

SYMPATHETIC DETONATION TESTS WITH CONCEPTS OF UNITARY WARHEADS FOR A ROCKET SYSTEM

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- **OBJECTIVE / METHODOLOGY**

- **EXPLOSIVE FORMULATIONS AND PAYLOAD ARCHITECTURES PRESENTATION**

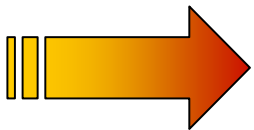
- **PERFORMANCE CHARACTERIZATION**

- **SYMPATHETIC DETONATION TESTS**

- **CONCLUSIONS**

OBJECTIVE

- ↪ Modern munitions/warheads are designed according to IM Standards
- ↪ Performances and costs must fulfill specific program requirements
- ↪ Development phase has to be as short as possible



- *Necessity to adapt existing concepts and materials*
- *Simple methods are required*

Increasing performances while preserving the IMness

METHODOLOGY

Framework : Preliminary study for the development of a new generation of explosive payload (rocket launch system)

The idea : to develop a synergy with :

- the use of insensitive grains (NTO, ...) in Plastic Bonded Explosives (PBXs)
- an adapted payload concept (dual composition architecture and Pre Determined Fragmented envelop (PDF)

The Work :

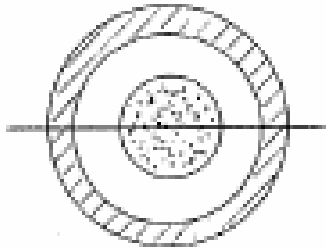
- Evaluation of the performances (velocity, fragment)
- Assessment of the vulnerability response (Sympathetic detonation test)

Other vulnerability tests : calculation responses (internal database, existing experimental results,...)

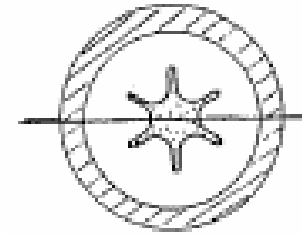
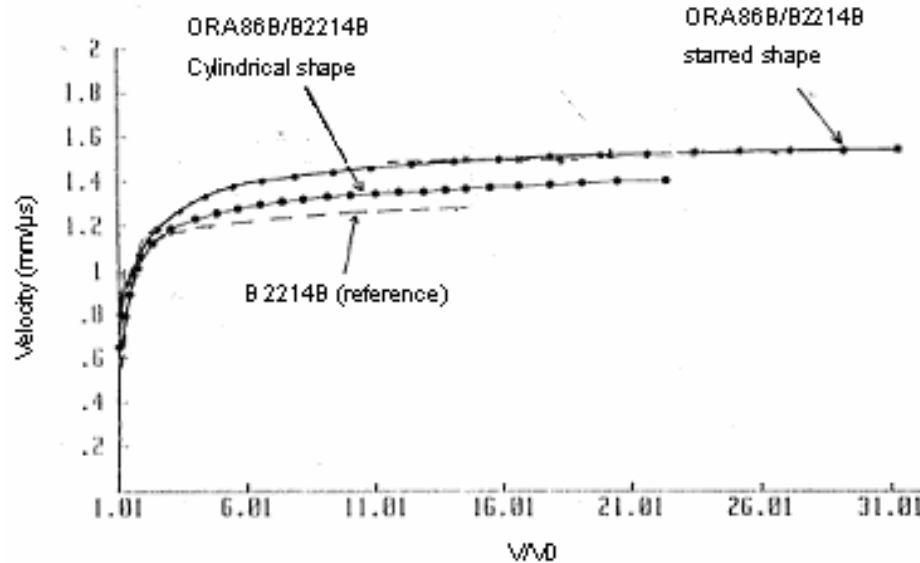
DUAL CHARGE FORMULATION (EURENCO PATENTS)

Inner formulation : HMX

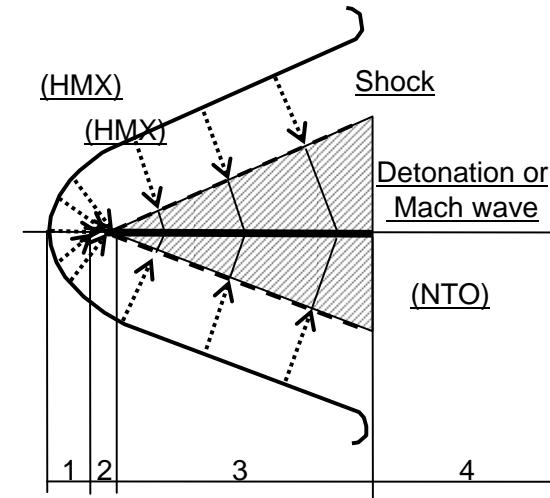
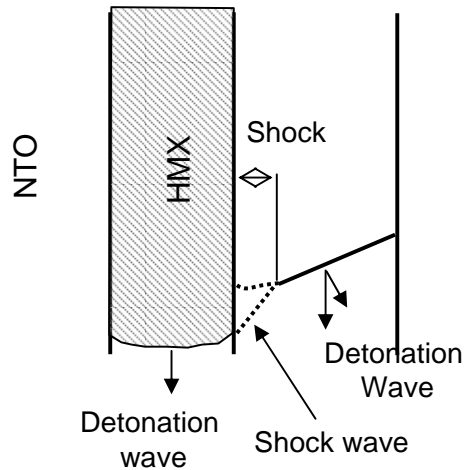
Outer formulation : NTO



CYLINDRICAL DUAL CHARGE



STARRED DUAL CHARGE



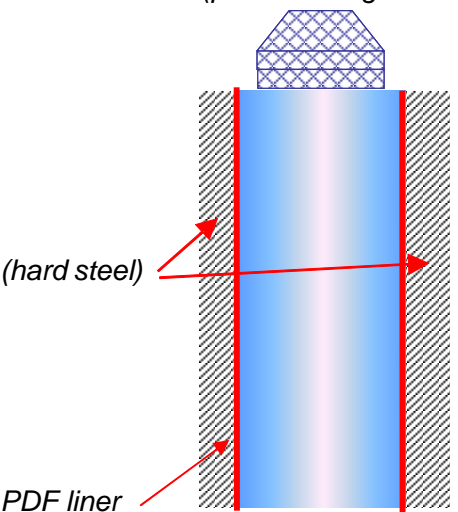
PRE DETERMINED FRAGMENTATION ENVELOP

Several functions :

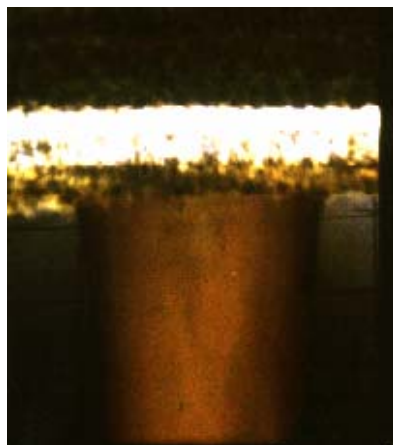
- Protection against friction (HE/casing)
- Thermal insulation
- Controlled fragmentation without degrading mechanical properties of the casing
- Internal drain of decomposition gases



(plane wave generator)

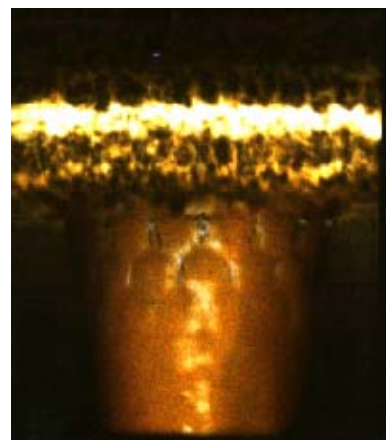


low sensitivity HE)



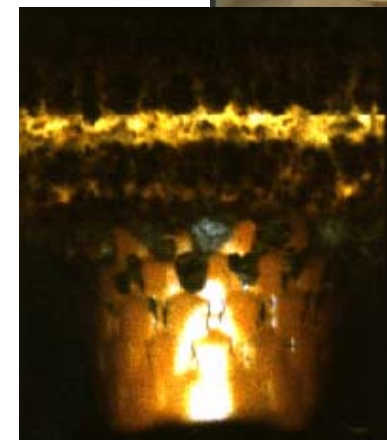
Casing Expansion

17,5 μ s



Fragments shaping

30 μ s

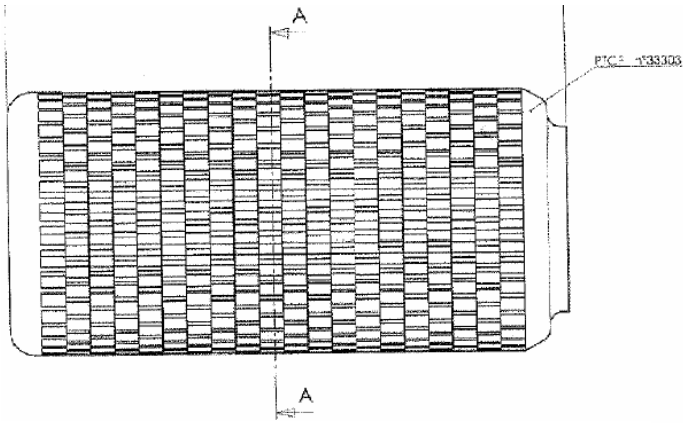


longitudinal fractures and leakage of Detonation products

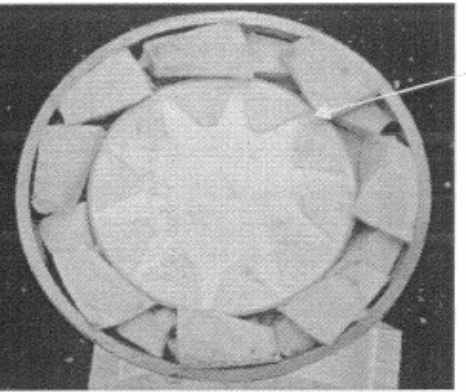
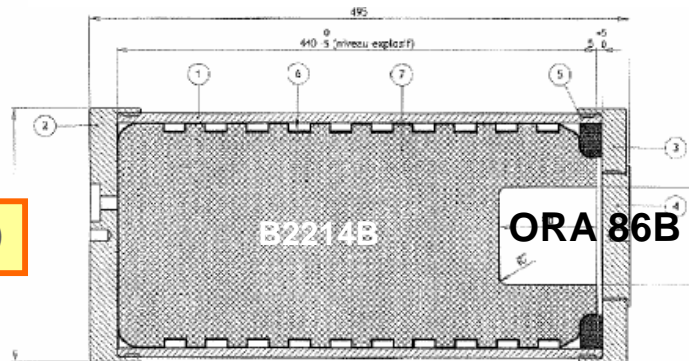
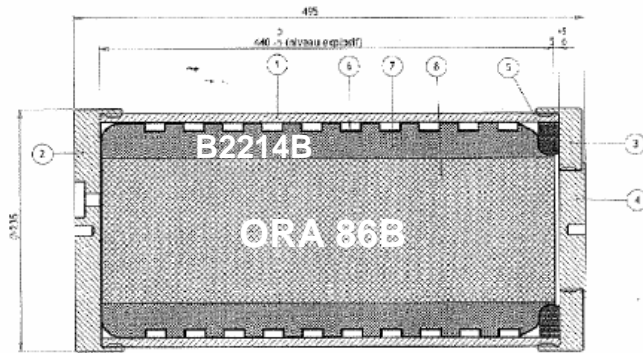
42,5 μ s

PROTOTYPE PRESENTATION

- Casing : steel tube Øext. 226 mm, length 445 mm, thickness 8 mm
- Total payload mass ≈ 22 kg



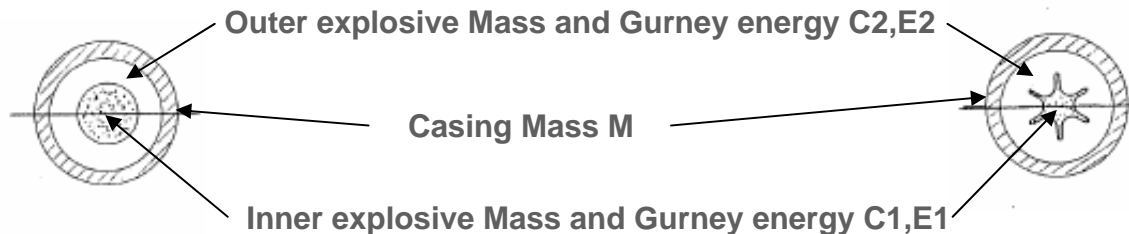
B2214B (HMX/NTO/HTPB 12/72/16)



ORA 86B (HMX/PU 86/14)

PERFORMANCE TEST ASSESSMENTS

Extended Gurney model for dual charge architectures



- Total Mass $M_{12} = M + (1 - \lambda)C_2$

- Efficient explosive mass $C_{12} = C_1 + \lambda C_2$



Envelop velocity: $V_{12} = \sqrt{2E_{12}} \cdot f\left(\frac{M_{12}}{C_{12}}\right)$

- Dual composition Gurney energy $E_{12} = (C_1 E_1 + \lambda C_2 E_2) / C_{12}$

λ Fitted on cylinder tests

Diameter effect: $\frac{V}{V_0} = 1.0146 + 2.4351 \cdot \frac{R - R_o}{R_o} + 0.99645 \cdot \left(\frac{R - R_o}{R_o}\right)^2$

	Reference	Cylindrical dual charge	Starred dual charge
Fragment velocity (m/s)	1770	1865 (+5%)	2037 (+15%)

PERFORMANCE TEST CONFIGURATION

Performed on reference and starred dual charges

Fragment velocity determination
(high speed camera and shock sensors)



Fragments collector



Efficiency assesment (steel plates)



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PERFORMANCE TEST RESULTS

Fragment velocity

Shot	Prototype	Velocity by high speed camera (m/s)	Analytical calculations (m/s)
N°1	Reference B2214B	1540	1770
N°2	Starred dual composition	1750	2037



different absolute values but
Same relative gap 14 / 15%

Collected fragments

Total	Reference	Starred dual composition
Mass (g)	3810	3905
Number = 0.2 g	849	885
Number = 1 g	231	230

Efficiency

Plate N°	Reference	Starred dual composition
	Number of open holes	Number of open holes
1	21	20
2	20	22
3	21	25
4	25	23
5	20	24
6	25	25
7	16	21
TOTAL	148	160



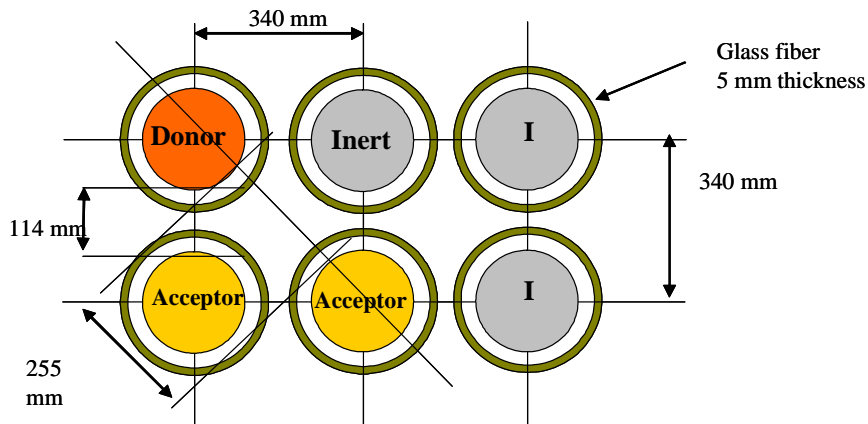
+ 8%

Cylindrical dual composition (analytical assessment) :
+ 5% on fragments velocity

Starred dual composition (Experimental/analytical) :
+ 14% on fragments velocity
+ 8% on efficiency
Equal for collected fragments (PDF liner)

SYMPATHETIC DETONATION TEST ASSESSMENTS

Logisitec pallet configuration



Assumptions for analytical calculations:

- Unitary Fragment aggression
- Glass fiber screen negligible
- Fragments mean mass and mean surface are defined (PDF)
- Detonation criterion based on Card Gap Test results:
ELSGT-1 Ø 75mm B2214B : 105 kBar
ISGT Ø 40mm ORA86B : 53kBar
- Critical diameter dimensions are taken into account
- Pressure attenuation in the outer explosive : Green formula

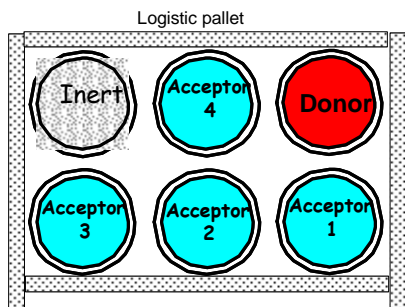
<i>Prototype</i>	<i>Impact velocity (m/s)</i>	<i>B2214B Pressure (kBar)</i>	<i>ORA86B Pressure (kBar)</i>
<i>Reference</i>	1770	98	41
<i>Cylindrical dual</i>	1865	107	44
<i>Starred dual</i>	2037	122	49

**CRITICAL DIAMETER > FRAGMENT DIAMETER:
NO DETONATION**

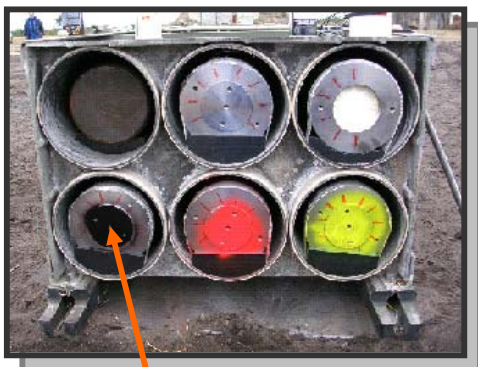
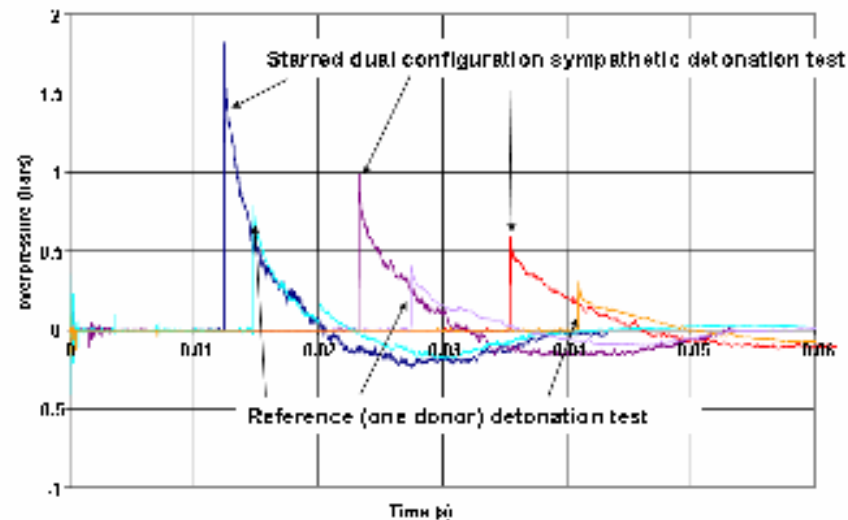
**DETONATION HAZARD CAN NOT BE AVOIDED
(STARRED CONFIGURATION)**

SYMPATHETIC DETONATION TEST RESULTS

Shot n°1 : Starred dual composition architecture



30 mm thickness steel witness plate

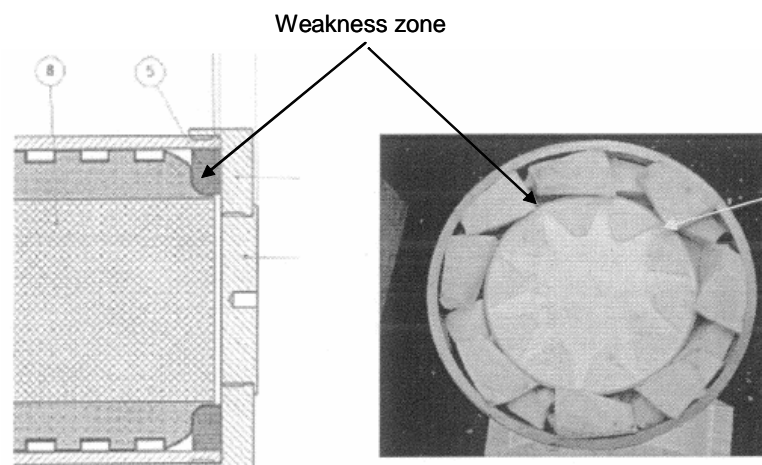


First acceptor to detonate

DETONATION

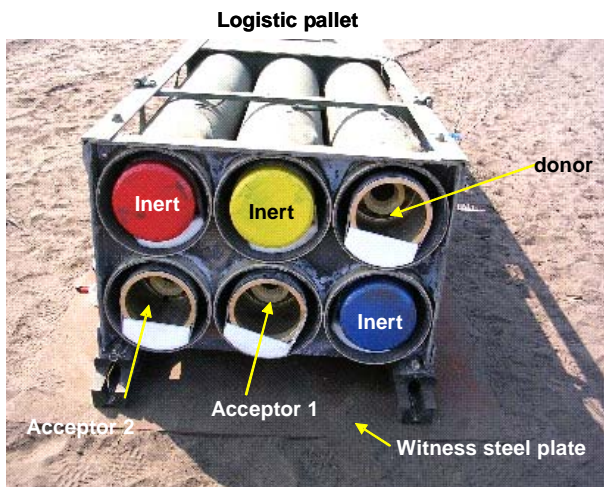
ASSUMPTIONS

- High fragments velocity
- ORA86B pressure underestimated
- Prototype non representative: Presence of a weakness zone



SYMPATHETIC DETONATION TEST RESULTS

Shot n°2 : Cylindrical dual composition architecture

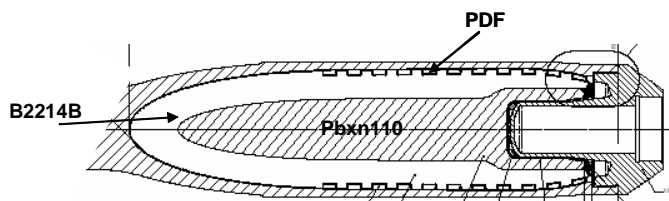


Differences with shot n°1 :

- More representative : real warhead
- Approximately the same geometries and mass
- Inner explosive PBXN110 (88% HMX / 12% HTPB) (slightly more shock sensitive)
- Pallet arrangement

**NO DETONATION
TYPE III**

Witness plate + one inert



Total recovery of acceptor n°2



Partial recovery of acceptor n°1



CONCLUSIONS

This preliminary study allows us :

- To define a new architecture concept which an increase efficiency : dual charge composition + PFD liner
- To keep a low vulnerability level (type III sympathetic detonation test) for the cylindrical dual charge

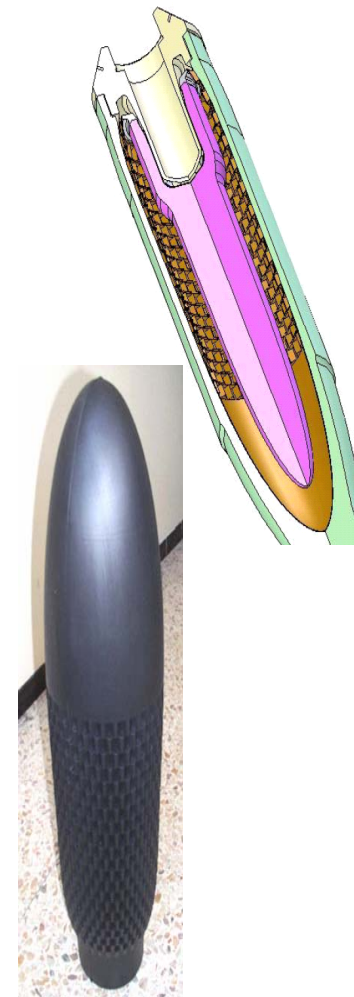
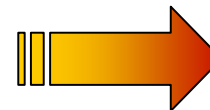
Explosive formulations match other IM requirements for the STANAG 4439

READY TO BE INTEGRATED
IN A DEVELOPMENT PHASE

Development and use of simple analytical methods and tools

POSSIBLE IMPROVEMENT:

Sympathetic detonation test with the performing starred configuration
To be tested in a real warhead



THANK YOU FOR YOUR ATTENTION