Presented to:

NDIA IMEM

Portland, OR

Paper #20136

Validation of the Army Burn to Violent Reaction (ABVR) Test as a Tool to Predict Full-Scale Motor Response to Fragment Impact

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Presented by:

Dr. Jamie B. Neidert

Dr. Mark A. Pfeil & Jessica A. Stanfield

U.S. Army Aviation and Missile Research, Development, and Engineering Center

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AMRDEC Mission

Deliver collaborative and innovative aviation and missile capabilities for responsive and cost-effective research, development and life cycle engineering solutions.

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~9,211	2,945	16	6,250
FY17 Strength	Civilian	Military	Contractor
			907 / 5343
			SETA Non-SETA

FY17

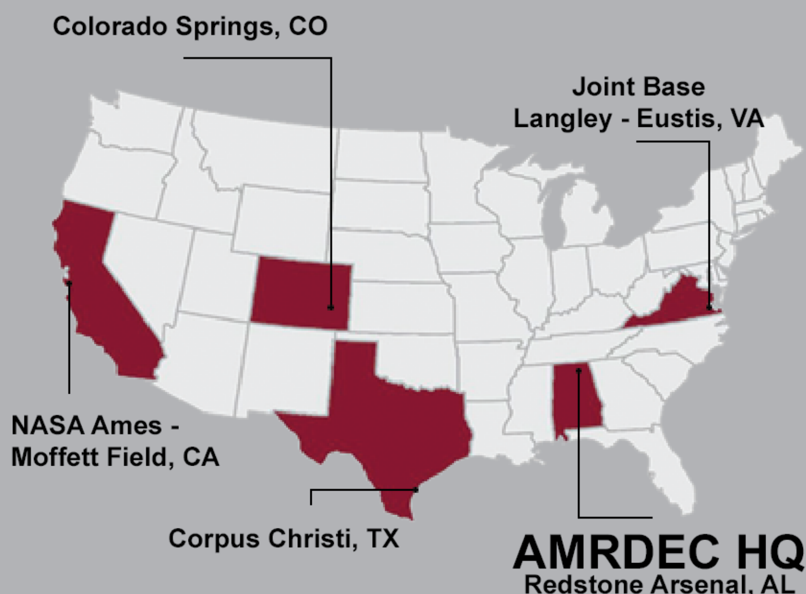
$2,904M

6% Aviation S&T

7% Missile S&T

63% Army

24% Other



Core Competencies

- Life Cycle Engineering
- Research, Technology Development and Demonstration
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- Software Engineering
- Systems Integration
- Test and Evaluation
- Qualification
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- Structures
- Propulsion
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- Image Processing
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#1: Readiness

Provide aviation and missile systems solutions to ensure victory on the battlefield today.

#2: Future Force

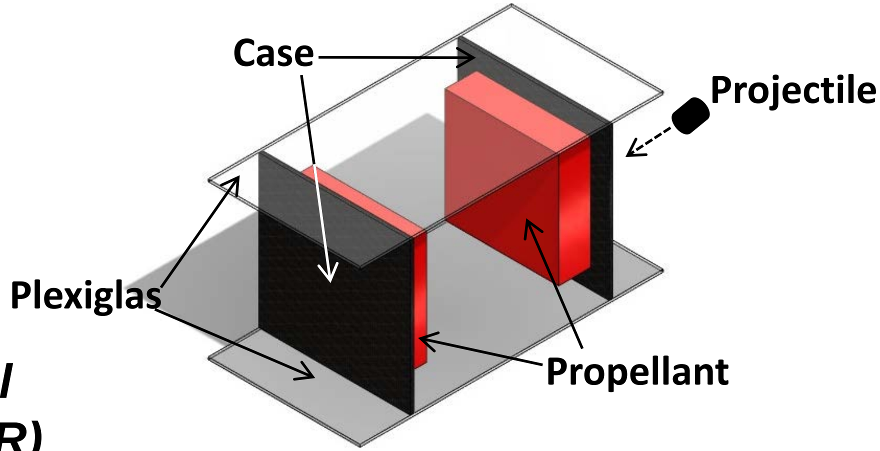
Develop and mature Science and Technology to provide technical capability to our Army's (and nation's) aviation and missile systems.

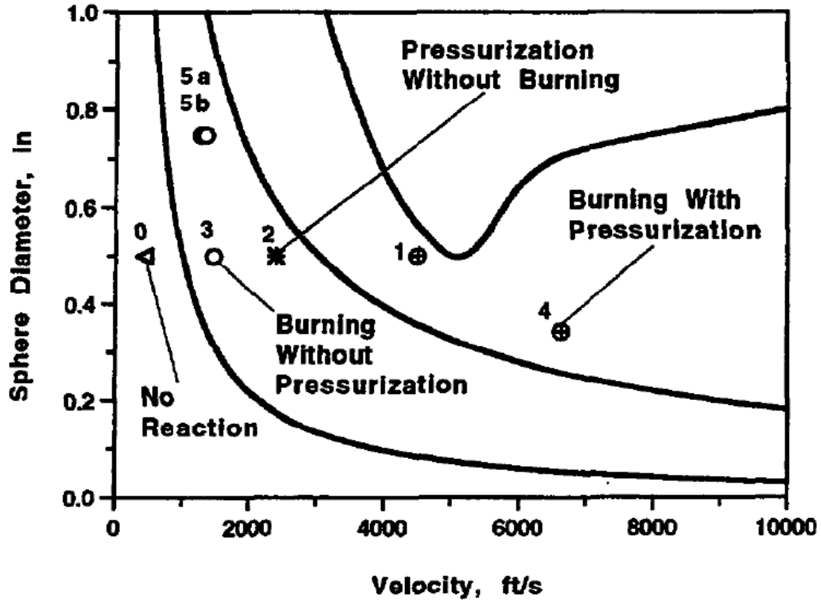
#3: Soldiers and People

Develop the engineering talent to support both Science and Technology and the aviation and missile materiel enterprise

Background

- *Burn to Violent Reaction (BVR) developed in early 1990's at the US Navy/China Lake*
  - *Independently developed in UK around same time frame*
  - *Similar work at Redstone Arsenal in mid 1990's → Army BVR (ABVR)*
  - *Over 30 publications on efforts associated with BVR*
- *Ammonium perchlorate propellants*
  - *Relate reaction to ballistic behaviors*
- *Nitramine based propellants*
  - *Map out detonation regions*
  - *First (known) observed demonstration of XDT (unknown detonation transition) related to traversing damaged propellant*

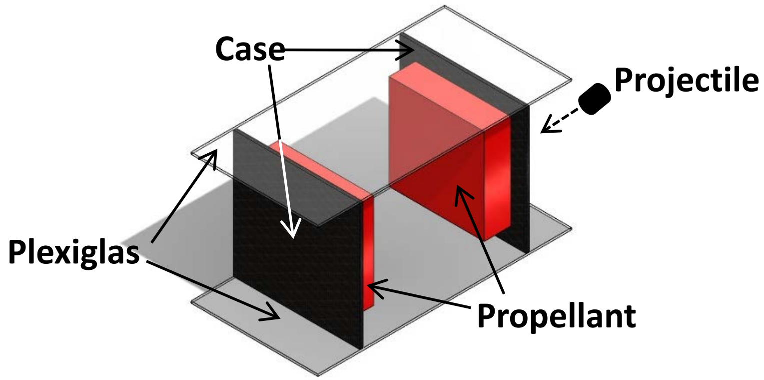




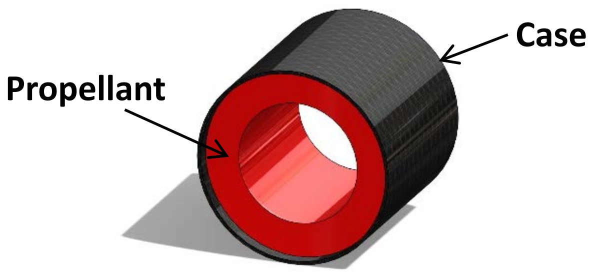
Finnegan et al., August, 1994

Project Overview

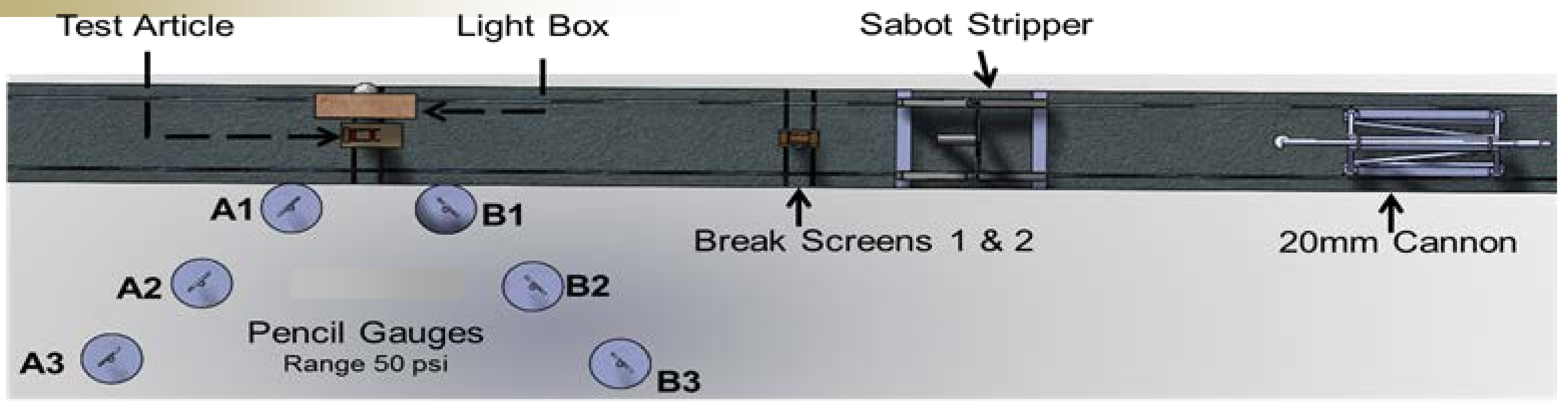
- **Use subscale, simplified tests to identify important parameters influencing munition response to external stimuli (fragment impact)**
  - **Velocity, geometry, projectile, web thickness, materials, etc.**

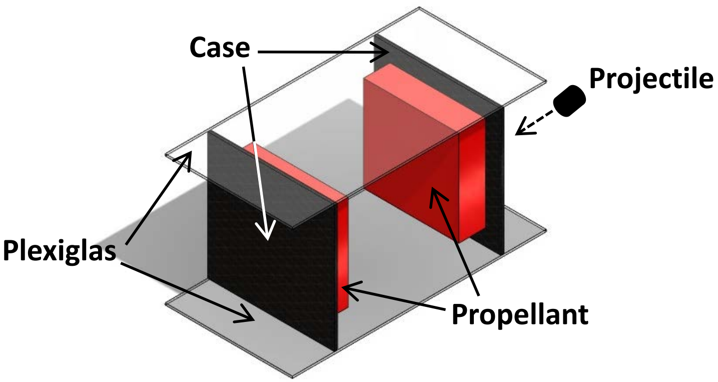


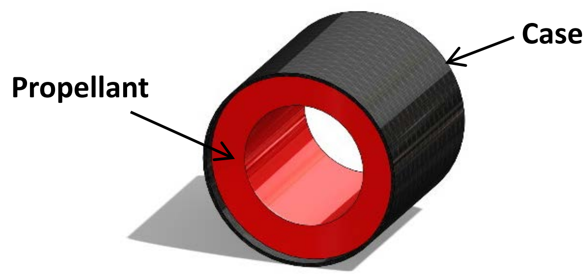
- **Verify similar behavior observed in cylindrical sections**
- **Design motor to demonstrate different reaction mechanisms**



Testing Setup – ABVR and Cylinders





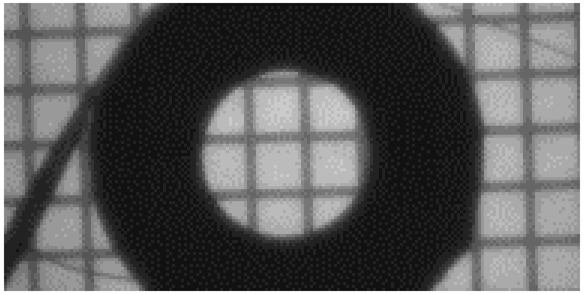


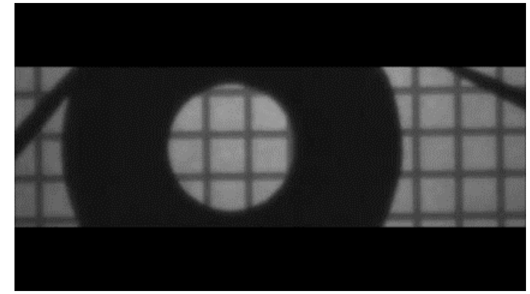
NATO STANAG Frag

- MSP-1 propellant
  - ABVR web thickness – 1.25 or 2.50 in
  - Cylindrical web thickness – 1.09 or 2.34 in
- Pressure gauges set at a 45° offset
- Cylindrical tests that focused on Shock to Detonation (SDT) reaction used quartered samples

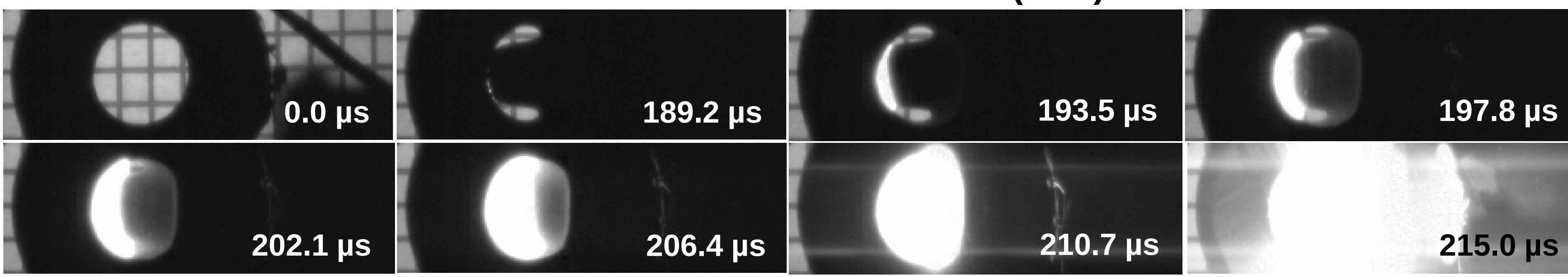
Reaction Mechanisms

Shock to Detonation Transition (SDT)

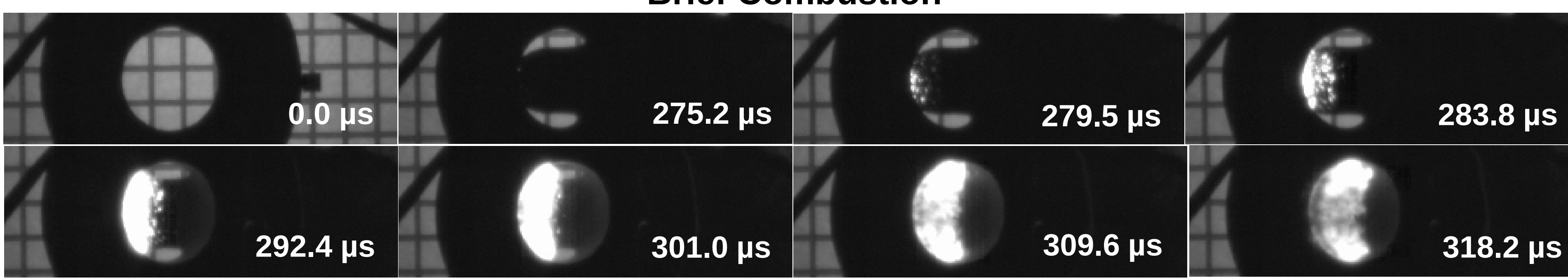




Unknown Detonation Transition (XDT)

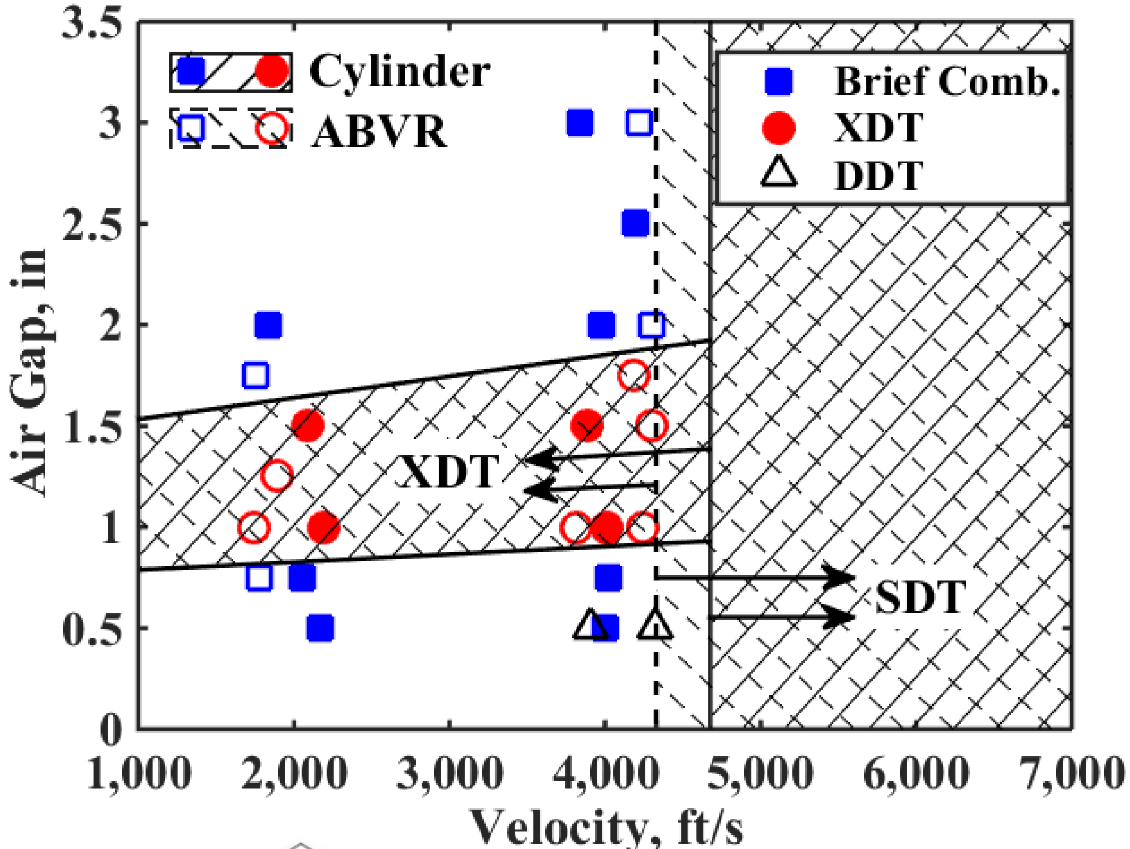


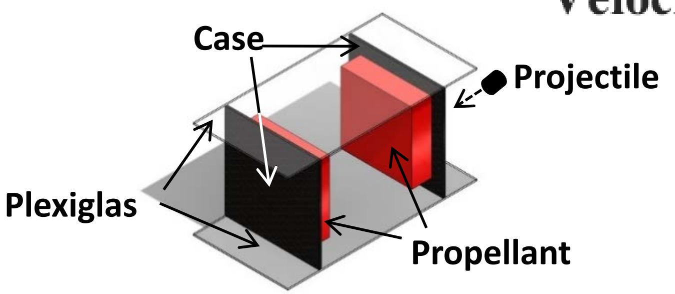
Brief Combustion

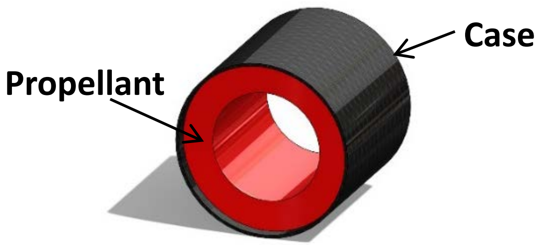


Results – Web Thickness of 1.09-1.25 in

- SDT thresholds
  - ABVR – 4329 ± 2 ft/s
  - Cylindrical – 4663 ± 63 ft/s
- XDT region includes 0.75-1.75 in air gaps (bore diameters) down to at least 2000 ft/s
  - Varies with projectile velocity
  - Regions nearly identical for ABVR and cylindrical

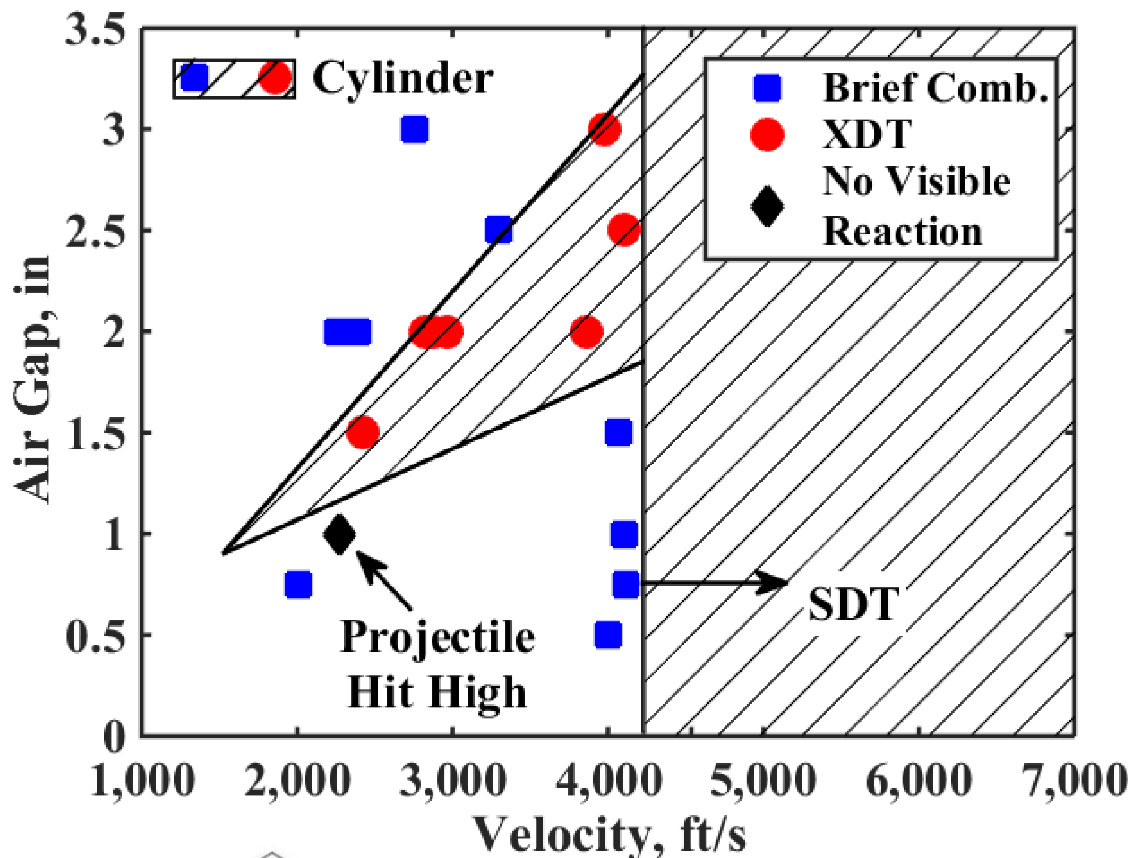


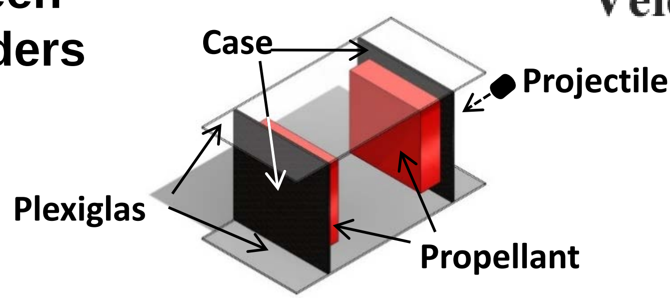


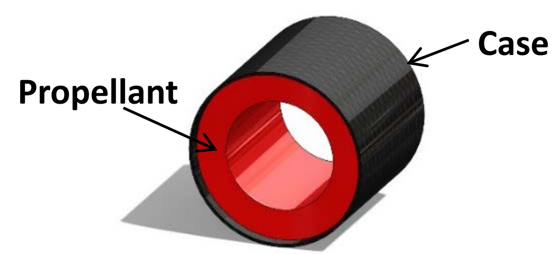


Results – Web Thickness of 2.34-2.50 in

- **SDT thresholds**
  - **ABVR – 4536 ± 125 ft/s**
  - **Cylindrical – 4219 ± 104 ft/s**
- **XDT region includes 1.00-3.25 in air gaps (bore diameters) down to at least 2000 ft/s**
  - **Varies notably with projectile velocity**
  - **Measurable difference between ABVR and cylinders**
  - **Region of no detonations**

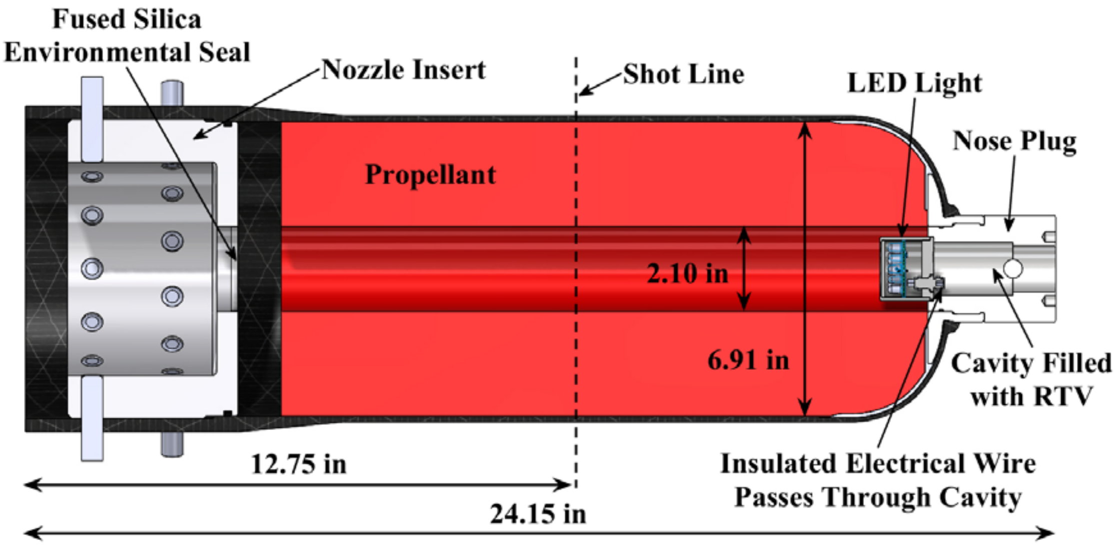






Analog Motor

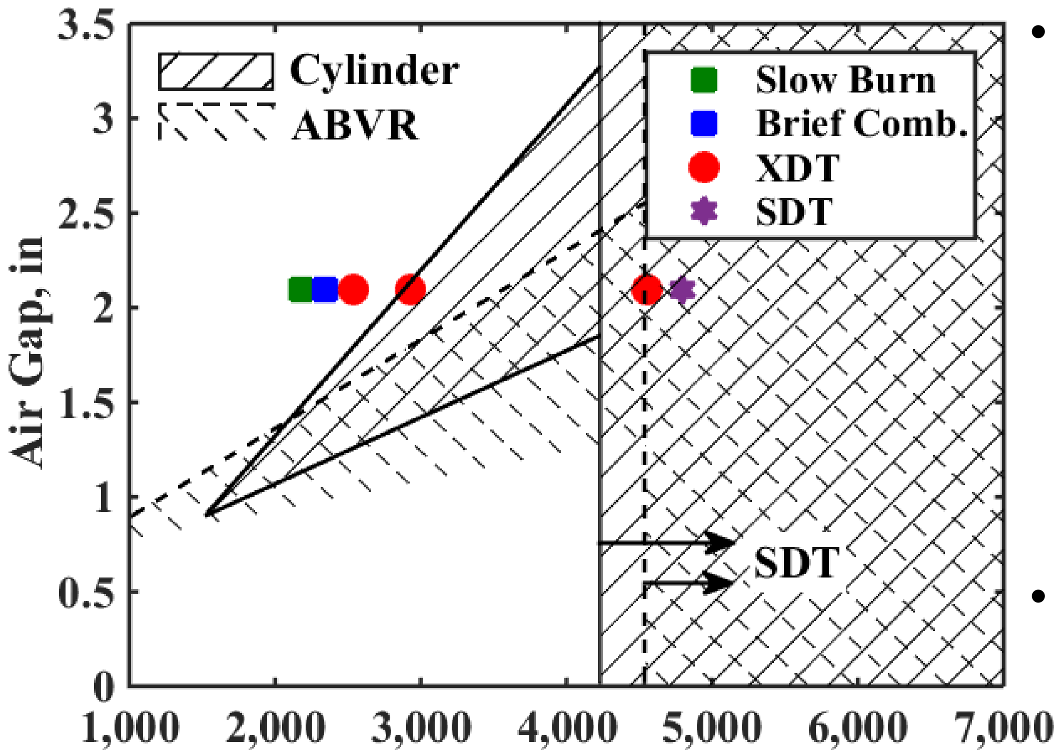
- MSP-1 propellant (31.3 lbs)
  - Web thickness of 2.41 in
- Oriented vertically – nose down
- First surface mirror allowed for internal viewing of motor
- Pressure gauges set in circular patter or 45° offset

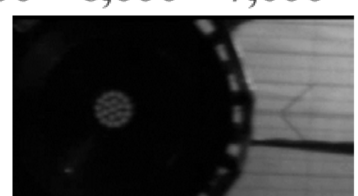


Analog Motor Tests





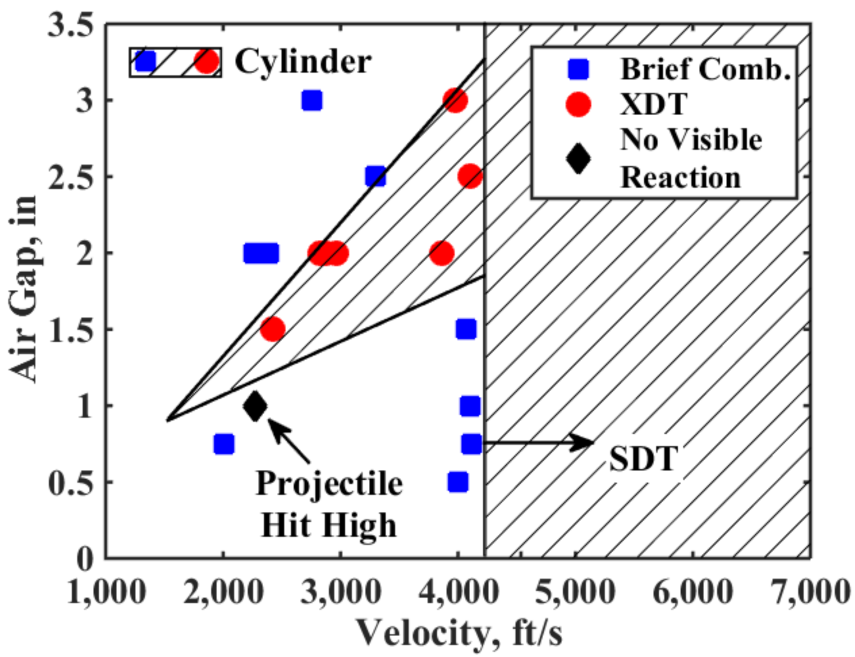


- SDT thresholds
  - ABVR – 4536 ± 125 ft/s
  - Cylindrical – 4219 ± 104 ft/s
  - Analog Motor – 4675 ± 118 ft/s
- XDT behavior very similar to cylinders

Conclusions

- ABVR reasonably predicts detonative behavior of a full scale motor
  - SDT threshold differs by <350 ft/s
  - XDT reaction region is the same for thinner web thickness
    - Thicker web causes some deviation
- Insufficient data available to compare non–detonative region
- Motors can detonate at lower velocities than what is typically expected
- Non-detonative regions may exist that are bounded by detonative regions at high and low fragment impact velocities



Acknowledgements

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Questions?

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