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80

MECHANICAL PROPERTIES OF EXPLOSIVES

A. L. Wilson

&

H. D. Johnson

DEVELOPMENT DIVISION

OCTOBER - DECEMBER 1971

SANL 900-006

For

Lawrence Livermore Laboratory

Livermore, California

Mason & Hanger-Silas Mason Co., Inc.

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Section E

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ABSTRACT

When tested in tension creep at 120 F and 50 psi, LX-10-0, Lot 710-2 had a significantly shorter time to fail than Lot 710-1, but the failure strains were not significantly different.

In the compressibility tests, three specimens of LX-10-0 Lot 710-2 showed high rate of compression creep which may have been due to a lower than usual initial density; the tests were terminated after thirty days. The compression creep of RX-04-EA, RX-04-EB, and RX-04-DW are continuing; none of them have shown any significant change since the 30-day reading.

DISCUSSION

Five tensile specimens from LX-10-0 Lot 710-2 were tested in tension creep at 120 F and 50 psi. The results are listed in Table I. This test was the last of a group of tests made to evaluate several lots of LX-10-0; results of the other tests have been reported *(1:12 and 2:5)*. For convenience in making comparisons, the same type of test for LX-10-0 Lot 710-1 and RX-04-DW have been included as Table II and III. RX-04-DW was selected for comparison because it contained the nominal composition of 5.0% viton. It should be noted that Lots 710-1 and 710-2 contain the Flourel binder manufactured by Minnesota Mining & Manufacturing Co. at a nominal concentration of 5.0%.

The creep curves for these three materials have been plotted in Fig. 1. The rectangles drawn about each failure point represent plus-and-minus one standard deviation. Fig. 1 shows that Lot 710-2 creeps faster than the others and fails at a slightly higher strain.

The student's t test for significance of difference between means, using the single-tailed test at 95% confidence level, was applied with the following results:

	710-2/710-1	710-2/RX-04-DW	710-1/RX-04-DW
Failure strain	No	No	No
Failure time	Yes	Yes	Yes

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(1) Wilson, A. L., H. D. Johnson, Mechanical Properties of Explosives (July - September 1971), SANL 900-006, Section E.

(2) Wilson, A. L., Mechanical Properties of LX-10 Variants (April - June 1971), SANL 804-011, MHSMP-71-47-G.

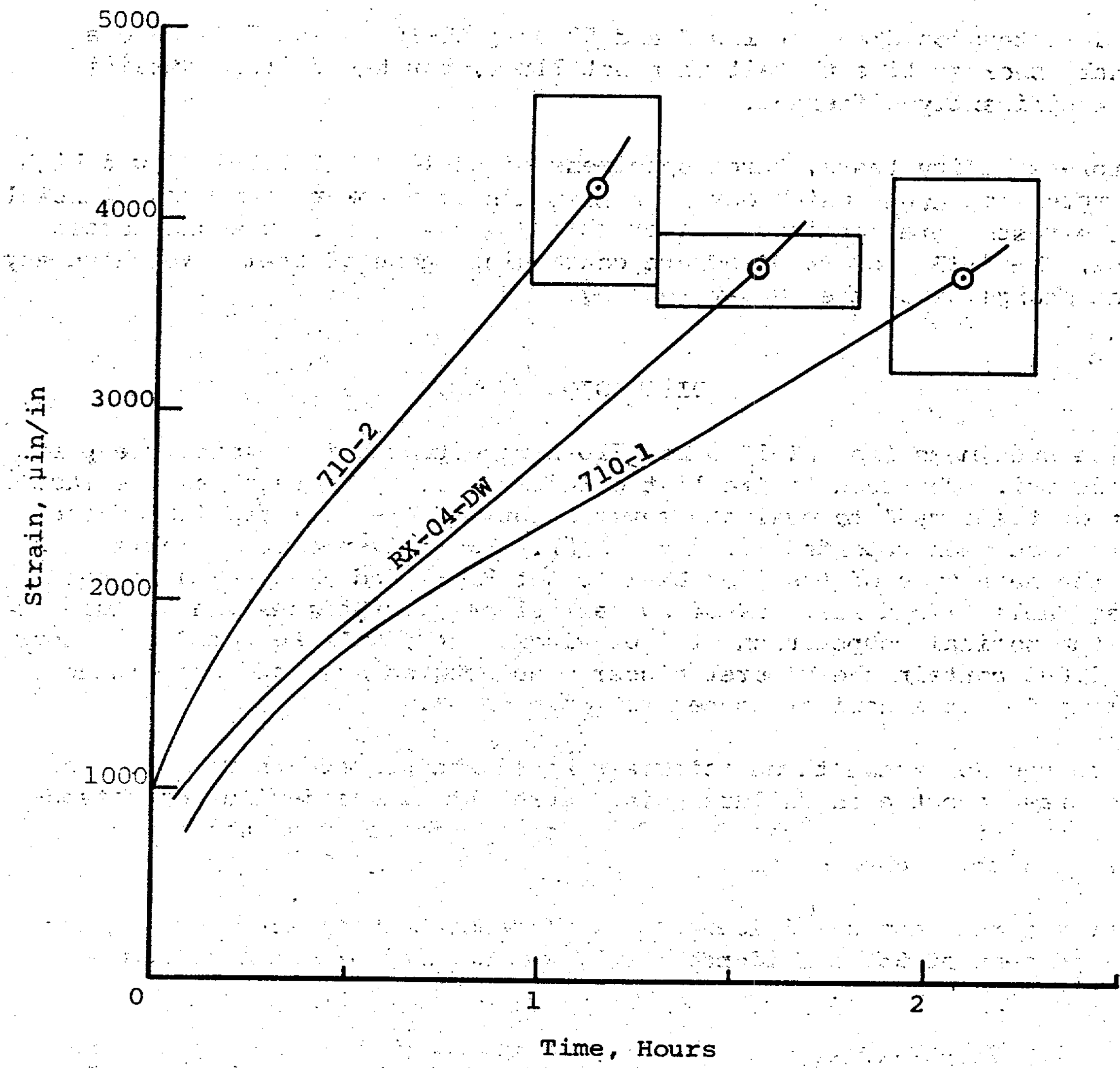

Fig. 1. Tensile Creep at 120 F and 50 psi for LX-10-0 Lots

Table I. Tensile Creep @ 120 F @ 50 psi for LX-10-0

(Lot No. 710-2, Pressing No. 78286E4601)

Piece No.	Mode*	Density (g/cc)	30 Min Creep McSt	T1 Hrs.	S1 McSt	T3 Hrs.	S3 McSt	First Transition T2 Hrs.	First Transition S2 McSt	Failure T4 Hrs.	Failure S4 McSt	90% Rupture T5 Hrs.	90% Rupture S5 McSt
1	6	1.869	3230	0.096	1670	0.199	2145	0.397	2895	1.060	4890	1.185	5300
2	7	1.869	2690	0.121	1610	0.242	1985	0.483	2650	1.027	3840	0.927	3685
3	2	1.868	2920	0.129	1650	0.259	2260	0.517	2985	1.022	4290	1.273	5040
4	6	1.868	2090	0.181	1395	0.363	1800	0.725	2500	1.400	3610	1.407	3630
5	6	1.869	2600	0.138	1520	0.209	1780	0.417	2400	1.150	4160	1.252	4475
Mean		1.869	2692	0.133	1569	0.254	1994	0.508	2686	1.132	4158	1.209	4426
Std. Dev.		0.000	424	0.031	113	0.065	210	0.131	250	0.158	489	0.177	762

Creep equation: $J = JO + AT^{m} + B(T - T2)$ JO = 17.85 A = 57.7563 m = 0.7033 B = 47.1795

Where: $T1 = 0.25(T2)$ and $T3 = [(T1)(T2)]^{\frac{1}{2}}$

**See Fig. 2 for location of break.*

Table II. Tensile Creep @ 120 F @ 50 psi for LX-10-0

(Lot No. 710-1, Pressing No. 78193E4602)

								First Transition		Failure		90% Rupture	
Piece No.	Mode	Density (g/cc)	30 Min Creep McSt	T1 Hrs.	S1 Mcst	T3 Hrs.	S3 McSt	T2 Hrs.	S2 McSt	T4 Hrs.	S4 McSt	T5 Hrs.	S5 McSt
7	6	1.866	1200	0.135	610	0.246	860	0.45	1150	2.01	3220	1.980	3180
9	7	1.866	2215	0.126	1515	0.230	1760	0.42	2130	2.21	4020	2.178	3980
10	2	1.866	1750	0.135	950	0.247	1250	0.45	1730	2.21	3620	2.250	3720
11	6	1.866	1904	0.186	1100	0.340	1540	0.62	2145	2.20	4420	2.610	5010
16	3	1.869	1350	0.135	760	0.247	960	0.45	1280	1.80	3200	1.962	3430
Mean		1.867	1684	0.143	987	0.262	1274	0.48	1687	2.09	3696	2.196	3864
Std. Dev.		0.001	412	0.024	349	0.044	380	0.08	464	0.18	526	0.263	708

Creep equation: $J + JO + AT^m + B(T - T2)$ $JO = 6.6656$ $A = 34.1904$ $m = 0.3161$ $B = 24.9876$

Where: $T1 = 0.3(T2)$ and $T3 = [(T1)(T2)]^{\frac{1}{2}}$

**See Fig. 2 for location of break.*

Table III. Tensile Creep @ 120 F @ 50 psi for RX-04-DW

(Pressing No. 99134E9902)

Piece No.	Mode*	Density (g/cc)	30 Min Creep McSt	T1 Hrs.	S1 Mcst	T3 Hrs.	S3 McSt	First Transition T2 Hrs.	First Transition S2 McSt	Failure T4 Hrs.	Failure S4 McSt	90% Rupture T5 Hrs.	90% Rupture S5 McSt
18	1	1.869	1650	0.19	1050	0.61	1770	1.93	3600	1.93	3600	2.20	4150
10	1	1.870	1890	0.13	1050	0.42	1790	1.33	3820	1.93	3820	1.46	4210
22	1	1.869	1840	0.18	1150	0.55	1940	1.75	3790	1.75	3790	1.73	3700
16	1	1.870	1860	0.14	1030	0.45	1760	1.42	3480	1.42	3480	1.64	3920
12	1	1.870	2190	0.14	1200	0.43	2020	1.37	3930	1.37	3930	1.44	4100
Mean		1.870	1886	0.16	1096	0.49	1856	1.56	3724	1.56	3724	1.69	4016
Std. Dev.		0.000	194	0.03	75	0.08	117	0.26	181	0.26	181	0.31	207

Creep equation: $J = JO + AT^m + B(T - T2)$ JO = 11.38 A = 45.41 m = 0.7809 B = 0

Where: $T1 = 0.1(T2)$ and $T3 = [(T1)(T2)]^{\frac{1}{2}}$

See Fig. 2 for location of break.

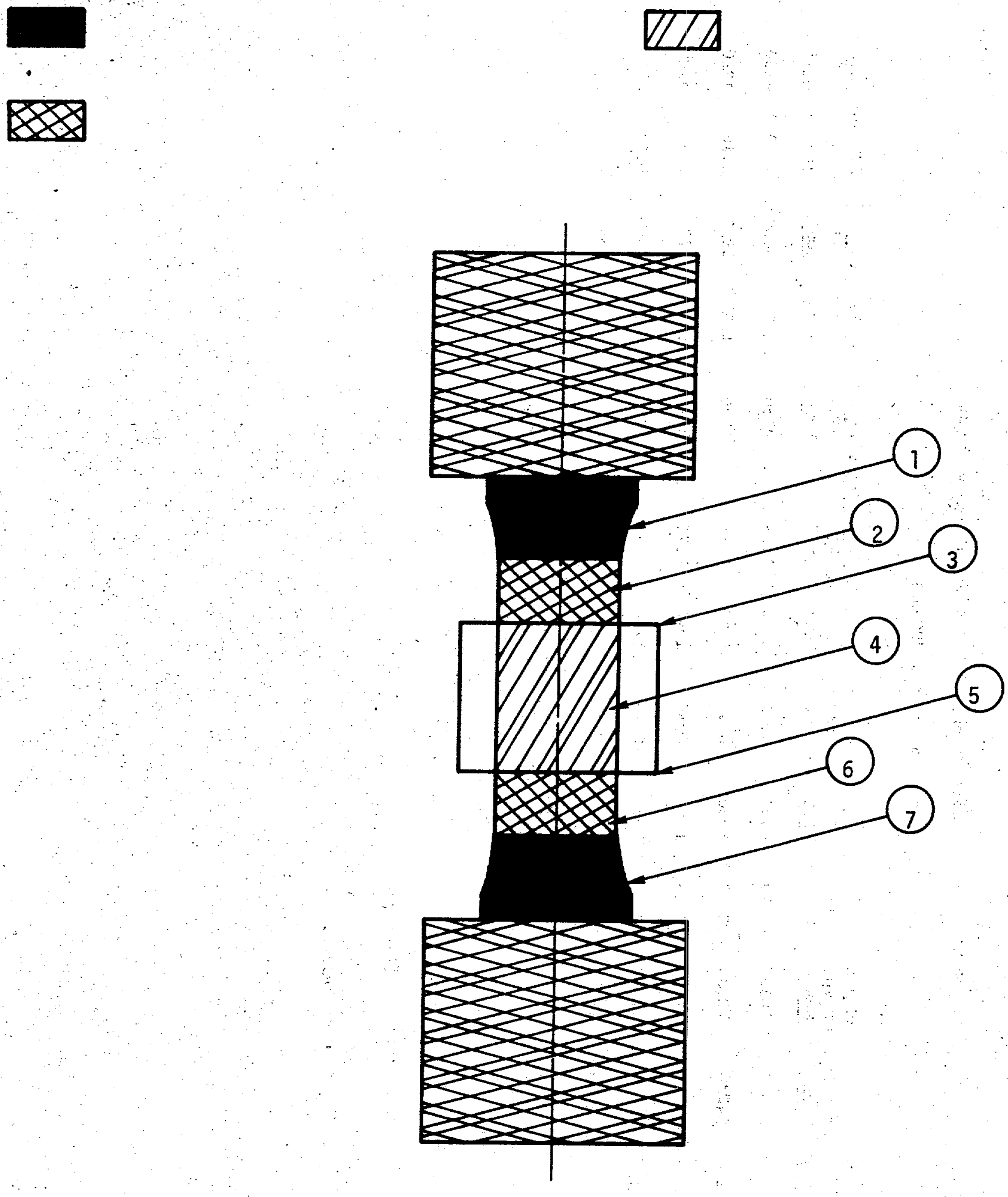

Fig. 2. Illustration of the Code for Rupture Mode Location

Table IV. Tensile Test @ 0.005 In/Min @ -35 F for RX-04-EC

(Pressing No. 99315E4602)

Piece No.	Mode	Initial* Modulus 10^6 psi	Rupture Stress psi	Rupture Strain (μin/in)	Time to Rupture Min
02	2	2.81	730	506	9.05
01	1	3.28	754	494	7.05
03	7	2.43	728	522	7.55
04	7	2.33	700	480	7.98
05	6	2.56	690	446	7.50
06	6	2.41	756	538	8.23
Mean		2.64	726	497	7.89
Std. Dev.		0.36	27	32	0.70

**Initial modulus was computed as stress/strain at 20% rupture stress.*

There was no significant difference in failure strain, whereas the time to failure varied significantly among the three Lots of LX-10-0.

Three cylindrical specimens of LX-10-0 Lot 710-2 were tested for compression creep by applying 500 pounds of force to the end of the HE cylinders by means of a spring-loaded assembly. The material compressed approximately 5.1 mils during the first 30 days. By this time the springs were no longer applying sufficient force to the HE because of the unexpectedly high compression creep experienced by the HE. Therefore these specimens were unloaded at the end of the 30-day period, even though the test was originally intended to last for one year. As a replacement, three other compressibility specimens were made from LX-10-0 Lot 710-2 having a higher initial density. Testing of these specimens will commence early in January, 1972.

The three specimens of Lot 710-2 which were unloaded after 30 days had a final density of 1.871 g/cc; before being compressed their density was 1.863 g/cc.

Formulation RX-04-EC is being tested, and results of the -35 F tensile tests have been completed. Those results are given in Table IV.

CONCLUSIONS

The tensile creep test at 120 F and 50 psi of LX-10-0 Lot 710-2 showed no significant difference in strain at failure from that of Lot 710-1, but the time to failure of Lot 710-2 was significantly shorter than that of Lot 710-1.

The total compression creep during the first 30 days for three specimens of LX-10-0, Lot 710-2 was high in comparison to the compression creep of RX-04-EA, RX-04-EB, and RX-04-DW(1). The most likely cause for this high creep rate was that the initial density of the 710-2 material was low. Three other specimens of Lot 710-2 having higher density will be tested.