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MECHANICAL PROPERTIES OF TATB/KEL-F 800
FORMULATIONS

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DEVELOPMENT DIVISION

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ABSTRACT

The growth of thermally cycled RX-03-BB dimensional stability specimens was reduced by confinement to 2.0 mm/m with a preloading of 69 kPa and to 0.5 mm/m with a preloading of 1379 kPa. The growth of unconfined specimens is 3.0 - 3.5 mm/m. The density loss due to growth for confined specimens ranged from 0.003 to 0.007 Mg/m³ compared with 0.019 Mg/m³ for unconfined specimens.

The compressive strength of LLL B7 is significantly higher than Blend 6. The tensile strength and elongation of B6 and B7 are approximately the same.

DISCUSSION

DIMENSIONAL STABILITY

The special test that was devised to confine the growth using the compressibility apparatus, reported last quarter(1), only confined the axial growth. The results showed the height deflection to be significantly decreased; however, the diameter growth did not seem to be affected. The total diameter growth experienced (3.5 mm/m) is normal for RX-03-BB. The purpose of this experiment was to observe the growth of RX-03-BB specimens that are mechanically confined both axially and diametrically and to determine the effects of various confinement loads.

The compressibility test apparatus was modified to accept silastic inserts to be used as the medium for transmitting pressure. Nine RX-03-BB LLL B6 test specimens (25.4 mm diameter x 25.4 mm long) were fabricated. The test specimens were preloaded to 69, 138, 345 and 1379 kPa. They were thermally cycled from -54 to +74 to -54 C once every 24 hours for twenty cycles. The densities and dimensions of the test specimens were measured before and after thermally cycling under confinement. The results in Table I show that the growth range of the confined parts were from 0.5 to 2.0 mm/m. Also included in Table I under the heading of "Thermally Cycled Under Confinement" are the loads before and after the twenty temperature cycles. The final values indicate that loads were not constant throughout the temperature cycles. Three disc springs (maximum number the test apparatus would accept) were stacked in series in order to maintain a constant load. However, the results indicate the compaction of the silastic was more than the full expansion of the three series disc springs. Therefore, it is not possible to conclude that 69 kPa load will only confine the dimensional growth to 2.0 mm/m.

(1) H. D. Johnson, *Mechanical Properties of TATB/Kel-F 800 Formulations* (April - June 1975).

The control specimen and the specimens that were thermally cycled under confinement were also thermally cycled unconfined for twenty cycles. The total growth of the control specimen was approximately 2.8 mm/m. The results in Table I and Figs. 1 and 2 show that the specimens preloaded to 1379 kPa growth was highest when subjected to temperature cycling unconfined. The specimens preloaded to 69 kPa produced the lowest growth when subjected to unconfined temperature cycling.

It was also observed that the total density loss for each of the nine specimens was approximately the same.

MECHANICAL PROPERTIES OF TATB/KEL-F

The RX-03-BB TATB/Kel-F Blend 7 formulation mechanical properties were evaluated using the standard test parameters for the large TATB/Kel-F blends. Fig. 3 shows the test results of the constant crosshead velocity test of LLL B7 with LLL B6, LLL B5, LLL B4 and TATB powder superimposed on the same plot. The application of the student "t" test for the difference of two means of the tensile results of LLL B6 and LLL B7 show there is no significant difference at the 95% confidence level. Previous test results have shown Blend 6 to be superior to all large blends formulated to date.

There is no significant difference between the strain rate control and the constant crosshead velocity of LLL B7 tensile and compression tests (see Tables II through V and Figs. 5 and 6). The compression failure stress (constant crosshead velocity test) for Blend 7 is 19.93 MPa as compared to 14.20 MPa for Blend 6. Fig. 4 shows the compression test results of LLL B7 with LLL B6, LLL B5 and TATB powder superimposed on the same plot for comparison purposes. It can be readily seen the compressive strength of Blend 7 is significantly higher than the other blends shown. A typical rupture mode of LLL B7 tensile and compression specimens is shown in Fig. 7.

FUTURE WORK, COMMENTS, CONCLUSIONS

The dimensional stability test results indicate the bartherm treatment does not eliminate material growth. Table I shows that confinement does contain growth somewhat; however, the total growth (approximately 3 mm/m) of the preloaded specimens are the same as the control specimen if they are subsequently allowed to grow unconfined. The total density change is approximately the same. A parallel test is being conducted where pressure is isostatically maintained with a silicone oil medium. It is planned to isostatically control the confinement load on the dimensional growth specimens in order to determine the minimum load required to control the permanent material growth.

The compression tests show that the compressive strength of LLL B7 is significantly higher than the other blends. The tensile results of Blend 7 is approximately the same as Blend 6 which has been found to be superior to all previous large blends. The above observations indicate that Blend 7 should be overall superior to Blend 6 with respect to mechanical properties.

Table I. Dimensional Stability Test for RX-03-BB

LLL B6 Lot 5136-145-01

Pressing No. 83170Y4601

<u>Piece No.</u>	<u>Preload (kPa)</u>	<u>Final Load ^a (kPa)</u>	<u>Dimensional Height (mm/m)</u>	<u>Growth Diameter (mm/m)</u>	<u>Density Change (Mg/m³)</u>
<u>Thermally Cycled Under Confinement</u>					
2	1379	1220	0.5	0.6	-0.003
3	1379	1220	0.9	0.4	-0.003
4	345	224	1.1	0.8	-0.004
5	345	224	1.0	1.4	-0.004
6	138	34	1.6	1.2	-0.006
7	138	34	1.7	1.3	-0.006
8	69	0	2.0	1.5	-0.007
9	69	0	2.0	1.5	-0.006
<u>Thermally Cycled Unconfined</u>					
1 ^b	-	0	2.8	2.6	-0.019
2	-	0	2.2	2.0	-0.014
3	-	0	2.5	2.3	-0.013
4	-	0	1.7	2.6	-0.013
5	-	0	1.8	1.6	-0.013
6	-	0	1.3	1.8	-0.013
7	-	0	1.5	1.4	-0.013
8	-	0	1.3	1.6	-0.013
9	-	0	1.4	1.6	-0.011

^aThe original load was decreased due to compaction of silastic material used to maintain the load^bControl specimen (part was not thermal cycled under confinement)

Fig. 1. Dimensional Stability Test for Confined RX-03-BB (LLL B6 Lot 5136-145-01)

Fig. 2. Dimensional Stability Test for Unconfined RX-03-BB (LLL B6 Lot 5136-145-01)

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Fig. 3. Tensile Test at a Constant Crosshead Velocity of 0.002 mm/sec at 21 C

Table II. Tensile Test at a Constant Crosshead Speed of 0.002 mm/sec at 21 C

(RX-03-BB LLL B7, Lot No. 5218-145-01-B7, Pressing No.
83220Y4601, Density 1.901 Mg/m³)

Piece No.	Rupture Mode ^a	Initial Modulus ^b (GPa)	Time (sec)	Rupture Stress (MPa)	Strain (%)
5	4	-	467	9.14	0.21
12	5	-	530	9.74	0.25
1	2	8.07	359	10.07	0.34
2	6	4.71	329	10.12	0.32
Mean		6.39	421	9.77	0.28
Std. Dev.		2.38	94	0.45	0.06

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

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

Table III. Tensile Test at a Constant Strain Rate of 16.67 $\mu\text{E}/\text{sec}$ at 21 C

(RX-03-BB LLL B7, Lot 5218-145-01, Pressing No.
83220Y4601, Density 1.901 Mg/m³)

Piece No.	Rupture Mode	Initial Modulus (GPa)	Time (sec)	Rupture Stress (MPa)	Strain (%)
3	6	-	188	8.89	0.30
4	4	3.29	172	8.89	0.29
6	6	7.66	193	9.20	0.31
Mean		5.47	184	9.00	0.30
Std. Dev.		3.08	11	0.18	0.01

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

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

Table IV. Compression Test at a Constant Crosshead Speed of 0.00085 mm/sec at 21 C

(RX-03-BB LLL B7, Lot No. 5218-145-01, Pressing No.
83220Y4601, Density 1.901 Mg/m³)

Piece No.	Initial Modulus ^a (GPa)	Failure			Rupture		Work to Rupture (MJ/m ³)
		Time (sec)	Stress (MPa)	Strain (%)	Time (sec)	Strain (%)	
18	3.05	2472	19.86	1.89	4722	6.84	1.1401
23	3.05	2340	19.79	1.86	5010	6.59	1.0916
25	2.12	2568	20.13	2.08	3825	4.70	0.8163
Mean	2.74	2460	19.93	1.94	4519	6.04	1.0165
Std. Dev.	0.54	114	0.18	0.12	618	1.17	0.1426

^aInitial Modulus: (20% Failure stress)/strain

Table V. Compression Test at a Constant Strain Rate of 16.67μE/sec at 21 C

(RX-03-BB LLL B7, Lot No. 5218-145-01, Pressing No.
83220Y4601, Density 1.901 Mg/m³)

Piece No.	Failure			Rupture		Work to Rupture (MJ/m ³)
	Time (sec)	Stress (MPa)	Strain (%)	Time (sec)	Strain (%)	
19	1100	19.77	1.80	4338	7.35	1.2041
26	1224	20.40	1.95	3048	6.31	1.1283
24	1327	19.44	2.13	3270	5.54	0.9722
27	1104	20.27	1.80	3144	5.20	0.9192
Mean	1189	19.97	1.92	3450	6.10	1.0559
Std. Dev.	109	0.45	0.16	600	0.95	0.1328

Fig. 4. Compression Tests at a Constant Crosshead Velocity of 0.001 mm/sec at 21 C

Fig. 5. RX-03-BB Tensile Test at 21 C (LLL B7; Lot 5218-145-01)

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Fig. 6. RX-03-BB Compression Test at 21 C (LLL B7; Lot 5218-145-01)

Tensile Specimen

Compression Specimen

Fig. 7. Typical Rupture for Tensile and Compression Specimen