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AN INVESTIGATION OF THE EFFECT OF BINDER
CRYSTALLINITY ON THE MECHANICAL PROPERTIES
OF A PLASTIC BONDED EXPLOSIVE

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DEVELOPMENT DIVISION

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AN INVESTIGATION OF THE EFFECT OF BINDER CRYSTALLINITY ON THE MECHANICAL PROPERTIES OF A PLASTIC BONDED EXPLOSIVE

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ABSTRACT

The tensile properties of a plastic bonded explosive RX-03-BB were investigated as a function of the degree of crystallinity of the plastic binder. This investigation was to determine if stress/strain properties of RX-03-BB would be affected by an increase in the crystallinity of the Kel-F 800 binder. RX-03-BB composition is 92.5%/7.5% TATB/Kel-F 800.

Forty-four tensile test specimens were machined from a single pressing of RX-03-BB. These specimens were divided into three groups. Group I specimens were ambient controls, Group II specimens were conditioned at 50 C for 1, 2, and 3 months. Group III specimens were conditioned the same as Group II but before testing they were heated to 100 C and held for 2 hours. All specimens were tested at 21 C.

The data from this investigation showed no significant difference in the ultimate stress of the three groups but Group III with reduced crystallinity gave a greater percentage strain than either of the other two groups.

DISCUSSION

The purpose of this investigation was to determine the stress/strain properties of RX-03-BB as a function of the degree of crystallinity of its Kel-F 800 binder.

RX-03-BB is a plastic bonded explosive consisting of 92.5% TATB and 7.5% Kel-F 800. The original crystallinity of Kel-F is destroyed during the formulation of RX-03-BB by dissolving the Kel-F in a solvent during the formulation of the RX-03-BB.

A previous investigation(1) has shown that Kel-F 800 will obtain a significant degree of crystallinity if it is thermally conditioned at 50 C for three months.

A second parameter that could affect the stress/strain properties of RX-03-BB is the dimensional change (growth) that occurs as the pressed material is heated for extended period of time. Therefore, the experiment was designed to control this parameter.

Forty-four mechanical test specimens were prepared from a single pressing of RX-03-BB and these were divided into three groups. Group I specimens were the controls and were maintained at ambient temperature, Group II specimens were stored at 50 C and Group III specimens were also stored at 50 C but before testing were heated to 100 C and held for 2 hours to remove any crystallinity that existed in the Kel-F. All specimens were tested at 21 C. Since Group II and III had essentially the same thermal history their dimensional growth should be the same, thus eliminating any effect that specimen growth might have on mechanical properties on these two groups.

(1) L. C. Myers, C. C. Blair, *An Investigation of the Crystallinity of Kel-F, Viton, and Estane*, MHSMP-76-17L (January-March 1976).

One third of the specimens from each group were tested at 1, 2, and 3 month intervals.

A Perkin Elmer Differential Scanning Calorimeter (Model DSC-2) was used to estimate the degree of crystallinity in the Kel-F binder. Fig. 1 shows selected thermograms of the RX-03-BB samples. The thermogram of the 90 day ambient control shows no indication of a melting endotherm (no detectable crystallinity) while the 50 C/30 day and the 50 C/60 day samples show small melting endotherms. The thermograms of the 50 C/90 day and 50 C/90 day and heated to 100 C for 2 hours sample show how heating a sample to 100 C will remove the crystallinity that has grown into the sample.

Table I* gives the average stress and percentage strain for the three groups. These data show no significant differences in the stress during these series of tests. The percentage strain for Group III sample shows a significant increase. From these data it appears that the increase in the percentage strain is the result of heating the sample to 100 C before testing. Group II shows a smaller percentage strain than Group I.

A second test was run on another set of tensile specimens to determine if the increase in the percentage strain was due only to the heating of the specimens to 100 C before testing. These data are given in Table II and there is an increase in the percentage strain but it is not as large as obtained for the samples preheated at 50 C for 1, 2, and 3 months. This indicates that the thermal conditioning (at 50 C) also aids in increasing the percentage strain.

CONCLUSIONS

This set of experiments show that an increase in the degree of crystallinity of the Kel-F 800 binder in RX-03-BB has little or no effect on the ultimate stress of this material. There was a significant increase in the percentage strain on heating the test specimens to 100 C before testing. Those specimens conditioned at 50 C for 1, 2, and 3 months show a slight decrease in the percentage strain as crystallinity increased.

**The test data for the individual parts and stress/strain plots are given in the appendix of this report.*

Ambient Temperature, 90 Days,
10.29 mg

50 C, 30 Days, 10.16 mg

50 C, 60 Days, 10.08 mg

50 C, 90 Days, 10.94 mg

50 C, then heated to 100 C,
90 Days, 10.21 mg

Fig. 1. DSC-2 Thermograms of RX-03-BB (Heating Rate 10 C/min)

Table I. Tensile Test Data for RX-03-BB
(Test Temperature: 21 C, Speed: 0.002 mm/sec)

<u>Temperature</u>		<u>1 Month</u>		<u>2 Months</u>		<u>3 Months</u>	
		<u>Stress</u> (MPa)	<u>Strain</u> (%)	<u>Stress</u> (MPa)	<u>Strain</u> (%)	<u>Stress</u> (MPa)	<u>Strain</u> (%)
Group I							
Control*	Mean	10.7	0.35	10.4	0.36	11.1	0.36
	σ	0.4	0.04	0.3	0.03	0.2	0.03
Group II							
50 C	Mean	10.8	0.32	10.4	0.34	10.7	0.32
	σ	0.3	0.02	0.4	0.05	0.1	0.02
Group III							
50 C**	Mean	10.2	0.51	9.9	0.47	10.2	0.45
	σ	0.2	0.03	0.4	0.07	0.1	0.07

*Ambient

**Preheated at 100 C for 2 hours.

Table II. Tensile Test Data for RX-03-BB

(Test Temperature: 21 C, Speed: 0.002 mm/sec)

<u>Temperature</u>		<u>Stress (MPa)</u>	<u>Strain (%)</u>
Control*	Mean	10.7	0.36
	σ	0.4	0.04
100 C**	Mean	9.5	0.40
	σ	0.7	0.10

**Ambient*

***Heated for 2 hours.*

APPENDIX

Table I. Tensile Test at 0.002 mm/s at 21 C for RX-03-BB HSM

(Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)

<u>Piece No.</u>	<u>Rupture Mode</u>	<u>Time (s)</u>	<u>Rupture Stress (MPa)</u>	<u>Strain (%)</u>	<u>Work To Rupture (KJ/m³)</u>
(Group I at 30 Days)					
9	3	387	10.8	0.319	24.75
10	2	360	10.2	0.289	19.50
29	6	406	11.0	0.399	31.34
33	6	383	10.8	0.364	27.45
Mean		384	10.7	0.343	25.76
Std. Dev.		19	0.37	0.049	4.97

(Group II at 30 Days)					
7	6	412	11.1	0.336	25.25
18	4	373	10.6	0.307	21.42*
19	2	371	10.6	0.313	21.89
Mean		385	10.8	0.319	22.85
Std. Dev.		23	0.28	0.016	2.09

*Broke on Machine Marks

(Group III at 30 Days)					
11	3	421	9.93	0.476	34.28
14	6	437	10.1	0.528	38.96
16	2	448	10.3	0.525	41.65
32	6	439	10.3	0.521	38.86
Mean		436	10.2	0.512	38.44
Std. Dev.		11	0.17	0.025	3.06

Fig. 1. RX-03-BB 30 Day Tensile Test at 21 C (Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)

Table II. Tensile Test at 0.002 mm/s at 21 C for RX-03-BB HSM
(Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)

<u>Piece No.</u>	<u>Rupture Mode</u>	<u>Time (s)</u>	<u>Rupture Stress (MPa)</u>	<u>Strain (%)</u>	<u>Work To Rupture (KJ/m³)</u>
(Group I at 60 Days)					
3	5	506	10.6	0.388	28.09
8	6	521	10.2	0.336	23.32
5	6	484	10.6	0.329	23.62
4	6	443	10.1	0.378	25.72
Mean		488	10.4	0.358	25.19
Std. Dev.		34	0.26	0.029	2.21
(Group II at 60 Days)					
20	4	453	9.81	0.283	17.83
13	6	485	10.8	0.388	27.92
22	4	487	10.6	0.289	19.24
21	4	476	10.3	0.352	24.02
12	6	484	10.3	0.365	25.03
Mean		477	10.4	0.335	22.81
Std. Dev.		14	0.36	0.047	4.19
(Group III at 60 Days)					
35	6	499	9.60	0.451	30.01
31	4	514	9.64	0.554	38.30
15	6	521	10.4	0.411	29.50
Mean		511	9.87	0.472	32.60
Std. Dev.		12	0.44	0.074	4.94

Fig. 2. RX-03-BB 60 Day Tensile Test at 21 C (Lot No. 6114-145-02, Presssing No. 83526Y4601, Density 1.900 Mg/m³)

Table III. Tensile Test at 0.002 mm/s at 21 C for RX-03-BB HSM
(Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)

<u>Piece No.</u>	<u>Rupture Mode</u>	<u>Time (s)</u>	<u>Rupture Stress (MPa)</u>	<u>Strain (%)</u>	<u>Work To Rupture (KJ/m³)</u>
(Group I at 90 Days)					
1	6	372	11.0	0.363	27.34
2	2	395	11.3	0.387	31.01
25	6	376	11.1	0.352	26.85
27	4	349	10.7	0.322	23.09
26	2	383	11.3	0.398	31.24
Mean		375	11.1	0.364	27.91
Std. Dev.		17	0.24	0.030	3.37
(Group II at 90 Days)					
37	2	388	10.8	0.328	23.19
39	2	359	10.6	0.307	20.91
Mean		374	10.7	0.318	23.05
Std. Dev.		21	0.1	0.015	1.51
(Group III at 90 Days)					
34	4	390	10.2	0.409	29.62
36	2	424	10.3	0.397	31.84
42	2	421	10.3	0.538	40.62
43	4	408	10.3	0.474	35.08
Mean		411	10.2	0.454	34.29
Std. Dev.		16	0.05	0.065	4.78

Fig. 3. RX-03-BB 30 Day Tensile Test at 21 C (Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)

Table IV. Tensile Test at 0.002 mm/s at 21 C for RX-03-BB HSM
(Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)

<u>Piece No.</u>	<u>Rupture Mode</u>	<u>Time (s)</u>	<u>Rupture Stress (MPa)</u>	<u>Strain (%)</u>	<u>Work To Rupture (KJ/m³)</u>
Control					
6	6	379	11.0	0.368	27.51
7	6	351	10.3	0.318	21.80
8	4	391	11.0	0.411	31.09
10	3	346	10.3	0.334	22.51
Mean		367	10.7	0.358	25.65
Std. Dev.		22	0.4	0.041	4.48
Thermal Conditioned					
4	2	428	10.4	0.574	42.36
5	2	379	10.0	0.415	28.48
3	2	343	9.41	0.370	23.49
2	4	332	9.03	0.332	19.49
1	4	306	8.55	0.331	18.51
Mean		358	9.47	0.404	26.46
Std. Dev.		47	0.73	0.101	9.71

Fig. 4. RX-03-BB Tensile Test at 21 C (Lot No. 6114-145-02, Pressing No. 83526Y4601, Density 1.900 Mg/m³)