Ageing Effects on Performance of Small and Medium Calibre Ammunition

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Introduction

- Ammunition in Out of Area operations: accelerated ageing due to external forces
  - Vibrations
  - Pressure
  - Temperature
  - Shock
  - Etc.

- Aim: qualitative insight in performance change

- Focus: ageing of propellant due to high temperature stress

Investigated ammunition

.50 BALL
- Total height: 138.5 mm
- Total weight: 110 gram
- Powder: 15 gram
- Muzzle velocity: 890 m/s

25mm APDS-T
- Total height: 223 mm
- Total weight: 454 gram
- Powder: 100 gram
- Muzzle velocity: 1345 m/s

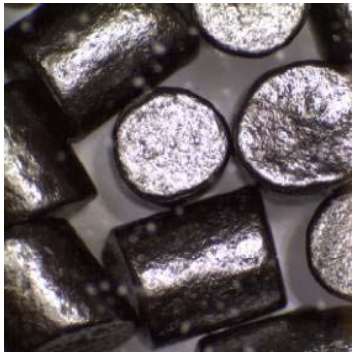
Artificial ageing

- Propellant removed from cartridges

- Ageing of propellant only
  - 4 weeks @ 71ºC *)
  - 8 weeks @ 71ºC

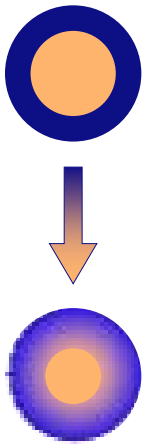
  *) MIL-STD-331A Test 112.1
  'Extreme Temperature Storage'

  → relatively short in comparison to expeditionary activities



Change of propellant characteristics

- Chemical: usual changes like stabiliser depletion
- Thermal: usual patterns
  (Heat Flow Calorimetry, HFC)
- Decrease calorific value negligible
- Ballistics: theoretically expected:



migration deterrent:

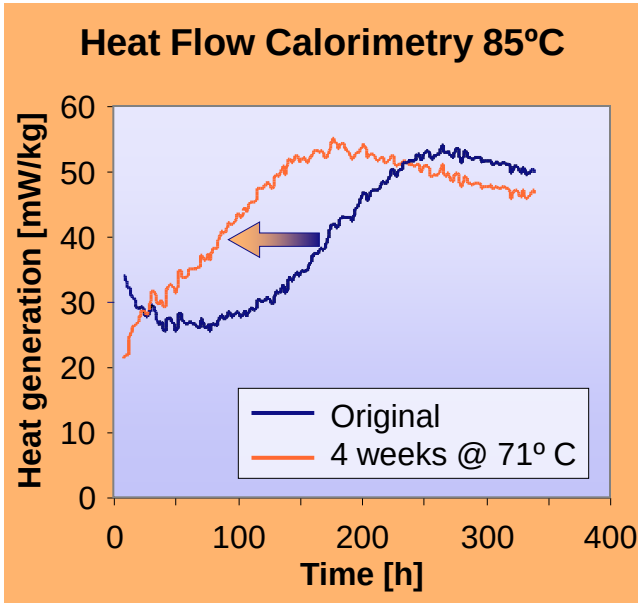
→ Propellant becomes faster

→ Ignition time decreases

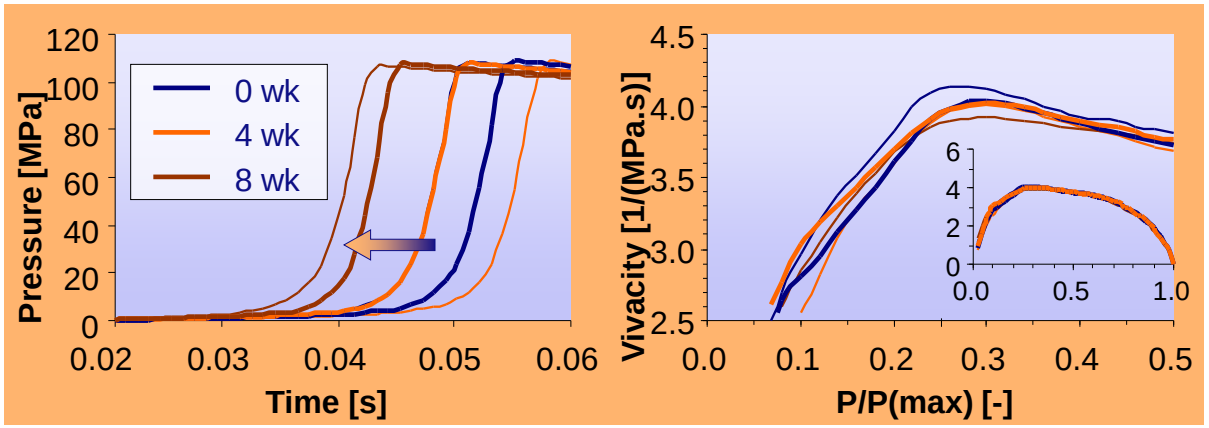
→ Pressure in weapon increases

→ Projectile velocity increases

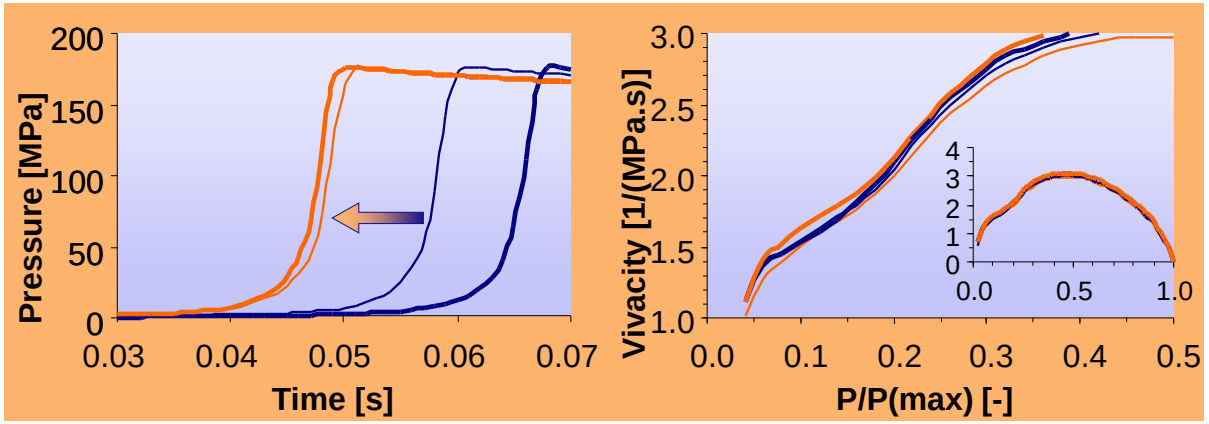
→ Propellant becomes more erosive



Ballistics: closed bomb tests



deterrent: DBP



deterrent: camphor

Ballistics: closed bomb tests

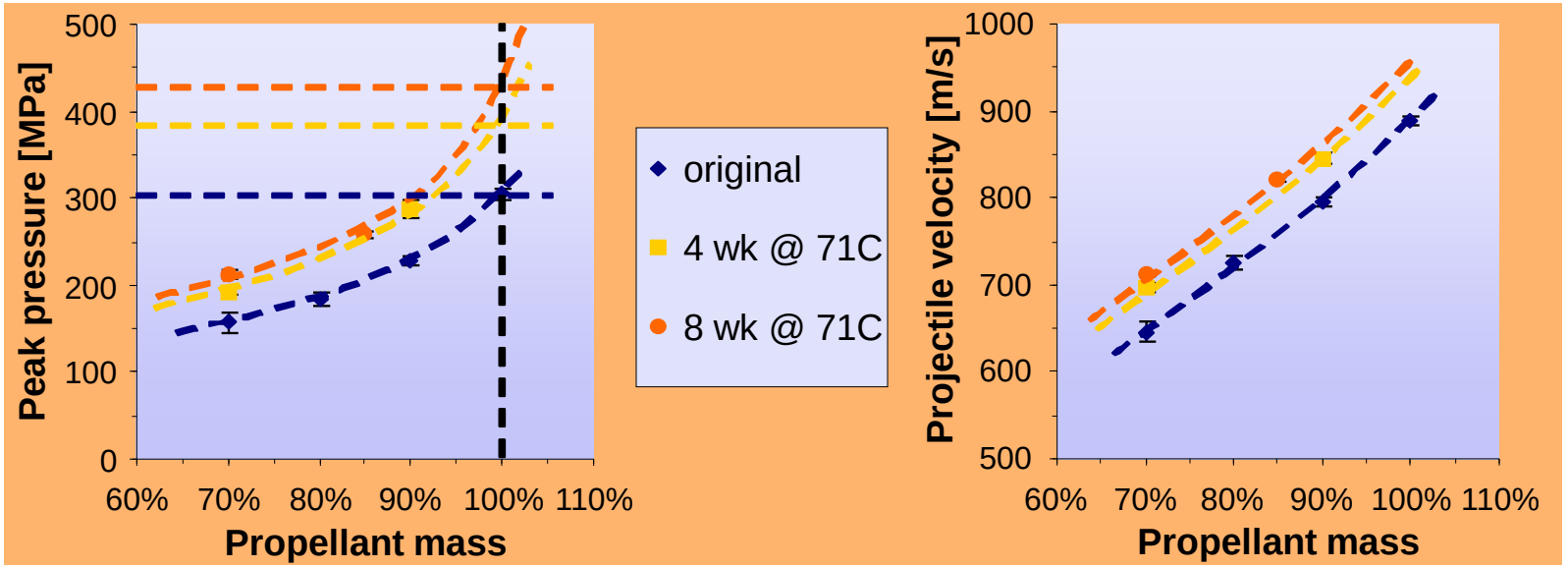
Both .50 and 25mm:

- Slight reduction of maximum pressure (reduction of energy content due to ageing)
- No change of vivacity
- Significant reduction of ignition delay

Firing tests .50

- Tests: variation propellant mass (safety reasons)
- Ambient temperature

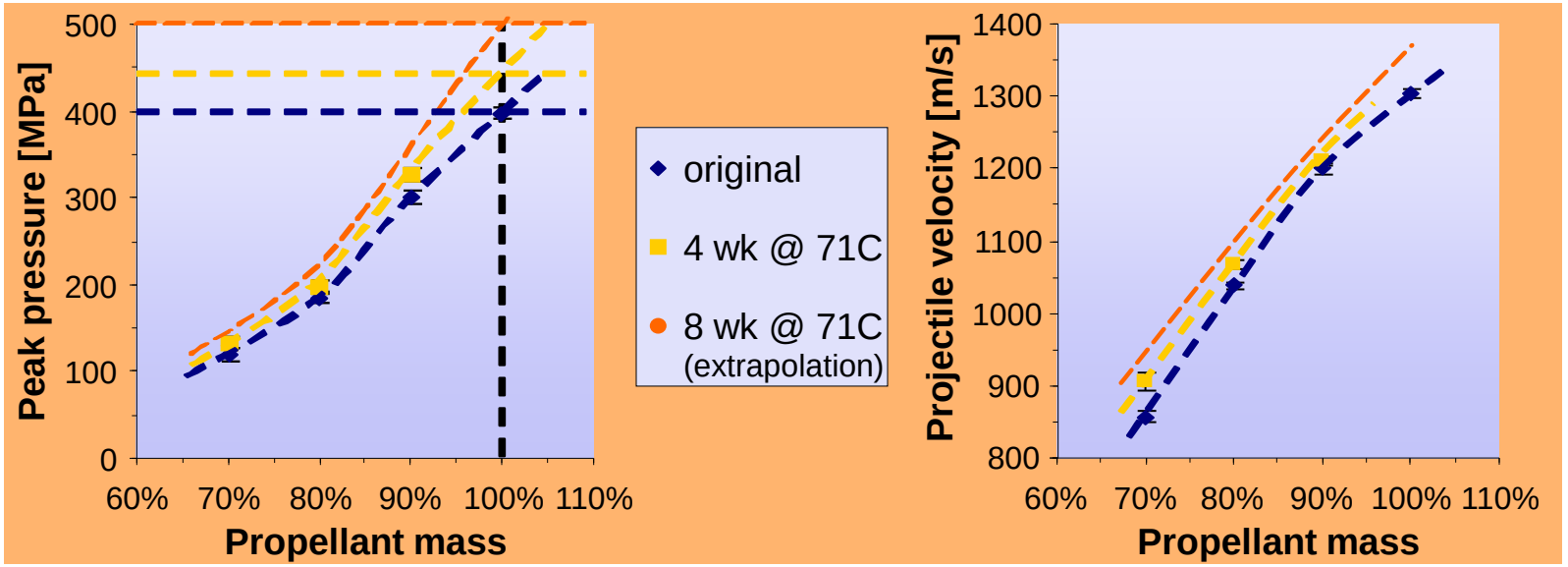
→ Significant increase of gas pressure after propellant ageing



Firing tests 25mm (1)

- Tests: variation propellant mass (safety reasons)
- Ambient temperature

→ Significant increase of gas pressure after propellant ageing



Firing tests 25mm (2)

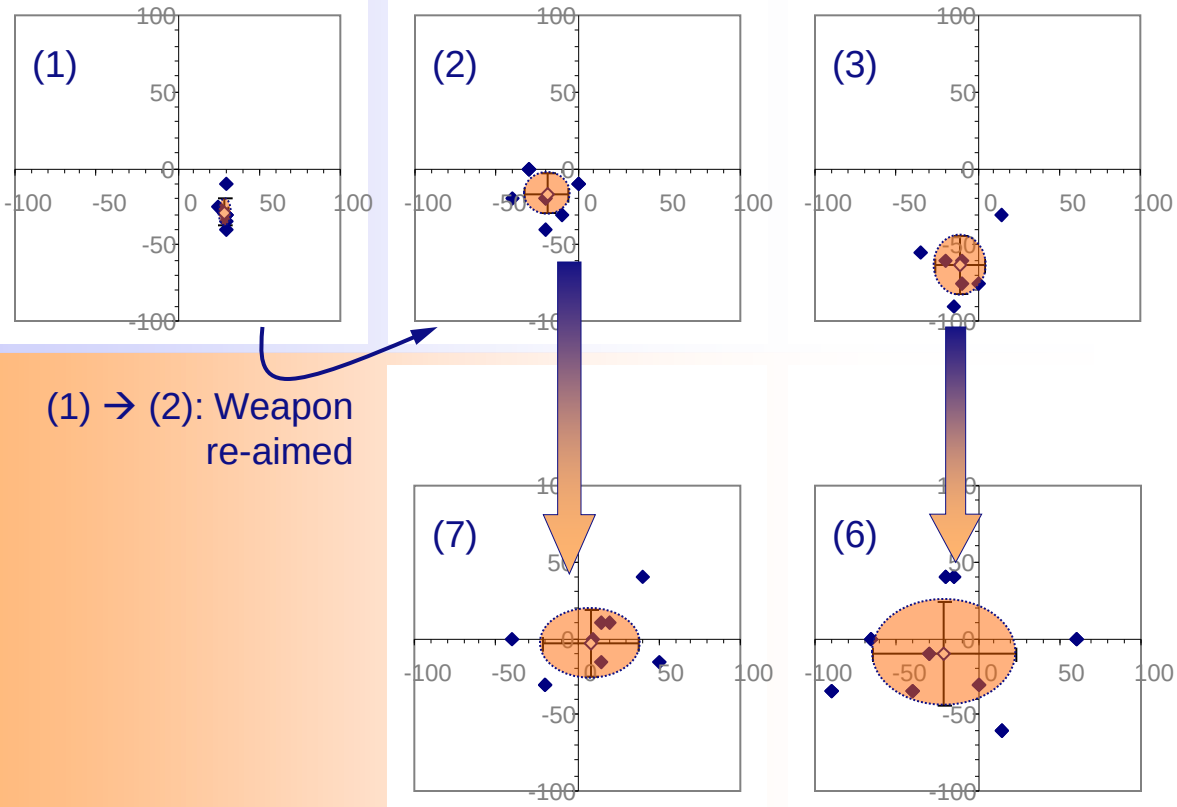
original

aged
(4 wk 71°C)

100% charge mass

90% charge mass

80% charge mass



(1) → (2): Weapon re-aimed

: 95% reliability

(1) – (7): firing sequence

No measurement of:
(4): 70% original prop.
(5): 70% aged prop.

Barrel erosion

- Not investigated in here, but known to occur:
  Barrel erosion more severe with aged ammunition
  - → higher pressures
  - → higher flame temperature (?) after prolonged ageing (migration deterrent)

- Result: further decrease of hit accuracy
  (added to observed effect of ageing)

- Possible effects on projectile orientation

Discussion

- Changes in peak pressure and projectile velocity though:
- No change in energy content and vivacities

→ Performance changes related to decrease of ignition delays: faster ignition affects flame spreading process resulting in higher pressures

- Decreased ignition delays impose …
  - irregularities of the flame spreading process, causing …
  - less defined engraving of projectile, causing …
  - increased radial projectile movement during translation in the barrel, resulting in …

    → decreased hit accuracy

Conclusion

Ageing of ammunition (4 / 8 weeks @ 71ºC) results in:

- Significant increase of peak pressures → **safe use**
- Possibly increase of barrel erosion
- Decrease of hit accuracty due to ageing + barrel erosion → **performance**
- Possibly: change of projectile orientation

Recommendations

- Substantiate observations by using a larger test set-up for better statistics

- Investigate effects on
  - barrel erosion
  - projectile orientation

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Pictures: www.defensie.nl; TNO

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