Melt-cast process applied to develop based IM ammunition
Scope of the study

Melt-cast process

Main detonics properties

Recent IM Results

New challenges

Conclusion

- Melt-cast process
- Major detonics performances of XF®11585
- Recent IM results on ammunition loaded with XF®11585
- New challenges for Energetics Materials
- Conclusion
Objectives of the R&D studies

Leadership for « IM » munitions and low sensitivity Energetic Materials

Artillery shell: XF® Family
155 mm HE-IM LU211
Fully compliant with STANAG 4439

Tank
Mortars
Navy

Searched for new explosive compositions
XF®11585 is a solution for this range of ammunition

Medium caliber: XP® Family

90’s  2000  2006
Melt-cast process

Recent IM Results

New challenges

Conclusion

Scope of the study

Melt-cast process

Main detonics properties

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Gravitational casting phase

Cooling phase

Mixing phase

Reversibility (demilitarisation)
Major detonics performances of XF®11585

Detonics performances

<table>
<thead>
<tr>
<th></th>
<th>Unconfined critical diameter</th>
<th>VoD Unconfined Ø 30 mm</th>
<th>VoD Unconfined Ø 50 mm</th>
<th>VoD Confined Ø 73 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF®11585</td>
<td>~10 mm</td>
<td>7070 m/s @ 1.73 g/cm³</td>
<td>7300 m/s @ 1.73 g/cm³</td>
<td>7468 m/s @ 1.73 g/cm³</td>
</tr>
<tr>
<td>Comp B</td>
<td>&lt; 4 mm</td>
<td>7920 m/s @ 1.72 g/cm³</td>
<td></td>
<td>7920 m/s @ 1.71 g/cm³</td>
</tr>
</tbody>
</table>

Mechanical properties

<table>
<thead>
<tr>
<th></th>
<th>Density</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>1.73 g/cm³</td>
<td>20.8</td>
<td>1986</td>
<td>1.18</td>
<td>20.8</td>
</tr>
<tr>
<td>Comp B</td>
<td>1.73 g/cm³</td>
<td>16.1</td>
<td>1877</td>
<td>0.94</td>
<td>16.1</td>
</tr>
</tbody>
</table>

Gap test STANAG 4488

<table>
<thead>
<tr>
<th></th>
<th>Density</th>
<th>PMMA</th>
<th>Equivalent pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF®11585</td>
<td>1.73 g/cm³</td>
<td>70 mm</td>
<td>~50 kbar</td>
</tr>
<tr>
<td>Comp B</td>
<td>1.69 g/cm³</td>
<td>130 mm</td>
<td>19.2 kbar</td>
</tr>
</tbody>
</table>

Similar to Comp B

a low sensitivity EM With Comp B performances
**IM performances already recorded**

**Ammunition filled with XF®11585**

<table>
<thead>
<tr>
<th>STANAG 4439</th>
<th>STANAG</th>
<th>GEMO-Mock up</th>
<th>120 mm Tank ammunition</th>
<th>100 mm Navy Ammunition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast heating</td>
<td>4240</td>
<td>IV</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Slow heating</td>
<td>4382</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bullet impact</td>
<td>4241</td>
<td>VI</td>
<td>VI</td>
<td></td>
</tr>
<tr>
<td>Sympathetic reaction</td>
<td>4396</td>
<td>IV</td>
<td>VI</td>
<td></td>
</tr>
<tr>
<td>Fragment impact</td>
<td>4496</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaped charge impact</td>
<td>4526</td>
<td>III</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Screwed cover](image)

*French Standard NF T 70-500*

GEMO Mock up represents an artillery shell
Recent results in ammunition

155 mm Artillery shell: LU107 modernized version of M107

Sympathetic reaction: STANAG 4396

Logistical configuration

Distance between donor and acceptor 12 cm
Recent results in ammunition

120 mm Tank ammunition

- Sympathetic reaction: logistic packaging (live HE shell only without “empennage”)

![Images of ammunition and packaging](images)

- Shaped charge Jet Impact with CCEB62 (Caliber 62 mm / HMX based)

  - Compliant with STANAG 4526

  ![Images of shaped charge impact](images)

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Recent results in ammunition

- **76 mm Navy ammunition**
  - Bullet Impact according to the STANAG 4241
  
  ![Bullet Impact](image)

- **Sympathetic reaction according to the STANAG 4396 (turret configuration)**
  
  ![Type VI](image)

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Recent results in ammunition

- **76 mm Navy ammunition**
  - Thermal Threat: Slow heating according to STANAG 4382

- **Thermal Threat: Fast heating according to STANAG 4240 (reviewed in progress)**

C. Coulouarn, and al., NEXTER Munitions, c.coulouarn@nexer-group.fr
# IM performances

## Overview on ammunition filled with XF®11585

<table>
<thead>
<tr>
<th>STANAG 4439</th>
<th>Result expected</th>
<th>155 mm LU107</th>
<th>120 mm Tank ammunition</th>
<th>100 mm Navy Ammunition</th>
<th>76 mm Navy Ammunition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast heating</td>
<td>4240</td>
<td>V</td>
<td>V</td>
<td>V*</td>
<td>V</td>
</tr>
<tr>
<td>Slow heating</td>
<td>4382</td>
<td>V</td>
<td>V**</td>
<td>V</td>
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<td>III</td>
<td>III**</td>
<td>III</td>
<td></td>
</tr>
</tbody>
</table>

*: ramp gas  
**: Gemo-mock up
Energetic materials available for Insensitive Munitions

- Energetic materials described in open literature for “IM” for the 60 mm up to 120 mm

<table>
<thead>
<tr>
<th>Technology process</th>
<th>Key ingredient</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF®11585</td>
<td>TNT + RDX + NTO + Al</td>
<td>60 mm up to 120 mm</td>
</tr>
<tr>
<td>IMX-104 (OSX-7)</td>
<td>DNAN + NTO + RDX</td>
<td>60 mm up to 120 mm</td>
</tr>
<tr>
<td>CLX-663</td>
<td>HTPB + RDX</td>
<td>76 mm</td>
</tr>
<tr>
<td>HBU-88A</td>
<td>DNAN + NTO + HMX</td>
<td>120 mm</td>
</tr>
<tr>
<td>OSX-12</td>
<td>DNAN + RDX + AP + MNA</td>
<td>120 mm</td>
</tr>
<tr>
<td>PAX-21</td>
<td>DNAN + NTO + RDX + AL</td>
<td>120 mm</td>
</tr>
<tr>
<td>PAX-48 (OSX-8)</td>
<td>DNAN + RDX + Wax</td>
<td>60 and 81 mm</td>
</tr>
<tr>
<td>PAX-195</td>
<td>DNAN + RDX + MNA</td>
<td></td>
</tr>
<tr>
<td>PAX-41</td>
<td>DNAN + RDX + MNA</td>
<td></td>
</tr>
</tbody>
</table>

- XF11585 is a solution for this range of ammunition
Energetic materials available for Insensitive Munitions

Energetic materials described in open literature for “IM” for the 60 mm up to 120 mm

<table>
<thead>
<tr>
<th>Technology process</th>
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</tr>
</thead>
<tbody>
<tr>
<td>XF®11585</td>
<td>TNT melt cast</td>
</tr>
<tr>
<td>IMX-104 (OSX-7)</td>
<td>DNAN melt cast</td>
</tr>
<tr>
<td>CLX-663</td>
<td>Composite</td>
</tr>
<tr>
<td>HBU-88A</td>
<td>Composite</td>
</tr>
<tr>
<td>OSX-12</td>
<td>DNAN melt cast</td>
</tr>
<tr>
<td>PAX-21</td>
<td>DNAN melt cast</td>
</tr>
<tr>
<td>PAX-48 (OSX-8)</td>
<td>DNAN melt cast</td>
</tr>
<tr>
<td>PAX-195</td>
<td>Wax melt cast</td>
</tr>
<tr>
<td>PAX-41</td>
<td>DNAN melt cast</td>
</tr>
</tbody>
</table>

The challenge is now to propose the best trade-off according the secondary criteria
Energetic materials available for Insensitive Ammunition

Basic hypothesis: Explosive composition must be efficient in terms of

• Detonics performances ✓
• Insensitivity ✓

⇒ Essential but **not discriminant** between solutions

What do we need to provide the best trade-off “IM” ammunition for the 60mm up to 120 mm?

• Low investment in terms of filling equipment

• Compliant with a simple method of demilitarisation

• Ageing compliance

• Best cost efficiency
New challenges: low investment in terms of filling equipment

- Melt-cast process: simple, no-specific equipment and worldwide widespread

![50's equipment](image1)

![80's equipment](image2)

Equipment compliant for TNT up to XF family

- Capability to fill shell:
  - From 60 mm to 155 mm shell
  - 3 batches 500kg / day / 2 shifts
New challenges: Demilitarization

Simple method…

1st: Re-melt phase

No additional booster:
Easy to dismantle

Detonics and vulnerability performances preserved

Compliant STANAG 4518

2nd: Recycling EM

Re-use of ammunition shell

Recycling Steel

3rd: Re-use phase

Re-use of explosive composition

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New challenges: performances after ageing

- **TNT binder:**
  - Worldwide used by the military forces for **more than 50 years** in TNT shells or NTO/TNT warheads: **excellent background!**

- **Exsudation:**
  - Problem solved by Nexter Munitions many years ago by using XF® Family

- **XF®11585:**
  - French ministry of Defense is going to evaluate XF11585 by applying complete set of tests according to the STANAG 4170
  - Results are expected for mid Y2014
New challenges: Better cost efficiency

**Economic performances**

*Of course, the last key of choice for the non-technical people*

- **3 main axes to obtain the best economics performances**
  - **(1/3) Simple industrial plant**
    - XF®11585 allows us to use standard filling plant for TNT or Comp B
  
  - **(2/3) Use of cheap raw materials**
    - TNT as powerful energetic binder: still the best choice in terms of economic performances in comparison with DNAN or plastic binder
    - TNT is 6900 m/s @ for less than 3,5€/kg

**XF®11585 formulation**

- NTO/RDX 48%
- TNT 31%
- Additive 21%
Economic performances:

- (3/3) Simple pyrotechnic train

Size or / and performances of additional Booster

Sensitivity of main charge

~76 mm config.

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Conclusion

Demilitarization aspect

IM use

Storage 1.6 HD
Reduced area

EVIDENT BENEFITS!

XF*11585

Simple industrial plant
Current TNT equipment

Studying board:
No additional booster

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XF®11585 presents numerous advantages:

✓ Standard filling plants
✓ Compatible with caliber from 60 mm up to 120 mm
✓ Stable and ages well ...
✓ Economic benefits

Thank you for your attention

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