Simulation and Low velocity impact testing on confined explosives

TNO | Kennis voor zaken

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Ammunition Safety

Low velocity impact testing

Overview

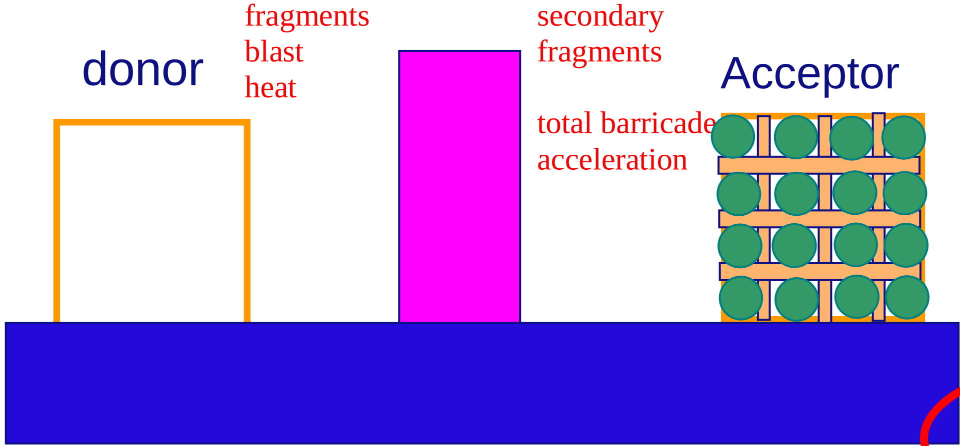
- Introduction
- Test set-up and first test series with PBX-N109 (lightly confined)
- Autodyn simulations
- Test series with N109, Comp B and RDX/was/graphite (95/4.5/0.5)
- Summary

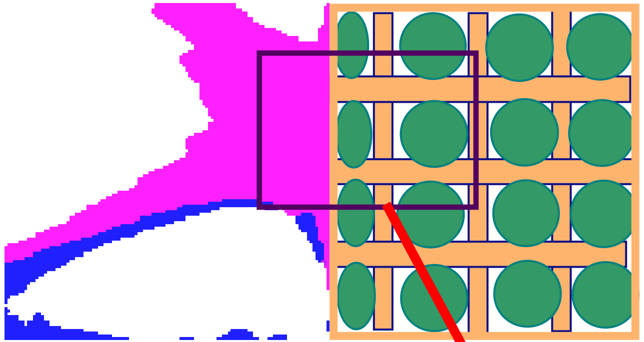
Introduction

- Modern Militairy operations put high requirements on Munitions
  - IM requirements (comparable performance),
  - Better performance (e.g. extended range munitions),
  - decreased barrel erosion, temperature independent performance,
  - Multi-mode or scalable functionality for MOUT intervention
  - reliable (# UXO’s) and have a long lifetime

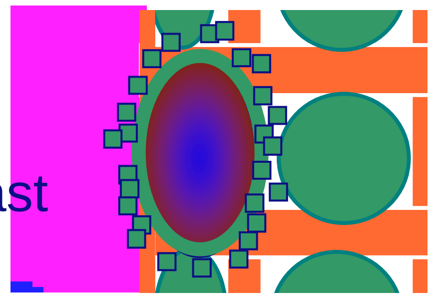
- Safety is still one of the most important requirements

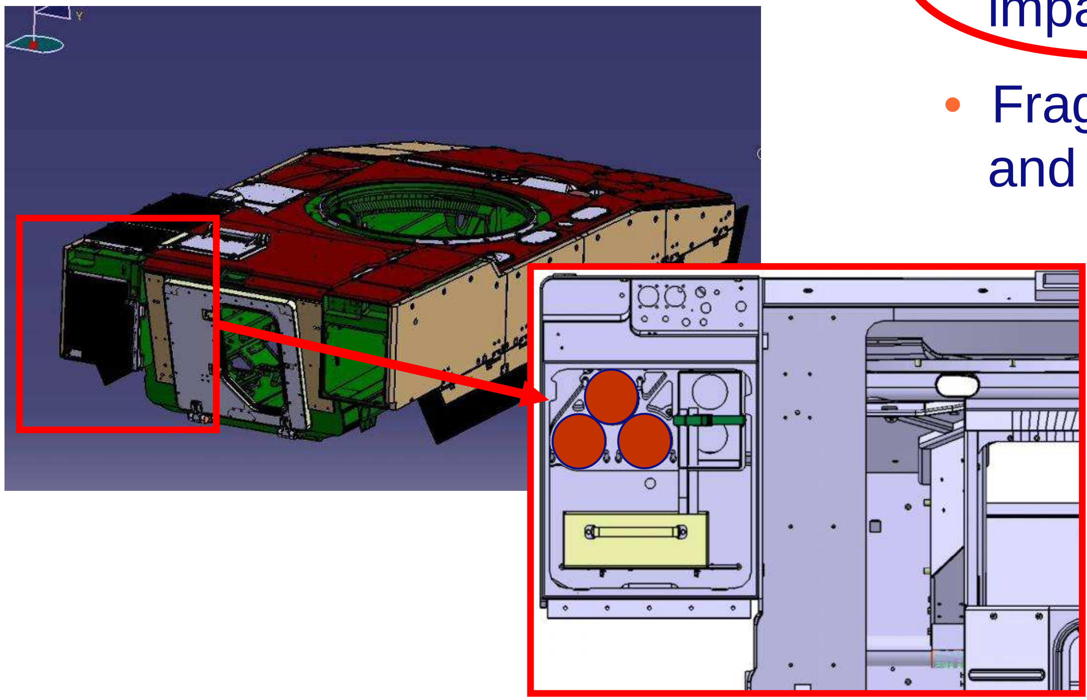
Safety of munitions - Threats (IM)





- Low-velocity impact
- Fragments and Pressure/blast

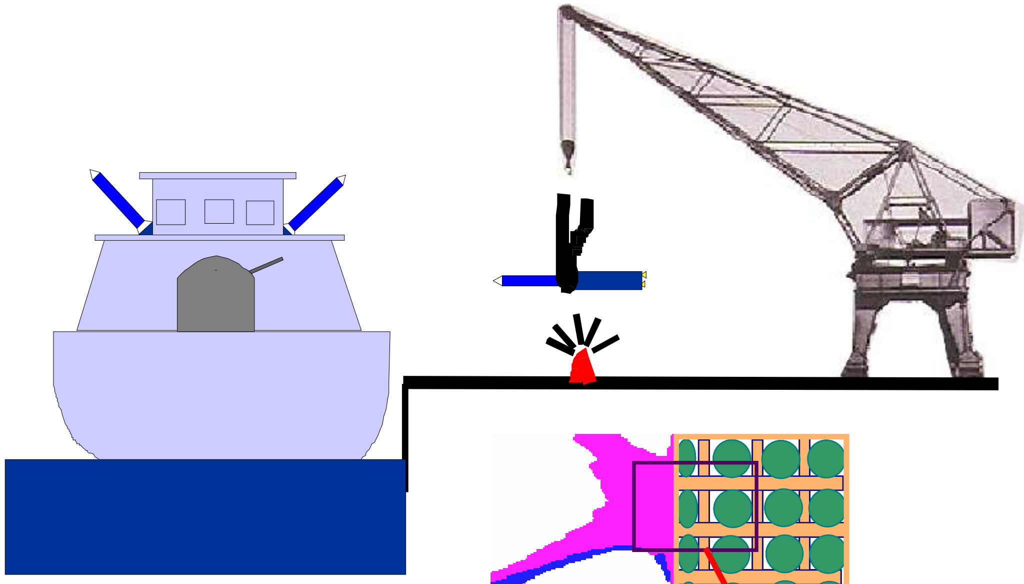




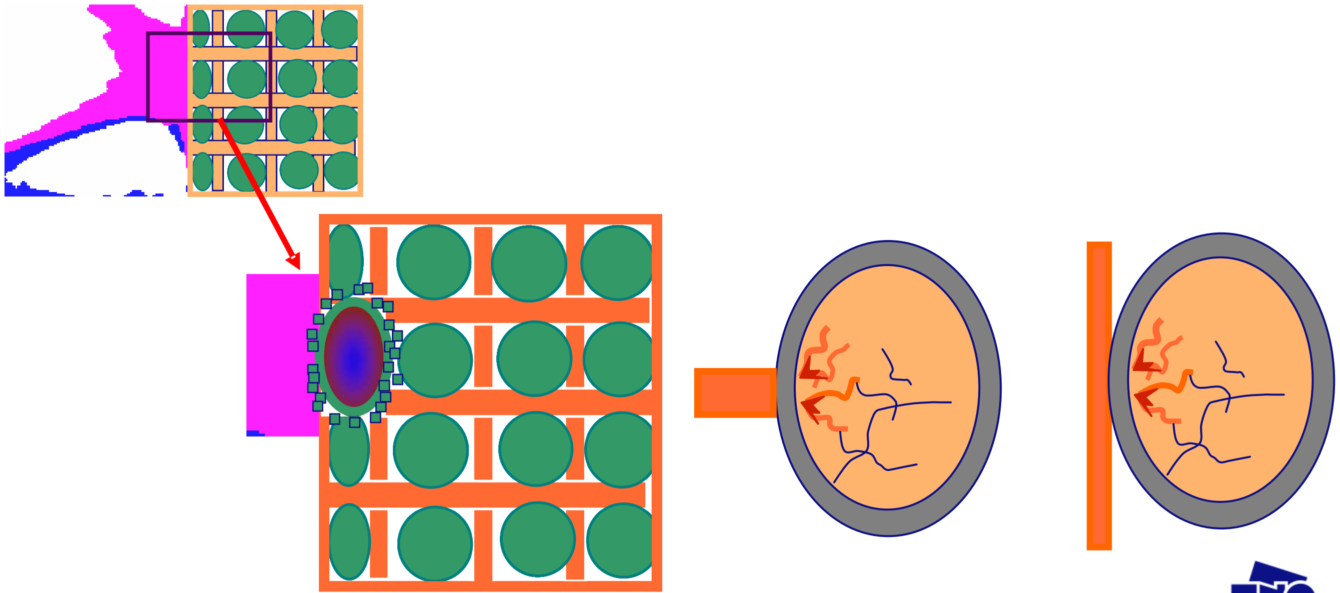
Also other threats:

- Cook-off
- Bullet impact
- SC Jet impact .
- Sympathetic reaction

Low velocity impact



Can lead to severe reactions

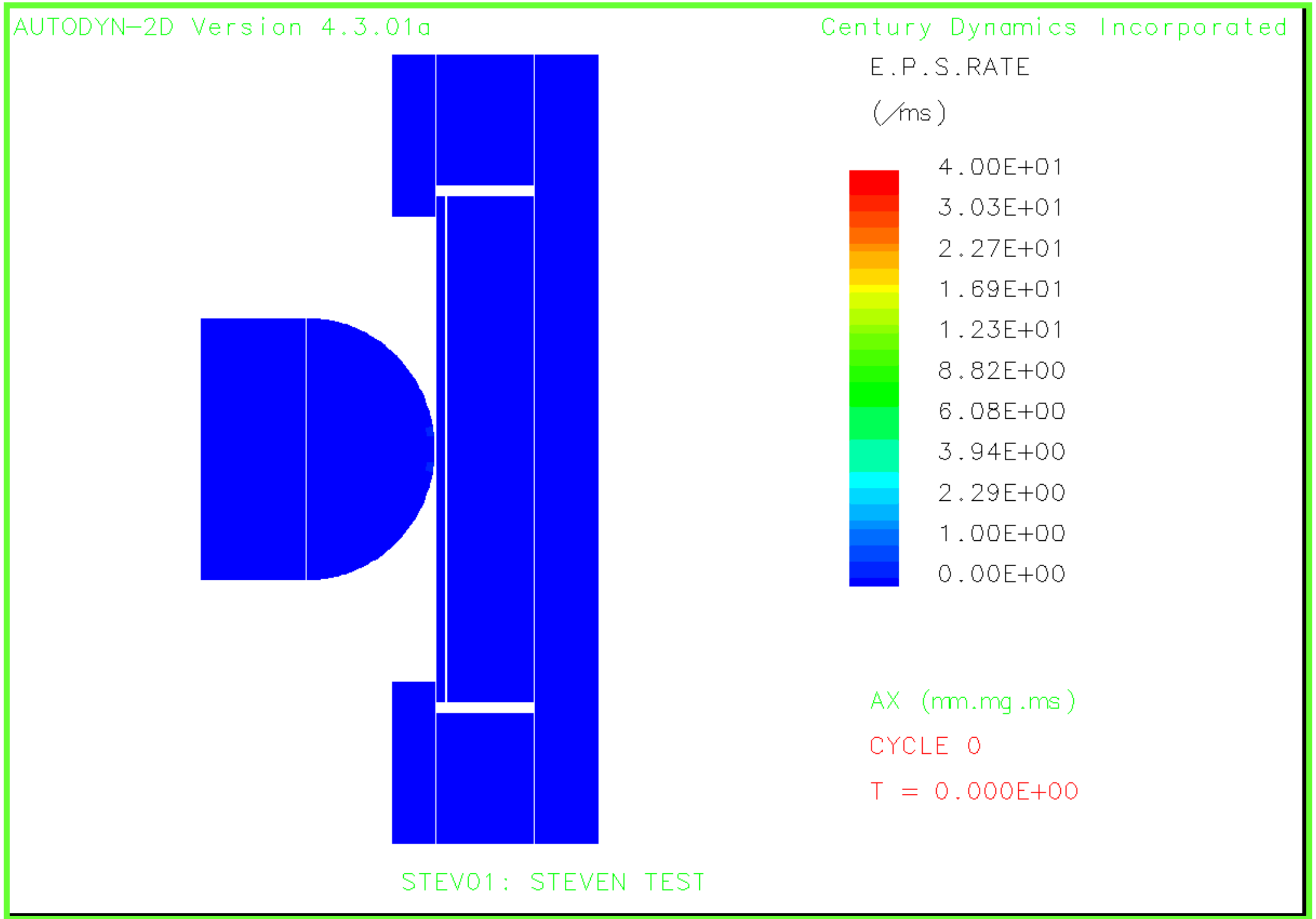


Influence of shear stress on the initiation; Low velocity impact test simulations

- Ballistic Impact Chamber (BIC)
- Friability (Gas gun experiment)
- Steven impact test
- Spigot intrusion
- Explosive deforming (aimable warhead)

- Relatively low velocities (no Shock initiation) but violent reactions; Why?

Mechanical damage: Simulation of Steven Impact test
Locations of stress



Summary of shear rate calculation i.c.t. BIC test results

- Friability (no reaction) : $4.4\ 10^4$ $\mathbf{s^{-1}}$
- Steven test 50-100 m/s (reaction at ~75 m/s) : $5\ 10^5$ $\mathbf{s^{-1}}$, **1**.8 10^5 $\mathbf{s^{-1}}$
- LANL impact test 196 m/s (reaction) : $1.6\ 10^6$ $\mathbf{s^{-1}}$
- Explosive deformation:
  with 5 mm explosive (reaction) : $1.51\ 10^5$ $\mathbf{s^{-1}}$
  with 4 mm explosive (no reaction, boundary) : $1.19\ 10^5$ $\mathbf{s^{-1}}$
  with 3 mm explosive (no reaction) : $7.2\ 10^4$ $\mathbf{s^{-1}}$
- BIC test results USA (reaction) :~$1.4\ 10^5$ $\mathbf{s^{-1}}$

TNO Steven impact test

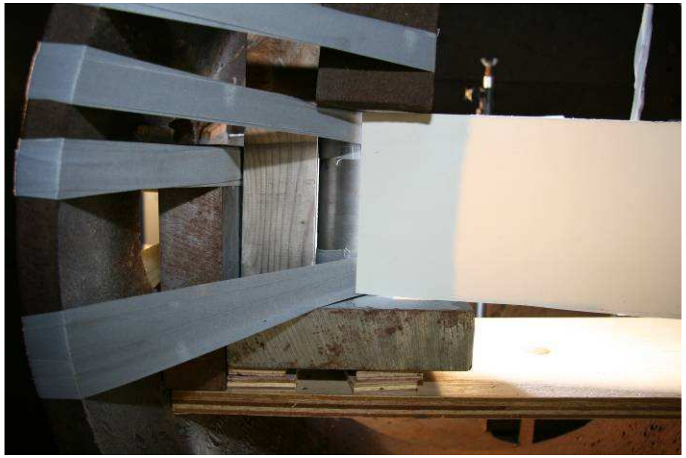
Test set-up with
60 mm gun

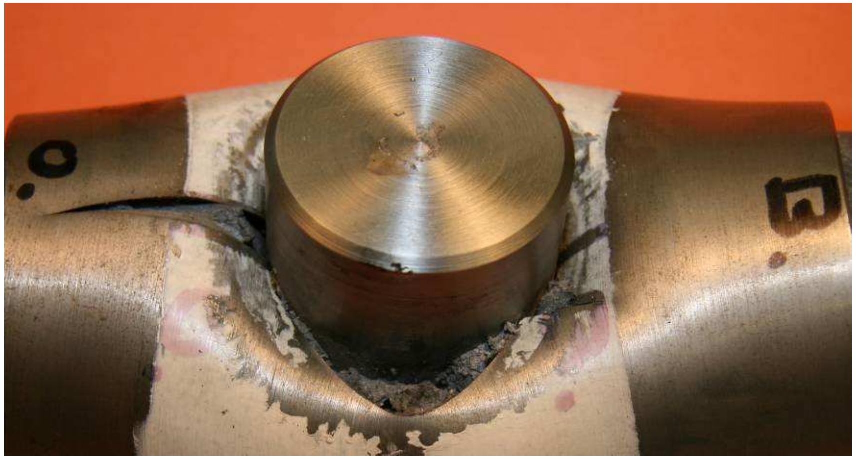
60 mm sabot and
48 mm projectile
(1.2 kg)

Confined
explosive

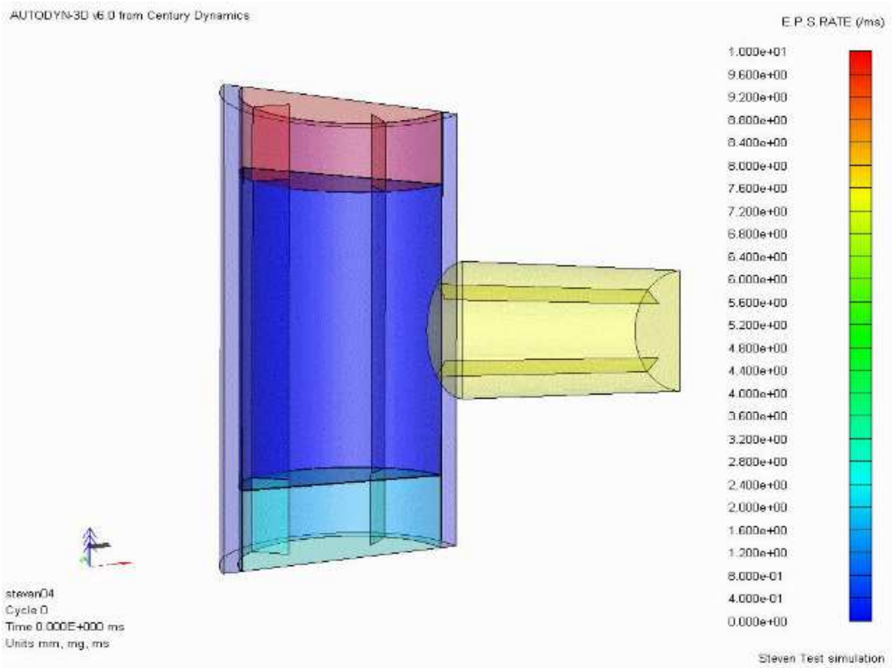
Partly confined PBXN-109, 195 m/s, sphere: no reaction

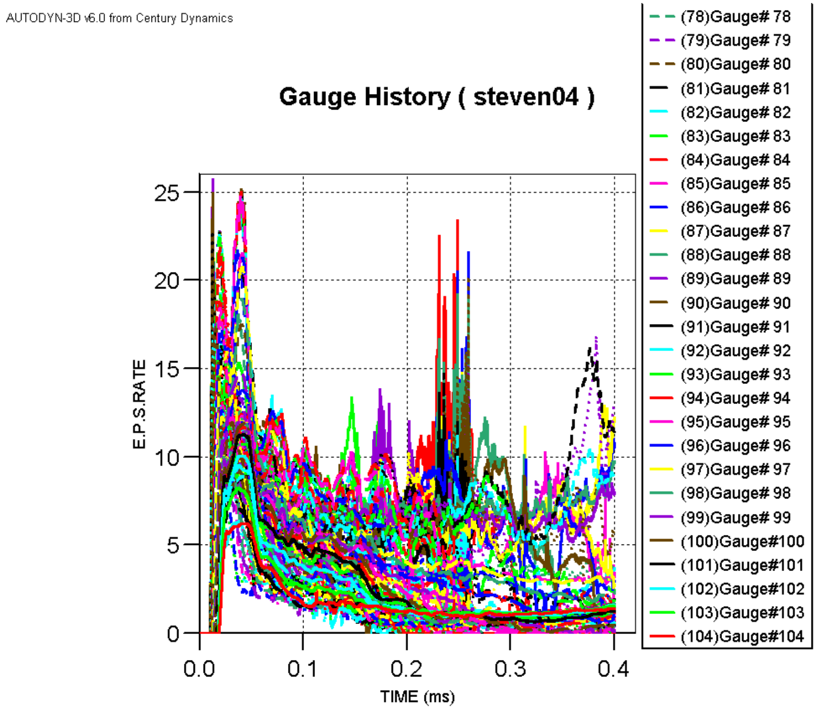
Experiments with PBXN-109, 201 m/s, Flat : no reaction



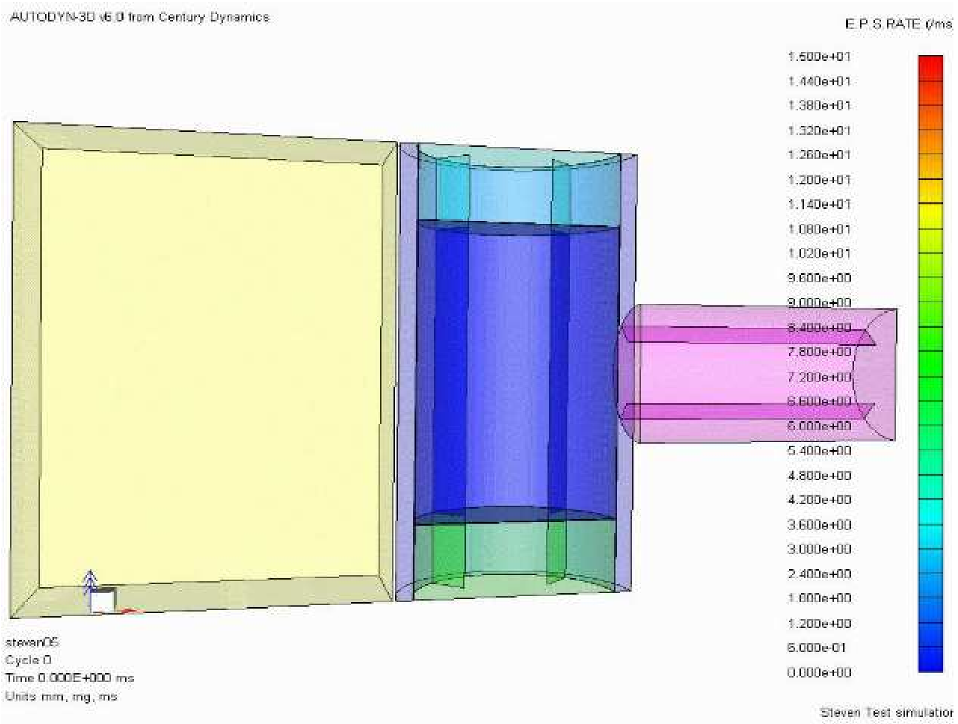


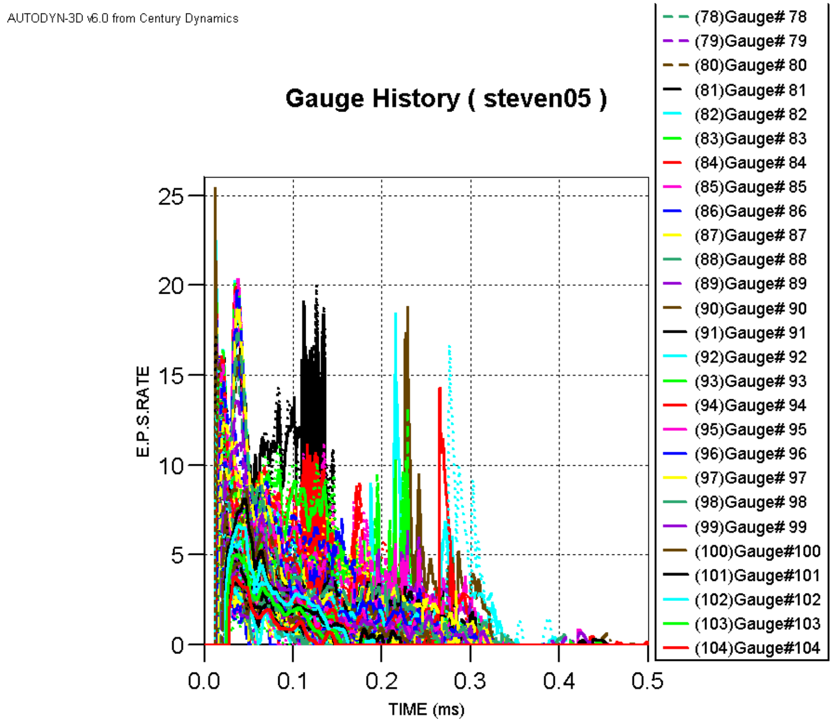
Simulation Flat nose, sphere, 205m/s in PBXN-109 low yield strength



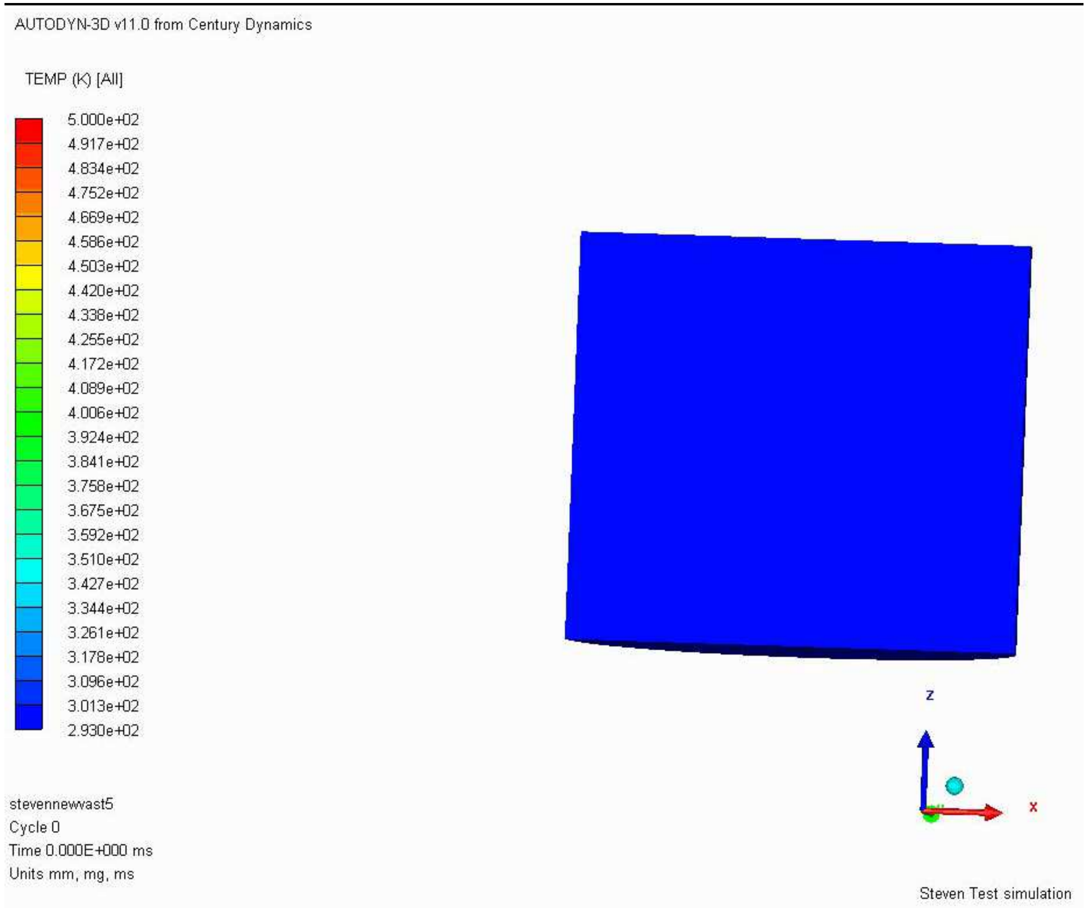


Simulation Flat nose, sphere, 205m/s in PBXN-109 high yield strength





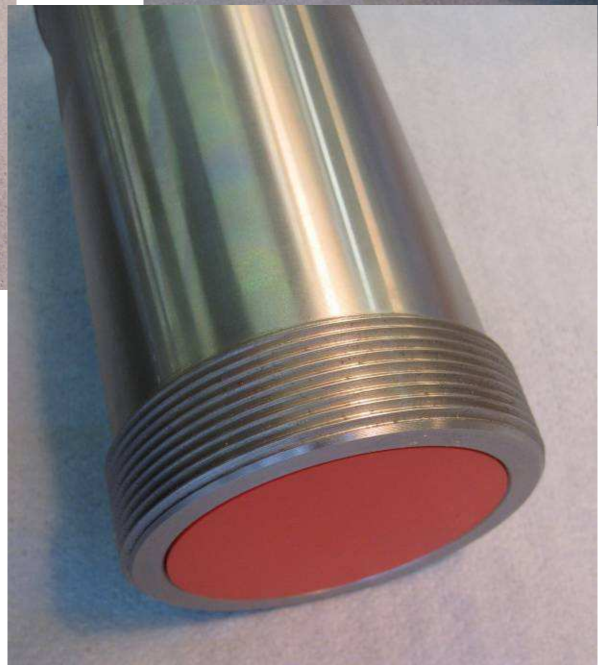
Simulation Flat nose, sphere, 200 m/s in PBXN-109; strain hardening, closed tube: Temperature



New series of experiments

- New test vehicle; confined with steel end-caps
- Improved gun (more reproducible velocity)
- Experiments with projectile with flat nose
  - PBX-N109: no reaction due to binder (no direct contact of crystals, small burning surface)
  - Hexocire (RDX/wax/graphite, 95wt% RDX): reaction due to easy initiation and propagation
  - Comp B? What about melting of TNT?

New test vehicle (hexocire; 95wt% RDX, wax, graphite)



Stevin impact: Hexocire flat impact 164 m/s

Stevin impact: Hexocire flat impact 84 m/s

Stevin impact: Hexocire flat impact 101 m/s

Summary Hexocire

J2734	081215a	Hexocire	164,29	Severe reaction
J2735	081217a	Hexocire	114,29	wrong shot
J2736	081218a	Hexocire	104,24	Severe reaction
J2737	081219a	Hexocire	77,10	no reaction
J2738	081222a	Hexocire	83,85	no reaction
J2739	081222b	Hexocire	100,68	Severe reaction

Response at 101 m/s more violent than 164 m/s

PBX-N109, flat nose, new set-up, 175 m/s

PBX-N109, flat nose, new set-up, 209 m/s

PBX-N109, flat nose, heavily confined, 214 m/s

Composition B at 155 m/s; mild reaction

* Stalen cilinder na het schot met ± 155.5
* Druk in de kruitkamer 244.2 bar.

Composition B at 108 m/s; severe deflagration reaction

Composition B at 97 m/s; no reaction

Summary comp B

Test number	Velocity [m/s]	Reaction
J2827	155	Mild reaction
J2828	122	Deflagration
J2830	108	Fast deflagration /severe reaction
J2831	97	No reaction / indention of cylinder

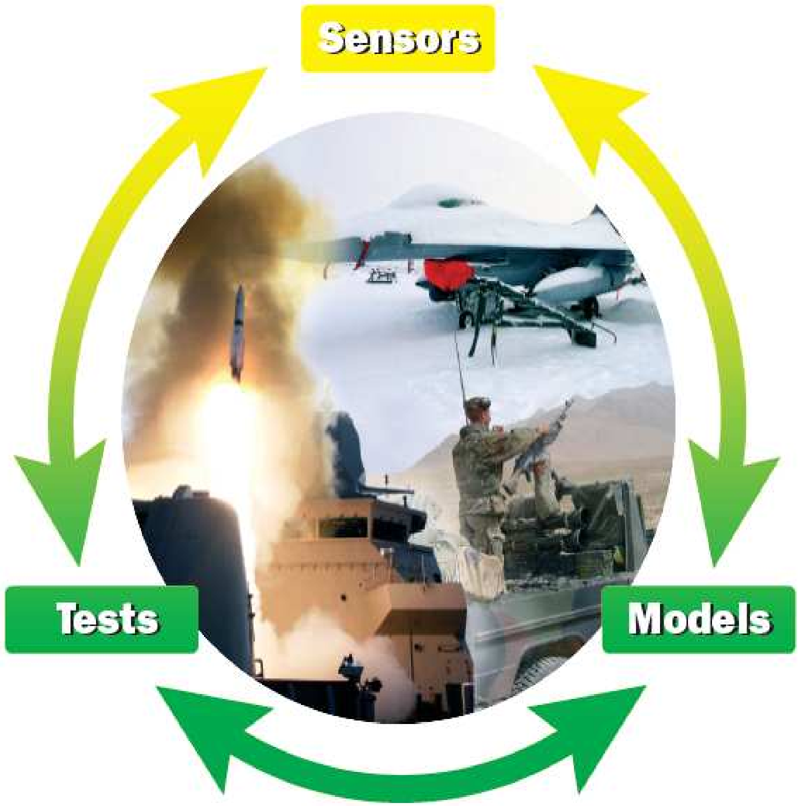
Response at 108 m/s more violent than 122 m/s

Summary

- 60 mm gun works very well, new test vehicle with end-caps is an improvement
- PBXN-109: no reaction at all
- Hexocire (RDX/wax): reaction around 100 m/s
- Comp B: reaction around 110 m/s
- Binder prevents propagation of the reaction

- Macro-scale model seems to be a good start (initiation, propagation not yet simulated)
- Implementation of propagation reaction needed, but question remains: what is influence on meso scale processes (crystal shear)
- Solution of localised share in bulk: combined calculation of macro-meso-micro-scale modelling

Center of Expertise for Ammunition Safety



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Questions?