RDECOM

IMPACT MITIGATION APPROACH FOR THE 105MM ARTILLERY PROPULSION SYSTEM

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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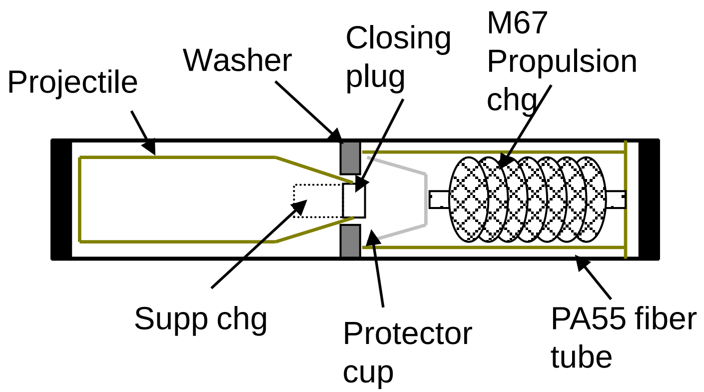
M1 IM Background

105mm M1 IM, HE cartridge – First Iteration

- 105mm M1 IM, HE cartridge is 1st iteration IM replacement for legacy munitions 105mm M1.
- Features an IM-enhanced projectile (IMX-101 fill) along with the M67 propulsion system (M67 propulsion charge and black powder primer)
- Single round is packaged in a fiber tube. Fiber tube is packaged in single metal container, or alternate packaging in wooden box (2 cartridges per box)

Sample Baseline Packaging



Impact Mitigation Background

M1 Propulsion System Impact Mitigation:

- Baseline IM assessment indicate propulsion system (M67 prop charge and black powder primer) will not achieve Type V Burning Reaction in Fragment Impact (FI) event
- During FI event, the impact shock from the high velocity fragment induces an explosive type reaction in the propellant bed and fragments the metal cartridge case
- Initial FI mitigation concept screening– None of the concepts improved upon baseline reaction

Test	Engineering Assessed Results
Baseline	Less than Type V
Combustible Cartridge Case (CCC) not in metal container	Less than Type V
CCC with metal container	Less than Type V
X” HDPE Liner	Less than Type V
2X” HDPE Liner	Less than Type V

Impact Mitigation Approach

Impact Barrier Technology

- Barrier technology has been demonstrated on explosive warheads
- Barrier material performance data available from previous ARDEC barrier effort
- Multiphysics code capability to model velocity reduction performance of barrier concepts
- Through use of threshold velocity approach, impact barrier can be designed to reduce the threat's impact velocity below the onset of a violent reaction.
  - A FI test series was conducted on the propulsion system to generate the threshold velocity information that would result in a TY V reaction

Threshold Velocity Approach

Modeling of propellant initiation and small-scale FI tests not yet applicable for propulsion systems. Design through threshold velocity approach allows for most efficient use of assets and resources for an impact mitigation solution.

1. Threshold Velocity Test - Bracket velocities that passing and non-passing reactions

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2. Through modeling, screen barrier concepts that best achieve threshold velocity

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3. Fabricate down-selected barrier concepts; screen concepts in performance testing

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4. Best-performing barriers assessed with live propulsion system

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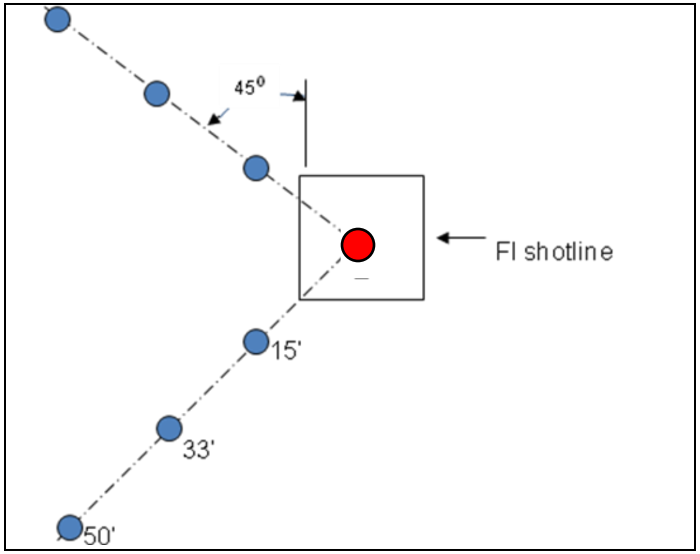
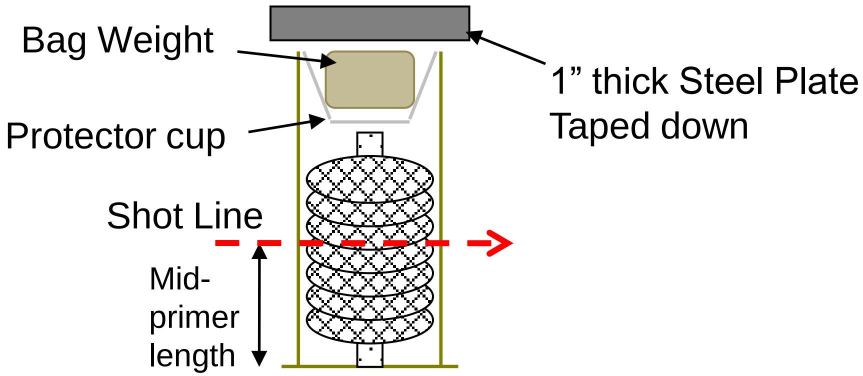
5. Down-select to best barrier concept

Threshold Velocity Test Setup





•Shot line into the middle of primer tube

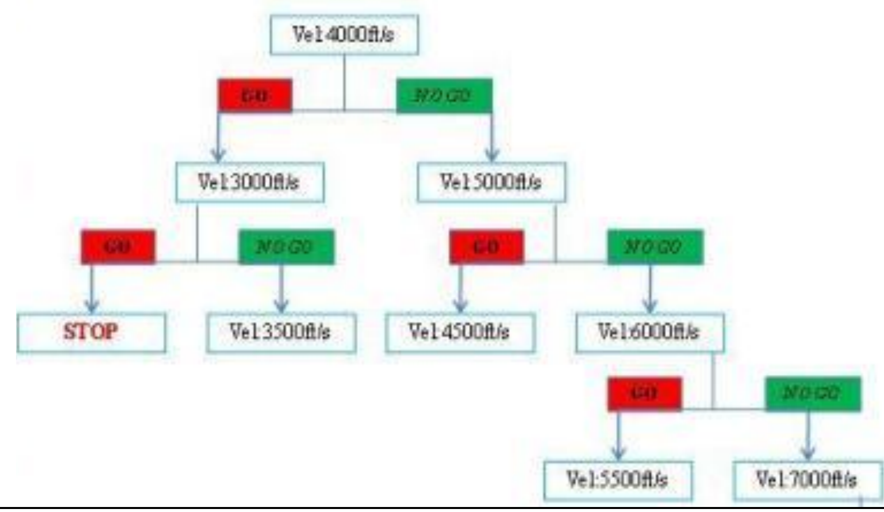
•Bag weight and steel plate to simulate confinement of its logistical configuration

•Ground pressure gages at 15’, 33’, and 50’

Testing Approach

Test	Fragment Vel (fps)	Live/Inert Propulsion	NOTES
1	8300	Live	Test shot is to re-establish baseline reaction
2	8300	Inert	Test shot to establish characteristics of a passing reaction. Inert cartridge case was filled with rabbit food pellets and without primer
3	6000	Live	Test shot to evaluate reaction to decreasing fragment velocity
4	4000	Live	Test shot to evaluate reaction to decreasing fragment velocity
5-TBD	TBD	Live	Follow testing flow chart until a passing reaction is bracketed
Last Shot	8300	Live w/o Primer	Test shot to assess possible benefits of integrating lower sensitivity primer

Propulsion FI Evaluation Flow Chart



8300 fps Shot – Live Test Results

• Many pieces outside 50 ft
• Pressure Gages P1 and P4 recorded pressures significantly higher than 1 psi

Results indicates cartridge case fragmented into several pieces that traveled over distances greater than 50'. Peak pressure from the item exceeded 1 psi.

8300 fps Shot – Live w/o Primer Test Results

• Many pieces outside 50 ft
• Pressure Gages P1 and P4 recorded pressures significantly higher than 1 psi

Results indicates cartridge case fragmented into several pieces that traveled over distances greater than 50'. Peak pressure from the item exceeded 1 psi. Results similar to baseline live shot with live primer.

8300 fps Shot – Inert Test Results

- No debris outside 50 ft
- Cartridge case was intact with 6” X 4” hole

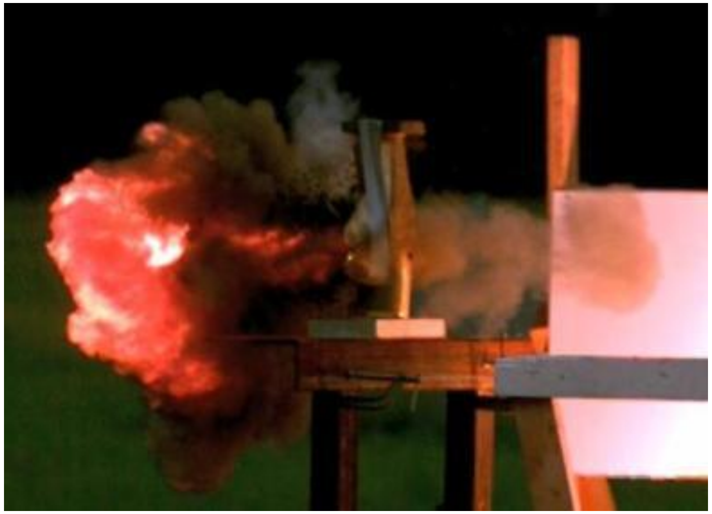
Results indicates cartridge case may sustain substantial damage from fragment exit in a passing reaction, even in absence of energetics.

6000 fps Shot – Live Test Results

• Some pieces outside 50 ft
• Pressure Gages P1 and P4 recorded pressures higher than 1 psi

Reaction indicates cartridge case fragmented into a few large pieces that traveled over distances greater than 50'. Peak pressure from the item exceeded 1 psi but were lower than pressures from 8300 shot.

4000 fps Shot – Live Test Results



- No debris outside 50 ft
- Pressure Gages P1 and P4 recorded pressures less than 1 psi

Results indicate passing reaction. Cartridge case behaved similarly to baseline inert shot, with intact ctg case with large exit hole. Pressures recorded were less than 1 psi.

4500 fps Shot – Live Test Results

- No debris outside 50 ft
- Pressure Gages P1 and P4 recorded pressures less than 1 psi

Results indicate passing reaction. Cartridge case behaved similarly to baseline inert shot, with intact ctg case with large exit hole. Pressures recorded were less than 1 psi. Actual velocity of shot was ~4800 fps.

3000 fps Shot – Live Test Results

- No debris outside 50 ft
- Pressure Gages P1 and P4 recorded pressures less than 1 psi

Results indicate passing reaction. Cartridge case remained intact with small exit hole. Pressures recorded were less than 1 psi.

Threshold Velocity Test Conclusions

Frag Vel. (fps)	Prop. System (L/I)	ARDEC Assessment*
8,300	Live	Less than TY V
6,000	Live	Less than TY V
5,500	Live	Less than TY V
5,000	Live	Less than TY V
4,500	Live	Type V
4,000	Live	Type V
3,000	Live	Type V
8,300	Live w/o primer	Less than TY V
8,300	Inert	---

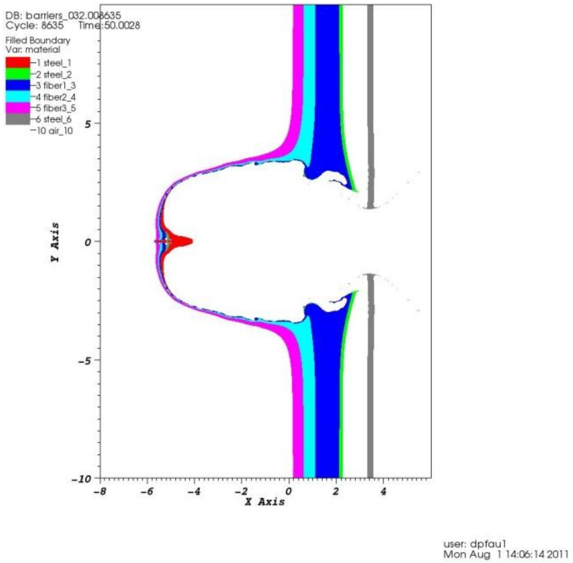
Follow-up testing fired additional shots at fragment velocities of 5000 and 5500 fps to isolate the threshold velocity.

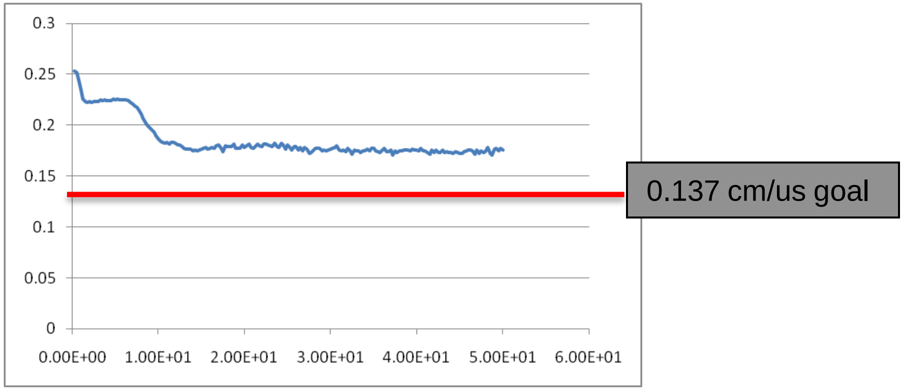
Test results indicate threshold velocity is in between the 4500 fps shot (recorded velocity of ~4800 fps) that produced a passing reaction, and 5000 fps shot that did not produce a passing reaction. Threshold velocity was set at 4800 fps.

The baseline live shot, and last test shot without a live primer, were both assessed to have similar reactions. This indicates the black powder primer has little contribution to the reaction at the fragment impact level, and demonstrate impact mitigation of the 105mm artillery propulsion system does not necessitate the investigation of a less sensitive primer.

Impact Barrier Concept Screening

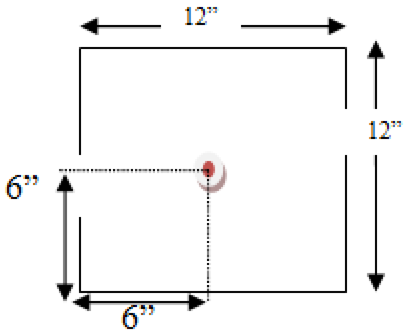
With threshold velocity in place, barrier concepts were screened through multiphysics code modeling to simulate the velocity distribution of a fragment impacting through the barrier material(s).





Several barrier concepts achieved the threshold velocity and were down-selected for FI performance assessment

Barrier Performance Test

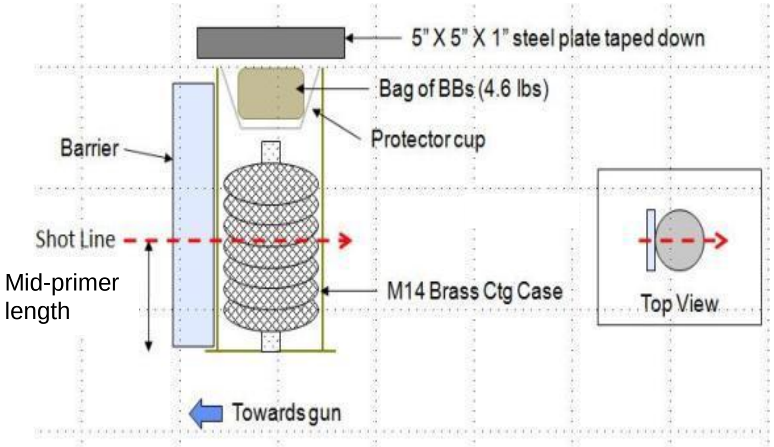


Test Results Summary

Test	Description	Recorded frag Vel (fps)	Recorded exit velocity (fps)	Delta V	Model Exit V
~~1~~	~~Barrier Concept 1~~	~~7933~~	~~6671~~	~~1262~~	~~---~~
2	Barrier Concept 2	7449	3340	4109	---
3	Barrier Concept 3	8003	5480	2523	5675
4	Barrier Concept 4	7923	4050	3873	4170
5	Barrier Concept 5	7940	5853	2087	5000
6	Barrier Concept 6	7993	4009	3984	3700
7	Barrier Concept 7	7982	5996	1986	---
8	Barrier Concept 1	7922	4363	3559	---

Barrier down selected to 3 candidates highlighted in table

Barrier Live Test Setup



Test Results Summary

Test	Description	Assessment
1	Barrier Concept 4	Less than TY V
2	Barrier Concept 6	Type V
3	Barrier Concept 1	Type V
4	Barrier Concept 6	Type V
5	Barrier Concept 1	Type V
6	Barrier Concept 4	Less than TY V

Best barrier candidates:
- Barrier concept 6
- Barrier concept 1

Conclusions/Future work

Program has down-selected to a single barrier concept

Program will proceed to design and develop a full-scale prototype for demonstration in FI testing

As propellant initiation modeling and small-scale FI testing are not yet applicable for propulsion systems, threshold velocity approach was the optimal approach for impact mitigation of the 105mm artillery propulsion system

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QUESTIONS?