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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Development of Particle Impact Mitigation Sleeves to Reduced IM Response

Arthur Daniels, James Pham, Koon Ng, and Dave Pfau*



- 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



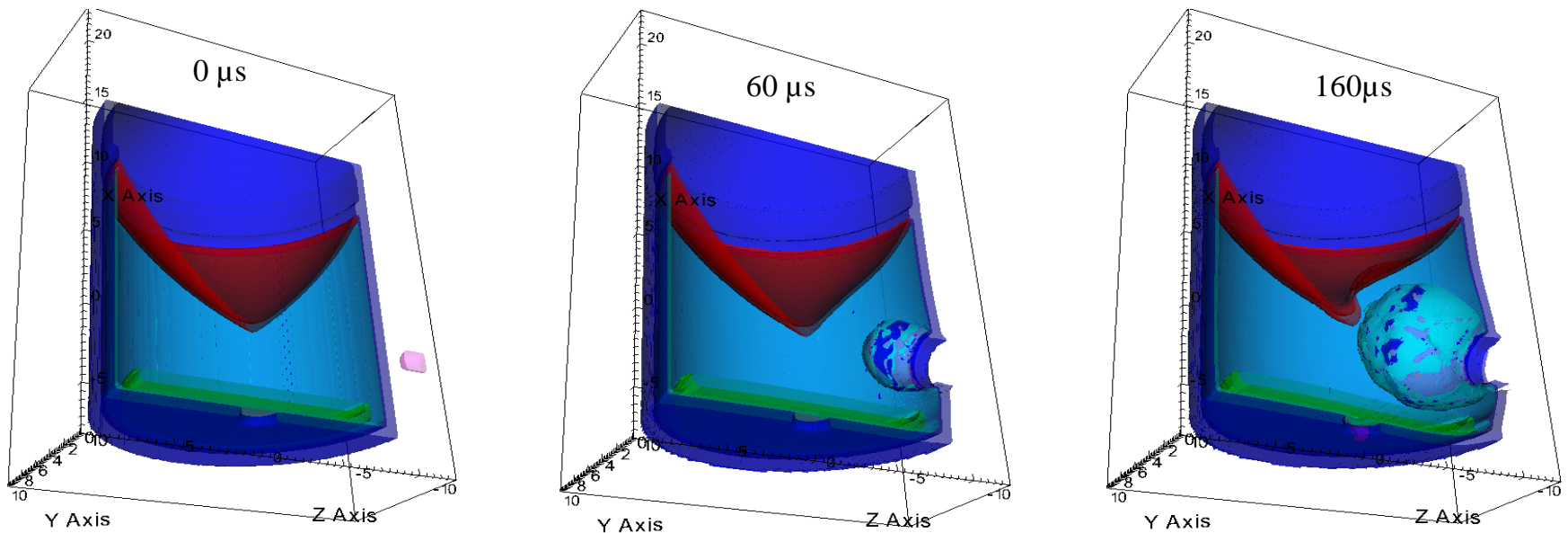
- Detonation behavior can be effected by barrier materials inserted between an incoming fragment or shock wave and an explosive material
 - Packaging materials used to ship and store munitions can be manipulated to help pass sympathetic detonation testing
 - Low density liners around the warhead body, 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



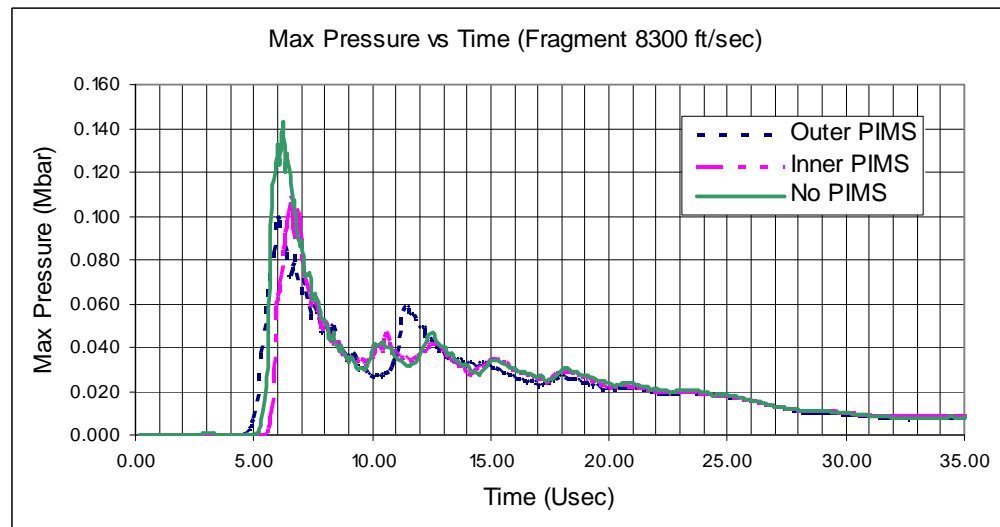
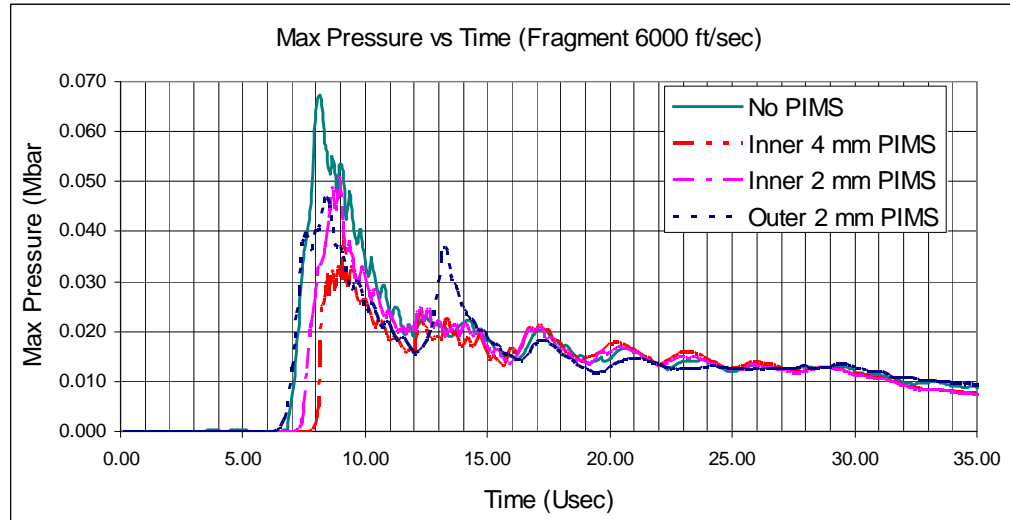
- **PIMS liners can effect warhead performance**
 - Shaped Charge/EFP liner collapse, warhead case fragmentation behavior and blast output
 - Need to be incorporated early on in the design process so that required warhead performance characteristics can be maintained, while mitigating fragment impact 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

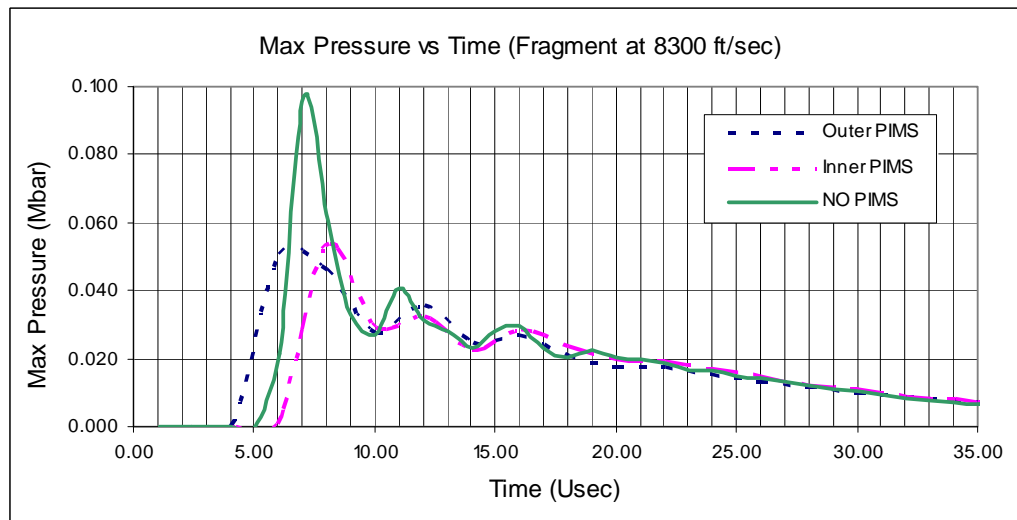
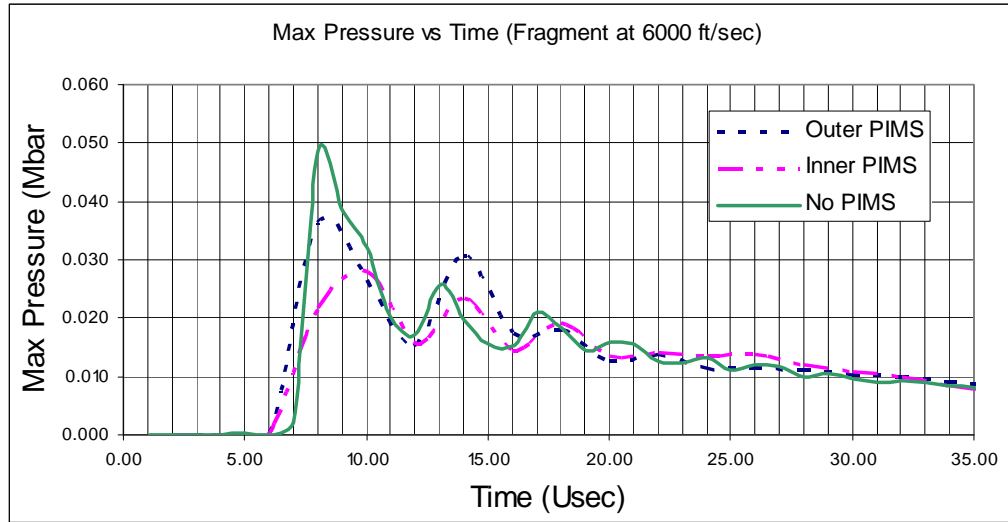
Fragment impact events were modeled using the high-rate continuum hydrocode ALE-3D.

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

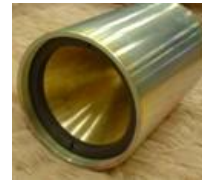


- Explosive replaced with mass matched inert material
- Tracer particles record pressure history





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



- 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



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



Typical type 4 reaction showing large chunks of unreacted explosive



Witness plate after type 4 reaction

Witness plate after type 1 reaction



External PIMS (4-mm) test hardware



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



6000 ft/sec frag impact test setup

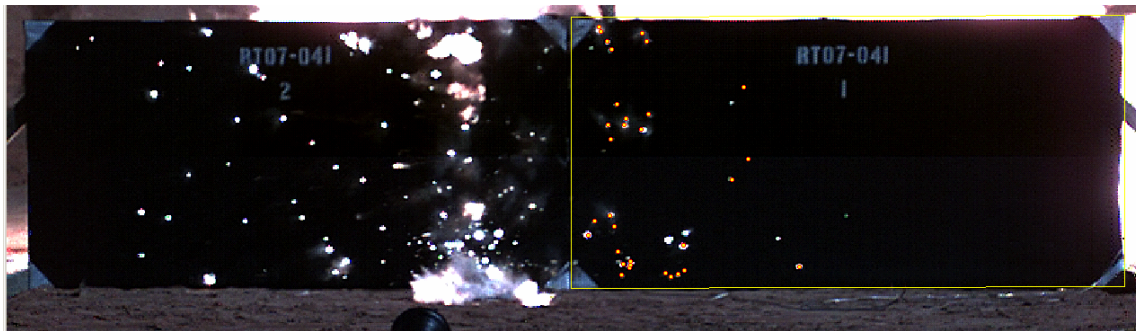


Setup



No change in penetration performance from outer PIMS

No PIMS



Larger overall fragment size and more forward fragments with PIMS

With PIMS





- 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.