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Insensitive Enhanced Blast Formulations

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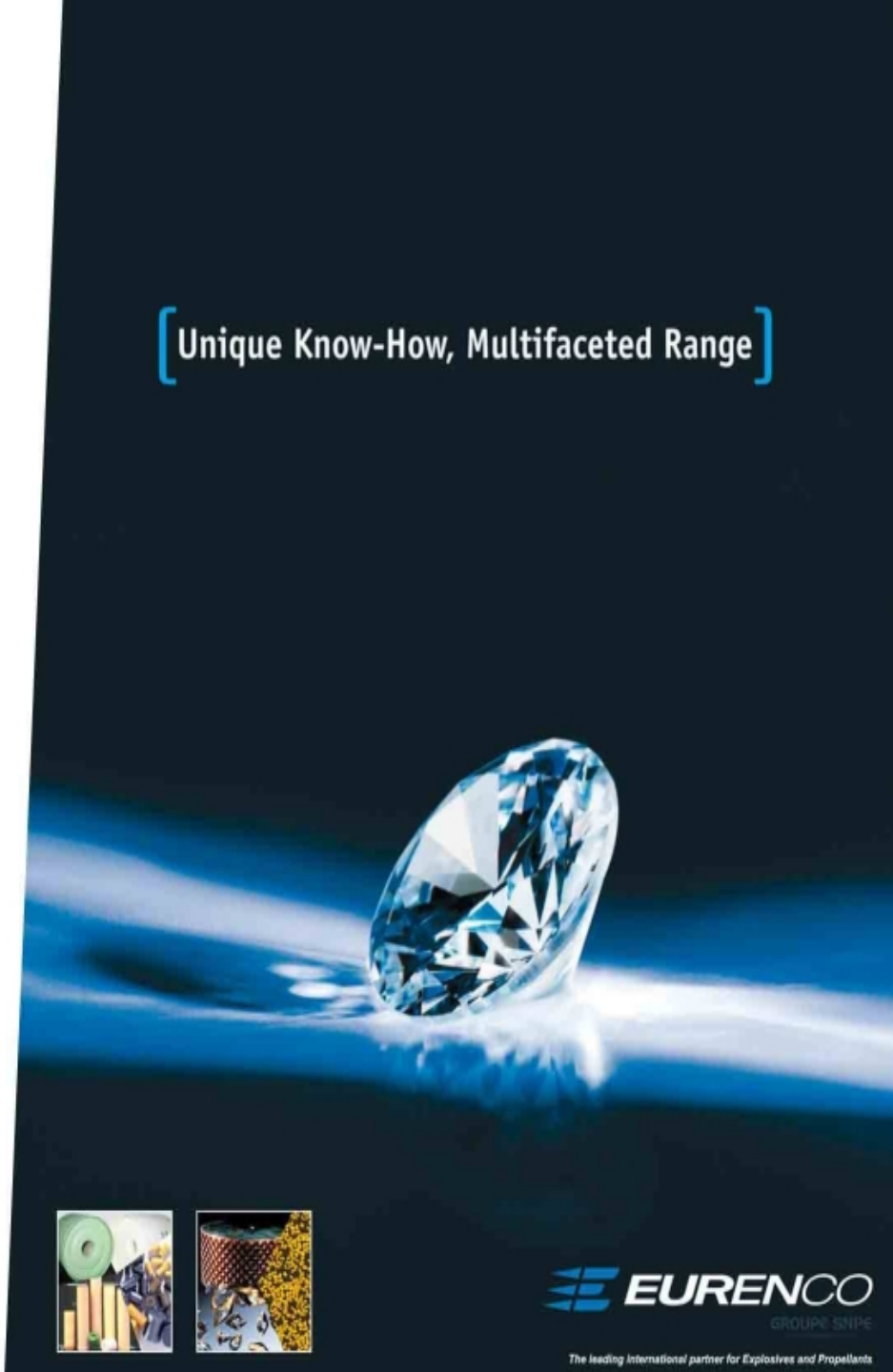


CONTENTS

1) Objectives

- Framework:
  - •Preliminary study
  - • Cast PBX Formulations/ Architectures
- Target: Small or medium caliber ammunitions (ϕ max 125 mm)
- Goal: Balance between EBX performances increase and preservation of low vulnerability characteristics
- Method:
  - • Step 1 : Bibliography
  - • Step 2 : Simple Thermo chemical calculations
  - • Step 3 : Testing
  - • Step 4 : IM assessments with Databases and SME/EURENCO background

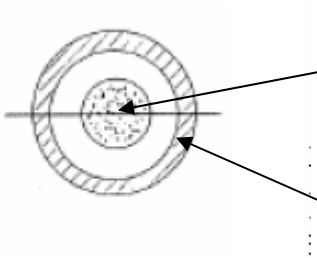
2-1) Cast PBX Overview: Formulations

➢ EBX = Energetic charge + Oxidizer + Reducer metallic particles + Binder (I or E)

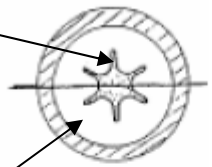
REFERENCES	COMPOSITIONS	APPLICATIONS
AFX 757	RDX/AP/Al/HTPB	JASSM
PBXN 113	HMX/Al/Inert binder	
PBXIH-135	HMX/Al/HTPB	BLU118/B, SMAW NE
Existing EURENCO references		
B2211D	RDX/AP/Al/HTPB	Anti-runway, underwater warhead
B2249	HMX/AP/Al/HPTB	Underwater warhead
B2237	HMX/AP/AL/HTPB	Performances / IM characteristics
B2242	HMX/Al/HTPB	Missile warheads
B2258B	RDX/PA/Alu/PBHT	General purpose bombs - penetrators
B3108B	HMX/Al/Energetic binder	Missile warheads

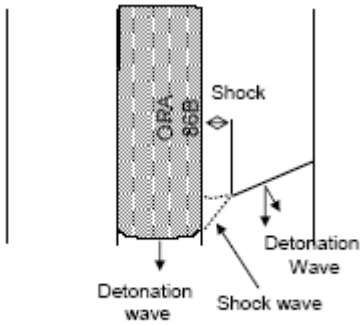
2-2) Cast PBX Overview: Architectures

➢ Use of dual charge formulation (EURENCO Patent)

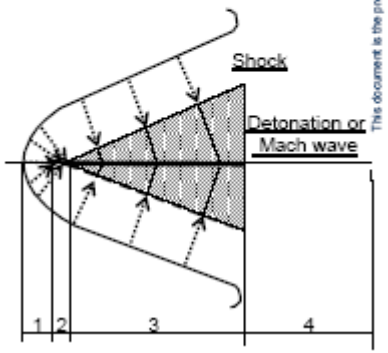


Core formulation
Very energetic charges (HMX, RDX,..)
→ Performances





Outer formulation
Higly loaded in reducing particles
→ EBX, IM



➢ Example :

- BIPS Penetrators : EURENCO formulations for core and outer explosives : B2237/B2250

2-3) Cast PBX Overview: Conclusions

- Choice of

  - Energetic charges : RDX, HMX with AP or AL particle size centered on some µm
  - No nanoscale particle : Cost / No EBX demonstration at this day
  - Inert binder : HTPB type for Economic reasons
  - Advanced binder : Facilitate the reaction of Al oxidation
  - Cylindrical Dual composition Architecture : Economic reasons

3-1) Explosive formulations pre selection : Presentation

- Mono Compositions

REFERENCES	COMPOSITIONS
AFX 757	RDX/AP/Al/HTPB
PBXIH-135	HMX/Al/HTPB
B2211D	RDX/AP/Al/HTPB
B2249	HMX/AP/Al/HTPB
B2237	HMX/AP/AL/HTPB
B2242	HMX/Al/HTPB
B2258B	RDX/AP/Al/HTPB

3-2) Explosive formulations pre selection: Presentation

- Dual Compositions

CORE FORMULATION	OUTER EXPLOSIVE	COMPOSITIONS
ORA86B HMX/Inert binder	B2211D	RDX/AP/Al/HTPB
	B2249	HMX/AP/Al/HTPB
	B2242	HMX/Al/HTPB
	C1	Al/RDX/HTPB
	C2	Al/RDX/Advanced binder
	C3	Al/AP/HTPB
	C4	Al/AP/Advanced binder

- Mono / Dual Compositions : ϕ 125 h 125 mm samples
- Dual compositions : core diameters : ϕ 50, 63 and 75 mm

3-3) Explosive formulations pre selection: Calculations

- Establish a relative ranking between the various compositions

- Use of CHEETAH v2.0
  - First alternative : CJ T°/ Energy released by adiabatic drop of detonation products
  - Second alternative: T°/P balance calculations to constant volume in the air

- Assumptions :
  - No kinetic law for the components reaction
  - Particle size not taken into account
  - Samples geometry not taken into account
    - Critical dimensions : post calculation analyses

- Comparisons with TNT references

3-4) Explosive formulations pre selection: Results

- Choice of a criterion of total performance to help in the classification

$$\xi = \sum_{i=1,4} \frac{x_i - \bar{x}_i}{\bar{x}_i}$$

x_i : Energy E, Tcj, P and T at the equilibrium (cst volume)

ξ : emphasize compositions which present the most positive variations (cumulated way)

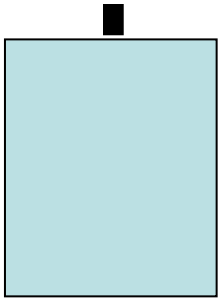
- Results :
  - Mono compositions : 1- B2211D, 2-B2258B and 3-B2237
  - Dual compositions : 1-Outer B2211D, 2-B2249 and 3-B2242
  - Highly outer formulation : 1-ORA86B/C2 formulation

- Critical dimensions analyses :
  - Mono compositions : Choice of the B2258B instead of the B2211D
  - Dual compositions : Core diameter : ϕ 63 (no significant gain with ϕ 75)
  - Highly outer formulation : Core diameter ϕ 75 mm

3-5) Explosive formulations pre selection: Conclusions

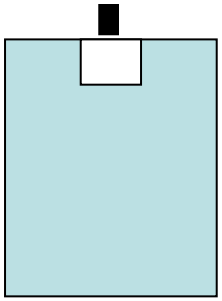
- CHOICE n°1 : MONO COMPOSITION B2258B
- CHOICE n°2 : DUAL COMPOSITION ϕ 63 mm ORA 86B / B2211D
- CHOICE n°3 : DUAL COMPOSITION ϕ 75 mm ORA86B / C2

4-1) Blast Characterization: Presentation

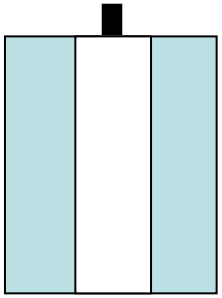


B2238

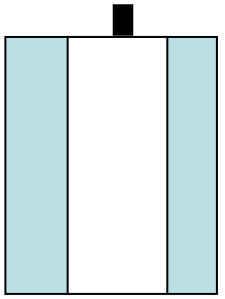
Mass : 2350 g



B2258B
With ORA86B Φ 50 H 30
Mass : 2600 g



ORA86B Φ 63 H 125
B2211D
Mass : 2730 g



ORA86B Φ 75 H 125
C2
Mass : 3270 g

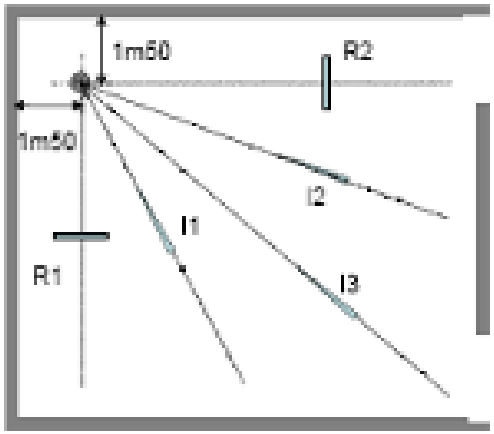
All external dimensions : ϕ 125 h 125 mm

- B2238A : RDX/PBHT : Reference composition

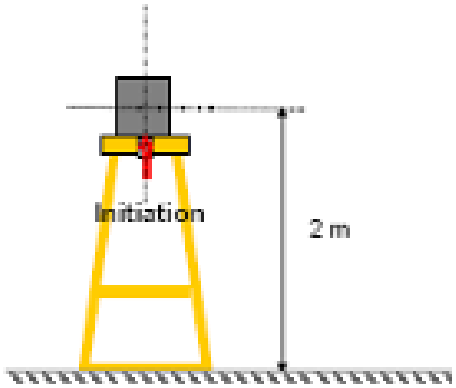
- Shot n°1 : Reference composition (bare configuration)
- Shot n°2, 3 and 4 : Selected compositions in bare configurations
- Shot n°5 : Most promising formulation or/and configuration with 5 mm Aluminum confinement

4-2) Blast Characterization: Experimental configuration

Top view:

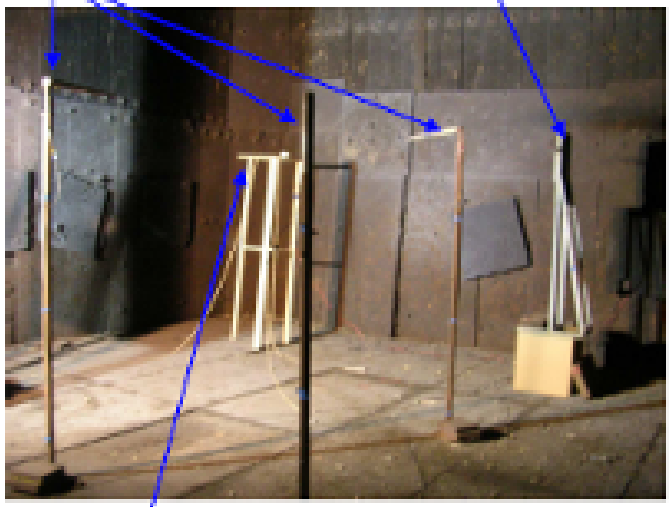


Side view:



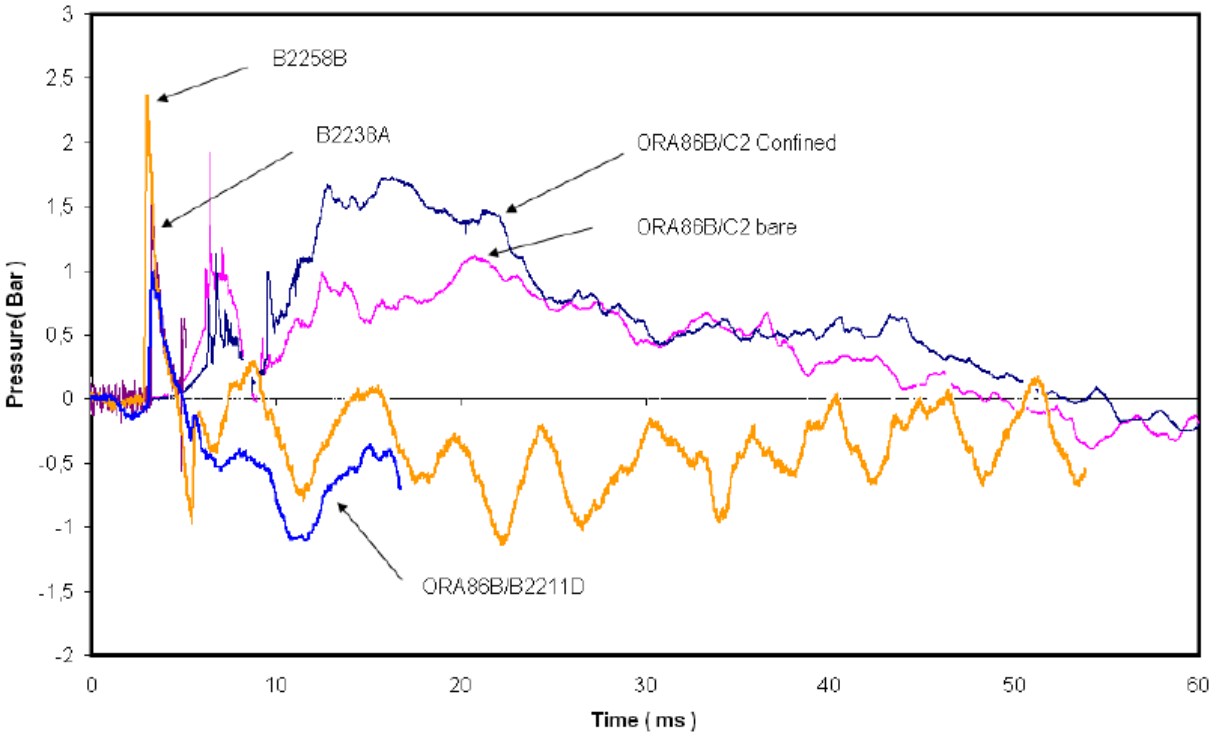
Static overpressure sensors

Reflected overpressure sensor



Charge holder

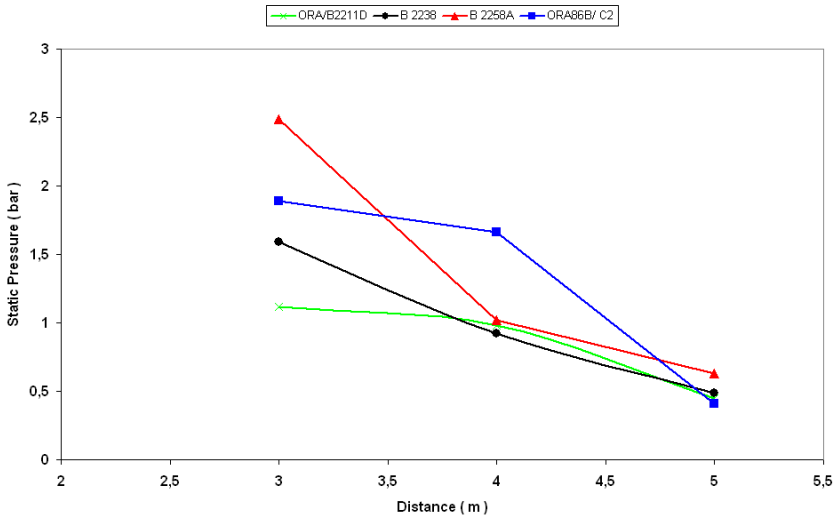
4-3) Blast Characterization: Results

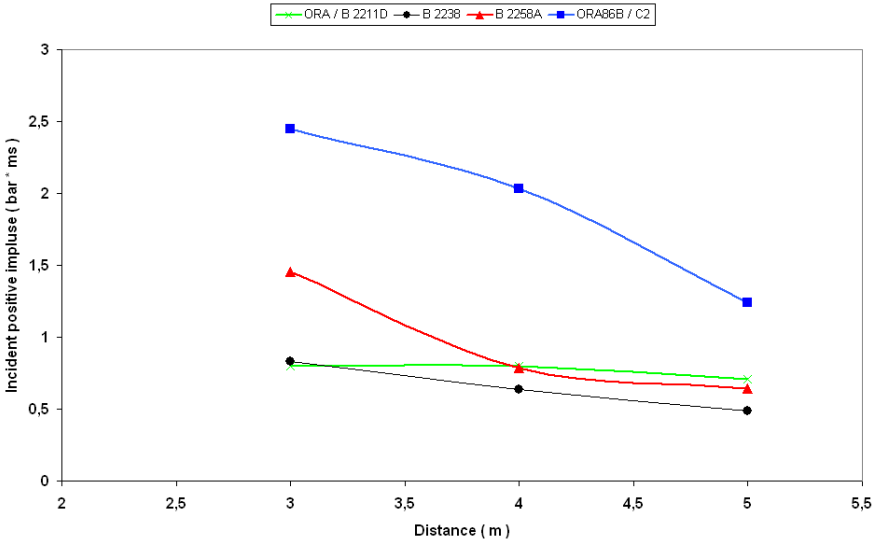


Example of static overpressure measurements

Test chamber after shot with ORA86B/C2 arrangement

4-4) Blast Characterization: Results(2)





COMPOSITIONS	Pressure TNT Eq. (3m)	Impulse TNT Eq. (3m)	Pressure TNT eq. (4m)	Impulse TNT Eq. (4m)	Pressure TNT eq. (5m)	Impulse TNT Eq. (5m)
B2238A shot 1	1,49	1,49	1,42	1,42	1,22	1,34
B2258B shot 2	2,23	3,26	1,46	1,83	1,46	1,86
ORA86B/B2211D shot 3	0,67	1,19	1,05	1,76	0,75	2,05
ORA86B/C2 shot 4	1,25	3,80	2,4	2,2	0,49	1,50

4-5) Blast Characterization: Conclusions

- Overpressure best choice : B2258B
- Positive impulse “short duration “: ORA86B/C2

But :

- Long duration overpressure/impulse: ORA86B/C2 (EBX and TBX ?)
- Need to:
  - Improve instrumentation “Ballistic measurement”
  - Optimize ratio between ORA86B and C2
  - Test different test chamber volumes

5) IM Assessments

	B2258B	B2211D	ORA86B
ISGT	130 cards	80 cards	160 cards
ELSGT	90 mm	50 mm	90 mm
Friability	12.4 Mpa/ms	3.8 Mpa/ms	5 MPa/ms
ESD	No sensitive	No sensitive	No sensitive
Self ignition T°	212 °C	213 °C	245°C
Bullet Impact		V	IV-V
Fast Cook Off		IV –V	
Slow Cook Off		IV- V	IV-V
Sympathetic detonation	III /IV		

Estimated IM Signature for a warhead

	FCO	SCO	BI	SD	SCJ
B2258B	V	V	NR à IV	III/IV	III à I
ORA86B/C2	V	V	NR à V	III/IV	III à I

6) Conclusions

- Preliminary study performed with the goal to choose the best compromise between EBX effect increase and low vulnerability characteristics for small/medium caliber ammunitions

- 3 formulations/architectures preselected after simple thermo dynamical calculations
  - Mono composition : B2258B (RDX/AP/AL/PBHT)
  - Dual composition : ORA86B/B2211D
  - Dual composition : ORA 86B/C2

- Tests highlight excellent EBX behavior for ORA86B/C2, B2258B is also a good candidate especially regarding static overpressures

- Depending the final warhead configuration – STANAG 4439 requirements could be achieved with these two formulations

- Results are very promising, the work is in progress with regard to :
  - Improvement on the geometry/architecture for the ORA86B/C2 arrangement
  - Improvement on instrumentation and experimental configuration