April 9, 1990

MEMO TO: R. Bossert, J. Carson, W. Koska, P. Mantsch, G. Pewitt,

FROM: J. Strait

SUBJECT: Preliminary Analysis of DS0309 Collaring Data

DS0309 was collared on April 5, 1990. It contains no Teflon slip planes in the ground insulation system. No radial shims were used between the collars and the tooling but a 10 mil shim was used between the upper collaring mold piece and the press platen. If the collars were of the same radius as the tooling, no shims were used and no deflection or compression of any parts occurred, then with the press fully closed the collar key slots should just line up for a zero clearance, zero interference key insertion. The collars are actually three mills smaller in radius than the tooling - two by design and one due to an error in the die and a 10 mil vertical shim is used. Thus there is a nominal four mil clearance if the press is fully closed.

The vertical press hydraulic pressure was increased to 9000 psi with strain gage and press gap data taken at 1000 psi increments. The keys were inserted with 1000 psi horizontal hydraulic pressure. Vertical and horizontal pressures were then reduced to 4000 psi and 400 psi respectively and then to zero. I have not seen the gap data but I believe that the press was closed at the ends and a few mils open at the center. Thus there may have been minimal clearance and possible small interference, due to component deflections, for key insertion toward the center.

Table I (6 pages) gives the strain gage data for the complete collaring sequence. Figure 1 is a plot of apparent coil stress verses press hydraulic pressure before key insertion. Unlike the data from previous magnets, the slope increases with increasing load. This is the opposite of what is expected - as contact is made between the upper press platen and the lower tooling, less of the press load should appear in the coil. This behavior suggests to me that the strain gage data are "wrong". Either a) the calibrations are wrong or b) too small a shim is used at the load cell so the coil fully contacts the beam only after it is sufficiently loaded to deform against the beam.

Among the virtues claimed for the beam-type coil load cells is that their response is nearly linear and the actual calibration matches that calculated from finite element analysis to within 10-20%. These claims have been substantiated by calibration measurements carried out at BNL. The calculated slope is about 1700 ue/10 kpsi or about 6 psi/ue. The

calibration in Table I, by contrast, have linear terms an order of magnitude or more smaller than this and quadratic terms that dominate above a few hundred micro strain. The stresses reported are all well below what would result from the nominal 6 psi/ue calibration.

Table II shows the average inner and outer load cell strains, the stresses that result from a 0.17 ue/psi calibration, and coil stress verses press hydraulic pressure slopes. The strains and stresses, plotted in Figure 2, are much more linear than those in Figure 1 and the slopes tend to decrease rather than increase with press load. This suggests that the problem is with the calibration and not with the load cell mounting. Using the nominal calibrations the coil stresses are 5.0 kpsi in the inner coil, 8.6 kpsi in the outer coil for an average of 6.8 kpsi. The slope of coil stress versus press load, shown in Figure 3, implies that about 70% of the press load is transferred to the coil at the pole while the press is fully open. This is typical of the force balance quoted by BNL.

Table III (courtesy of Wayne) shows the collared coil diameter measurements and the deflections relative to the undeflected vertical radius of 2.182 inches. The vertical radial deflections are plotted in Figure 4 and the inferred average coil stress (at 0.56 mils/kpsi) are plotted in Figure 5. The strain gage collar packs cover positions 16-22 and correspond to the largest deflections. The vertical deflections are smallest at the ends, where the collaring press was fully closed, and are largest at the center where they are 1-2 mils larger than expected from the coil preload. A possible explanation for this is that due to non-closure of the press and component deflections there was interference between the keys and the collars. Indeed, the coil stress went up a few hundred psi when the keys were inserted. This may have caused 1-2 mils of scoring on the keys resulting in the excess vertical deflection.

The suggested course of action is as follows:

1. Measure the harmonics of the body of the magnet using the mole.

2. Place the collard coil in the collaring mold with three mils of radial shim. Reduce the shim on the press platen to four mils.

3. Close the press to 9000 psi and remove the keys.

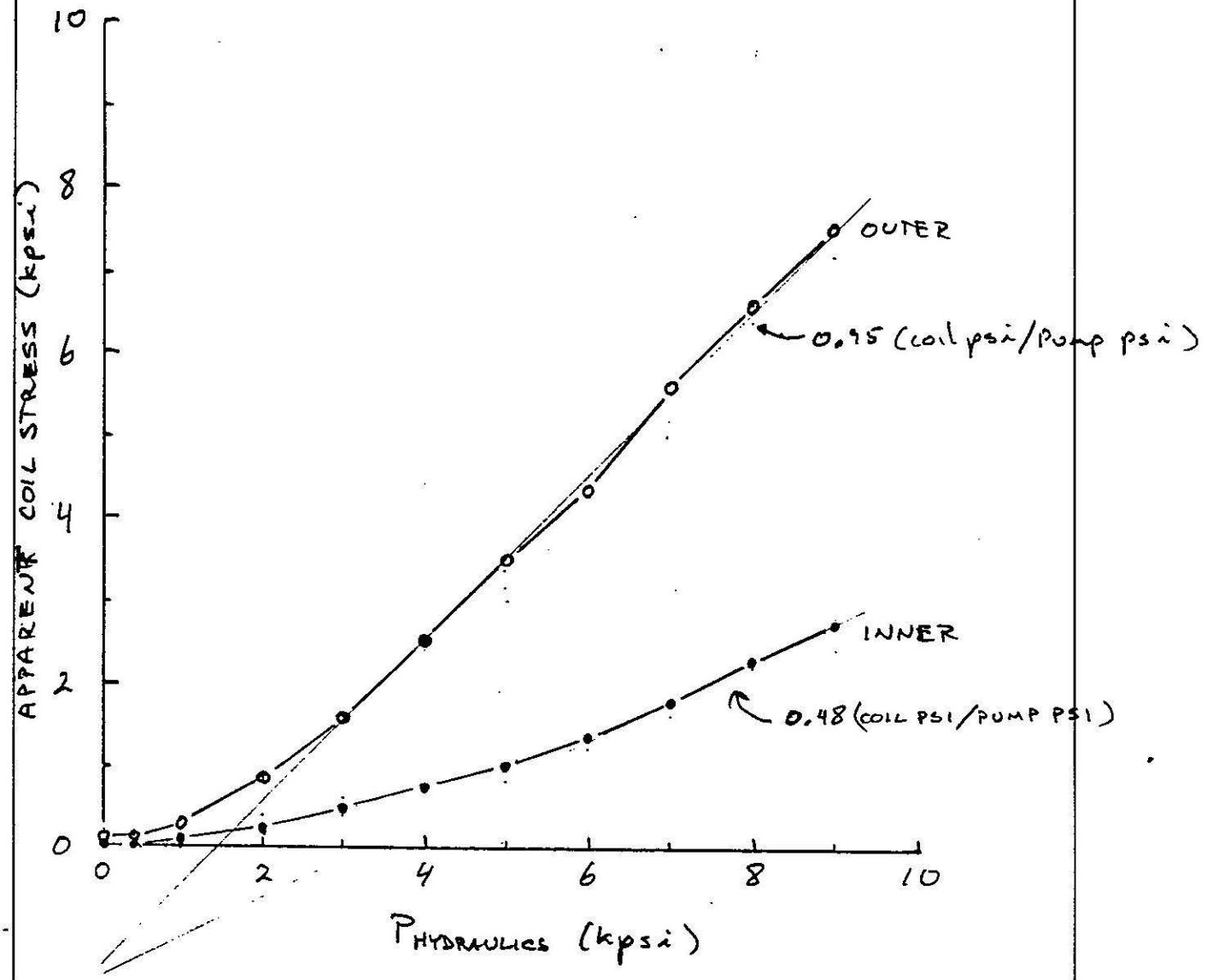
4. Examine the keys for scoring.

5. Re-collar using the keys; use the same tooling shims as in step (2).

6. Repeat the mole measurements.

My expectations are that b_2 will be much smaller than DS0308 because of the additional pole shims and will differ little between steps (1) and (6). The use of radial shims on the tooling should reduce collar deflections

making key insertion (and removal) easier and eliminating key scoring (if it is present at all). If key scoring is a problem then after reassembly the collar deflections should be smaller and the prestress larger.



average (inner + outer) slope = 0.71 (coil psi)/(pump psi)

$\Rightarrow$ 0.42 pole psi / pump psi

Figure 1

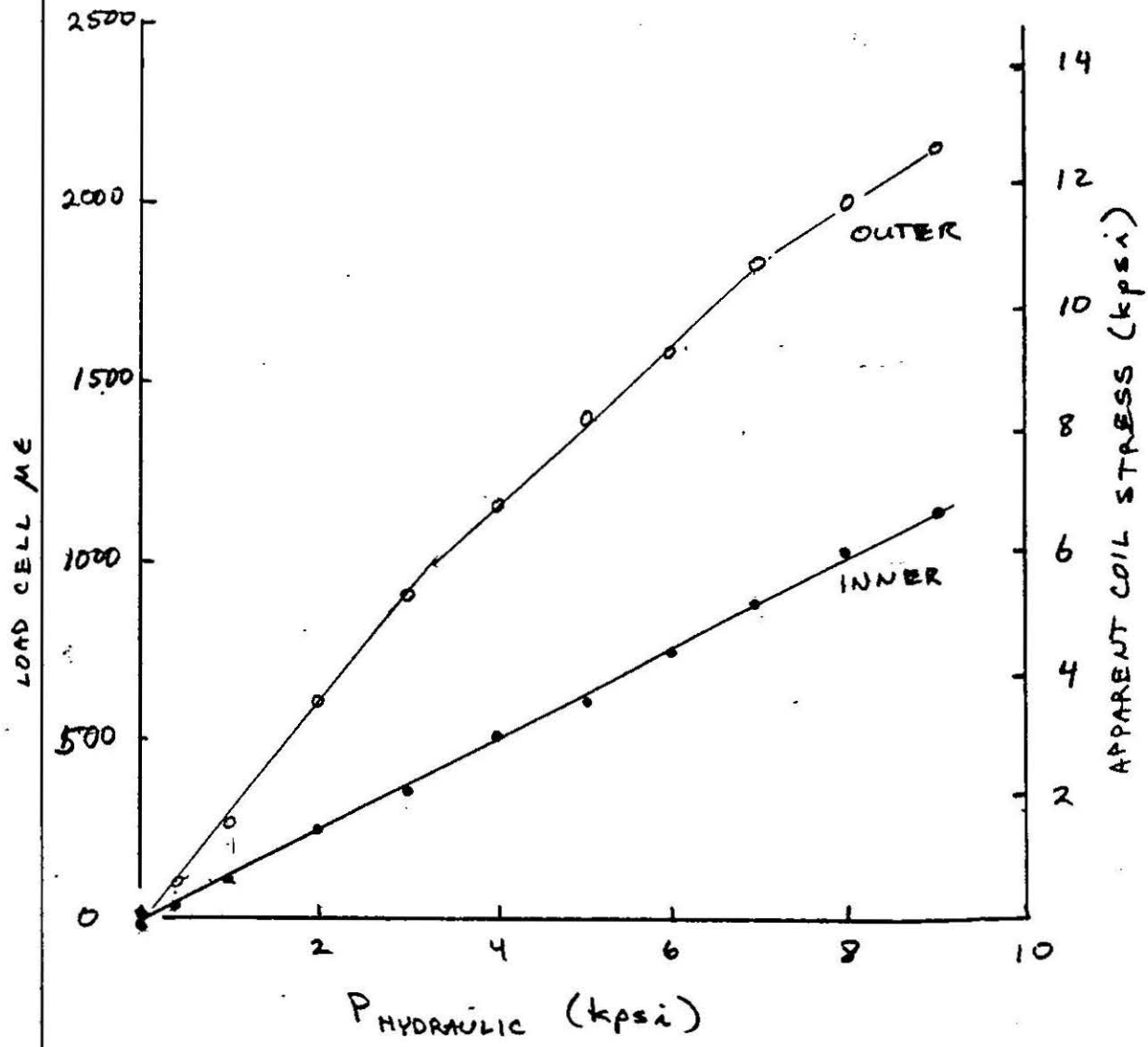

2500
2000
1500
1000
500
0
LOAD CELL με
14
12
10
8
6
4
2
APPARENT COIL STRESS (kpsi)
OUTER
INNER
2
4
6
8
10
P HYDRAULIC (kpsi)

Figure 2

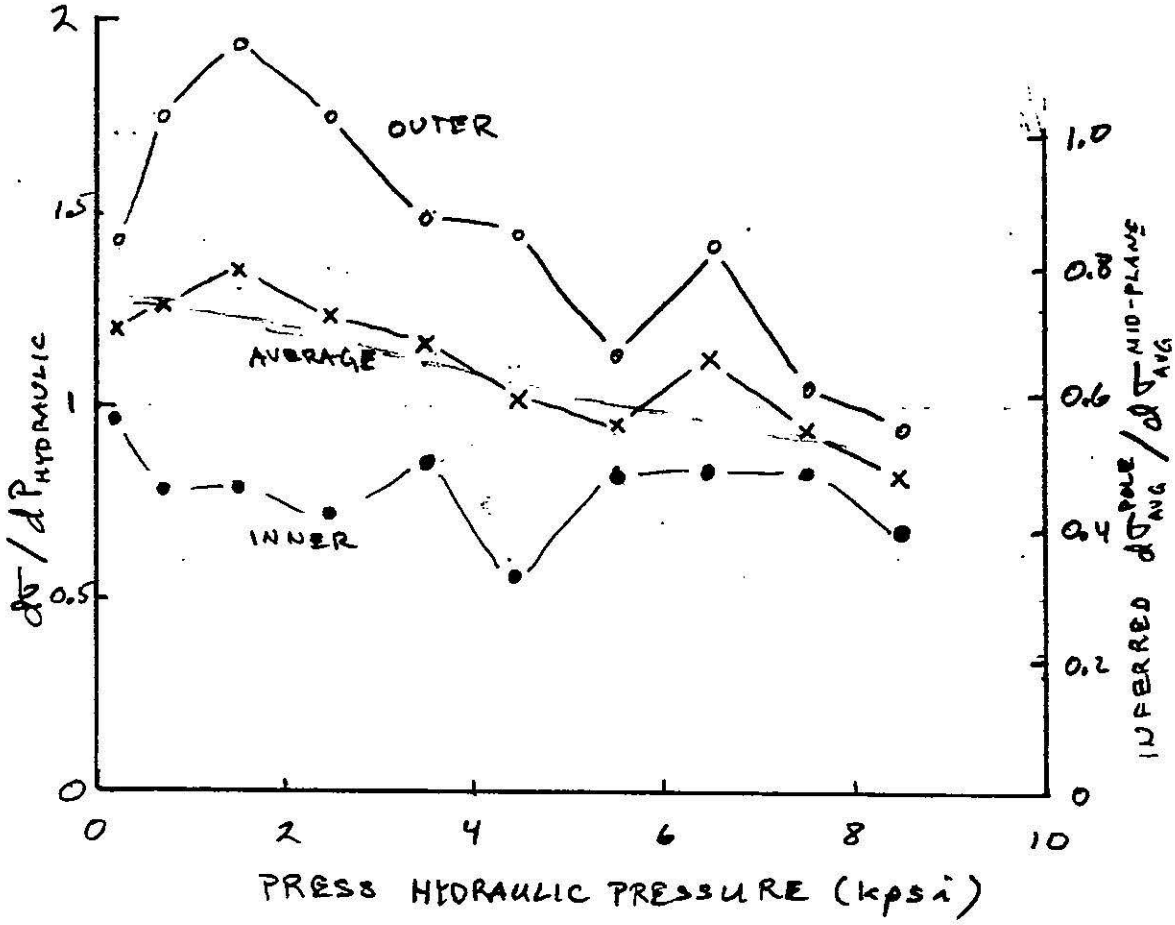

OUTER
AVERAGE
INNER
$d\bar{T}/dP_{HYDRAULIC}$
INFERRED $d\bar{T}^{PANE}_{AVG}/d\bar{T}^{MID-PLANE}_{AVG}$
PRESS HYDRAULIC PRESSURE (kpsi)
0
0.5
1
1.5
2
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10

Figure 3

Table I

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2													
3													
4							GAGE NO.	Gage Facto	R0 (Ohms)	A0	A1	A2	A3
5							70	2.02	350.242	75.1	0.17866	1.71E-03	-1.4E-07
6							53	2.02	349.941	104.8	0.07811	1.79E-03	-1.5E-07
7							249	2.02	350.099				
8							87	2.02	350.627	-9.7	0.84707	1.95E-03	-2.1E-07
9							88	2.02	350.351	-75.2	0.81203	2.02E-03	-2.0E-07
10							244	2.02	349.948				
11							71	2.02	350.423	70.6	0.51314	1.93E-03	-1.7E-07
12							76	2.02	350.212	124.9	-0.09113	1.85E-03	-1.5E-07
13							248	2.02	350.135				
14							266	2.02	350.394				
15							263	2.02	350.489				
16							262	2.02	350.412				
17							68	2.02	350.030	179.4	0.02636	1.88E-03	-1.6E-07
18							77	2.02	350.408	124.4	-0.32542	2.00E-03	-1.7E-07
19													
20													

$$\mu\epsilon = 10^6 \times \frac{(R_A - R_{A0}) - (R_C - R_{C0})}{G \times R_{A0}}$$

$$\sigma = A_0 + A_1 \times \mu\epsilon + A_2 \times (\mu\epsilon)^2 + A_3 \times (\mu\epsilon)^3$$

	A	B	C	D	E	F	G	H	I	J	K	L	M
21	Name: Ethel				Date: 4-4-90								
22	Pump Psi Vertical cylinders: R. 0												
23	Pump Psi Horizontal Vyclinders:R 0												
24	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
25	70	Active	Inner	1	2.49987	875.544	350.235	-0.007	70	-34	-17	73	
26	53	Active	Inner	2	2.49988	874.701	349.898	-0.044	53	-139	-69	108	
27	249	Comp.	Inner	1&2	2.49988	875.218	350.104	0.005	249	-5	-2		Avg Stress
28	87	Active	Inner	3	2.49988	876.452	350.598	-0.030	87	-104	-51	-48	Inner
29	88	Active	Inner	4	2.49988	875.827	350.347	-0.004	88	-29	-14	-86	12
30	244	Comp.	Inner	3&4	2.49988	874.845	349.954	0.007	244	5	2		Outer
31	71	Active	Outer	1	2.49987	876.002	350.419	-0.003	71	-19	-10	66	124
32	76	Active	Outer	2	2.49987	875.488	350.214	0.002	76	30	15	124	Total
33	248	Comp.	Outer	1	2.49987	875.301	350.138	0.004	248	34	17		68
34	266	Comp.	Outer	2	2.49987	875.919	350.385	-0.008	266	-34	-17		
35	263	Comp.	Outer	4	2.49987	876.195	350.496	0.007	263	-1	-1		
36	262	Comp.	Outer	3	2.49987	876.003	350.419	0.007	262	1	1		
37	68	Active	Outer	4	2.49988	875.047	350.036	0.006	68	-2	-1	179	
38	77	Active	Outer	3	2.49988	875.974	350.407	-0.001	77	-23	-12	128	
39													
40													
41	Name: Ethel 4-5-90.8am												
42	Pump Psi Vertical cylinders:0												
43	Pump Psi Horizontal Vyclinders: 0												
44	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
45	70	Active	Inner	1	2.50053	875.775	350.236	-0.006	70	-34	-17	73	
46	53	Active	Inner	2	2.50052	874.928	349.898	-0.043	53	-140	-69	108	
47	249	Comp.	Inner	1&2	2.50052	875.444	350.105	0.006	249	-11	-5		Avg Stress
48	87	Active	Inner	3	2.50052	876.668	350.595	-0.032	87	-119	-59	-53	Inner
49	88	Active	Inner	4	2.50051	876.054	350.350	-0.001	88	-30	-15	-87	10
50	244	Comp.	Inner	3&4	2.50051	875.070	349.957	0.009	244	11	5		Outer
51	71	Active	Outer	1	2.50049	876.221	350.420	-0.003	71	-25	-12	65	124
52	76	Active	Outer	2	2.50048	875.702	350.213	0.002	76	29	15	124	Total
53	248	Comp.	Outer	1	2.50048	875.518	350.141	0.006	248	41	20		67
54	266	Comp.	Outer	2	2.50047	876.127	350.385	-0.009	266	-41	-20		
55	263	Comp.	Outer	4	2.50044	876.390	350.494	0.004	263	-2	-1		
56	262	Comp.	Outer	3	2.50043	876.194	350.417	0.005	262	2	1		
57	68	Active	Outer	4	2.50042	875.239	350.037	0.006	68	5	3	179	
58	77	Active	Outer	3	2.50041	876.167	350.409	0.001	77	-11	-5	126	
59													
60													
61	Name: Ethel 4-5-90.10am												
62	Pump Psi Vertical cylinders: 400												
63	Pump Psi Horizontal Vyclinders: 0												
64	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
65	70	Active	Inner	1	2.49972	875.575	350.270	0.027	70	73	36	84	
66	53	Active	Inner	2	2.49972	874.737	349.933	-0.008	53	-28	-14	104	
67	249	Comp.	Inner	1&2	2.49973	875.158	350.101	0.002	249	-4	-2		Avg Stress
68	87	Active	Inner	3	2.49974	876.518	350.644	0.017	87	39	19	7	Inner
69	88	Active	Inner	4	2.49974	875.908	350.399	0.048	88	129	64	-15	45
70	244	Comp.	Inner	3&4	2.49975	874.789	349.951	0.003	244	4	2		Outer
71	71	Active	Outer	1	2.49975	875.848	350.374	-0.049	71	-140	-70	44	141
72	76	Active	Outer	2	2.49975	875.492	350.231	0.020	76	94	46	125	Total
73	248	Comp.	Outer	1	2.49976	875.253	350.136	0.001	248	39	19		93
74	266	Comp.	Outer	2	2.49976	875.867	350.381	-0.013	266	-39	-19		
75	263	Comp.	Outer	4	2.49976	876.144	350.491	0.001	263	-2	-1		
76	262	Comp.	Outer	3	2.49976	875.952	350.414	0.002	262	2	1		
77	68	Active	Outer	4	2.49977	875.272	350.142	0.111	68	314	156	228	
78	77	Active	Outer	3	2.49977	876.394	350.590	0.183	77	515	255	168	
79													
80													

	A	B	C	D	E	F	G	H	I	J	K	L	M
81	Name: Ethel 4-5-90.2.45pm												
82	Pump Psi Vertical cylinders: 1000												
83	Pump Psi Horizontal Vyclinders: 0												
84	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
85	70	Active	Inner	1	2.49951	875.599	350.308	0.066	70	176	87	103	
86	53	Active	Inner	2	2.49952	874.778	349.979	0.038	53	95	47	112	
87	249	Comp.	Inner	1&2	2.49952	875.091	350.103	0.004	249	-3	-1		Avg Stress
88	87	Active	Inner	3	2.49954	876.639	350.721	0.093	87	251	124	126	Inner
89	88	Active	Inner	4	2.49953	876.019	350.474	0.123	88	337	167	115	114
90	244	Comp.	Inner	3&4	2.49953	874.718	349.953	0.005	244	3	1		Outer
91	71	Active	Outer	1	2.49952	876.008	350.470	0.048	71	127	63	110	288
92	76	Active	Outer	2	2.49952	875.634	350.321	0.110	76	343	170	162	Total
93	248	Comp.	Outer	1	2.49951	875.174	350.138	0.003	248	38	19		201
94	266	Comp.	Outer	2	2.49951	875.786	350.383	-0.010	266	-38	-19		
95	263	Comp.	Outer	4	2.49951	876.066	350.496	0.006	263	-1	0		
96	262	Comp.	Outer	3	2.49951	875.873	350.418	0.007	262	1	0		
97	68	Active	Outer	4	2.49951	875.722	350.358	0.328	68	918	455	564	
98	77	Active	Outer	3	2.49951	876.588	350.704	0.297	77	828	410	315	
99													
100													
101	Name: Ethel 4-5-90.3.15pm												
102	Pump Psi Vertical cylinders: 2000												
103	Pump Psi Horizontal Vyclinders: 0												
104	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
105	70	Active	Inner	1	2.49950	875.842	350.407	0.164	70	454	225	200	
106	53	Active	Inner	2	2.49950	875.008	350.073	0.132	53	361	179	175	
107	249	Comp.	Inner	1&2	2.49950	875.087	350.105	0.005	249	-4	-2		Avg Stress
108	87	Active	Inner	3	2.49950	876.846	350.808	0.181	87	498	246	314	Inner
109	88	Active	Inner	4	2.49950	876.265	350.576	0.225	88	623	309	361	263
110	244	Comp.	Inner	3&4	2.49950	874.711	349.954	0.007	244	4	2		Outer
111	71	Active	Outer	1	2.49955	876.606	350.706	0.283	71	800	396	566	833
112	76	Active	Outer	2	2.49954	876.139	350.521	0.309	76	909	450	444	Total
113	248	Comp.	Outer	1	2.49953	875.179	350.138	0.003	248	35	17		548
114	266	Comp.	Outer	2	2.49952	875.792	350.384	-0.009	266	-35	-17		
115	263	Comp.	Outer	4	2.49952	876.071	350.496	0.006	263	8	4		
116	262	Comp.	Outer	3	2.49953	875.874	350.415	0.003	262	-8	-4		
117	68	Active	Outer	4	2.49954	876.446	350.643	0.612	68	1731	857	1480	
118	77	Active	Outer	3	2.49955	877.130	350.915	0.507	77	1437	711	842	
119													
120													
121	Name: Ethel 4-5-90.3.30pm												
122	Pump Psi Vertical cylinders: 3000												
123	Pump Psi Horizontal Vyclinders: 0												
124	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
125	70	Active	Inner	1	2.49949	876.087	350.506	0.264	70	738	365	361	
126	53	Active	Inner	2	2.49949	875.256	350.174	0.232	53	648	321	309	
127	249	Comp.	Inner	1&2	2.49949	875.085	350.105	0.006	249	-1	-1		Avg Stress
128	87	Active	Inner	3	2.49950	877.011	350.875	0.248	87	690	341	498	Inner
129	88	Active	Inner	4	2.49950	876.469	350.658	0.307	88	859	425	620	447
130	244	Comp.	Inner	3&4	2.49950	874.709	349.954	0.006	244	1	1		Outer
131	71	Active	Outer	1	2.49949	877.137	350.927	0.504	71	1429	707	1339	1612
132	76	Active	Outer	2	2.49949	876.612	350.717	0.505	76	1466	726	974	Total
133	248	Comp.	Outer	1	2.49949	875.166	350.138	0.003	248	33	16		1030
134	266	Comp.	Outer	2	2.49949	875.784	350.385	-0.008	266	-33	-16		
135	263	Comp.	Outer	4	2.49949	876.063	350.497	0.008	263	4	2		
136	262	Comp.	Outer	3	2.49949	875.866	350.418	0.006	262	-4	-2		
137	68	Active	Outer	4	2.49949	877.018	350.879	0.848	68	2402	1189	2596	
138	77	Active	Outer	3	2.49949	877.576	351.102	0.694	77	1963	972	1540	
139													
140													

	A	B	C	D	E	F	G	H	I	J	K	L	M
141				Name: Ethel 4-5-90.3.40pm									
142					Pump Psi Vertical cylinders: 4000								
143					Pump Psi Horizontal Vyclinders: 0								
144	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
145	70	Active	Inner	1	2.49951	876.316	350.595	0.352	70	998	494	563	
146	53	Active	Inner	2	2.49951	875.505	350.270	0.329	53	932	461	508	
147	249	Comp.	Inner	1&2	2.49951	875.084	350.102	0.003	249	-5	-2		Avg Stress
148	87	Active	Inner	3	2.49951	877.214	350.954	0.327	87	920	456	760	Inner
149	88	Active	Inner	4	2.49911	876.676	350.795	0.445	88	1256	622	1160	748
150	244	Comp.	Inner	3&4	2.49951	874.708	349.952	0.004	244	5	2		Outer
151	71	Active	Outer	1	2.49951	877.618	351.116	0.693	71	1965	973	2238	2478
152	76	Active	Outer	2	2.49952	877.045	350.886	0.674	76	1953	967	1627	Total
153	248	Comp.	Outer	1	2.49952	875.179	350.139	0.004	248	40	20		1613
154	266	Comp.	Outer	2	2.49952	875.792	350.384	-0.010	266	-40	-20		
155	263	Comp.	Outer	4	2.49951	876.061	350.494	0.004	263	2	1		
156	262	Comp.	Outer	3	2.49951	875.867	350.416	0.004	262	-2	-1		
157	68	Active	Outer	4	2.49951	877.500	351.069	1.038	68	2954	1462	3730	
158	77	Active	Outer	3	2.49952	877.981	351.261	0.853	77	2423	1199	2317	
159													
160													
161					Name: Ethel 4-5-90.3.50pm								
162						Pump Psi Vertical cylinders: 5000								
163	linders: 0												
164	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
165	70	Active	Inner	1	2.49952	876.558	350.691	0.449	70	1271	629	828	
166	53	Active	Inner	2	2.49952	875.756	350.370	0.429	53	1215	601	768	
167	249	Comp.	Inner	1&2	2.49952	875.088	350.103	0.004	249	-1	-1		Avg Stress
168	87	Active	Inner	3	2.49952	877.358	351.011	0.384	87	1083	536	972	Inner
169	88	Active	Inner	4	2.49952	876.861	350.812	0.462	88	1305	646	1236	951
170	244	Comp.	Inner	3&4	2.49952	874.710	349.952	0.004	244	1	1		Outer
171	71	Active	Outer	1	2.49952	878.066	351.294	0.872	71	2481	1228	3293	3501
172	76	Active	Outer	2	2.49952	877.469	351.055	0.844	76	2434	1205	2430	Total
173	248	Comp.	Outer	1	2.49952	875.174	350.137	0.002	248	31	15		2226
174	266	Comp.	Outer	2	2.49952	875.794	350.385	-0.009	266	-31	-15		
175	263	Comp.	Outer	4	2.49951	876.063	350.494	0.004	263	5	2		
176	262	Comp.	Outer	3	2.49951	875.865	350.415	0.003	262	-5	-2		
177	68	Active	Outer	4	2.49951	877.992	351.266	1.235	68	3516	1741	5066	
178	77	Active	Outer	3	2.49951	878.369	351.416	1.009	77	2870	1421	3213	
179													
180													
181				Name: Ethel	4-5-90.4pm								
182						Pump Psi Vertical cylinders:6000								
183	linders: 0												
184	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
185	70	Active	Inner	1	2.49952	876.779	350.779	0.537	70	1528	756	1125	
186	53	Active	Inner	2	2.49952	875.992	350.464	0.523	53	1489	737	1077	
187	249	Comp.	Inner	1&2	2.49952	875.084	350.101	0.002	249	-2	-1		Avg Stress
188	87	Active	Inner	3	2.49952	877.633	351.121	0.493	87	1400	693	1444	Inner
189	88	Active	Inner	4	2.49952	877.083	350.901	0.550	88	1562	773	1664	1327
190	244	Comp.	Inner	3&4	2.49952	874.707	349.950	0.003	244	2	1		Outer
191	71	Active	Outer	1	2.49952	878.432	351.441	1.018	71	2890	1431	4251	4371
192	76	Active	Outer	2	2.49952	877.817	351.194	0.983	76	2833	1402	3209	Total
193	248	Comp.	Outer	1	2.49952	875.183	350.140	0.005	248	42	21		2849
194	266	Comp.	Outer	2	2.49952	875.794	350.384	-0.009	266	-42	-21		
195	263	Comp.	Outer	4	2.49951	876.168	350.535	0.046	263	172	85		
196	262	Comp.	Outer	3	2.49951	875.824	350.398	-0.014	262	-172	-85		
197	68	Active	Outer	4	2.49951	878.373	351.418	1.387	68	3832	1897	5888	
198	77	Active	Outer	3	2.49951	878.684	351.542	1.134	77	3277	1622	4137	
199													
200													

	A	B	C	D	E	F	G	H	I	J	K	L	M
201	Name: Ethel 4-5-90.4.05pm												
202	Pump Psi Vertical cylinders:7000												
203	Pump Psi Horizontal Vyclinders: 0												
204	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
205	70	Active	Inner	1	2.49951	877.018	350.877	0.634	70	1805	894	1497	
206	53	Active	Inner	2	2.49951	876.244	350.567	0.626	53	1782	882	1466	
207	249	Comp.	Inner	1&2	2.49951	875.080	350.101	0.002	249	-6	-3		Avg Stress
208	87	Active	Inner	3	2.49951	877.884	351.223	0.596	87	1688	835	1936	Inner
209	88	Active	Inner	4	2.49951	877.324	350.999	0.648	88	1838	910	2180	1770
210	244	Comp.	Inner	3&4	2.49951	874.706	349.952	0.004	244	6	3		Outer
211	71	Active	Outer	1	2.49950	878.837	351.605	1.183	71	3360	1663	5472	5614
212	76	Active	Outer	2	2.49950	878.204	351.352	1.140	76	3280	1624	4193	Total
213	248	Comp.	Outer	1	2.49950	875.175	350.140	0.005	248	39	19		3692
214	266	Comp.	Outer	2	2.49950	875.788	350.385	-0.008	266	-39	-19		
215	263	Comp.	Outer	4	2.49960	876.061	350.481	-0.009	263	1	0		
216	262	Comp.	Outer	3	2.49960	875.866	350.403	-0.009	262	-1	0		
217	68	Active	Outer	4	2.49959	878.827	351.588	1.558	68	4475	2215	7703	
218	77	Active	Outer	3	2.49950	879.026	351.680	1.273	77	3657	1810	5087	
219													
220													
221	Name: Ethel 4-5-90.4.15pm												
222	Pump Psi Vertical cylinders: 8000												
223	Pump Psi Horizontal Vyclinders: 0												
224	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
225	70	Active	Inner	1	2.49952	877.243	350.965	0.723	70	2049	1014	1864	
226	53	Active	Inner	2	2.49952	876.486	350.662	0.721	53	2045	1012	1866	
227	249	Comp.	Inner	1&2	2.49952	875.092	350.104	0.005	249	-4	-2		Avg Stress
228	87	Active	Inner	3	2.49952	878.221	351.356	0.729	87	2061	1020	2660	Inner
229	88	Active	Inner	4	2.49952	877.549	351.087	0.736	88	2084	1032	2685	2269
230	244	Comp.	Inner	3&4	2.49952	874.716	349.954	0.006	244	4	2		Outer
231	71	Active	Outer	1	2.49952	879.152	351.729	1.306	71	3716	1840	6476	6587
232	76	Active	Outer	2	2.49952	878.537	351.483	1.271	76	3653	1808	5095	Total
233	248	Comp.	Outer	1	2.49952	875.180	350.139	0.004	248	36	18		4428
234	266	Comp.	Outer	2	2.49952	875.797	350.386	-0.008	266	-36	-18		
235	263	Comp.	Outer	4	2.49951	876.063	350.494	0.005	263	-2	-1		
236	262	Comp.	Outer	3	2.49951	875.872	350.418	0.006	262	2	1		
237	68	Active	Outer	4	2.49951	879.171	351.737	1.707	68	4862	2407	8879	
238	77	Active	Outer	3	2.49951	879.331	351.801	1.393	77	3959	1960	5898	
239													
240													
241	Name: Ethel 4-5-90.4.30pm												
242	Pump Psi Vertical cylinders: 9000												
243	Pump Psi Horizontal Vyclinders: 0												
244	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
245	70	Active	Inner	1	2.49953	877.424	351.035	0.793	70	2258	1118	2209	
246	53	Active	Inner	2	2.49953	876.693	350.743	0.801	53	2284	1131	2269	
247	249	Comp.	Inner	1&2	2.49953	875.090	350.101	0.002	249	-4	-2		Avg Stress
248	87	Active	Inner	3	2.49953	878.455	351.448	0.820	87	2330	1153	3239	Inner
249	88	Active	Inner	4	2.49953	877.738	351.161	0.810	88	2302	1140	3168	2721
250	244	Comp.	Inner	3&4	2.49953	874.714	349.951	0.003	244	4	2		Outer
251	71	Active	Outer	1	2.49954	879.401	351.826	1.403	71	3993	1977	7299	7517
252	76	Active	Outer	2	2.49954	878.863	351.610	1.399	76	4022	1991	6057	Total
253	248	Comp.	Outer	1	2.49954	875.184	350.139	0.004	248	38	19		5119
254	266	Comp.	Outer	2	2.49954	875.798	350.384	-0.010	266	-38	-19		
255	263	Comp.	Outer	4	2.49954	876.074	350.495	0.005	263	6	3		
256	262	Comp.	Outer	3	2.49954	875.875	350.415	0.003	262	-6	-3		
257	68	Active	Outer	4	2.49954	879.467	351.852	1.822	68	5190	2569	9913	
258	77	Active	Outer	3	2.49954	879.611	351.910	1.502	77	4277	2117	6800	
259													
260													

	A	B	C	D	E	F	G	H	I	J	K	L	M
261	Name: Ethel 4-5-90.4.30pm												
262	Pump Psi Vertical cylinders: 9000												
263	Pump Psi Horizontal Vyclinders: 1000												
264	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
265	70	Active	Inner	1	2.49953	877.543	351.083	0.841	70	2390	1183	2441	
266	53	Active	Inner	2	2.49953	876.536	350.680	0.739	53	2101	1040	1958	
267	249	Comp.	Inner	1&2	2.49953	875.093	350.103	0.003	249	0	0		Avg Stress
268	87	Active	Inner	3	2.49953	878.625	351.516	0.889	87	2524	1250	3684	Inner
269	88	Active	Inner	4	2.49953	877.848	351.205	0.854	88	2428	1202	3460	2886
270	244	Comp.	Inner	3&4	2.49953	874.714	349.951	0.004	244	0	0		Outer
271	71	Active	Outer	1	2.49953	879.508	351.869	1.446	71	4114	2037	7669	8101
272	76	Active	Outer	2	2.49953	879.079	351.697	1.486	76	4270	2114	6738	Total
273	248	Comp.	Outer	1	2.49953	875.185	350.139	0.004	248	40	20		5493
274	266	Comp.	Outer	2	2.49953	875.797	350.384	-0.010	266	-40	-20		
275	263	Comp.	Outer	4	2.49953	876.072	350.494	0.005	263	3	1		
276	262	Comp.	Outer	3	2.49953	875.876	350.416	0.004	262	-3	-1		
277	68	Active	Outer	4	2.49953	879.626	351.916	1.886	68	5374	2660	10510	
278	77	Active	Outer	3	2.49953	879.815	351.992	1.584	77	4509	2232	7487	
279													
280													
281	Name: Ethel 4-5-90.4.45pm												
282	Pump Psi Vertical cylinders: 4000												
283	Pump Psi Horizontal Vyclinders: 400												
284	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
285	70	Active	Inner	1	2.49955	877.271	350.972	0.730	70	2073	1026	1902	
286	53	Active	Inner	2	2.49955	876.571	350.692	0.751	53	2134	1056	2012	
287	249	Comp.	Inner	1&2	2.49955	875.099	350.103	0.004	249	-2	-1		Avg Stress
288	87	Active	Inner	3	2.49955	878.383	351.417	0.790	87	2239	1108	3038	Inner
289	88	Active	Inner	4	2.49955	877.477	351.055	0.704	88	1995	988	2497	2362
290	244	Comp.	Inner	3&4	2.49955	874.722	349.952	0.005	244	2	1		Outer
291	71	Active	Outer	1	2.49955	878.870	351.612	1.189	71	3385	1676	5541	6126
292	76	Active	Outer	2	2.49955	878.516	351.470	1.259	76	3621	1792	5015	Total
293	248	Comp.	Outer	1	2.49955	875.186	350.138	0.003	248	36	18		4244
294	266	Comp.	Outer	2	2.49955	875.802	350.384	-0.009	266	-36	-18		
295	263	Comp.	Outer	4	2.49954	876.080	350.496	0.007	263	1	1		
296	262	Comp.	Outer	3	2.49954	875.885	350.418	0.006	262	-1	-1		
297	68	Active	Outer	4	2.49954	879.056	351.687	1.656	68	4713	2333	8419	
298	77	Active	Outer	3	2.49954	879.224	351.754	1.346	77	3824	1893	5529	
299													
300													
301	Name: Ethel 4-5-90.5pm												
302	Pump Psi Vertical cylinders .0												
303	Pump Psi Horizontal Vyclinders: 0												
304	GAGE NO.	TYPE	COIL	Quadrant	I (mA)	V (mV)	R (Ohms)	dR= R-R0	GAGE NO.	1E6*dR/R0	µE	COIL Psi	
305	70	Active	Inner	1	2.49952	876.902	350.828	0.586	70	1662	823	1298	
306	53	Active	Inner	2	2.49952	876.219	350.555	0.613	53	1742	862	1410	
307	249	Comp.	Inner	1&2	2.49952	875.090	350.103	0.004	249	-8	-4		Avg Stress
308	87	Active	Inner	3	2.49952	878.044	351.285	0.658	87	1857	919	2252	Inner
309	88	Active	Inner	4	2.49952	877.101	350.908	0.557	88	1570	777	1678	1659
310	244	Comp.	Inner	3&4	2.49952	874.718	349.954	0.007	244	8	4		Outer
311	71	Active	Outer	1	2.49953	877.931	351.239	0.816	71	2317	1147	2940	3772
312	76	Active	Outer	2	2.49953	877.826	351.197	0.986	76	2837	1404	3218	Total
313	248	Comp.	Outer	1	2.49953	875.182	350.139	0.004	248	36	18		2716
314	266	Comp.	Outer	2	2.49953	875.798	350.386	-0.008	266	-36	-18		
315	263	Comp.	Outer	4	2.49953	876.068	350.494	0.004	263	3	1		
316	262	Comp.	Outer	3	2.49953	875.872	350.415	0.003	262	-3	-1		
317	68	Active	Outer	4	2.49953	878.088	351.302	1.272	68	3620	1792	5332	
318	77	Active	Outer	3	2.49953	878.530	351.479	1.071	77	3046	1508	3600	
319													
320													

Table II

(0.17 με/psi)

P_V	P_H	$\langle \mu\epsilon \rangle_I$	$\langle \mu\epsilon \rangle_O$	σ_I	σ_O	σ_{AVG}	$d\sigma_I/dP_V$	$d\sigma_O/dP_V$	$d\sigma_A/dP_V$	FIT $d\sigma_A/dP_V$
0	0	-38	-2	-224	-12	-118				
0	0	-40	0	-235	0	-118				
400		+26	97	153	571	362	0.970	1.428	1.200	
1000		+106	275	624	1618	1121	0.785	1.745	1.265	
2000		240	604	1412	3553	2483	0.788	1.935	1.362	1.30
3000		363	899	2135	5288	3712	0.723	1.735	1.229	
4000		508	1150	2988	6765	4877	0.853	1.477	1.165	
5000		603	1399	3547	8229	5888	0.559	1.464	1.011	1.05
6000		740	1588	4353	9341	6847	0.806	1.112	0.959	
7000		880	1828	5176	10753	7965	0.823	1.412	1.118	
8000		1020	2004	6000	11788	8894	0.824	1.035	0.929	0.87
9000		1136	2164	6682	12729	9706	0.682	0.941	0.812	
9000	1000	1169	2261	6876	13300	10088				
4000	400	1045	1924	6147	11318	8733				
0	0	845	1463	4971	8606	6789				

	A	B	C	D	E	F	G	H	I	J	K
1		Magnet DS0309									
2											
3	Measurement Positio	Vertical Dimensio	Horizontal Dimensio	45 Degree Dimensior	135 Degree Dimensio	Vertical Deflectio	Prestress from	Horizontal Deflectio	45 Deg Deflectio	135 Deg Deflection	
4		4.3xx	4.2xx	4.3xx	4.3xx	on Radius	Vertical Deflection				
5	0	71	86	65	65	3.	6250.		0.50	0.50	
6	1	71	85	64	65	3.	6250.		0.00	0.50	
7	2	71	85	64	65	3.	6250.		0.00	0.50	
8	3	70	86	64	64	3.	5357.		0.00	0.00	
9	4	71	85	64	65	3.	6250.		0.00	0.50	
10	5	72	85	64	66	4.	7143.		0.00	1.00	
11	6	72	85	64	66	4.	7143.		0.00	1.00	
12	7	72	86	64	65	4.	7143.		0.00	0.50	
13	8	72	86	64	64	4.	7143.		0.00	0.00	
14	9	72	86	64	64	4.	7143.		0.00	0.00	
15	10	72	86	64	64	4.	7143.		0.00	0.00	
16	11	73	85	64	66	4.	8036.		0.00	1.00	
17	12	73	84	64	66	4.	8036.		0.00	1.00	
18	13	73	85	64	66	4.	8036.		0.00	1.00	
19	14	73	84	64	65	4.	8036.		0.00	0.50	
20	15	73	84	63	65	4.	8036.		-0.50	0.50	
21	16	74	84	63	65	5.	8929.		-0.50	0.50	
22	17	74	83	64	65	5.	8929.		0.00	0.50	
23	18	74	84	64	65	5.	8929.		0.00	0.50	
24	19	76	84	65	66	6.	10714.		0.50	1.00	
25	20	75	84	64	65	5.	9821.		0.00	0.50	
26	21	75	84	65	65	5.	9821.		0.50	0.50	
27	22	75	84	65	66	5.	9821.		0.50	1.00	
28	23	73	84	65	65	4.	8036.		0.50	0.50	
29	24	73	85	64	66	4.	8036.		0.00	1.00	
30	25	72	85	66	65	4.	7143.		1.00	0.50	
31	26	72	85	64	65	4.	7143.		0.00	0.50	
32	27	72	85	64	64	4.	7143.		0.00	0.00	
33	28	72	85	64	65	4.	7143.		0.00	0.50	
34	29	72	85	64	64	4.	7143.		0.00	0.00	
35	30	72	85	64	64	4.	7143.		0.00	0.00	
36	31	73	85	65	64	4.	8036.		0.50	0.00	
37	32	73	85	64	65	4.	8036.		0.00	0.50	
38	33	73	85	64	65	4.	8036.		0.00	0.50	
39	34	73	85	65	65	4.	8036.		0.50	0.50	
40	35	72	85	65	65	4.	7143.		0.50	0.50	
41	36	72	85	65	65	4.	7143.		0.50	0.50	
42	37	72	85	65	65	4.	7143.		0.50	0.50	
43	38	71	84	64	64	3.	6250.		0.00	0.00	
44	39	71	84	64	64	3.	6250.		0.00	0.00	
45	40	71	85	64	65	3.	6250.		0.00	0.50	

Table III

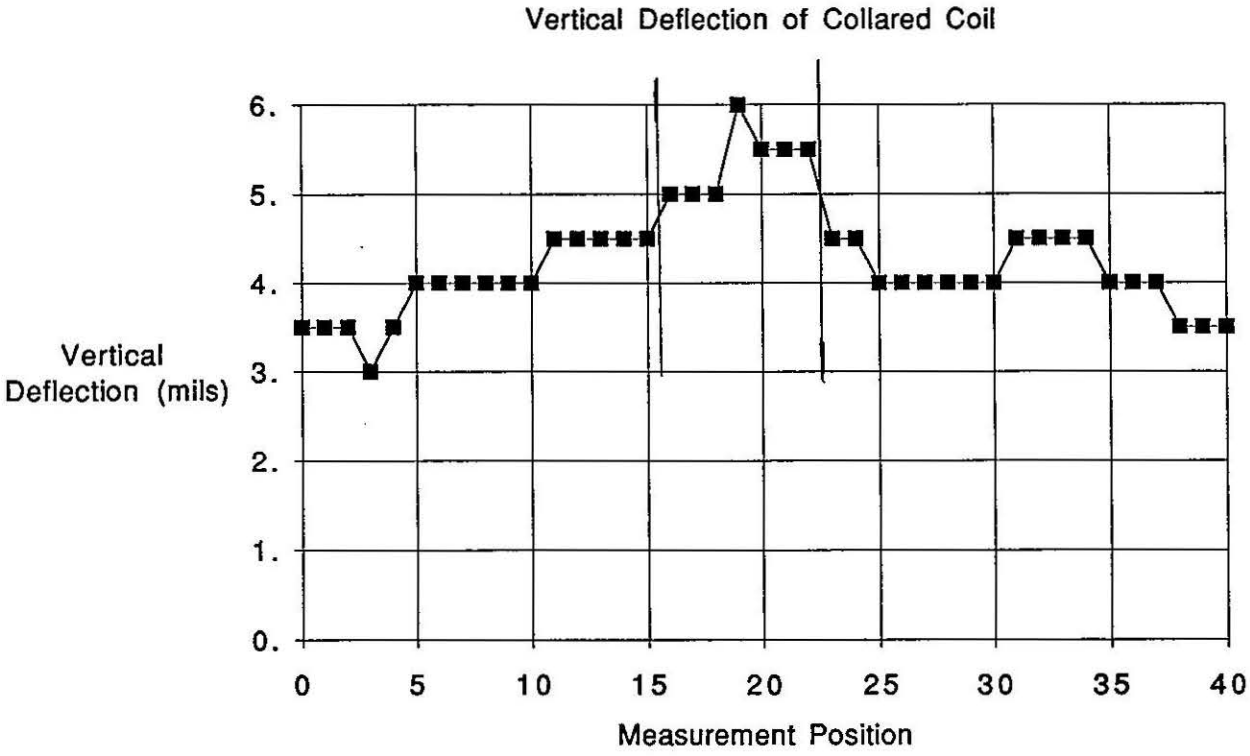
Vertical Deflection of Collared Coil
Vertical Deflection (mils)
6.
5.
4.
3.
2.
1.
0.
0
5
10
15
20
25
30
35
40
Measurement Position

Figure 4

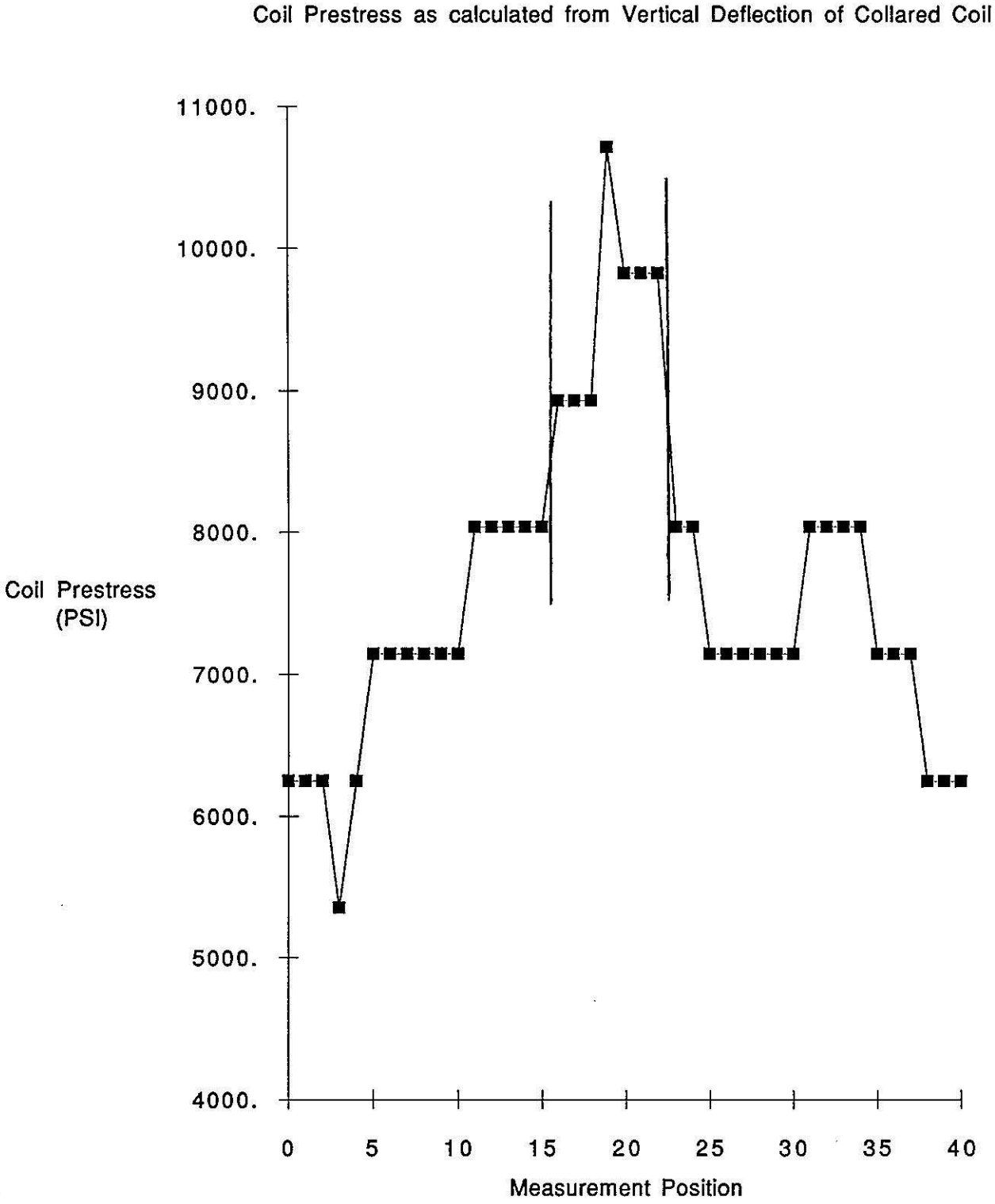
Coil Prestress as calculated from Vertical Deflection of Collared Coil
11000.
10000.
9000.
8000.
7000.
6000.
5000.
4000.
Coil Prestress (PSI)
0
5
10
15
20
25
30
35
40
Measurement Position

Figure 5