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Development of Particle Impact Mitigation Sleeves to Reduced IM Response

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Introduction

- Modern weapons systems are being design to provide multipurpose capabilities against a broad array of targets
  - Current urban environment is unpredictable
  - Soldiers would prefer ‘point and shoot’
  - Single function warheads are costlier, time consuming and higher logistics burden
- High performance warheads are pushing the limits of their performance potentials
  - Armor, materiel, personnel and urban target requirements with small explosive loads
  - Will require high energy-density explosives to provide sufficient energy output
  - May not be easy for systems to meet IM requirements using IM explosives alone

Background

- Detonation behavior can be effected by barrier materials inserted between an incoming fragment or shock wave and an explosive material
  - Packaging materials used to ship and store munitions can be manipulated to help pass sympathetic detonation testing
  - Low density liners around the warhead body, or between the explosive and warhead body can reduce fragment impact violence
- As a practical application of this technology, low density liners, called Particle Impact Mitigation Sleeves (PIMS), were investigated to help reduce the violent response from fragment impact
  - Computationally modeled and shown to significantly reduce peak pressure in the explosive resulting from fragment impact
  - PIMS were incorporated in surrogate shaped charge warhead configurations and evaluated experimentally for IM response

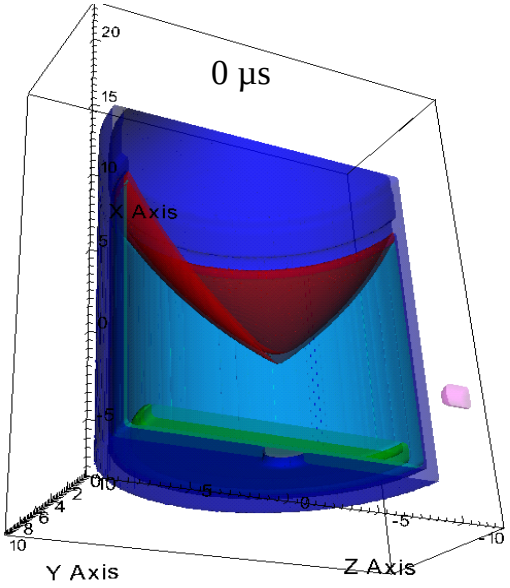
Internal and External PIMS

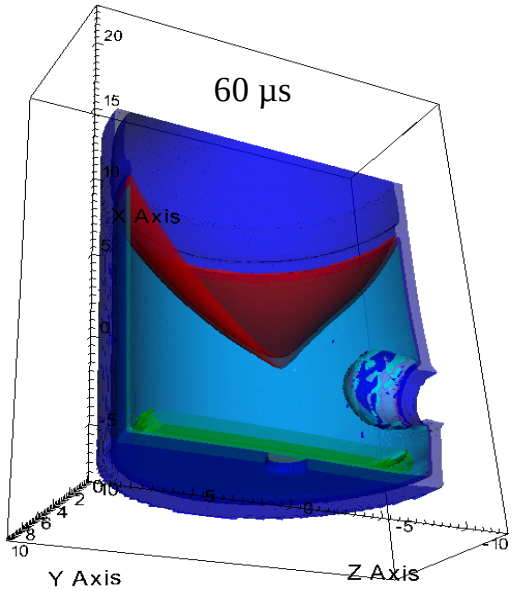
- PIMS liners can effect warhead performance
  - Shaped Charge/EFP liner collapse, warhead case fragmentation behavior and blast output
  - Need to be incorporated early on in the design process so that required warhead performance characteristics can be maintained, while mitigating fragment impact behavior
- External PIMS application
  - Modern missile warheads are often sub calibered in the missile airframe or can accommodate a wrap on the outside of the missile skin
  - The use of external sleeves allows the maximum interior diameter of the warhead to be used for the explosive charge for maximum munition effectiveness
- Internal PIMS application
  - Gun fired munitions are diameter constrained on the outside and also subjected to the high temperature gaseous products of the reacting propellant
  - The use of an internal PIMS may be used in conjunction with warhead venting techniques to mitigate the cook-off response of confined explosives

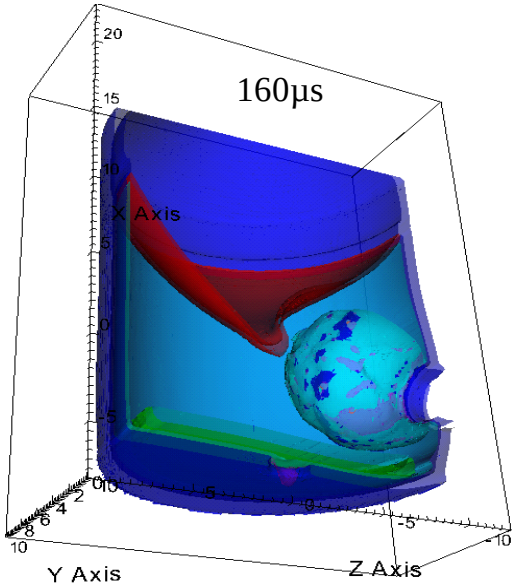
Fragment Impact M&S

Fragment impact events were modeled using the high-rate continuum hydrocode ALE-3D.

Maximum pressure in the explosive versus time was calculated for impact velocities of 6000-fps and 8300-fps.

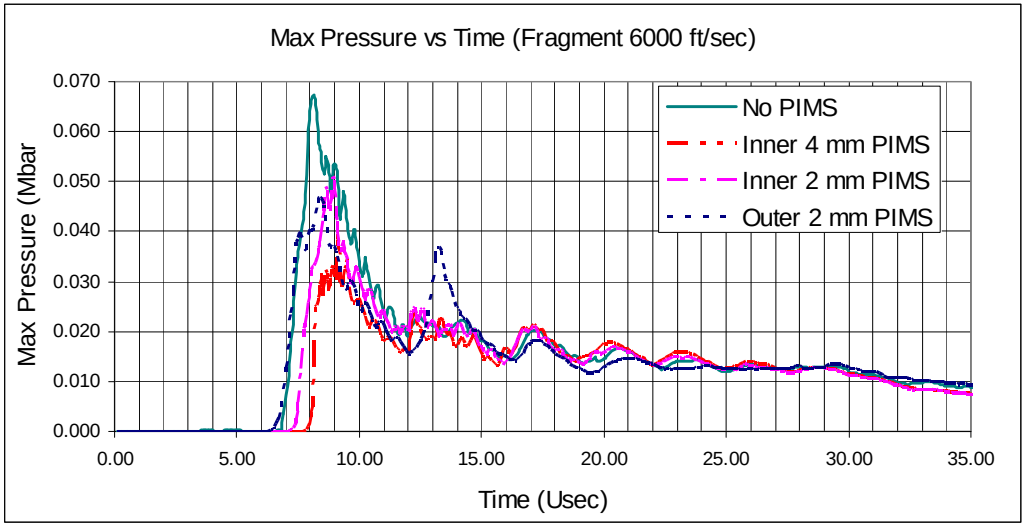


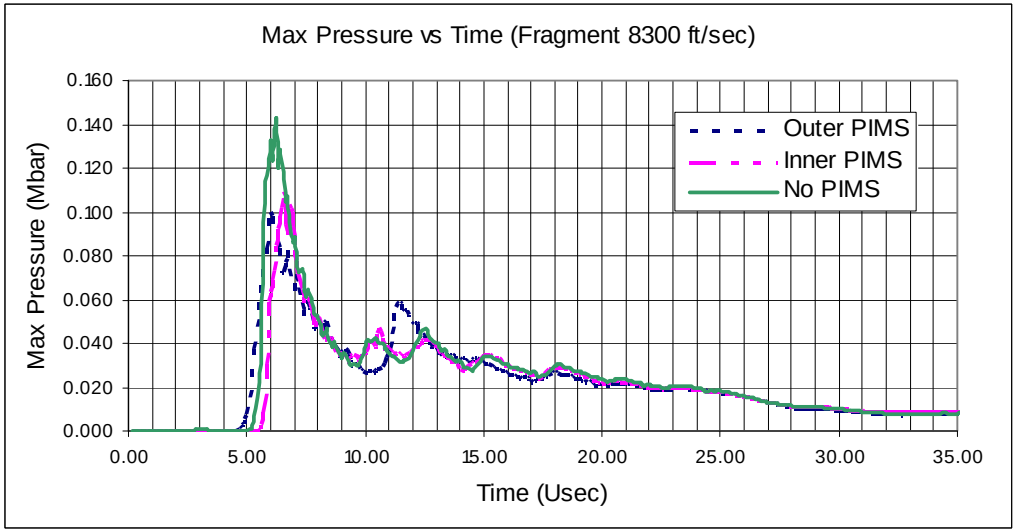




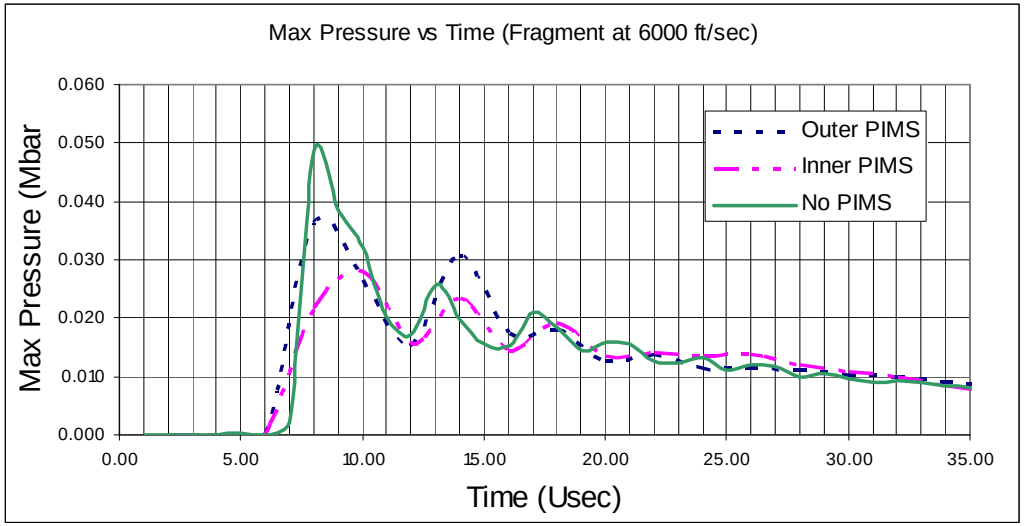
- Explosive replaced with mass matched inert material
- Tracer particles record pressure history

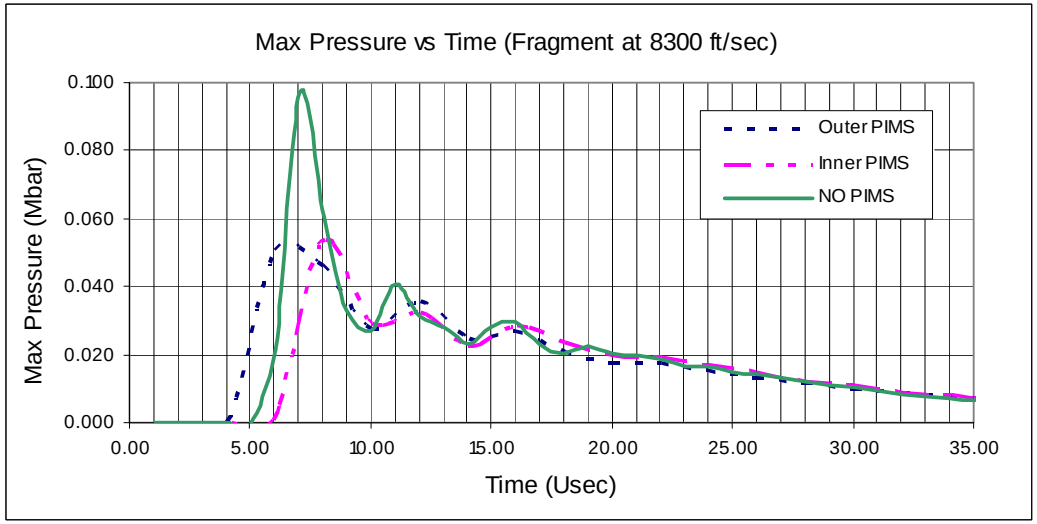
Max Pressure Plots for High-G Launched Type System





Max Pressure Plots for Low-G Launched Type System





PIMS Fragment Impact Testing of High-G Launched Type Warheads

6000 ft/sec frag impact test setup

Internal PIMS Test Warhead

PIMS liners reduce shock transfer from Bullet/frag impact

- Evaluating Effect of PIMS on various explosives
- Evaluating effects of liner thicknesses

Tested Explosives

- PBXN-9: 92% HMX, Hycar/Di-2-EHA binder
- PAX-2A: 85% HMX, BDNPA/F & CAB binder
- PAX-3: 64% HMX, 20% Aluminum, binder
- PAX-30: 77% HMX, 15% Aluminum, binder
- PAX-42: 77% RDX, 15% Aluminum, binder

Frag Impact Test Results

Explosive	No PIMS Reaction*	2mm PIMS Reaction	4mm PIMS Reaction
PBXN-9	Type 1	Type 1&4	Type 4
PAX-2A	Type 1	Type 1	Type 4
PAX-3	Type 2	Type 4	Type 4
PAX-42	Type 1	Type 3	Type 3
PAX-30	Type 1	Type 1	Type 3

* Baseline information provided by Raytheon and AMRDEC

Test Results

Typical type 4 reaction showing large chunks of un-reacted explosive

Witness plate after type 4 reaction

Witness plate after type 1 reaction

PIMS Fragment Impact Testing of Low-G Launched Type Warheads

External PIMS (4-mm) test hardware

6000 ft/sec frag impact test setup

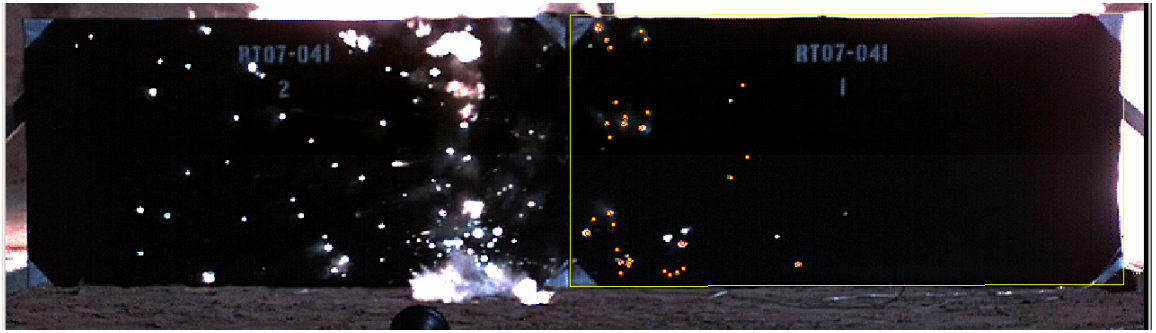
Type 4 test results for PAX-30 showing large case fragments and unreacted explosive

Effect of PIMS on Warhead Performance

Setup

No change in penetration performance from outer PIMS

No PIMS



With PIMS

Larger overall fragment size and more forward fragments with PIMS

Summary

- PIMS liners were computationally studied and shown to reduce peak pressure in the explosive during fragment impact.
- PIMS liners were experimentally shown to greatly reduce the overall violence of the reaction.
- Internal and external PIMS can be application specific and may effect warhead performance characteristics.
- PIMS liners have the potential to allow high-performance warheads to meet IM bullet and fragment impact requirements when these mitigation techniques are incorporated early into the warhead design process.