FOX-7 based Insensitive Cast PBX

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EURENCO and the French Research Centre of SNPE Group are working together to manufacture new cast Plastic Bonded eXplosives (PBXs):
- More and more powerful
- Less and less sensitive
- And cost effective, of course!

FOX-7 is known for:
- its detonation properties close to the ones of RDX
- its low sensitivity on raw material and in pressed and melt poured High Explosives

QUESTION: what would be the result of introducing FOX-7 in a cast PBX?

The composition chosen to support this study is the PBXN-109, well known for its low shock sensitivity: 140 acetate cards at French Large Scale Gap Test

The French version of PBXN-109 contains:
- I-RDX®: 64 %
- Aluminum: 20 %
- Inert binder: 16 %
Methodology of this study

Raw material

Safety results

Composition

PBXN-109 containing I-RDX®: I-PBXN-109

PBXN-109 containing FOX-7: F-PBXN-109

Safety results

Shock sensitivity and detonation performances
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FOX-7 Characteristics

- Chemical Formula of FOX-7 molecule
  \[
  \begin{array}{c}
  \text{H}_2\text{N} \\
  \text{H}_2\text{N} \\
  \text{NO}_2 \\
  \text{NO}_2
  \end{array}
  \]

- Aspect of FOX-7 crystals
  - FOX-7 powder
  - Microscopy picture
  - SEM picture
FOX-7 Characteristics

Thermochemical and Detonation properties

<table>
<thead>
<tr>
<th></th>
<th>FOX-7</th>
<th>RDX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal density (g/cc)</td>
<td>1.885</td>
<td>1.806</td>
</tr>
<tr>
<td>Heat of Formation (kcal/mol)</td>
<td>-32.0</td>
<td>-16.5</td>
</tr>
<tr>
<td>Activation Energy (kcal/mol)</td>
<td>58</td>
<td>40</td>
</tr>
<tr>
<td>Theoretical Det. Velocity (m/s)*</td>
<td>8849</td>
<td>8940</td>
</tr>
<tr>
<td>Theoretical Det. Pressure (GPa)*</td>
<td>33.7</td>
<td>34.6</td>
</tr>
</tbody>
</table>

* from CHEETAH v2.0 calculations

The detonation properties of raw FOX-7 are expected to be very close to the ones of raw RDX
### FOX-7 Characteristics

#### Safety Results on raw material

<table>
<thead>
<tr>
<th></th>
<th>FOX-7</th>
<th>RDX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction Sensitivity (ISF*)</td>
<td>&gt; 350 N</td>
<td>120 N</td>
</tr>
<tr>
<td>Impact Sensitivity (ISI**)</td>
<td>20 - 40 J</td>
<td>4 - 5 J</td>
</tr>
<tr>
<td>Sensitivity to ElectroStatic Discharge (ESD)</td>
<td>Not sensitive</td>
<td>Not sensitive</td>
</tr>
<tr>
<td>Auto Ignition Temperature</td>
<td>215°C</td>
<td>223°C</td>
</tr>
</tbody>
</table>

* corresponding to the French norm AFNOR NF T70-503
** corresponding to the French norm AFNOR NF T70-500

FOX-7 clearly appears less sensitive than RDX at impact and friction
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Preliminary Study

Estimation of Detonation properties for both compositions with the help of CHEETAH v2.0

<table>
<thead>
<tr>
<th></th>
<th>F-PBXN-109</th>
<th>I-PBXN-109</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cc)</td>
<td>1.703</td>
<td>1.665</td>
</tr>
<tr>
<td>Detonation Velocity (m/s)</td>
<td>7018</td>
<td>7074</td>
</tr>
<tr>
<td>Detonation Pressure (GPa)</td>
<td>18.85</td>
<td>19.38</td>
</tr>
<tr>
<td>Energy @ V/V0 = 2 (GPa cm³ / cm³)</td>
<td>4.30</td>
<td>4.63</td>
</tr>
<tr>
<td>Energy @ V/V0 = 7 (GPa cm³ / cm³)</td>
<td>6.63</td>
<td>7.11</td>
</tr>
</tbody>
</table>

The use of FOX-7 in PBXN-109 leads to equivalent detonation performances than standard PBXN-109 containing RDX
The total mass of RDX in PBXN-109 (64 wt%) has been substituted by the same mass of FOX-7:

I-PBXN-109:

F-PBXN-109:

N.B: 2 qualities of FOX-7 have been used in F-PBXN-109 to comply with the RDX PSD in I-PBXN-109.
Safety Results

F-PBXN-109 | I-PBXN-109
--- | ---
Friction Sensitivity (ISF) | > 353 N | > 353 N
Impact Sensitivity (ISI) | > 50 J | 26 J

→ No more sensitivity difference at friction
→ F-PBXN-109 is less sensitive than I-PBXN-109 at impact

5 cylinders Ø 40 H 200 mm of F-PBXN-109 were cured to evaluate:

• Shock Sensitivity at Large Scale Gap test (LSGT)
• Detonation Velocity
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Experimental set up for LSGT

Description of French Large Scale Gap Test (LSGT) according to STANAG 4488 annex B

Donor: RDX/Wax Ø 40 mm

Barrier: acetate cards 0.19 mm thick. The result is the number of cards which does not transmit the detonation to the acceptor

Acceptor: Ø 40 H 200 mm in a steel confinement 4 mm thick
F-PBXN-109 results and comparison with I-PBXN-109:

<table>
<thead>
<tr>
<th></th>
<th>F-PBXN-109</th>
<th>I-PBXN-109</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal quality</td>
<td>FOX-7 class 2&amp;3</td>
<td>I-RDX®</td>
</tr>
<tr>
<td>Detonation Velocity (m/s)</td>
<td>7300 ± 50</td>
<td>7527 ± 38</td>
</tr>
<tr>
<td>LSGT Result</td>
<td>115</td>
<td>140 ± 5</td>
</tr>
<tr>
<td>Pressure in acetate (kbar)</td>
<td>68.2</td>
<td>53.7</td>
</tr>
</tbody>
</table>

- The Det. Velocity of F-PBXN-109 is 3% lower ...
- … but the initiation pressure is 27% higher
Comparison with PBXN-109s containing miscellaneous qualities of RDX
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A cast Plastic Bonded eXplosive containing FOX-7 has been successfully realized.

Comparing to regular PBXN-109, the “PBXN-109 like” composition containing FOX-7 exhibits:
- Equivalent or lower sensitivities to standard safety tests
- Equivalent detonation properties
- A significant improvement of shock sensitivity

These first results concerning the introduction of FOX-7 in a cast PBX are very promising for the industrial development of new Extremely Insensitive Detonable Substances (EIDS).