The melt-cast XF®11585: a low vulnerability composition
Ammunition application from 60 to 155 mm

May 15th, 2012, Las Vegas, NV

Christophe Coulouarn, R. Aumasson, P. Lamy-Bracq, S. Cotet, S. Bulot

Nexter Munitions
Outline

- Explosive Composition XF®11585
  - Context of the study
  - Melt cast process based on TNT
  - Energetic material: XF®11585
    - Pyrotechnic properties
    - Detonics properties
  - Ammunition examples filled with XF®11585
    - Vulnerability performances
    - Ammunition performances
  - Potential IM munitions using XF®11585
- Conclusion
“IM” technology at Nexter Munitions

155 mm LU211 IM artillery shell is the first French IM Field Artillery ammunition under mass production

- Researching explosive compositions to extend the Nexter Munitions ammunition offers to 120 mm and below.
The next challenges have been followed for developing an explosive composition:

- Best cost effectiveness
- Searching for new explosive compositions
- Compliant with standard filling plant
- Compatible with a large range of calibers from tank ammunition to mortar bombs
- Insensitivity, detonics performances and terminal efficiency
- Simple way of demilitarization
Melt cast process: Strategy developed by Nexter Munitions for 20 years.

Detonics performances

XF®12366 (HMX-based)

Today

XF®11585
(NTO / RDX-based)

Insensitivity

XF®13333 (NTO-based)

Fully qualified by French DGA and mass production in progress
“IM” technology is a trade-off between energetic material and ammunition design.

Development of low vulnerability explosive compositions
XF® Family

Design ammunition
For example venting plug for 155 mm LU211 IM

Synergy between these 2 departments:
From low vulnerability ammunition to insensitive ammunition
Explosive melt cast process

- Description of the melt cast process: TNT based
  - Leadership of Nexter Munitions in this field
  - Conventional & simple process

Melt cast process:
- stirrer
- granule explosive
- liquid explosive
- valve
- mould / shell

Mixing phase

Reversibility
(demilitarisation)

Cooling phase

Gravitational casting phase
Pyrotechnics properties of XF®11585

- **Main properties**
  - Hazard characterisation

<table>
<thead>
<tr>
<th></th>
<th>XF®11585</th>
<th>TNT</th>
<th>Compo B</th>
<th>AFNOR standard</th>
<th>STANAG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction sensitivity</td>
<td>0% at 353 N</td>
<td>10% at 353 N</td>
<td>158 N</td>
<td></td>
<td>4489</td>
</tr>
<tr>
<td>Electrostatic Discharge</td>
<td>&gt; 736 mJ</td>
<td>&gt; 4,5 J</td>
<td>&gt; 736 mJ</td>
<td>NF T70-539</td>
<td></td>
</tr>
<tr>
<td>Impact Sensitivity</td>
<td>30 % at 50 J</td>
<td>50 % at 25 J</td>
<td>&gt; 50 J</td>
<td></td>
<td>4487</td>
</tr>
</tbody>
</table>

- **Low sensitivity to basic stimuli**

- **Mechanical properties**

<table>
<thead>
<tr>
<th>Composition Sample</th>
<th>Caliber</th>
<th>Density (g.cm⁻³)</th>
<th>Stress, max (MPa)</th>
<th>Young Modulus (MPa)</th>
<th>Deformation, max (%)</th>
<th>Sample porosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF®11585</td>
<td>From 155 to 60 mm</td>
<td>1,73</td>
<td>20,8</td>
<td>1986</td>
<td>1,18</td>
<td>&lt; 0,8</td>
</tr>
<tr>
<td>XF®13333</td>
<td>155 mm</td>
<td>1,75</td>
<td>23,1</td>
<td>1853</td>
<td>1,35</td>
<td>&lt; 1,2</td>
</tr>
<tr>
<td>Compo B</td>
<td>From 155 to 60 mm</td>
<td>1,70</td>
<td>16,1</td>
<td>1877</td>
<td>0,94</td>
<td>ND</td>
</tr>
</tbody>
</table>
Pyrotechnics properties of XF®11585

- Main properties
  - Thermal properties: DSC according to the STANAG 4515: 5°C/min

<table>
<thead>
<tr>
<th></th>
<th>Compo B</th>
<th>XF®11585</th>
<th>IMX 104</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endothermic peak</td>
<td>80°C</td>
<td>80°C</td>
<td>89°C</td>
</tr>
<tr>
<td>Onset / Exothermic peak</td>
<td>202 / 235°C</td>
<td>204 / 230 °C</td>
<td>212 / 224 °C</td>
</tr>
<tr>
<td>Activation energy</td>
<td>163 kJ/mol</td>
<td>151 kJ/mol</td>
<td>ND</td>
</tr>
</tbody>
</table>

- Detonics performances
  - Confined detonation velocity and unconfined critical diameter

7468 m/s
Detonics properties of XF®11585

- Ignition pressure characterisation
  - Large Scale Gap test: according to the STANAG 4488

**Table:**

<table>
<thead>
<tr>
<th>PMMA barrier</th>
<th>Charge density</th>
<th>Go or No go</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm (P=62 kbar)</td>
<td>1.73 g/cm³</td>
<td>Go</td>
</tr>
<tr>
<td>60 mm (P=50 kbar)</td>
<td>1.73 g/cm³</td>
<td>Go</td>
</tr>
<tr>
<td>70 mm (P=41 kbar)</td>
<td>1.73 g/cm³</td>
<td>No Go</td>
</tr>
<tr>
<td>80 mm (P=33 kbar)</td>
<td>1.73 g/cm³</td>
<td>No Go</td>
</tr>
<tr>
<td>90 mm (P=26 kbar)</td>
<td>1.73 g/cm³</td>
<td>No Go</td>
</tr>
</tbody>
</table>

**Diagram:**
- Detonator
- Donor: HCG 95/5/0.5 CH
- # PMMA barrier
- Steel tube
- Acceptor: XF®11585 Ø 73 mm H: 280 mm
- Witness plate

**Images:**
- Large Scale Gap test results:
  - 50 mm: Go (P=62 kbar)
  - 60 mm: Go (P=50 kbar)
  - 70 mm: No Go (P=41 kbar)
  - 80 mm: No Go (P=33 kbar)
  - 90 mm: No Go (P=26 kbar)
Detonics properties

- Ignition tests
  - Ignition with a standard fuze without booster: 4 configurations have been performed

155 & 120 mm configurations

- PDM 557 Fuze
- Pellet of XF®11585
- Witness plate

Caliber 76 up to 100 mm configurations

- 120 mm Fuze
- Ø73 mm H 280 mm

XF®11585 nominal detonation

- Steel mark: Ø 60 mm & depth 8 mm

No booster required
Vulnerability performances (1/4)

- Thermal threats: Fast cook off and slow cool off in 2 configurations
  - GEMO mock up: representative of artillery shell
    - Screwed cover
    - Shell body
      - 1 cm thickness
    - Bottom
    - French Standard NF T 70-500

- 120 mm HE

- Slow Heating: SH
  - Type V

- Fast Heating: FH
  - Type IV

- Vent plug patent
  - Nuctor Munitions
  - Ramp gaz device
  - mid 2012

- Expert Working Group
Vulnerability performances (2/4)

- Mechanical threats: Bullet impact in 2 configurations
  - GEMO mock up: representative of artillery shell

- 120 mm HE

- Screwed cover
- Shell body 1 cm thickness
- Bottom

French Standard NF T 70-500

<table>
<thead>
<tr>
<th>Bullet Impact – GEMO Mock-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 m/s</td>
</tr>
<tr>
<td>Type V</td>
</tr>
<tr>
<td>No Reaction</td>
</tr>
<tr>
<td>STANAG 850 m/s</td>
</tr>
<tr>
<td>600 m/s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bullet impact – 120 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANAG 850 m/s</td>
</tr>
<tr>
<td>Entry hole</td>
</tr>
<tr>
<td>No Reaction</td>
</tr>
<tr>
<td>Exit hole</td>
</tr>
</tbody>
</table>
Vulnerability performances (3/4)

- Mechanical threats: Shaped Charge Jet and Fragment Impact in 2 configurations

**Fragment Impact**

**Speed camera views**

- **Type V**

**SCJI CCEV62 – GEMO Mock-up**

- Work in progress- Trial expected in June 2012.
- On GEMO mock-up and on 155 mm artillery shell

**Shaped Charge**

Ø 62 mm
Vulnerability performances (4/4)

- Mechanical threats: Sympathetic Reaction
  - Ignition with a standard fuze without additional booster: 2 configurations performed

120 mm Tank ammunition

- Donor + 120 mm Fuze
- Receptor
- D=125mm

100 mm Navy ammunition

- 100 mm Fuze
- Receptor
- D=100mm

XF®11585 nominal detonation – SR types of reaction

- Donor witness plate
- Receptor
- Type IV

- Donor witness plate
- Receptor
- No Reaction
Ammunition terminal efficiency

- Fragment impact efficiency 120 mm HE-IM:

95% fragment mass recovery was achieved

As the explosive composition XF®13333, this new explosive composition allows us to treat a large range of targets.
Potential IM munitions using XF®11585

Cost comparison for constitutive raw materials

Cost of raw materials (CRW)

- Compo B
- IMX 104
- OSX-8 (PAX 48)
- XF11585

Reminder:
XF®11585 is based on NTO/RDX/TNT and Aluminium

Industrial aspect

New XF®11585 requires the same equipments: mixing, casting and cooling than those used for conventional explosives.

Upgrading casting equipment at La Chapelle filling plant (France)

3 batches 500kg / day / 2 shifts
### Potential IM munitions using XF®11585

**Signature expected with explosive composition XF®11585:**

<table>
<thead>
<tr>
<th>Description</th>
<th>FCO</th>
<th>SCO</th>
<th>FI</th>
<th>FI</th>
<th>SR</th>
<th>SCJI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artillery shell: 155 mm</strong></td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>III</td>
<td>III</td>
</tr>
<tr>
<td><strong>Tank ammunition: 120 mm</strong></td>
<td>V</td>
<td>V</td>
<td>NR</td>
<td>V</td>
<td></td>
<td>IV</td>
</tr>
<tr>
<td><strong>Navy ammunition: 100 mm</strong></td>
<td>V</td>
<td>V</td>
<td>NR</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mortar bombs: 76 mm (81 &amp; 60 mm)</strong></td>
<td>V</td>
<td>V</td>
<td>NR</td>
<td>V</td>
<td>NR</td>
<td></td>
</tr>
</tbody>
</table>

Caption: 

- t for tested and recorded result

Required signature for IM test results according to STANAG 4439:

- FCO: V
- SCO: V
- FI: V
- SR: III
- SCJI: III
### R&D activities
- Researching low sensitivity explosive composition to enhance XF® Family
- Work on the “IM” design ammunition to be compliant with STANAG 4439

### Intrinsic explosive composition XF®11585 performances
- Low sensitivity, detonics performances similar to Compo B
- Raw materials relatively less expensive than EM competitors

### Operational advantages of ammunition filled with XF®11585
- Cost effectiveness
- IM & detonics performances
- Simple pyrotechnic train (robust design)
- Simple way of demilitarisation (potential re-use of raw materials)

*Standard “IM” explosive XF®11585 dedicated to multipurpose “IM” ammunition*
QUESTIONS?