Reactive Material Candidates for Low Collateral Damage - Part 1: Arena Testing

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Outline

• Introduction and Background
• Approach
• Test Setup
• Test Results
• Summary and Conclusions
Introduction and Background

- Frequent military engagements in urban areas continue to drive the push for warhead systems that reduce collateral damage.
- Program purpose: Develop consumable fragment material that:
  - Has good mechanical strength
  - Has reasonably high overall fragment density
  - Facilitates high lethality for short period
  - Reduces lethal radius by reacting/consuming

![Graph showing Lethality vs Distance comparing Typical solid fragment to Consumable fragment (goal)]
Approach

• Fragments should exhibit several characteristics
  – Good mechanical strength to minimize breakup upon explosive launch
  – Sufficient density for lethality close in
  – Structure that lends itself to fast oxidation/consumption in air
  – If possible, not require built-in oxidizer, thereby avoiding
    • Processing time and cost to manufacture a formulation
    • Formulation safety, handling, storage, aging issues

• Identified several types of metals fragments as candidates
  – Multiple types at varying densities were chosen for testing
Approach

• Range of fragment properties
  – Several metal fragment types
  – Screened to various sizes
  – Range of densities
  – Range of mechanical properties
  – Range of combustion potential

• Two polymer types chosen to provide a “matrix” to hold fragments
Approach

• Twelve arena tests carried out to look at three major variables:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Fragment Type</td>
<td>Variety of metal fragment types and stainless steel shot (baseline)</td>
</tr>
<tr>
<td>Fragment Size</td>
<td>Range of diameters, weights</td>
</tr>
<tr>
<td>Polymer type</td>
<td>Two types</td>
</tr>
</tbody>
</table>

• Molds fabricated to house/cure metal fragments in polymer matrix:
Approach

• Annular articles cast with varying metal type/size, and polymer type

Steel shot/cured polymer baseline

• 50/50 Pentolite HE charge positioned inside each annular test article

Schematic of test setup

3.75" x 3.75" HE charge
Fragment/polymer annular matrix
air gap

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Test Setup

- Arena tests: various targets at 5/10/15/20/30 ft, high-speed video
Test Results

• Data acquired from arena tests
  – 3 high-speed digital video cameras, 12,000 fps (83 millionths sec/frame)
  – Over 1,500 fragments extracted from ballistic gel/plywood, cataloged
  – Weights recorded on over 500 of recovered fragments
  – Penetration data and fragment weight cataloged as function of distance

• Still pictures taken from typical high speed video, front

Test at t= +87μs

Test at t= +1,921μs
Test Results

- Side view of arena two arena tests showing reaction of fragments
Test Results- Avg Frag Velocities

- Candidate metal frags have steeper velocity gradient than baseline stainless
- Fragments showed marked decrease in weight traveling outward compared with baseline stainless shot, which (as expected) experienced no attrition.

Baseline 3/8” stainless shot
In general, candidate frags decreased in KE at a faster rate than the baseline.

Some candidates showed a steeper KE gradient than others.
Summary and Conclusions

- Twelve annular test articles consisting of candidate fragments, including stainless steel shot (as a baseline), along with one of two polymers, were each explosively tested with the same size 50/50 Pentolite charge. Targets of steel panels, plywood, and ballistic gel were used to catalog fragment penetration and capture fragments to estimate degree of oxidative consumption as a function of distance from the blast, in order to assess if these types of metal fragments might be useful as a consumable fragment for the purpose of reducing collateral damage.

- While there is almost certainly a significant amount of break-up near the blast, there appears to also be a significant amount of reaction as the candidate fragments are traveling outward away from the blast.

- Further chemical analyses of extents of oxidation should help clarify.

- This particular family of metal fragment types demonstrated the tendency to undergo oxidation and consumption while moving through the air.