RDECOM

2010 NDIA
IMEM
Munich

The Army Burn-to-Violent Reaction (ABVR) Test: A Sub-scale Impact Screening Tool

AMRDEC
STRENGTH THROUGH TECHNOLOGY

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

12 October 2010

Jamie B. Neidert, PhD

Chief Scientist, Energetics

Aviation and Missile Research, Development and Engineering Center

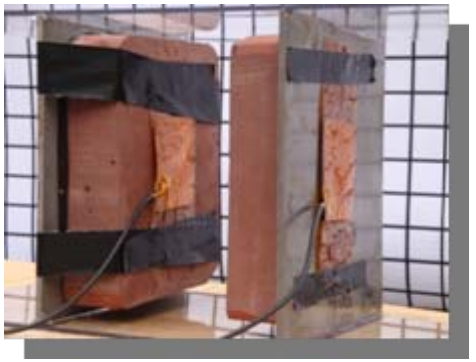
Objective

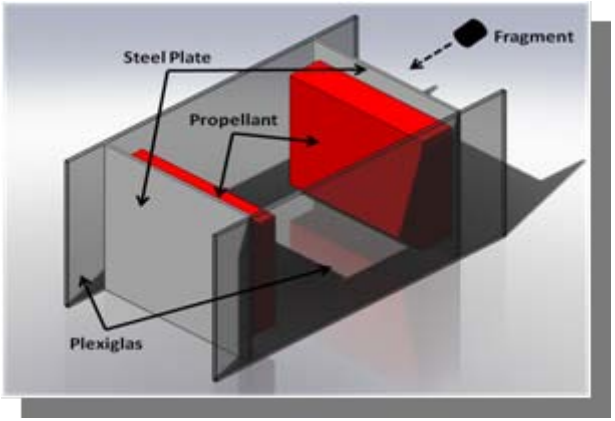
Develop sub-scale tests to understand and predict reaction violence for screening and early sensitivity indications during formulation activities.

- **Based on previous work by Steven Finnegan at China Lake in the 1980s**
  - Update testing to incorporate current technology
  - Better understand the phenomena and mechanisms for reactivity
  - Low cost testing capabilities

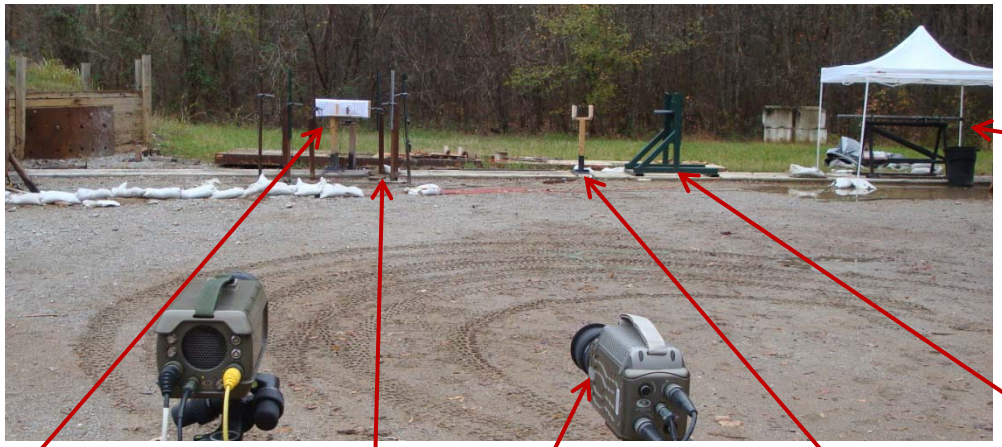
Approach

- Test Article represents a 2-D Analog of a Rocket Motor
- Projectile Impact Range 3000-6000 ft/sec
- Instrumentation
  - Open Air Pressure Data
  - Projectile Velocity
  - Propellant Debris Velocity
  - High Speed Video
- Primary variables
- Propellant formulation
  - Class 1.3 HPP and Class 1.1 MS
- Case material
  - Steel, Aluminum, and Composite
- Air Gap & Web Thickness





ABVR Test Set-Up

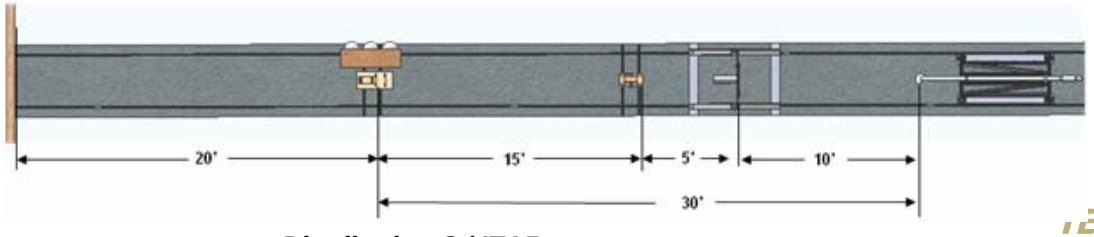


High Speed Video

20mm Cannon

Test Article &
Flash Bulb/Grid

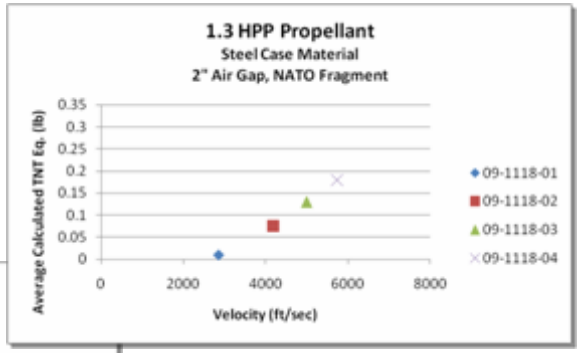
Sabot Stripper

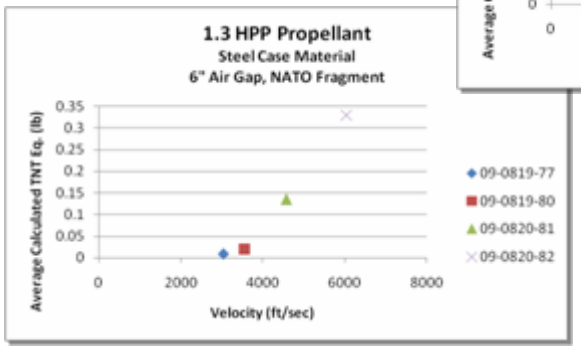


Distribution C / ITAR

High Performance Propellant

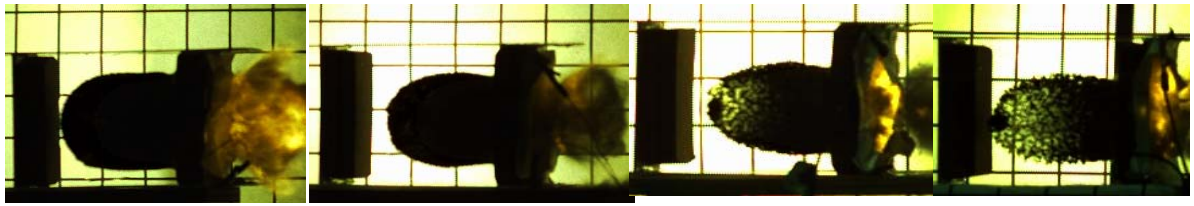
Class 1.3





Increasing reactions with increasing velocities observed.

Data shows a less violent reaction when using sphere's. Importance: Projectile geometry.

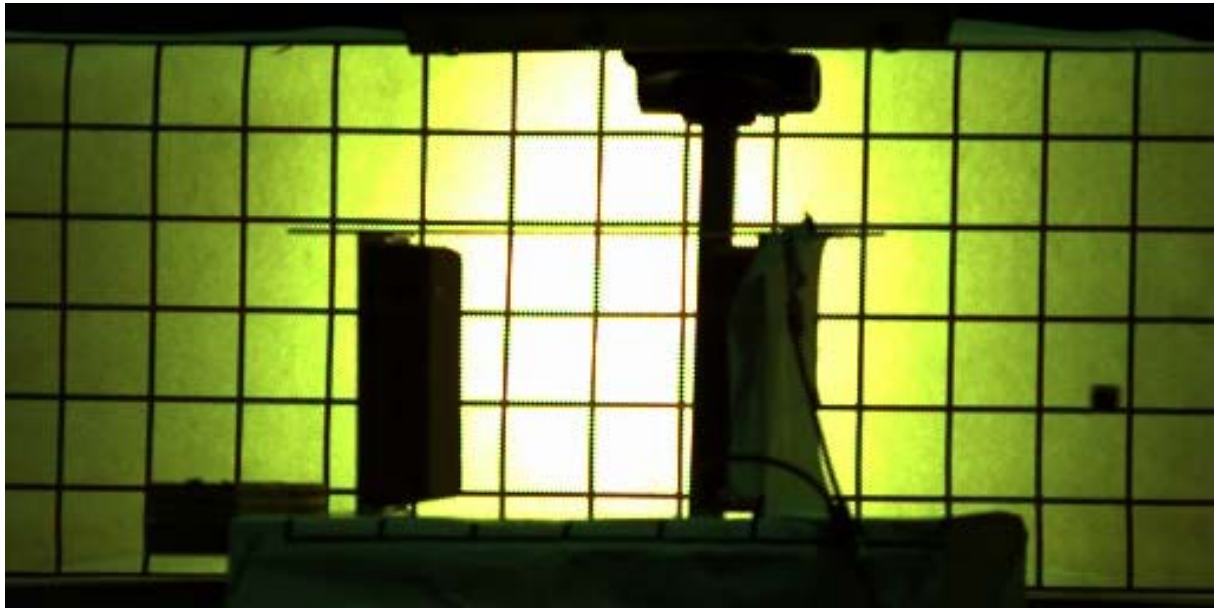


6000 fps **3000 fps**

Violent Reactivity related to Dispersal of Debris **:**
As the impact velocity increases the debris cloud becomes more dense.

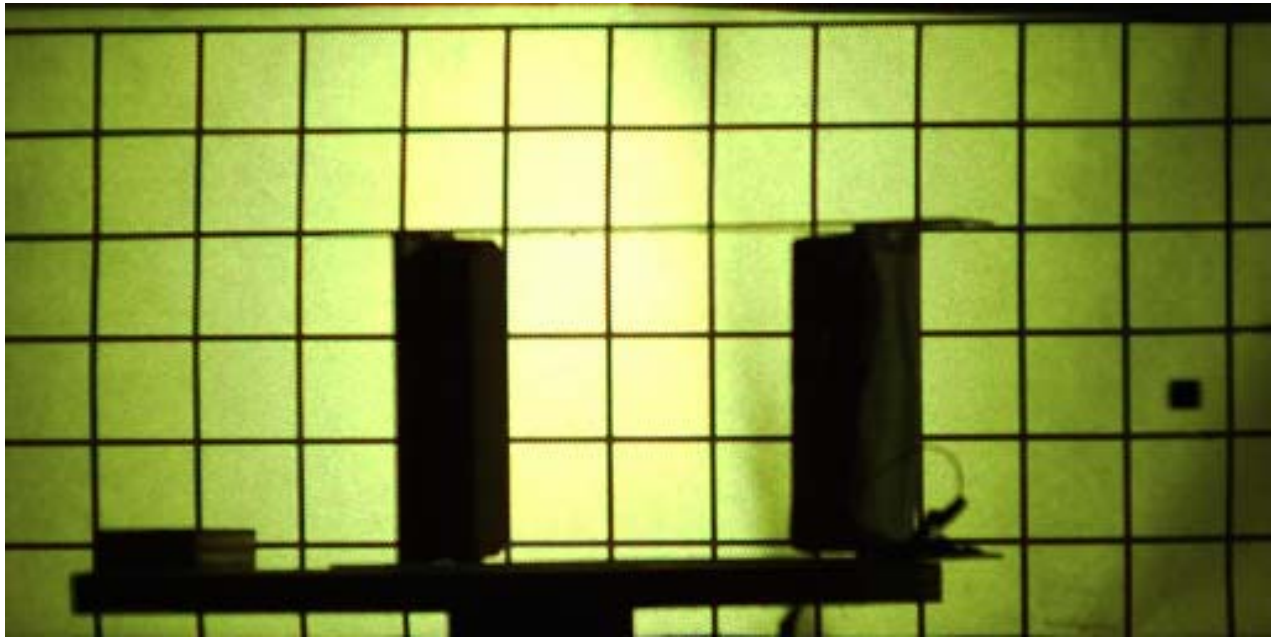
HPP Video

STANAG Fragment at 3000 fps

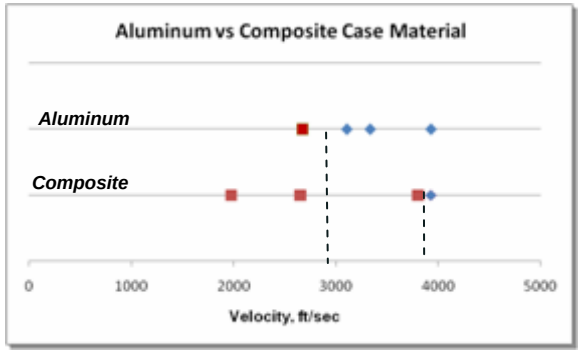


HPP Video

STANAG Fragment at 6000 fps



Minimum Signature Propellant
Class 1.1



■ = No Sustained Burning
◆ = Violent Reaction/Partial Detonation

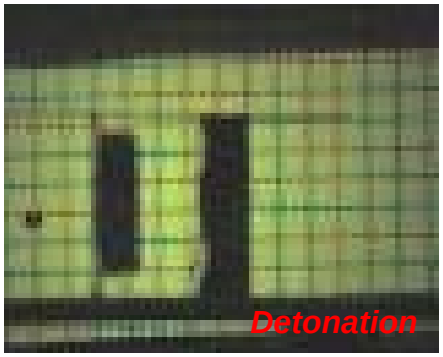
MS Propellant produced similar results to HPP study:
- Increasing violence with increasing velocities
- Violent reactions related to debris cloud dispersal

MS Propellant Additional Study:
- Aluminum Case material was compared to Composite Case material
- Composite was found to have a higher threshold

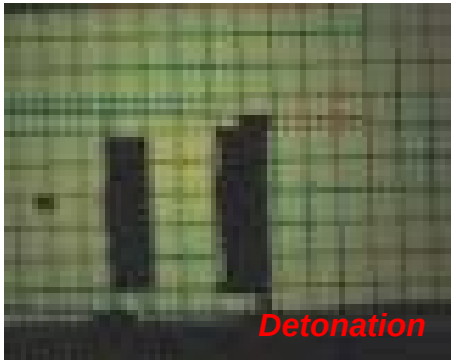
Front Slab *Fragment Exit Side* | **Back Slab** *Fragment Entrance Side*

Recovered MS Propellant Below Detonation Threshold
Similar entrance/exit patterns observed in low velocity HPP tests

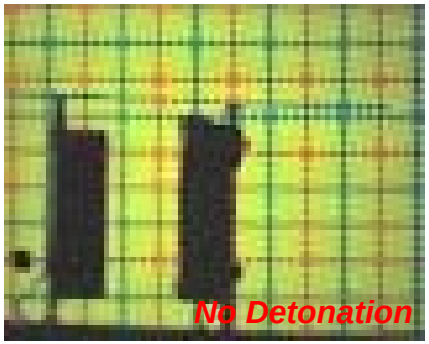
MS Video



STANAG Fragment at 3900 fps
MS propellant bonded to Composite Plate



STANAG Fragment at 3900 fps
MS propellant bonded to Aluminum Plate



STANAG Fragment at 3800 fps
MS propellant bonded to Composite Plate

ABVR Conclusions

- **Fragments produce a greater violence than spheres.**
  - **Comparisons of high speed video, pressure data, and calculated TNT eq. support this conclusion.**
  - **Debris cloud is noticeably larger in fragment testing.**

- **Violence of the reaction is dependent of the projectile velocity.**

  The following increase by increasing Projectile Velocity:
  - **Propellant Debris Geometry**
  - **Debris Cloud Velocities**
  - **TNT Eq.**

- **Vertical impact surface required for reaction to occur in all tests excluding one.**
  - **All HPP Propellants tested at 6000 ft/sec and below**
  - **All but one MS Propellants tested at 4000 ft/sec and below**

- **Composite case has a higher threshold velocity than the aluminum case for 1.1 propellant.**
  - **Propellant spall is greater in the aluminum case.**
  - **Both increase in violence as projectile velocity increases.**

- **Threshold velocities were determined for HPP and MS propellants.**
  - **HPP threshold ~ 3550 to 4200 ft/sec**
  - **MS threshold ~ 3000 to 4000 ft/sec**

Work Status

Current:

- ***Effects with no case***
- ***Study Web Thickness/Air Gap Ratio***
  - ***Will it become less violent as the air gap decreases?***

Future:

- ***Modify test article design to better represent motor***
  - ***2D - Cylinders***
- ***Investigate other case materials***
  - ***Barriers (internal and external)***
- ***Shock mitigation***
- ***Compare propellants directly***

Collaborators

- AMRDEC Co-Authors
  - Jessica Stanfield
  - William Chew
  - Joey Reed
  - Pam Johns
  - William Thomas
- AMCOM Safety: Pat Vittitow
- DOE
  - LANL: Eric Mas, Thomas Mason
  - LLNL: Bruce Watkins, Rose McCallen, Keo Springer
  - SNL: Paul Butler, Eric Harstad