Venting Technology for Large Caliber Gun Propulsion Systems – Metal Cartridge Case and Packaging Container Venting

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Outline

- ***Background***
- ***Baseline Test Fixture Design***
- ***Baseline FI Test***
  - ***Setup***
  - ***Results from Tests 1 through 3***
- ***Tabulated Results (and Discussion on Igniter Contribution)***
- ***Summary***

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Background

Tree of Venting Technology Development for the Large Caliber Gun Propulsion System

- Tier I: Lg. Cal metal CC w/in metal container
- Tier II: Lg. Cal metal cartridge case (e.g. Mk67/3;105mm Tank)
- Tier III: Lg. Cal metal container (no metal CC) – 3D Venting (e.g. MACS; 120mm Tank)
- Tier IV: Med Cal CC – 2D Venting

- Venting (IM) Requirements
- Ballistic Performance/Functional Requirements
- Structural Requirements
- Manufacturing/Inspection Requirements
- Logistic Requirements …

6.3 and Post 6.3 (Applied)

R&D and Engineering

- Thermally Activated Technology
- Manufacturing/ Inspection Technology
- Structural Model
- Combustion Model

Attempting to Obtain These Skill Sets in this Program

6.2 (Intermediate) Research

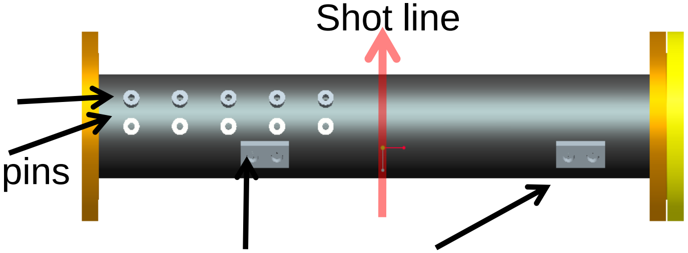
- Coupling of Combustion model and Structural model
- Effects of various venting techniques on dynamics of structural change and dP/dt
- Venting Tech. Development Process (Sub-System Level)

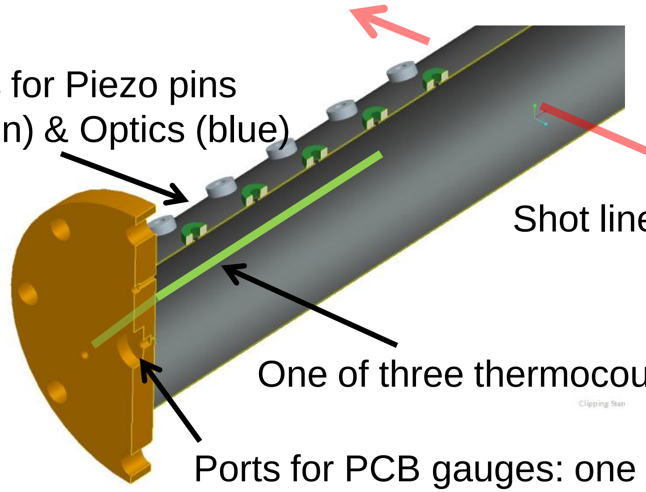
6.1 (Basic) Research

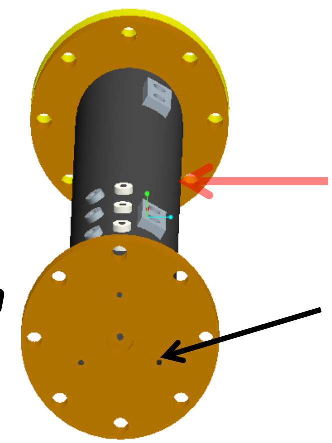
- Fundamentals of Propellant Bed Behavior: at elevated T; against Shock
- Predictive Technology (Fundamental Level)

Baseline Test Fixture (1st Iteration)

- ***Four (4) baseline test fixtures (generic containers) were fabricated***
  - ***Tube: L = 34 in, D = 6 in;***
  - ***Flange: thick. = 1 in, D = 10 in.***
  - ***Similar to MACS container dimensions***







Distance away from impact point:

- ***Five (5) optics and 5 piezo pins:***
  - ***76mm, 152mm, 229mm, 305mm, and 381mm → 3 in increments***
- ***Three (3) Thermocouples (TC):***
  - ***L = 110mm, 215mm, and 328mm → 120^o apart***
- ***Two sets of twin PCB gauges (Left → through; Right → blind)***

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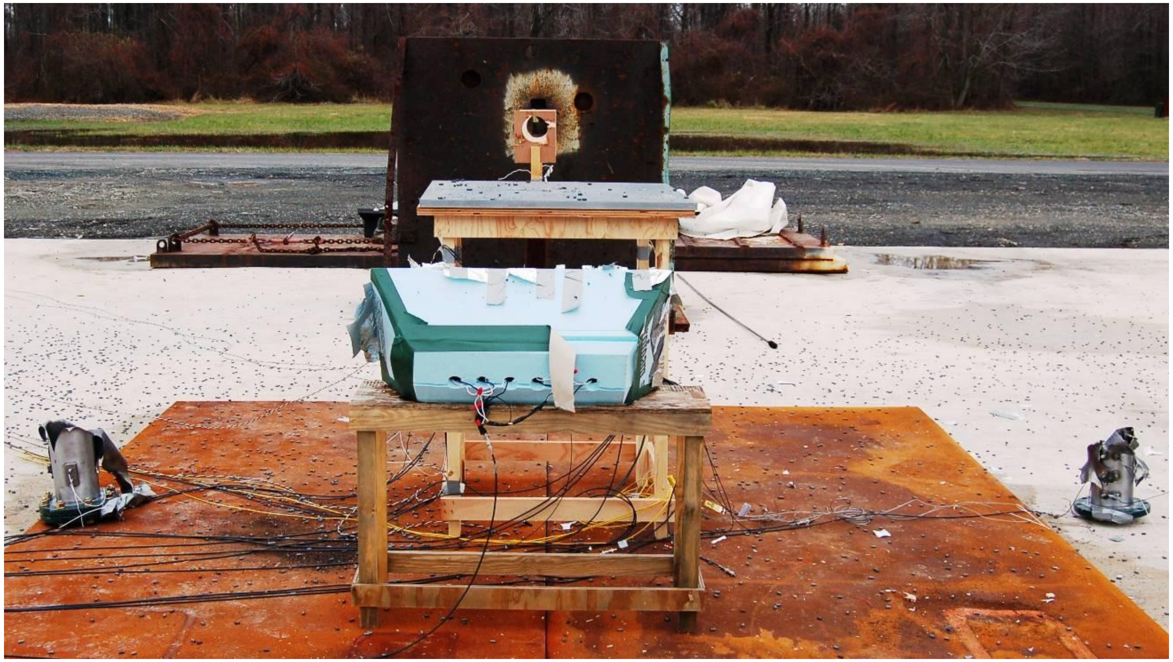
Fragment Impact Test Setup

FI Test 1 Results



- Fragment velocity: 7081 ft/s
    - new barrel resolved the issue later
- Container split into two pieces – traveled ~5 ft away from the center
- Very slow developing internal reaction, ~2.25 ms
- No damage to the foam flash bulb holder
- Both ends were intact

FI Test 2



- Fragment velocity: 8323 ft/s
- Internal reaction <1ms in duration
- End caps not thrown far (12' and 19') due to heavy mass
- Igniter tube split open in center part of tube (+/- 200 mm from impact point)
    - Igniter tube: craft paper and tape; no perforation
    - Split asymmetrically
- Both ends were intact

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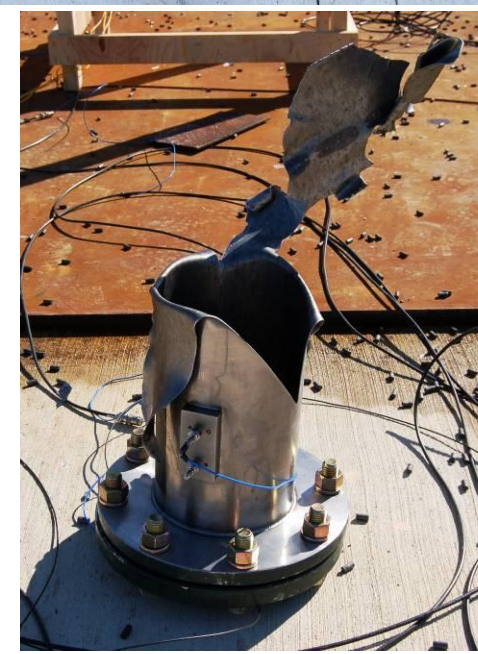
Distribution Statement A: Unlimited

FI Test 3

- Fragment velocity estimated to be ~8200 ft/s from high speed video
- Internal reaction <1ms in duration
- End caps not thrown far due to heavy mass
  - Lesser distance than Test 2
- Igniter tube shows evidence of M47 reaction +/- 150mm from impact point
  - Igniter Tube: craft paper and tape; perforations
  - Tube split evenly
- Both ends were intact
- Measured 450psi peak surface pressure at 190mm from the impact point



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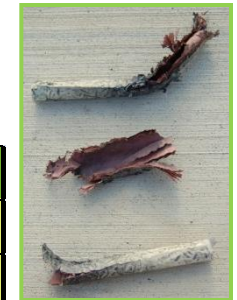
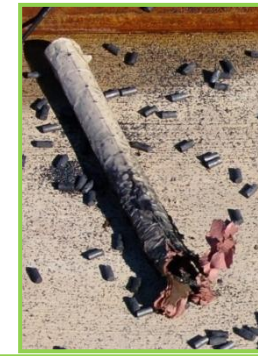
Tabulated Results and Igniter Contribution

Comparison: Tests 1-3

	Test 1	Test 2	Test 3	MACS
Frag Velocity (ft/s)	7081	8323	~8200	~8200
FI Rxn Level	(V)	(V)	(V)	-
Igniter tube	no	yes	yes	yes
Igniter tube material	N/A	paper + tape	paper + tape	combust-ible case
Igniter tube hole	N/A	no	yes	no
Rxn time (ms)	~2.25	~0.75	~0.75	-
Igniter	none	M47	M47	WC864
Propellant	M31A2	M31A2	M31A2	M31A2



Sealed Tube (Test 2) - Above



Perforated Tube (Test 3)

Igniter Tube and Igniter (therefore **initial dP/dt**) seemed to **play a bigger role than** the **overall energy density** of the propulsion system

Relative Comparisons

	Comparison
Impetus	WC864 > M47 > M31A2
Flame T	WC864 > M47 > M31A2
Violence of Rxn	Test 2 > Test 3 > Test 1

Summary

- Generic container was designed, instrumented, and FI tested to establish a baseline by obtaining the following: pressure, temperature, flamespread, reaction level, etc.
- Localized reactions were observed about 6 in. away from the point of impact
- Igniter and Igniter Tube played a big role in the overall reaction level
  - Addition of a surrogate igniter material shortened internal reaction times by a factor of 3 (750μs vs 2.25ms)
  - The rupturing of a “sealed” igniter tube resulted in a more violent reaction (possibly an increased brisance at point of igniter rupture)
  - The vented (perforated) igniter tube provided a more uniform transfer of energy to the propellant bed although overall reaction wasn’t as violent
- Overall reaction time before the rupture (in this setup) with the igniter is about 0.75 ms
- Several important factors influencing the Fragment Impact test results:
  - Location of impact – localized reactions were observed
  - Function of igniter/igniter-tube system (initial dP/dt)
  - Container’s ability to withstand force at both ends is important