70-1 A

2

Mason & Hanger-
Silas Mason Co., Inc.

ENGINEERS AND CONTRACTORS
SINCE 1827

Pantex Plant

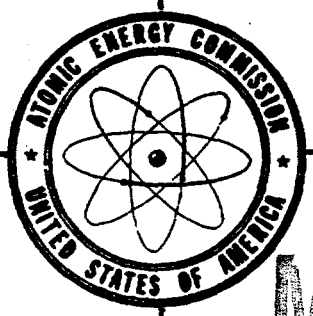
DISCLAIMER

PHYSICAL PROPERTIES OF EXPLOSIVES
MECHANICAL PROPERTIES

SANL 712-001

A. L. Wilson

January, February, March 1970



DEVELOPMENT DIVISION

MASTER

8

PHYSICAL PROPERTIES OF EXPLOSIVES

MECHANICAL PROPERTIES

A. L. Wilson

January, February, March 1970
SANL 712-001

ABSTRACT

Further testing of lots SR-94-14 and 15 of LX-04-1 has confirmed that these two lots are more "resilient" than a typical LX-04-1.

Results for a number of miscellaneous HE lots are presented.

DISCUSSION

Since the mechanical behavior of two lots of LX-04-1 (SR-92-14 and -15) was different from others, additional testing was done at the request of LRL. Objectives were to determine if and how these two lots differed from other lots of LX-04-1, and to determine if any noticeable change had occurred since they were first tested 1½ years ago. Three specimens per group were tested as follows:

Group 1. Creep at 75 psi at 120°F.

Group 2. Creep at 200 psi at 70°F.

Group 3. Tensile at -35°F at 0.005 inch/min.

All normal precautions were observed; the test results are listed in Tables I and II.

In order to visualize the results and compare with other lots of LX-04-1, Figs. 1 and 2 have been prepared with the failure envelope drawn representing all lots of LX-04-1, but omitting the mass of test data that was previously published with these curves. The failure envelope is drawn as a series of contours indicating the proportion of specimens that have not failed at the given stress and strain.

In both figures, the older tests of these two lots are plotted as squares and the latest data as circles. At stresses below approximately 250 psi, the two lots group themselves at (or beyond) the 25% contour indicating they are more resilient than the usual LX-04-1, especially in the vicinity of the "knee" of the failure envelope. Above 250 psi they appear to be undistinguishable from others. The tests show them to be still at least as resilient as when first tested since the circles tend to be located well to the right of the data field.

Table I

PX 375 LX-04-1 #92-14 PC#52324Y2401-XX

PC #	T°F	Stress psi	Min. 10 με	Min. 30 με	Fail με	Time to Fail (min.)	Time to Rupture (min.)	90% Rupture με	10% Fail με	Jo	A	M	1T* Min.	1T με
**3	120	60	4,140	5,770	9,480	93.5	168.0	13,790	4,080				33.7	6,000
10	120	75	6,880	12,200	11,900	29.0	40.0	14,200	4,600	40.12	68.24	.1640	8.1	6,360
1	120	75	8,710	16,620	12,450	19.7	34.4	16,620	5,140	47.05	73.14	.1632	6.8	7,580
2	120	73	7,440	12,620	12,600	29.9	44.3	15,800	5,100	48.48	70.23	.1676	7.8	6,800
MEAN		74.3	7,677	13,813	12,317	26.2	39.6	15,540	4,947	45.22	70.54	.1649	7.6	6,913
SD			938	2,440	369	5.6	5.0	1,231	301	4.47	2.46	.0023	.7	618
12	70	200	-	-	6,020	2.06	6.03	21,800	2,500	8.07	19.73	.1528	0.82	3,915
7	70	200	-	-	6,745	2.42	6.57	24,350	2,640	7.42	23.15	.1445	0.99	4,360
9	70	200	-	-	6,160	2.08	5.22	14,400	2,510	7.33	21.14	.1432	0.79	3,925
MEAN		200	-	-	6,308	2.19	5.94	20,183	2,550	7.61	21.34	.1468	0.87	4,067
SD		0	-	-	385	.20	0.68	5,168	78	.40	1.72	.0052	.11	254

PC #	T°F	Eo, 10^6 psi	Rupture S, psi	Rupture με	Time to Rupture
8	-35	1.68	1,264	852	10.2
5	-35	1.64	1,216	822	9.5
4	-35	-	1,278	-	9.7
MEAN		1.66	1,253	837	9.8
SD		-	32	-	.4

First Transition Point

**Not included in MEAN and Standard Deviation*

Table II

PX 376 LX-04-1 #92-15 PC#52324Y2402-XX

PC #	T°F	Stress psi	Min. 10 με	Min. 30 με	Fail με	Time to Fail (min)	Time to Rupture (min)	90% Rupture με	10% Fail με	Jo	A	M	1T* Min.	1T με
**12	120	60	4,920	6,770	11,400	108.7	188.6	15,750	5,200	62.53	60.60	.1586	42.3	7,610
7	120	75	7,440	12,440	11,800	27.6	44.4	15,700	4,920	41.30	70.77	.1490	13.6	8,380
3	120	75	4,600	7,100	8,800	44.7	66.3	10,820	3,590	30.50	48.48	.1534	16.8	5,540
4	120	75	3,930	7,840	9,710	50.0	63.0	10,640	3,930	36.21	48.54	.1669	13.1	5,290
MEAN		75	5,323	9,127	10,103	40.8	57.9	12,387	4,147	36.00	55.93	.1564	14.5	6,403
SD			1,863	2,893	1,538	11.7	11.8	2,871	691	5.03	12.85	.0093	2.0	1,716
11	70	200			5,560	2.80	7.34	15,800	2,290	7.22	17.62	.1508	1.17	3,620
10	70	200			5,580	2.36	6.26	14,200	2,440	7.20	18.44	.1353	1.10	3,980
1	70	200			4,940	2.52	6.98	12,560	2,220	7.34	15.18	.1458	1.07	3,410
MEAN		200			5,360	2.56	6.86	14,187	2,317	7.25	17.08	.1440	1.11	3,337
SD					364	0.22	.55	1,620	112	.08	1.70	.0079	.05	326

Tensile @ .005"/Min

PC #	T°F	Eo, 10^6 psi	Rupture S, psi	Rupture με	Time to Rupture
9	-35	1.54	1,384	1,155	11.7
8	-35	1.56	1,310	1,055	11.6
6	-35	1.78	1,358	1,016	9.9
MEAN		1.63	1,351	1,075	11.1
SD		.13	38	72	1.0

*First transition point
**Not included in MEAN and SD

Fig. 1

LX-04-1 Lot No. 92-14

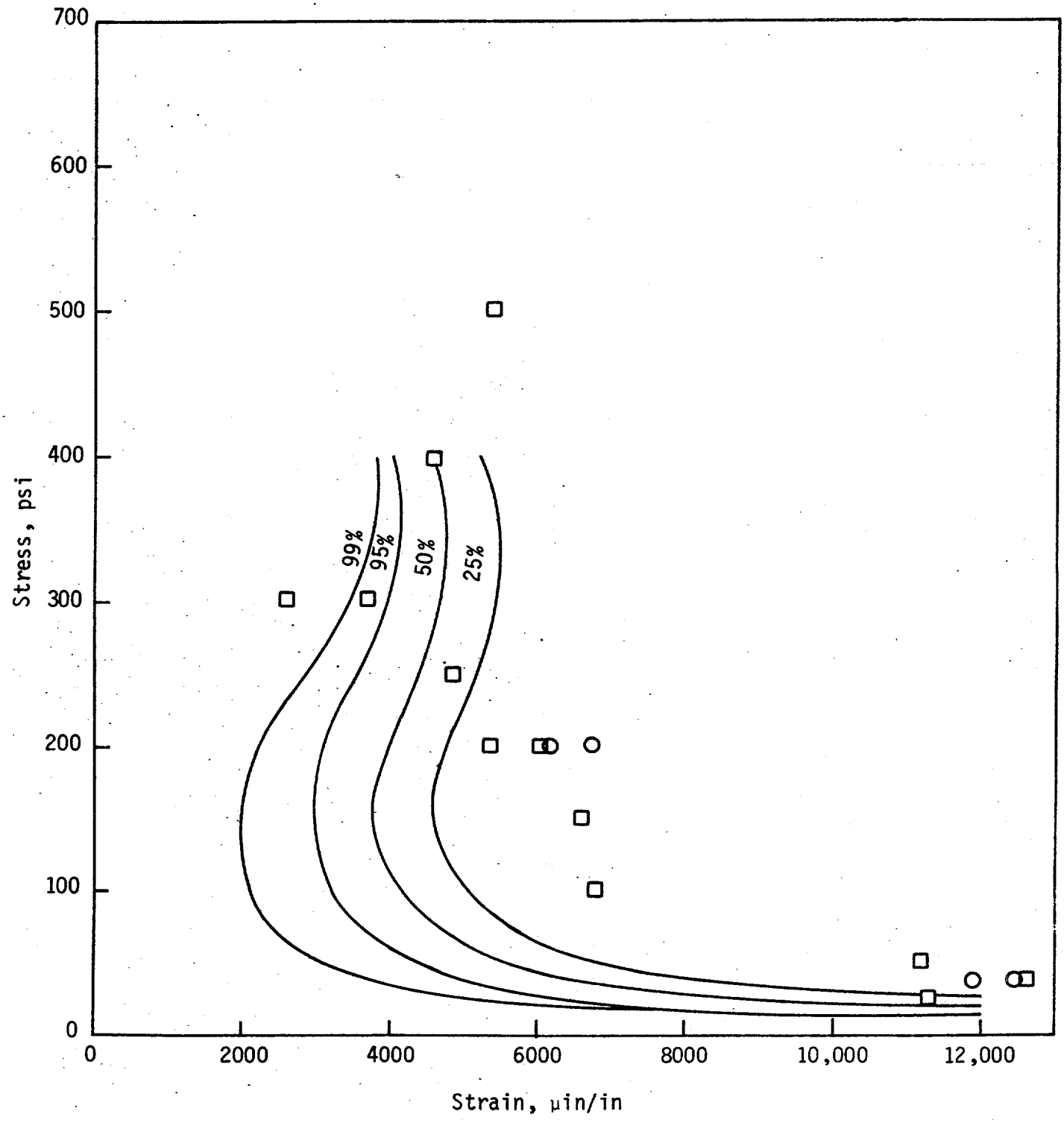
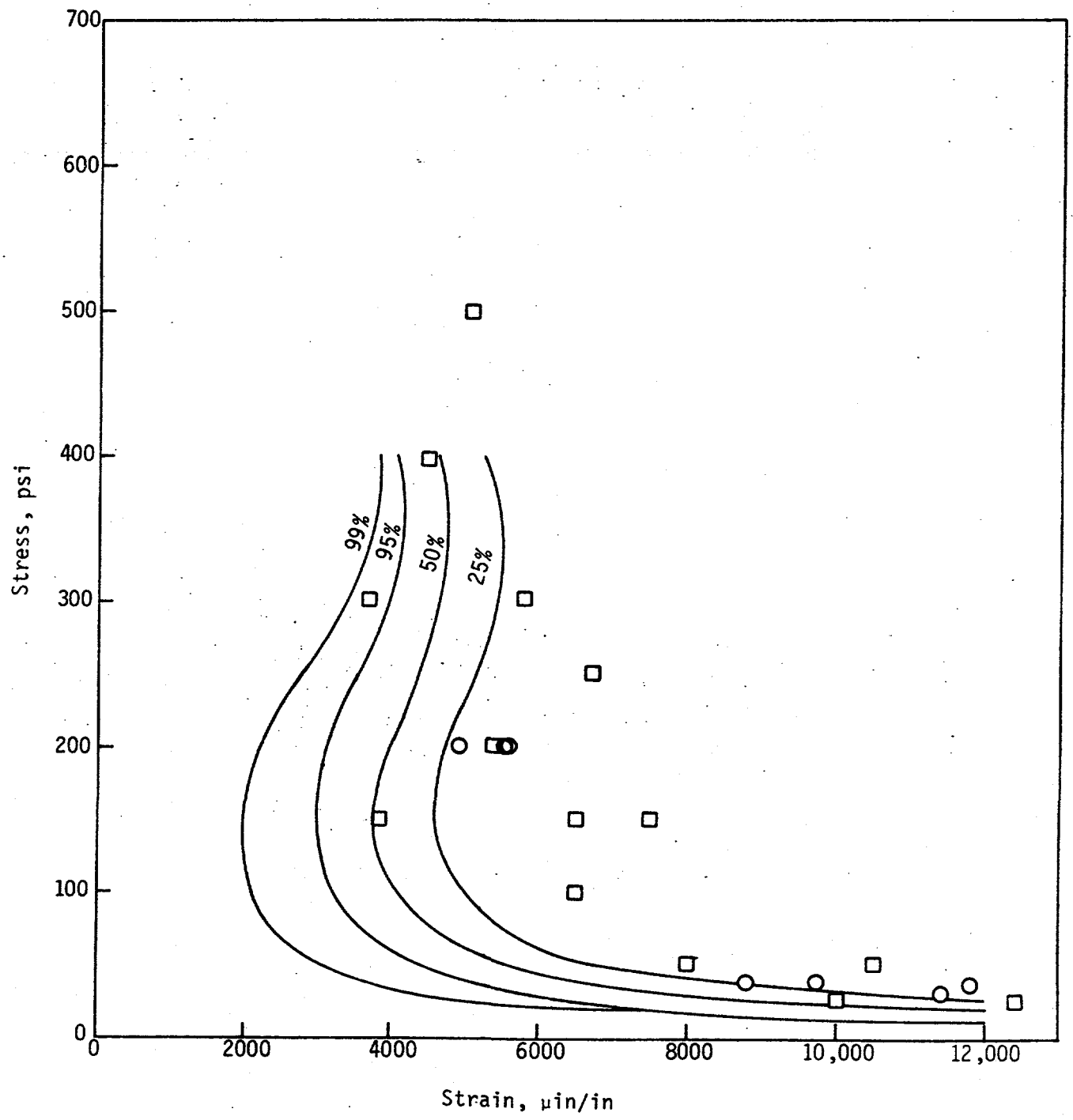


Fig. 2

LX-04-1 Lot No. 92-15



A number of miscellaneous lots of HE have been run through the standard series of mechanical properties tests and the results are tabulated in Table III. One additional lot, 94-8, of LX-09-0 has been evaluted and it is listed along with all other lots of LX-09-0. The results show lot 94-8 to be typical, not differing significantly from the average value in any property.

Tabulated results for the other HE lots, LX-07-2, are included in Table IV and not much can be said about them because not enough LX-07-2 has been tested to really establish "norms".

Table III

LX-09-0 Lot Summary

Lot No.		-35°F Tensile			70°F Creep @ 50 psi			120°F Creep @ 20 psi			Compression Creep @ 120°F, 100 psi			
		Initial Modulus 10^6 psi	Ultimate Stress psi	Ultimate Strain µin/in	10 Min Strain µin/in	Fail Strain µin/in	90% Rupture Strain µin/in	10 Min Strain µin/in	Fail Strain µin/in	90% Rupture Strain µin/in	10 Min Strain µin/in	1 Hour Strain µin/in	1 Hr. Strain µin/in	2 Hours Recovery µin/in
27-02-67	Avg	1.57	716	475	1059	2642	3025	1559	2432	2462	2546	3259	3583	
	σ	.26	43	101	27	131	366	293	494	521	95	177	207	
94-1	Avg	1.77	843	559	670	1752	2387	1079	2263	2355	2318	2889	3110	
	σ	.10	54	42	59	93	485	42	320	490	596	646	698	
94-2	Avg	1.96	774	427	1422	1775	2346	1581	1655	1680	2571	3084	3300	
	σ	.19	66	57	159	106	161	21	30	21	216	319	346	
94-3	Avg	2.40	791	459	738	1720	2780	966	2273	2228	2090	2378	2522	
	σ	.02	21	13	145	0	608	9	256	255	-	-	-	
R-94-3	Avg	2.92	823	466	970	3442	3451	1845	3590	4050	2498	2890	3042	1029
	σ	1.58	86	64	97	253	347	289	1013	666	522	591	604	612
94-4	Avg	2.10	784	470	980	2477	3287	1873	3571	3460	2338	2895	3185	1490
	σ	.24	98	102	198	368	825	275	999	993	103	124	159	354
94-5	Avg	3.69	846	437	1258	2686	3428	1411	2482	2917	2730	3356	3626	1686
	σ	2.15	24	91	432	658	781	341	899	196	342	466	570	372
94-6	Avg	4.15	880	470	1338	3108	4836	1790	4186	4091	2580	3220	3542	1474
	σ	1.47	70	10	507	642	740	296	744	808	156	170	200	203
94-7	Avg	4.63	880	451	1238	2766	4195	1896	4159	3969	2912	3620	3933	1798
	σ	1.06	12	31	191	333	544	239	877	882	13	17	25	147
94-8	Avg	1.98	775	417	1251	2612	3672	1446	3487	3450	2587	3196	3483	1368
	σ	.55	65	104	172	301	257	160	457	497	109	112	118	141
Overall	Avg	2.80	815	468	1075	2485	3304	1556	2957	3024	2509	3066	3316	1495
	σ	1.11	53	57	202	287	540	200	626	537	255	314	351	337

Table IV

LX-07-2 Lot Summary

Lot No.		-35°F Tensile			70°F Creep				120°F Creep				Compression Creep @ 120°F, 100 psi			
		Initial Modulus 10^6 psi	Ultimate Stress psi	Ultimate Strain µin/in	10 Min Strain µin/in	Fail Strain µin/in	90% Rupture Strain µin/in	Stress psi	10 Min Strain µin/in	Fail Strain µin/in	90% Rupture Strain µin/in	Stress psi	10 Min Strain µin/in	1 Hr. Strain µin/in	2 Hrs. Strain µin/in	2 Hrs. Recovery µin/in
901-1	Avg	1.78	1338	884	1472	2786	3162	180	1850	5392	5648	75	1488	1761	1855	618
	σ	.11	108	90	60	230	264	-	395	388	573	-	258	308	307	205
902-1	Avg	1.68	1185	848	1350	3318	3792	140	2358	5500	5800	75	1602	1890	2372	740
	σ	.26	70	63	264	332	630	-	555	314	581	-	360	412	584	265
90B	Avg	2.10	1120	760	1315	2382	2307	200	2767	3753	3617	20	1950	2300	2438	1094
	σ	.61	106	112	297	534	526	-	111	817	751	-	78	135	115	173

FUTURE WORK; COMMENTS; CONCLUSIONS

For the first time values for the material constants are being reported that fit the power law equation:

$$J - J_0 = At^m \qquad (1)$$

In order to impart maximum usefulness to equation (1) by extending it all the way to failure, the upper datum was selected to be the failure point. Next the lowest datum point was chosen to be 10% of failure, then the "rational method" of determining material constants was followed. It is a bit early to predict accuracy in all cases, but a single comparison is shown for LX-09-0 Lot 94-8 (Piece No. 76434E2401-12):

Time Hour	Calculated Strain μin/in	Experimental Strain μin/in	Percent Error
.05	1027	958	7.20
.10	1265	1250	1.20
.50	2331	2374	-1.81
1.06	3254	3272	-0.55

The error shown here is far less than the piece-to-piece variation.

Whenever requested by LRL, other lots of HE will be evaulated. In the mean-time further investigation and tabulation of the "rational" material constants will be made.