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

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Prepared for:

2012 NDIA Insensitive Munitions & Energetic Materials Technology Symposium

May 14-17, 2012 — Las Vegas, Nevada

Acknowledgments

- **Appreciation is extended to:**

Sean Swaszek, Ruslan Mudryy and Dan Murphy of ARDEC

- Overall technical guidance of this advanced technology initiative
- Financial support

Dr. Jared Olson of ATK Aerospace Systems

- Program management

Jake Simmons, Robert Goodell and Greg Price of ATK Aerospace Systems

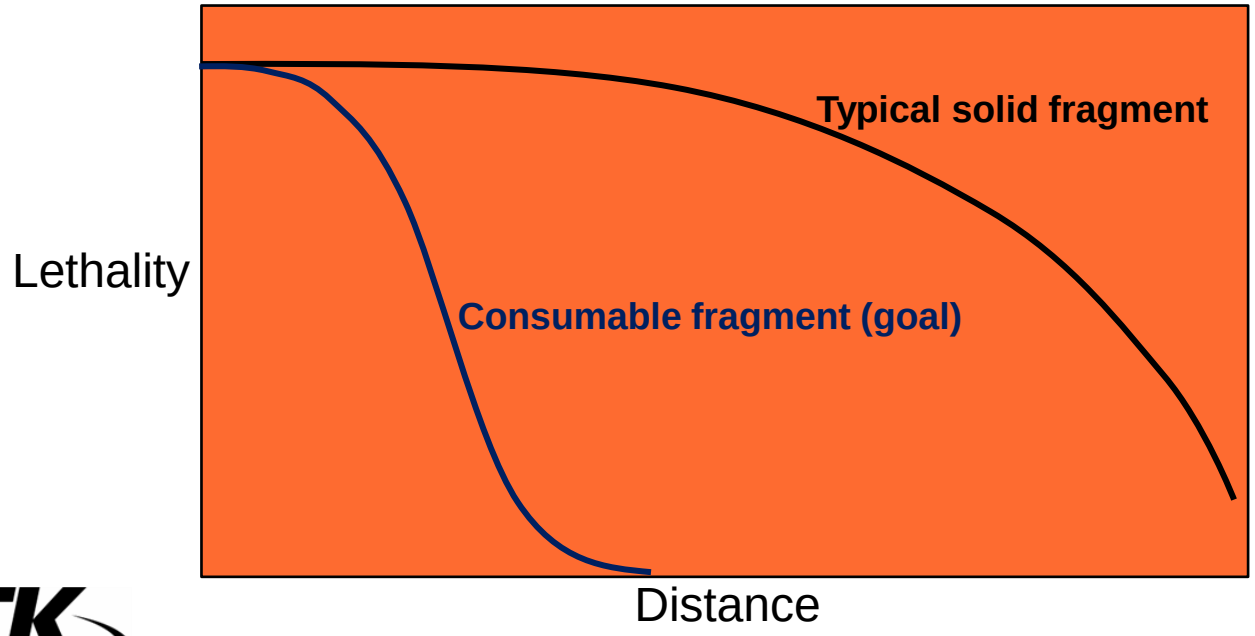
- Test engineering, execution, and data collection

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**



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**

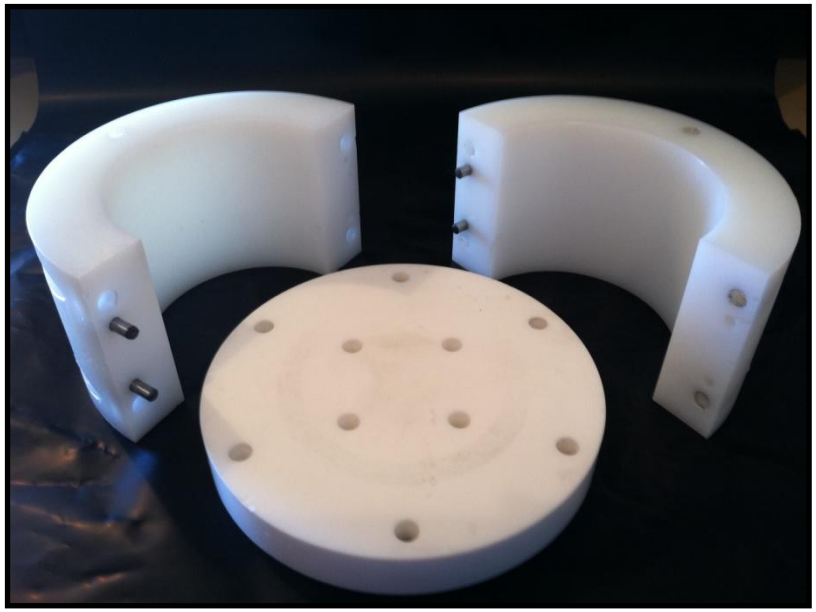
- **Two polymer types chosen to provide a “matrix” to hold fragments**

Approach

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

Variable	Range Covered
Metal Fragment Type	Variety of metal fragment types and stainless steel shot (baseline)
Fragment Size	Range of diameters, weights
Polymer type	Two types

- **Molds fabricated to house/cure metal fragments in polymer matrix:**

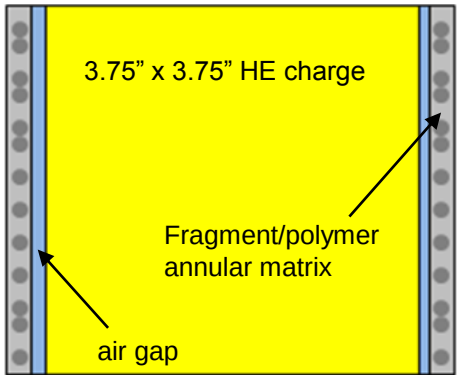


Approach

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

Steel shot/cured polymer baseline

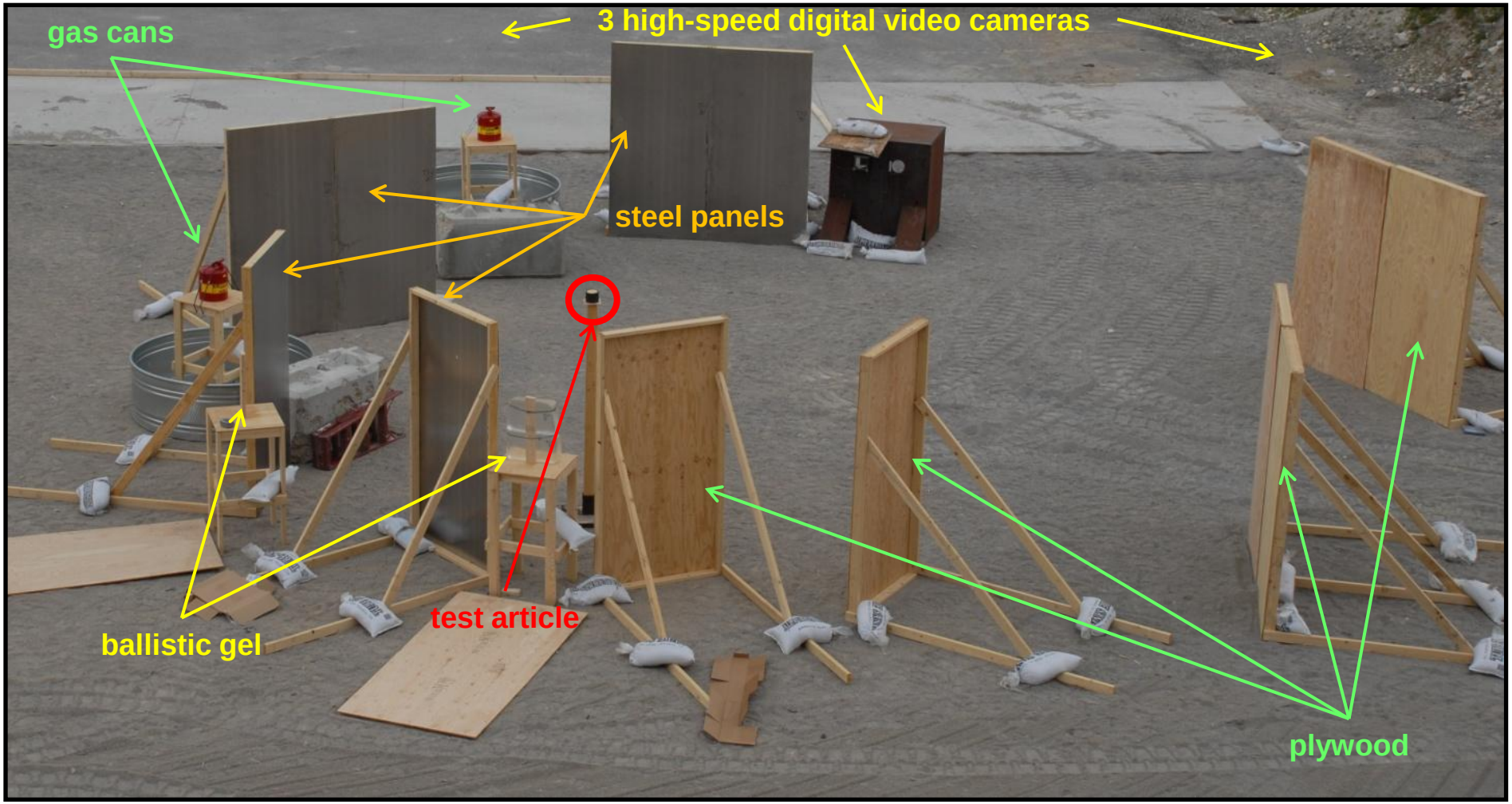
- **50/50 Pentolite HE charge positioned inside each annular test article**



Schematic of test setup

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**

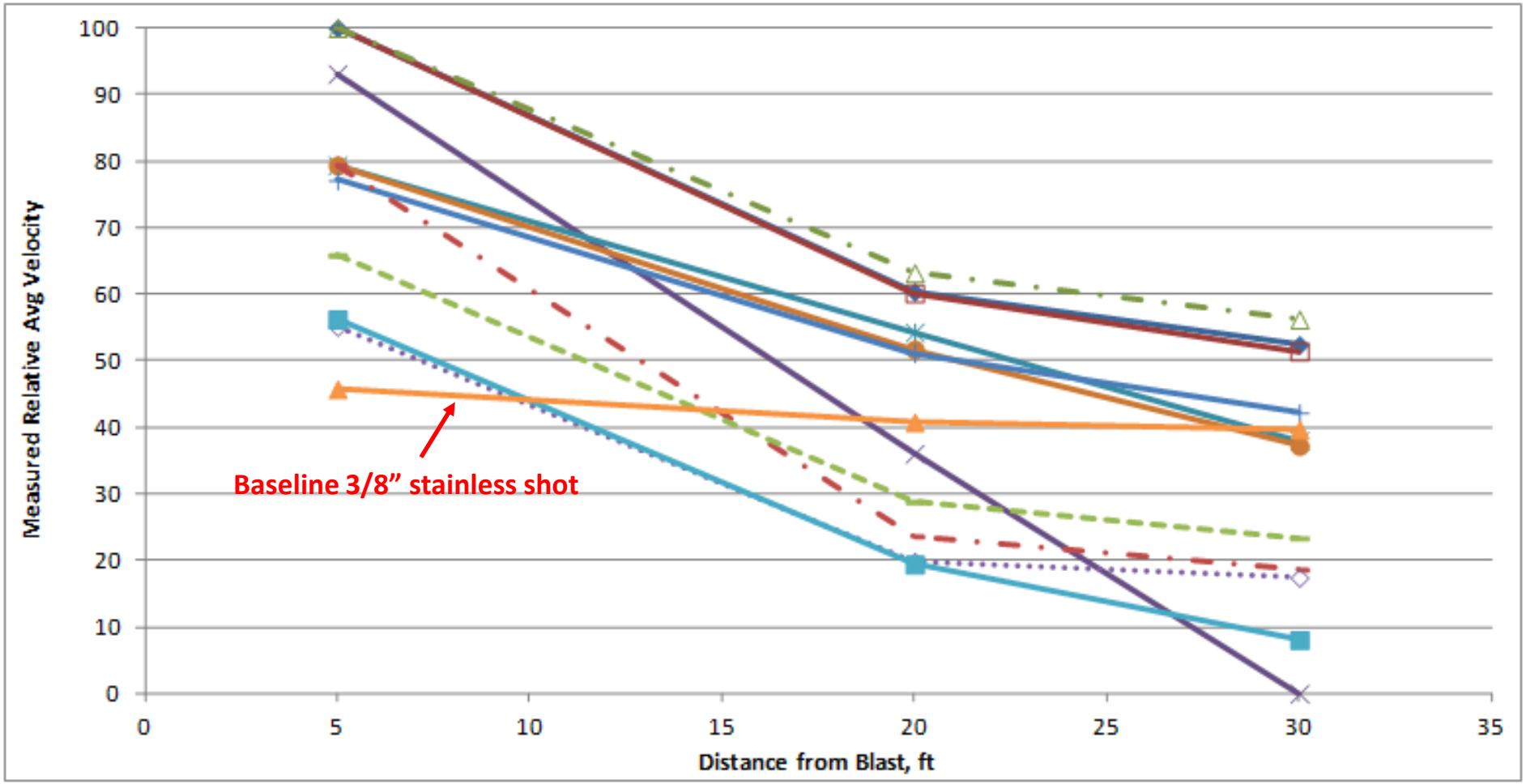
Test at t= +87μs

Test at t= +1,921μs

Test Results

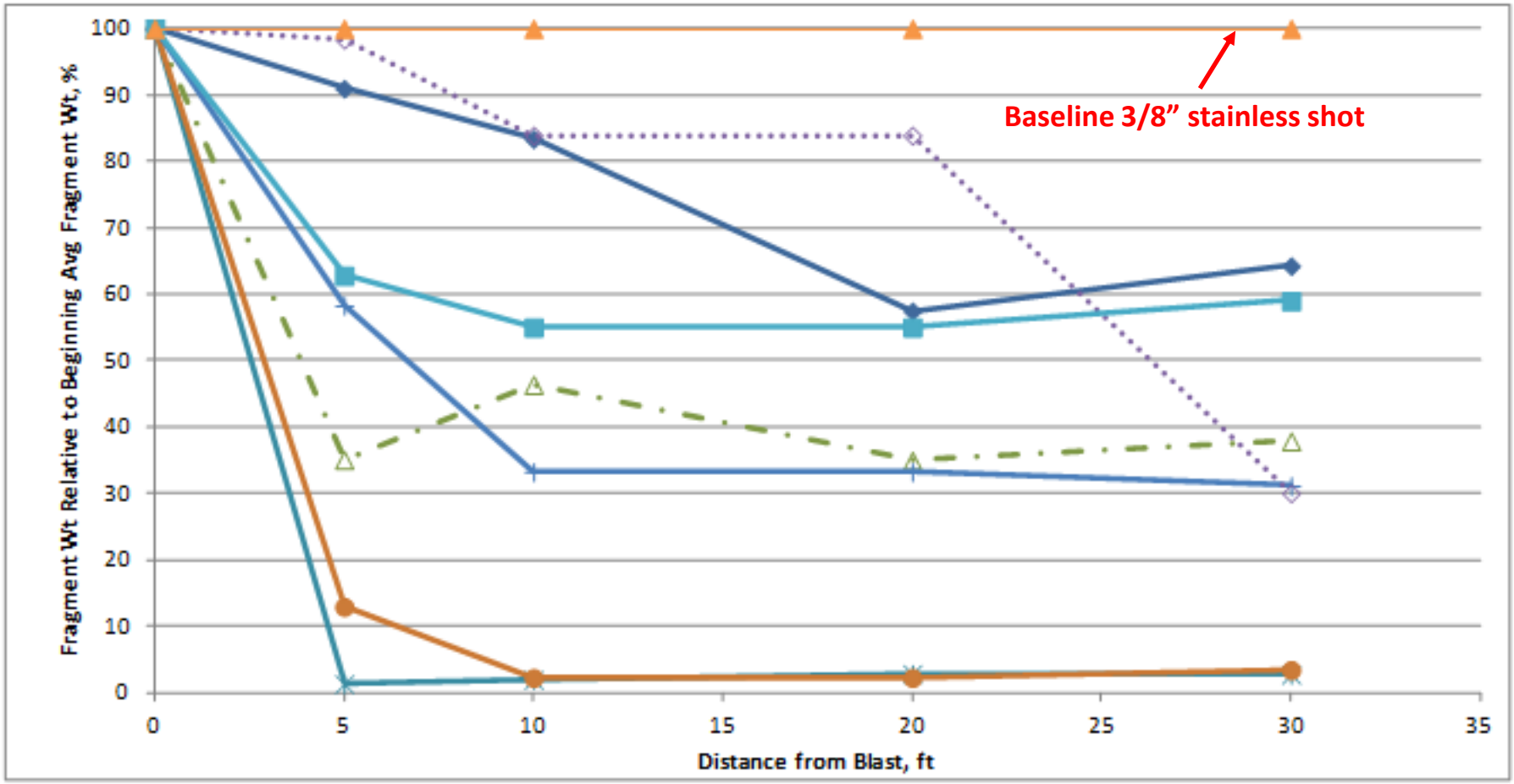
- **Side view of arena two arena tests showing reaction of fragments**

Test Results- Avg Frag Velocities



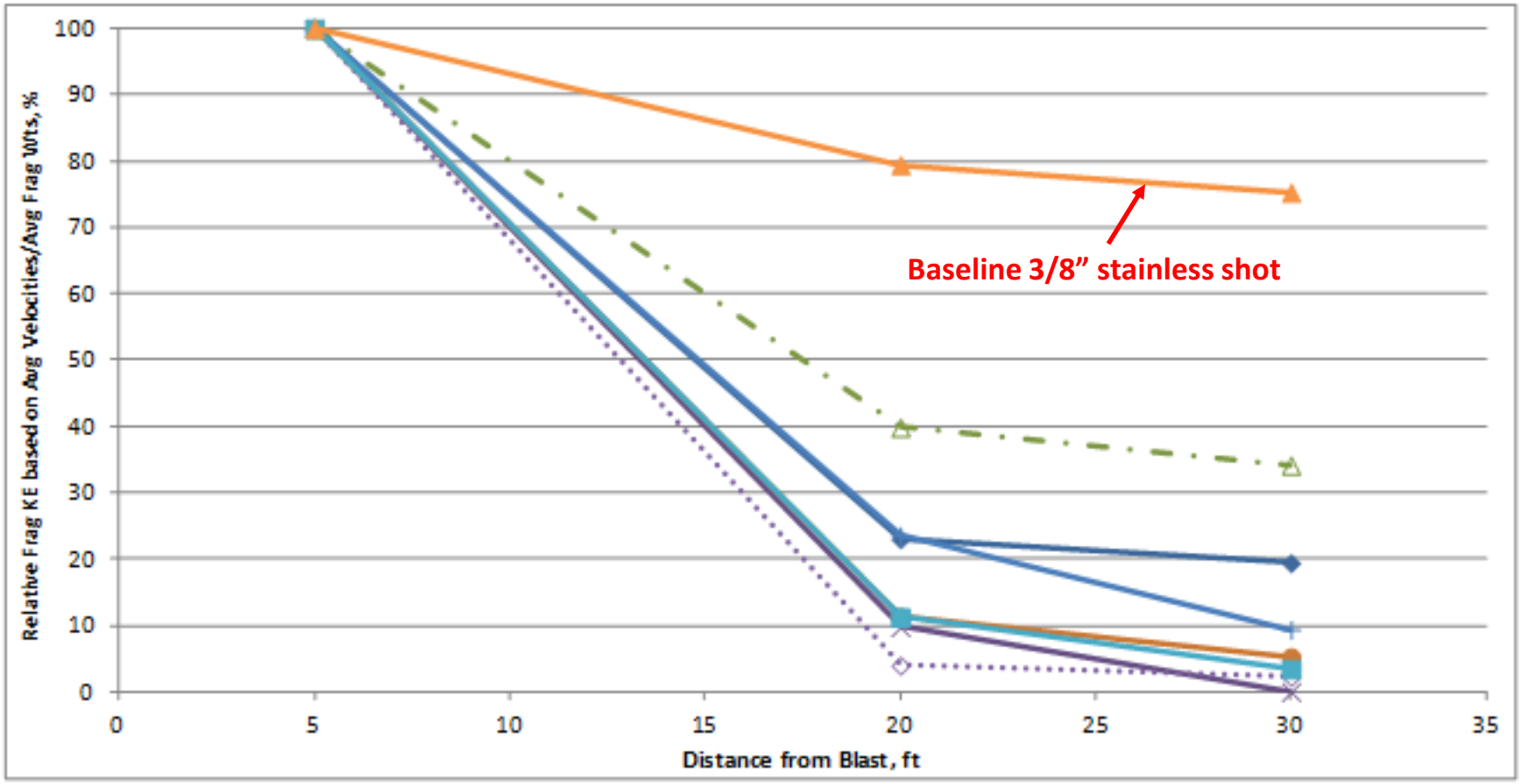
- **Candidate metal frags have steeper velocity gradient than baseline stainless**

Test Results- Avg Frag Wt Change



- **Fragments showed marked decrease in weight traveling outward compared with baseline stainless shot, which (as expected) experienced no attrition**

Test Results- KE vs. Distance



- **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