3/29/90

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From: Jim Strait
Subj: Preliminary results on teflon slip planes in DS0307

I have looked briefly at the strain gage data taken during multiple collaring cycles of DS0307 to see what effect, if any, the presence of teflon slip planes has on the force balance between the press (which presumably corresponds to the coil stress at the mid-plane) and the coil stress at the pole. The data discussed here were taken under several conditions: no teflon, 3 mil teflon adhesive tape attached to the coil "caps" similar to the method used by BNL and LBL and non-adhesive teflon plumber's tape burnished into the surfaces of the coils. The adhesive teflon tape was applied to the outer surfaces of the inner and outer coils caps. The plumber's tape was applied to the outer surface of the inner coil and both surfaces of the outer coil.

There are two confounding variable: 1) For the earlier tests every other hydraulic cylinder was valved off, while in later tests the full press load was used and 2) Between the tests with adhesive teflon tape and plumber's tape the outer coils were replace because one of the original coils was damaged during disassembly. Alternate press cylinders are staggered relative to the press center line. With every other cylinder valved off, the press tended to close asymmetrically. This is not believed to compromise the quality of the data. However, because of the model magnet lenght is not large relative to the spacing between the hydraulic cylinders it is difficult to know what the effective press load was on the active part of the coil in the earlier tests making it difficult to make quantitative measurements of force balance under these conditions. Fortunately a complete set of data exists with the press in this asymmetric configuration so a valid comparison of the different collaring conditions can be made.

More serious is the change of coils between the two different teflon tests. The original coils were molded with fiberglass tape with a high epoxy content (25%?), while the substitute coils used tape with a low epoxy content (18%?). The first coils had a smooth epoxy finish on both surfaces while the second coils had a rougher finish. It is not obvious, however, which one results in a lower friction coefficient against kapton.

Part of the same set of experiments involved adding several mils of radial shim between the collars and the collaring tooling. Between the time the tooling was design and the collars were designed, the radius of the collars shrank by 2 mils. In addition the collars were punched with a radius 1 mil smaller than the design, making them 3 mils smaller than the tooling. It was conjectured that this allowed the collars to bend outwards

making it harder to insert the keys and wasted some of the vertical press load. To test this DS0307 was compressed in the collaring press with radial shims of 0, 3 and 6 mils. This was done with plumber's tape applied to the coils, once with the press in the asymmetric configuration and once with all cylinders energized.

Figure 1 plots the average coil stress versus the press hydraulic system pressure for the three different teflon configurations with half of the press cylinders turned off. The addition of adhesive teflon tape to the coil caps has no significant effect on the fraction of the press load that appears at the coil pole. With plumber's tape applied to the coils there is an apparent large increase in the force transfer. However, because the outer coils are different for this test, it is not certain that this is a result of the teflon. Figure 2 shows the same data for three different radial shim thicknesses now with the full press energized. There is no significan difference among the three in terms of force balance. Because the keys were inserted only on the third trial it is not know whether collar bending with no shim makes a difference for key insertion. A copy of the portion of the Excel spread sheet that contains the analysed data is attached as Table I.

Because the plumber's tape, once burnished into the coils, cannot be entirely removed, the no-teflon and adhesive teflon experiments cannot be repeated with these coils. A set of 4 new test coils with "junk" ends is currently being wound to allow a complete comparison of the three teflon configurations with a common set of coils and with the press operated in the proper way.

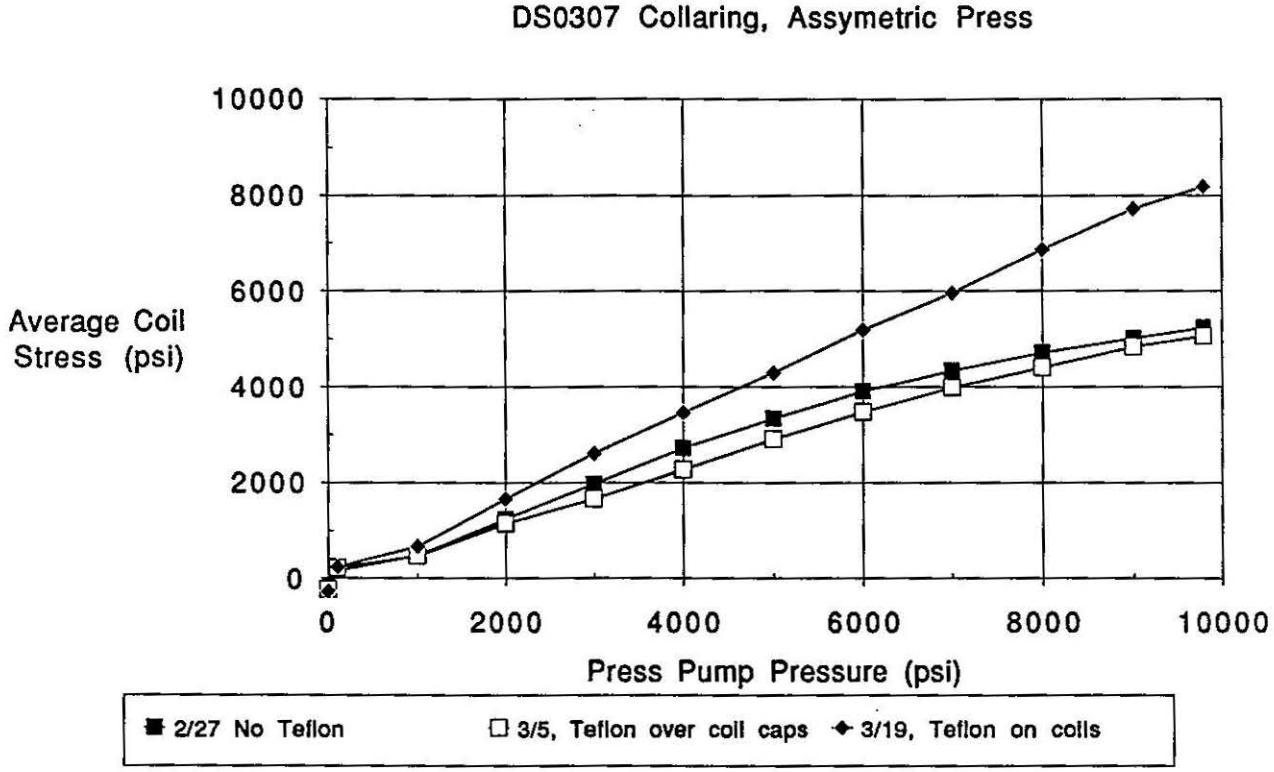
DS0307 Collaring, Assymetric Press
Average Coil Stress (psi)
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
Press Pump Pressure (psi)
2/27 No Teflon
3/5, Teflon over coil caps
3/19, Teflon on coils

Figure1

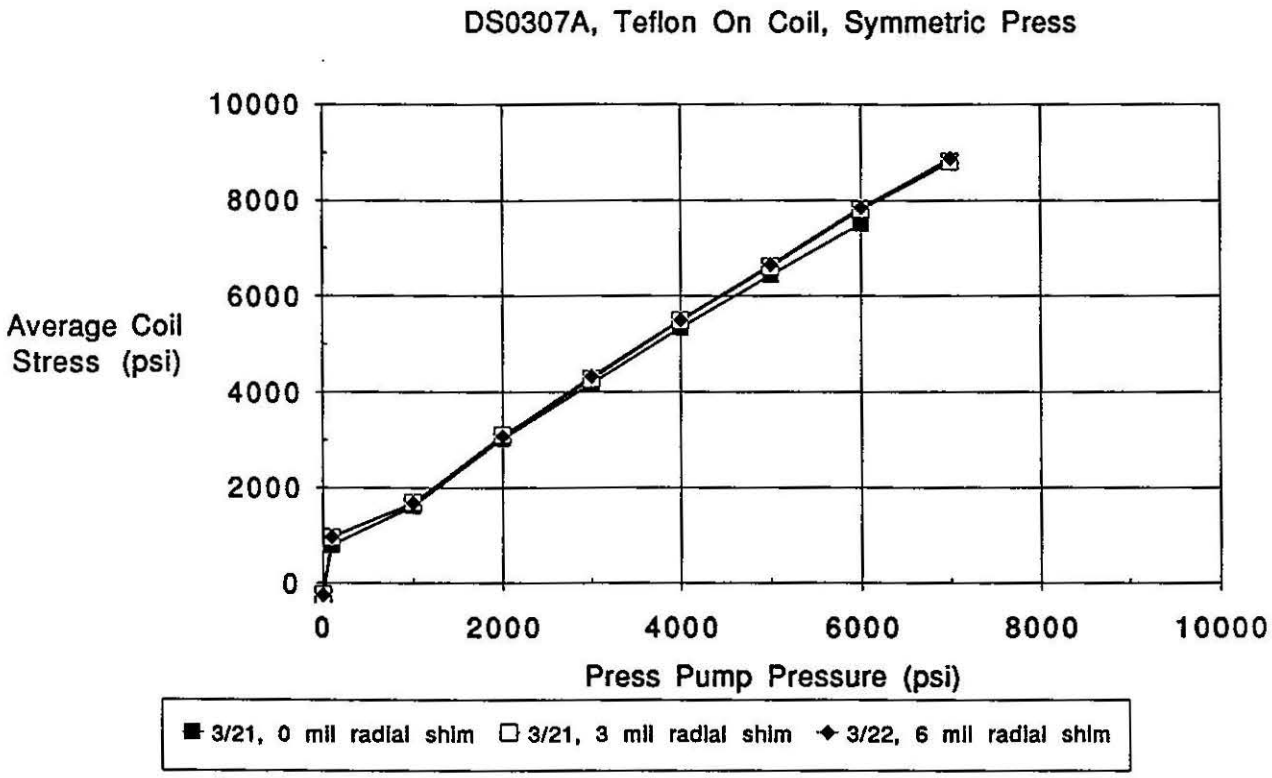
DS0307A, Teflon On Coil, Symmetric Press
Average Coil Stress (psi)
10000
8000
6000
4000
2000
0
0
2000
4000
6000
8000
10000
Press Pump Pressure (psi)
3/21, 0 mil radial shim
3/21, 3 mil radial shim
3/22, 6 mil radial shim

Figure 2

Table I

DS0307 2/27/90

	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
1	PUMP PSI 2/27/90 A.M. KEYING	Press psi (V)	Press psi (H)	#169-I coil psi	#198-I coil p	#184-o coil p	#186-o coil p	#1005-I coil p	#1004-I coil p	#183-o coil p	#188-o coil p	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
2	No Teflon, Asymmetric Press											2/27 No Tefla	2/27 No Tefla	2/27 No Tefla	2/27 No Tefla	2/27 No Tefla	2/27 No Tefla
3	Press 0	0	0	-29	-535	-78	-180	-270	-510	-77	-111	-206	-242	-224			
4	Line V	100	0	901	-266	-373	644	-318	-517	226	995	226	96	161	4.32	3.39	3.85
5	1000 V	1000	0	1387	66	-526	1081	38	-359	406	1722	502	451	477	0.31	0.39	0.35
6	2000 V	2000	0	2231	611	-332	1953	772	14	1128	3499	1116	1353	1234	0.61	0.90	0.76
7	3000 V	3000	0	2807	1087	98	2808	1374	398	2041	5140	1700	2238	1969	0.58	0.89	0.73
8	4000 V	4000	0	3481	1558	646	3615	1902	750	3003	6768	2325	3106	2715	0.62	0.87	0.75
9	5000 V	5000	0	3950	1958	1166	4308	2357	1073	3828	8035	2845	3823	3334	0.52	0.72	0.62
10	6000 V	6000	0	4468	2245	1579	5040	2707	1377	4438	9353	3333	4469	3901	0.49	0.65	0.57
11	7000 V	7000	0	4824	2474	1912	5648	2987	1624	4903	10298	3714	4952	4333	0.38	0.48	0.43
12	8000 V	8000	0	5145	2670	2193	6185	3214	1841	5323	11140	4048	5379	4714	0.33	0.43	0.38
13	9000 V	9000	0	5366	2823	2442	6629	3407	2024	5659	11795	4315	5721	5018	0.27	0.34	0.30
14	9800 V	9800	0	5548	2948	2637	6988	3529	2132	5933	12310	4530	5976	5253	0.27	0.32	0.29
15	9800 V/400 H	9800	400	5841	3159	2918	7467	3764	2343	6270	12953	4844	6338	5592			
16	9800 V/1000 H	9800	1000	6287	3455	3326	8145	4192	2669	6828	13780	5303	6867	6085			
17	4000 V/ 1000 H	4000	1000	5960	3265	2707	7306	4138	2544	5968	12387	4809	6259	5534			
18	Press 0	0	0	5259	2741	1416	6521	3536	1924	4195	9274	3734	4732	4233			
19	press 0	0	0	4901	2505	1100	5183	3324	1768	3908	8638	3422	4407	3916			
20	4000V/400H	4000	400	5029	2702	2173	6296	3281	1898	5211	10376	4060	6191	4621			
21	9800V/400H	9800	400	6386	3581	3370	8265	4088	2650	7209	12925	5400	6718	6059			
22	9800V/1000H	9800	1000	6858	3813	3708	8763	4374	2862	7660	13404	5733	7050	6392			
23	4000V/1000H	4000	1000	6356	3644	3068	7839	4312	2749	6513	11937	5227	6378	5802			
24	0V/0H	0	0	5603	3008	1911	6074	3911	2167	5004	9817	4149	5225	4687			
25	press 0 2/28/90	0	0	5328	2843	1625	5809	3709	2023	4825	9163	3902	4880	4391			
26	0					-76											
27	PUMP PSI 3/5/90 KEYING	Press psi (V)	Press psi (H)	#169-I coil psi	198-I coil ps	#184-o coil p	186-o coil p	1005-I coil p	1004-I coil p	183-o coil p	188-o coil p	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
28	Teflon Over Coil Caps, Assymetric Press									3/5, Teflon over coi		elton over coi	elton over coi	elton over coi	elton over coi	elton over coi	elton over coi
29	Bench 0 3/5/90	0	0	-88	-452	-80	-222	-225	-542	-68	-105	-211	-235	-223			
30	Line V	100	0	879	-73	-143	296	-185	-394	227	1240	240	222	231	4.61	4.67	4.64
31	1000 V	1000	0	1280	223	-243	470	87	-197	361	1727	432	492	462	0.21	0.30	0.26
32	2000 V	2000	0	2442	1055	-246	901	650	449	832	2881	1038	1248	1143	0.61	0.76	0.68
33	3000 V	3000	0	3162	1609	-100	1228	1360	885	1417	3734	1475	1849	1662	0.44	0.60	0.52
34	4000 V	4000	0	3880	2158	126	1603	1940	1329	2223	4862	1942	2588	2265	0.47	0.74	0.60
35	5000 V	5000	0	4601	2751	475	2110	2446	1750	3052	5992	2485	3310	2897	0.54	0.72	0.63
36	6000 V	6000	0	5179	3204	779	2591	2894	2145	3784	7194	2938	4004	3471	0.45	0.69	0.57
37	7000 V	7000	0	5705	3592	1092	3201	3271	2508	4360	8222	3397	4588	3993	0.48	0.58	0.52
38	8000 V	8000	0	6089	3837	1287	3675	3574	2823	4833	9169	3722	5100	4411	0.32	0.51	0.42
39	9000 V	9000	0	6555	4186	1584	4255	3858	3118	5264	9935	4145	5544	4844	0.42	0.44	0.43
40	9800 V	9800	0	6752	4320	1710	4525	3990	3257	5529	10414	4327	5797	5062	0.23	0.32	0.27
41	9800 V/400 H	9800	400	7018	4515	1951	4989	4266	3511	5896	10924	4618	6149	5384			
42	9800 V/1000 H	9800	1000	7580	4937	2341	5682	4726	3959	6546	11848	5136	6769	5952			
43	4000 V/ 1000 H	4000	1000	6556	3986	1635	4674	4014	3236	5285	9978	4213	5628	4920			
44	Press 0	0	0	5172	3018	608	3319	3213	2348	3674	7117	3029	4088	3559			
45	Press 0 3/6/90	0	0	4799	2762	388	3013	2955	2140	3419	6523	2740	3769	3250			
46	4000V/400 H	4000	400	5848	3392	1107	3850	3684	2858	4725	8143	3499	4855	4177			
47	9800 V/400 H	9800	400	7655	5179	2508	5821	5138	4265	7426	11651	5290	7120	6205			
48	9800 V/1000 H	9800	1000	7918	5284	2766	6226	5331	4466	7699	12112	5546	7402	6476			
49	4000 V/1000 H	4000	1000	6281	3908	1678	4778	4216	3420	5084	9877	4161	5674	4917			
50	Press 0	0	0	5161	3115	843	3585	3380	2488	4124	8892	3176	4721	3948			
51	press 0 3/8/90	0	0	4988	2982	708	3459	3191	2342	3873	7035	3034	4110	3572			
52	4000V/400 H	4000	400	5717	3479	1142	4233	3573	2761	4906	8349	3643	4897	4270			
53	9800 V/400 H	9800	400	6643	4237	1785	5179	4230	3425	6177	9867	4461	5926	5193			
54	9800 V/1000 H	9800	1000	6604	4254	1820	5203	4263	3438	6206	9846	4470	5938	5204			
55	4000 V/1000 H	4000	1000	5741	3587	1282	4400	3710	2876	5131	8412	3763	5082	4417			
56	Press 0	0	0	4997	3046	786	3829	3230	2387	3999	7164	3089	4193	3641			
57																	
58	PUMP PSI 3/19/90	Press psi (V)	Press psi (H)	#169-I coil psi	198-I coil ps	184-o coil p	186-o coil p	1005-I coil p	1004-I coil p	183-o coil p	188-o coil p	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
59	Teflon on coils, Asymmetric Press											3/19, Teflon	3/19, Teflon	3/19, Teflon	3/19, Teflon	3/19, Teflon	3/19, Teflon
60	0 V	0	0	-158	-550	-316	-212	-356	-494	-118	-121	-259	-273	-266			
61	Line V	100	0	400	-573	137	658	-296	-344	576	1309	155	311	233	4.14	5.84	4.99
62	1000 V	1000	0	656	-367	549	1190	-69	-261	1422	2249	515	835	675	0.40	0.58	0.49
63	2000 V	2000	0	1182	30	1565	2446	407	68	3293	4338	1306	2026	1666	0.79	1.19	0.99
64	3000 V	3000	0	1718	436	2607	3585	797	359	4996	6334	2087	3121	2604	0.78	1.09	0.94
65	4000 V	4000	0	2289	873	3678	4658	1190	660	6528	7782	2875	4040	3457	0.79	0.92	0.85
66	5000 V	5000	0	2818	1288	4692	5623	1611	958	8127	9329	3605	5006	4306	0.73	0.97	0.85
67	6000 V	6000	0	3402	1786	6218	6720	2007	1250	9556	10833	4532	6861	5196	0.93	0.86	0.89
68	7000 V	7000	0	3912	2216	6763	7643	2475	1580	11041	12111	5133	6801	5967	0.60	0.94	0.77
69	8000 v	8000	0	4590	2824	7936	8911	2892	1904	12424	13451	6065	7668	6867	0.93	0.87	0.90
70	9000 v	9000	0	5175	3285	8798	9997	3369	2310	13657	15149	6814	8621	7717	0.75	0.95	0.85
71	9800 v	9800	0	5519	3542	9245	10840	3601	2514	14169	16018	7286	9081	8184	0.59	0.67	0.63
72	0 v	0	0	-171	-628	-112	-157	-405	-605	-58	-42	-267	-278	-272	0.77	0.95	0.86

	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
74	PUMP PSI 3/20/90 AM	Press psi (V)	Press psi (H)	#169-i coil psi	#198-i coil ps	#184-o coil ps	#186-o coil ps	#1005-i coil ps	#1004-i coil ps	#183-o coil ps	#168-o coil ps	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
75	ation on Coils, Asym Press, 3 mil rad shim																
76	0 V	0	0	-153	-553	-95	-207	-352	-552	-72	-91	-252	-267	-259			
77	Line V	100	0	342	-402	307	1016	-157	-284	1032	1712	316	676	446	5.68	8.43	7.05
78	1000 V	1000	0	628	-238	824	1678	67	-154	1975	2850	723	1190	956	0.45	0.68	0.57
79	2000 V	2000	0	1220	173	1926	3137	570	169	3838	5036	1614	2408	2011	0.89	1.22	1.05
80	3000 V	3000	0	1811	586	2929	4287	995	514	5442	6858	2403	3452	2928	0.79	1.04	0.92
81	4000 V	4000	0	2344	1016	3953	5393	1406	842	6894	8271	3177	4353	3765	0.77	0.90	0.84
82	5000 V	5000	0	2911	1407	4839	6327	1793	1145	8240	9688	3871	5217	4544	0.69	0.86	0.78
83	6000 V	6000	0	3472	1857	5846	7392	2205	1475	9537	10977	4642	6048	5345	0.77	0.83	0.80
84	7000 V	7000	0	3978	2247	6664	8250	2552	1760	10688	12263	5285	6816	6050	0.64	0.77	0.71
85	8000 v	8000	0	4377	2570	7397	9159	2901	2046	11811	13300	5876	7465	6670	0.59	0.65	0.62
86	9000 v	9000	0	4799	2849	7927	9950	3172	2309	12305	14394	6381	8045	7213	0.51	0.58	0.54
87	9800 v	9800	0	5013	3008	8230	10472	3304	2440	12636	14888	6681	8317	7499	0.37	0.34	0.36
88	0 v	0	0	-189	-615	-100	-148	-374	-579	-43	-18	-263	-253	-258	0.71	0.87	0.79
89																	
90	PUMP PSI 3/20/90 PM	Press psi (V)	Press psi (H)	#169-i coil psi	#198-i coil ps	#184-o coil ps	#186-o coil ps	#1005-i coil ps	#1004-i coil ps	#183-o coil ps	#168-o coil ps	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
91	ation on Coils, Asym Press, 6 mil rad shim																
92	0 V	0	0	-137	-523	-76	-184	-286	-498	-26	-47	-226	-213	-219			
93	Line V	100	0	422	-326	412	1137	-90	-185	1266	1885	411	720	565	6.36	9.32	7.84
94	1000 V	1000	0	715	-165	867	1804	133	-10	2132	2913	805	1292	1049	0.44	0.64	0.54
95	2000 V	2000	0	1446	302	2030	3217	651	391	4037	5181	1749	2565	2157	0.94	1.27	1.11
96	3000 V	3000	0	1999	695	2988	4316	1059	735	5462	6816	2500	3518	3009	0.75	0.95	0.85
97	4000 V	4000	0	2598	1125	4013	5388	1479	1077	6951	8410	3276	4479	3878	0.78	0.98	0.87
98	5000 V	5000	0	3115	1544	4982	6354	1868	1398	8239	9664	3999	5292	4646	0.72	0.81	0.77
99	6000 V	6000	0	3621	1931	5880	7269	2270	1722	9527	11056	4675	6144	5410	0.68	0.85	0.76
100	7000 V	7000	0	#VALUE!	#VALUE!	#VALUE!	#VALUE!	2661	2068	10765	12384	#VALUE!	6969	#VALUE!	#VALUE!	0.83	#VALUE!
101	8000 v	8000	0	4677	2797	545	9424	3110	2413	12013	13839	4361	7844	6102	#VALUE!	0.87	#VALUE!
102	9000 v	9000	0	5138	3130	8457	10246	3466	2735	12883	14953	6743	8504	7624	2.36	0.98	1.62
103	9800 v	9800	0	5340	3261	8758	10695	3591	2862	13174	15421	7014	8762	7888	0.34	0.32	0.33
104	0 v	0	0	-176	-581	-82	-163	-352	-561	-22	-25	-250	-240	-245	0.74	0.92	0.83
105																	
106	PUMP PSI 3/21/90 A.M.	Press psi (V)	Press psi (H)	#169-i coil psi	#198-i coil ps	#184-o coil ps	#186-o coil ps	#1005-i coil ps	#1004-i coil ps	#183-o coil ps	#168-o coil ps	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
107	Teflon on Coils, No radial shim											3/21, 0 mil r	3/21, 0 mil r	3/21, 0 mil r	3/21, 0 mil r	3/21, 0 mil r	3/21, 0 mil r
108	0 V	0	0	-125	-577	-87	-224	-330	-545	-10	-37	-253	-231	-242			
109	Line V	100	0	502	-363	722	1723	-76	-293	1493	2649	846	943	795	8.99	11.74	10.37
110	1000 V	1000	0	957	-59	1546	2948	262	-9	2884	4454	1348	1898	1623	0.76	1.06	0.92
111	2000 V	2000	0	1920	523	3005	4917	861	544	5107	7304	2591	3454	3023	1.24	1.56	1.40
112	3000 V	3000	0	2726	1074	4338	6623	1395	1029	6917	9363	3690	4673	4182	1.10	1.22	1.16
113	4000 V	4000	0	3562	1644	5656	8226	1960	1538	8749	11422	4772	5917	5345	1.08	1.24	1.16
114	5000 V	5000	0	4349	2235	6967	9813	2518	2040	10403	13198	5841	7039	6440	1.07	1.12	1.10
115	6000 V	6000	0	5087	2800	8204	11184	3107	2555	12089	15002	6819	8188	7503	0.98	1.15	1.06
116	0 V	0	0	-169	-587	-91	-125	-361	-556	-18	-3	-241	-234	-238	1.18	1.40	1.29
117																	
118	PUMP PSI 3/21/90 P.M.	Press psi (V)	Press psi (H)	#169-i coil psi	#198-i coil ps	#184-o coil ps	#186-o coil ps	#1005-i coil ps	#1004-i coil ps	#183-o coil ps	#168-o coil ps	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
119	Teflon on Coils, 3 mil radial shim											3/21, 3 mil r	3/21, 3 mil r	3/21, 3 mil r	3/21, 3 mil r	3/21, 3 mil r	3/21, 3 mil r
120	0 V	0	0	-165	-568	-82	-182	-322	-556	-11	-20	-249	-227	-238			
121	Line V	100	0	546	-321	842	1896	35	-189	1797	3009	741	1163	952	9.90	13.90	11.90
122	1000 V	1000	0	977	-50	1580	2970	333	41	2995	4590	1369	1990	1680	0.70	0.92	0.81
123	2000 V	2000	0	1884	507	3027	4937	954	601	5233	7636	2589	3606	3097	1.22	1.62	1.42
124	3000 V	3000	0	2711	1090	4376	6618	1474	1079	7052	9753	3899	4639	4269	1.11	1.23	1.17
125	4000 V	4000	0	3547	1673	5714	8234	2107	1624	8993	12008	4792	6183	5487	1.09	1.34	1.22
126	5000 V	5000	0	4385	2303	7061	9861	2678	2132	10664	13868	5902	7335	6619	1.11	1.15	1.13
127	6000 V	6000	0	5202	2939	8409	11392	3311	2661	12500	15980	6955	8618	7802	1.08	1.28	1.18
128	7000 V	7000	0	5930	3538	9633	12646	3839	3153	13959	17615	7987	9617	8802	1.00	1.00	1.00
129	0 V	0	0	-119	-588	-79	-118	-348	-547	7	29	-226	-215	-220	1.17	1.40	1.29
130																	
131	PUMP PSI 3/22/90 8.30/ AM.KEVING	Press psi (V)	Press psi (H)	#169-i coil psi	#198-i coil ps	#184-o coil ps	#186-o coil ps	#1005-i coil ps	#1004-i coil ps	#183-o coil ps	#168-o coil ps	Avg In Stress	Avg Out Stres	Avg Stress	d(in)/dPv	d(out)/dPv	d(avg)/dPv
132	Teflon on Coils, 6 mil radial shim											3/22, 6 mil r	3/22, 6 mil r	3/22, 6 mil r	3/22, 6 mil r	3/22, 6 mil r	3/22, 6 mil r
133	0 V	0	0	-147	-574	-80	-167	-326	-558	6	-28	-237	-227	-232			
134	Line V	100	0	595	-236	786	1818	81	-135	1916	2940	740	1201	970	9.77	14.27	12.02
135	1000 V	1000	0	1026	22	1460	2791	427	147	3115	4495	1325	2046	1686	0.65	0.94	0.79
136	2000 V	2000	0	1955	626	2846	4702	1086	736	5313	7438	2532	3643	3088	1.21	1.60	1.40
137	3000 V	3000	0	2821	1202	4153	6330	1698	1262	7314	9818	3628	5028	4327	1.09	1.38	1.24
138	4000 V	4000	0	3636	1857	5531	7974	2298	1805	9102	11825	4750	6257	5504	1.12	1.23	1.18
139	5000 V	5000	0	4456	2469	6802	9443	2940	2348	10906	13901	5792	7524	6658	1.04	1.27	1.15
140	6000 V	6000	0	5337	3187	8223	11091	3670	2915	12658	15787	6959	8733	7846	1.17	1.21	1.19
141	7000 V	7000	0	6030	3780	9422	12340	4175	3433	14305	17521	7893	9858	8878	0.93	1.13	1.03
142	7000 V/400 H	7000	400H	6319	4050	9922	12938	4423	3619	14902	18164	8307	10277	9292			
143	7000 V/1000 H	7000	1000H	6481	4208	10214	13121	4578	3724	15257	18576	8501	10533	9517			
144	3000 V/1000 H	3000	1000H	4930	3035	8000	10651	3506	2656	12486	15285	6854	8484	7669			
145	0	0	0	3780	2501	6140	8349	2604	1850	10084	12153	5188	6558	5928			