

APPENDIX

Fracture Toughness Data

J data (X60, D=30, t=0.375)

t (in)	Y (lb/in-in)	stress	modulus	radius (in)	n	alpha
0.375	60000	60000	30000000	15	10	10453943

Stress=72% Yield Stress

c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J	h1	J pl	J (72%)
0.5	54143	0.569834275	63274.65862	133.4560808	5.59	94.515	227.97106
1	76570	1.139668551	101424.3487	342.8966172	5.59	189.03	531.92658
1.5	93779	1.709502826	142193.3098	673.9645789	5.59	283.545	957.50952
2	108286	2.279337101	187314.6913	1169.559785	5.59	378.06	1547.6197
2.5	121068	2.849171377	236844.1834	1869.838907	5.59	472.575	2342.4138
3	132623	3.419005652	290459.0571	2812.215462	5.59	567.09	3379.3053
3.5	143249	3.988839927	347765.4305	4031.359821	5.59	661.605	4692.9647
4	153140	4.558674203	408382.1447	5559.199204	5.59	756.12	6315.319
4.5	162430	5.128508478	471961.3654	7424.917679	5.59	850.635	8275.5525
5	171216	5.698342753	538190.1941	9654.956168	5.59	945.15	10600.106
5.5	179573	6.268177028	606786.9257	12273.01244	5.59	1039.66	13312.677
6	187557	6.838011304	677496.2977	15300.04111	5.59	1134.18	16434.2211
6.5	195216	7.407845579	750085.0683	18754.25366	5.59	1228.69	19982.948
7	202585	7.977679854	824338.2508	22651.11839	5.59	1323.21	23974.328
7.5	209696	8.54751413	900056.0064	27003.36049	5.59	1417.72	28421.085
8	216573	9.117348405	977051.1036	31820.96197	5.59	1512.24	33333.202
8.5	223238	9.68718268	1055146.838	37111.16169	5.59	1606.75	38717.916
9	229710	10.25701696	1134175.322	42878.45539	5.59	1701.27	44579.725
9.5	236005	10.82685123	1213976.058	49124.59563	5.59	1795.78	50920.38
10	242136	11.39668551	1294394.745	55848.59182	5.59	1890.3	57738.891
10.5	248115	11.96651978	1375282.265	63046.71025	5.59	1984.81	65031.525
11	253954	12.53635406	1456493.811	70712.47402	5.59	2079.33	72791.804
11.5	259662	13.10618833	1537888.128	78836.66311	5.59	2173.84	81010.508
12	265246	13.67602261	1619326.845	87407.31434	5.59	2268.36	89675.674

Stress=60% Yield Stress

c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J	h1	J pl	J (60%)
0.5	45119	0.554144385	51837.05997	89.56935953	5.59	12.7206	102.28994
1	63808	1.10828877	82740.06022	228.1972522	5.59	25.4412	253.63841
1.5	78149	1.662433155	115555.9295	445.1057616	5.59	38.1617	483.2675
2	90239	2.21657754	151770.8772	767.8133053	5.59	50.8823	818.69563
2.5	100890	2.770721925	191478.5602	1222.134634	5.59	63.6029	1285.7375
3	110519	3.32486631	234447.0622	1832.180833	5.59	76.3235	1908.5043
3.5	119374	3.879010695	280376.1395	2620.359321	5.59	89.0441	2709.4034
4	127617	4.43315508	328969.9309	3607.373849	5.59	101.765	3709.1385
4.5	135358	4.987299465	379956.2279	4812.224503	5.59	114.485	4926.7097
5	142680	5.54144385	433089.1722	6252.207703	5.59	127.206	63794.135
5.5	149644	6.095588235	488146.9923	7942.916202	5.59	139.926	80828.426
6	156298	6.64973262	544928.594	9898.239086	5.59	152.647	100508.86
6.5	162680	7.203877005	603250.241	12130.36178	5.59	165.368	12295.729
7	168821	7.75802139	662942.6678	14649.76603	5.59	178.088	14827.854
7.5	174746	8.312165775	723848.6705	17465.22993	5.59	190.809	17656.039
8	180477	8.86631016	785821.1227	20583.8279	5.59	203.529	20787.357
8.5	186032	9.420454545	848721.3445	24010.93069	5.59	216.25	24227.181
9	191425	9.97459893	912417.7562	27750.2054	5.59	228.97	27979.176
9.5	196671	10.52874332	976784.7579	31803.61544	5.59	241.691	32045.306
10	201780	11.0828877	1041701.789	36171.42058	5.59	254.412	36425.832
10.5	206763	11.63703209	1107052.531	40852.17689	5.59	267.132	41119.309
11	211628	12.19117647	1172724.224	45842.73682	5.59	279.853	46122.59
11.5	216385	12.74532086	123860707	5113824911	5.59	292.573	51430.822

J data (X60, D=30, t=0.375)

12	221039	13	29946524	1304593	717	56732.15885	5	59	305	294	57037	4531
Stress=50% Yield Stress												
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el		h1	J pl	J (50%)				
0.5	37599	0.540909091	42568.05473	60.40130946		5.59	171204	62.113347				
1	53174	1.081818182	677034549	152.7919268		5.59	3.42407	156.216				
1.5	65124	1.622727273	9424724692	296.084785		5.59	5.13611	301.2209				
2	75199	2.163636364	1234648241	508.1187598		5.59	6.84815	514.96691				
2.5	84075	2.704545455	1554662667	805.6586696		5.59	8.56019	814.21886				
3	92099	3.245454545	190083.8191	1204.395276		5.59	10.2722	1214.6675				
3.5	99479	3.786363636	227086.6761	1718.945282		5.59	11.9843	1730.9295				
4	106347	4.327272727	266243.385	2362.851335		5.59	13.6963	2376.5476				
4.5	112798	4.868181818	307339.3251	3148.582025		5.59	15.4083	3163.9904				
5	118900	5.409090909	350179.8917	4087.531884		5.59	17.1204	4104.6523				
5.5	124703	5.95	394589.2062	5190.021388		5.59	18.8324	5208.8538				
6	130248	6.490909091	440407.6618	6465.296953		5.59	20.5444	6485.8414				
6.5	135567	7.031818182	487489.4134	7921.530941		5.59	22.2565	7943.7874				
7	140684	7.572727273	535700.149	9565.821655		5.59	23.9685	9589.7902				
7.5	145622	8.113636364	584915.2077	11404.19334		5.59	25.6806	11429.8741				
8	150398	8.654545455	635018.02	13441.59619		5.59	27.3926	13468.989				
8.5	155026	9.195454545	685898.819	15681.90633		5.59	29.1046	15711.011				
9	159521	9.736363636	7374535749	1812792584		5.59	30.8167	18158743				
9.5	163892	10.27727273	7895831064	2078138273		5.59	32.5287	20813911				
10	168150	10.81818182	842192.335	23642.93097		5.59	34.2407	23677.172				
10.5	172302	11.35909091	895189.6524	26712.15046		5.59	35.9528	26748.103				
11	176357	11.9	948486.379	29987.54704		5.59	37.6648	30025212				
11.5	180321	12.44090909	1001996.295	33466.5525		5.59	39.3769	33505929				
12	184199	12.98181818	1055635.229	37145.52458		5.59	41.0889	37186613				

Stress=40% Yield Stress												
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el		h1	J pl	J (40%)				
0.5	30080	0.528213166	33569.43343	37.56356203		5.59	0.14706	37.710625				
1	42539	1.056426332	53209.27351	94.37422625		5.59	0.29413	94.6683521				
1.5	52099	1.584639498	73836.23909	181.7263401		5.59	0.44119	182.16753				
2	60159	2.112852665	96481.47299	310.2891543		5.59	0.58825	310.87741				
2.5	67260	2.641065831	121256.7717	490.1068232		5.59	0.73531	490.84214				
3	73680	3.169278997	148047.128	730.5984041		5.59	0.88238	731.48078				
3.5	79583	3.697492163	176682.5847	1040.557858		5.59	1.02944	1041.5873				
4	85078	4.2257053298	206989.4236	1428.154049		5.59	1.1765	1429.3306				
4.5	90239	4.753918495	238805.1975	1900.930745		5.59	1.32357	1902.2543				
5	95120	5.282131661	271981.9819	2465.806617		5.59	1.47063	2467.2772				
5.5	99763	5.810344828	306385.7979	3129.075238		5.59	1.61769	3130.6929				
6	104199	6.338557994	341894.9439	3896.405088		5.59	1.76475	3898.1698				
6.5	108453	6.86677116	378398.185	4772.839547		5.59	1.91182	4774.7514				
7	112547	7.394984326	415793.1059	5762.796899		5.59	2.05888	5764.8558				
7.5	116498	7.923197492	453984.7023	6870.070332		5.59	2.20594	6872.2763				
8	120318	8.451410658	492884.2036	8097.827937		5.59	2.35301	8100.1809				
8.5	124021	8.979623824	532408.0966	9448.612709		5.59	2.50007	9451.1128				
9	127617	9.507836991	572477.3152	10924.34255		5.59	2.64713	10926.99				
9.5	131114	10.03605016	613016.5638	12526.31025		5.59	2.79419	12529.1041				
10	134520	10.56426332	653953.7489	14255.18352		5.59	2.94126	14258.125				
10.5	137842	11.09247649	695219.4972	16111.00497		5.59	3.08832	16114.093				
11	141086	11.62068966	736746.7431	18093.19212		5.59	3.23538	18096.428				
11.5	144256	12.14890282	778470.3725	20200.53736		5.59	3.38245	20203.92				
12	147359	12.67711599	820326.9111	22431.20803		5.59	3.52951	22434.738				

J data (X60, D=24, t=0.375)

t (in)	Y (lb/in-in)	stress	modulus	radius (in)	n	alpha
0	0	0	0	10	10	10.453943
Stress=72% Yield Stress						
c (in)	K1(c) c[eff] (in)	K1(c[eff])	J ei	h1	J pl	J (72%)
0.5	54143	0.569834275	64138.78896	137.1261416	5.59	94.515
1	76570	1.139668551	104688.7602	365.3245505	5.59	189.03
1.5	93779	1.709502826	149101.4931	741.0418417	5.59	283.545
2	108286	2.279337101	198762.9967	1316.890962	5.59	378.06
2.5	121068	2.849171377	253474.9212	2141.651189	5.59	472.575
3	132623	3.419005652	312742.7761	3260.268133	5.59	567.09
3.5	143249	3.988839927	376052.6719	4713.853734	5.59	661.605
4	153140	4.558674203	442934.0672	6539.686263	5.59	756.12
4.5	162430	5.128508478	512968.1372	8771.21075	5.59	850.635
5	171216	5.698342753	585782.4729	11438.03685	5.59	945.15
5.5	179573	6.2681777028	661043.337	14565.94311	5.59	1099.66
6	187557	6.838011304	738448.4959	18176.8727	5.59	1134.18
6.5	195216	7.407845579	817721.2646	22288.93555	5.59	1228.69
7	202585	7.977679854	898605.7187	26916.40792	5.59	1323.21
7.5	209696	8.54751413	980862.8711	32069.7324	5.59	1417.17
8	216573	9.117348405	1064267.606	37755.51791	5.59	1512.24
8.5	223238	9.68718268	1148606.195	43976.53971	5.59	1606.75
9	229710	10.25701696	1233674.261	50731.73937	5.59	1701.27
9.5	236005	10.82685123	1319275.083	58016.22483	5.59	1795.78
10	242136	11.39668551	1405218.112	65821.27032	5.59	1890.3
10.5	248115	11.96651978	1491318.039	74134.31642	5.59	1984.81
11	253954	12.53635406	1577393.135	82938.97006	5.59	2079.33
11.5	259662	13.10618833	1663264.902	92715.00445	5.59	2173.84
12	265246	13.67602261	1748756.923	101938.3592	5.59	2268.36
Stress=60% Yield Stress						
c (in)	K1(c) c[eff] (in)	K1(c[eff])	J ei	h1	J pl	J (60%)
0.5	45119	0.554144385	52519.63251	91.94372664	5.59	12.7206
1	63808	1.10828877	85320.39813	242.6523446	5.59	25.4412
1.5	78149	1.662433155	121030.1302	488.2764137	5.59	38.1617
2	90239	2.21657754	160865.0566	862.5855479	5.59	50.8823
2.5	100890	2.770721925	204717.0058	1396.968415	5.59	63.6029
3	110519	3.32486631	252216.1416	2120.432736	5.59	76.3235
3.5	119374	3.879010695	302965.6064	3059.605288	5.59	89.0441
4	127617	4.43315508	356597.7523	4238.731899	5.59	101.765
4.5	135358	4.987299465	412783.6281	5679.677453	5.59	114.485
5	142680	5.54144385	471230.0676	7401.925888	5.59	127.206
5.5	149644	6.095688235	531674.1538	9422.580195	5.59	139.926
6	156298	6.64973262	593877.8263	11756.36242	5.59	152.647
6.5	162680	7.203877005	657623.3039	14415.61366	5.59	165.368
7	168821	7.75802139	722709.3621	17410.29407	5.59	178.088
7.5	174746	8.312165775	788948.3416	20747.98286	5.59	190.809
8	180477	8.86631016	856163.7392	24433.87828	5.59	203.529
8.5	186032	9.420454545	924188.2544	28470.79766	5.59	216.25
9	191425	9.97459893	992862.1861	32859.17735	5.59	228.97
9.5	196671	10.52874332	1062032.101	37597.07279	5.59	241.691
10	201780	11.0828877	1131549.713	42680.15846	5.59	254.412
10.5	206763	11.63703209	1201270.925	48101.72787	5.59	267.132
11	211628	12.19117647	1271054.998	53852.69362	5.59	279.853
11.5	216385	12.745322086	1340763.82	59921.58735	5.59	292.573

J data (X60, D=24, t=0.375)

12	221039	1329946524	141026125	6629455974	5.59	305.294	66599854
Stress=50% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (50%)
0.5	37599	0.540909091	43111.12697	61.95230896	5.59	1.71204	63.664346
1	53174	1.081818182	69757.38733	162.2031029	5.59	3.42407	165.62718
1.5	65124	1.622727273	98613.76848	324.1558445	5.59	5.13611	329.29196
2	75199	2.163636364	130734.0379	569.7129555	5.59	6.84815	576.5611
2.5	84075	2.704545455	166067.0784	919.2758173	5.59	8.56019	927.836
3	92099	3.245454545	204333.9011	1391.744771	5.59	10.2722	1402.017
3.5	99479	3.786363636	245225.5563	2004.519116	5.59	11.9843	2016.5034
4	106347	4.327272727	288452.6189	2773.497112	5.59	13.6963	2787.1934
4.5	112798	4.868181818	333754.8192	3713.075979	5.59	15.4083	3728.4843
5	118900	5.409090909	380899.6676	4836.151894	5.59	17.1204	4853.2723
5.5	124703	5.95	429678.4843	6154.119995	5.59	18.8324	6172.9524
6	130248	6.490909091	479902.3144	7676.874379	5.59	20.5444	7697.4188
6.5	135567	7.031818182	531398.3846	9412.808104	5.59	22.2565	9435.0646
7	140684	7.572727273	584007.1879	11368.81318	5.59	23.9685	11392.782
7.5	145622	8.113636364	637580.1266	13550.28059	5.59	25.6806	13575.961
8	150398	8.654545455	691977.6067	15961.10027	5.59	27.3926	15988.493
8.5	155026	9.195454545	747067.4891	18603.66111	5.59	29.1046	18632.766
9	159521	9.736363636	802723.8184	21478.85096	5.59	30.8167	21509.668
9.5	163892	10.27727273	858825.7675	24586.05663	5.59	32.5287	24618.585
10	168150	10.81818182	915256.7493	27923.16391	5.59	34.2407	27957.405
10.5	172302	11.35909091	971903.6605	31486.55751	5.59	35.9528	31522.51
11	176357	11.9	1028656.227	35271.12114	5.59	37.6648	35308.786
11.5	180321	12.44090909	1085406.432	39270.23743	5.59	39.3769	39309.614
12	184199	12.98181818	1142048.003	43475.78801	5.59	41.0889	43516.877
Stress=40% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (40%)
0.5	30080	0.528213166	33984.58683	38.49840474	5.59	0.14706	38.645468
1	42539	1.056426332	54779.92642	100.0280113	5.59	0.29413	100.32214
1.5	52099	1.584639498	77181.94311	198.5684114	5.59	0.44119	199.0096
2	60159	2.112852665	102062.5687	347.2255978	5.59	0.58825	347.81385
2.5	67260	2.641065831	129410.0418	558.2319642	5.59	0.73531	558.96728
3	73680	3.169278997	159023.2346	842.9463049	5.59	0.88238	843.82868
3.5	79583	3.697492163	190671.4831	1211.853815	5.59	1.02944	1212.8833
4	85078	4.225705329	224136.0809	1674.566092	5.59	1.1765	1675.7426
4.5	90239	4.753918495	259219.2778	2239.821132	5.59	1.32357	2241.1447
5	95120	5.282131661	295743.9771	2915.483333	5.59	1.47063	2916.954
5.5	99763	5.810344828	333551.0528	3708.543495	5.59	1.61769	3710.1612
6	104199	6.338557994	372496.3953	4625.118816	5.59	1.76475	4626.8836
6.5	108453	6.86677116	412448.284	5670.452899	5.59	1.91182	5672.3647
7	112547	7.394984326	453285.1998	6848.915744	5.59	2.05888	6850.9746
7.5	116498	7.923197492	494894.0418	8164.003754	5.59	2.20594	8166.2097
8	120318	8.451410658	537168.6811	9618.339733	5.59	2.35301	9620.6927
8.5	124021	8.979623824	580008.7814	11213.67288	5.59	2.50007	11216.173
9	127617	9.507836991	623318.8305	12950.87881	5.59	2.64713	12953.526
9.5	131114	10.03605016	667007.3357	14829.95953	5.59	2.79419	14832.754
10	134520	10.56426332	710986.1483	16850.04343	5.59	2.94126	16852.985
10.5	137842	11.09247649	755169.8883	19009.38534	5.59	3.08832	19012.474
11	141086	11.62068966	799475.449	21305.36645	5.59	3.23538	21308.602
11.5	144256	12.14890282	843821.5637	23734.49438	5.59	3.38245	23737.877
12	147359	12.67711599	888128.4221	26292.40314	5.59	3.52951	26295.933

data (X00, D=24, t=0.312)

(in)	Y (lb/in-in)	stress'	modulus	radius (in) .n	alpha		
0 312	60000	60000	30000000	12	10 10.453943		
stress=72% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (72%)
0.5	54143.17073	0.569834275	64961 58867	140.6669	5.59	94.51498	235.1819
1	76570.00636	1.139668551	107784.7072	387.2514	5.59	189.02996	576.2814
1.5	93778.72259	1.709502826	155589.0985	806.9323	5.59	283.54494	1090.477
2	108286.3415	2.279337101	209416.0819	1461.837	5.59	378.05992	1839.896
2.5	121067.8103	2.849171377	268833.0193	2409.04	5.59	472.5749	2881.615
3	132623.1413	3.419005652	333192.1005	3700.566	5.59	567.08988	4267.656
3.5	143249.3649	3.988839927	401872.6359	5383.387	5.59	661.60486	6044.992
4	153140.0127	4.558674203	474323.4468	7499.424	5.59	756.11984	8255.544
4.5	162429.5122	5.128508478	550060.3594	10085.55	5.59	850.63482	10936.18
5	171215.7393	5.698342753	628655.0251	13173.57	5.59	945.1498	14118.72
5.5	179572.5823	6.268177028	709723.8429	16790.26	5.59	10396648	1782993
6	187557.4452	6.838011304	792918.7886	20957.34	5.59	1134.1798	22091.52
6.5	195215.9783	7.407845579	877920.1769	25691.46	5.59	1228.6947	26920.16
7	202585.1947	7.977679854	964431.0031	31004.24	5.59	1323.2097	32327.45
7.5	209695.5986	8.54757413	1052172.494	36902.23	5.59	1417.7247	38319.96
8	216572.6829	9.117348405	1140880.566	43386.95	5.59	1512.2397	44899.19
8.5	223238.0118	9.68718268	1230302.959	50454.85	5.59	1606.7547	52061.6
9	229710.0191	10.25701696	1320196.884	58097.33	5.59	1701.2696	59798.6
9.5	236004.6097	10.82685123	1410327.047	66300.75	5.59	17957846	6809653
10	242135.6205	11.39668551	1500463.967	75046.4	5.59	18902996	769367
10.5	248115.1782	11.96651978	1590382.507	84310.55	5.59	19848146	86295.37
11	253953.9813	12.53635406	1679860569	94064.38	5.59	2079.3296	96143.71
11.5	259661.525	13.10618833	1768677.91	104274.1	5.59	2173.8445	106447.9
12	2652462827	1367602261	1856615.045	1149006	5.59	2268.3595	117769
stress=60% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (60%)
0.5	45119.30894	0.554144385	53169.45397	94.23303	5.59	12.720581	106.9536
1	63808.33863	1.10828877	87768.76401	256.7785	5.59	25.441162	282.2197
1.5	78148.93549	1.662433155	126175.2627	530.6732	5.59	38.161742	568.835
2	90238.61789	2.21657754	169335.4499	955.8165	5.59	50.882323	1006.699
2.5	100889.8419	2.770721925	216954.163	1568.97	5.59	63.602904	1632.573
3	110519.2845	3.32486631	268538.226	2403.759	5.59	76.323485	2480.083
3.5	119374.4708	3.879010695	323604.8868	3490.671	5.59	89.044065	3579.715
4	127616.6773	4.43315508	381721.938	4857.055	5.59	101.76465	4958.819
4.5	135357.9268	4.987299465	442508.4192	6527.123	5.59	114.48523	6641.809
5	142679.7827	5.54144385	505626.9057	8521.952	5.59	127.20581	8649.158
5.5	149643.8186	6.095588235	570775.2385	10859.48	5.59	139.92639	10999.41
6	156297.871	6.64973262	637679.4889	13554.5	5.59	152.64697	13707.15
6.5	162679.9819	7.203877005	706088.3328	16618.69	5.59	165.36755	16784.06
7	168820.9956	7.75802139	775768.622	20060.57	5.59	178.08813	20238.65
7.5	174746.3321	8.312165775	846501.8874	23885.51	5.59	190.80871	24076.32
8	180477.2358	8.86631016	918081.5519	28095.79	5.59	203.52929	28299.32
8.5	186031.6765	9.420454545	990310.6767	32690.51	5.59	216.24987	32906.76
9	191425.0159	9.97459893	1063000.111	37665.64	5.59	228.97045	37894.61
9.5	196670.5081	10.52874332	1135966.946	43014.03	5.59	241.69103	43255.72
10	201779.6838	11.0828877	1209033.201	48725.313	5.59	254.41162	48979.79
10.5	206762.6485	11.63703209	1282024.689	54786.24	5.59	267.1322	55053.38
11	2116283177	12.19117647	1354770.006	61180.06	5.59	279.85278	61459.91
11.5	2163846041	12.74532086	1427099634	67887.11	5.59	292.57336	68179.69

J data (X60, D=24, t=0.312)

12	221038	5689	1E	29946524	1498845	708	74884	56	5.59	EOS	29394	75189	85
Stress=50% Yield Stress													
c (in) K1(c) c[eff] (in) K1(c[eff]) J ei h1 J pl J (50%)													
0	S	37599	42412	0	540909091	43628	06144	6E	44692	S	59	1	7120373
1	S	53173	61553	1	081818182	71707	04788	171	3967	S	59	E	748208
1	S	65124	11291	1	622727273	702720	6586	EST	7178	S	59	5	136112
2	S	75198	84824	Z	163636364	137510	081E	630	3008	S	59	6	8481494
2.5	Z	84074	86825	Z	10SPSPSS	175874	2501	1031	058	S	59	8	5601867
3	E	92099	DOE1Z	3	245454545	217434	4947	1S7S	9ZS	S	59	10	77ZZD
3.5	E	99478	72566	E	786363636	261812	4369	2284	8S8	S	59	11	984261
4	—	106347	2311	4	327272727	308666	6444	3175	8C7	S	59	-1E	696299
4	S	112798	Z7ZD	4	868181818	357695	7S1Z	4264	861	S	59	1S	408336
4	S	118899	8189	5	409090909	408630	1865	5565	954	S	59	17	120373
5	S	124703	1821	S	9S	461231	898S	7091	162	S	59	18	832411
6	S	130248	2258	6	490909091	515282	9788	8850	552	S	59	20	544448
6	S	135566	6516	7	031818182	570584	2285	10852	21	S	59	22	256485
7	S	140684	16E	7	572727273	626951	07E	13102	ZS	S	59	Z	968523
7.5	PEP	145621	9PEP	8	113636364	684210	7956	15604	81	S	59	25	68056
8	S	150397	6965	8	654545455	7PZ700	3262	18362	QI	S	59	27	392598
8	S	155026	3971	9	195454545	800764	PPSS	Z7E1P	12	S	59	29	104635
9	S	159520	8466	9	736363636	859754	3677	24639	ZS	S	59	30	816672
9	S	163892	0901	10	277272723	919026	4193	28153	65	S	59	32	52871
10	S	168149	7365	10	818181818	978441	1027	31911	S7	S	59	34	ZPLOPL
10	S	17ZE0Z	Z07D	11	35909091	1037862	1SD	35905	26	S	59	SE	952784
11	S	176356	9315	11	9	1097155	768	40125	03	S	59	ET	664822
11	S	180320	SOES	12	44090909	1156189	9	44559	17	S	59	EP	376859
12	S	184198	8074	12	98181818	1214833	625	49194	02	S	59	4	088896
Stress=40% Yield Stress													
c (in) K1(c) c[eff] (in) K1(c[eff]) J ei h1 J pl J (40%)													
0	S	30079	5393	0	528213166	34379	69332	EP	39878	S	59	0	1470629
1	S	42538	89242	1	056426332	56271	139578	105	SDP	S	59	0	2941258
1	S	52099	29033	1	584639498	80330	81972	215	1014	S	59	0	4411887
Z	S	60159	07859	Z	112852665	107269	1084	383	5554	S	59	0	5882516
Z	S	67259	8946	Z	2641065831	136959	0646	625	2595	S	59	0	7353144
E	S	73679	52297	E	1692778997	169122	2342	9SE	411	S	59	0	8823773
3	S	79582	98053	E	697492163	203474	0Z7S	1380	056	S	59	1	0294402
4	S	85077	78484	4	225705329	239755	4684	1916	089	S	59	1	1765031
4	S	90238	61789	4	753918495	277736	6743	2571	ZSS	S	59	1	323566
4	S	95119	85514	5	2827131661	317213	4745	3354	146	S	59	1	4706289
S	S	99762	54571	S	810344828	358002	9563	PZ7Z	204	S	59	1	6176918
6	S	104198	5807	6	338557994	399939	4438	5331	719	S	59	1	7647547
6.5	S	108453	3213	6	866777116	442871	11931	6537	83	S	59	1	9118175
7	S	112547	3304	7	394984326	486657	7512	7894	526	S	59	2	0588804
7	S	116497	5548	7	923197492	531167	7541	9404	643	S	59	Z	2059433
8	S	120318	1572	8	451410658	576277	7437	11069	87	S	59	2	3530062
8	S	124021	1177	8	979623824	621869	806	12890	74	S	59	2	5000691
9	S	127616	671E	9	S07836991	667831	14542	14866	63	S	59	Z	647132
9	S	131113	6721	10	03605016	714054	1991	16995	78	S	59	Z	7941949
10	S	134519	7892	10	56426332	760432	86E7	19275	21	S	59	Z	9412578
10	S	137841	7657	11	09247649	806864	9084	21701	03	S	59	E	0883207
11	S	141085	5452	11	62068966	853249	8415	24267	84	S	59	E	2363835
11	S	144256	4028	12	14890282	899488	69SS	26969	33	S	59	E	3824464
1Z	S	147359	0459	1Z	677711599	945483	SSZS	29797	91	S	59	3	5295093

t (in)-	Y (lb/in-in)	stress'	modulus	radius (in)-n	alpha		
0.312	60000	60000	30000000	8	10- 10453943		
Stress=72% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (72%)
0.5	5414317073	0.569834275	6720563226	1505532	5.59	94.51498	245.0682
1	7657000636	1.139668551	1161379733	449601	5.59	189.02996	638.6309
1.5	93778.72259	1.709502826	1728025015	9953568	5.59	283.54494	1278.902
2	108286.3415	2.279337101	237281.7339	1876.754	5.59	378.05992	2254.814
2.5	121067.8103	2.849171377	308550.4243	3173.445	5.59	472.5749	3646.02
3	1326231413	3.419005652	3855828151	4955804	5.59	567.08988	5522.893
3.5	1432493649	3.988839927	4674907611	728492	5.59	661.60486	7946.525
4	153140.0127	4.558674203	5535144328	1021261	5.59	756.11984	10968.73
4.5	162429.5122	5.128508478	642994.4727	13781.4	5.59	850.63482	14632.03
5	171215.7393	5.698342753	735347.6265	18024.54	5.59	945.1498	18969.69
5.5	179572.5823	6.268177028	830048.2281	22966	5.59	1039.6648	24005.67
6	187557.4452	6.838011304	926614.473	28620.48	5.59	1134.1798	29754.66
6.5	195215.9783	7.407845579	1024598.158	34993.38	5.59	1228.6947	36222.07
7	202585.1947	7.977679854	1123576.854	42080.83	5.59	1323.2097	43404.04
7.5	209695.5986	8.54751413	1223147.799	49869.68	5.59	1417.7247	51287.41
8	216572.6829	9.117348405	1322922.98	58337.51	5.59	1512.2397	59849.75
8.5	223238.0118	9.68718268	1422525.082	67452.59	5.59	1606.7547	69059.34
9	229710.0191	10.25701696	1521584.032	77173.93	5.59	1701.2696	78875.2
9.5	236004.6097	10.82685123	1619733.958	87451.27	5.59	1795.7846	89247.05
10	2421356205	11.39668551	1716610.442	98225.05	5.59	1890.2996	100115.3
10.5	248115.1782	11.96651978	1811847.925	109426.4	5.59	1984.8146	111411.2
11	253953.9813	12.53635406	1905077205	120977.3	5.59	2079.3296	123056.6
11.5	259661.525	13.10618833	1995922.931	132790.3	5.59	2173.8445	134964.1
12	265246.2827	13.67602261	2084001015	144768.7	5.59	2268.3595	147037
Stress=60% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (60%)
0.5	4511930894	0.554144385	54941.59222	1006193	5.59	12.720581	113.3399
1	6380833863	1.10828877	94380.8209	296.9246	5.59	25.441162	322.3658
1.5	78148.93549	1.662433155	139844.7002	651.8847	5.59	38.161742	690.0464
2	9023861789	2.21657754	191523.17831	1222.704	5.59	50.882323	1273.587
2.5	100889.8419	2.770721925	248645.8082	2060.825	5.59	63.602904	2124.428
3	110519.2845	3.32486631	310415.3593	3211.923	5.59	76.323485	3288.247
3.5	119374.4708	3.879010695	376134.8341	4715.914	5.59	89.044065	4804.958
4	127616.67731	4.43315508	445206.0142	6606.947	5.59	101.76465	6708.711
4.5	135357.9268	4.987299465	517109.4968	8913.408	5.59	114.48523	9027.893
5	142679.7827	5.54144385	591386.1716	11657.92	5.59	127.20581	11785.13
5.5	149643.8186	6.095588235	667622.8585	14857.34	5.59	139.92639	14997.27
6	156297.871	6.64973262	745441.5618	18522.77	5.59	152.64697	18675.42
6.5	162679.9819	7.203877005	824491.4032	22659.54	5.59	165.36755	22824.91
7	168820.9956	7.75802139	904442.4654	27267.21	5.59	178.08813	27445.29
7.5	174746.3321	8.312165775	984980.9872	32339.58	5.59	190.80871	32530.39
8	180477.2358	8.86631016	1065805.519	37864.71	5.59	203.52929	38068.24
8.5	186031.6765	9.420454545	1146623763	43824.87	5.59	216.24987	44041.12
9	191425.0159	9.97459893	1227149903	50196.56	5.59	228.97045	50425.53
9.5	196670.5081	10.52874332	1307102.284	56950.55	5.59	241.69103	57192.24
10	2017796838	11.0828877	1386201.324	64051.8	5.59	254.41162	64306.22
10.5	2067626485	11.63703209	1464167.591	71459.56	5.59	267.1322	71726.69
11	2116283177	12.19117647	1540719.961	79127.27	5.59	279.85278	79407.12
11.5	216384.6041	12.74532086	1615573812	87002.62	5.59	292.57336	87295.2

J data (X60, D=16, t=0.312)

12	221038 5689	13.29946524	1688439187	9502756	559	30529394	9533286
Stress=50% Yield Stress							
c (in)	K1(c)	c[eff] (in)	K1(c[eff])	J el	h1	J pl	J (50%)
0.5	37599.42412	0.540909091	45037.66762	67.61305	5.59	1.7120373	69.32509
1	53173.61553	1.081818182	76976.31589	197.5118	5.59	3.4240747	200.9358
1.5	65124.11291	1.622727273	113644.0135	430.4987	5.59	5.136112	435.6348
2	75198.84824	2.163636364	155281.3066	803.7428	5.59	6.8481494	810.591
2.5	84074.86825	2.704545455	201304.1911	1350.779	5.59	8.5601867	1359.339
3	92099.40372	3.245454545	251088.2089	2101.51	5.59	10.272224	2111.782
3.5	99478.72566	3.786363636	304082.317	3082.202	5.59	11.984261	3094.186
4	1063472311	4.327272727	3598120419	431549	5.59	13.696299	4329.186
4.5	112798.2724	4.868181818	417865.1176	5820.375	5.59	15.408336	5835.784
5	118899.8189	5.409090909	477877.3027	7612.224	5.59	17.120373	7629.344
5.5	124703.1821	5.95	539521.1614	9702769	5.59	18.832411	9721.602
6	1302482258	6.490909091	6024975903	1210011	5.59	20.544448	1212066
6.5	1355666516	7.031818182	6665294315	1480872	5.59	22.256485	1483097
7	140684.163	7.572727273	731356.5907	1782942	5.59	23.968523	17853.38
7.5	145621.9434	8.113636364	796732.2287	21159.41	5.59	25.68056	21185.09
8	150397.6965	8.654545455	862419.7218	24792.26	5.59	27.392598	24819.65
8.5	155026.3971	9.195454545	928190.1741	28717.9	5.59	29.104635	28747
9	159520.8466	9.736363636	993820.3266	32922.63	5.59	30.816672	32953.44
9.5	163892.0901	10.27727273	1059090.753	37389.11	5.59	32.52871	37421.64
10	168149.7365	10.81818182	1123784.256	42096.37	5.59	34.240747	42130.61
10.5	172302.2071	11.35909091	1187684.4	47019.81	5.59	35.952784	47055.76
11	176356.9315	11.9	1250574.13	52131.19	5.59	37.664822	52168.85
11.5	180320.5035	12.44090909	1312234.428	57398.64	5.59	39.376859	57438.02
12	184198.8074	12.98181818	1372442.977	62786.66	5.59	41.088896	62827.75
Stress=40% Yield Stress							
c (in)	K1(c)	c[eff] (in):	K1(c[eff])	J el	h1	J pl	J (40%)
0.5	30079.5393	0.528213166	35456.96492	41.90655	5.59	0.1470629	42.05361
1	42538.89242	1.056426332	60305.23645	121.2241	5.59	0.2941258	121.5182
1.5	52099.29033	1.584639498	88715.23741	262.3464	5.59	0.4411887	262.7876
2	60159.07859	2.112852665	120940.4248	487.5529	5.59	0.5882516	488.1411
2.5	67259.8946	2.641065831	156557.4395	817.0077	5.59	0.7353144	617.743
3	73679.52297	3.169278997	195096.9451	1268.761	5.59	0.8823773	1269.643
3.5	79582.98053	3.6974921631	236140.6139	1858.746	5.59	1.0294402	1859.776
4	85077.78484	4.2257053291	279326.9557	2600.785	5.59	1.1765031	2601.961
4.5	90238.61789	4.753918495	324341.5673	3506.582	5.59	1.323566	3507.905
5	95119.85514	5.282131661	370906.7497	4585.727	5.59	1.4706289	4587.198
5.5	99762.54571	5.810344828	418773.1059	5845.697	5.59	1.6176918	5847.315
6	104198.5807	6.338557994	467713.1306	7291.852	5.59	1.7647547	7293.617
6.5	108453.3213	6.86677116	517516.3548	8927.439	5.59	1.9118175	8929.351
7	112547.3304	7.394984326	567985.626	10753.59	5.59	2.0588804	10755.65
7.5	116497.5548	7.923197492	618934.2072	12769.32	5.59	2.2059433	12771.52
8	120318.1572	8.451410658	670183.4658	14971.53	5.59	2.3530062	14973.88
8.5	124021.1177	8.979623824	721560.9875	17355.01	5.59	2.5000691	17357.51
9	127616.6773	9.507836991	772899.0004	19912.43	5.59	2.647132	19915.081
9.5	131113.6721	10.036050161	824033.0225	22634.35	5.59	2.7941949	22637.14
10	134519.7892	10.56426332	874800.6707	25509.21	5.59	2.9412578	25512.15
10.5	137841.7657	11.09247649	925040.5819	28523.34	5.59	3.0883207	28526.421
11	141085.5452	11.62068966	974591.4081	31660.95	5.59	3.2353835	31664.18
11.5	144256.4028	12.14890282	1023290.853	34904.14	5.59	3.3824464	34907.52
12	147359.0459	12.67711599	1070974.724	38232.9	5.59	3.5295093	3823642