
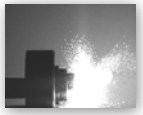

TNO innovation for life

VARIABLE PLASMA IGNITER OUTPUT FOR TEMPERATURE COMPENSATION OF AMMUNITION PERFORMANCE

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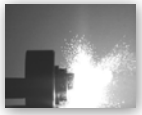

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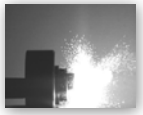
Overview

- Introduction
- Boundary conditions
- Temperature compensation
- Experimental
- Conclusions

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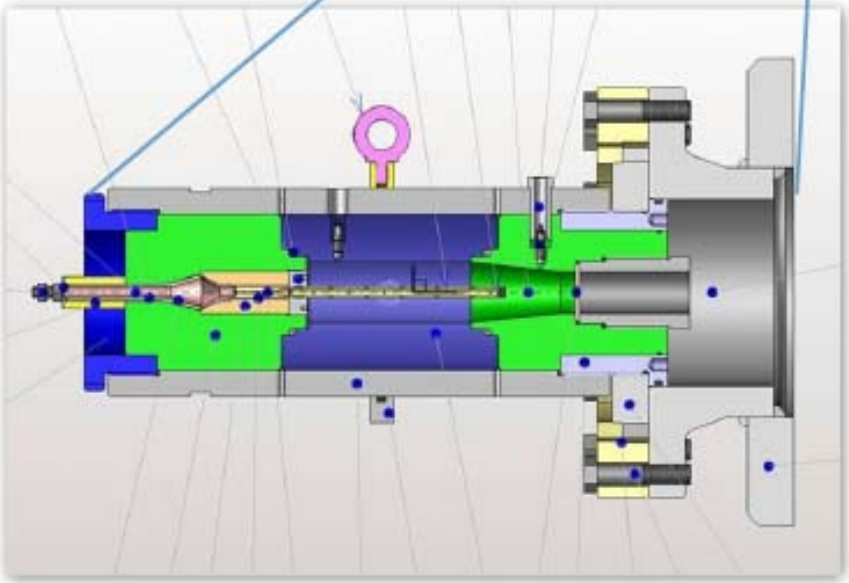
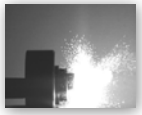
Introduction


- Previous work
  - Plasma ignition (exploding wire, external igniter)
  - Experimental facilities: closed bomb, gun simulator

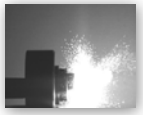


TNO innovation for life


Introduction

- Previous work
  - Plasma ignition (exploding wire, external igniter)
  - Experimental facilities: closed bomb, gun simulator
- Project aims current project
  - To enable a practical design of a plasma igniter and the integration inside the cartridge (medium caliber)
  - To support the potential for better ignition (reduced spread, good ignition of LOVA) for that design
  - To prove the potential for compensation of temperature dependencies
  - To achieve an energy consumption <10 kJ per shot

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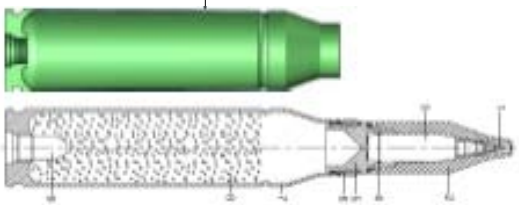
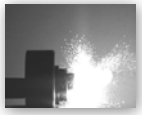
Boundary conditions

- Focus on 35mm Bushmaster III
- Reference ammunition: TP, FAPDS, etc.
  - DM144 igniter
  - Dimensions chamber volume, igniter, etc.
  - Equal or better performance
  - Temperature independent
- Integration in cartridge

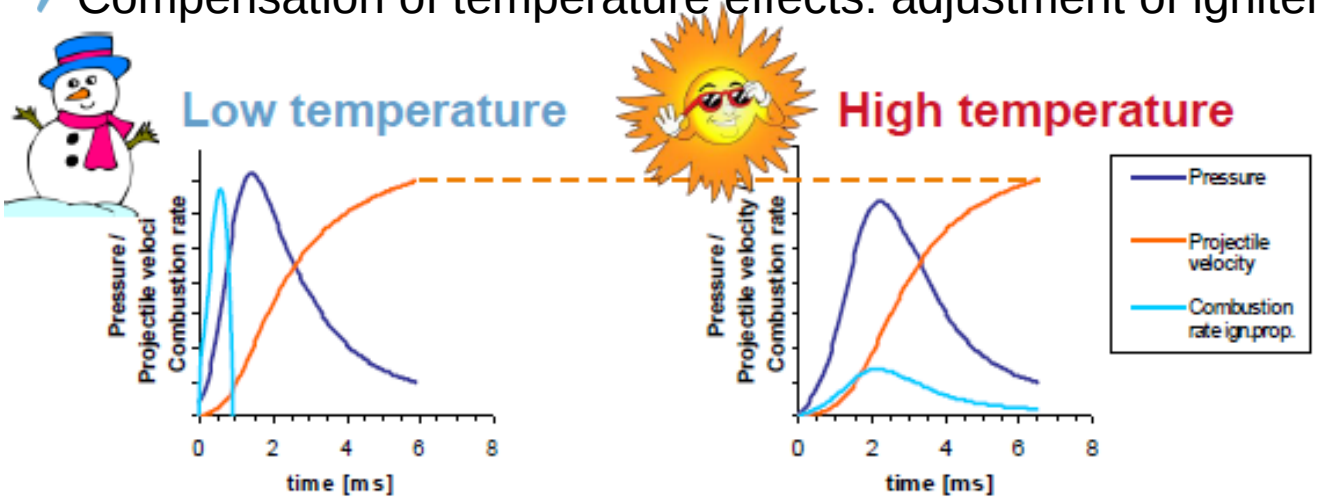


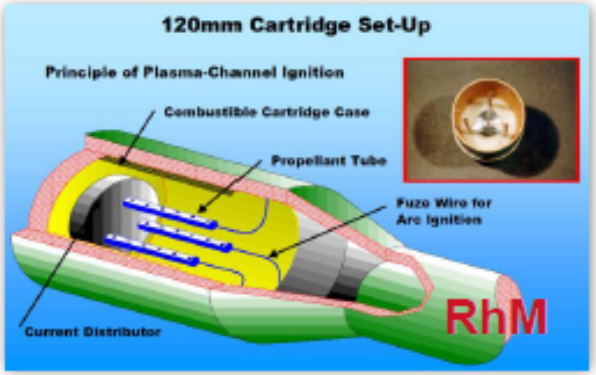



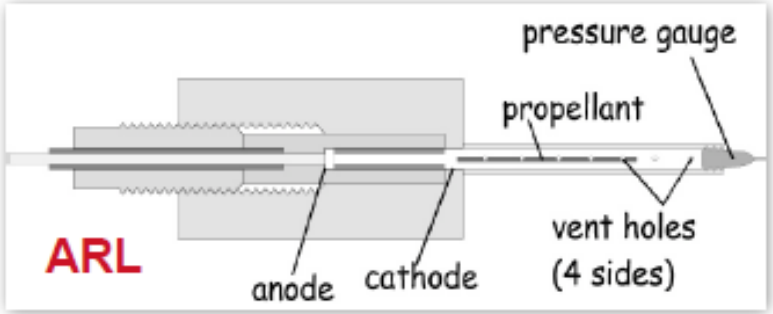
Igniter concepts

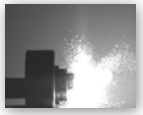
Temperature compensation by plasma ignition

- Compensation of temperature effects: adjustment of igniter output









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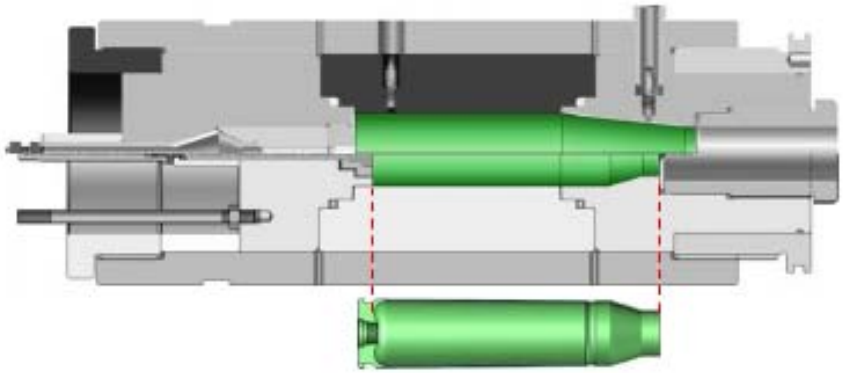
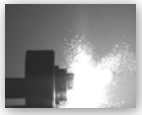
Experiments



- Gun simulator



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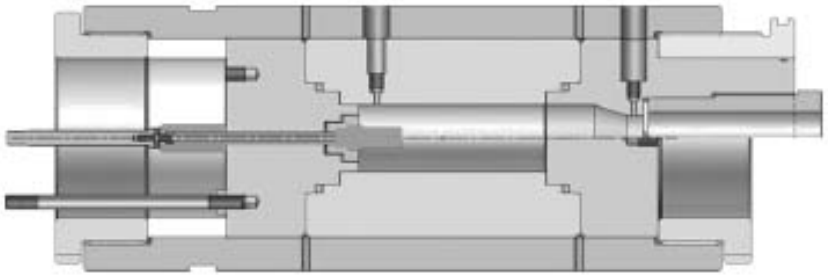
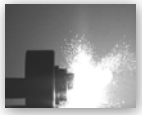
Experiments



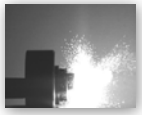
- Gun simulator vs. closed bomb

Experiments

Propellants

- **B6320**
  - NC-Camphor-based
  - Single perforated
  - Manufacturer: NCW
  - Applied as a series propellant in 35mm x 228 DM31
- **NL008**
  - RDX-CAB-NC-based
  - 19-perforated
  - Manufacturer: Eurenco
  - Applied in plasma ignition studies QinetiQ



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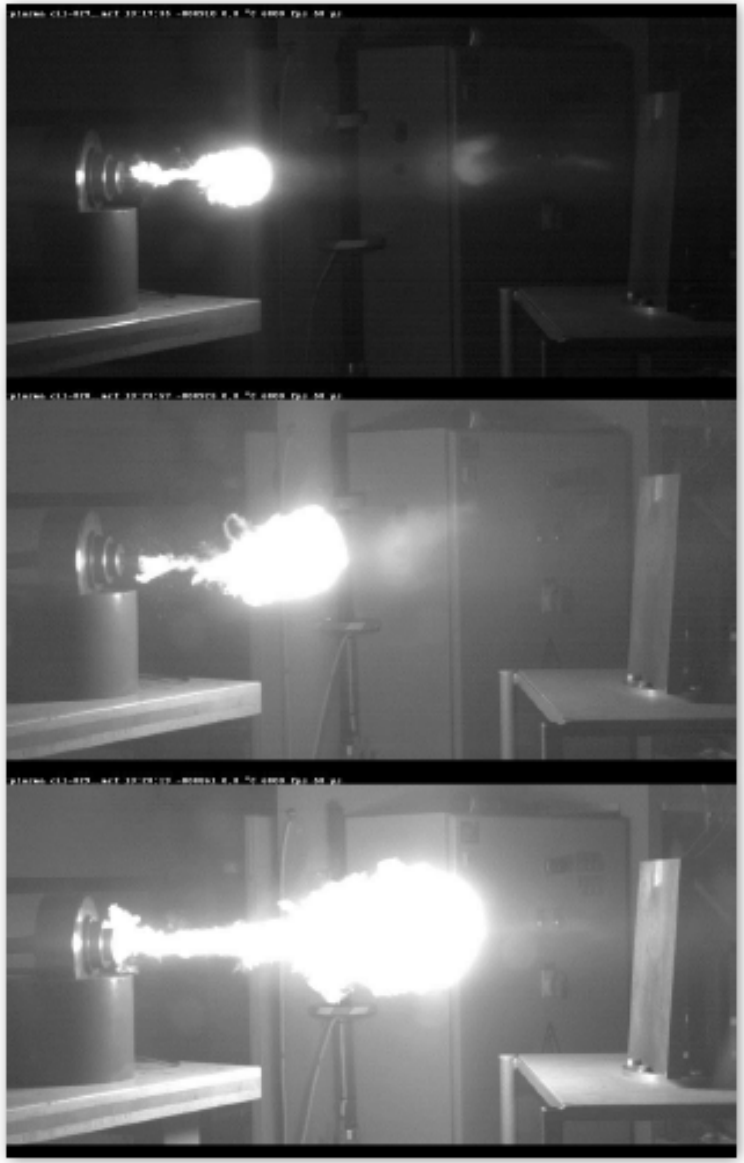
Experiments

Atmospheric tests

1 kV 733 µH

2 kV 733 µH

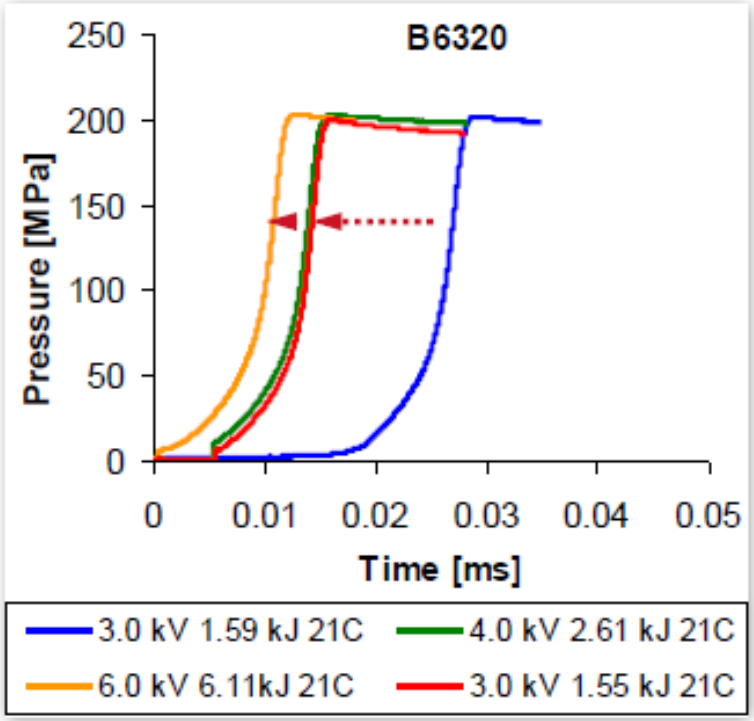
4 kV 733 µH

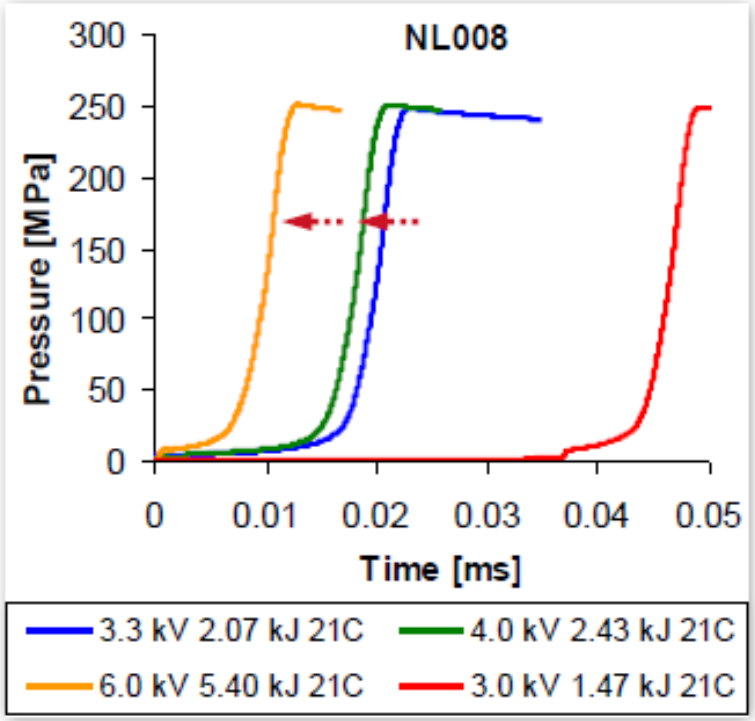


Experiments

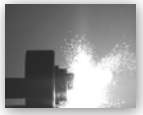
Closed bomb – plasma ignition

- Loading density 0.2 g/cc





- Ignition delay time decreases with increasing electric energy

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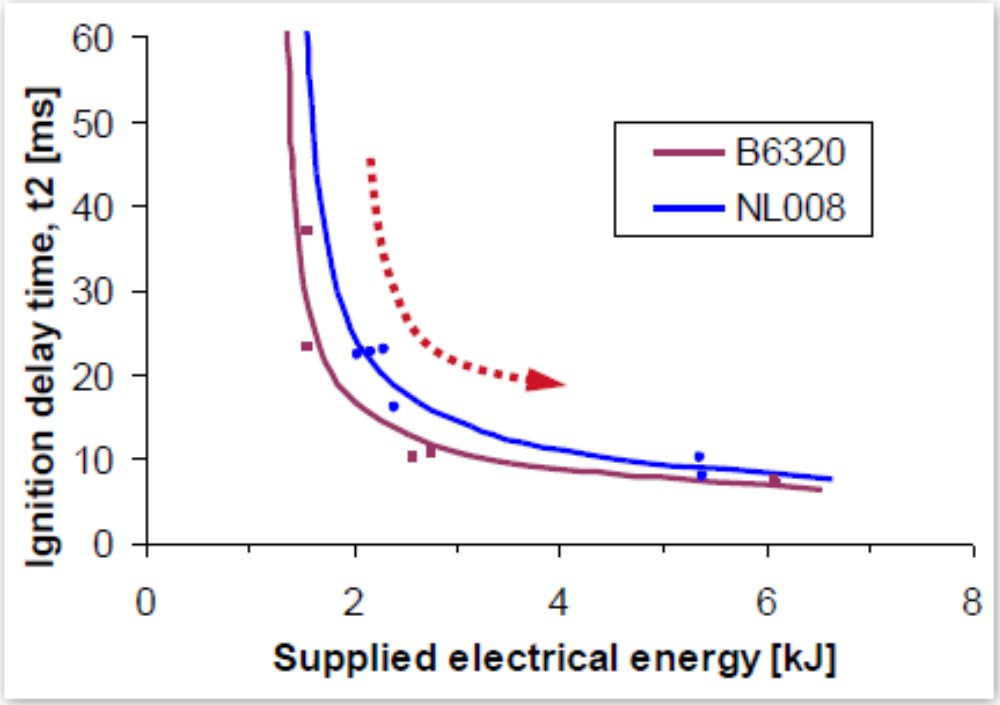
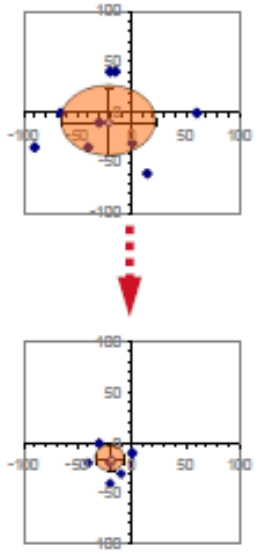
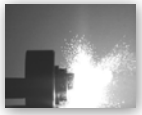
Experiments

Closed bomb – plasma ignition





- Ignition delay time decreases with increasing electric energy
- High reproducibility → improved hit accuracy



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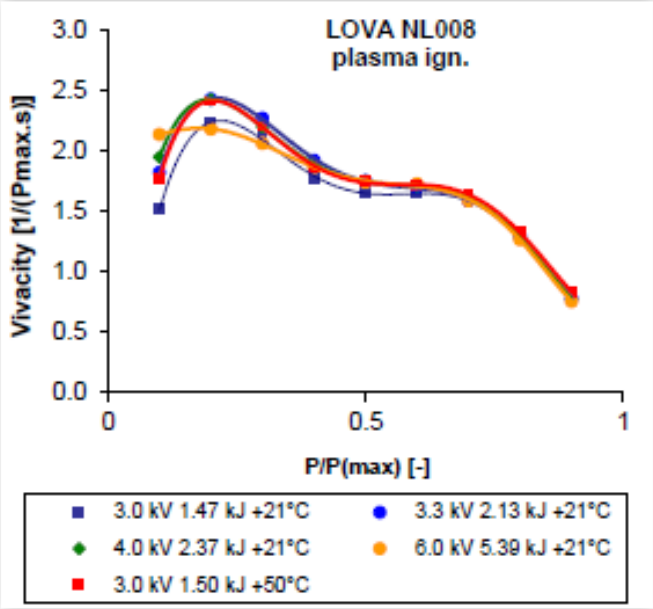
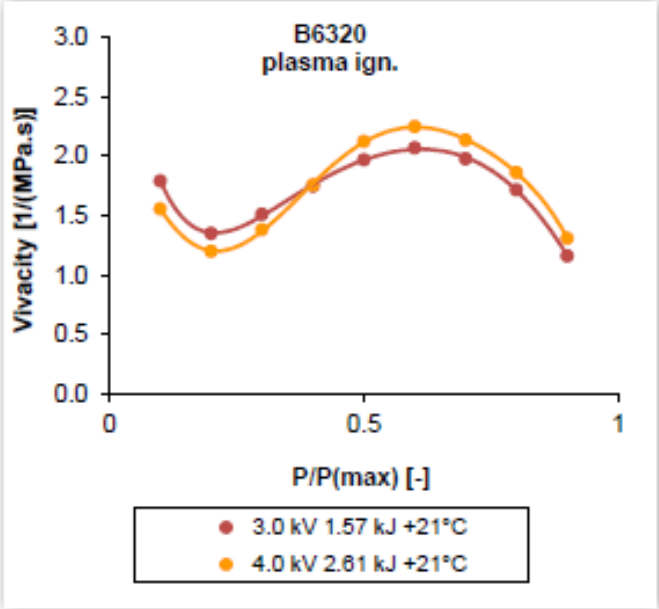
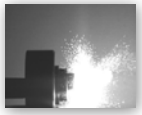
Experiments

Closed bomb – plasma ignition

- Conventional propellant: temperature independent behaviour achievable by variation of electrical energy
- LOVA propellant shows elevated vivacity at low pressures
  - No linear burning rate for LOVA propellant



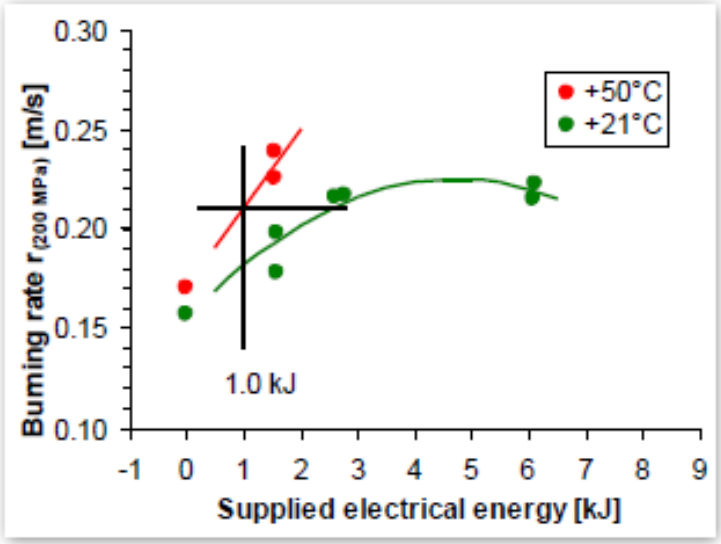


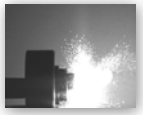



Experiments

Closed bomb – plasma ignition

- Conventional propellant: temperature independent behaviour achievable by variation of electrical energy
  - $r_{(200\ MPa)}$ from closed bomb tests
  - 0 kJ from conventional ignition
- Combustion rate is adjustable
  - Burning rate at 50 C achievable at 21 C supplying electrical energy up to 5 kJ



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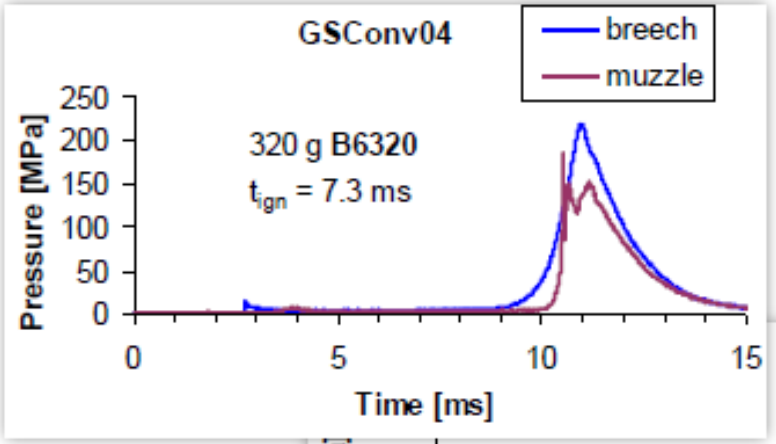
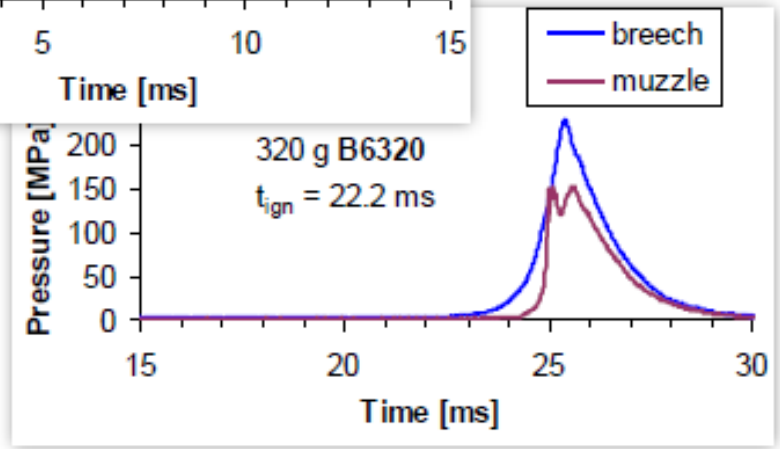
Experiments

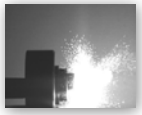
Gun simulator – conventional ignition

- Reference behaviour of conventional DM144 igniter
- Loading density 0.8 g/cc





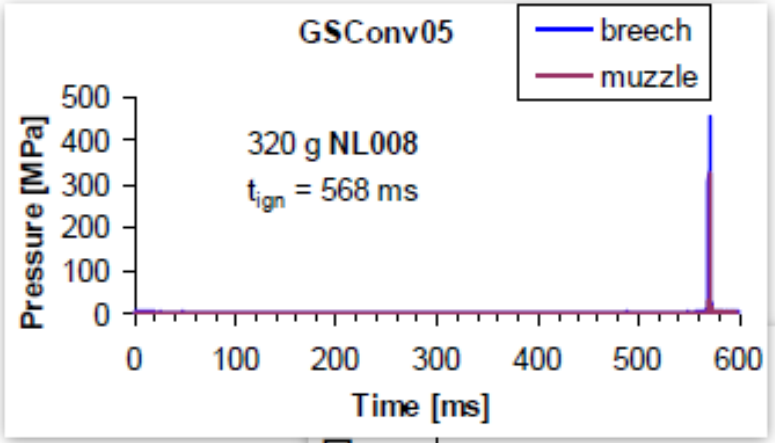
- Reproducible
- Variation ignition delay

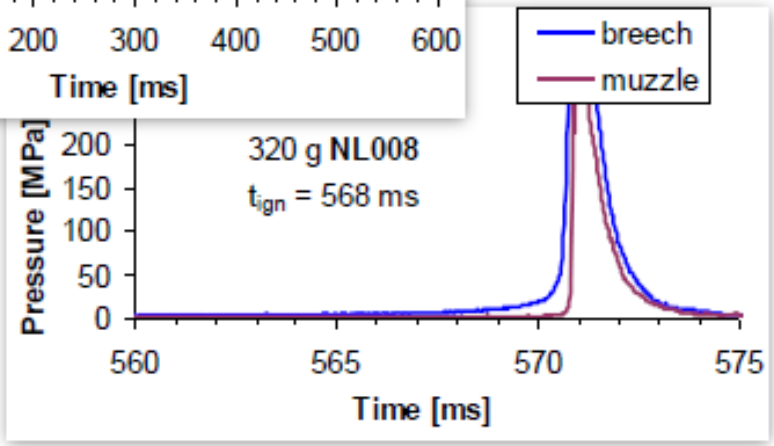
Experiments

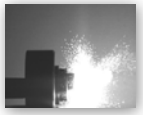
Gun simulator – conventional ignition

- Reference behaviour of conventional DM144 igniter
- Loading density 0.8 g/cc
- Single test



- Extremely long ignition delay
- NL008 not compatible with DM144





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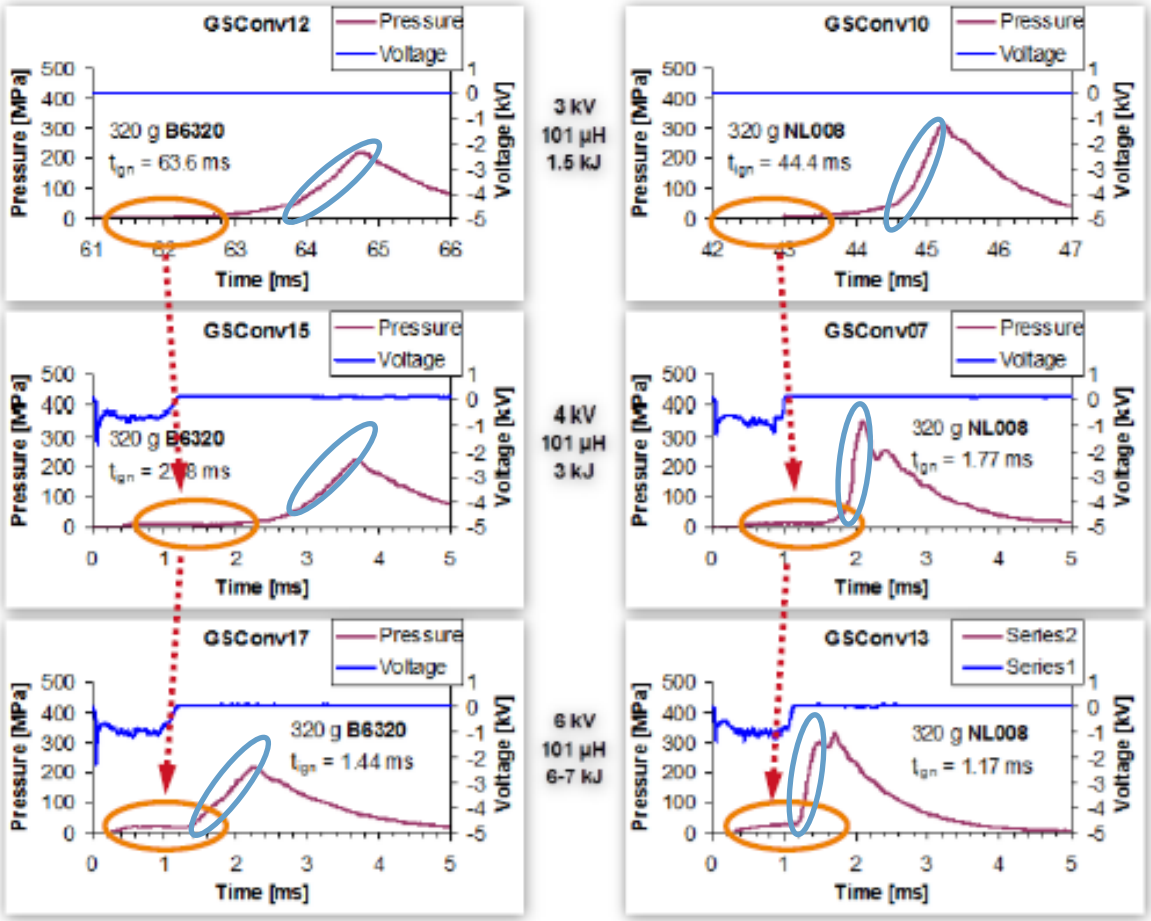
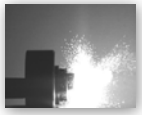
Experiments

Plasma ignition – gun simulator

- Depending on electrical energy:
  - Initial pressure
  - Rate of pressure rise after ignition



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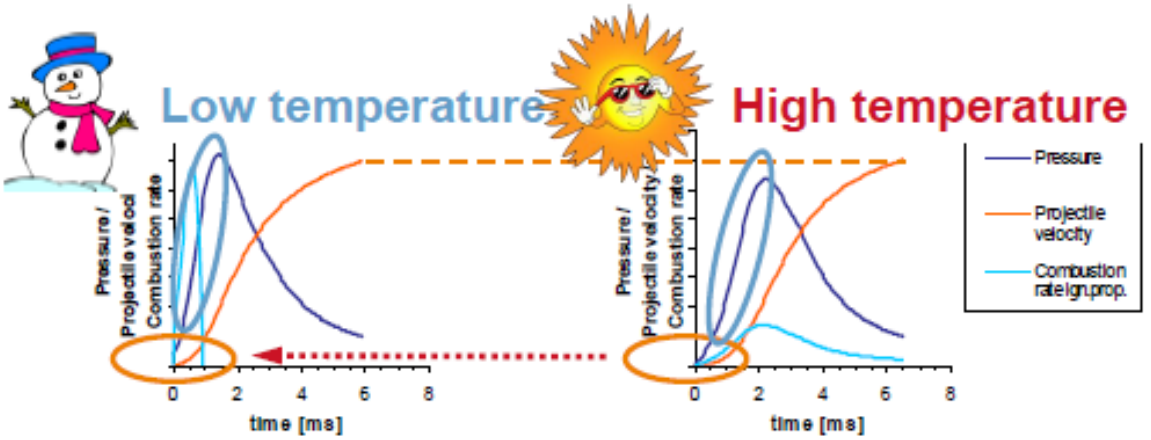
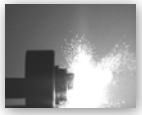
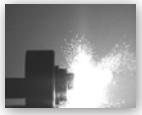


Conclusions

- Practical design
  - Integrated in cartridge base
  - Simple design, robust, cheap
  - Volume < 1/10 DM144 igniter
- Performance for LOVA and conventional propellant
  - Ignition delay reduced to < 5 ms
  - Variation delay < 0.2 ms
  - Ignition behaviour sensitive to variation of electrical energy input
  - Energy use < 4 kJ
  - Variation of electrical energy input (2 – 4 kJ) gives temperature neutral behaviour

Acknowledgements

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