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Insensitive Cast Plastic Bonded Explosive Solution for a 76 mm shell Application

UNIQUE KNOW-HOW

MULTIFACETED RANGE

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1) Objectives

- Framework:
  - HORIZON Frigates
  - French Navy / DGA contract
  - Development and qualification of a PBX solution for the explosive charge for a 76 mm shell by OTO MELARA and EURENCO

- Key points:
  - To combine the objectives of :
    - Performances (COMP B / A3)
    - Survivability (gun firing)
    - IM results

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2-1) Presentation of the gun system and 76 mm shell

Basic data :

- Rate : Round by round to 120 rounds/min
- Gas pressure : Around 3000 bars
- Muzzle velocity : 905 m/s
- Weight of projectile : 6,25 kg
- Maximum acceleration : 20000 g
- Maximum rotation speed: 2590 r/s

Focus : To ensure the survivability of the explosive loading during gun firing

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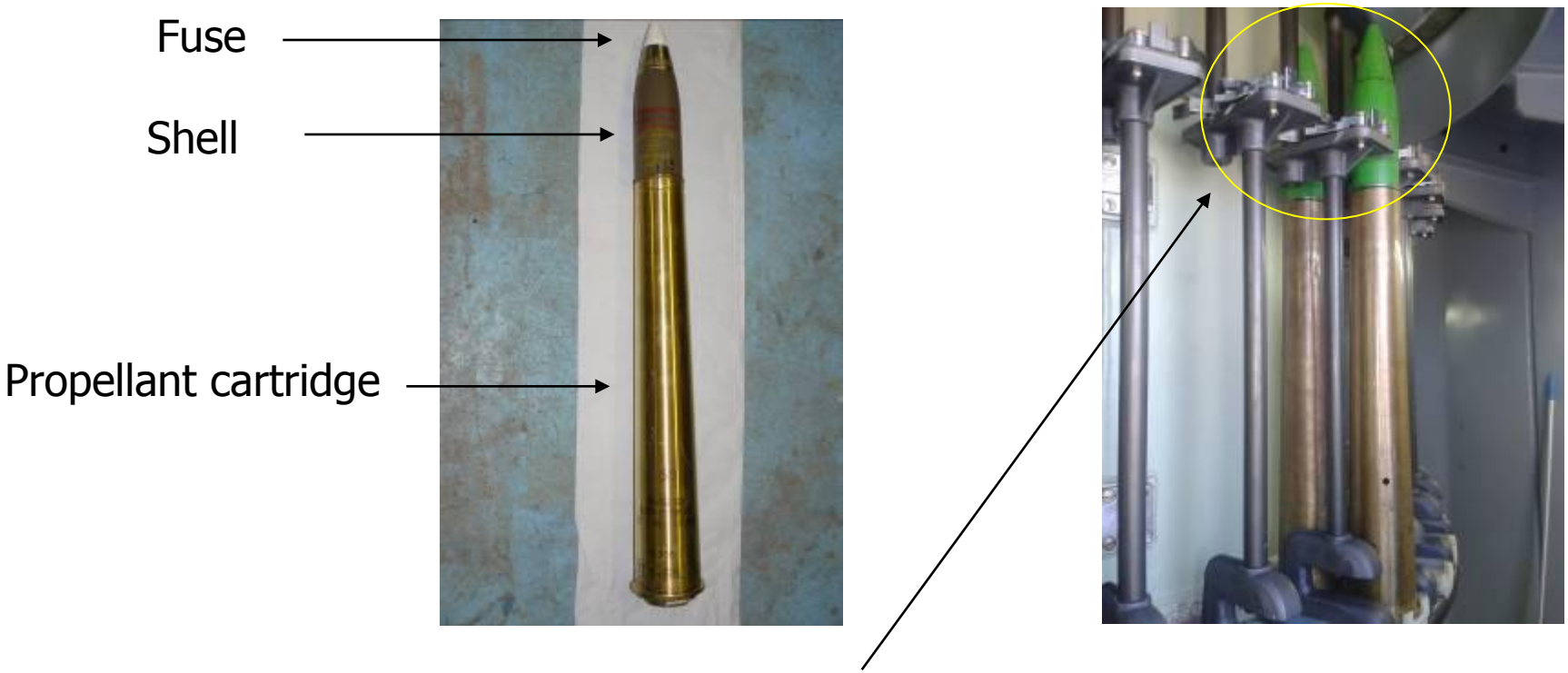
2-2) Presentation of the gun system and 76 mm shell



No Sympathetic Detonation with regard to the specific arrangement of the shells into the storage magazine located in the turret

Same or better performances than Comp B and good environmental behaviour also requested for this development

3-1) Explosive formulation characteristics

- Choice of the Cast Plastic Bonded eXplosive B2263A (HBU 88B)
- Used at industrial scale for more than 25 years
- B2263A explosive is qualified according to S-CAT n°17500 Instruction (French application of STANAG 4170 and AOP 7)
- B2263A (HBU88B) high explosive is also type qualified by US Army for military use
- The formulation of B2263A is as follows:
  - Binder : HTPB polymer + additives (12%)
  - Filler : I-RDX® (88%)

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3-2) Explosive formulation characteristics

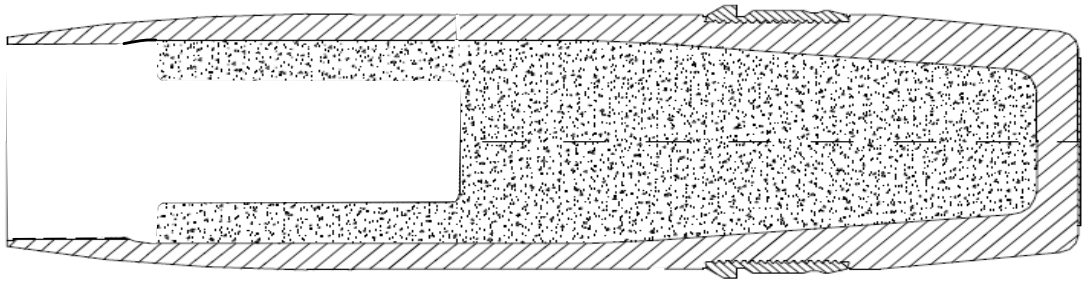
	B2263A	Comp B
Density	1,626	1,73
Detonation velocity	8180 m/s	7942 m/s
Theoretical Detonation Pressure	27,2 GPa	27,3
Critical diameter	7 mm	3-4 mm
Shock sensitivity (ISGT) – STANAG 4488 Annex A	150 cards	360 cards
Friction sensitivity (BAM test)	20+/30 @ 353 N	132 N
Fall Hammer	No reaction > 4m No propagation > 4 m	No reaction = 1m No Propagation = 2,25 m
Electrostatic sensitivity	Not sensitive	Not sensitive

Same level of performance – Less sensitive

4-1) Explosive loading design

Direction of firing

←

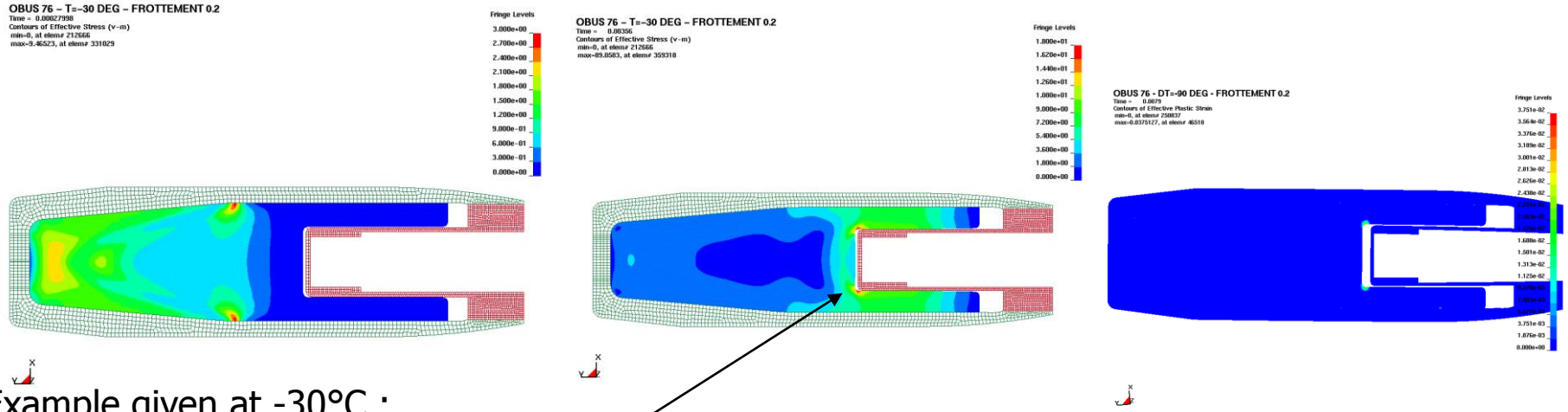


Key points:

- Same explosive loading design than the already existing geometry (fuse shape not changed)
- Internal dimensions obtained directly by the use of a punching tool inserted just after the filling phase.
- Anti adhesive liner is put on the internal parts of the structure except on a specific zone where the explosive loading bonds directly to the metal part.

4-2) Explosive loading design

- Calculation performed to validate the design
- Stress/strain state calculated from axial/spin accelerations at high and low temperatures
- Solicitations compared to the mechanical properties determined in a dynamic way (Split Hopkinson bars).



Example given at -30°C :

- Max stress at the corner bottom of the fuse well but below explosive capacity
- No residual strain
- Physical integrity of the explosive loading is ensured during the gun firing
- No relative motion has been determined between the explosive loading and the structure that cancels risks of friction and so risks of initiation of the explosive

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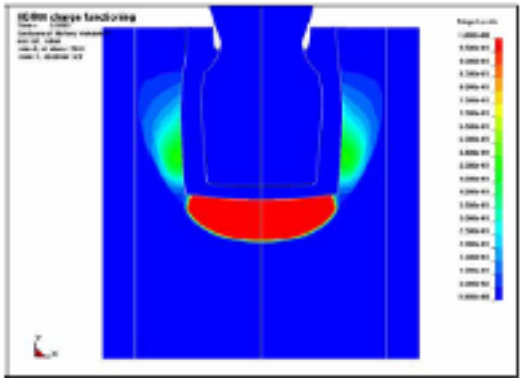
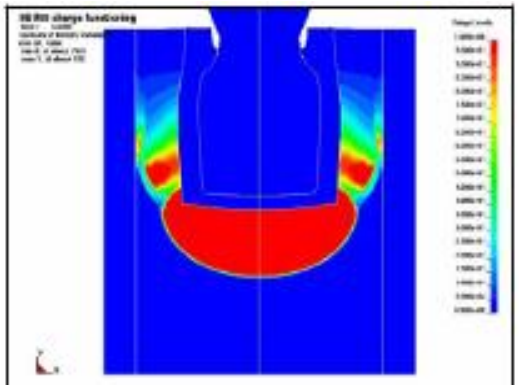
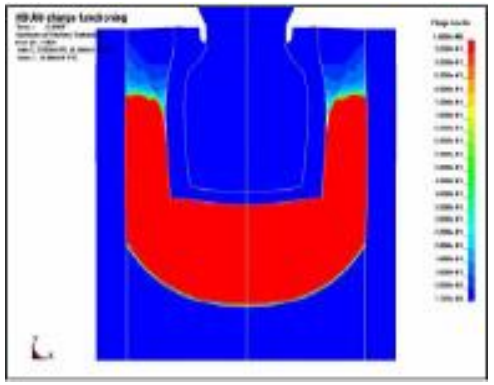
4-3) Explosive loading design

Initiation of the B2263A and its detonation behaviour (fuse well) checked by numerical simulation (Lee-Tarver model and JWL EOS)







Gun firings and detonation tests were performed on a first lot of 20 IM 76 mm shells that allow us to validate this design

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5-1) Performance testing

- Two types of tests performed : Arena test and in Shaft
- Six rounds have been used for each test
- B2263A, Comp B and A3 explosive loadings.

Example of Arena test configuration

Results :

- In Shaft : No significant difference between B2263A and Comp B/A3
- Arena test : Best fragmentation for B2263A compared to Comp B and A3

6-1) Environmental testing

- Shell safety tests on 60 rounds with thermal cycling, drop and jolt tests, vibration:

  No observation made for the explosive loading
  6 shells were cut : No damage found within the explosive
  Other shells to be used for gun firing

- Sequential environment tests (STANAG 4224) on 120 rounds:

  No observation made on the explosive loading at this step.

- Internal and ballistic tests on 30 rounds picked up from the first safety tests.
  Firing at 3 temperatures : -30°C, +21°C and +50°C

  Correct functioning of the explosive loading during ground impact.

The qualification program is still in progress with the last gun firings with the shells submitted to the STANAG 4224 program

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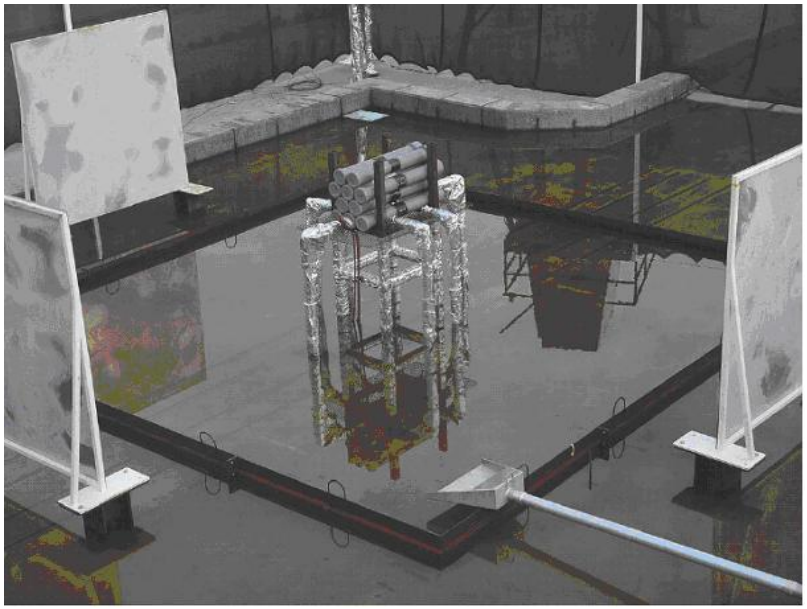
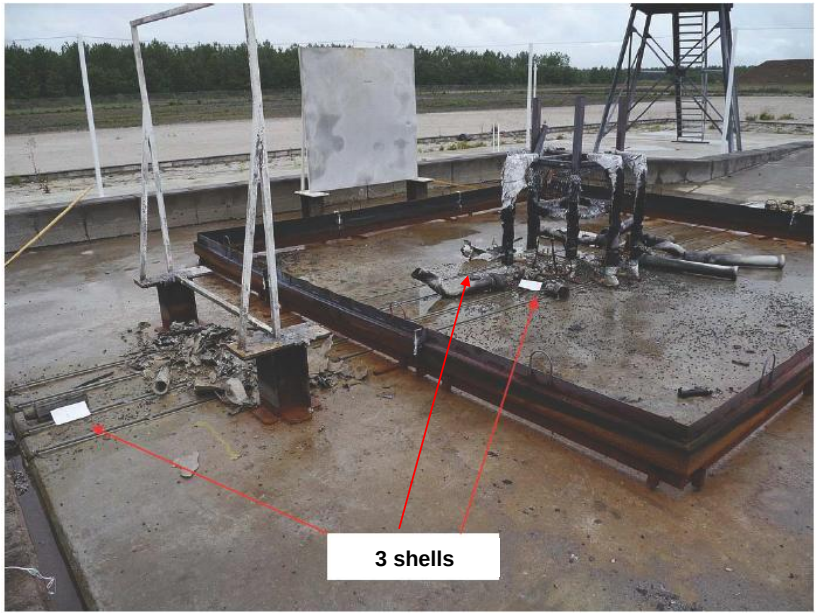
7-1) Vulnerability testing : Fast Cook Off

- STANAG 4240
- Three shells (+fuse + propellant) used + spares
- Container configuration





The three shells were recovered close to the test location without reaction for the explosive loading (only the propellant)
Type IV reaction

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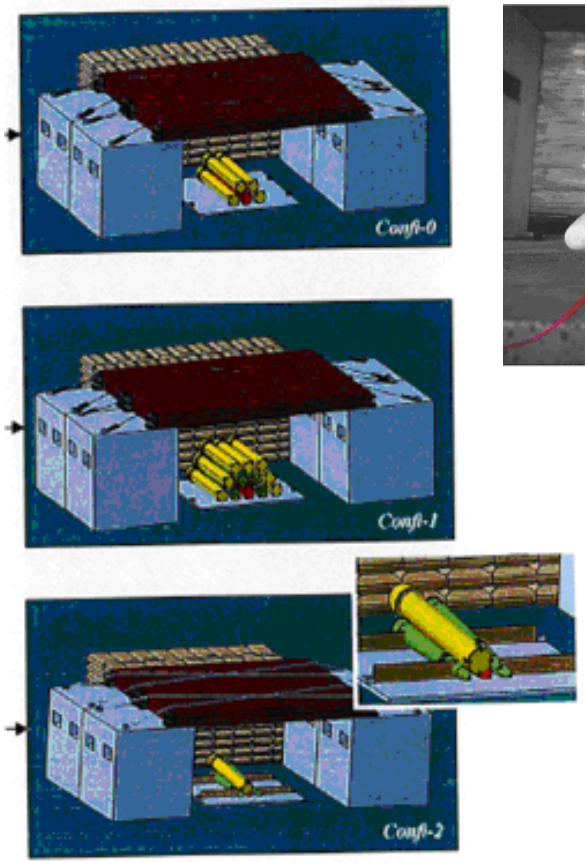
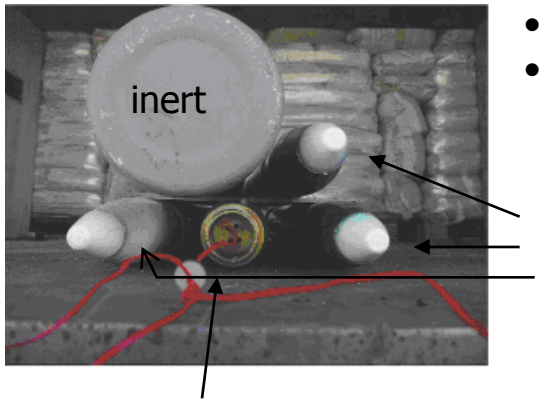
7-2) Vulnerability testing : Sympathetic Detonation Test



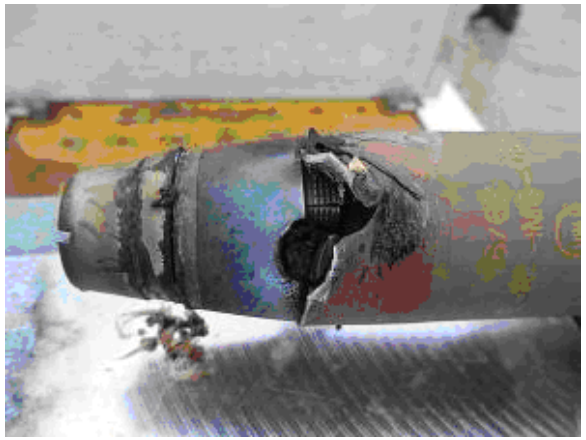


- Several configurations (bare shell or with container)
- Distance between shells similar to the storage magazine in the gun turret (≈ 45 mm)

Results :
For all the tests performed : No Reaction of the explosive loading

7-2) Vulnerability testing : Bullet Impact

- STANAG 4241
- Seven rounds with or without containers
- Three locations for the bullet impact (fuse, explosive loading, propellant)



- For the 3 shots performed on the explosive loading, only combustion of the explosive was observed

- Reaction was qualified as a type V.

8-1) Conclusions

- An Insensitive explosive loading has been developed for the 76 mm shell

- Key points were linked to the survivability for the gun firing and a good result for the Sympathetic Detonation Test (compact storage in the gun magazine)

- B2263 (I-RDX® based composition) has been chosen and Numerical simulations were used to design and validate the explosive loading.

- Qualification program was undertaken with the following results:
  - Performance efficiency equal or better than Comp B/A3
  - Correct functioning and no damage after environmental program
  - Type IV for FCO, type V for BI and No reaction for SDT.

8-2) Conclusions

- Results match with the French criteria MURAT * for the complete round equipped with its fuse and propellant cartridge.

- More than 1000 explosive loadings have been produced for this qualification program and for the first board lot.

- Mass production is ready to be started in the mass production workshop

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