IMPROVED IM PROPERTIES OF AN RDX/TPE BASED LOVA PROPELLANT FOR ARTILLERY APPLICATIONS

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Overview

› Introduction
  › LOVA versus IM; IM requirements
    › LOVA characteristics (cook-off, flame temp, ignition, …)
  › Gun propellant developments TNO
› LOVA propellant improvement
  › Aim of the study
› Experimental
  › Manufacturing
  › Closed vessel test
  › LSP test
› Conclusions
Introduction

Why LOVA propellants?

- IM ammunition components: propellant, igniter/primer, case, charge configuration
- Propellant IM aspects: less sensitive, low energy/explosiveness, high ignition temperatures, high extinguishability (high alpha), low response to shock/fragment impact, good cook-off properties
- LOVA propellants: **cook-off OK, bullet/fragment impact?**
- LOVA propellants often applied in Naval ammunition

Ammo magazines below waterline: low risk of bullet/fragment impact
Introduction

What are LOVA propellants?

- Composite gun propellants (not NC-based)
- Energetic filler: RDX, FOX-7, FOX-12
- Non- or low energetic binder system: CAB, TPE, plasticizer, …
- Examples: XM39, M43, NL0XX / NL1XX / NL2XX
  \[ \rightarrow \text{good cook-off behaviour} \]
- Low flame temperature / good force
- Ignition difficulties
- Problems related to mechanical properties, especially at cold
  \[ \rightarrow \text{affect bullet/fragment impact sensitivity} \]

Source: MSIAC
Gun propellant developments TNO

- Solventless extrusion
  - LOVA propellants: early HTPB, CAB, TPE
  - Also NC-based propellants
- Safety and ballistic properties
  - Thermal safety: stability, ageing, ...
  - Ballistic stability/safety: burning behaviour, mechanical properties (bed) compression, 40mm/35mm gun simulator, gun firings
- IM properties
- Propellant ignition
  - New primer comp. for LOVA
  - Plasma primer development (fully IM, T-compensation, green)

[NDIA Joint Armaments Conference 2012, Seattle]
Investigated LOVA gun propellants

Propellants (IBK1000 family)

› Fillers:
  › ~ 75% RDX (bi-modal size distribution)
  › 0 – 10% additional compounds

› Binder systems:
  › CAB / NC / inert plasticizer
  › Non-energetic TPE systems

Thermodynamic properties

› HoE / Force: 4010 – 4050 kJ/kg / 1040 – 1060 kJ/kg
› $T_{\text{flame}}$: 2475 – 2530 K

Geometry

› 19-perf, D = 6.7 mm, web = 0.7 mm, L/D = 1.5
Improvement mechanical properties

Aims

› To improve mechanical properties at low temperature
› burning properties → prevent high vivacity due to brittleness at cold
› IM properties (extend suitability for land systems)
› To improve processing properties (solventless)

Bad burning properties of RDX/TPE based propellant at low temperature
Manufacturing

- Up to kg-scale production by mixing and ram extrusion
- RDX/CAB based compositions require too high pressures for solventless processing
- Improvement processing properties by variation of:
  - CAB type
  - Plasticizer content
  - Temperature
- TPE based compositions are relatively easy to manufacture (websizes for large calibre application)
Results

- **RDX/CAB based compositions**
  - Too high viscosity, even at $T > 90^\circ C$
  - Increasing viscosity at keeping the compositions at the high processing temperatures (not confirmed by measurements)
  - Extrudable compositions lack sufficient mechanical strength
  - RDX/CAB based propellant compositions: not solventless processable

- **TPE based compositions**
  - Good processability
  - Scale-up to 2 kg scale
Results

› TPE based compositions
  › Burning properties (closed vessel, charge density 0.2 – 0.25 g/cc)

![Graph showing burning properties](image)
Results

- IM properties: LSP test (Rheinmetall)

Actual 35mm LSP Test- Set-Up
Results

- IM properties: LSP test (Rheinmetall)
Results

- IM properties: LSP test (Rheinmetall)

IBK1037-1

reference (commercially available)
Conclusions

RDX/CAB based LOVA propellant
› No solution found that meets both production and performance requirements

RDX/TPE based LOVA propellant
› Good manufacturing and IM properties
› Improved mechanical properties due to lower glass transition point

Future research
› Improvement die design (smaller websizes for medium calibre)
› Increase burning rate
› RDX replacement
Acknowledgements

The authors are grateful to the Netherlands Ministry of Defence for funding this investigation.

LSP tests were executed by Rheinmetall Defence, Unterlüß, Germany.