CLP - IMI's Nitramine Propellant Family for LOVA

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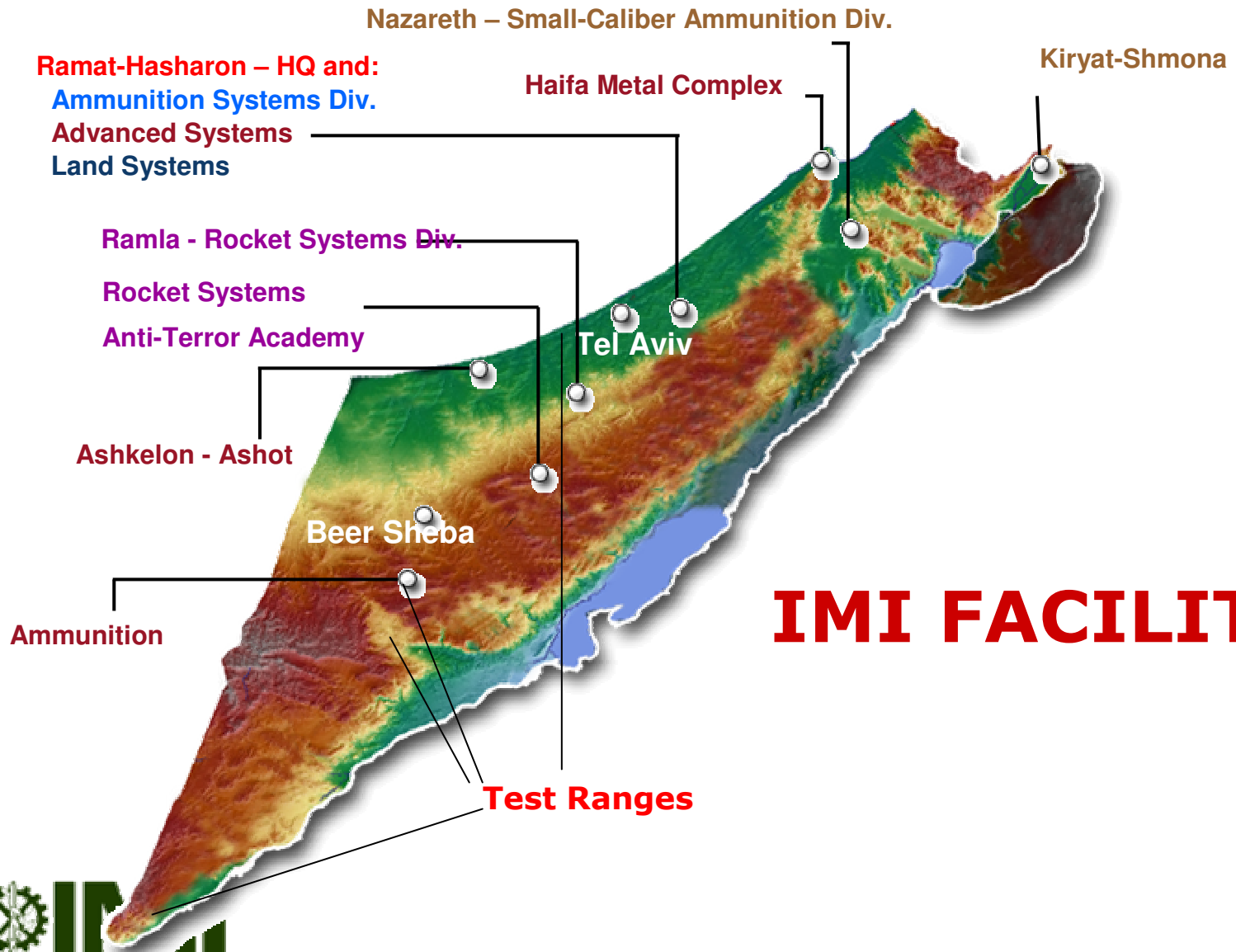


IMI FACILITIES

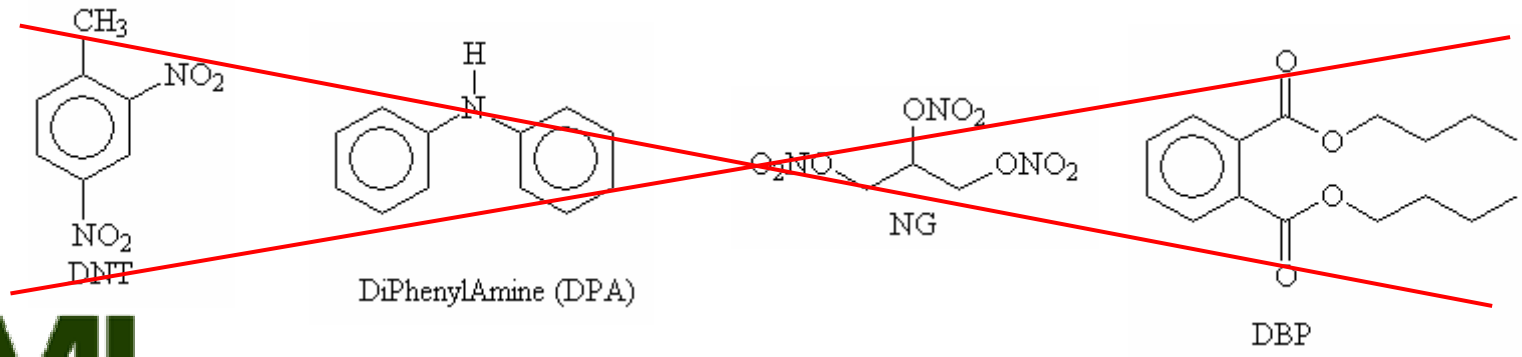
Israel Military Industries Ltd.

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:

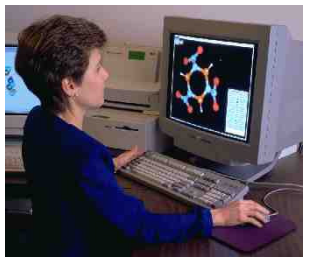
Development of a high performance LOVA propulsion systems for gun ammunitions

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

Synthesis R&D – Lab scale



- Potential energetic materials
- Thermochemical evaluation

Synthesis R&D – Pilot scale

Production

Formulation & testing

Qual. & Ammunition

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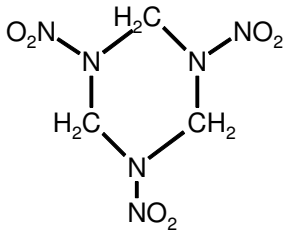
Energy Increase

To maximize the Impetus $F = R \frac{Tv}{MW}$

High Energetic materials + *Novel Energetic plasticizer*

Nitramine (RDX)



~~*Nitroglycerin*~~

Propellant for 105-mm Gun Ammunition

Thermo-Chemical evaluation

APFSDS-T 105 mm

Formulation	Impetus [j/g]	T [K]	M [g/mol]
# 1	1169	3517	25.0
# 2	1218	3442	23.5
#3 – (CLP-26)	1204	3259	22.5
M-26	1090	3231	24.6

Propellant for 105-mm Gun Ammunition

Safety features

	CLP-26	*M-26*
Impact sensitivity	5.5 N	3.2 N
Friction sensitivity	>360 N	Mild reaction at 360N
Electrostatic discharge (ESD) sensitivity	No reaction	No reaction
DSC ignition temperature	193ºC	186ºC
Stability	100 min	65 min
GAP-TEST	No detonation	No detonation

Gap-test

Propellant for 105-mm Gun Ammunition

Accelerated aging program

Oven 65℃ - 60 days

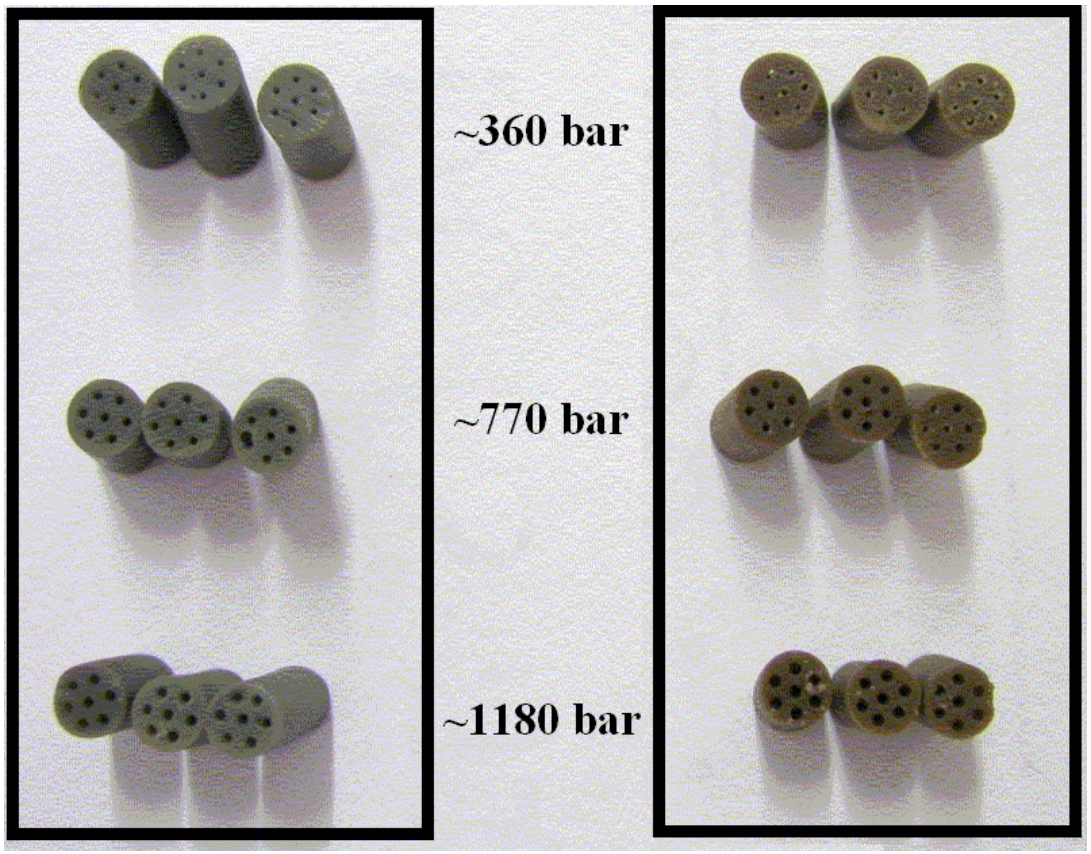
Interruption bomb	*Closed vessel bomb*	*Lab Test*

40 mm firing test

105 mm firing test

Propellant for 105-mm Gun Ammunition

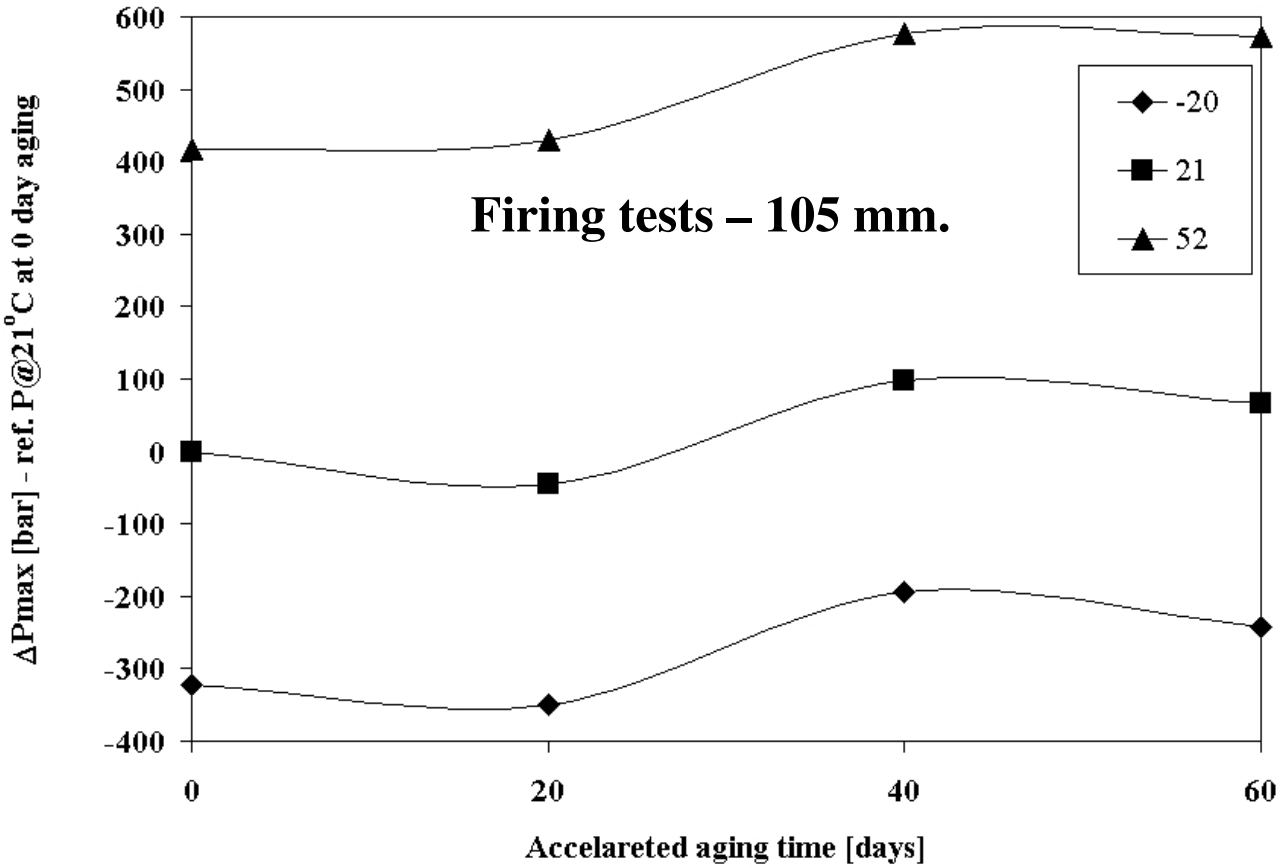
Accelerated aging
Interruption bomb



Un-aged propellant *After 60 days aging*

Propellant for 105-mm Gun Ammunition

Ballistic Stability After Aging



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

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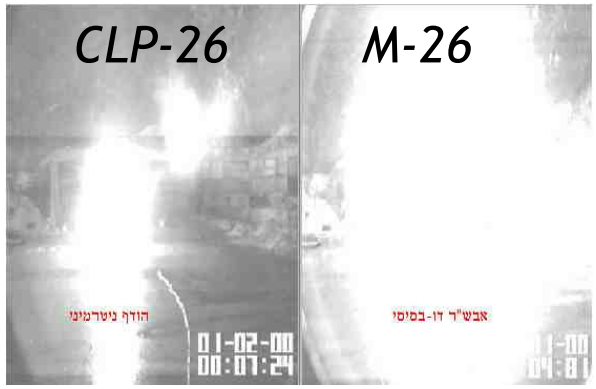
Propellant for 105-mm Gun Ammunition

Open air burning

After 30% of burning time

IR photo after 70% of burning time



IR photo after 10% of burning time

Propellant for 120-mm Gun Ammunition

Safety features

	CLP-15	CEP-2
Impact sensitivity	6 N	3.2 N
Friction sensitivity	>360 N	Mild reaction at 360N
Electrostatic discharge (ESD) sensitivity	No reaction	No reaction
DSC ignition temperature	200 & 237ºC	186ºC
Stability	100 min	70 min
GAP-TEST	No detonation	No detonation

Gap-test

Propellant for 120-mm Gun Ammunition

Accelerated aging program

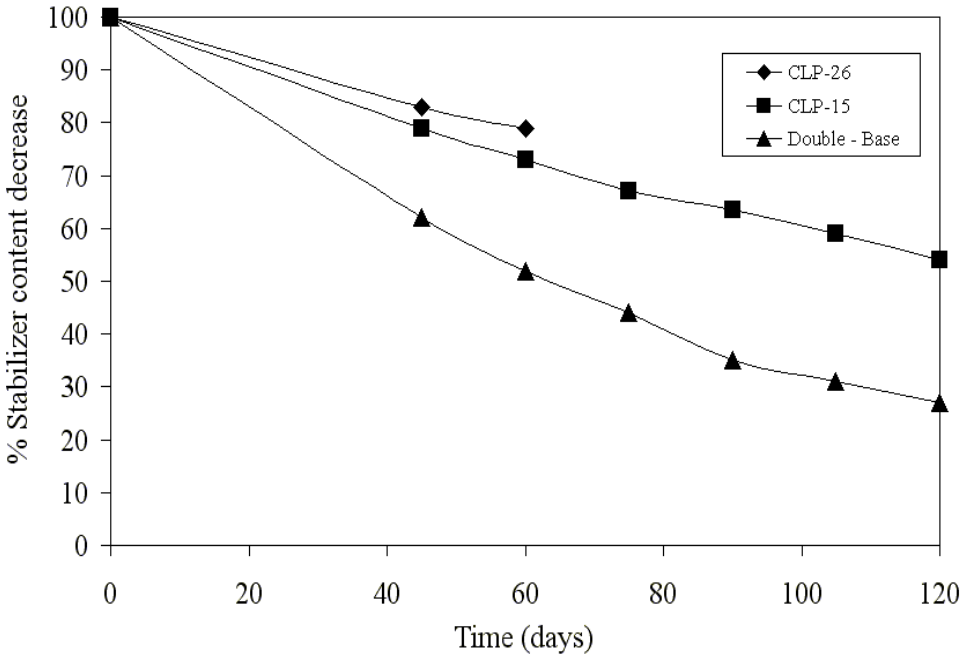
Oven 65 °C - 120 days

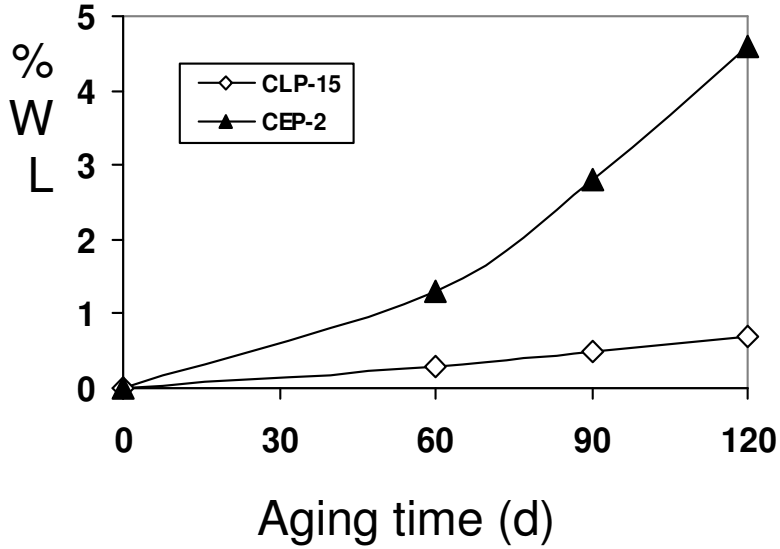
Interruption bomb	***Closed vessel bomb***	***Lab Test***

120 mm firing test

Propellant for 120-mm Gun Ammunition

Accelerated aging

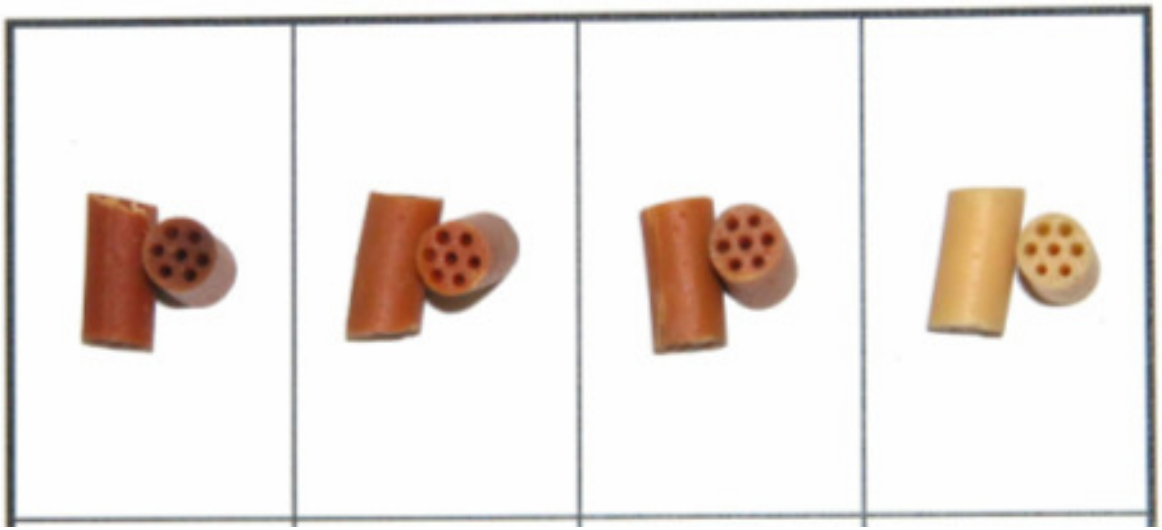




Stabilizer depletion & weight loss of Nitramine compared to DB propellants

Propellant for 120-mm Gun Ammunition

Accelerated aging
Interruption bomb

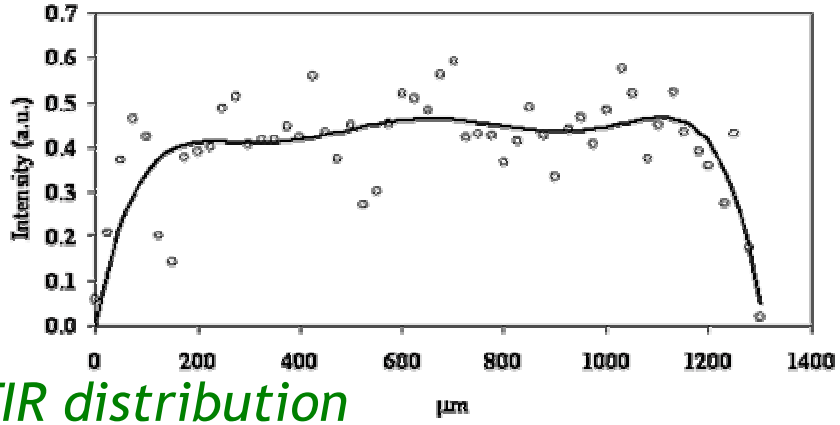


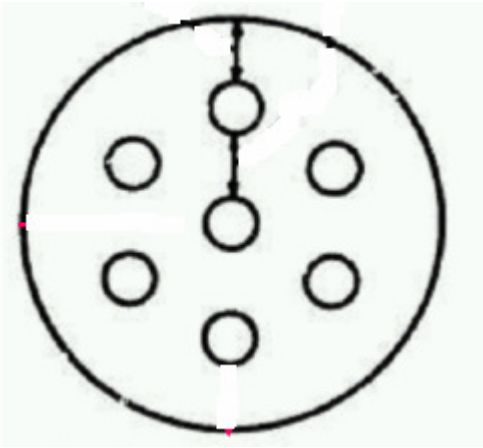
120 d *90d* *60 d* *no aging*

Propellant for 120-mm Gun Ammunition

Accelerated aging

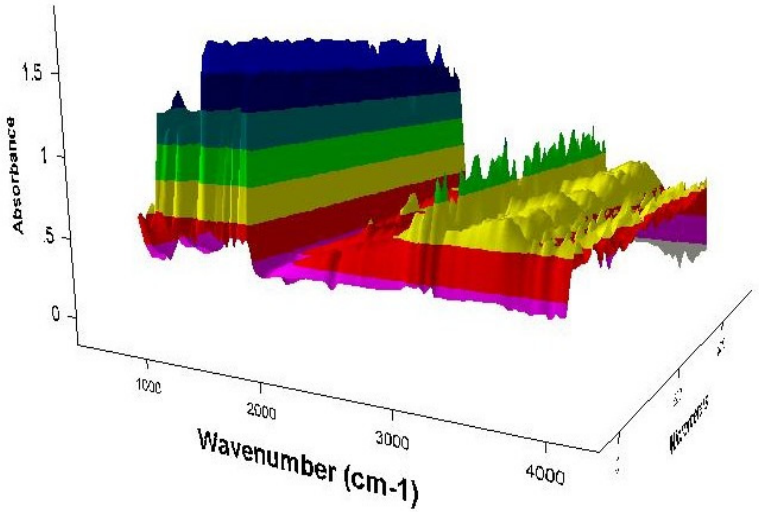
Microscope FTIR investigation





Nitramine FTIR distribution across the web size grain

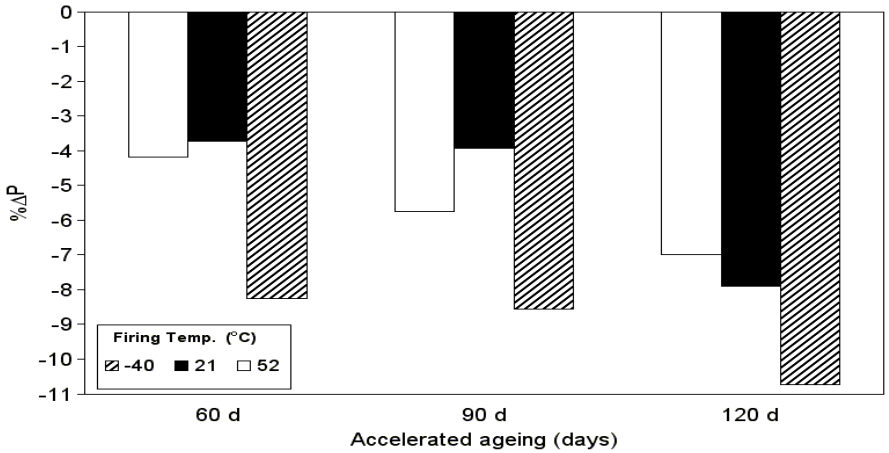
Nitramine FTIR imaging along the LOVA grain

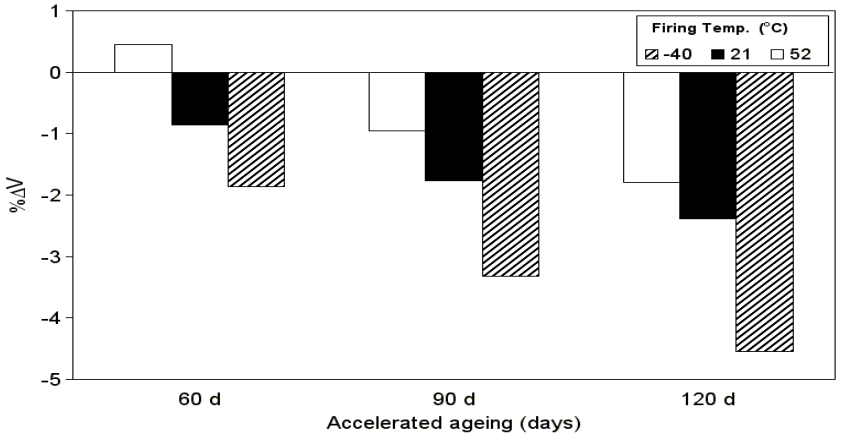


Propellant for 120-mm Gun Ammunition

Accelerated aging

Ballistic Shelf Life





Ballistic Performances after accelerated ageing

Propellant for 120-mm Gun Ammunition

IM tests

FCO – TEST - Stanag 4240

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

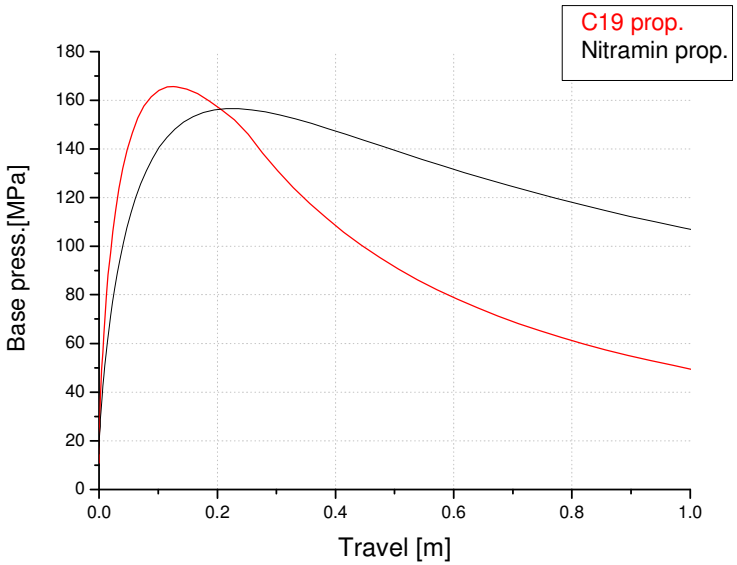
After burning

Set up before

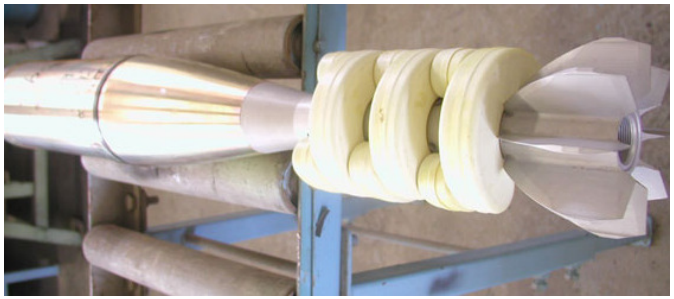
Result: *Moderate burning (~ 75 sec)*

Reference (CEP-2): Faster burning (-10 sec)

Propellant for 120-mm Mortar Ammunition



CLPM-15

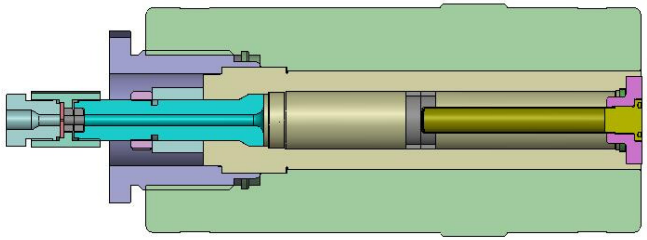


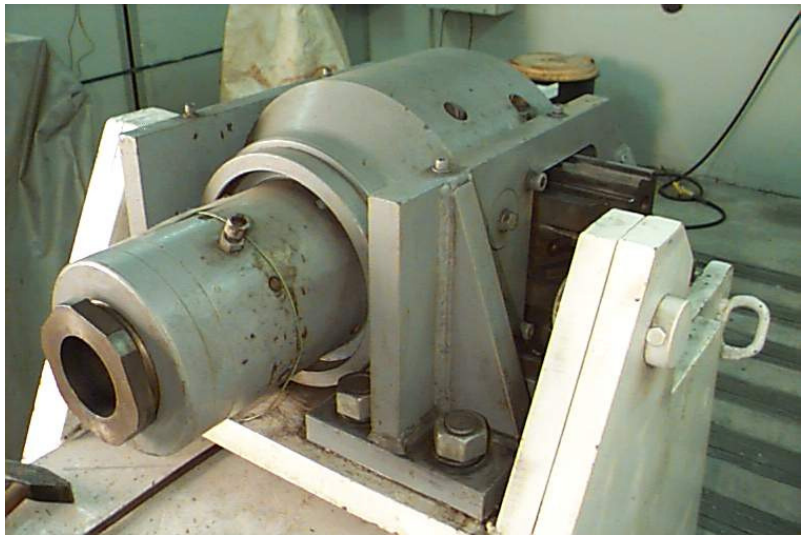
The new mortar CLPM-15 propellant shows superior ballistic performance

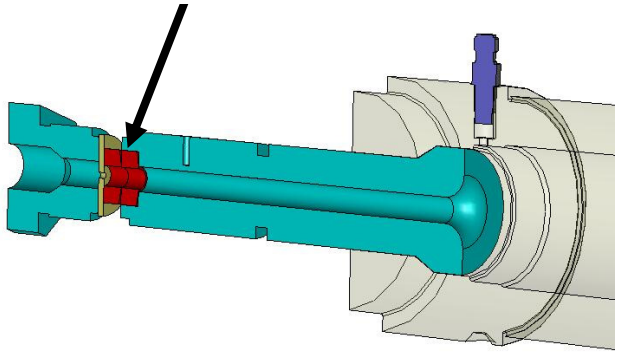
- *Extended range*
- *Force > 1200 j/gr*
- *Low temperature dependence*

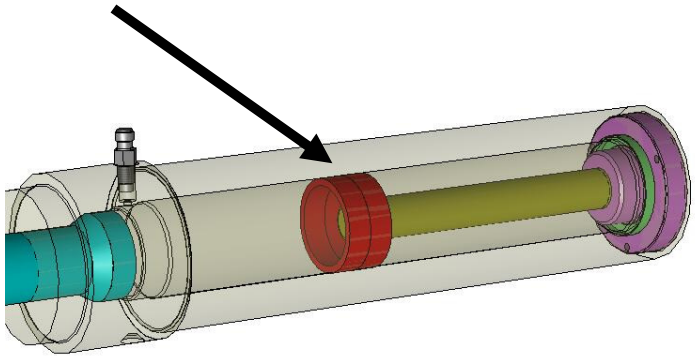
Propellant for 120-mm Mortar Ammunition

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

Low Vulnerability Ammunition (LOVA) Propellant

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