Pyrotechnic Shock Loading of the M82 Percussion Primer in the M777 Light Weight Howitzer Magazine Assembly

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Pyrotechnic Shock Loading of the M82 Percussion Primer in the M777 Light Weight Howitzer Magazine Assembly

- **Background**
  - M82 Percussion Primer Description and Design
  - M777 Primer Feed Mechanism
  - Premature Primer Functioning Observations
  - Test Design and Objective

- **Evaluation of Operational Loading of M777 Magazine Assembly**
  - Instrumentation Description
  - Field Test Firing Schedule
  - Data Reduction/Signals Analysis

- **Simulation of Operational Loading with Laboratory Shock Tests**
  - Baseline Sensitivity Test
  - Pyrotechnic Shock
  - Sine Burst
  - Drop Shock

- **FEA and Test Results**

- **Summary and Conclusions**
M82 Percussion Primer Description

- US Army and Marine Corps standard primer for the initiation of all 155mm Howitzers
- During functioning, black powder output ignites propelling charge
- On earlier Howitzers the primer was hand loaded into breach
- New Howitzer designs incorporate a mechanical loading assembly
M82 Percussion Primer Design

PRIMER CHARGE
(BLACK POWDER)

PRIMER

BODY

PLUNGER
M777 Howitzer Primer Feed Mechanism Description

PRIMER FEED AT BREACH ASSEMBLY

PRIMER MAGAZINE AND TRAY ASSEMBLY
Premature Primer Functioning

- During initial weapon testing, multiple primers functioned in the magazine during firing
- Field malfunctions associated with functioning of primers during chambering
- Primer is subjected to extreme forces associated to M777 firing
- Primer not designed to withstand these types of forces
**Test Design and Objective**

Understand the impact of M777 firing on the M82 primer
- Measure forces associated with M777 firing
- Simulate these forces
- Condition M82 Primers to simulated forces
- Verify their functional performance and sensitivity
Instrumentation Description

- 3 Each Endevco 2225M5A Piezoelectric Accelerometers (100,000 g’s)
- Installed on Tri-axial Mounting Block
- Mounting Block Bolted to Top of Primer Magazine Assembly
- Cables Tied Down and Routed to Side of Gun System
- Endevco 133 Charge Amplifier
- LDS Genesis Digital Data Recorder
  - 125 kHz Sampling Rate
### Field Test Firing Schedule

<table>
<thead>
<tr>
<th>Round Numbers</th>
<th>Projectile</th>
<th>Fuze</th>
<th>Propelling Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>M795 HE</td>
<td>M739A1</td>
<td>MACS at Increment 5</td>
</tr>
<tr>
<td>5-8</td>
<td>M795 HE</td>
<td>M739A1</td>
<td>M203A1</td>
</tr>
<tr>
<td>9-12</td>
<td>M107 HE</td>
<td>M739A1</td>
<td>M4A2 White Bag - Charge 7</td>
</tr>
</tbody>
</table>
Data Reduction/Signals Analysis

Raw Accel Data – Z Axis

Smoothed

Band Pass Filter
Composite Acceleration Shock Response Spectra

- X Axis
- Y Axis
- Z Axis
Data Reduction/Signals Analysis Summary

• Forces compromised of 3 distinct phenomena
  – Shock associated with propellant combustion
  – Harmonics associated with projectile travelling down barrel
  – Recoil force
"Data Reduction/Signals Analysis - Conclusions"

- Laboratory simulation requires three techniques
  - Pyrotechnic Shock
    - Simultaneous in all 3 axes
    - Based on Composite SRS
  - Electro-Dynamic Shaker
    - 250 Hz, 200 g Sine Burst in Z axis
  - Drop Test
    - 200 g, 10 msec Half Sine Pulse in Z axis
Simulation of Operational Loads – Test Methodology

• Sensitivity Testing
  – Establish Baseline M82 Percussion Primer Lot Sensitivity
  – Evaluate Impact of Sequential Shock Testing on Sensitivity

• Shock Testing w/Test Fixtures to Replicate Tactical Magazine Interfaces
  – 100 Primers Total
  – Replica Magazine Test Fixture Holds 10 Primers
  – 9 Shock Replications Applied to Each Group Sequentially
    • Drop Shock
    • Pyrotechnic Shock Tests
    • Sine Burst Tests
Drop Shock Testing

M82 Primers in Magazine Fixture

Drop Shock Test Setup

Accel Data – Z Axis
**Pyrotechnic Shock Testing**

- Magazine Fixture w/Accels
- Magazine Fixture Mounted to Resonating Plate
- Det Cord Patterns for Pyroshock

Example +/- SRS Response Curve
Pyrotechnic Shock Testing
Premature Function of M82 Primer

Group 5 Pre-Test

Group 5 Post-Test

Group 5 SN 1 Premature Function (overstress of force)
Sine Burst Shock Testing

Group 10 Pre-Test

Example Response Accel Output

Electro-Dynamic Shaker Test Setup
Dynamic FEA Analysis Results

Plunger/Primer Only Model:
Primer Cup Material Yield Strength Approx 17 ksi

<table>
<thead>
<tr>
<th>Dynamic Shock Load</th>
<th>Max Von Mises Stress in Primer Cup (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z Axis Pyroshock SRS</td>
<td>19.8</td>
</tr>
<tr>
<td>Z Axis Drop Shock</td>
<td>0.136</td>
</tr>
<tr>
<td>Z Axis Sine Burst</td>
<td>0.235</td>
</tr>
</tbody>
</table>
Summary and Conclusions

- Operational Loading of M82 Percussion Primers During M777 Firings Evaluated for Various Maximum Charge Configurations
  - Loading consists of three aspects: pyrotechnic shock, 250 Hz harmonic burst, and recoil shock

- Pyrotechnic Shock Loading is Most Severe Aspect of Operational Loads Based on Lab Tests and Dynamic FEA Analysis
  - Overstress induced premature function of primers

- Sensitivity testing of conditioned primers in progress