CLP - IMI’s Nitramine Propellant Family for LOVA

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IMI FACILITIES
New Requirements for Propellants:

- Increased performance.
- Reduced sensitivity / LOVA.
- Reduced toxicity / Environmental impact - Replacement of toxic components. Environmental regulations.
Toxicity of Propellants Components:

- Dinitrotoluene (DNT) has been used for years as energetic plasticizer in many propellants - DNT, however, is extremely toxic.
- Current Stabilizers are either very toxic by themselves or they produce toxic products during ageing.
- Nitroglycerine NG has physiological effects in cardiovascular system. nitroglycerine has migration tendency.
- Phthalate-Plasticizers (DBP) is toxic.
The Task:

Development of a high performance LOVA propulsion systems for gun ammunitions

Desired Features:

• Extended range.
• Raising Energy contents by using high impetus formulations.
• Increase progressivity.
• Low temperature dependency.
• Controllable burning rate regime.
• Improved safety and toxicity properties.
• Green ingredients as much as possible.
Methodology of New Propellant Development

- Potential energetic materials
- Thermochemical evaluation

Synthesis R&D – Lab scale

Synthesis R&D – Pilot scale

Production

Formulation & testing

Qual. & Ammunition
Energy Increase

To maximize the Impetus

\[ F = R \frac{T_v}{MW} \]

High Energetic materials + Novel Energetic plasticizer

Nitramine (RDX)

Nitroglycerin

IsrMIL

Munition Systems Division

Subject

Unclassified
# Propellant for 105-mm Gun Ammunition

## Thermo-Chemical evaluation

### APFSDS-T 105 mm

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Impetus [ j/g ]</th>
<th>T [ K ]</th>
<th>M [ g/mol ]</th>
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<tbody>
<tr>
<td># 1</td>
<td>1169</td>
<td>3517</td>
<td>25.0</td>
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<tr>
<td># 2</td>
<td>1218</td>
<td>3442</td>
<td>23.5</td>
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<tr>
<td>#3 – (CLP-26)</td>
<td>1204</td>
<td>3259</td>
<td>22.5</td>
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<tr>
<td>M-26</td>
<td>1090</td>
<td>3231</td>
<td>24.6</td>
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</tbody>
</table>
# Propellant for 105-mm Gun Ammunition

## Safety features

<table>
<thead>
<tr>
<th></th>
<th>CLP-26</th>
<th>M-26</th>
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</thead>
<tbody>
<tr>
<td>Impact sensitivity</td>
<td>5.5 N</td>
<td>3.2 N</td>
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<tr>
<td>Friction sensitivity</td>
<td>&gt;360 N</td>
<td>Mild reaction at 360N</td>
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<tr>
<td>Electrostatic discharge (ESD) sensitivity</td>
<td>No reaction</td>
<td>No reaction</td>
</tr>
<tr>
<td>DSC ignition temperature</td>
<td>193°C</td>
<td>186°C</td>
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<tr>
<td>Stability</td>
<td>100 min</td>
<td>65 min</td>
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<tr>
<td>GAP-TEST</td>
<td>No detonation</td>
<td>No detonation</td>
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</tbody>
</table>

**Gap-test**
Propellant for 105-mm Gun Ammunition

Accelerated aging program

Oven 65°C - 60 days

- Interruption bomb
- Closed vessel bomb
- Lab Test

40 mm firing test

105 mm firing test
Propellant for 105-mm Gun Ammunition

Accelerated aging

Interruption bomb

Un-aged propellant

After 60 days aging

Un-aged propellant

~360 bar

~770 bar

~1180 bar
Propellant for 105-mm Gun Ammunition

Ballistic Stability After Aging

Firing tests – 105 mm.

\[ \Delta P_{\text{max}} \text{[bar]} - \text{ref. } P_{21^\circ C} \text{ at 0 day aging} \]

\[ \text{Accelerated aging time [days]} \]

-20
-21
-52
Propellant for 105-mm Gun Ammunition

IM tests

Bullet impact test

Packaged / Unpackaged round

Reaction Type V:
Rupture of packaging, ejection of propellant, partly burning

Loose propellant
Propellant for 105-mm Gun Ammunition  
IM tests

FCO - TEST - Stanag 4240

Reaction Type V:

 Projectile ejection
 followed by ejection of propellant.

In logistic level test:

Rupture of packaging, Projectile ejection, partly burning.
Propellant for 105-mm Gun Ammunition

IM tests

Shaped charge jet attack

Reaction Type III-IV:

Rupture of cartridge, Projectile ejection followed by ejection of propellant, partly burning
Propellant for 105-mm Gun Ammunition

Open air burning

IR photo after 70% of burning time

CLP-26

M-26

IR photo after 10% of burning time

CLP-26

M-26

After 30% of burning time

CLP-26

M-26
## Propellant for 120-mm Gun Ammunition

### Safety features

<table>
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<tr>
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<th>CLP-15</th>
<th>CEP-2</th>
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<tr>
<td>Impact sensitivity</td>
<td>6 N</td>
<td>3.2 N</td>
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<tr>
<td>Friction sensitivity</td>
<td>&gt;360 N</td>
<td>Mild reaction at 360N</td>
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<tr>
<td>Electrostatic discharge (ESD) sensitivity</td>
<td>No reaction</td>
<td>No reaction</td>
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<tr>
<td>DSC ignition temperature</td>
<td>200 &amp; 237°C</td>
<td>186°C</td>
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<tr>
<td>Stability</td>
<td>100 min</td>
<td>70 min</td>
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<tr>
<td>GAP-TEST</td>
<td>No detonation</td>
<td>No detonation</td>
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</table>

**Gap-test**

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**Munition Systems Division**

**Subject**

**Unclassified**
Propellant for 120-mm Gun Ammunition

Accelerated aging program

- Oven 65 °C - **120 days**

**Interruption bomb**

**Closed vessel bomb**

**Lab Test**

**120 mm firing test**
Propellant for 120-mm Gun Ammunition

Accelerated aging

Stabilizer depletion & weight loss of Nitramine compared to DB propellants
Propellant for 120-mm Gun Ammunition

Accelerated aging

Interruption bomb

<table>
<thead>
<tr>
<th>120 d</th>
<th>90d</th>
<th>60 d</th>
<th>no aging</th>
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</thead>
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Accelerated aging interruption bomb

Munition Systems Division
Propellant for 120-mm Gun Ammunition

Accelerated aging

Microscope FTIR investigation

Nitramine FTIR distribution across the web size grain

Nitramine FTIR imaging along the LOVA grain
Propellant for 120-mm Gun Ammunition

Accelerated aging

Ballistic Shelf Life

Ballistic Performances after accelerated ageing
Reaction Type V:
Burning of propellant and combustible cartridge.
Propellant for 120-mm Gun Ammunition

IM tests

Bullet Impact Test - Stanag 4241

Requirement: No explosion or detonation.

Result: Type V reaction rupture of cartridge, ejection of propellant, partly burning

Propellant grains

Same results when tested in logistic level
Propellant for 120-mm Gun Ammunition

Open Burning of loose CLP 15 propellant

After burning

Set up before

Result: Moderate burning (~ 75 sec)

Reference (CEP-2): Faster burning (~10 sec)
Propellant for 120-mm Mortar Ammunition

The new mortar CLPM-15 propellant shows superior ballistic performance
- Extended range
- Force > 1200 j/gr
- Low temperature dependence
Propellant for 120-mm Mortar Ammunition

Small scale erosion bomb
IMI has introduced a novel LOVA propellant family

Improved Ballistic performances
- Higher muzzle velocity
- Low flame temperature (< 3500K)
- High Impetus (>1200 j/g)

- Stable formulation
  - Low weight loss during aging
  - Low stabilizer degradation

- Enhanced safety properties
  - Low vulnerability in IM test
  - Nitroglycerin free

105 & 120 mm gun propellant are IDF qualified

120 mm mortar propellant is under qualification phase
Future plans

IMI intends to further increase its insensitive nitramine propellant family and to broaden the range of applications in actual and future ammunition systems.

Acknowledgments

To IMI propellant team: Yael C., Eli S., Idit M., Haim R.

And to the audience for the attention