Fermilab

TS-SSC 92-022

SSC Collider Dipole Magnet End Force Issues

Wayne Koska
Fermilab

January 21, 1992

Outline:

- End Force Measurement Variations
- Fermilab 50 mm Dipole End Design
- Construction Variations which might affect end force
- Conclusions

Acknowledgments: Jim Strait
Steve Delchamps
Rodger Bossert
Tricia Heger

15 m Dipole Magnet

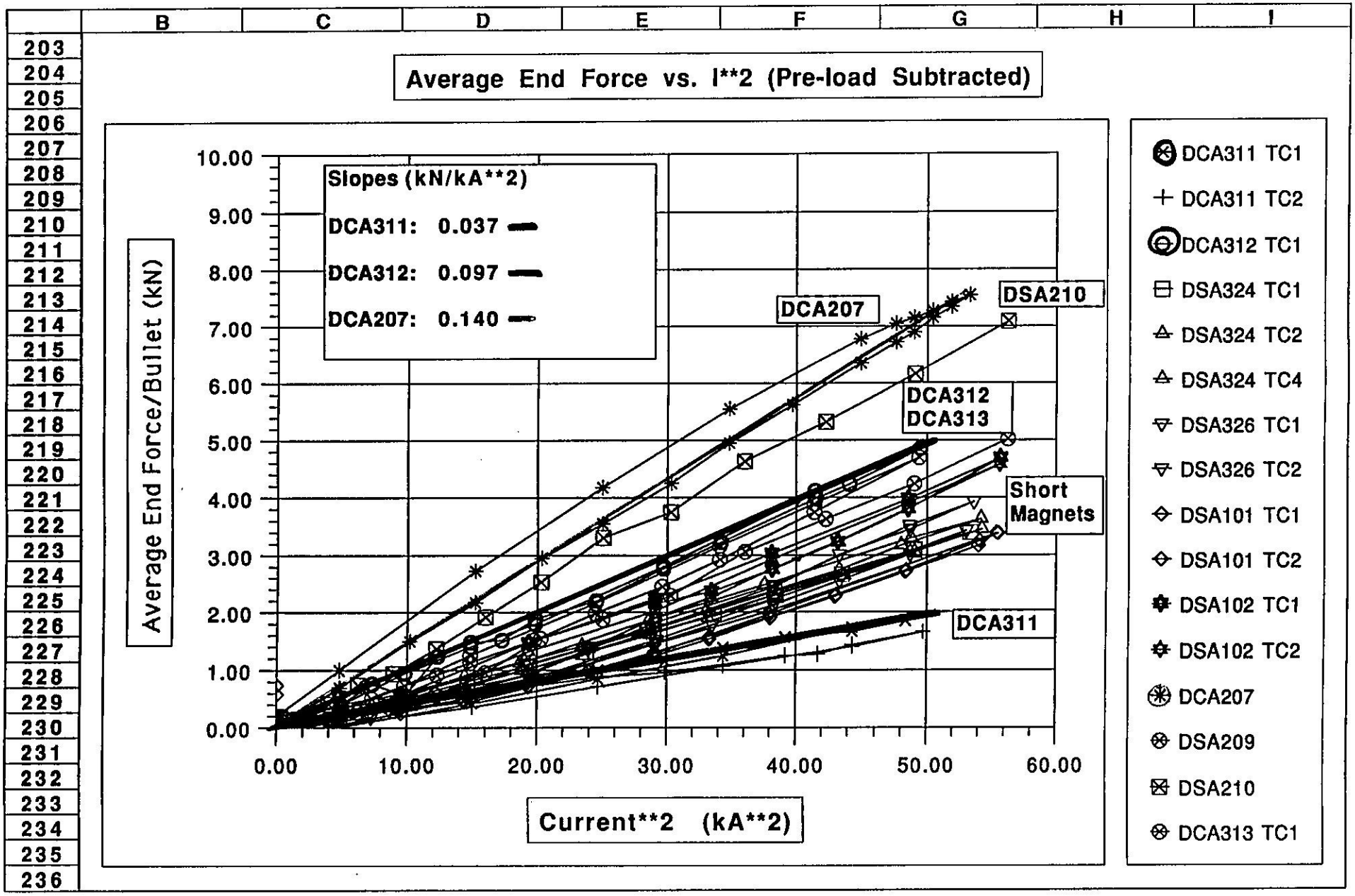
Performance

DCA311, 312 + 207 reached operating current without quenching.

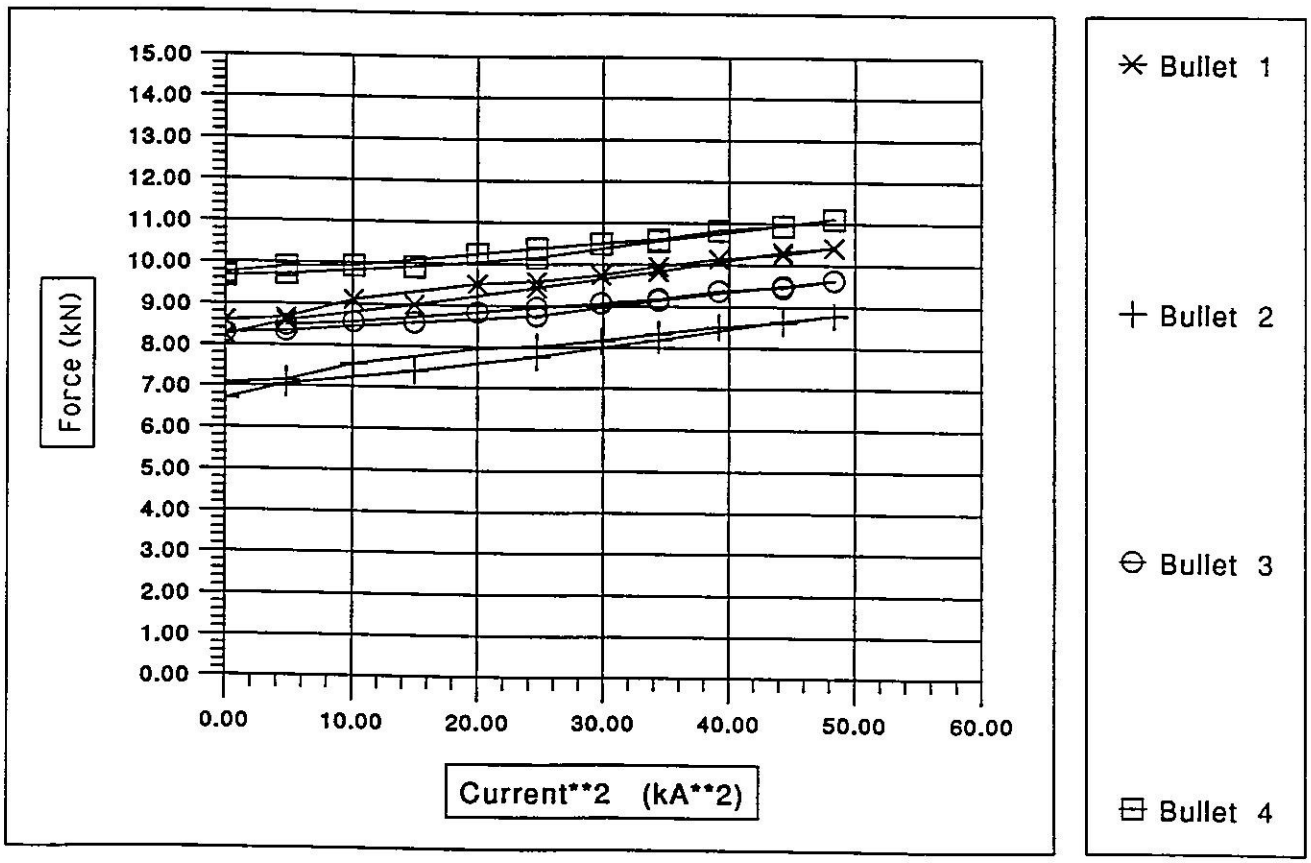
DCA313 quenched at ≈ 5 kA, then went to short sample.

All magnets exhibit a strong ramp rate dependence

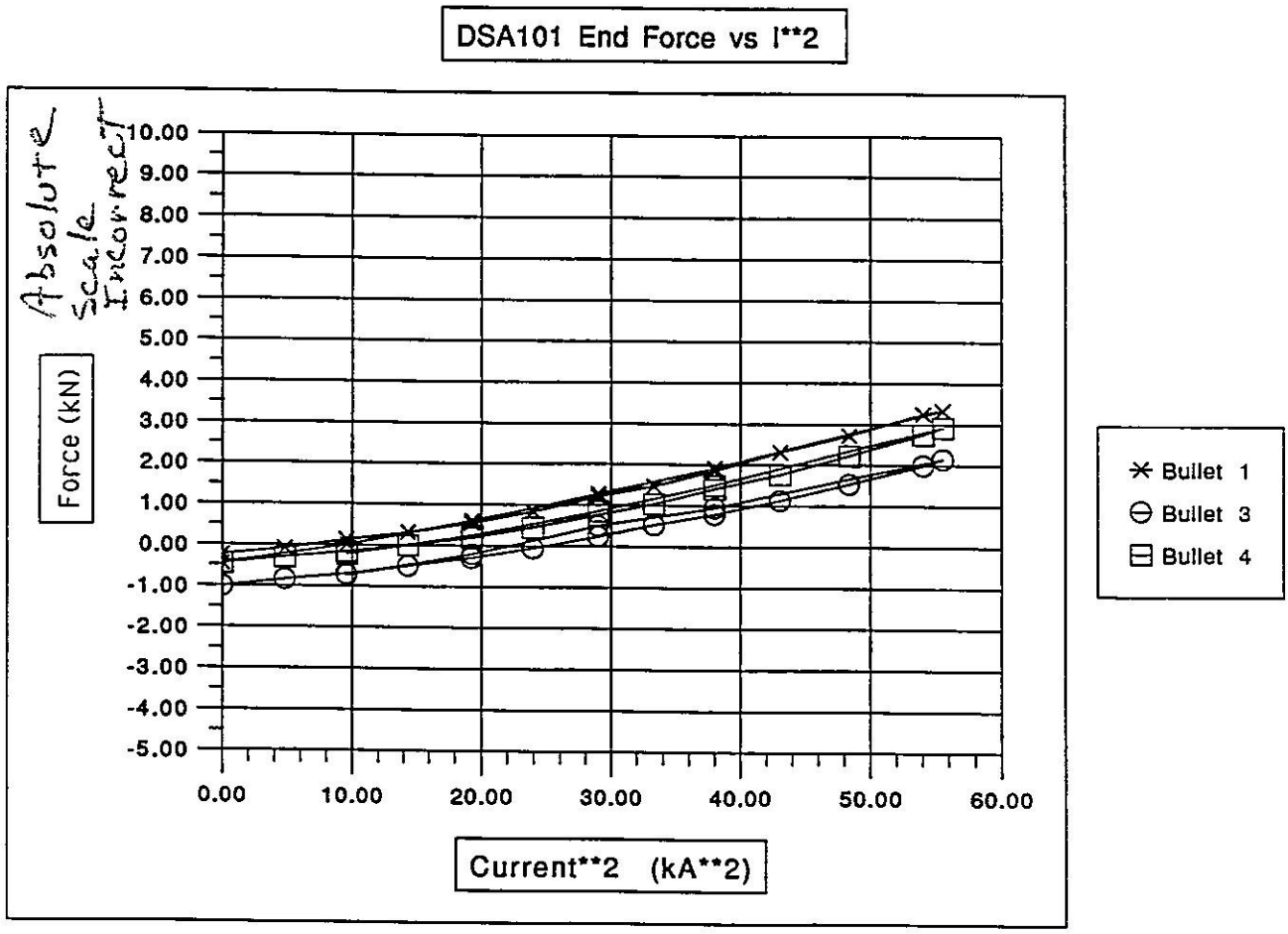
All magnets had adequate azimuthal pre load to prevent unloading.


Average End Force vs. I**2 (Pre-load Subtracted)
Slopes (kN/kA**2)
DCA311: 0.037
DCA312: 0.097
DCA207: 0.140
DCA207
DSA210
DCA312
DCA313
Short Magnets
DCA311
Average End Force/Bullet (kN)
Current**2 (kA**2)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
DCA311 TC1
DCA311 TC2
DCA312 TC1
DSA324 TC1
DSA324 TC2
DSA324 TC4
DSA326 TC1
DSA326 TC2
DSA101 TC1
DSA101 TC2
DSA102 TC1
DSA102 TC2
DCA207
DSA209
DSA210
DCA313 TC1

	B	C	D	E	F	G
53	DCA311 TC1					
54	Current	Bullet 1	Bullet 2	Bullet 3	Bullet 4	Ave 311 TC 1
55	0.00	8.58	7.07	kkk	9.74	8.44
56	4.79	8.66	7.14	8.48	9.89	8.54
57	10.12	9.11	7.55	8.57	9.93	8.79
58	19.99	9.51	7.95	8.83	10.24	9.13
59	24.68	9.59	8.01	8.96	10.37	9.23
60	29.85	9.74	8.14	9.06	10.50	9.36
61	34.35	9.96	8.33	9.18	10.61	9.52
62	39.16	10.14	8.50	9.38	10.82	9.71
63	44.29	10.25	8.62	9.45	10.92	9.81
64	48.35	10.43	8.79	9.63	11.10	9.99
65	44.29	10.31	8.64	9.50	10.93	9.84
66	34.35	9.83	8.18	9.13	10.55	9.42
67	24.68	9.43	7.77	8.75	10.16	9.03
68	15.02	9.00	7.39	8.56	9.91	8.72
69	4.79	8.59	7.05	8.34	9.71	8.42
70	0.00	8.22	6.69	8.29	9.66	8.22
71	0.00	0.00	0.00	0.00	0.00	0.00
72	0.00	0.00	0.00	0.00	0.00	0.00
73	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
77	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00



	BD	BE	BF	BG	BH	BI
53	0.		Bullet 1	Bullet 3	Bullet 4	
54	DSA101 TC1	Bullet 1	Bullet 3	Bullet 3	Bullet 4	Average
55	0.00	-0.25	4529.21	-1.02	-0.47	-0.58
56	4.82	-0.09	4529.66	-0.85	-0.31	-0.42
57	9.55	0.13	4529.21	-0.71	-0.17	-0.25
58	14.33	0.31	4529.66	-0.52	-0.01	-0.07
59	19.29	0.54	4530.10	-0.30	0.19	0.14
60	23.92	0.83	4530.10	-0.06	0.45	0.40
61	29.00	1.20	4530.99	0.24	0.76	0.73
62	33.31	1.46	4530.99	0.53	1.03	1.01
63	38.00	1.85	4530.55	0.78	1.40	1.34
64	43.05	2.29	4530.99	1.13	1.76	1.73
65	48.40	2.72	4530.55	1.53	2.23	2.16
66	54.07	3.26	4531.44	1.99	2.75	2.67
67	55.51	3.34	4531.44	2.14	2.92	2.80
68	38.00	1.91	4530.55	0.94	1.49	1.45
69	29.02	1.27	4530.10	0.49	0.85	0.87
70	19.31	0.60	4529.66	-0.21	0.24	0.21
71	9.56	0.00	4529.66	-0.74	-0.23	-0.33
72	0.00	-0.46	4529.21	-1.15	-0.57	-0.73
73	0.00	-0.33	4528.77	-1.07	-0.47	-0.63
74	0.00	0.00	0.00	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
77	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00



	CH	CI	CJ	CK	CL	CM
53						0.00
54	DCA313 TC1	Bullet 1	Bullet 2	Bullet 3	Bullet 4	Average
55	0.00	4486.49	7.33	8.92	5.91	7.39
56	2.47	4486.49	7.27	9.07	6.06	7.47
57	4.91	4486.49	7.67	9.32	6.25	7.75
58	5.02	4486.49	7.54	9.33	6.29	7.72
59	7.36	4486.49	7.63	9.54	6.50	7.89
60	9.83	4486.94	7.97	9.74	6.69	8.13
61	12.30	4486.49	7.98	10.02	6.93	8.31
62	14.85	4486.49	8.23	10.23	7.11	8.52
63	19.79	4486.94	8.60	10.67	7.46	8.91
64	24.46	4486.94	8.97	11.22	7.94	9.38
65	29.62	4486.94	9.45	11.73	8.34	9.84
66	34.09	4486.94	9.80	12.32	8.82	10.31
67	41.39	4487.38	10.61	13.29	9.52	11.14
68	49.42	4487.38	11.52	14.37	10.35	12.08
69	41.39	4486.94	10.72	13.48	9.66	11.28
70	34.09	4486.94	10.20	12.54	8.92	10.55
71	24.46	4486.94	9.17	11.42	8.06	9.55
72	14.85	4486.49	8.42	10.36	7.14	8.64
73	9.82	4486.49	8.04	9.73	6.61	8.13
74	4.91	4486.49	7.61	9.30	6.24	7.72
75	0.00	4486.49	7.17	8.86	5.84	7.29
76	0.00	0.00	0.00	0.00	0.00	0.00
77	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00
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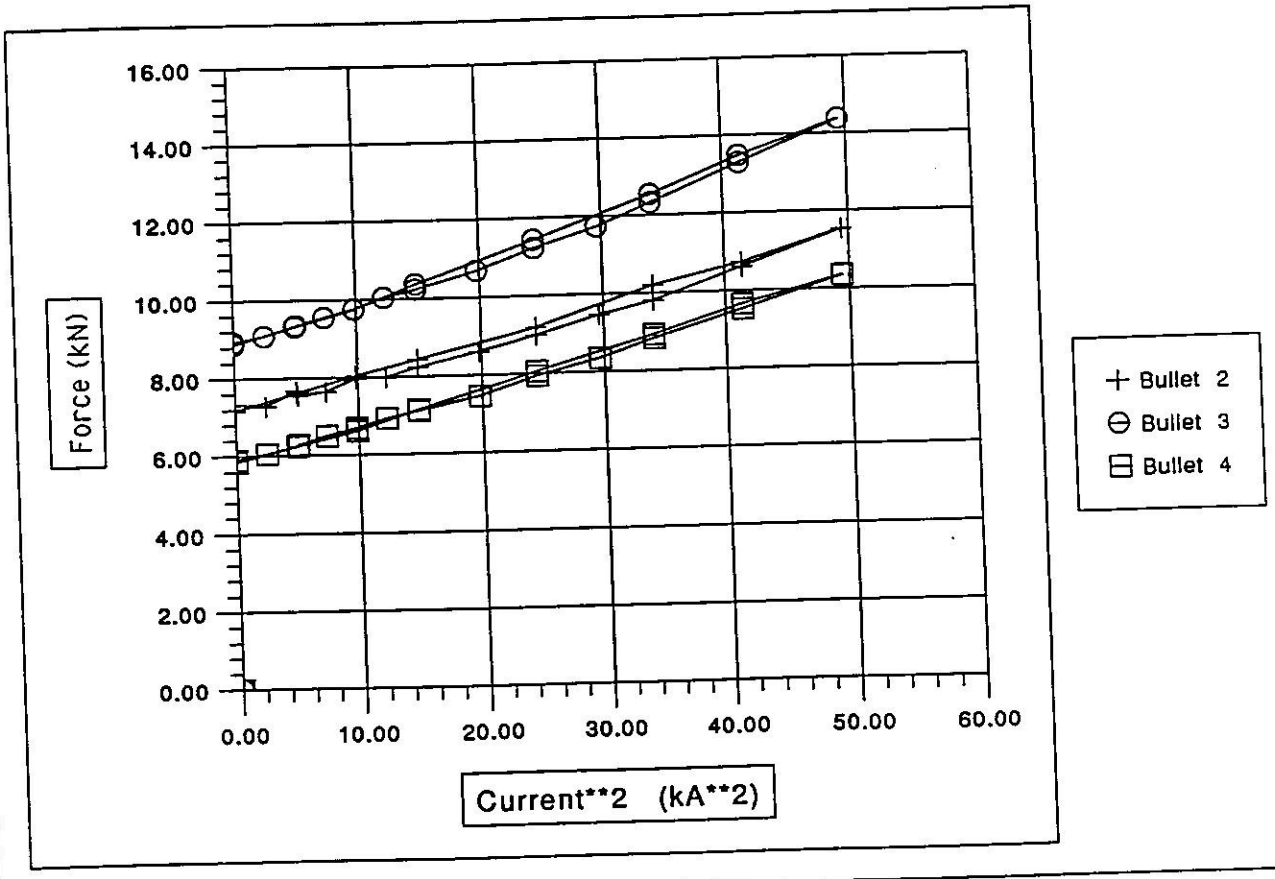
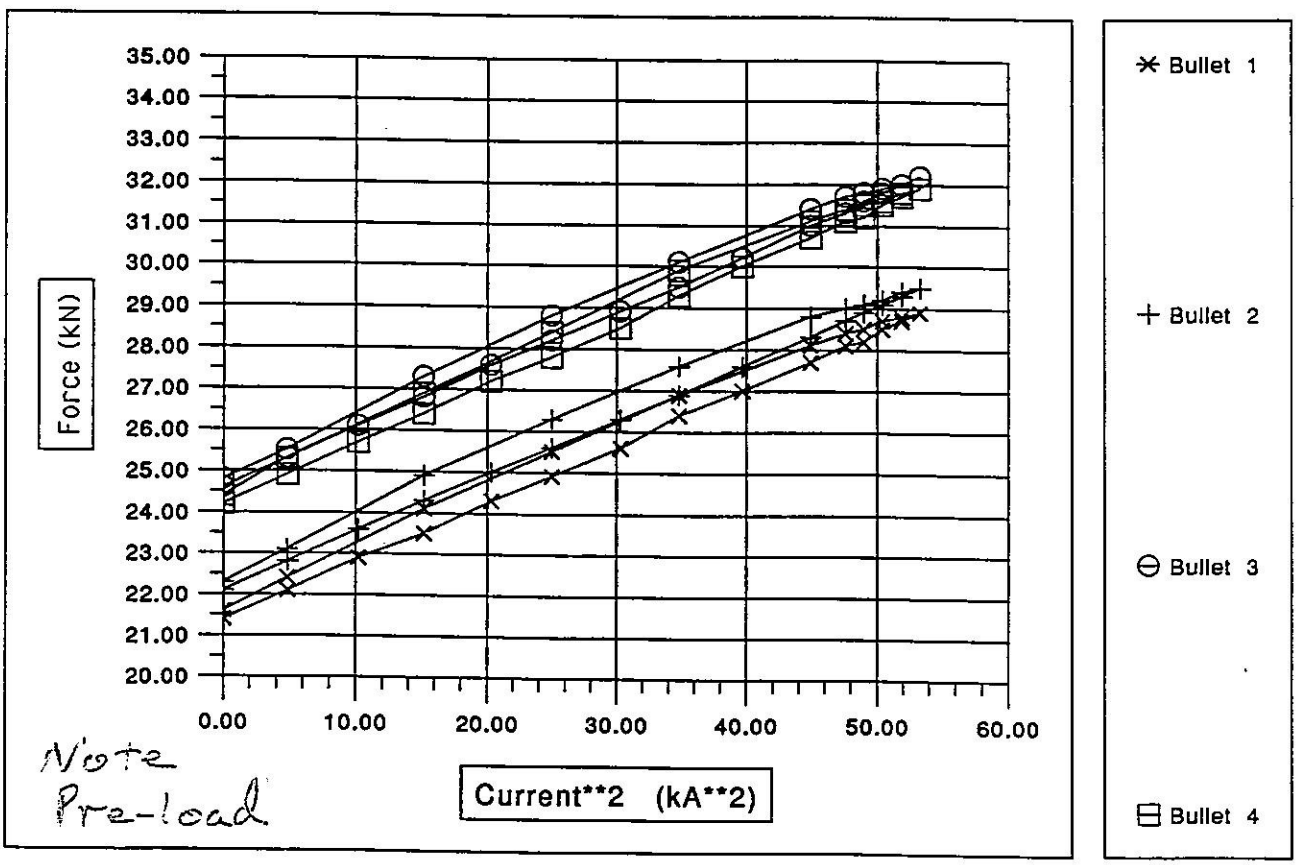


	CB	CC	CD	CE	CF	CG
53	0.					
54	DCA207	Bullet 1	Bullet 2	Bullet 3	Bullet 4	Average
55	0.00	21.40	22.10	24.60	24.20	23.08
56	4.84	22.10	22.80	25.30	24.90	23.78
57	10.20	22.90	23.60	26.10	25.70	24.58
58	15.20	23.50	24.30	26.80	26.40	25.25
59	20.30	24.30	25.00	27.60	27.20	26.03
60	25.00	24.90	25.60	28.20	27.80	26.63
61	30.30	25.60	26.30	28.90	28.50	27.33
62	34.80	26.40	26.90	29.50	29.30	28.03
63	39.70	27.00	27.60	30.20	30.00	28.70
64	44.90	27.70	28.30	31.00	30.70	29.43
65	47.60	28.10	28.70	31.30	31.10	29.80
66	49.00	28.20	28.90	31.60	31.20	29.98
67	50.40	28.50	29.10	31.80	31.50	30.23
68	51.90	28.70	29.30	32.00	31.70	30.43
69	53.30	28.90	29.50	32.20	31.90	30.63
70	51.90	28.80	29.40	32.00	31.80	30.50
71	50.40	28.70	29.20	31.90	31.60	30.35
72	49.00	28.50	29.10	31.80	31.50	30.23
73	47.60	28.40	29.00	31.70	31.40	30.13
74	44.90	28.10	28.80	31.40	31.10	29.85
75	34.80	26.90	27.60	30.10	29.90	28.63
76	25.00	25.50	26.30	28.80	28.40	27.25
77	15.20	24.10	24.90	27.30	26.90	25.80
78	4.80	22.40	23.10	25.50	25.30	24.08
79	0.00	21.60	22.30	24.80	24.40	23.28
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00



	N	O	P	Q	R	S
53	0.					
54	DCA312 TC1	Bullet 1	Bullet 2	Bullet 3	Bullet 4	Average 312 TC1
55	0.00	5.21	4.78	5.54	4.41	4.99
56	2.49	5.49	5.12	5.78	4.58	5.24
57	4.94	5.69	5.31	5.94	4.65	5.40
58	7.40	5.97	5.66	6.37	5.01	5.75
59	9.87	5.59	5.30	6.37	4.95	5.55
60	12.35	6.48	6.18	6.88	5.38	6.23
61	14.91	6.77	6.50	7.11	5.50	6.47
62	17.30	6.67	6.42	7.29	5.65	6.51
63	19.86	7.13	6.92	7.59	5.86	6.87
64	24.53	7.35	7.17	8.04	6.21	7.19
65	29.70	8.05	7.85	8.52	6.57	7.75
66	34.18	8.42	8.27	9.11	7.04	8.21
67	41.50	9.22	9.12	9.90	7.62	8.96
68	44.11	9.31	9.23	10.33	8.00	9.22
69	49.52	10.05	10.03	10.89	8.40	9.84
70	41.49	9.27	9.17	10.13	7.81	9.10
71	29.70	8.00	7.79	8.69	6.67	7.79
72	19.86	7.06	6.78	7.55	5.78	6.79
73	14.91	6.62	6.32	7.14	5.50	6.40
74	9.87	6.25	5.90	6.53	5.09	5.94
75	4.94	5.62	5.28	5.98	4.65	5.38
76	0.00	5.36	4.92	5.55	4.42	5.06
77	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
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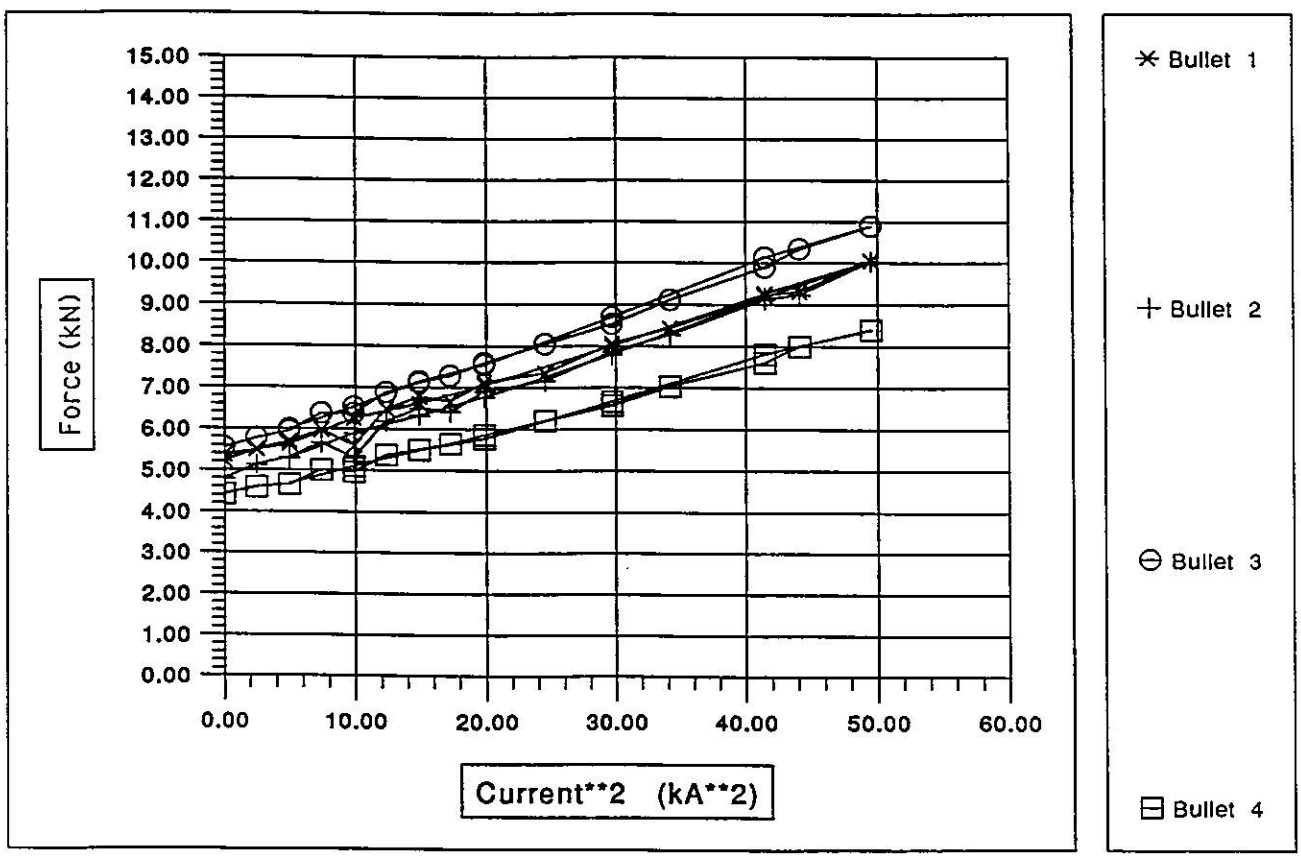
84	0.00	0.00	0.00	0.00	0.00	0.00



	CN	CO	CP	CQ	CR	CS
53						
54	DSA209	Bullet 1	Bullet 2	Bullet 3	Bullet 4	Average
55	0.00	1.18	1.17	0.39	4.28	1.95
56	0.25	0.93	1.11	0.35	3.99	1.82
57	1.00	1.05	1.18	0.30	4.24	1.91
58	2.25	1.02	1.50	0.57	4.12	2.06
59	4.00	1.17	1.60	0.57	4.15	2.11
60	6.25	1.15	1.59	0.82	4.25	2.22
61	9.01	1.31	1.54	0.76	4.45	2.25
62	12.26	1.51	1.90	1.06	4.60	2.52
63	16.01	1.71	2.14	1.49	5.10	2.91
64	20.27	2.08	2.72	2.09	5.67	3.49
65	25.02	2.38	2.93	2.44	6.13	3.83
66	30.27	2.76	3.25	3.06	6.42	4.24
67	36.03	3.56	4.17	3.74	7.11	5.01
68	42.28	4.21	4.89	4.35	7.49	5.57
69	49.04	4.92	5.42	4.86	8.28	6.19
70	56.30	5.93	6.36	5.50	9.06	6.97
71	64.05	6.68	7.47	6.57	9.60	7.88
72	65.66	7.00	7.55	6.66	10.05	8.09
73	67.29	7.15	7.93	6.86	9.81	8.20
74	68.95	7.27	7.94	6.93	9.85	8.24
75	70.61	7.51	8.16	7.07	10.26	8.50
76	72.30	7.83	8.24	7.26	10.51	8.67
77	74.02	7.81	8.76	7.45	10.47	8.89
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00
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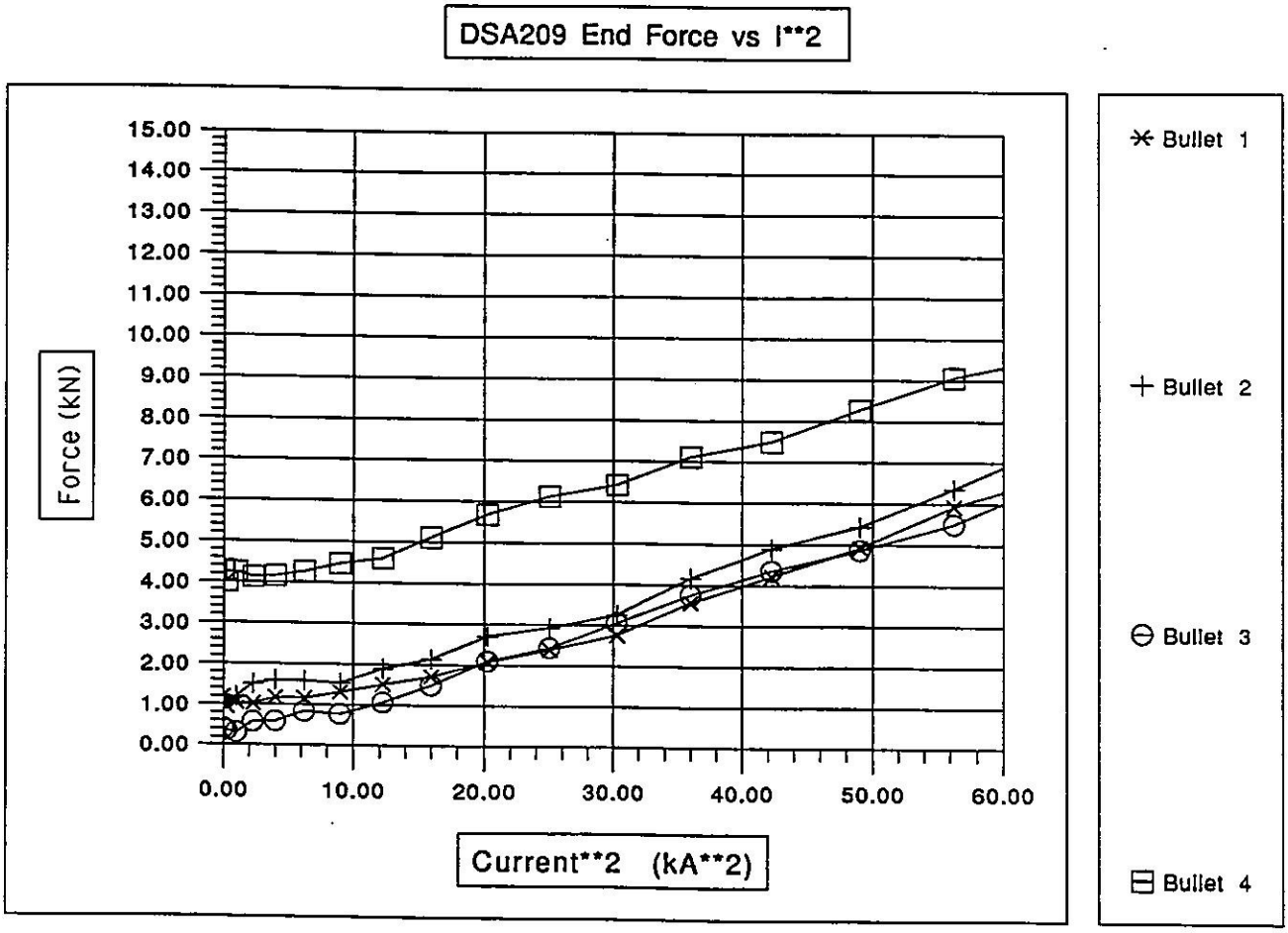
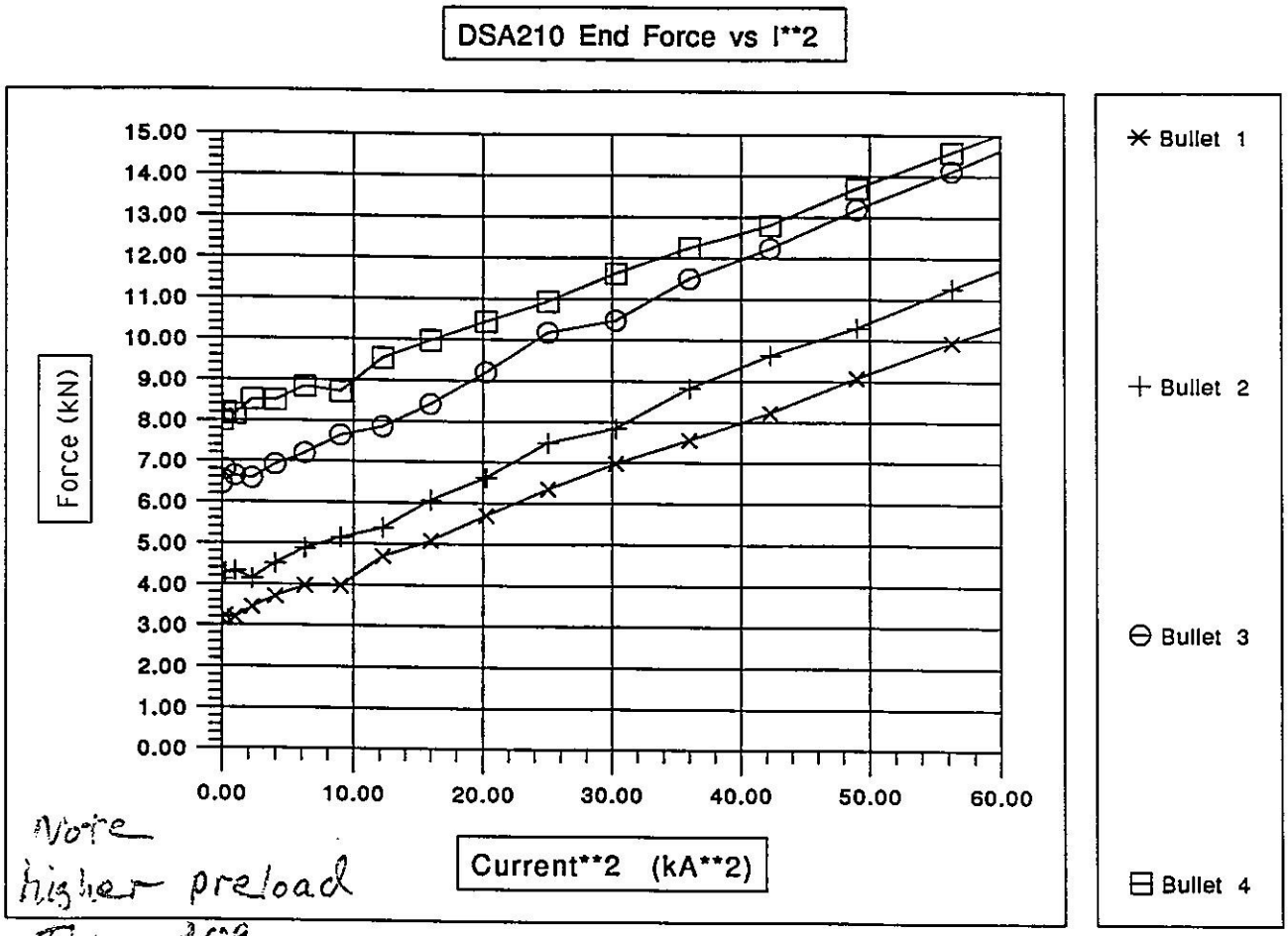


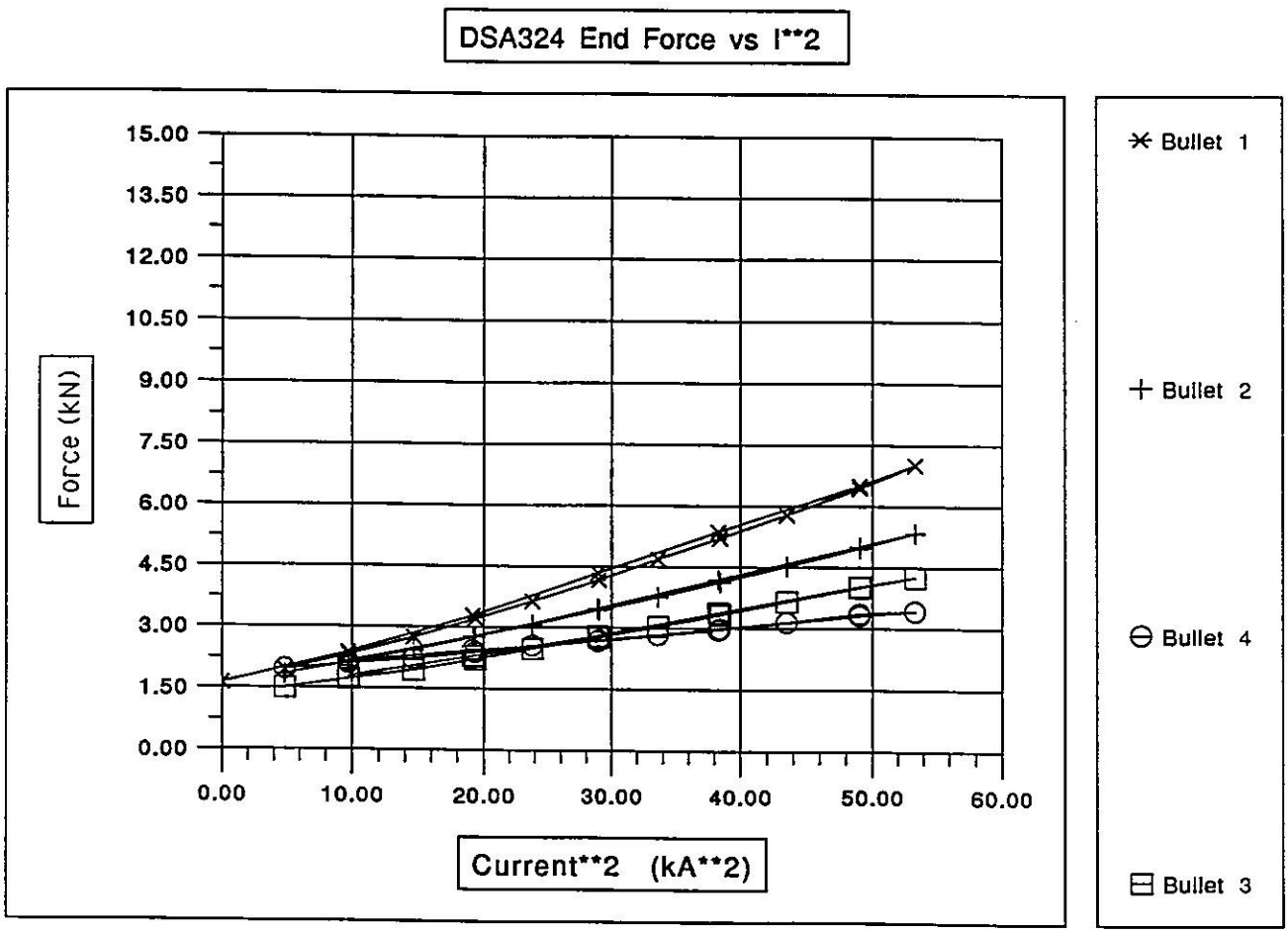
Both DSA209 + DSA210 unloaded azimuthally

	CT	CU	CV	CW	CX	CY
53						
54	DSA210	Bullet 1	Bullet 2	Bullet 3	Bullet 4	Average
55	0.00	3.14	4.12	6.43	8.00	6.22
56	0.25	3.23	4.26	6.79	8.19	6.41
57	1.00	3.19	4.31	6.63	8.15	6.37
58	2.25	3.44	4.14	6.58	8.51	6.41
59	4.00	3.70	4.51	6.92	8.50	6.64
60	6.25	3.96	4.88	7.20	8.82	6.97
61	9.01	3.97	5.14	7.64	8.71	7.16
62	12.26	4.69	5.39	7.85	9.54	7.59
63	16.01	5.07	6.06	8.41	9.97	8.15
64	20.27	5.70	6.62	9.19	10.44	8.75
65	25.02	6.34	7.49	10.17	10.94	9.53
66	30.27	6.97	7.84	10.47	11.61	9.97
67	36.03	7.57	8.82	11.50	12.24	10.85
68	42.28	8.23	9.63	12.23	12.80	11.55
69	49.04	9.08	10.30	13.19	13.70	12.40
70	56.29	9.94	11.26	14.11	14.58	13.32
71	64.05	10.78	12.22	15.19	15.50	14.30
72	65.66	10.79	12.65	15.62	15.45	14.57
73	67.29	11.01	12.87	15.82	15.70	14.80
74	68.95	11.14	13.16	16.10	15.76	15.01
75	70.62	11.40	13.37	16.53	16.27	15.39
76	72.31	11.81	13.44	16.46	16.62	15.51
77	74.02	11.83	13.87	16.76	16.69	15.77
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00



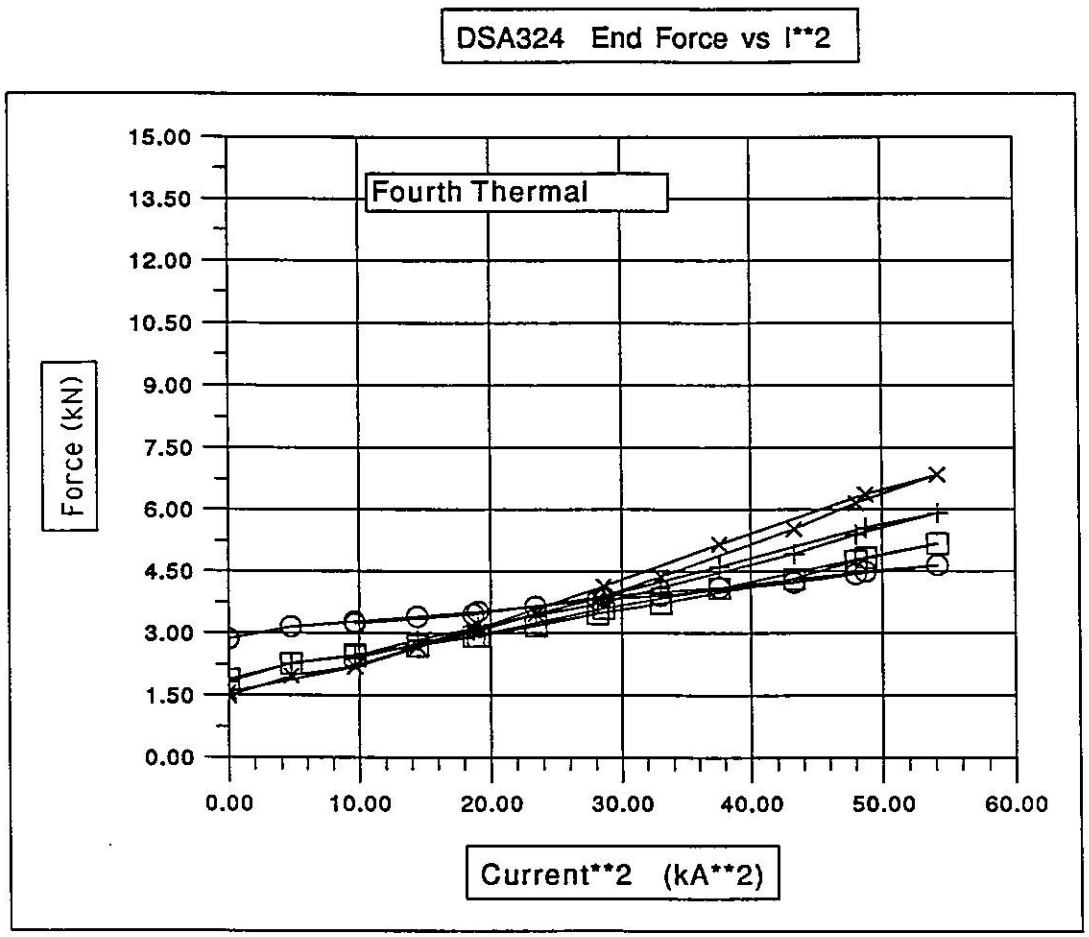
Note
higher preload
Than 209

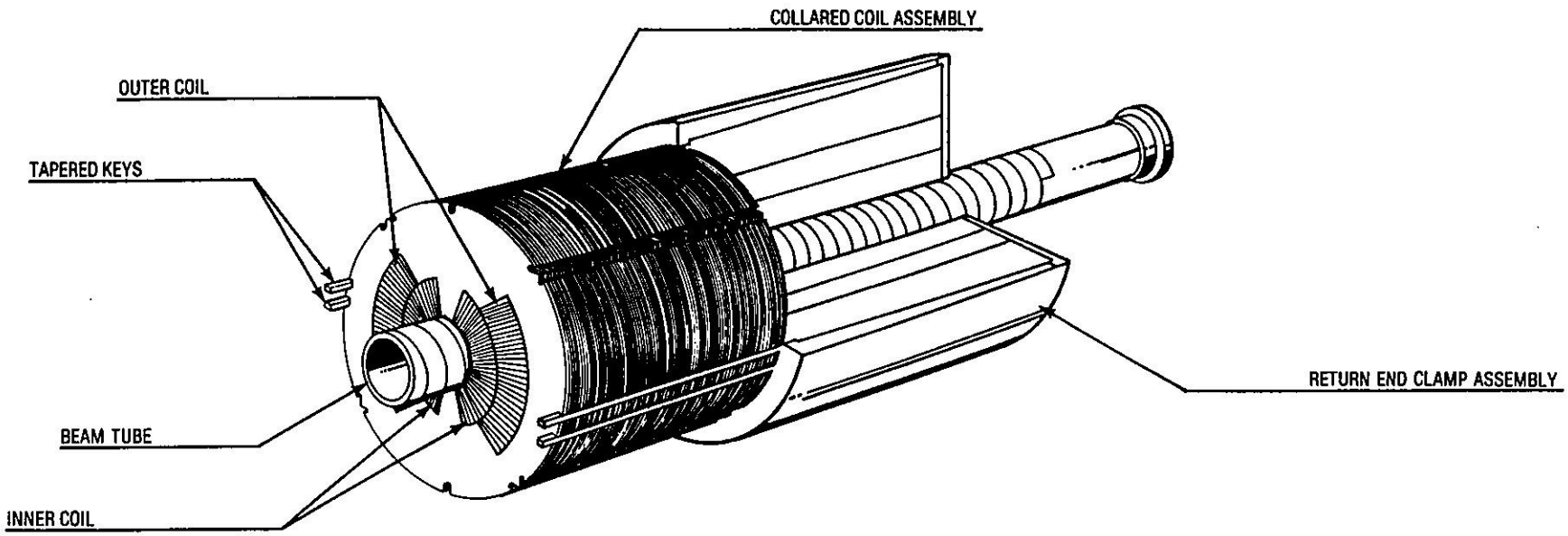
	T	U	V	W	X	Y
53	0.					
54	DSA324 TC1	Bullet 1	Bullet 2	Bullet 4	Bullet 3	Average
55	4.84	1.93	1.83	1.96	1.50	1.81
56	9.73	2.31	2.12	2.09	1.72	2.06
57	14.66	2.74	2.43	2.23	1.94	2.33
58	19.37	3.21	2.77	2.38	2.22	2.65
59	23.76	3.64	3.07	2.55	2.48	2.94
60	28.99	4.17	3.43	2.69	2.76	3.26
61	33.62	4.68	3.76	2.83	3.04	3.58
62	38.45	5.19	4.13	2.98	3.32	3.91
63	43.51	5.77	4.51	3.14	3.65	4.27
64	49.03	6.44	4.97	3.36	4.01	4.70
65	53.35	7.00	5.34	3.43	4.26	5.00
66	49.03	6.50	5.00	3.31	4.03	4.71
67	38.32	5.35	4.19	2.96	3.37	3.97
68	28.91	4.33	3.47	2.67	2.80	3.32
69	19.17	3.28	2.78	2.43	2.30	2.70
70	9.69	2.38	2.16	2.13	1.78	2.11
71	0.00	1.61	1.63	1.87	1.34	1.61
72	0.00	0.00	0.00	0.00	0.00	0.00
73	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
77	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00

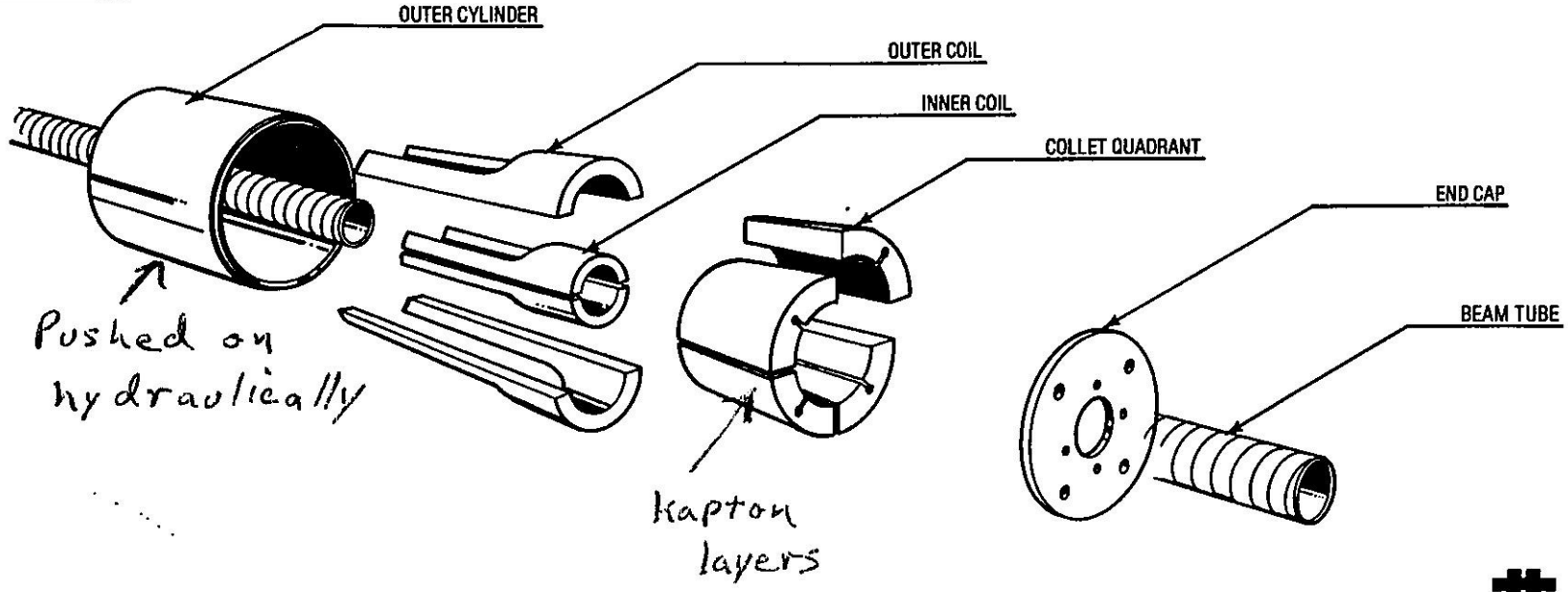


Note variation in individual Bullets

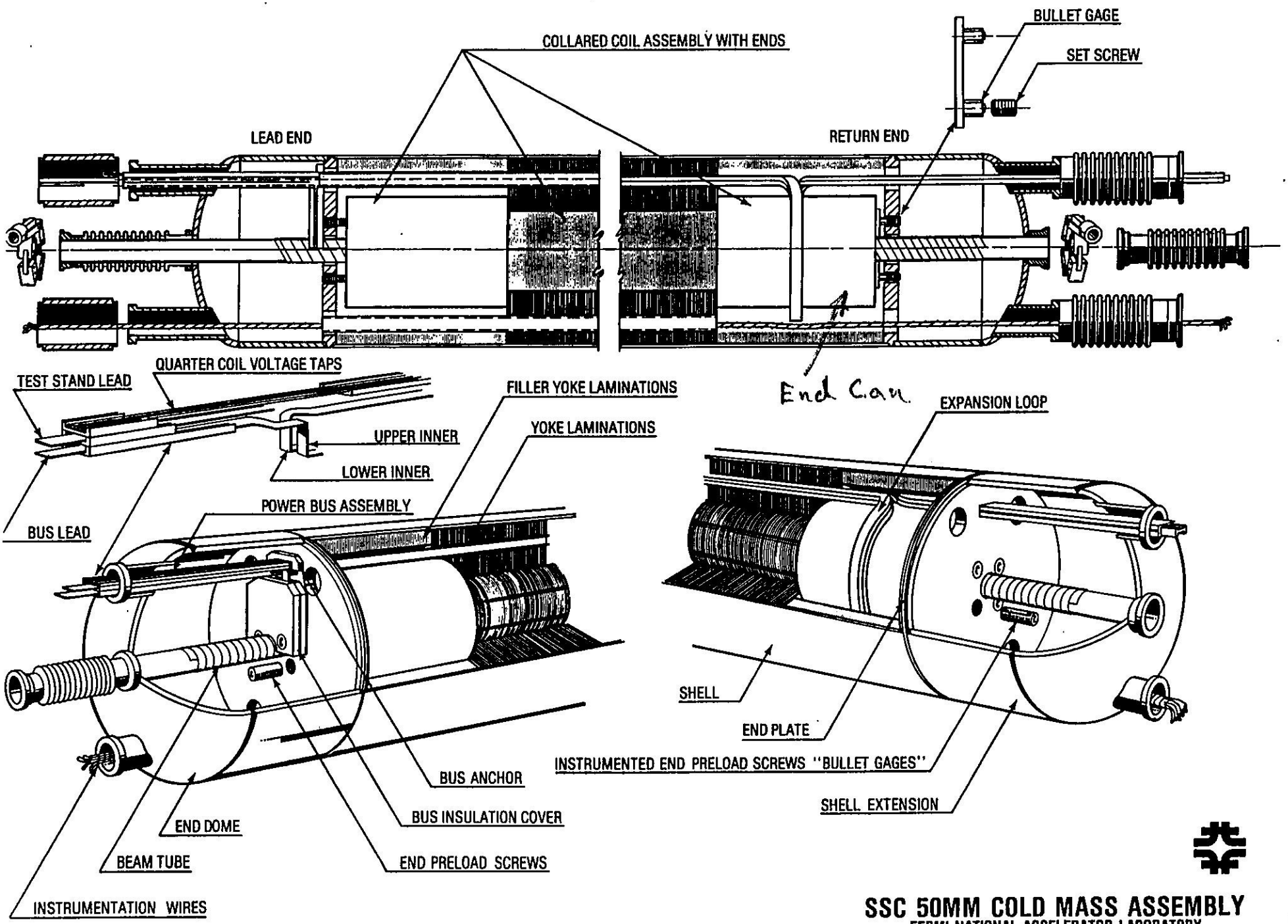
	AL	AM	AN	AO	AP	AQ
53	0.					
54	DSA324 TC4	Bullet 1	Bullet 2	Bullet 4	Bullet 3	Average
55	0.00	1.48	1.82	2.84	1.88	2.00
56	4.78	1.97	2.28	3.15	2.26	2.42
57	9.62	2.19	2.44	3.26	2.48	2.59
58	14.46	2.69	2.83	3.39	2.70	2.90
59	19.05	3.06	3.14	3.52	2.93	3.16
60	23.44	3.45	3.43	3.64	3.18	3.42
61	28.16	3.85	3.69	3.81	3.47	3.70
62	33.04	4.37	4.10	3.91	3.71	4.02
63	43.34	5.52	4.92	4.23	4.32	4.75
64	48.03	6.14	5.39	4.42	4.75	5.18
65	54.19	6.84	5.90	4.64	5.17	5.64
66	48.77	6.36	5.55	4.48	4.83	5.30
67	37.58	5.15	4.61	4.11	4.08	4.49
68	28.59	4.14	3.88	3.88	3.59	3.87
69	18.72	3.07	3.06	3.46	2.93	3.13
70	9.68	2.19	2.38	3.22	2.46	2.56
71	0.00	1.57	1.90		1.97	1.81
72	0.00	0.00	0.00	0.00	0.00	0.00
73	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
77	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
79	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
81	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
83	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00







SSC 50MM COLLARED COIL RETURN END ASSEMBLY
FERMI NATIONAL ACCELERATOR LABORATORY



SSC 50MM COLD MASS ASSEMBLY
FERMI NATIONAL ACCELERATOR LABORATORY

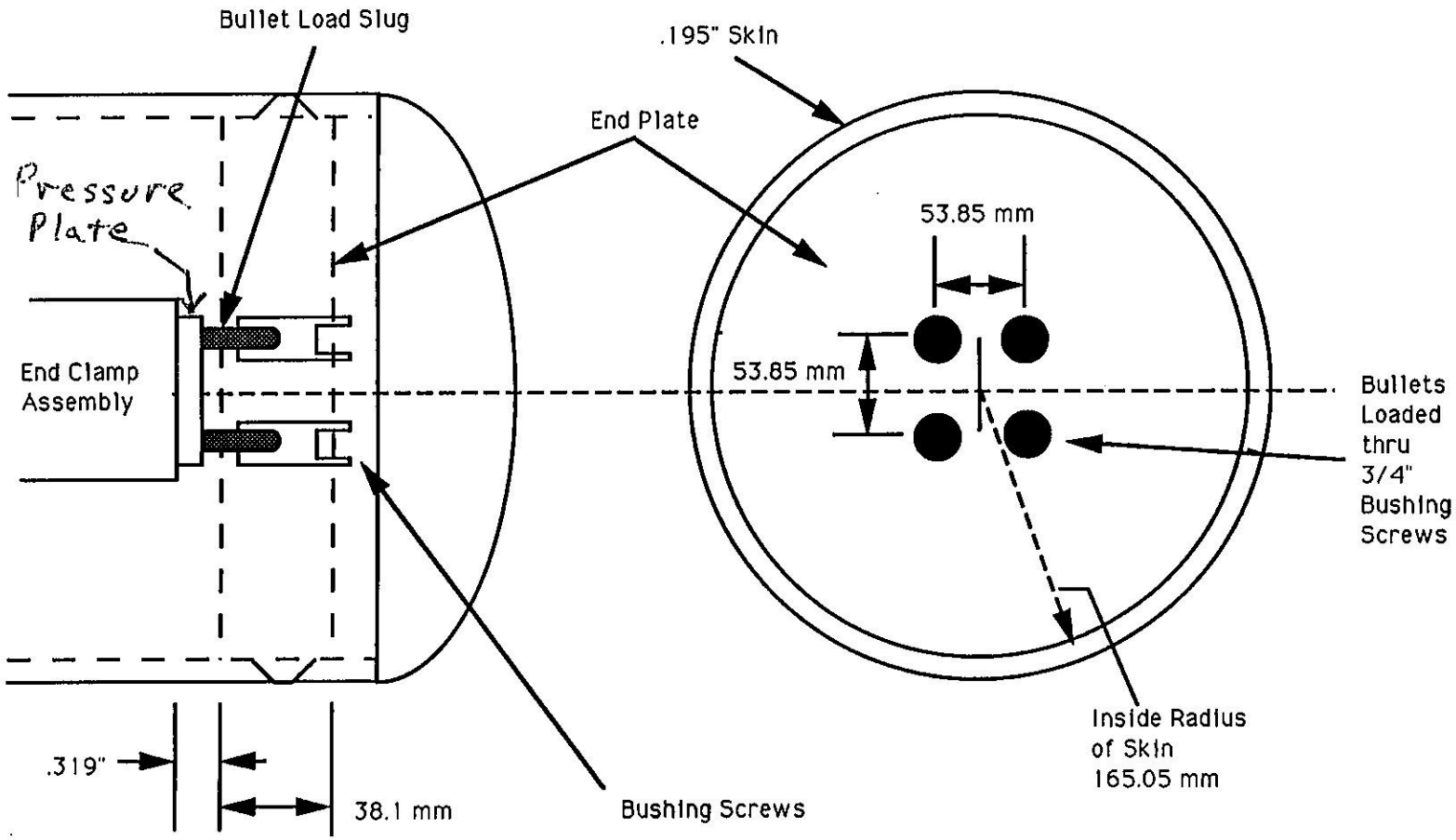
Bullet Gage Assembly Sketch

50 mm SSC Collider Dipole

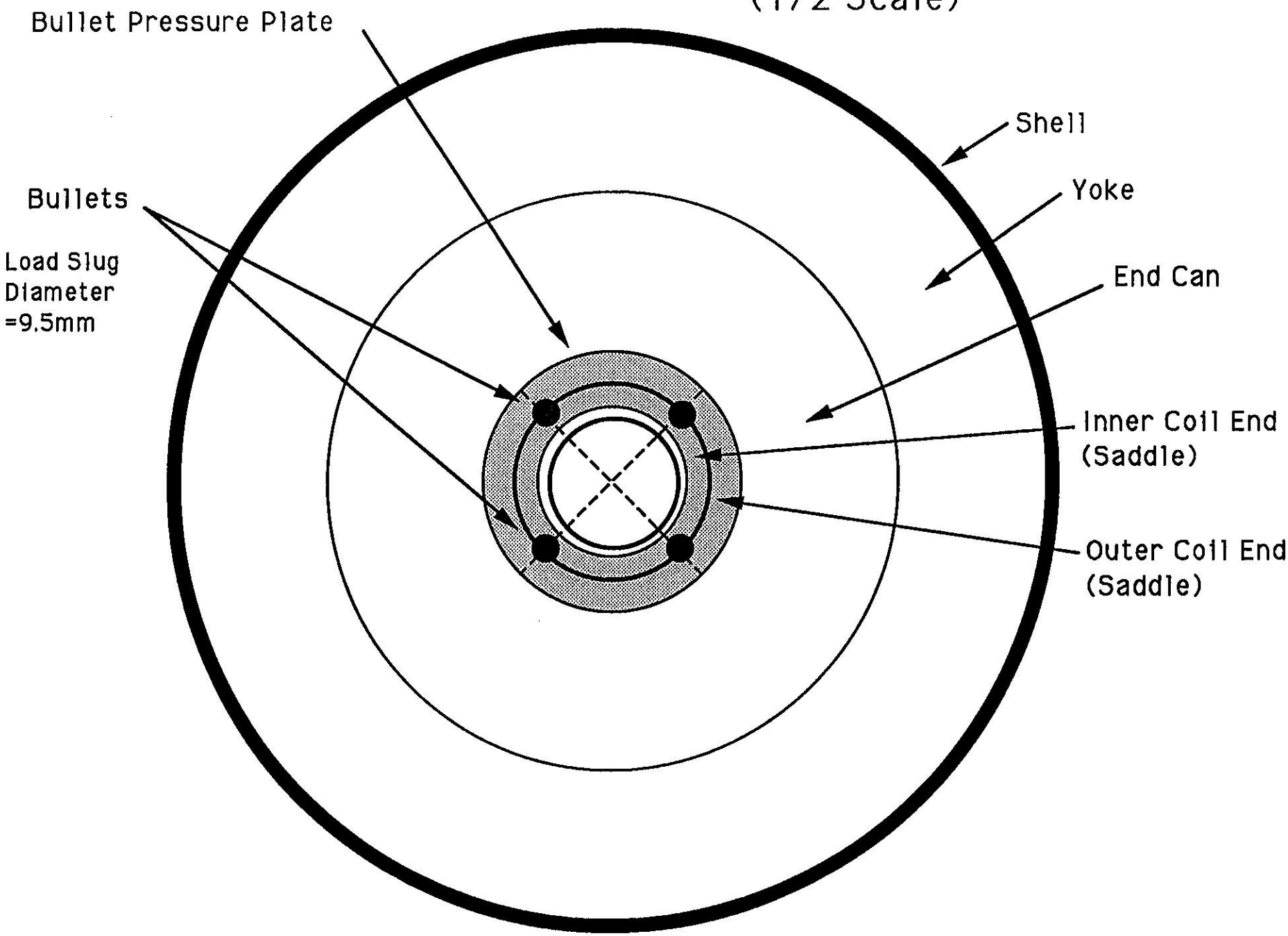
Not to Scale

Modified 1/16/91

Wayne Koska
11-19-90



Bullet Load Slug Location Relative to Coil Ends
(1/2 Scale)



Tariq Jaffery
TS-SSC 91-175

DSA324 QUENCH HISTORY

Model Magnet

Poor quench behavior on removal of end pre-load also observed on BNL magnets

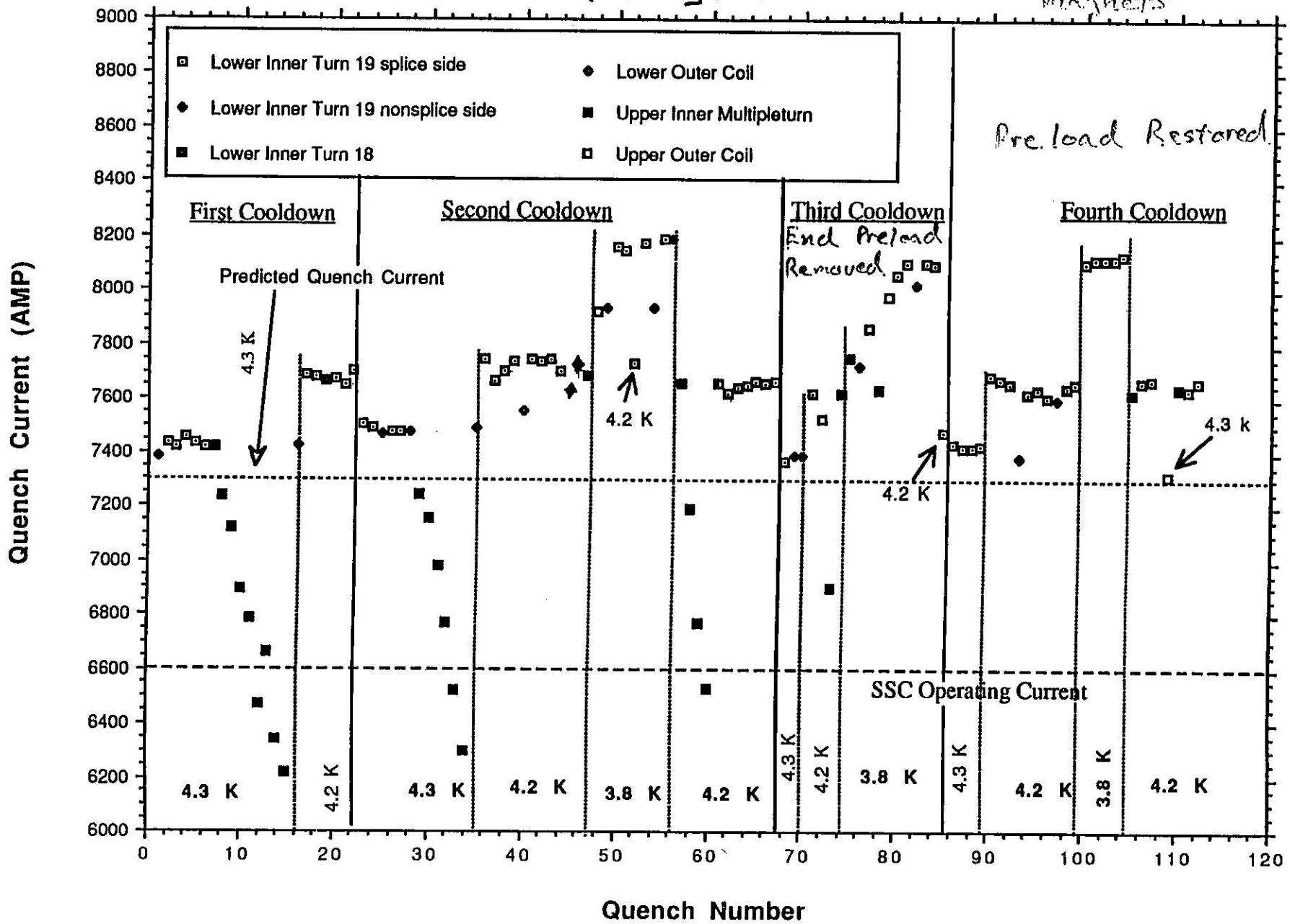


Figure 1

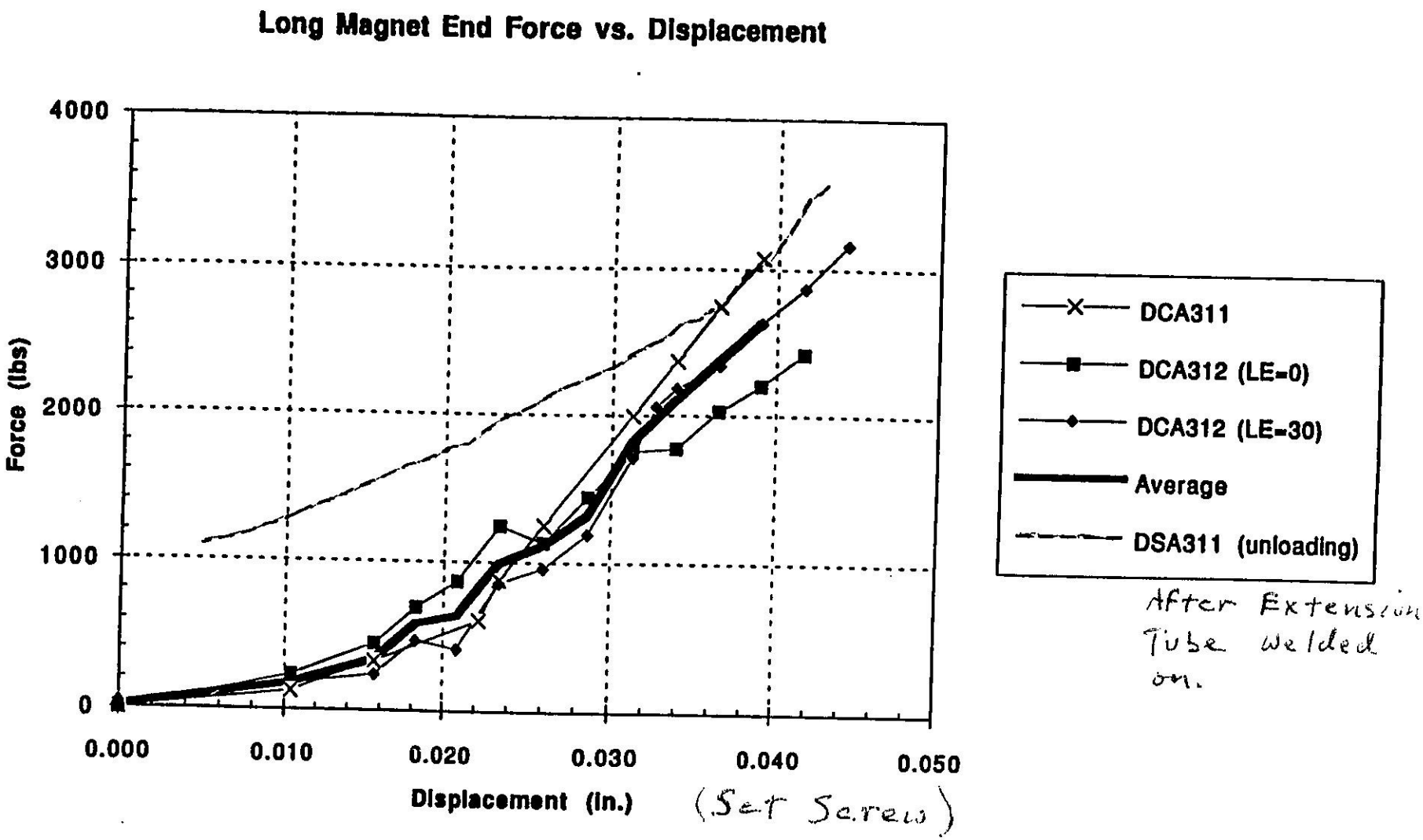
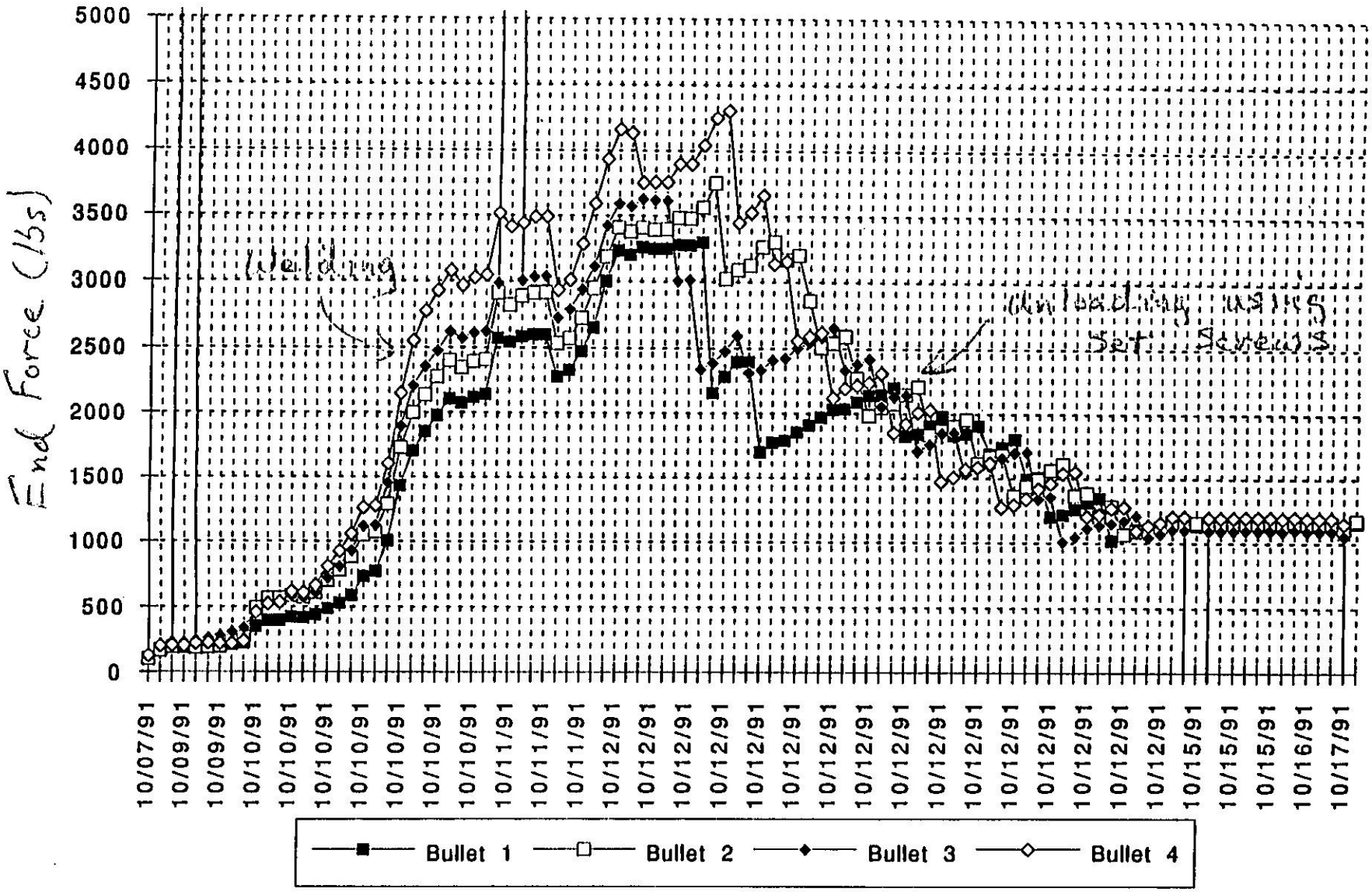


Figure 5

TS-SSC 91-198

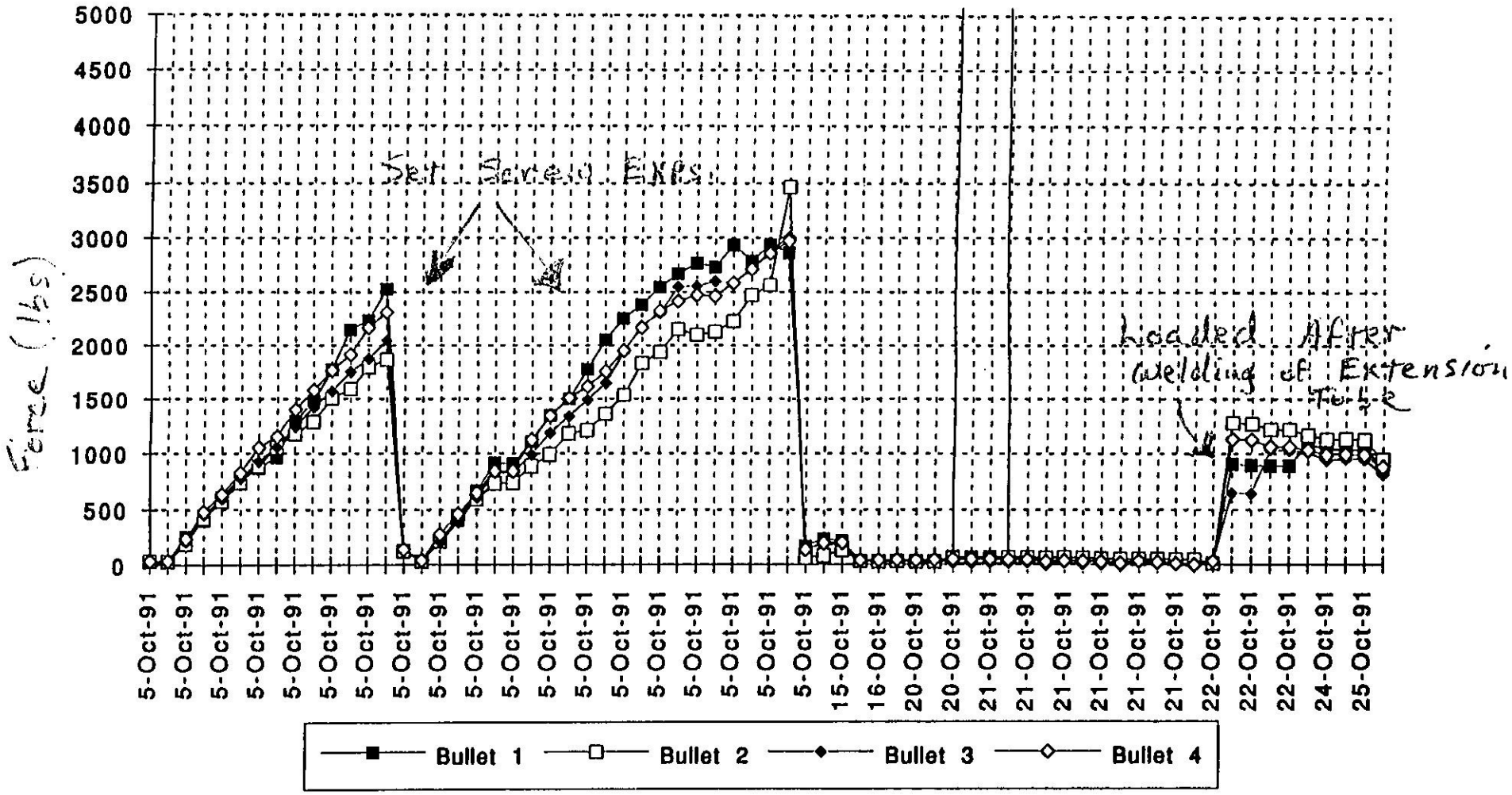
J. Strait

DCA 311 End Force Plot



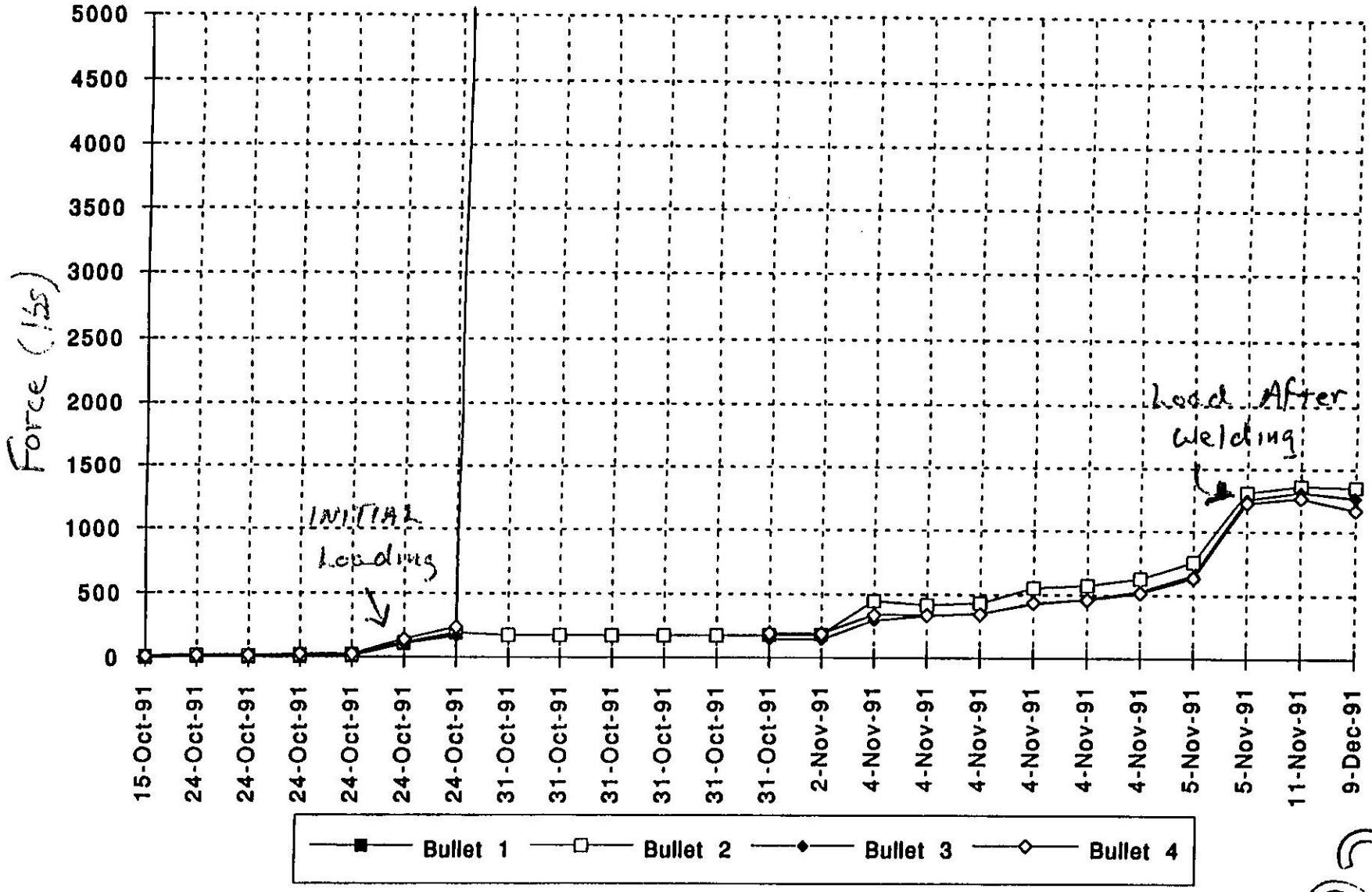
T. Skweres 11/7/91

DCA 312 End Force Plot



T. Skweres 11/18/91

DCA 313 End Force Plot

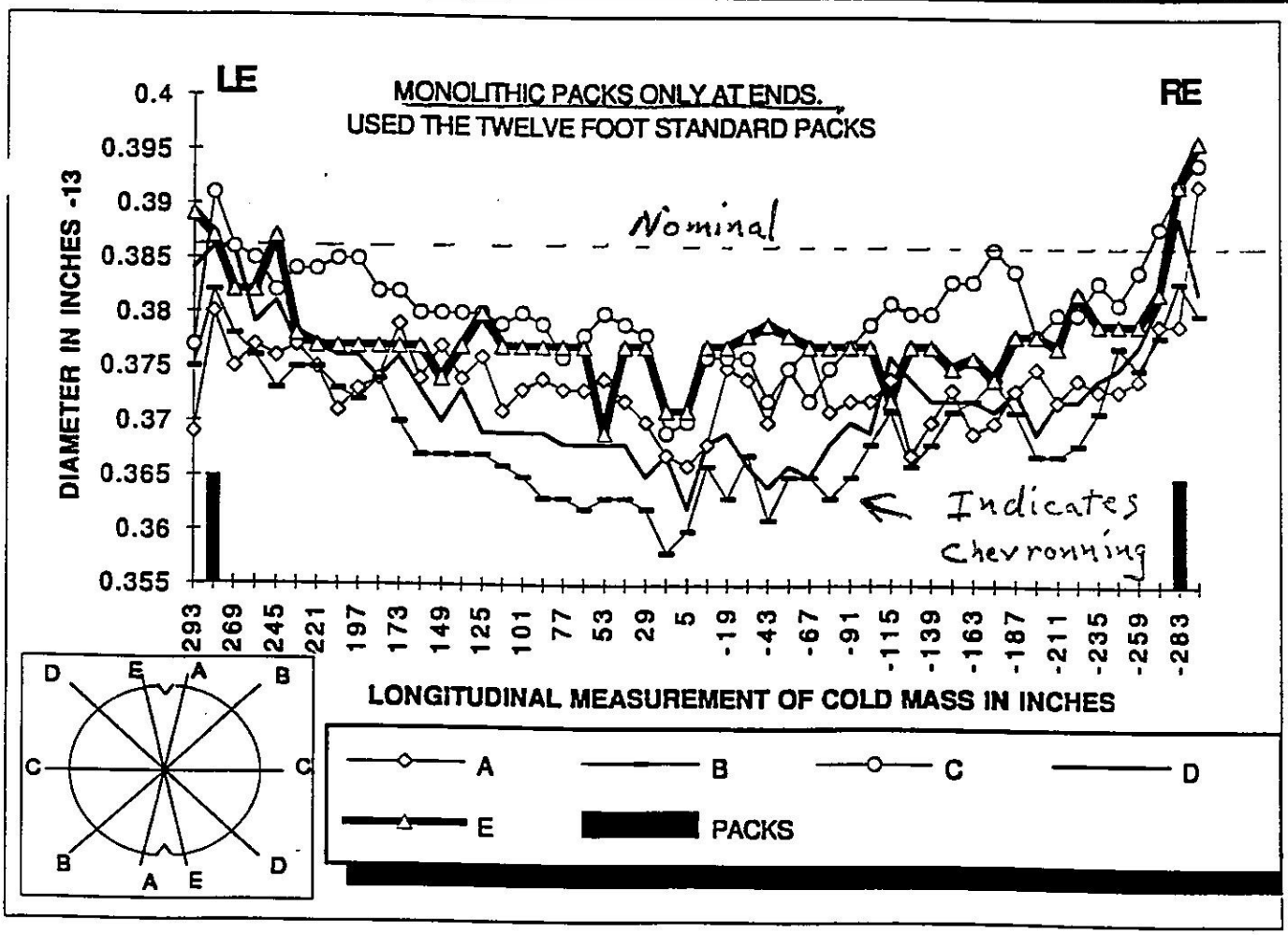


Packing Factor
98%

DIAMETRAL DATA DCA 311

RC ARNOLD 11/11/91

	A	B	C	D	E
IDEAL SIZE 13.386 INCHES	OFFSET 0.0124	OFFSET 0.0168	OFFSET 0.0055	OFFSET 0.0133	OFFSET 0.0076
POSITION FROM THE COLD MASS CENTERLINE IN INCHES	AVERAGE 13.3736	AVERAGE 13.3692	AVERAGE 13.3805	AVERAGE 13.3727	AVERAGE 13.3784
	STD DEVIATION 0.00414	STD DEVIATION 0.00593	STD DEVIATION 0.00507	STD DEVIATION 0.00606	STD DEVIATION 0.00485
-199	13.375	13.367	13.378	13.369	13.378
-211	13.372	13.367	13.38	13.372	13.377
-223	13.374	13.368	13.38	13.372	13.382
-235	13.373	13.371	13.383	13.374	13.379
-247	13.373	13.377	13.381	13.375	13.379
-259	13.374	13.375	13.384	13.377	13.379
-271	13.379	13.378	13.388	13.381	13.382
-283	13.379	13.383	13.392	13.389	13.392
-295	13.392	13.38	13.394	13.382	13.396

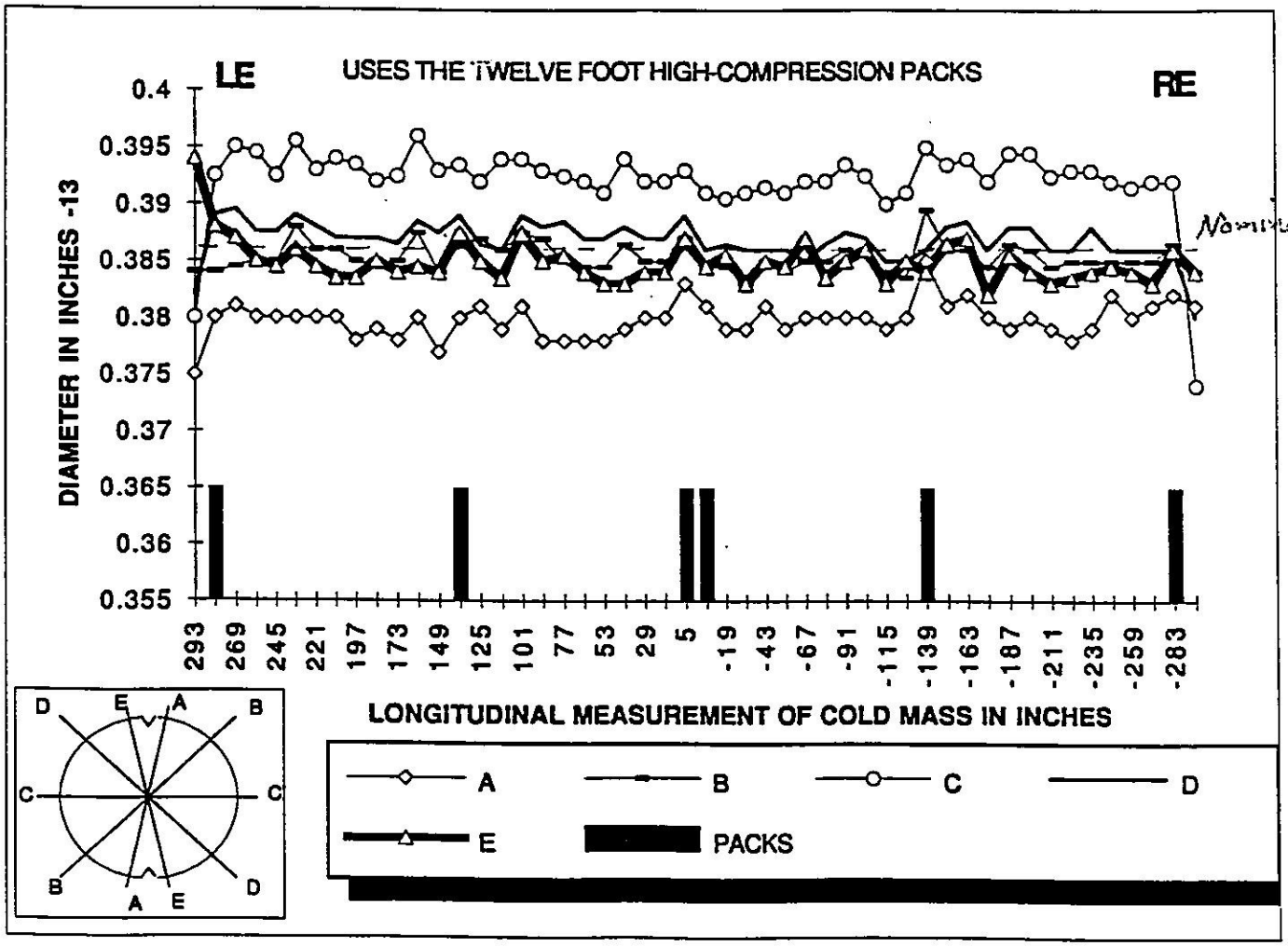


Packing Factor 99%

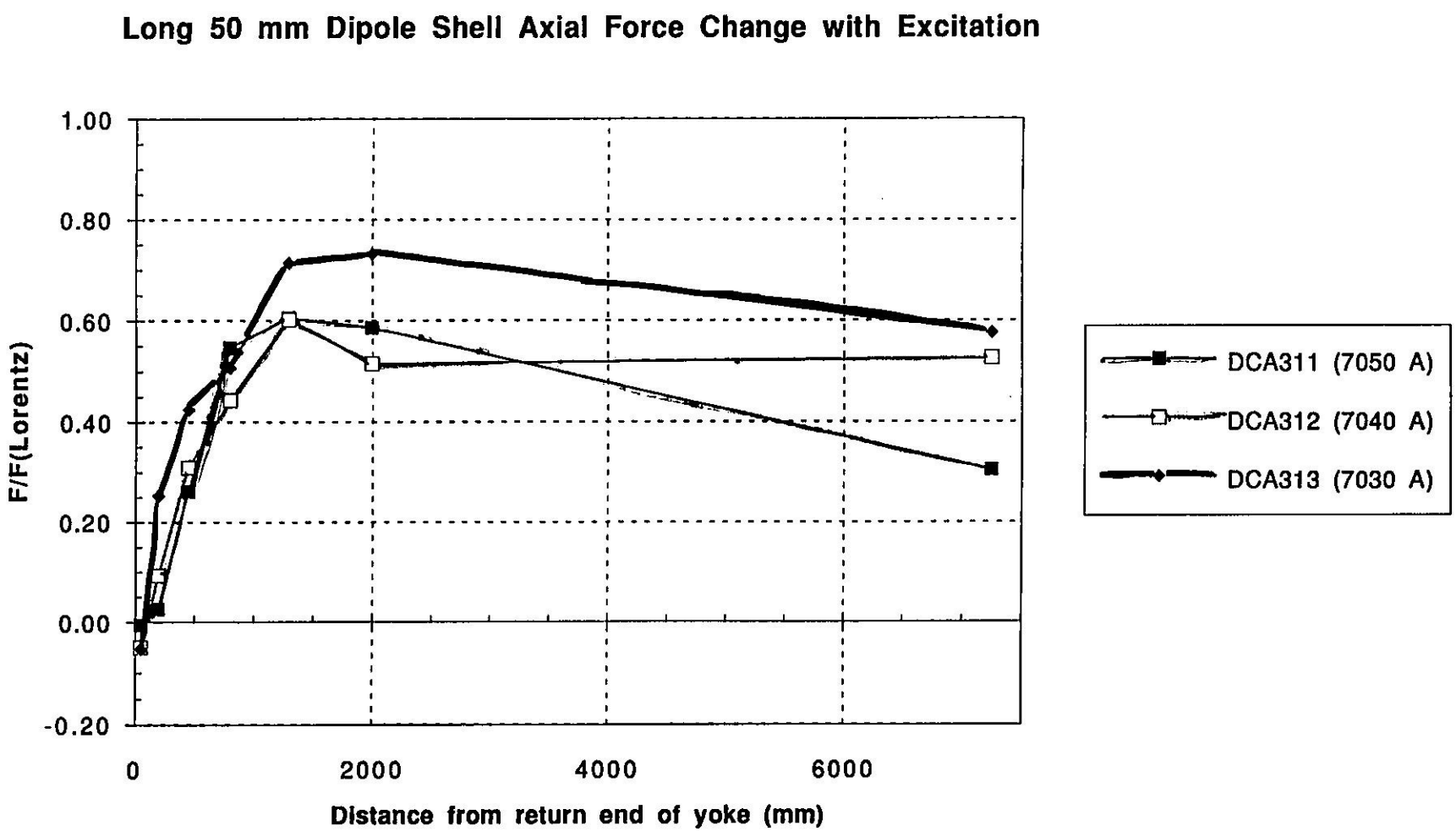
DIAMETRAL DATA DCA 312

RC ARNOLD **11/11/91**

	A	B	C	D	E
IDEAL SIZE 13.386 INCHES	OFFSET 0.0062	OFFSET 0.0006	OFFSET -0.0061	OFFSET -0.0009	OFFSET 0.0011
POSITION FROM THE COLD MASS CENTERLINE IN INCHES	AVERAGE 13.3798	AVERAGE 13.3854	AVERAGE 13.3921	AVERAGE 13.3869	AVERAGE 13.3849
	STD DEVIATION 0.00159	STD DEVIATION 0.00126	STD DEVIATION 0.00344	STD DEVIATION 0.00169	STD DEVIATION 0.00192
-199	13.38	13.386	13.3945	13.388	13.384
-211	13.379	13.3845	13.3925	13.386	13.383
-223	13.378	13.385	13.393	13.386	13.3835
-235	13.379	13.385	13.393	13.388	13.384
-247	13.382	13.385	13.392	13.386	13.3845
-259	13.38	13.385	13.3915	13.386	13.384
-271	13.381	13.385	13.392	13.386	13.383
-283	13.382	13.3865	13.392	13.386	13.386
-295	13.381	13.384	13.374	13.38	13.384

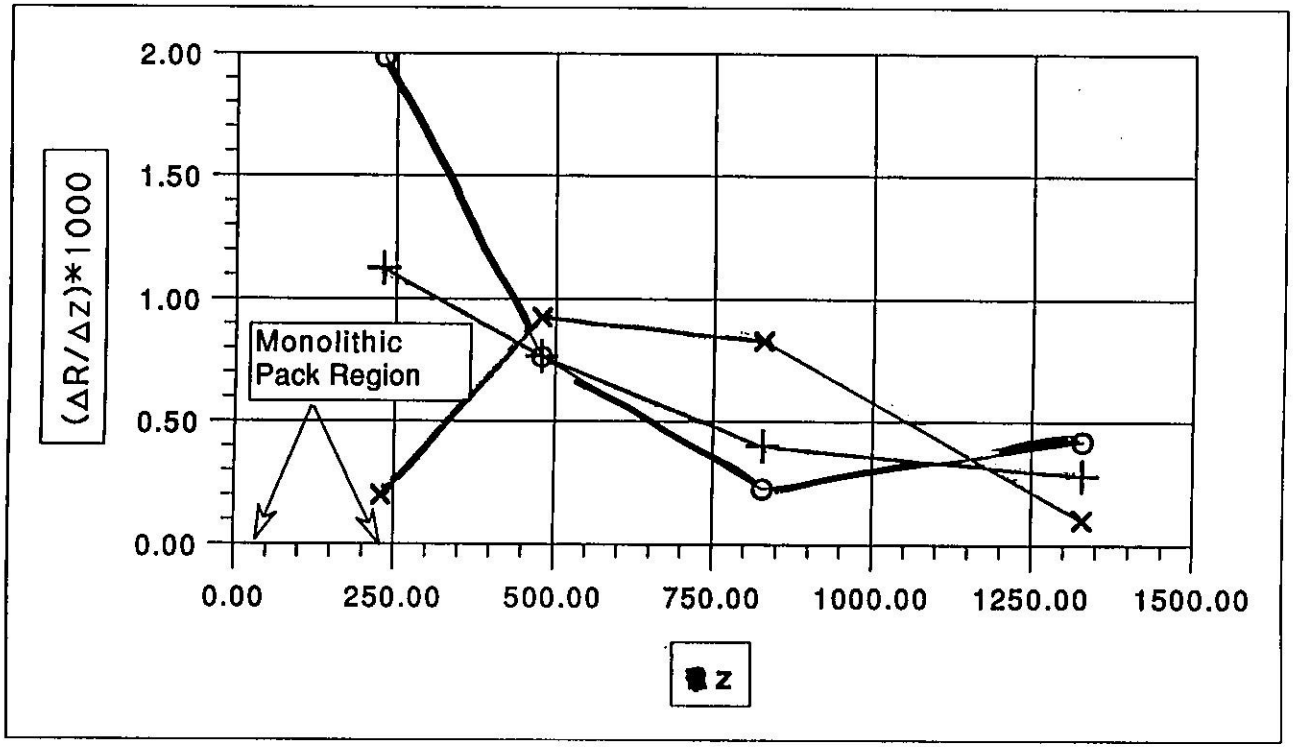


I. Strait


Long 50 mm Dipole Shell Axial Force Change with Excitation
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
F/F(Lorentz)
0
2000
4000
6000
Distance from return end of yoke (mm)
DCA311 (7050 A)
DCA312 (7040 A)
DCA313 (7030 A)

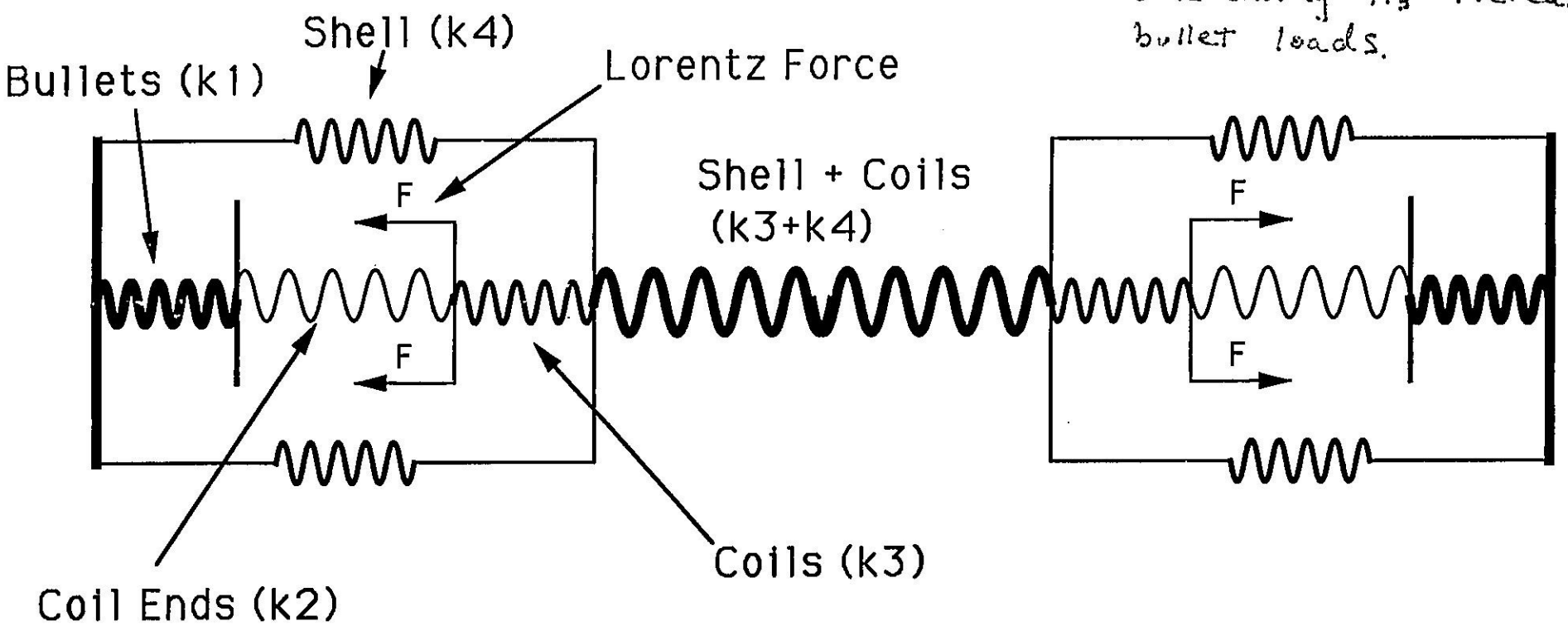
	O	P	Q	R	S	T	U
1	Position from Beginning	DCA311	DCA312	DCA313			
2	of Yoke (mm)	(ΔR/Δz)*10(	(ΔR/Δz)*1000	(ΔR/Δz)*1000			
3	78.99						
4	230.12	0.20	1.12	1.99			
5	479.04	0.92	0.76	0.76			
6	829.06	0.83	0.40	0.23			
7	1328.93	0.10	0.28	0.42			
8	2028.44	-0.01	-0.14	0.01			
9							
10							

Preliminary



Factor of 4 change in k_2 produces observed change in bullet loads.

Decreasing k_3 increases bullet loads.



Very Simple Spring Model of Coil End Axial Mechanics

Conclusions:

1) Variations in average forces measured by bullet gauges in Fermilab long magnets may be due to differences in bullet loading and/or the chevronning of yoke packs in DCA311.

2) Variations in measured average forces between Fermilab long magnets and Brookhaven long magnets may be due to differences in end pre-loading and/or shell clamping of vertical versus horizontal yokes

3) Variations in bullet measurements of Fermilab short magnets may be due to uneven axial support.