MASTER

MECHANICAL PROPERTIES OF LX-14

H. D. Johnson

DEVELOPMENT DIVISION

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Normal Process Development
Endeavor No. 105

Mason & Hanger-Silas Mason Co., Inc.
Pantex Plant
P. O. BOX 647
AMARILLO, TEXAS 79177
806-335-1581

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ABSTRACT

A 4.54 Mg Holston shipment of LX-14 Lot 713-1 (95.5% HMX/4.5% Estane) was evaluated for mechanical properties. The 21 C and the -37 C tensile test average failure stresses were 3.72 MPa and 5.64 MPa.

DISCUSSION

LX-14, Lot 713-1, a plastic bonded explosive having a nominal by weight composition of 95.5/4.5 HMX/Estane 5702-F1, was evaluated. The HMX is a 65/25/10 mixture of Class A/LX-04-1 Type/Class B by weight. The Estane is a polyester polyurethane elastomer. The molding powder is a 4 to 1 mixture of undyed and dyed pellets. The dying is accomplished by the addition of 0.1% Heliogen Violet during manufacture.

A relatively standard multiple cycle pressing procedure was used for compacting LX-14, and is outlined below:

- a. Preheat molding powder to 120 C.
- b. First Cycle - Isostatically pressed (wet bag) one pulse at 137.9 MPa for 10 minutes and stored at ambient temperature for 48 hours.
- c. Second Cycle - Water-bag repressed at ambient temperature and 137.9 MPa for 10 minutes and stored at ambient temperature for 24 hours.
- d. Third Cycle - Water-bag repressed again at 137.9 MPa and ambient temperature for 10 minutes.

The pressed LX-14 parts used had an average density of 1.829 Mg/m³. The standard mechanical tests for high explosives (tensile, tensile creep, compression test at various temperatures) were performed. The indirect tension creep test, a relatively new test for explosives, was also included to accumulate data for correlating the regular tensile creep tests with the indirect tension creep tests.

Results from tension tests made at -37 C at 0.002 mm/sec constant cross-head speed are plotted in Fig. 1. The failure envelope shown in Fig. 2 is the result of tension tests made at -37 C, -6.7 C, 21 C, 49 C and 74 C. The failure envelope plot is used normally to choose the stress and temperature for a creep test which will give failure strain in a reasonable time (longer than 10 minutes but less than 12 hours). Previous tests conducted during the development of LX-14 have shown that the most sensitive test is the 49 C tensile creep test. The stresses selected for the 49 C tensile creep, compression creep and indirect tension creep were 0.63 MPa, 1.24 MPa and 0.48 MPa, respectively. The compression specimens were creep tested for a minimum of 24 hours. These parts did not rupture since the required load for rupture on compression exceeds the capacity for the multiple creep frames. The average strain-time plots of tensile and compression creep tests are shown in Figs. 3 and 4.

The average indirect tension creep curve was superimposed in Fig. 3 for comparison purposes. The individual test data for each specimen are given in Tables I through VIII. The creep equation and the equation constants (J_0 , A, M and B) are also included in the creep test tables.

CONCLUSIONS

The average time to failure for the tensile creep and the indirect tension creep tests are 0.90 ks and 1.04 ks, respectively. The LX-14 probably ranks second to TATB/ Kel-F in tensile strength (at 21 C) of those plastic bonded explosives studied within the ERDA complex.

Fig. 1. LX-14 Tensile Test at -37 C at a Constant Crosshead Velocity of 0.002 mm/sec

Fig. 2. Failure Envelope for LX-14 Lot 713-1

Fig. 3. Tensile Creep Test at 0.62 MPa at 49 C for LX-14

Fig. 4. Compression Creep Test at 1.24 MPa at 49 C for LX-14

Table I. Tensile Test at a Constant Crosshead
Speed of 0.0021 mm/sec at -37 °C

(LX-14 Lot No. 713-1, Pressing No. 81098Y4601,
Density 1.829 Mg/m³)

Piece Number	Rupture ^a Mode	Initial Modulus ^b (GPa)	Time (sec)	Rupture Stress (MPa)	Strain (%)
15	3	19	-	6.62	0.070
16	6	22	414	4.85	0.057
18	-	12	450	6.07	0.088
28	-	11	378	5.10	0.067
36	2	15	462	5.54	0.072
Mean		15.8	426	5.64	0.071
Std. Dev.		4.6	38	0.72	0.01

Table II. Tensile Test at a Constant Crosshead
Speed of 0.0021 mm/sec at -6.7 °C

(LX-14 Lot No. 713-1, Pressing No. 81098Y4601,
Density 1.829 Mg/m³)

Piece Number	Rupture ^a Mode	Initial Modulus ^b (GPa)	Time (sec)	Rupture Stress (MPa)	Strain (%)
30	-	5.5	390	4.83	0.17
35	2	10.3	354	4.66	0.12
2 ^c	1-2	6.5	300	3.92	0.13
1 ^c	2	6.0	378	4.11	0.13
Mean		7.1	356	4.38	0.14
Std. Dev.		2.2	40	0.43	0.02

^a 1 & 7 are in curved section, 2 & 6 are in the straight section outside the extensometer, 3 & 5 are at the knife edges and 4 is between the knife edges

^b Initial Modulus: (20% Rupture stress)/strain

^c Pressing No. 81240Y3101

Table III. Tensile Test at a Constant Crosshead
Speed of 0.0021 mm/sec at 21 C

(LX-14 Lot 713-1, Pressing No.
81098Y4601, Density 1.829 Mg/m³)

Piece Number	Rupture ^a Mode	Initial Modulus ^b (GPa)	Rupture		
			Time (sec)	Stress (MPa)	Strain (%)
17	6	9.6	330	3.31	0.125
19	6	8.5	384	3.85	0.210
22	6	5.1	318	3.79	0.190
26	6	5.6	372	3.96	0.210
Mean		7.2	351	3.72	0.184
Std. Dev.		2.2	32	0.29	0.040

Table IV. Tensile Test at a Constant Crosshead
Speed of 0.0021 mm/sec at 49 C

(LX-14 Lot 713-1, Pressing No.
81098Y4601, Density 1.829 Mg/m³)

Piece Number	Rupture ^a Mode	Initial Modulus ^b (GPa)	Rupture		
			Time (sec)	Stress (MPa)	Strain (%)
20	6	3.3	264	0.83	0.40
21	6	1.9	216	0.85	0.43
23	6	1.8	222	0.83	0.39
25	6	1.9	246	0.85	0.42
Mean		2.2	237	0.84	0.41
Std. Dev.		0.7	22	0.01	0.02

^a 1 & 7 are in the curved section, 2 & 6 are in the straight section outside the extensometer, 3 & 5 are at the knife edges and 4 is between the knife edges

^b Initial Modulus: (20% Rupture stress)/strain

Table V. Tensile Test at a Constant Crosshead
Speed of 0.0021 mm/sec at 74 C

(LX-14 Lot 713-1, Pressing No.
81098Y4601, Density 1.829 Mg/m³)

Piece Number	Rupture ^a Mode	Time (sec)	Ultimate Stress (MPa)	Strain (%)
27	5	246	0.45	0.55
29	5	234	0.48	0.55
4 ^c	2	284	0.35	0.62
5 ^c	4	222	0.36	0.53
Mean		249	0.41	0.56
Std. Dev.		32	0.07	0.04

^a1 & 7 are in curved section, 2 & 6 are in the straight section outside the extensometer, 3 & 5 are at the knife edges and 4 is between the knife edges

^bInitial Modulus: (20% Rupture stress)/strain

^cPressing No. 81240Y3101

Table VI. Tensile Creep Test at 49 C at 0.62 MPa

(LX-14 Lot 713-1, Pressing No.
81098Y4601, Density 1.829 Mg/m³)

Piece No.	Rupture Mode	T1 (sec)	S1 (μm/m)	T3 (sec)	S3 (μm/m)	First Transition		Failure		90% Rupture	
						T2 (sec)	S2 (μm/m)	T4 (sec)	S4 (μm/m)	T5 (sec)	S5 (μm/m)
31	6	72	1140	227	1625	720	2620	986	2960	936	2900
32	2	58	1115	184	1595	587	2365	990	2940	940	2860
34	6	58	900	180	1245	569	1850	925	2255	878	2190
37	6	43	1025	140	1600	443	2660	695	3455	659	3350
Mean		58	1045	183	1516	580	2374	899	2903	853	2825
Std. Dev.		12	109	35	181	113	373	139	493	133	478

Creep Equation: $J = J_0 + AT^M + B(T - T_2)$ $J_0 = 5.2419$ $A = 54.7292$ $M = 0.5209$ $B = 65.9175$
 Where: $T_1 = 0.1(T_2)$ and $T_3 = [(T_1)(T_2)]^{\frac{1}{2}}$

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Table VII. Compression Creep Test at 49 C at 1.24 MPa

(LX-14 Lot 713-1, Pressing No.
81098Y4601, Density 1.829 Mg/m³)

Piece No.	T1 (sec)	S1 (μm/m)	T3 (sec)	S3 (μm/m)	First Transition		24-Hr Creep (μm/m)
					T2 (sec)	S2 (μm/m)	
2	5382	4420	15880	5160	53820	6300	7060
3	4446	3320	14058	4080	44460	5140	5960
10	4140	3240	13093	3920	41400	5000	5900
12	3420	3640	10814	4300	34200	5240	6280
Mean	4257	3655	13461	4365	42570	5420	6300
Std. Dev.	667	538	2109	552	6671	595	533

Creep Equation: $J = J_0 + AT^M + B(T - T_2)$ $J_0 = 12.1879$ $A = 7.6628$ $M = 0.3440$ $B = 0.4016$
 Where: $T_1 = 0.1(T_2)$ and $T_3 = [(T_1)(T_2)]^{\frac{1}{2}}$

Table VIII. Indirect Tension Creep Test at 21 C at 0.48 MPa

(LX-14 Lot No. 713-1, Pressing No.
81098Y4601, Density 1.825 Mg/m³)

Piece No.	T1 (sec)	S1 (μm/m)	T3 (sec)	S3 (μm/m)	First Transition		Failure		90% Rupture	
					T2 (sec)	S2 (μm/m)	T4 (sec)	S4 (μm/m)	T5 (sec)	S5 (μm/m)
38	13	950	41	1290	131	1570	612	2600	810	3800
39	29	900	91	1280	290	1790	1320	3260	1577	4030
40	67	1300	214	1720	678	2500	1446	3500	1898	4630
41	27	1120	85	1600	267	2220	894	3540	1095	4690
42	27	1010	91	1420	288	1990	978	3290	1171	4460
43	35	1520	110	1950	348	2520	1008	3640	1242	4710
Mean	34	1133	106	1543	334	2098	1043	3305	1299	4387
Std. Dev.	18	237	58	264	183	385	301	375	384	383

Creep Equation: $J = J_0 + AT^M + B(T - T_2)$ $J_0 = 0.000$ $A = 56.7279$ $M = 0.2630$ $B = 87.4828$
 Where: $0.1(T_2)$ and $T_3 = [(T_1)(T_2)]^{\frac{1}{2}}$