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MIXED HIGH EXPLOSIVES FOR INSENSITIVE BOOSTER COMPOSITIONS

AR-006-903

I.J. DAGLEY, R.P. PARKER, L. MONTELLI AND C.N. LOUEY

MRL-TR-92-22

JULY 1993

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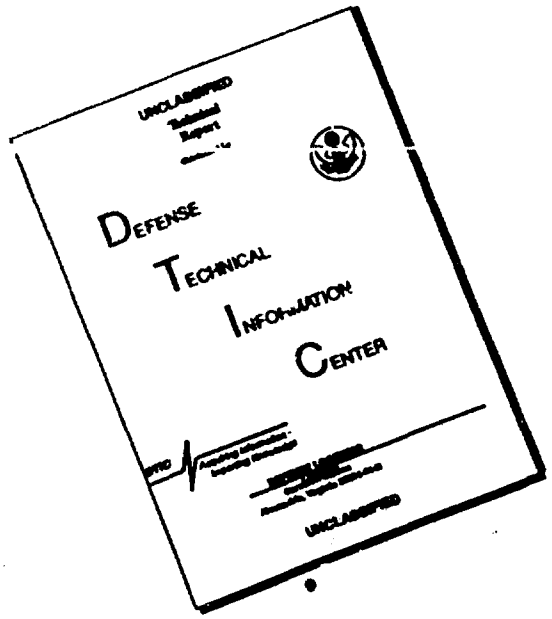

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I.J. Dagley, R.P. Parker, L. Montelli and C.N. Louey

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Abstract

Three series of candidate insensitive booster compositions based on RDX (Grade A)/Elvax 210, and incorporating various amounts of PETN, DATB and TATB (ranging from 5 to 35%) have been prepared and characterized for impact sensitiveness (Rotter F of I), shock sensitivity (SSGT) and cookoff behaviour (SSCB).

The RDX/PETN/Elvax 210 compositions are generally more impact sensitive than RDX, have shock sensitivities between those of tetryl and PBXW-7 Type II, and give less violent cookoff responses than RDX/Elvax 210 (95:5) at the slow heating rate but more violent responses at the fast heating rate.

All the RDX/DATB/Elvax 210 and RDX/TATB/Elvax 210 compositions had acceptable impact sensitiveness, but most were extremely shock insensitive. Use of finer particle size RDX led to increase in both the impact sensitiveness and shock sensitivity of RDX/TATB/Elvax 210 (75:20:5) composition. The compositions generally gave less violent reactions than RDX/Elvax 210 (95:5) at both fast and slow heating rates. The RDX/TATB/Elvax 210 (65:30:5) composition was the best of those examined, giving mild explosions or deflagrations in most tests; however, further reduction of cookoff violence is still required to give an acceptable insensitive booster composition.

93-20056

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93 8 26 084

Published by

Materials Research Laboratory
Cordite Avenue, Maribyrnong
Victoria, 3032 Australia

Telephone: (03) 246 8111
Fax: (03) 246 8999
© Commonwealth of Australia 1992
AR No. 006-903

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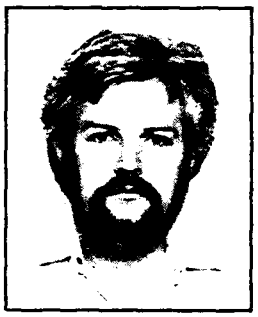
Authors

I.J. Dagley

Dr Ian Dagley attended University of Melbourne, graduating BSc (Hons) in Chemistry and PhD in Organic Chemistry in 1979. He was awarded a Perkin Fellowship for two years postdoctoral studies at Oxford University, then returned to Australia in 1981 to be Chief Chemist at Beta Chemical (Dunlop-Olympic). Ian joined Explosives Ordnance Division, MRL in 1985, where he has conducted R & D on booster explosives, insensitive high explosives, and mechanisms of their initiation under mechanical impact.

R.P. Parker



Robert Parker graduated Dip App Chem from Ballarat School of Mines and Industries in 1968, and joined MRL in that year. He has worked exclusively on explosive materials; his present major areas of interest are cookoff of explosives and PBX formulations.

L. Montelli

Lucianna Montelli graduated BAppSc in Chemistry in 1987 from Royal Melbourne Institute of Technology. She was then recruited to MRL where she has conducted R & D into a number of aspects of explosives technology including polymer bonded explosives formulation and thermally stable high explosives for initiating devices.

C.N. Louey

Craig Louey graduated BAppSc (Hons) in Chemistry in 1987 from University of Melbourne. He was recruited to MRL in 1988 where he has worked exclusively in the explosives materials area, specializing in desensitization of explosives through the use of polymers. Craig has since left MRL.

Contents

1. INTRODUCTION **7**

2. EXPERIMENTAL APPROACH **7**

3. EXPERIMENTAL **8**
3.1 Materials **8**
3.2 Mixing Equipment **8**
3.3 Preparation of the Compositions **9**
3.4 Characterization **9**
3.4.1 Rotter Impact Sensitiveness: Figure of Insensitiveness (F of I) **9**
3.4.2 Shock Sensitivity: Small Scale Gap Test **9**
3.4.3 Cookoff Test **9**

4. RESULTS AND DISCUSSION **10**
4.1 Impact Sensitiveness **10**
4.2 Shock Sensitivity **12**
4.3 Cookoff Behaviour **14**

5. CONCLUSIONS **19**

6. ACKNOWLEDGEMENTS **20**

7. REFERENCES **20**

Mixed High Explosives for Insensitive Booster Compositions

1. *Introduction*

Recommendations for the progressive introduction of an insensitive munitions policy into the Australian Defence Forces [1] have been adopted and are being implemented. New ordnance designed to meet insensitive munitions criteria will respond mildly to hazardous stimuli such as bullet and fragment impact, fire (cookoff), and detonation of adjacent munitions; such ordnance will need to contain new, less sensitive explosive compositions. In an Australian program to develop suitable booster compositions for use in insensitive munitions, several promising RDX/polymer (95:5) compositions have been identified [2–4]. These meet most of the requirements for an insensitive booster composition [4], having acceptable impact sensitiveness and shock sensitivity; however further reduction of the violence of cookoff response is necessary. Partial replacement of the RDX with either a more thermally stable explosive (to reduce response by acting as an "explosive diluent" — see below, Section 4.3) or a less thermally stable explosive (to initiate an earlier, milder response) were two options proposed [2] for modifying the cookoff response. This report describes the properties of such compositions and their suitability for use as boosters in insensitive munitions.

2. *Experimental Approach*

The reference composition chosen for this study was RDX/Elvax 210 (95:5). Elvax 210 was the most promising ethylene-vinyl acetate binder identified in previous work [2]. From this, compositions containing TATB, DATB (explosives which are more thermally stable than RDX [5]) and PETN (a less thermally stable explosive [5]), at levels ranging from 5% to 35%, were prepared and their impact sensitiveness, shock sensitivity and cookoff response were determined. To examine the effect of the RDX particle size on these properties, one composition (RDX/TATB/Elvax 210 75:20:5) was also prepared using fine RDX and included in the study.

It is worth noting that the US-developed insensitive booster composition PBXW-7 Type II, which consists of RDX/TATB/Viton A 35:60:5, was formulated with a large amount of TATB to give the required insensitivity.

3. *Experimental*

3.1 *Materials*

DATB was prepared from 1,3-dimethoxybenzene by the method of Dacons, Kamlet and Hoffsommer [6]. The product was initially purified by crystallization from either ethanol or acetic acid, and a final recrystallization from dimethyl sulphoxide [7] gave a crystalline material (median particle size of 47 μm) which was used in the preparation of the various compositions. TATB Type A (median particle size of 40 μm), obtained from Royal Armament Research and Development Establishment (RARDE), Sevenoaks, UK, was used in these studies. PETN obtained from ICI was dissolved in acetone and then precipitated by addition of this solution to water. This process gave fine PETN (median particle size of 27 μm) which was used in these experiments. RDX Grade A Class 1 (recrystallized, with a median particle size of 160 μm) produced by Albion Explosives Factory was used to prepare most of the compositions described in this report. Compositions containing fine RDX were prepared using RDX BUK Class 5 (median particle size of 20 μm) from Royal Ordnance plc, Bridgwater, UK; this material is designated as RDX Grade E in this report. All the explosives were received wet and were routinely dried at the pump prior to use.

Elvax 210 is an ethylene-vinyl acetate copolymer manufactured by Du Pont; it has a vinyl acetate content of 28% w/w. Mowiol 4-88, an additive used in the slurry coating process, is a partially saponified polyvinyl alcohol manufactured by Hoechst. Distilled water and laboratory reagent grade toluene were used in all preparations.

3.2 *Mixing Equipment*

Batches of all compositions were prepared in an open metal mixing vessel fitted with a heating jacket and containing two internal baffles mounted perpendicular to the walls of the vessel. The slurries were stirred by an overhead air-motor driving a rod with an impeller having twelve flat blades fitted at the base.

3.3 *Preparation of the Compositions*

A slurry consisting of the mixed explosives (142.5 g) and water (430 mL) was stirred at 500 r/min for 5 min, then an aqueous solution of Mowiol 4-88 (0.01% w/w, 15 mL) was added and the slurry heated to 65°C. After a further 10 min a solution of Elvax 210 in toluene (10% w/w, 75 g) was slowly added. The mixture was stirred vigorously at 700 r/min and the temperature of the slurry was maintained at 65°C until the solvent had evaporated and hard moulding granules had formed. The agitated slurry was cooled to 30°C and the granules were filtered off, washed with water, dried at the pump and finally dried at 60°C under vacuum over silica gel.

3.4 *Characterization*

3.4.1 *Rotter Impact Sensitiveness: Figure of Insensitiveness (F of I)*

A Rotter apparatus [8, 9] fitted with a 5 kg drop-weight was used to determine the impact sensitiveness of the composition. The results were obtained using 25 caps and the tests were carried out in accordance with the Bruceton procedure. The F of I values quoted, derived from the drop height for 50% initiation probability, are relative to RDX Grade F = 80 and are rounded to the nearest 5 units. The average gas volumes for positive results are also quoted.

3.4.2 *Shock Sensitivity: Small Scale Gap Test*

The MRL small scale gap test (SSGT) [10] was used to obtain the shock sensitivity data. A UK Mk. 3 exploding bridgewire detonator was used as the donor and the shock was attenuated by brass shim. The acceptor was two 12.7 mm diameter × 12.7 mm high cold-pressed cylinders of the explosive under study. A detonation was confirmed using a mild steel witness block. The results were obtained from 20 to 30 firings using the Bruceton staircase method and are quoted in mm of brass shim for a 50% detonation probability, together with 95% confidence limits and standard deviation.

3.4.3 *Cookoff Test*

The cookoff behaviour of the compositions was assessed using the Super Small-scale Cookoff Bomb [11]. The SSCB samples consisted of four pellets 16 mm diameter × 16 mm long, pressed to 90% theoretical maximum density (TMD), with a total mass of approximately 20 g. Tests were performed at both fast (approximately 1°C/second) and slow (approximately 0.1°C/second) heating rates. In some cases the modified (shorter, symmetrical) SSCB test assembly [4] was used. The results presented include the type of response obtained, the explosive surface temperature at reaction and the time to reaction.

4. Results and Discussion

4.1 Impact Sensitiveness

Impact sensitiveness data for RDX/Elvax 210 (95:5), the various compositions containing the mixed explosives, and several reference explosives are presented in Table 1. The RDX/Elvax 210 (95:5) moulding powder prepared in this study was more sensitive to impact than the same composition prepared in an earlier study [2] (F of I = 90 cf. 130). The difference was attributed to some variations in processing conditions and operator technique which might be expected to influence the coating process. It has been shown that the impact sensitiveness of compositions of this type is influenced by the distribution of polymer in the moulding powder and the extent of the polymer coating on the RDX crystal surfaces [12]. Care was taken to try to prepare all the mixed explosive moulding powders under the same conditions used to prepare the reference RDX/Elvax 210 (95:5) composition in an attempt to minimize the effects of variation in the extent of coating on the properties of the compositions.

The replacement of increasing portions of RDX with the less sensitive explosives TATB (F of I > 200) and DATB (F of I = 170) does not produce large increases in the F of I values, indicating that the sensitiveness to impact initiation of all these compositions is largely determined by the RDX. The RDX/TATB/Elvax 210 (75:20:5) composition containing the finer (Grade E) RDX is more sensitive to impact than the composition containing RDX Grade A (F of I = 90 cf. 115). The decrease in F of I value with the large increase in specific surface area of the explosive may be caused by the expected reduction in polymer coating efficiency in the composition containing RDX Grade E. The compositions containing the highest level (30%) of the less sensitive explosives gave comparatively low evolved gas volumes (3 mL), indicating that in these compositions the less sensitive explosive causes a marked reduction in the degree of reaction propagation [8] after ignition.

PETN is more sensitive to impact than is RDX (F of I = 30 to 50 cf. 80) and partial replacement of RDX with PETN would be expected to increase impact sensitiveness. There is evidence for this in the data for the RDX/PETN/Elvax 210 compositions, with the F of I generally decreasing as the PETN content increases. We surmise that the surprisingly high result obtained with RDX/PETN/Elvax 210 (70:25:5) may be caused by unintended variations in the coating process and enhancements in the coating efficiency (as discussed above for the RDX/Elvax 210 (95:5) composition), and similar reasoning may apply to the comparatively high result for RDX/TATB/Elvax 210 (80:15:5) in that series of compositions. Partial substitution of PETN for TATB in the RDX/TATB/Elvax 210 (65:30:5) composition caused a substantial increase in impact sensitiveness; the RDX/TATB/PETN/Elvax 210 (65:20:10:5) composition has an F of I value of 80 compared to 115 for the original composition.

Table 1: *Impact Sensitiveness of Explosive/Elvax 210 (95:5) Compositions and Reference Explosives*

Composition	Figure of Insensitiveness	Gas Evolution (mL)
RDX/Elvax 210		
95:5	90[a], 130[2]	15[a], 15[2]
RDX/TATB/Elvax 210		
85:10:5	90	14
80:15:5	125	14
75:20:5	115	7
75:20:5 - Grade E RDX	90	4
65:30:5	115	3
RDX/DATB/Elvax 210		
85:10:5[a]	110	10
80:15:5	115	17
75:20:5[a]	120	12
65:30:5[a]	125	3
RDX/PETN/Elvax 210		
90:5:5	75	15
80:15:5	65	10
70:25:5	100	13
60:35:5	50	11
RDX/TATB/PETN/Elvax 210		
65:20:10:5	80	2
Reference Explosives		
RDX, Grade F[9]	80	na
TATB	> 200	0.5
DATB	170, 140[13]	0.5, na
PETN	30[14], 50[15]	na, na
Tetryl, granular	90[16], 110[17]	na, 16[17]
Tetryl, crystalline	105[17]	16[17]
PBXW-7 Type II[18]	90	4

a Result for a small (50 g) batch.

na Data not available.

Granular tetryl has an F of I of 90 [16], and this figure is the accepted limit for acceptability of materials below the shutter in a fuze train [19]; typical production batches of both granular and crystalline tetryl have F of I values of 105 to 110 [17]. All the compositions containing RDX blended with the less sensitive explosives (DATB and TATB) have F of I values that are above or within the range of those of tetryl and would be acceptable in this respect.

4.2 *Shock Sensitivity*

Reported shock sensitivity results (summarized in Table 2) indicate that the three explosives blended with RDX in this study differ greatly in shock sensitivity — PETN is more shock sensitive and both DATB and TATB are much less shock sensitive than RDX.

Table 2: NOL Small Scale Gap Test Data for Selected Explosives

Explosive	Density (% TMD)	Decibangs[a] (DBg)
PETN	90.0	2.468
RDX	89.5	3.76
DATB	91.1	8.10
TATB	90.9	9.63

Data from reference 20.

a Related to the attenuator thickness (t, in mils) for a 50% probability of detonation by the equation: $DBg = 30 - 10 \log t$

Shock sensitivity data for pressed explosive/Elvax 210 (95:5) compositions and several reference explosives, determined using the MRL small scale gap test, are shown in Table 3. The RDX/Elvax 210 (95:5) composition has an $m_{50\%}$ value of 2.23 mm. As more RDX (Grade A) is replaced by either DATB or TATB the compositions become less shock sensitive. The decrease is very pronounced, even at the lowest level of incorporation, and when the compositions contain 20% or more of the less sensitive explosives the $m_{50\%}$ values are extremely low (≤ 0.7 mm). Progressive replacement of RDX with the more sensitive explosive (PETN) leads to the expected increase in shock sensitivity, and the composition containing 35% PETN has an $m_{50\%}$ value of 2.99 mm. In an attempt to raise the shock sensitivity of the RDX/TATB/Elvax 210 compositions, PETN was incorporated to give the RDX/TATB/PETN/Elvax 210 (65:20:10:5) composition. However, this did not enhance the shock sensitivity, and this composition was less shock sensitive than the RDX/TATB/Elvax 210 (75:20:5) composition (0.52 mm cf. 0.69 mm).

Table 3: Shock Sensitivity of Explosive/Elvax 210 (95:5) Compositions and Reference Explosives

Composition	Density (% TMD)	Shock Sensitivity (mm)		
		$M_{50\%}$	Range	Standard Deviation
RDX/Elvax 210				
95:5[2]	90.00	2.23	2.34 - 2.11	0.054
RDX/TATB/Elvax 210				
85:10:5	89.99	1.60	1.67 - 1.54	0.030
75:20:5	91.15	0.69	0.71 - 0.68	0.008
75:20:5 - Grade E RDX	90.00	2.53	2.59 - 2.47	0.028
65:30:5	90.00	0.30	0.31 - 0.28	0.007
RDX/DATB/Elvax 210				
85:10:5	90.00	1.15	1.19 - 1.11	0.017
75:20:5	90.00	0.72	0.74 - 0.69	0.011
65:30:5	89.86	0.50	0.52 - 0.48	0.010
RDX/PETN/Elvax 210				
90:5:5	89.87	2.35	2.38 - 2.33	0.012
80:15:5	89.99	2.45	2.49 - 2.40	0.022
70:25:5	89.99	2.84	2.89 - 2.79	0.024
60:35:5	90.02	2.99	3.07 - 2.90	0.039
RDX/TATB/PETN/Elvax 210				
65:20:10:5	90.01	0.52	0.55 - 0.49	0.015
Reference Explosives				
RDX Grade A[a, 21]	90.0	3.360	3.622 - 3.100	0.120
Tetryl, granular[17]	90.0	3.259	3.315 - 3.203	0.026
Tetryl, crystalline[17]	90.0	2.814	2.858 - 2.771	0.021
PBXW-7 Type II[18]	90.0	1.415	1.448 - 1.382	0.015

[a] 250–300 µm sieve cut.

An insensitive booster composition is required to be no more sensitive than tetryl to shock initiation [4], and it would be desirable to have a composition which is more shock sensitive than PBXW-7 Type II. Of the various mixed explosive compositions prepared with Grade A RDX, all those containing PETN and the RDX/TATB/Elvax 210 (85:10:5) composition meet this requirement. Replacement of the Grade A RDX (median particle size of 160 µm) with Grade E RDX (median particle size of 20 µm) in the RDX/TATB/Elvax 210 (75:20:5) composition produced a considerable increase in shock sensitivity, raising the $m_{50\%}$ value from 0.69 mm to 2.53 mm. Spear and Nanut [21] observed that Grade E RDX was more shock sensitive than was a 125 to 150 µm sieve cut of Grade A RDX when both materials were examined under the conditions used in this study; however the differences in the $m_{50\%}$ values (3.785 mm

cf. 3.513 mm) were comparatively small. Eadie [22] studied the shock sensitivity of HMX/wax compacts and observed an increase in sensitivity as the percentage of HMX surface coated with wax decreased. Presumably the much higher specific surface area of the explosive, and hence the less effective crystal surface coating by the Elvax 210 polymer in the composition containing the Grade E RDX, contributes to its higher shock sensitivity. This composition has acceptable shock sensitivity for use as an insensitive booster composition.

4.3 Cookoff Behaviour

The results of SSCB tests on the RDX/Elvax 210 compositions containing DATB, TATB and PETN are presented in Table 4, together with previously reported results for the RDX/Elvax 210 (95:5) composition.

As described above (see Section 2), the approach of this study was to modify the cockoff response of RDX Grade A/Elvax 210 (95:5) by incorporation of other explosives having different thermal stabilities. Differential thermal analysis data for the explosives considered is available in reference [5], and indicates that PETN is less thermally stable than RDX, whereas both DATB and TATB are much more thermally stable. Critical temperatures have been determined for these explosives by Rogers [23], both experimentally using a small-scale time-to-explosion test [24], and by calculation using the Frank-Kamenetskii equation [25][1] with kinetic parameters determined by differential scanning calorimetry; this data is shown in Table 5.

The addition of PETN was expected to lead to reaction at lower temperatures and to produce milder responses due to the initial reaction of the PETN producing an early release of confinement. At the slow heating rate such behaviour was observed, with the explosive surface temperature at reaction decreasing as the PETN content increased; milder responses were also obtained in most cases. However, at the fast heating rate there was no appreciable effect on the reaction temperature until a considerable amount of PETN (25 to 35%) had been added, and all the compositions gave more violent responses than the RDX/Elvax 210 (95:5) — explosions and/or detonations were obtained for all PETN levels. The results for all RDX/PETN/Elvax 210 compositions are presented graphically in Figure 1.

---

[1] The Frank-Kamenetskii equation is

$$E/T_c = R \ln \{a^2 \rho Q Z E / T_c^2 \lambda \delta R\}$$

where R is the gas constant, a is the radius of a sphere or cylinder or the half-thickness of a slab, ρ is the density, Q is the heat of reaction during the self-heating process, Z is the pre-exponential factor and E the activation energy from the Arrhenius expression, λ is the thermal conductivity, and δ is a shape factor.

Table 4: Cookoff Test (SSCB) Results for Explosive/Elvax 210 (95:5) Compositions

Composition	Heating Rate	Temp (°C)	Time (s)	Response
RDX/Elvax 210[2]				
95/5	Fast	245, 234	235, 238	Burn[a], Deflagration[b]
95/5	Fast	237, 242	246, 264	Mild explosion, Mild explosion
95/5	Slow	217, 220	1628, 1681	Detonation, Detonation
95/5 - Grade E RDX	Fast	234, 237	275, 244	Mild explosion[a], Detonation
95/5 - Grade E RDX	Slow	220	1757	Detonation
RDX/DATB/Elvax 210				
85/10/5	Fast	220, 252	257, 356	Detonation, Burn[b]
85/10/5	Slow	222, 222	1549, 1790	Detonation, Burn[b]
75/20/5	Fast	225, 252	245, 322	Explosion[b], Deflagration[a]
75/20/5	Slow	217, 217	1499, 1843	Mild explosion[b], Deflagration
65/30/5	Fast	231, 238	285, 367	Burn[b], Burn[a]
65/30/5	Slow	219, 205	1473, 2023	Detonation, Deflagration[b]
RDX/TATB/Elvax 210				
85/10/5	Fast	250, 251	267, 294	Mild explosion[b], Explosion
85/10/5	Slow	215, 223	1778, 1554	Mild explosion[b], Deflagration[b]
75/20/5	Fast	252, 246	275, 265	Explosion/DDT[c], Mild explosion[b]
75/20/5	Slow	215, 223	1537, 1361	Deflagration[b], Deflagration[b]
75/20/5 - Grade E RDX	Fast	240, 242	254, 248	Explosion[b], Deflagration[b]
75/20/5 - Grade E RDX	Slow	224, 215	1545, 1537	Burn[b], Deflagration[b]
65/30/5	Fast	242, 244	262, 288	Deflagration[b], Deflagration[a]
65/30/5	Slow	218, 223	1586, 1667	Deflagration[b], Mild explosion[b]
RDX/PETN/Elvax 210				
90/5/5	Fast	239, 246	264, 279	Detonation, Explosion[b]
90/5/5	Slow	208, 207	1437, 1326	Deflagration, Mild explosion[b]
80/15/5	Fast	231, 247	271, 254	Explosion[b], Detonation
80/15/5	Slow	203, 209	1314, 1478	Detonation, Explosion
70/25/5	Fast	232, 212	255, 230	Explosion[b], Detonation
70/25/5	Slow	198, 203	1294, 1385	Mild explosion, Deflagration
60/35/5	Fast	218, 213	234, 219	Detonation, Detonation
60/35/5	Slow	195, 206	1318, 1194	Mild explosion, Deflagration
RDX/TATB/PETN/Elvax 210				
65/20/10/5	Fast	255, 244	229, 274	Explosion[b], Detonation
65/20/10/5	Slow	205, 203	1243, 1240	Deflagration[b], Explosion[b]

a Appreciable amounts (> 1.5 g) of unconsumed explosive recovered after test.

b Traces of explosive on parts after test.

c Deflagration to detonation transition possibly occurring — baseplate was cracked through and spalled on rear surface, but not holed.

Table 5: Critical Temperatures of Selected Explosives

Explosive	T_{crit} (°C) - experimental[a]	T_{crit} (°C) - calculated
PETN	200 – 203	196
RDX	215 – 217	217
DATB	320 – 323	323
TATB	331 – 332	334

Data from reference 23.

a Determined from time-to-explosion of small slab samples.
b Calculated using Frank-Kamenetskii equation, for experimental-size samples.

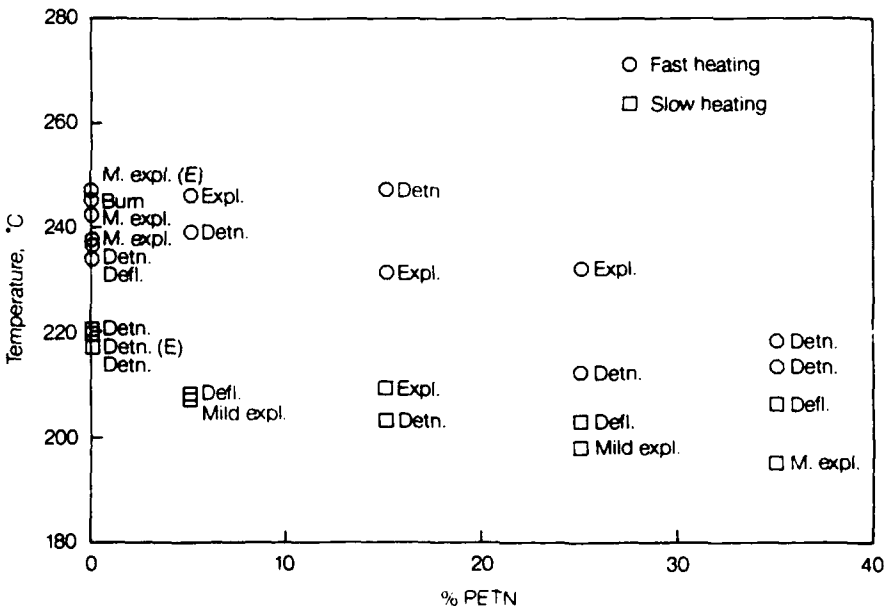


Figure 1: SSCB Tests of RDX/PETN/Elvax 210.

Both DATB and TATB are insensitive heat-resistant explosives, and were expected to reduce the violence of the cookoff reaction by acting as "explosive diluents". Although they are explosives and will contribute to the reaction driving a detonation when initiated by a shock mechanism, when thermal decomposition occurs (as in initiation of reaction in a cookoff situation) they will act essentially as a diluent for the less thermally stable material (RDX). The results for both the RDX/DATB/Elvax 210 and RDX/TATB/Elvax 210 compositions (presented graphically in Figures 2 and 3 respectively) show that the reactions generally occur in the same temperature range as for RDX/Elvax 210 (95:5) and other RDX/EVA compositions [2], indicating that the reaction is being triggered by RDX in all these compositions. Similar behaviour has been reported for a series of RDX/TATB/PTFE compositions subjected to small-scale fuel fire cookoff tests [26]; the cookoff temperature did not increase until 60 to 75% TATB was incorporated into the composition.

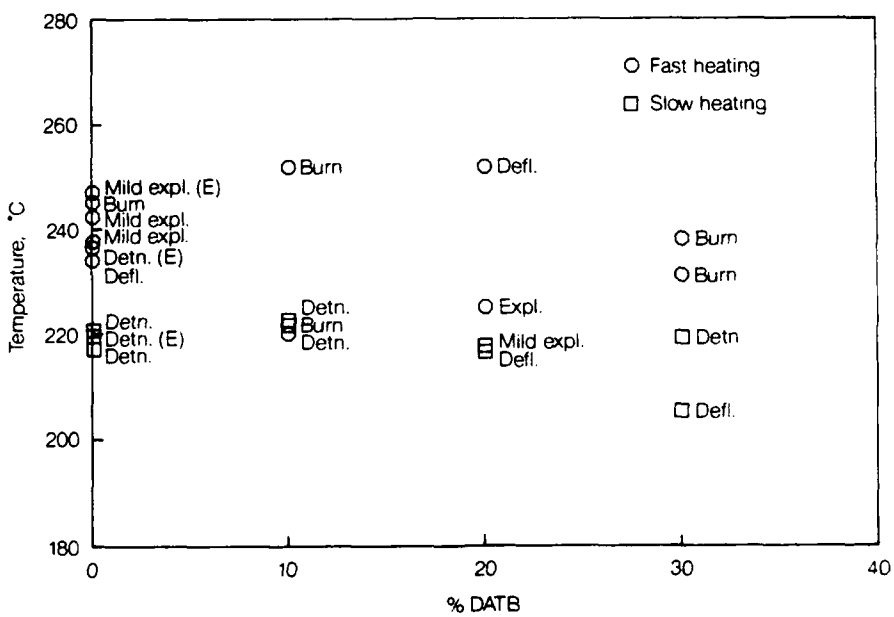


Figure 2: SSCB Tests of RDX/DATB/Elvax 210.

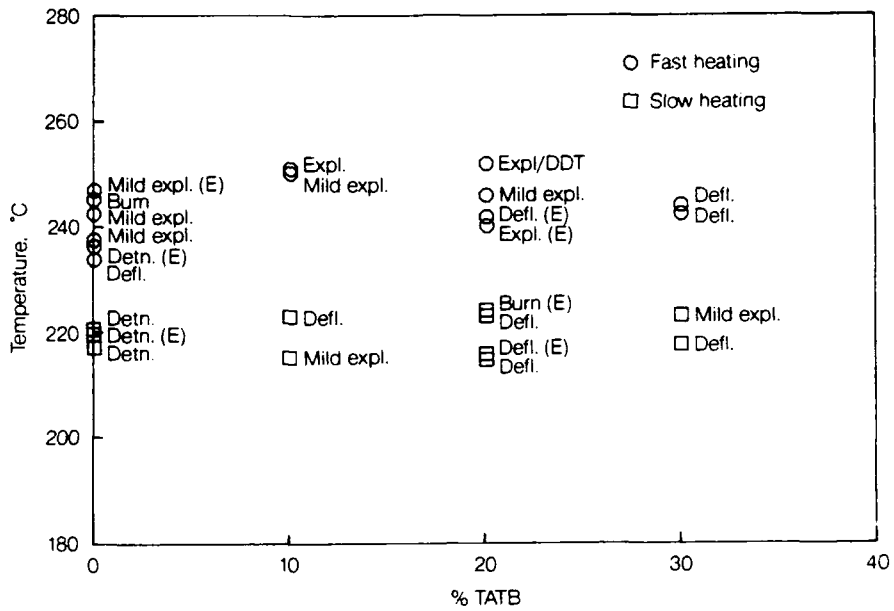


Figure 3: SSCB Tests of RDX/TATB/Elvax 210.

The cookoff responses of the RDX/DATB/Elvax 210 and RDX/TATB/Elvax 210 compositions were generally milder than for RDX/Elvax 210 (95:5) at the slow heating rate, but at the fast heating rate the responses were generally similar to those of RDX/Elvax 210 (95:5). The composition containing 20% TATB prepared with Grade E RDX behaved similarly to the composition containing Grade A RDX, although marginal improvement in cookoff response was noted. These results were unexpected, since the RDX/Elvax 210 (95:5) composition containing Grade E RDX had previously been found to respond more violently than the composition containing Grade A RDX [2]. In several tests violent reactions were obtained — detonations from the RDX/DATB/Elvax 210 (85:10:5) composition at both fast and slow heating rates and from the RDX/DATB/Elvax 210 (65:30:5) composition at the slow heating rate, and a violent explosion (possibly indicative of a deflagration to detonation transition occurring) with the RDX/TATB/Elvax 210 (75:20:5) composition at the fast heating rate.

The best composition (with regard to cookoff behaviour) appears to be RDX/TATB/Elvax 210 (65:30:5); however, further reduction of cookoff reaction violence is desirable. IM requirements for complete munitions require reaction no more severe than burning [27]. This does not necessarily imply that a suitable booster material must give only burn responses in the SSCB test; deflagrations, or possibly even mild explosions, may be acceptable provided that such reaction of the booster in a munition does not cause the main charge to react violently. The

RDX/TATB/Elvax 210 (65:30:5) composition gives similar cookoff responses (in the SSCB test) to PBXW-7 Type II [11], which has recently been qualified (as PBXN-7) as an insensitive booster in the US, and may therefore be an acceptable material. It should be noted that there is no data available to firmly establish the relationship between SSCB response of the booster composition and full-scale IM test response of the main charge occassioned by reaction of the booster. We therefore believe that an SSCB test response milder than that of PBXW-7 Type II is desirable for a booster composition for IM applications; this would increase confidence that a munition containing such a material would pass IM qualification tests and provide a greater safety margin.

Earlier work [2] has shown that the ethylene-vinyl acetate copolymer Elvax 210 is more effective in moderating cookoff response than is the fluorocarbon polymer Viton A (used in PBXW-7 Type II). This study confirms that conclusion; large amounts (60 to 75%) of TATB are necessary to give mild cookoff responses when Viton A is used as the binder/coating material [11, 28], but similar mild responses were obtained in this study with 35% TATB in the compositions using Elvax 210.

5. *Conclusions*

Three series of candidate insensitive booster compositions based on RDX/Elvax 210, and incorporating various amounts of PETN, DATB and TATB (ranging from 5 to 35%) have been prepared and characterized for impact sensitiveness, shock sensitivity and cookoff behaviour.

The RDX/PETN/Elvax 210 compositions are generally more impact sensitive than RDX, and these compositions would not comply with fuze system safety guidelines if used in fuze train systems below the shutter. One of the compositions, RDX/PETN/Elvax 210 (70:25:5), was found to have acceptable impact sensitiveness; this result did not follow the expected (and observed) trend of increasing impact sensitiveness with increasing PETN content. It is surmised that this result was due to variation in the coating process and enhancement of the coating efficiency for this composition. All the compositions containing DATB and TATB had acceptable impact sensitiveness. Replacement of the Grade A RDX with a finer particle size (Grade E) material increased the impact sensitiveness of the RDX/TATB/Elvax 210 (75:20:5) composition; however, the more sensitive material was still acceptable.

The shock sensitivities of all the RDX/PETN/Elvax 210 compositions were intermediate between those of tetryl (the current fuze booster composition) and PBXW-7 Type II. In contrast, the RDX/DATB/Elvax 210 and RDX/TATB/Elvax 210 compositions, with the exception of RDX/TATB/Elvax 210 (85:10:5), were found to be extremely insensitive and would probably be unacceptable in practical fuze systems. Replacement of the Grade A RDX with a finer particle size (Grade E) material increased the shock sensitivity of the RDX/TATB/Elvax 210 (75:20:5) composition to an acceptable level. This approach (tailoring shock sensitivity by controlling particle size) could be applied to other compositions which may be otherwise acceptable but have insufficient shock sensitivity for the desired application.

The three series of compositions all exhibited modified cookoff behaviour relative to that of the RDX/Elvax 210 (95:5) composition. Incorporation of PETN gave less violent responses at the slow heating rate, together with a decrease in the reaction

temperature; however, at the fast heating rate responses were more violent. DATB and TATB both generally gave compositions with less violent reactions at both heating rates, and the RDX/TATB/Elvax 210 (65:30:5) composition was the best of those examined, giving mild explosions or deflagrations in most tests. This composition gave similar cookoff responses to PBXW-7 Type II, and would probably be an acceptable insensitive booster composition (when formulated with Grade E RDX to give acceptable shock sensitivity). However, further reduction of cookoff violence is desired to increase confidence that munitions containing the material would pass IM qualification tests, and would provide a greater safety margin over the current US insensitive booster composition PBXN-7.

6. Acknowledgements

Considerable technical assistance was provided by Mrs B. Pletikapa (cookoff testing), Mr E. Wanat (Rotter testing), Mr M.G. Wolfson (SSGT) and Mr T. Ryan (SSGT). Dr R.J. Spear assisted this project through several useful discussions. The contributions of all these people are gratefully acknowledged.

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SECURITY CLASSIFICATION OF THIS PAGE **UNCLASSIFIED**

REPORT NO.	AR NO.	REPORT SECURITY CLASSIFICATION
MRL-TR-92-22	AR-006-903	Unclassified

TITLE

Mixed high explosives for insensitive booster compositions

AUTHOR(S)
I.J. Dagley, R.P. Parker, L. Montelli and C.N. Louey

CORPORATE AUTHOR
DSTO Materials Research Laboratory
PO Box 50
Ascot Vale Victoria 3032

REPORT DATE	TASK NO.	SPONSOR
July, 1993	AIR 87/156	RAAF

FILE NO.	REFERENCES	PAGES
G6/4/8-4189	28	23

CLASSIFICATION/LIMITATION REVIEW DATE	CLASSIFICATION/RELEASE AUTHORITY
August, 1995	Chief, Explosives Ordnance Division

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Approved for public release

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KEYWORDS

Insensitive booster compositions	Impact sensitiveness	RDX
Cookoff behaviour	Shock sensitivity	ELVAX
TATB	DATB	PBXW-7

ABSTRACT

Three series of candidate insensitive booster compositions based on RDX (Grade A)/Elvax 210, and incorporating various amounts of PETN, DATB and TATB (ranging from 5 to 35%) have been prepared and characterized for impact sensitiveness (Rotter F of I), shock sensitivity (SSGT) and cookoff behaviour (SSCB).

The RDX/PETN/Elvax 210 compositions are generally more impact sensitive than RDX, have shock sensitivities between those of tetryl and PBXW-7 Type II, and give less violent cookoff responses than RDX/Elvax 210 (95:5) at the slow heating rate but more violent responses at the fast heating rate.

All the RDX/DATB/Elvax 210 and RDX/TATB/Elvax 210 compositions had acceptable impact sensitiveness, but most were extremely shock insensitive. Use of finer particle size RDX led to increase in both the impact sensitiveness and shock sensitivity of RDX/TATB/Elvax 210 (75:20:5) composition. The compositions generally gave less violent reactions than RDX/Elvax 210 (95:5) at both fast and slow heating rates. The RDX/TATB/Elvax 210 (65:30:5) composition was the best of those examined, giving mild explosions or deflagrations in most tests; however, further reduction of cookoff violence is still required to give an acceptable insensitive booster composition.

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I.J. Dagley, R.P. Parker, L. Montelli
and C.N. Louey

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