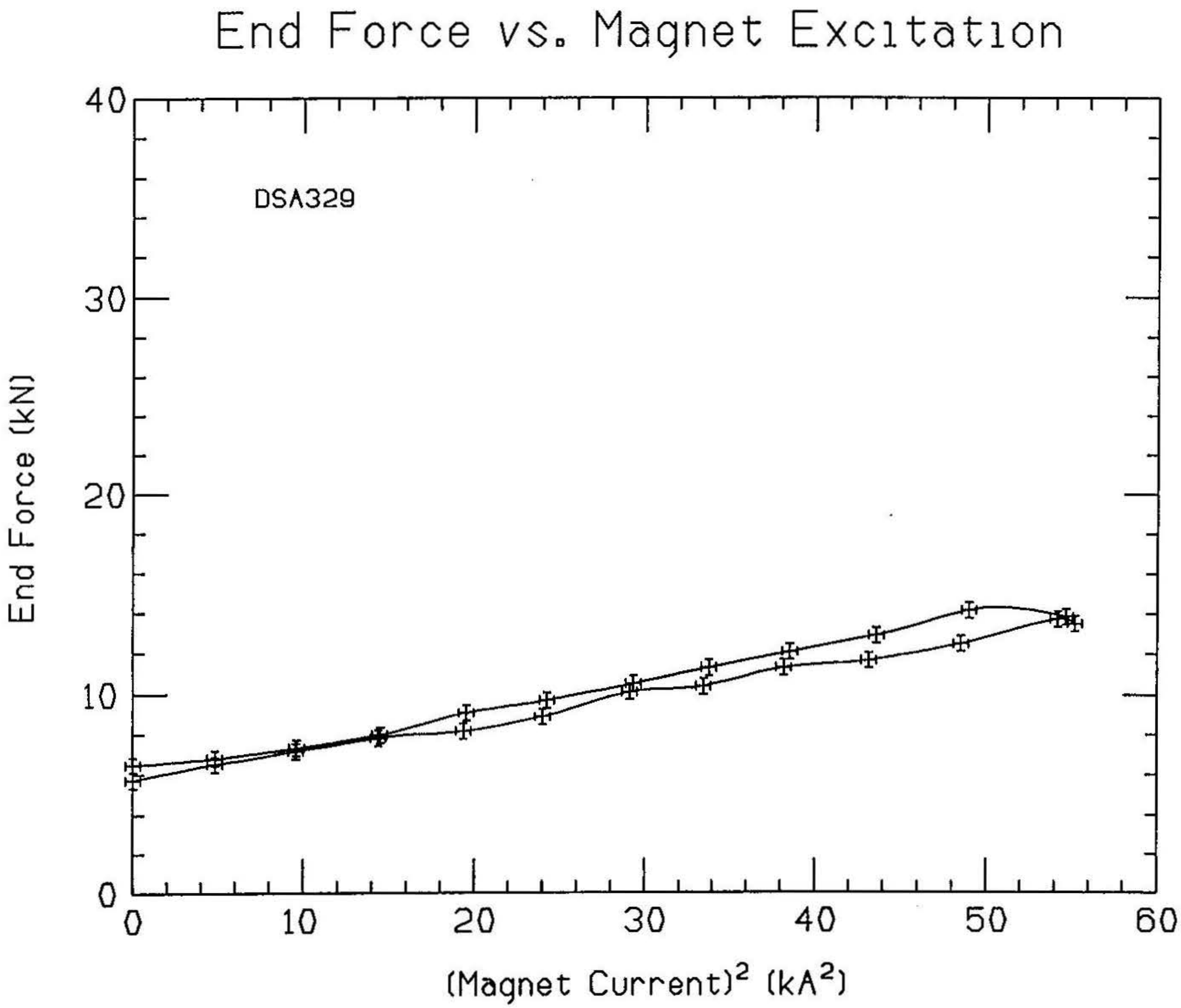
Temperature Fluctuation ~30 - 50 mK

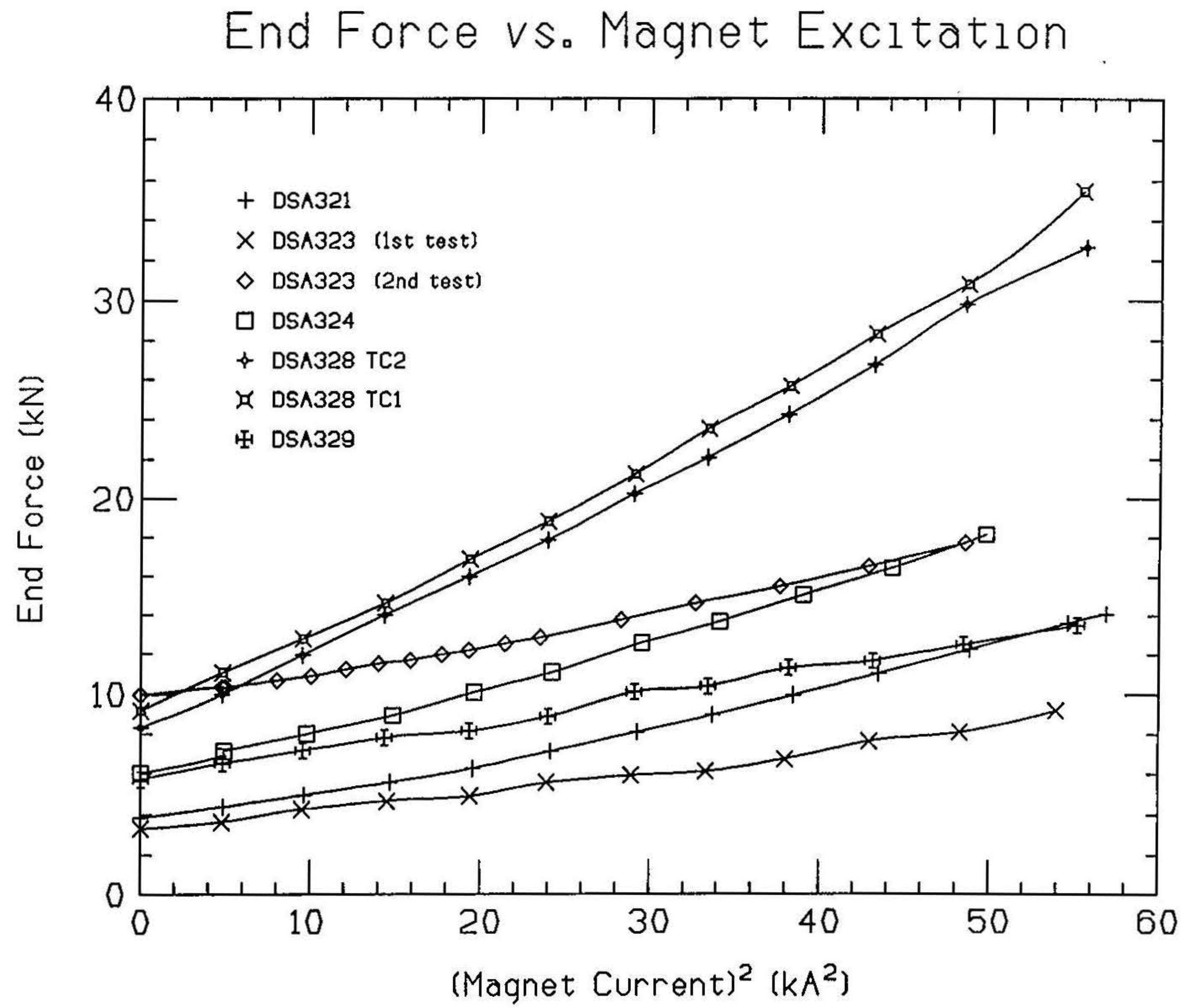


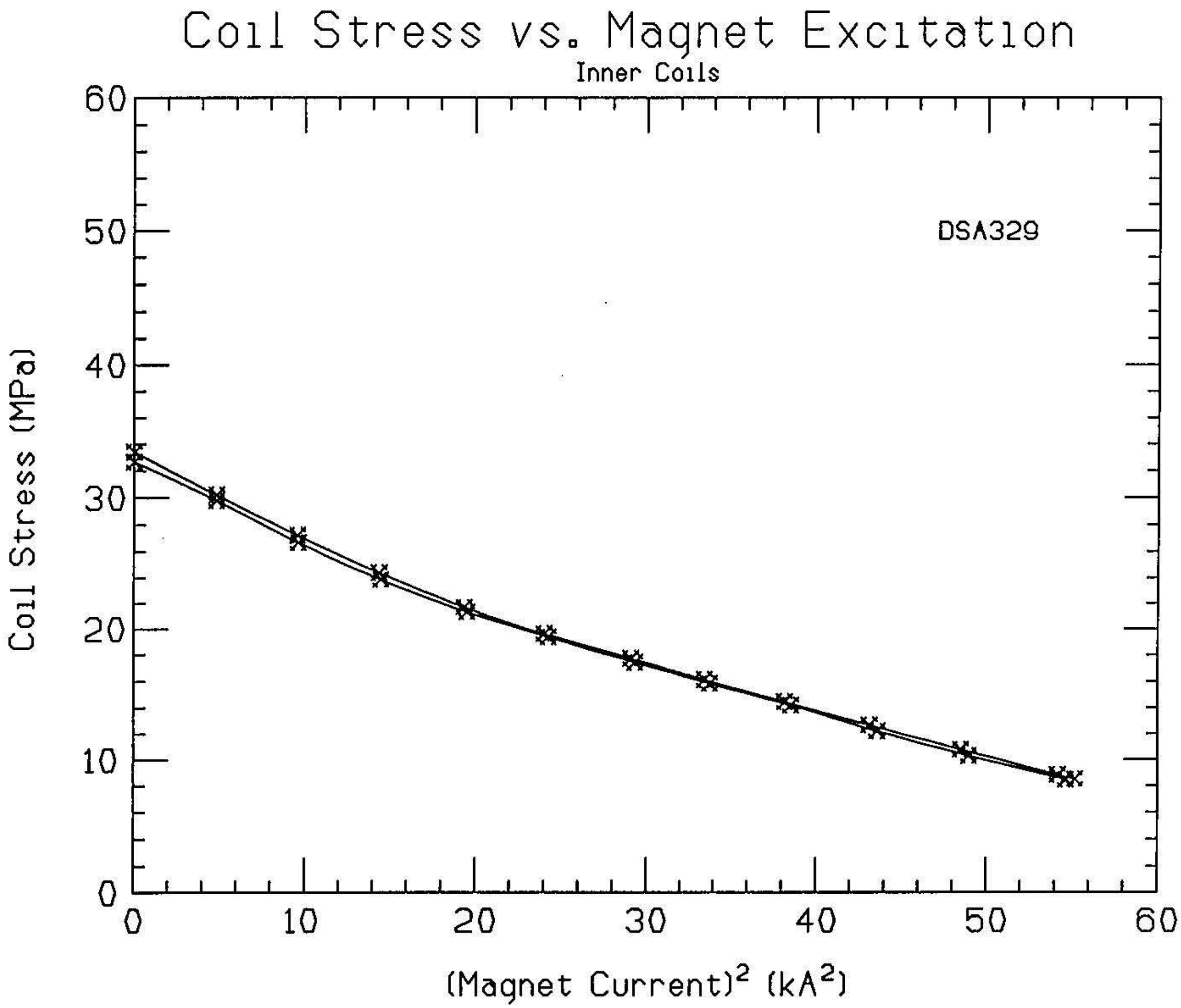
DSA329 Quench Current vs Temperature
Magnet Current (A)
10000
9000
8000
7000
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
Avg. Temperature (K)
Multiturn
Iq Ll-Rsplside
Iq Ul-Rspl side
OU coil
OL coil

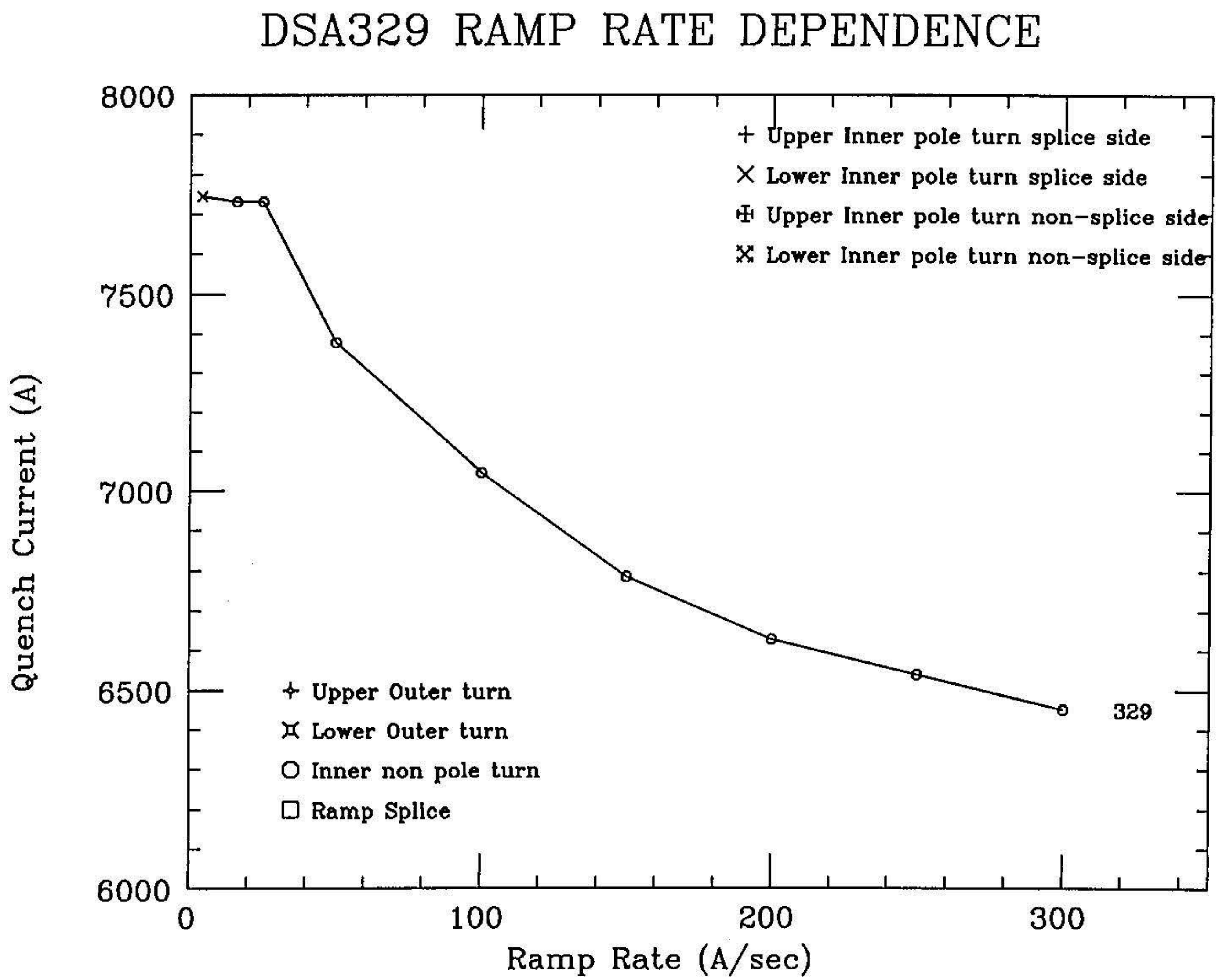

Magnet Excitation vs. Coil Stress
Outer Coils
DSA329
Coil Stress (MPa)
(Magnet Current)^2 (kA^2)
0
20
40
60
80
0
10
20
30
40
50
60

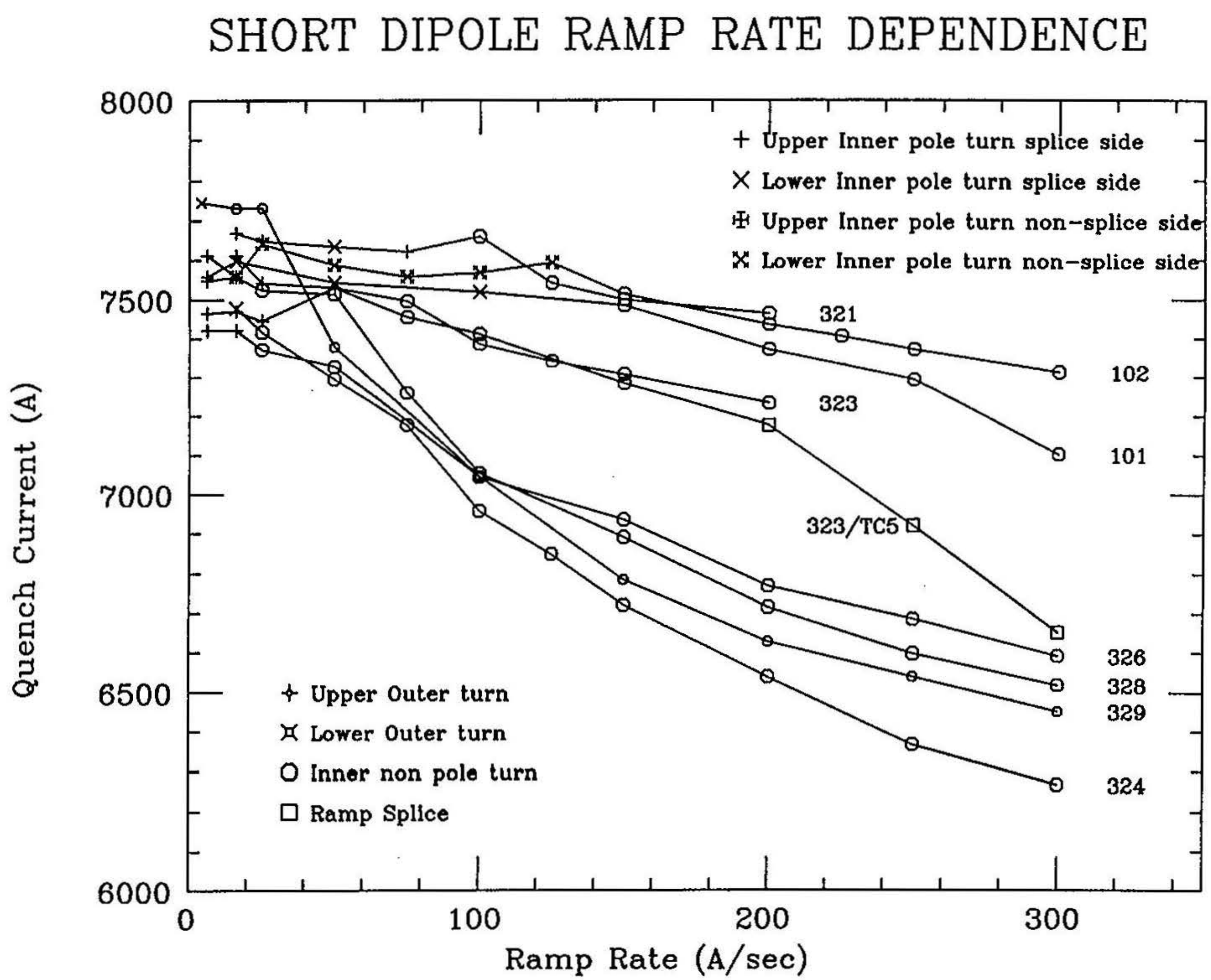

Coil Stress vs. Magnet Excitation
Inner Coils
Coil Stress (MPa)
(Magnet Current)^2 (kA^2)
0
10
20
30
40
50
60
DSA321 INNER
DSA323 INNER
DSA324 INNER
DSA326 INNER
DSA101 INNER
DSA102 INNER
DSA328 INNER
DSA329 INNER

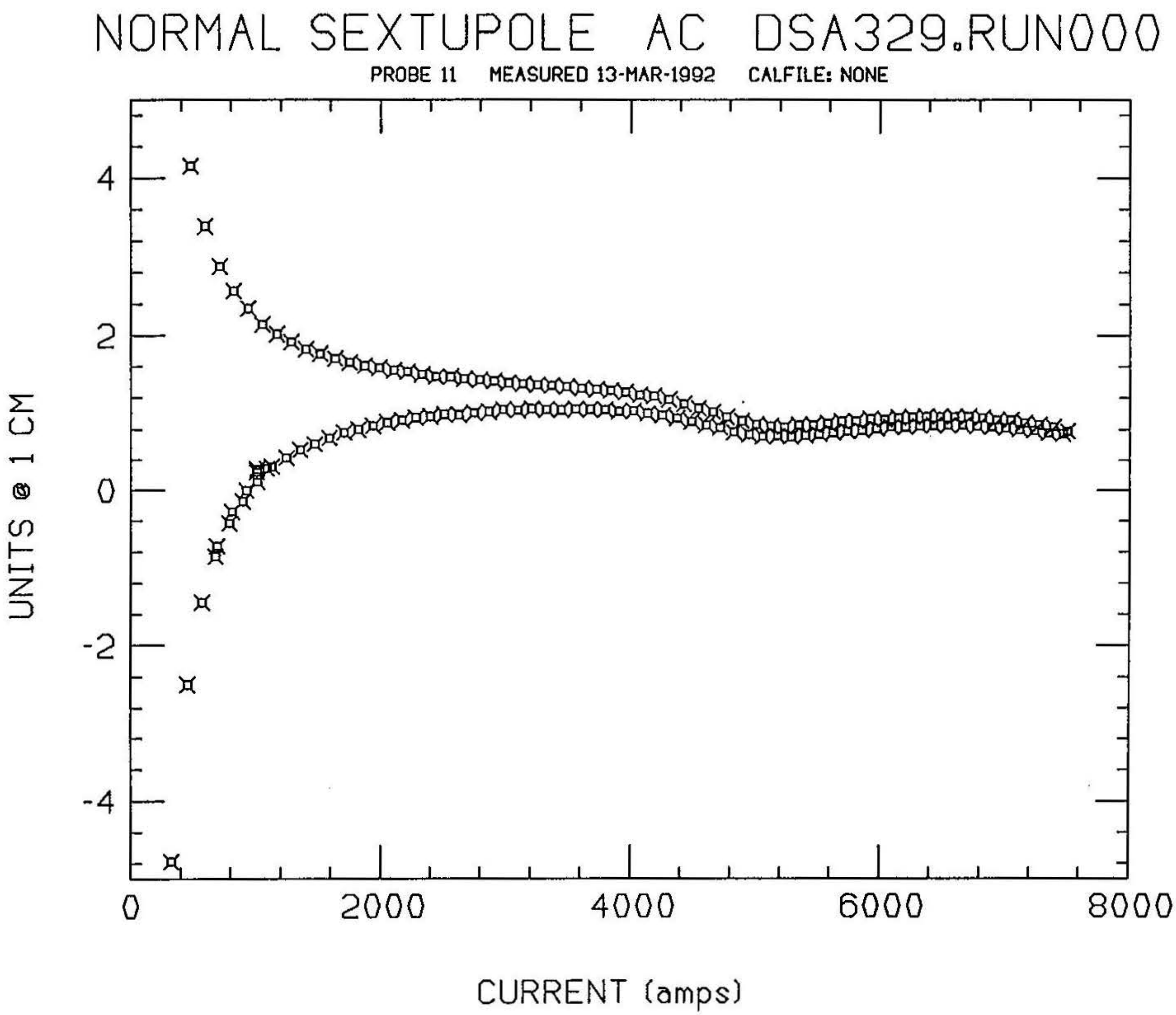

End Force vs. Magnet Excitation
DSA329
End Force (kN)
(Magnet Current)^2 (kA^2)
0
10
20
30
40
50
60


End Force vs. Magnet Excitation
End Force (kN)
(Magnet Current)^2 (kA^2)
0
10
20
30
40
50
60
DSA321
DSA323 (1st test)
DSA323 (2nd test)
DSA324
DSA328 TC2
DSA328 TC1
DSA329


Coil Stress vs. Magnet Excitation
Inner Coils
DSA329
Coil Stress (MPa)
0
10
20
30
40
50
60
(Magnet Current)^2 (kA^2)

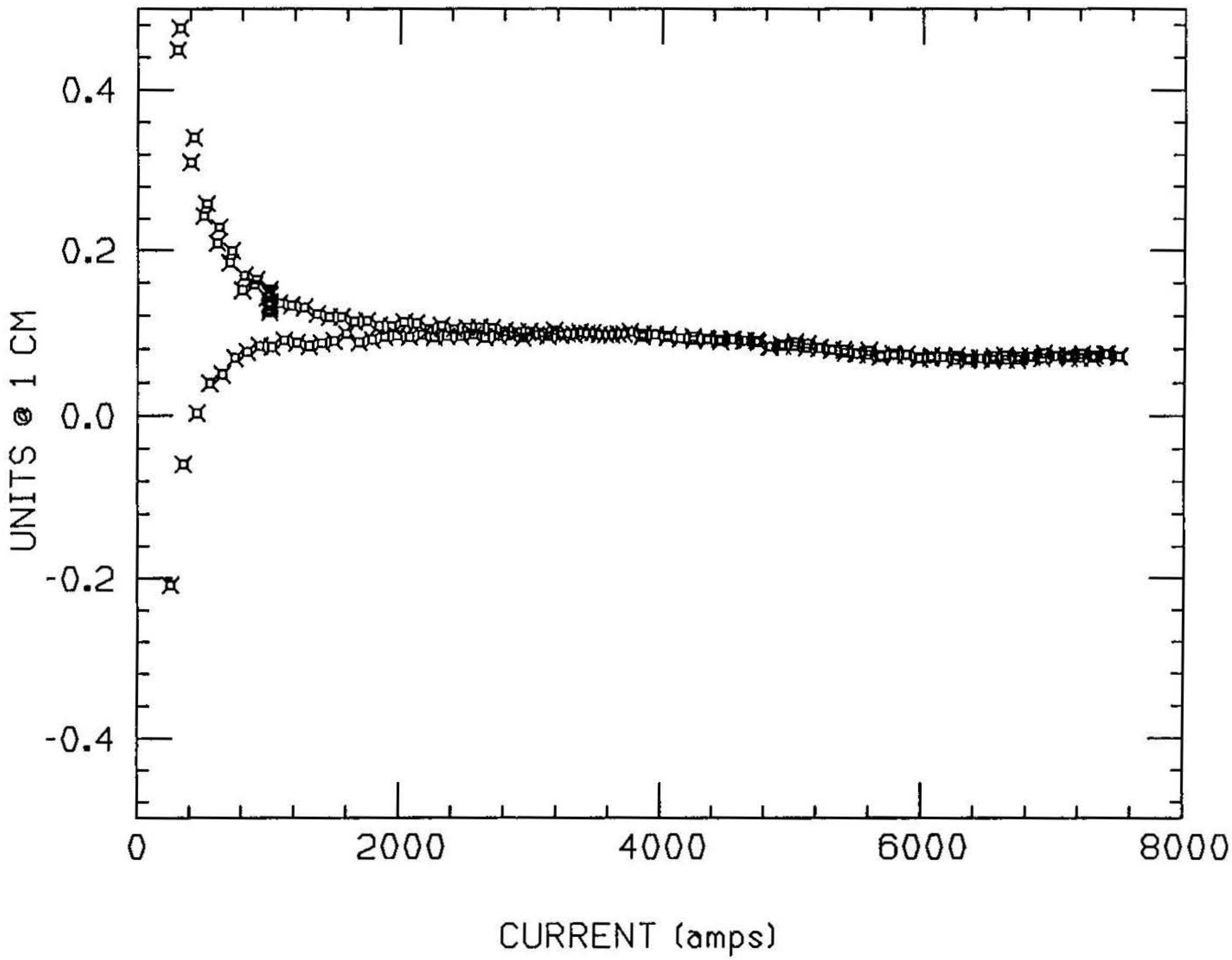

DSA329 RAMP RATE DEPENDENCE
8000
7500
7000
6500
6000
0
100
200
300
Quench Current (A)
Ramp Rate (A/sec)
Upper Inner pole turn splice side
Lower Inner pole turn splice side
Upper Inner pole turn non-splice side
Lower Inner pole turn non-splice side
Upper Outer turn
Lower Outer turn
Inner non pole turn
Ramp Splice
329


SHORT DIPOLE RAMP RATE DEPENDENCE
Quench Current (A)
Ramp Rate (A/sec)
8000
7500
7000
6500
6000
0
100
200
300
Upper Inner pole turn splice side
Lower Inner pole turn splice side
Upper Inner pole turn non-splice side
Lower Inner pole turn non-splice side
Upper Outer turn
Lower Outer turn
Inner non pole turn
Ramp Splice
321
102
323
101
323/TC5
326
328
329
324


NORMAL SEXTUPOLE AC DSA329.RUN000
PROBE 11 MEASURED 13-MAR-1992 CALFILE: NONE
UNITS @ 1 CM
4
2
0
-2
-4
0
2000
4000
6000
8000
CURRENT (amps)

NORMAL DECAPOLE AC DSA329.RUN009

PROBE 14 MEASURED 24-MAR-1992 CALFILE: NONE



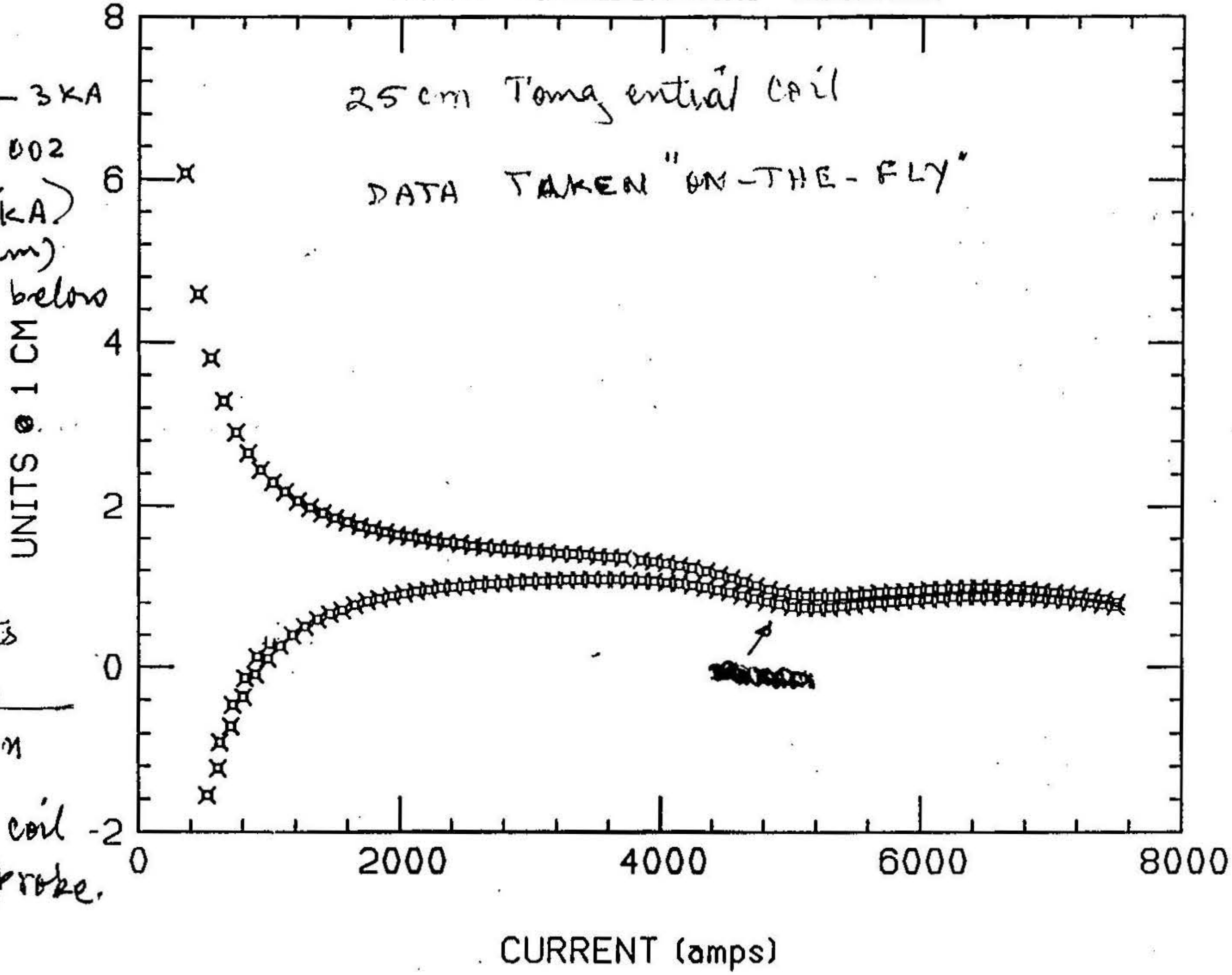
NORMAL SEXTUPOLE AC DSA329.RUN009

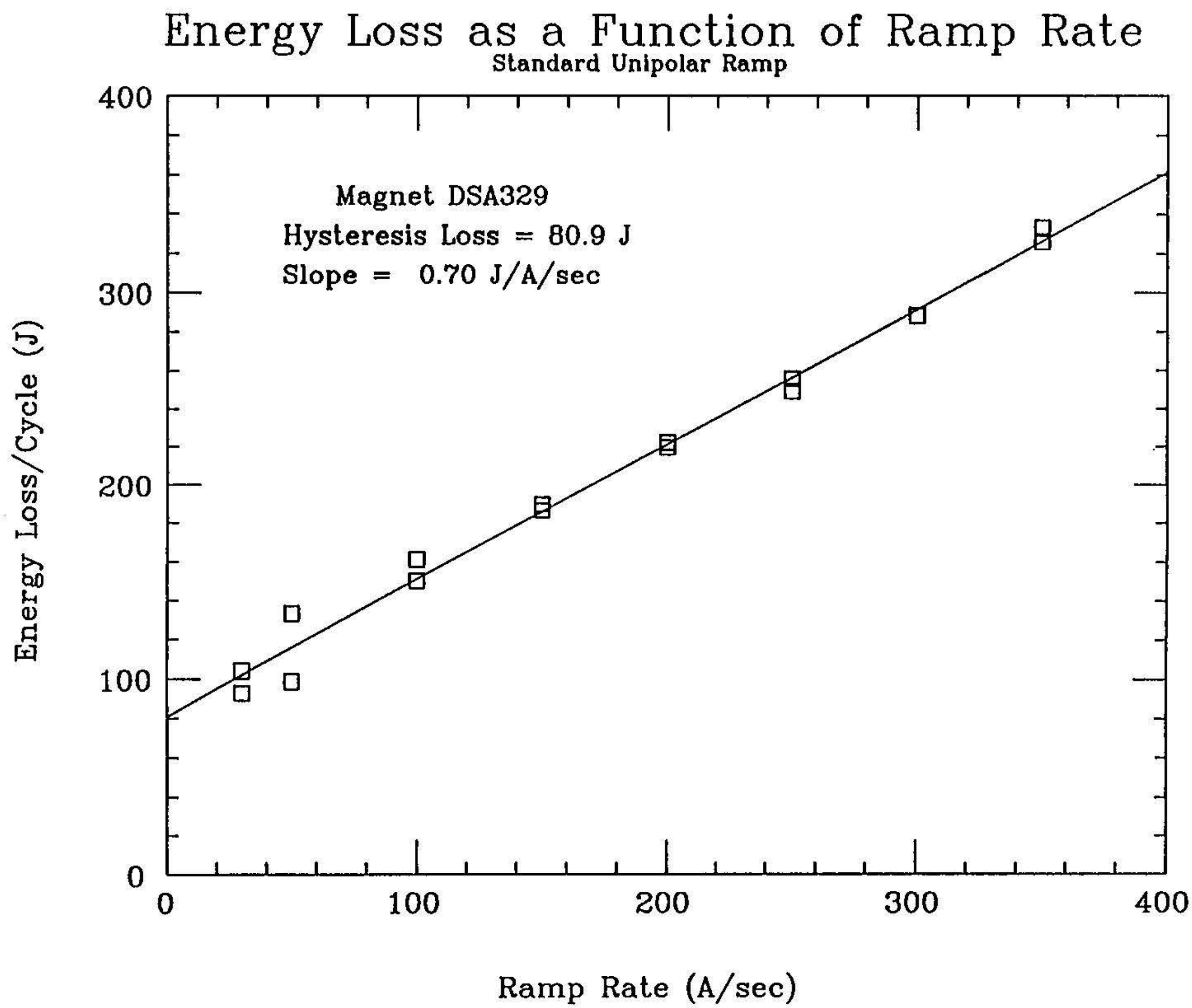
PROBE 14 MEASURED 24-MAR-1992 CALFILE: NONE

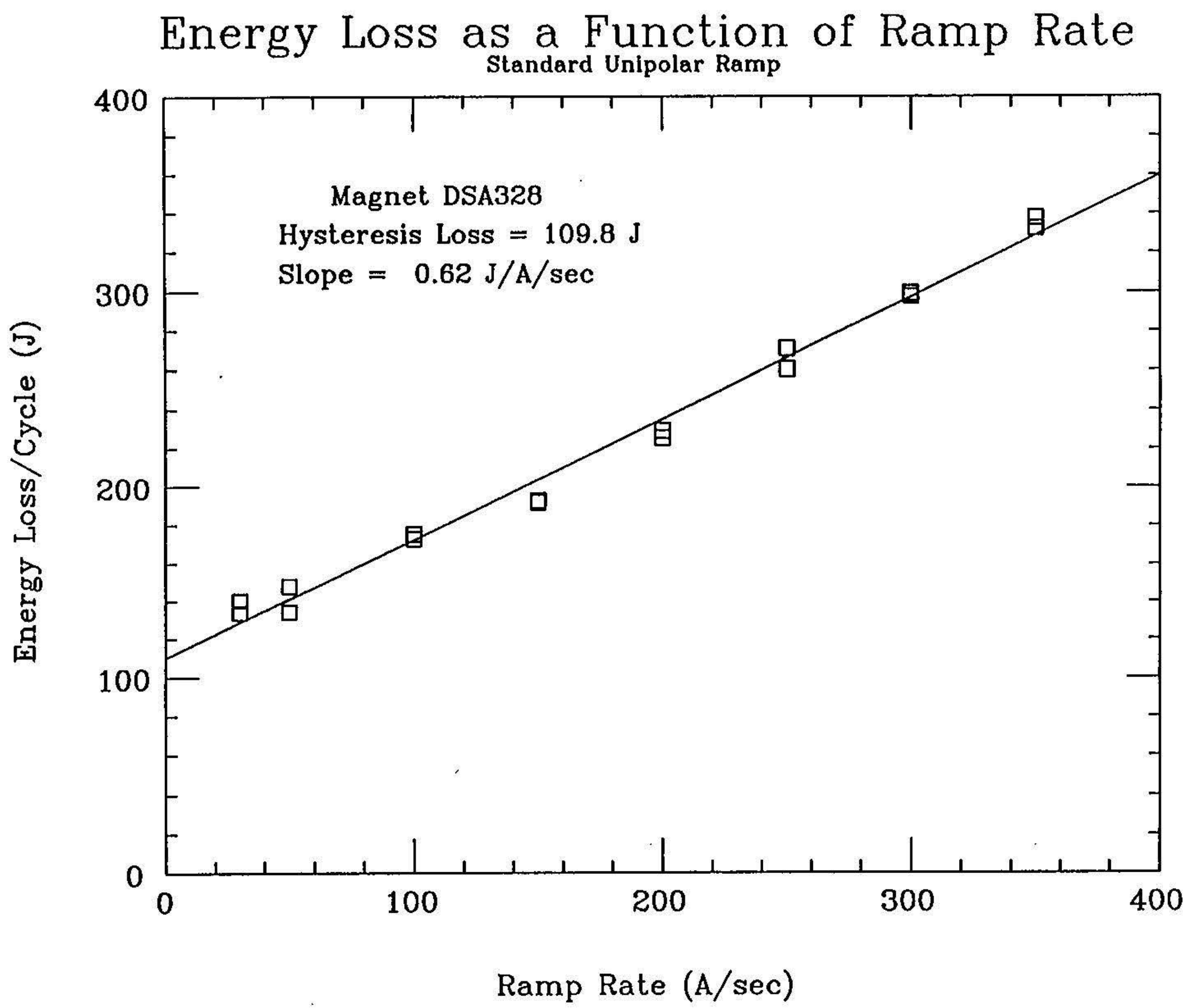
T-fcn @ 2KA – 3KA
= 1.045 ± .002
(T/KA)
@ 30.5" (77.5cm)
~9" (23 cm) below
gage pack

$b_2 \approx 1.22$ units
$b_4 \approx 0.1$ units

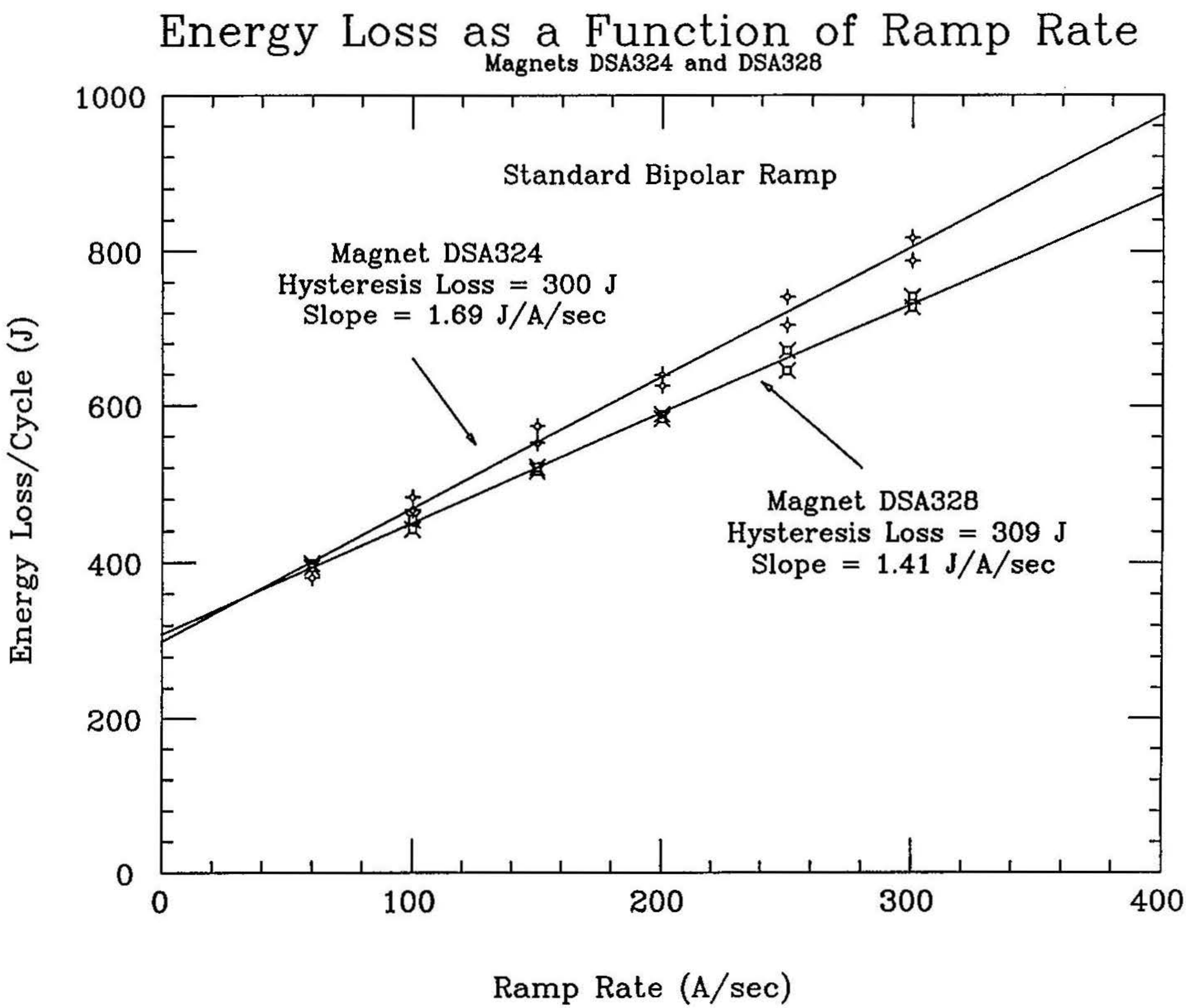
@ 2 KA up-Down
Avg. at 4.2K
using morgan coil
& Tangential probe.




Energy Loss as a Function of Ramp Rate
Standard Unipolar Ramp
Magnet DSA329
Hysteresis Loss = 80.9 J
Slope = 0.70 J/A/sec
Energy Loss/Cycle (J)
Ramp Rate (A/sec)
0
100
200
300
400

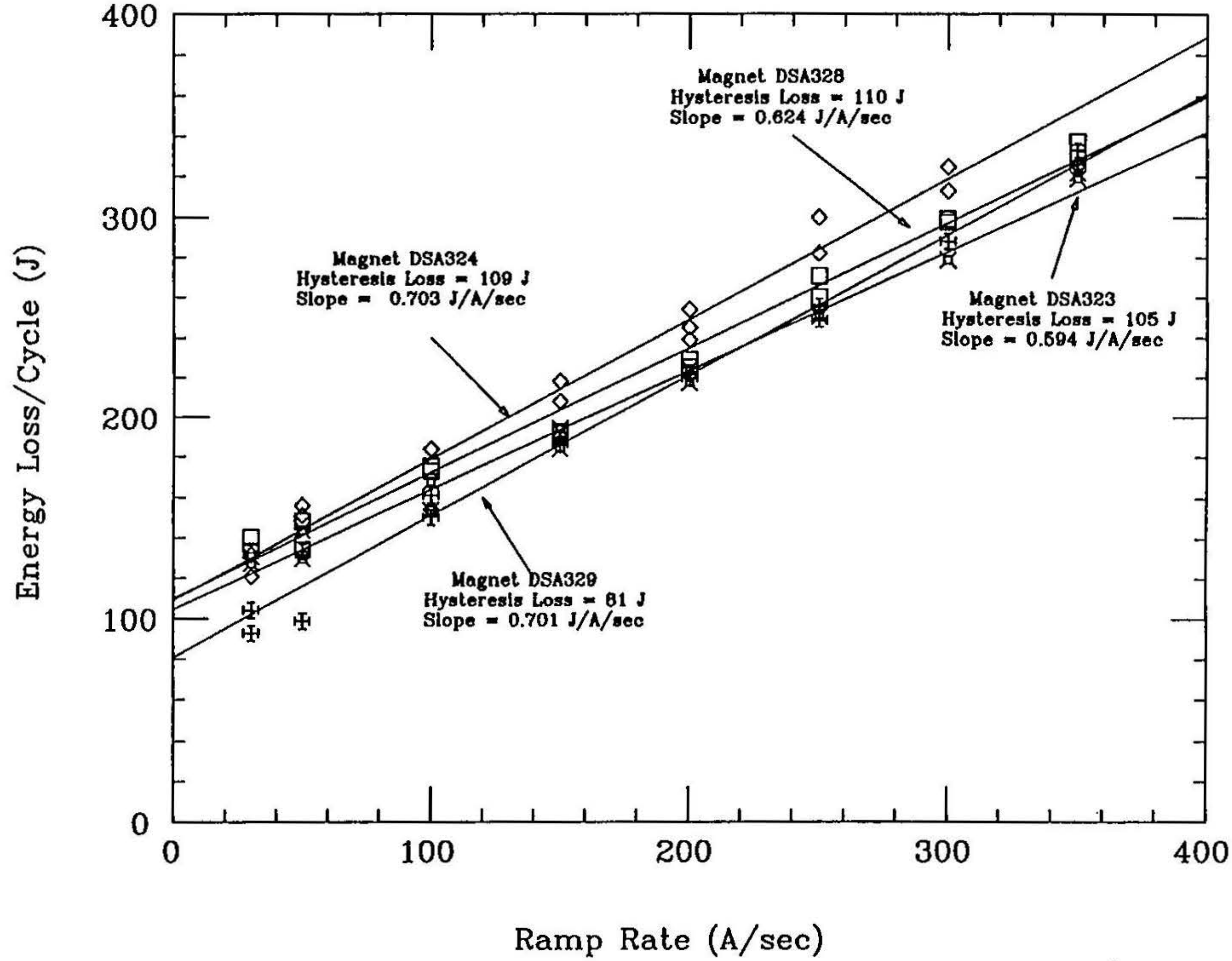


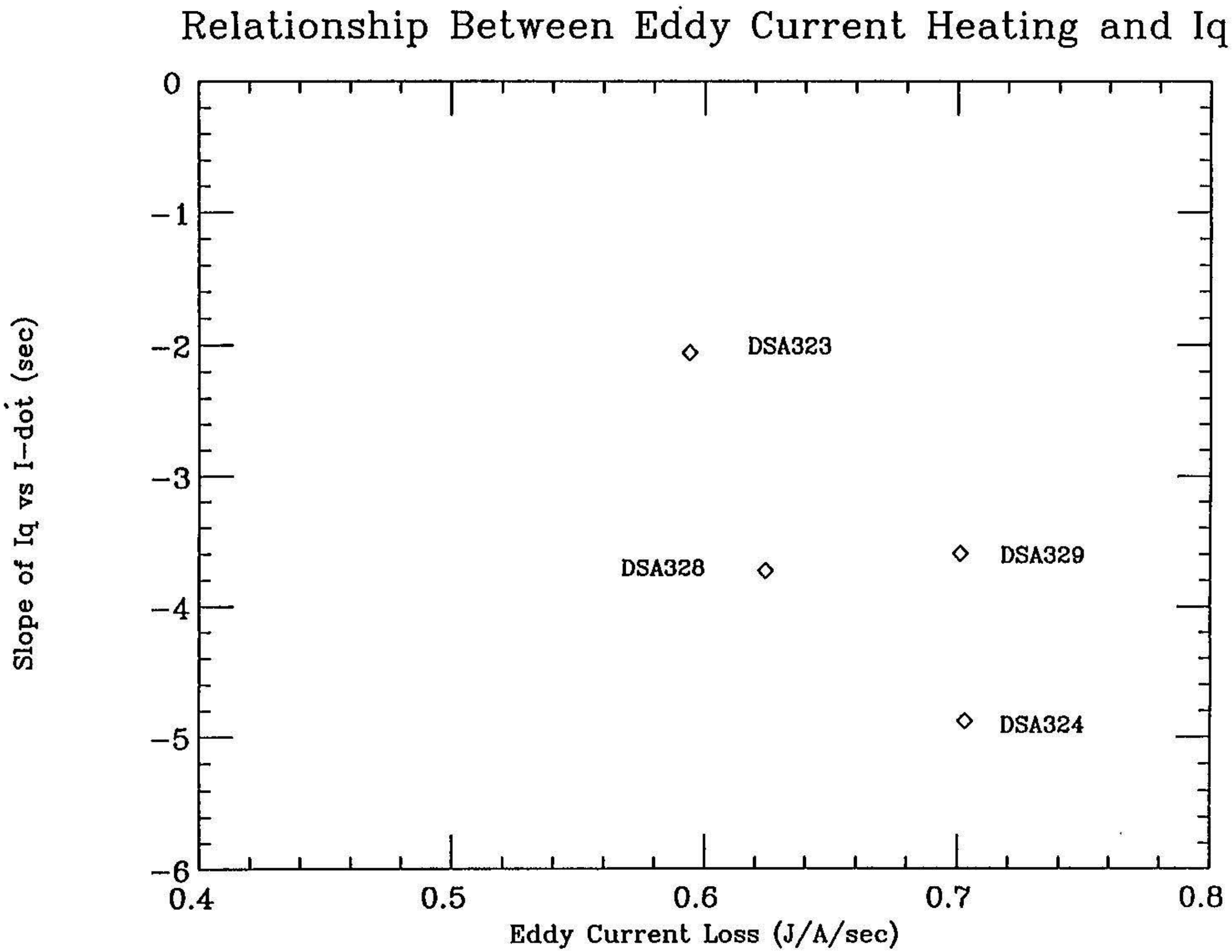
Energy Loss as a Function of Ramp Rate
Standard Unipolar Ramp
Magnet DSA328
Hysteresis Loss = 109.8 J
Slope = 0.62 J/A/sec
Energy Loss/Cycle (J)
Ramp Rate (A/sec)
0
100
200
300
400


Energy Loss as a Function of Ramp Rate
Magnets DSA324 and DSA328
Standard Bipolar Ramp
Magnet DSA324
Hysteresis Loss = 300 J
Slope = 1.69 J/A/sec
Magnet DSA328
Hysteresis Loss = 309 J
Slope = 1.41 J/A/sec
Energy Loss/Cycle (J)
1000
800
600
400
200
0
0
100
200
300
400
Ramp Rate (A/sec)

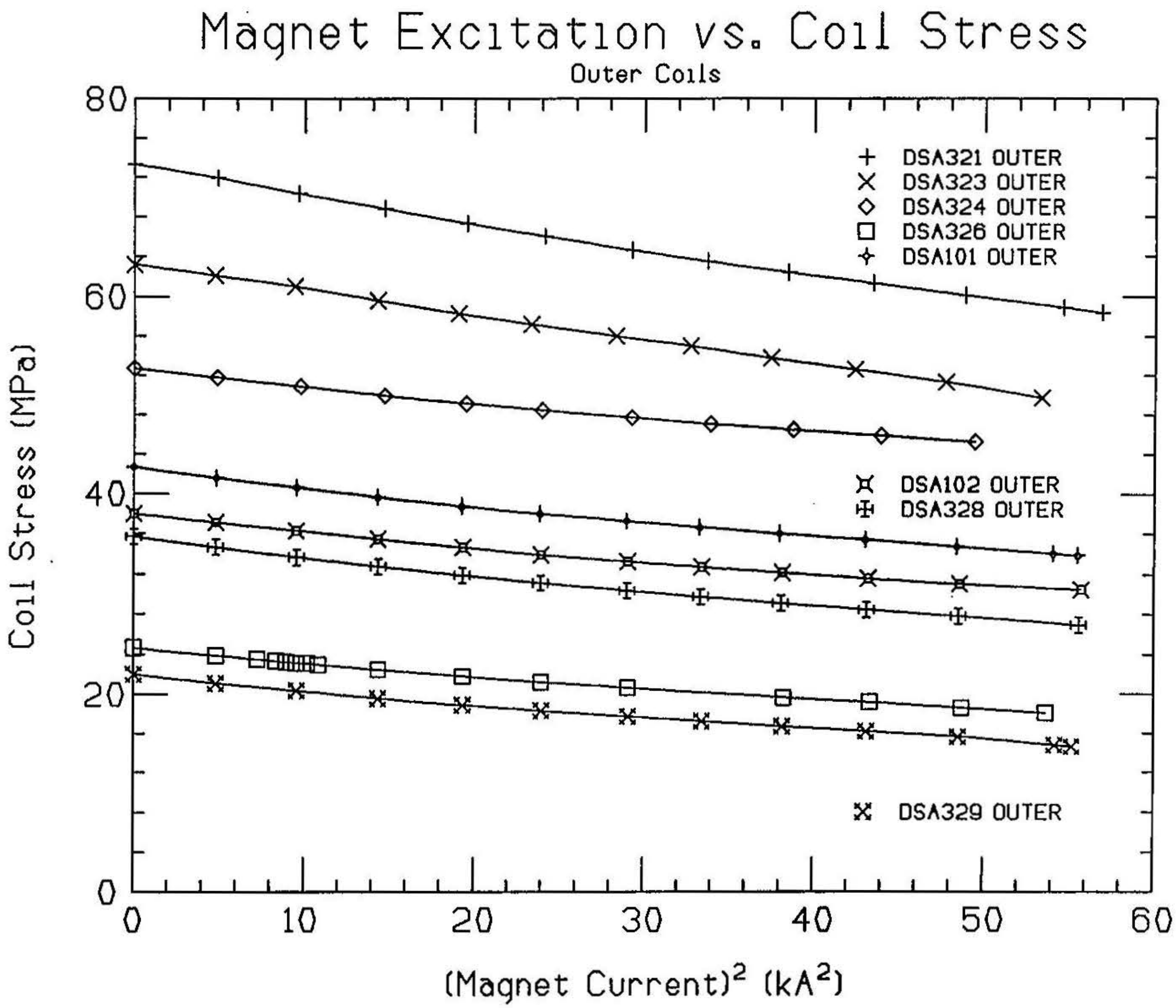
Energy Loss as a Function of Ramp Rate

Magnets DSA323, DSA324, DSA328, and DSA329





Relationship Between Eddy Current Heating and Iq
Slope of Iq vs I-dot (sec)
Eddy Current Loss (J/A/sec)
0
−1
−2
−3
−4
−5
−6
0.4
0.5
0.6
0.7
0.8
DSA323
DSA328
DSA329
DSA324



Magnet Excitation vs. Coil Stress
Outer Coils
DSA321 OUTER
DSA323 OUTER
DSA324 OUTER
DSA326 OUTER
DSA101 OUTER
DSA102 OUTER
DSA328 OUTER
DSA329 OUTER
Coil Stress (MPa)
(Magnet Current)² (kA²)
0
20
40
60
80
0
10
20
30
40
50
60