Israel Military Industries Ltd. (IMI)

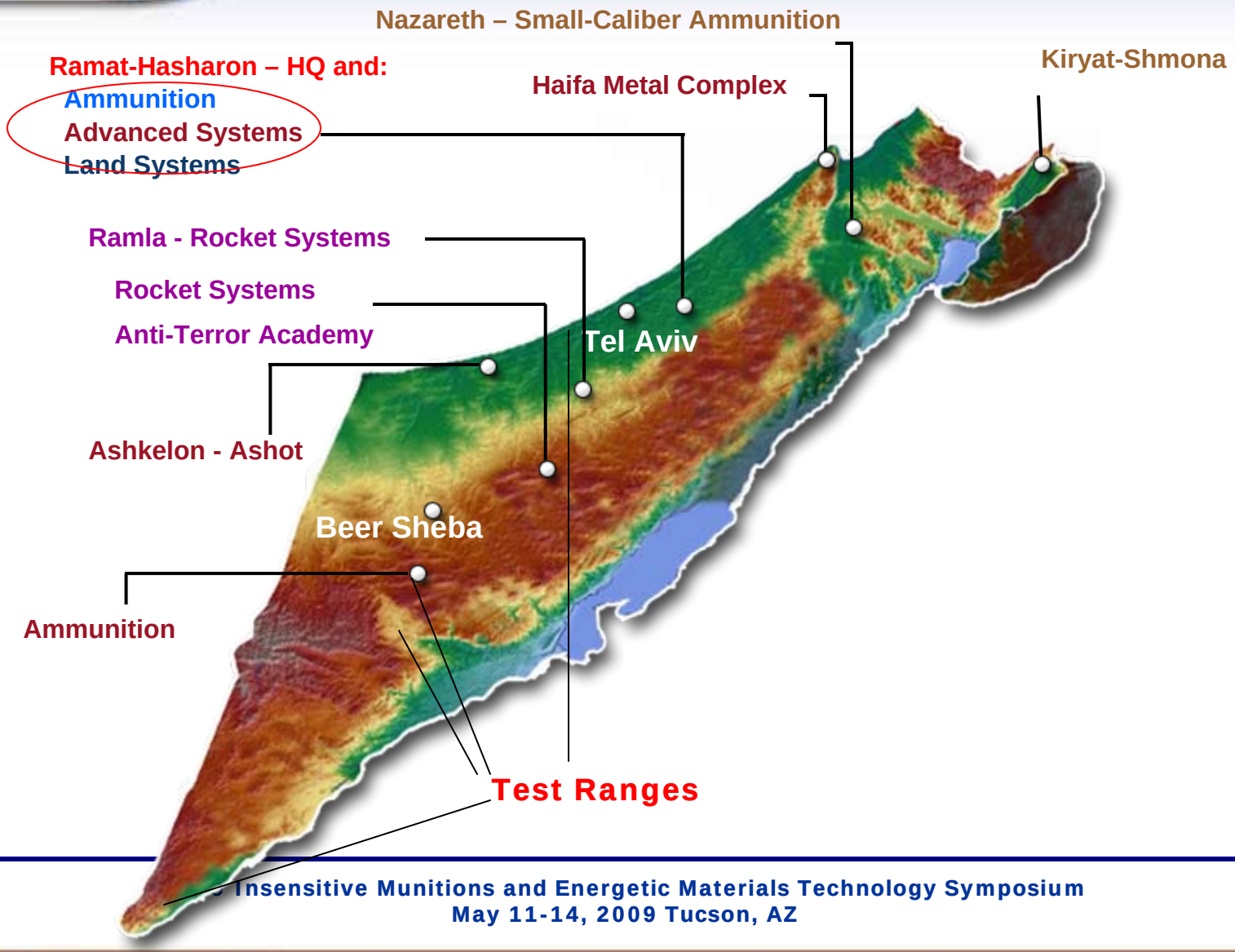
Munition Systems Division

CLX 533 A new Insensitive High explosive

E. Shachar, A. Maish, G. Strul, I. Mandel, H. Rosentswieg

2009 Insensitive Munitions and Energetic Materials Technology Symposium
May 11-14, 2009 Tucson, AZ

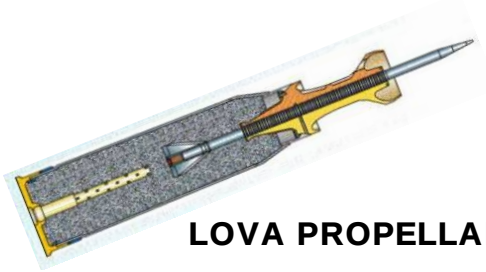
IMI FACILITIES



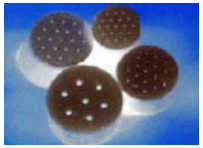
IMI Munitions System Division

Commitment for Safety and Performance

- **Tank**

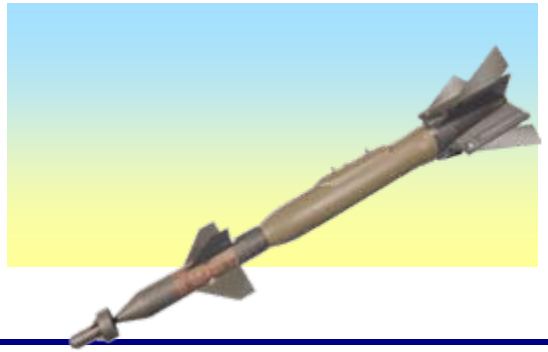


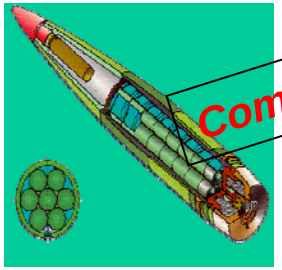
LOVA PROPELLANT



- **Infantry and medium caliber**
- **Air-to-Ground**
- **Artillery**

Combat Proven





Combat Proven

Outline of the presentation :

- Background.
- Objectives.
- Approach.
- Qualification Process.
- Summary.

Background

Propellant for LOVA

IHE Compositions

CLX 663

CLX 851

Tank & Artillery Ammo

IM Technologies in IMI

IM Testing
Under Mil Std 2105 and stanag 4439

- Fast cook-off (FCO)
- Slow cook-of (SCO)
- Bullet impact (BI)
- Sympathetic detonation
- Shape charge

FCO

IM
Insensitive Munition

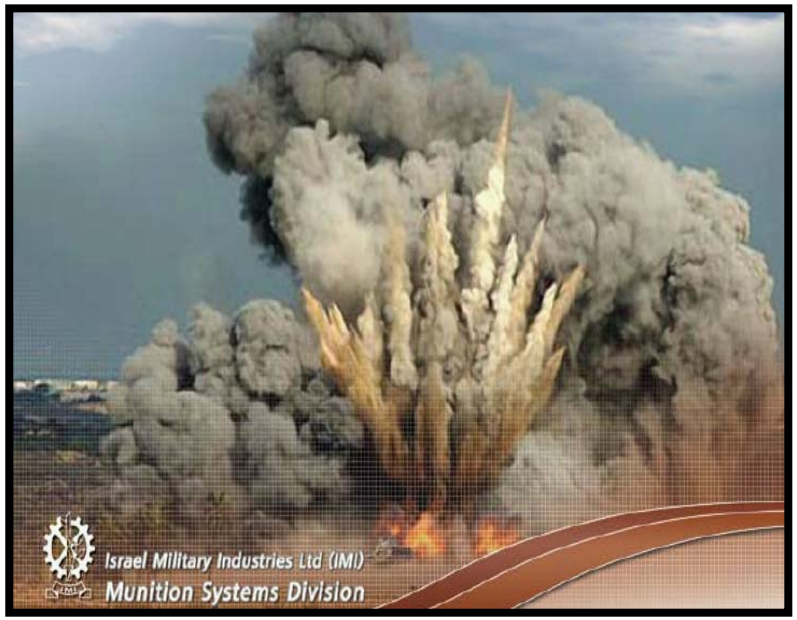
IM-Material

IHE Compositions
- CLX 663
- CLX 851

LOVA Propellant

OBJECTIVES

- The objective of this task was to introduce a new HE composition with high impulse and fragmentation features. Must have an output greater than PBXN-109.
- Comply to the definition of IHE and IM characteristics at least as good as CLX-663.
- Qualify the new composition for the IDF (Additional requirements).



Formulation & Production

- Down selection from several formulations.
- The composition is a bi modal high nitramine (HMX), Aluminum and HTPB Binder and additives.
- Nominal Density (97% TMD) of 1.8 g/cc for the cured material.
- Production of medium batches (100 Gal) at IMI-Chemical Plant.

The Approach of this task:

- Finalizing the Ingredients and composition.
- Determining the final ballistic requirements.
- Configuration of the final process production.
- Qualification of the composition according the IDF standards including an aging protocol.

Testing Protocol

- Hazard analysis – Impact, Friction, ESD
- Thermal analysis.
- Mechanical properties.
- Detonation and critical diameter.
- EIDS tests : Cap test.
  LSGT.
  External Fire test.
  Bullet Impact.

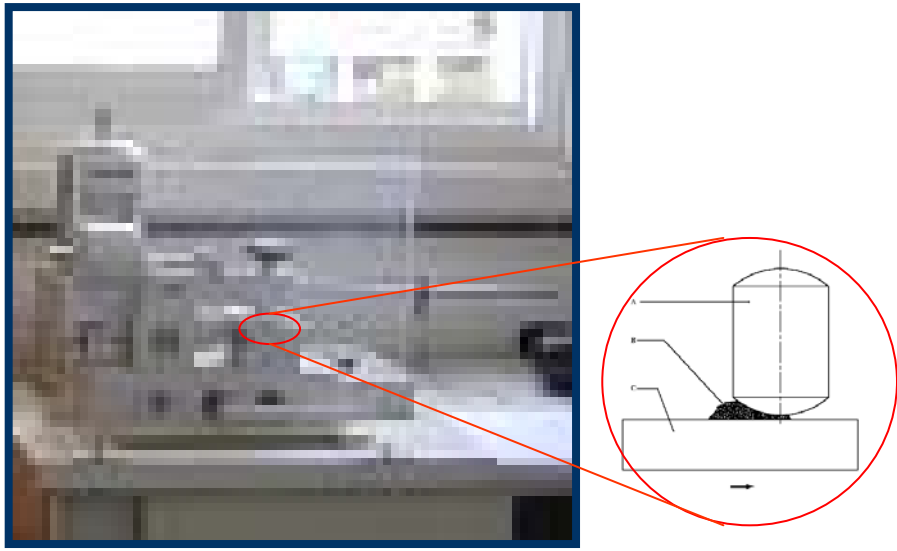
Hazard Characterization - Friction Sensitiveness

Requirement: Less sensitive than RDX and similar to CLX 663.

Method: MIL-STD-1751 Method 1024

Results : 20/20 consecutive negative tests - no reaction at 36 Kg F (72 Lb f)

Explosive	Friction Sensitivity [kgf]
CLX-533	No reaction (max 36) * No reaction (max 36)
Comp. B	No reaction (max 36)
CLX-663	No reaction (max 36) * No reaction (max 36)



* After aging (28d, 95%RH, 70°C) – IDF requirement.

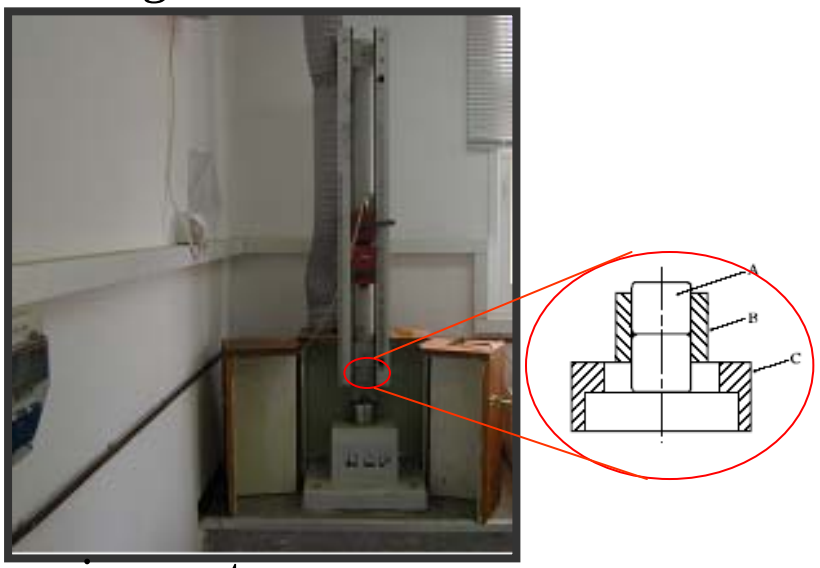
Hazard Characterization - Impact Sensitiveness

Requirement: Less sensitive than RDX and similar to CLX 663.

Method: MIL-STD-1751 Method 1101

Results : Impact results remain fairly consistent, results comparable to RDX and CLX 663 - $E_{50\%}$ Bruceton method– 3.04 Kg m

Explosive	$H_{50\%}$ [cm]	Energy [kg m]
CLX-533	60.72 (5 kg) *66.83	3.04 *3.34
CLX-663	58.4 (5 kg) *50.12	2.92 *2.51
Comp B	50.1 (5 kg)	2.51



* After aging (28d, 95%RH, 70°C) - IDF requirement.

Test results of the qualification process

Hazard Characterization - ESD Sensitiveness

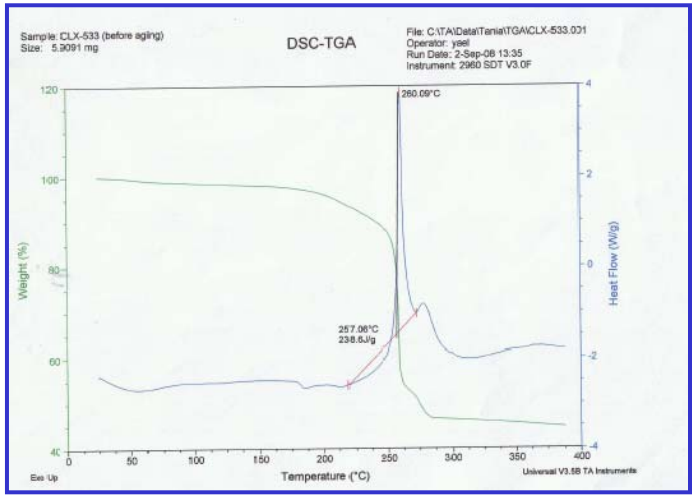
Requirement: 30/30 No Fires at 0.25 J

Method: MIL-STD-1751 Method 1032

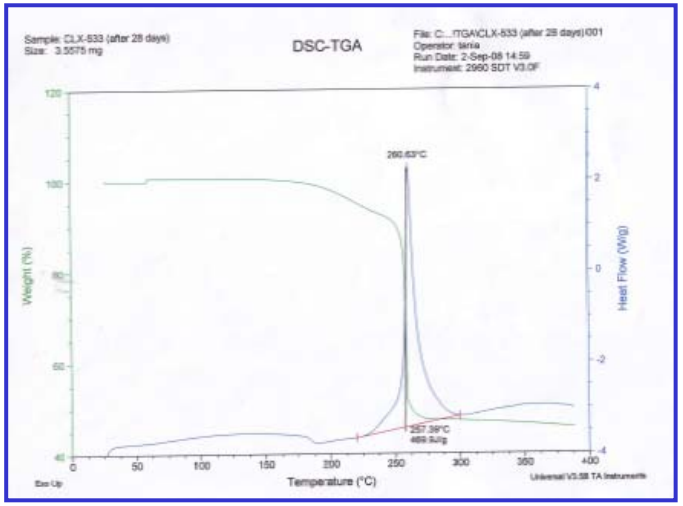
All results pass.

Test results of the qualification process

Thermal Analysis : DSC-TGA



Explosive	Self Ignition Temp. [°C]
CLX-533	257.1 * 257.4
CLX-663	220.2
Comp. B	232.5



* After aging (28d, 95%RH, 70°C) - IDF requirement

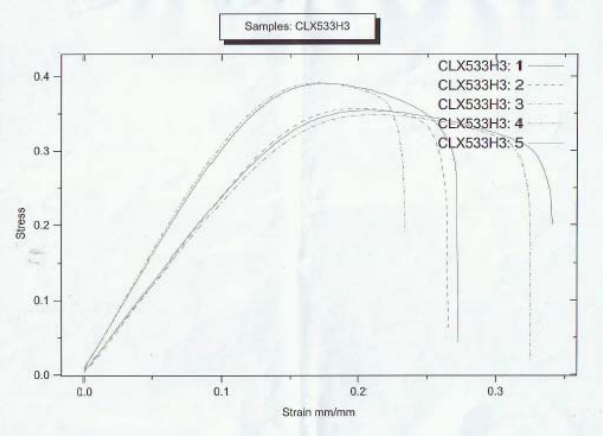
Vacuum Stability

This method is used to determining the energetic material stability by measuring the volume gas liberated of a heated sample under vacuum.

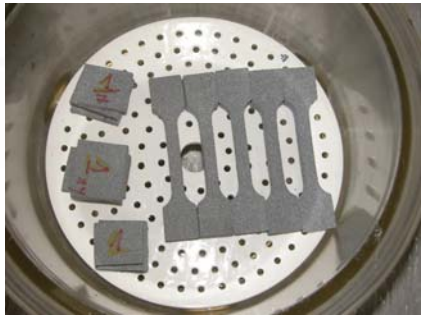
Explosive	Volume/gr (mm)	IDF Req.
CLX-533	0.17	Less than 1 ml/gr
CLX-663	0.05	
Comp B	0.24	

Test results of the qualification process

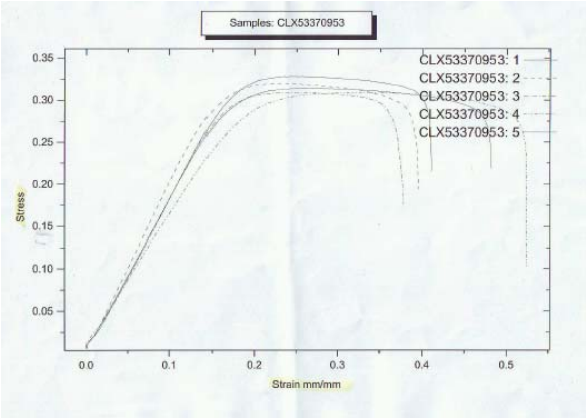
Mechanical properties



After*



Before



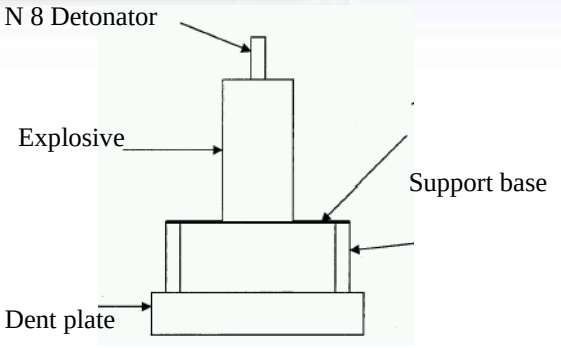
	Area (cm^2)	Modulus (Kg/cm^2)	Stress at Max. Load (Kg/cm^2)	% Strain at Max. Load (%)	% Strain at break (%)
1	1.178	24.297	3.610	20.681	33.333
2	1.201	24.504	3.640	20.073	25.912
3	1.232	22.950	3.551	20.925	31.873
4	0.990	32.373	3.986	16.910	22.871
5	1.035	31.005	3.982	17.397	27.008
Mean	1.127	27.026	3.754	19.197	28.200
S.D.	0.108	4.326	0.213	1.899	4.327
Mean +3.00 SD	1.450	40.003	4.392	24.895	41.181
Mean -3.00 SD	0.804	14.049	3.116	13.499	15.218

* After aging (28d, 95%RH, 70°C) - IDF requirement.

Detonation Velocity & Critical Diameter

Sample	Detonation Velocity (m/s)	Critical Diameter (mm)
CLX-663	7598	18.4
CLX-533	7389	14.8
Comp. B (cast)	7900	4.3*

* MIL-STD-1751A



EIDS testing of CLX-533

Cap Test

Requirement: No detonation
Method: TB 700-2 Chapter 5-8 (UN Test 7 (a))
Results : No penetration through witness plate

This shock test is designed to determine the sensitivity of an EIDS candidate to intense mechanical stimulus.

EIDS testing of CLX-533

Large Scale Gap Test (LSGT)

Requirement: No clean hole punched through the plate.
Method: TB 700-2 Chapter 5-8 (UN Test 7 (b))
Results : Dents in witness plates

The test is used to predict the sensitivity of an EIDS candidate, under confinement in a steel tube, to a specified shock level i.e. a specified donor charge and gap.

EIDS testing of CLX-533

External Fire Test

Requirement: No detonation, no fragment > 1 gram, > 15m

Method: TB 700-2 Chapter 5-8 (UN Test 7 (e))

Results : All parts remained in place. Explosive burned inside the tubes.

This external fire test is used to determine the reaction of an EIDS candidate, to external fire when it is confined.

EIDS testing of CLX-533

Bullet Impact

Requirement: No explosion or detonation.
Method: TB 700-2 Chapter 5-8 (UN Test 7 (d))

Results : 9/10 Explosive scattered.

1/10 Explosive burned inside the tube.

The bullet impact test is used to evaluate the response of an EIDS candidate to the kinetic energy transfer associated with impact and penetration of a given energy source, i.e. a 12.7 mm projectile, traveling at a specified velocity (840 ± 40 m/s).

Conclusions & Summary

- IMI has introduced a new and powerful IHE – CLX 533.
- According to the tests results described above IMI CLX 533 formulation was designated as Insensitive Detonating Substance.
- CLX 533 was qualified by the IDF as IHE with a class/division 1.5 UN (Very Insensitive Explosive Substance).

Acknowledgments

To the directorate of technologies,
Israel Ministry of Defense (IMOD)
for their assistance and the support for this research task.
To IMI explosive team : Avi, Gila, Hagay, Idit, Giora , Haiim R.

We thank you for your attention !