Development of Insensitive Munitions (IM) Thermoplastic elastomer (TPE) propellants for Large Calibre Gun Systems

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NC Symposium 31st May to 1st June 2016

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Introduction

- Background
- LOVA propellants
  - Why?
  - Route to
  - What?

- 120mm Tank LOVA propellants
- Artillery LOVA propellants
- Summary

Background

- Re-established propellant R & D at BAE SYSTEMS, Glascoed
  - After closure of Bishopton site in early 2000s
  - To develop next generation of propellants
- Small scale manufacture ≤ 10kg batches
  - Formulate & model propellants
  - Manufacture suitable formulations
  - Test and assess

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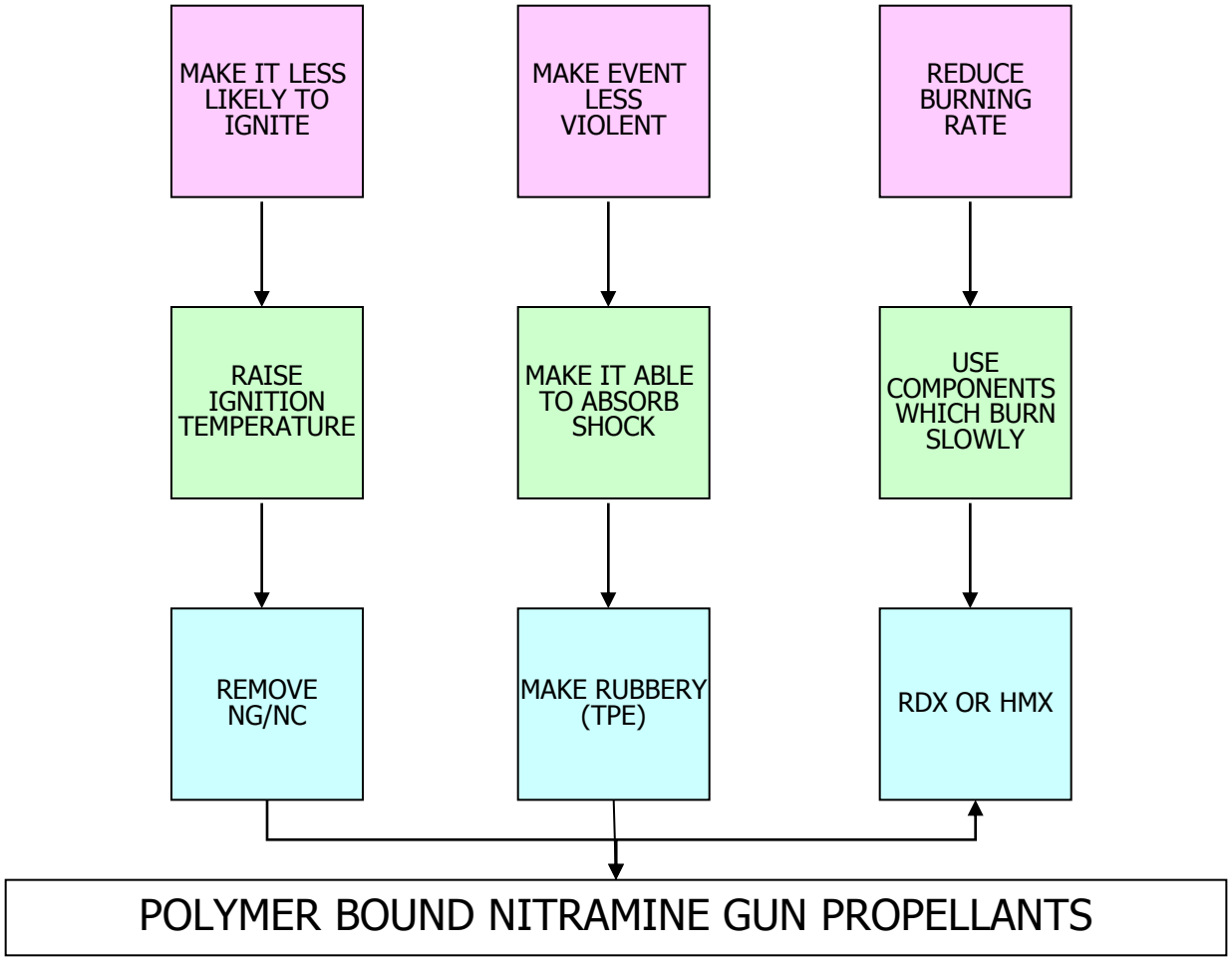
Why LOVA propellants?

- Conventional GUN propellants single, double and triple base
  - Contain NC and NG and Picrite
  - Current formulations are old technology
  - IM signature could be improved

- LOVA (LOw Vulnerability Ammunition) propellants aim to:
  - Give improved IM signature
  - Ballistic match current propellants
  - Improve system performances against current requirements

Route to LOVA propellants



What are LOVA propellants?

LOVA TPE propellants:

- Removed NG from composition
- Reduce amount of NC in composition
- A unique binding system

Ingredient	Conventional propellant	LOVA propellant
NC	18% -35%	Up to 10%
NG	18% - 35%	-
Picrite	20% - 60%	-
Nitramine	-	Up to 80%
Stabiliser	1% - 7%	1%
Plasticiser	-	Up to 9%
Other binders	-	Up to 7%

What are LOVA propellants?

Two families of LOVA propellants have been developed

- Thermoplastic elastomer (TPE) based
  - High energy
    - 1100 – 1200 J/g
    - For high performance tank
  - Lower energy
    - 1000 – 1100 J/g
    - For low energy tank and artillery applications

- Conventional based
  - High energy
    - 1100 – 1200 J/g
    - For high performance tank

LOVA propellants – general assessment

LOVA propellant have undergone a number of assessments, these include:

- Small scale such as chemical and physical analysis, EMTAP, CV etc…
- Large scale IM and ballistic assessments
- EMATP results…..

Parameter	Conventional Propellants			LOVA TPE Propellants	
	Solvent based		Solventless	Lower energy	High Energy
Energy (kJ/kg)	1061	1159	1156	1065	1154
F of I	38	20	7	73	64
F of F	6	3.5	>6	>6	5.6
Ignition Temperature (K)	154	171	170	251	251

120mm Tank LOVA propellants

120mm Tank LOVA propellants

IM signature for high energy LOVA TPE propellant

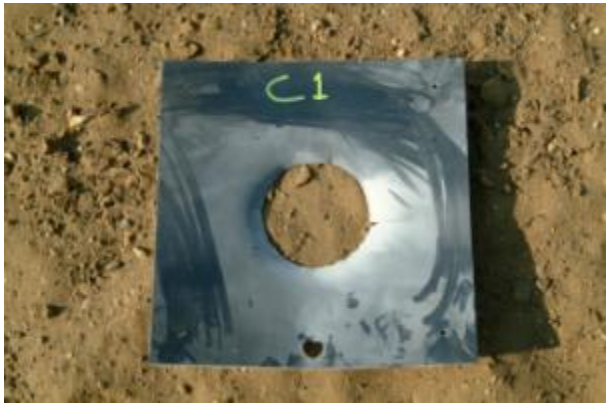
- **Achieved** pass criteria
- **Improved** Shape Charge response compared to current in service charges
- **Improved** IM signature over current in service charges

	Slow Heating	Fast Heating	Sympathetic Reaction	Fragment Impact	Shaped Charge
Pass criteria*	V	V	III	V	III
High energy Conventional Propellant	IV	V	V	II/III	II/III
High energy LOVA TPE propellant	**V**	**V**	**IV**	**V**	**III/IV**

* STANAG 4439

120mm Tank LOVA propellants

Witness plates from the Shaped Charge Attack trial



Conventional
Propellant
TYPE II

LOVA TPE propellant
TYPE III Reaction

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120mm Tank LOVA propellants

Ballistic performance of high energy LOVA TPE propellant

- Fired in UK 120mm tank system
- Comparable performance to current conventional propellant
- Good function and consistency demonstrated
- Potentially low barrel wear due to lower flame temperatures

120mm Tank LOVA propellants summary

Processing (conventional equipment):
- LOVA TPE propellant, Rowanite 318, can be **manufactured consistently**
- All manufacturing parameters are well defined

IM performance:
- Propellant has been shown to be less sensitive and is safer than conventional colloidal propellants
- Propellant has shown the potential to meet the Insensitive Munitions criteria laid out in STANAG 4439

Ballistic performance:
- Ballistic firings on small and large scale shown propellant function well and is comparable to other Tank Gun Propellants
    - Lower barrel wear to be expected - lower flame temperature
    - No shatter at low temperatures

Overall:
    - LOVA propellants are **suitable** candidates for 120mm high energy rounds
    - Cost comparable to current conventional propellants (NQ and Row 316)

Artillery LOVA propellants

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Artillery LOVA propellants

Shaped Charge IM test of lower energy LOVA TPE propellant

- Configuration similar to 105mm L36 propelling charges
- Improved Shape Charge response over conventional propellant (V vs III)
- Visible difference in witness plate damage and high speed camera footage

Propellant	WP damage	Type
Pass criteria*	-	III
Lower energy Conventional propellant	51mm x 55mm	III
Lower energy LOVA TPE Propellant A	1mm x 1.5mm	V
Lower energy LOVA TPE Propellant B	No damage	V

* STANAG 4439

Artillery LOVA propellants

Witness Plate

- Conventional showed damage
- LOVA Propellant has effectively no damage

Lower energy
Conventional Propellant

Lower energy LOVA
TPE Propellant

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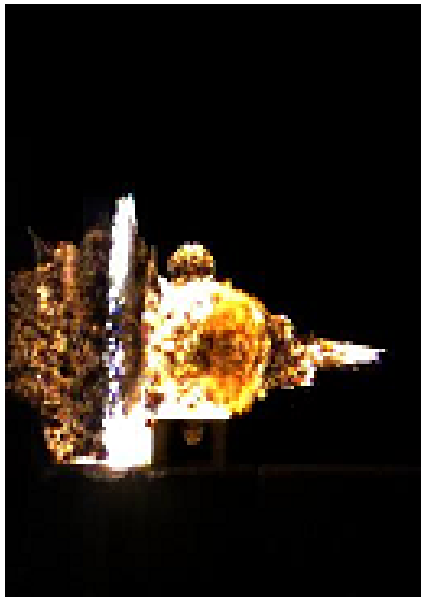
Artillery LOVA propellants

Stills from high speed camera taken at the same relative point of the trial

- Conventional propellant shows a much large reaction



Lower energy
Conventional Propellant
Type III

Lower energy LOVA
TPE Propellant
Type V

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Artillery LOVA propellants

Ballistic performance of lower energy LOVA TPE propellants for artillery systems

- Fired successfully in a UK 105mm gun system, L36 charge super configuration
  - Used as a technical demonstrator for artillery systems
  - 105mm and 155mm possible propellant options

- Comparable performance of all lower energy LOVA TPE propellants to low energy conventional
- Potential for increased performance over NQ propellants (for L36)

Artillery LOVA propellants

Processing (conventional equipment):

- Low energy LOVA (TPE and conventional IM) propellants can be **manufactured consistently** with parameters well defined

IM performance:

- Lower energy LOVA TPE Propellants perform much better than conventional propellants under the **SCJ** attack test, III vs **V** response

Ballistic performance:

- Ballistic firings on small and large scale shown lower energy LOVA TPE propellants to function well and is comparable to conventional artillery propellants
- Demonstrated in a 105mm system, 155mm possible too
- Artificially aged (10 years) LOVA TPE propellants also performed well
- Lower barrel wear to be expected - lower flame temperature

Overall:

- Lower energy LOVA TPE propellants are suitable candidates for artillery systems
- Cost comparable to conventional propellants (N and NQ)

Summary

- LOVA TPE propellants have been successfully manufacture using conventional equipment
- Achieved good IM signatures
- Comparable ballistics to current conventional propellants
- Suitable for 120mm, 155mm and 105mm applications

Next steps

- Develop formulations further to optimise in artillery systems
- Qualify LOVA TPE propellant in a large calibre system

Acknowledgements

LOVA Team:

Dr. Anne Marie Wilton

Mr. Tom Somerville

Mr. Shane Stephens

Ms Dawn Jones

Sponsors - UK MoD for all their funding and support including:

DGM

DOSG

Thank you

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