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

Mark J Penny[1], Anne Marie Wilton[2]
[1]BAE Systems, Glascoed, Usk, Monmouthshire, NP15 1XL
[2]BAE Systems, Georgetown Reception Centre, Houston Road, Johnston, PA6 7GB
Email: mark.penny@baesystems.com

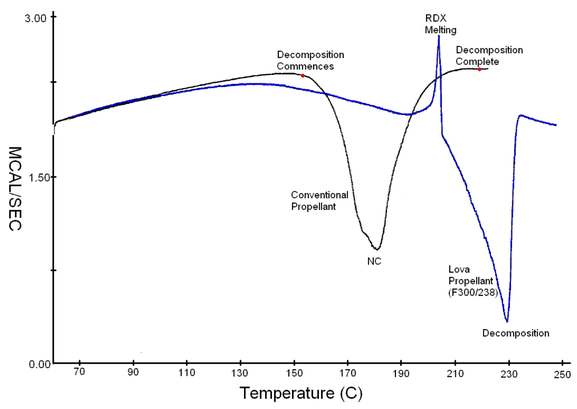
Background to IM (LOVA) propellants

Insensitive munitions (IM) has become an important part of developing new munition products, particularly in the UK, propellants being no exception. Low Vulnerability Ammunition (LOVA) propellants have been in the concept stage for many years however recently their use as real alternatives to the conventional propellants has taken a big step forward.

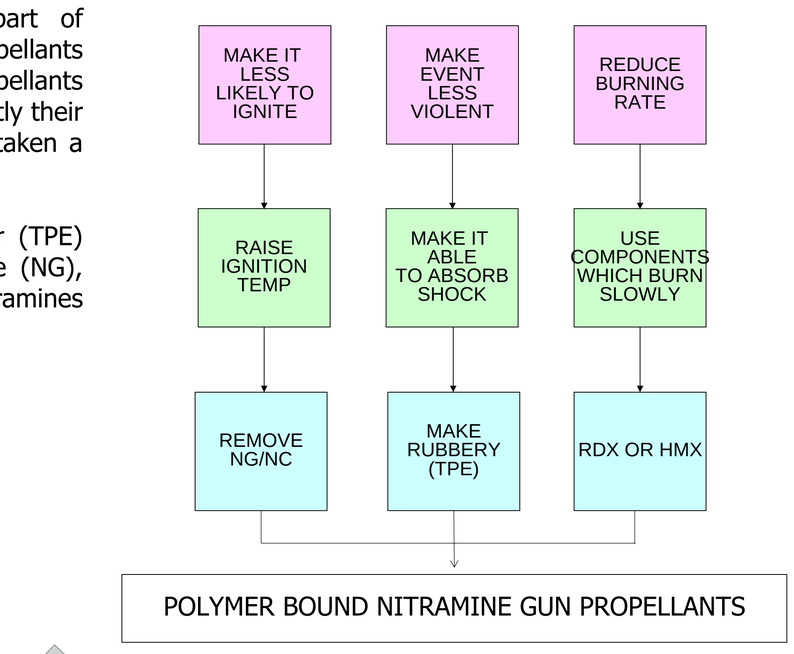
UK LOVA propellants are based on Thermoplastic elastomer (TPE) technology which has enabled the removal of Nitroglycerine (NG), reduction in Nitrocellulose (NC) and the incorporation of nitramines (e.g. HMX/RDX) within a polymer-bound matrix.

Ingredient	Conventional propellant	LOVA propellant
NC	~20%	5% to 10%
NG	~20%	-
Picrite	~55%	-
Nitramine	-	70% to 80%
Stabiliser	~5%	1%
Plasticiser/binder	-	Up to 16%

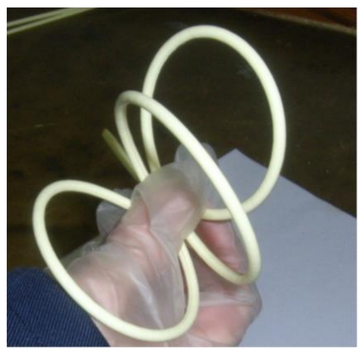
Table 1 Propellant compostions



Route to LOVA Propellants



Various Conventional propellants



LOVA propellant

LOVA propellant facility

LOVA propellant R & D facility was moved to BAE SYSTEMS Glascoed from BAE SYSTEMS Bishopton in the early 2000s when propellant production was ceased at Bishopton. Current facility includes 3 incorporators (2kg, 5kg and 10kg), 2 presses (3inch and 8inch) and a charge build.

We currently have the capacity to formulate, model and manufacture new and developing propellant formulations for assessment.

Incorporators

Presses

Propellant	Burning Rate mm/s	Force kJ/kg
Conventional propellant	144	1170
Rowanite 318 LOVA propellant	75	1154

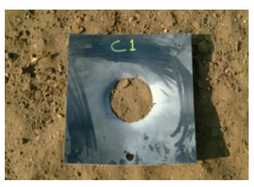
120mm Tank (UK) LOVA propellants

During the late 2000s BAE SYSTEMS developed high energy LOVA propellants in conjunction with the UK MoD, looking at a possible CHARM3 replacement. **Rowanite 318** propellant was chosen as the most suitable candidate which is based on HMX and reduced nitrocellulose content. The 3 year programme consisted of optimising the HMX particle size, processing, a full suite of IM tests and ballistic assessments. All propellant manufactured at the R & D facility in Glascoed, UK.

IM results:
Assessments were carried out at BAE SYSTEMS Ridsdale, UK. Rowanite 318 achieved the **pass criteria** giving an equal or improved response to each of the tests, see table 2, compared to the current high energy conventional . Particularly the Shape Charge jet attack results gave a marked **improvement** with an obvious difference in the witness plate damage, see pictures.

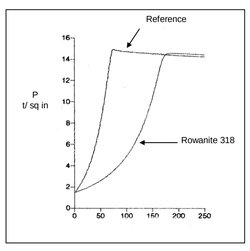
	Slow Heating	Fast Heating	Sympathetic Reaction	Fragment Impact	Shaped Charge
Pass criteria*	V	V	III	V	III
High energy conventional propellant	IV	V	V	II/III	II/III
High energy LOVA TPE propellant	**V**	**V**	**IV**	**V**	**III/IV**

*STANAG 4439
Table 2 IM results for Rowanite 318 high energy LOVA propellant



Conventional high energy propellant
TYPE II Reaction

Rowanite 318 high energy LOVA propellant
TYPE III Reaction



Burn rate (CV)
Conventional vs Rowanite 318 propellant

Ballistic assessment results:
Ballistic assessment of **Rowantie 318** propellant was conducted at QinetiQ, Shoeburyness Range, UK using 120mm Tank system. This was fired at 3 temperatures (+21°C, -46°C & +63°C) on two separate occasions to give a fuller understanding of its performance in the gun. **Comparable performance** to the current conventional propellant was observed across the 3 temperatures. Good function and consistency was demonstrated.

In conclusion **Rowanite 318** is **capable** of **replacing** current conventional propellant in the 120mm high energy round

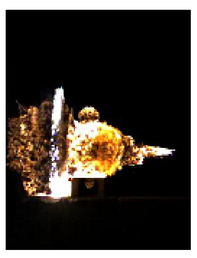
Artillery LOVA propellants

After the success of 120mm tank programme the next stage in development of LOVA propellants centred around artillery systems. As limited work has been carried out in this area the 105mm L36 charge super (UK) was used as a technical demonstrator. With L36 propellant charge being a single stick and a low charge weight this enable assessments to be carried out at relatively low cost. All propellant manufactured at the R & D facility in Glascoed, UK. Initial IM, ballistic and environmental assessments have been carried out as described below.

IM results:
All propellant was assessed for IM in the Shape Charge jet attack test. The configuration was set up to mimic two bare stick bundles with the Shape Charge fired directly into them. Results were extremely promising with both **LOVA** formulations tested giving a **type V** response, see table 3 and witness plate pictures.

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**

Table 3 IM results for artillery LOVA propellants



Lower energy conventional propellant
Type III

Lower energy LOVA TPE propellant
Type V

Ballistic assessment results:
Lower energy **LOVA** propellants were assessed in a 105mm gun system using L36 charge super configuration at QinetiQ, Shoeburyness Range, UK. All propellants fired and functioned **successfully** giving comparable ballistic performance to the current convectional lower energy propellant. With one formulation giving **increased** performance.

Environmental assessment results:
Lower energy **LOVA** propellants have also been put through a short diurnal cycle of 107 hot cycles and 7 cold cycles to replicate a 10 year life. These then underwent ballistic assessment against the control (un-aged) variants. Results look promising with only a **small reduction** in performance (<1%) comparable to the lower energy conventional propellants.

In conclusion lower energy **LOVA** propellants for **artillery** applications are potential **suitable replacement** candidates for the current conventional propellants.

Lower energy conventional propellant

Lower energy LOVA TPE propellant

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