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
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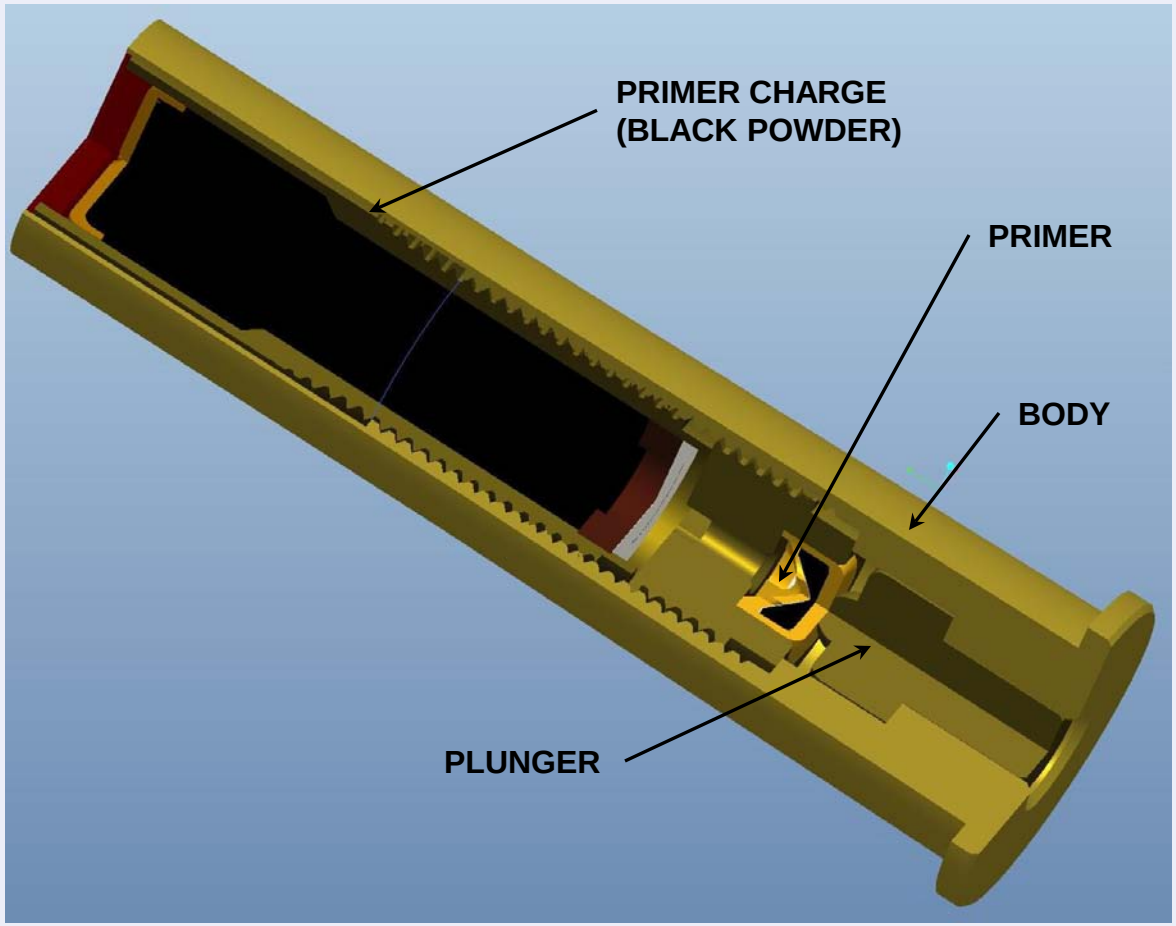
  - M777 Primer Feed Mechanism
  - Premature Primer Functioning Observations
  - Test Design and Objective
- Evaluation of Operational Loading of M777 Magazine Assembly
  - Instrumentation Description
  - Field Test Firing Schedule
  - Data Reduction/Signals Analysis
- Simulation of Operational Loading with Laboratory Shock Tests
  - Baseline Sensitivity Test
  - Pyrotechnic Shock
  - Sine Burst
  - Drop Shock
- FEA and Test Results
- Summary and Conclusions

M82 Percussion Primer Description

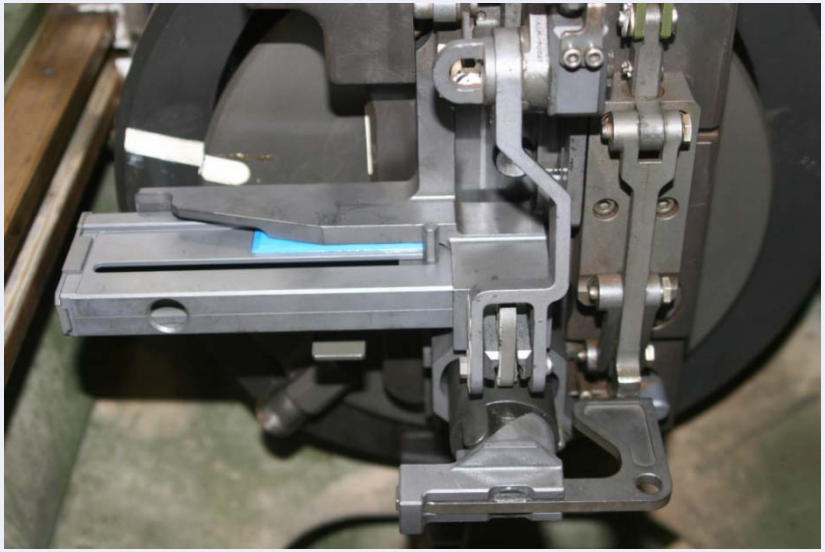
- US Army and Marine Corps standard primer for the initiation of all 155mm Howitzers
- During functioning, black powder output ignites propelling charge
- On earlier Howitzers the primer was hand loaded into breach
- New Howitzer designs incorporate a mechanical loading assembly

M82 Percussion Primer Design



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

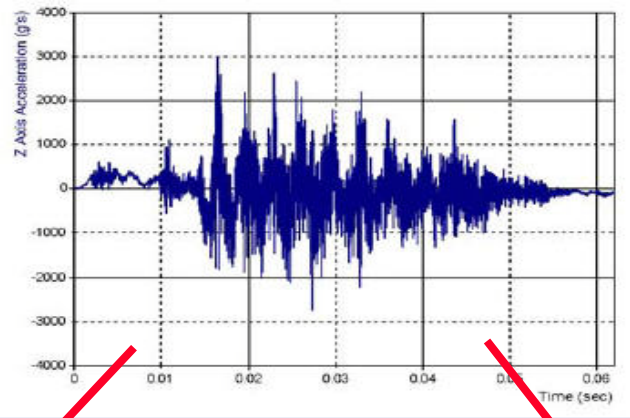
- 3 Each Endevco 2225M5A Piezoelectric Accelerometers (100,000 g's)
- Installed on Tri-axial Mounting Block
- Mounting Block Bolted to Top of Primer Magazine Assembly
- Cables Tied Down and Routed to Side of Gun System
- Endevco 133 Charge Amplifier
- LDS Genesis Digital Data Recorder
  - 125 kHz Sampling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

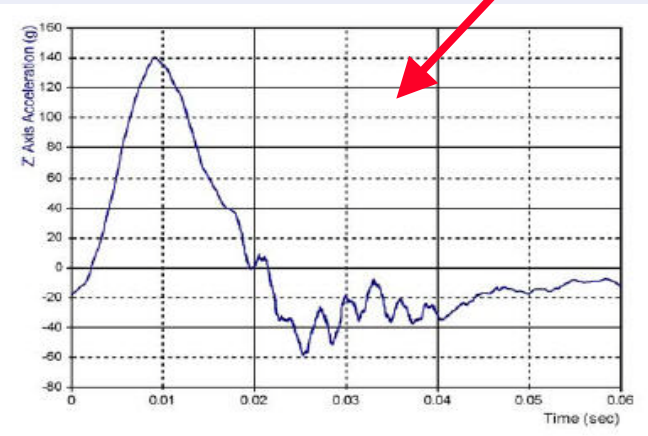
Field Test Firing Schedule

Round Numbers	Projectile	Fuze	Propelling Charge
1-4	M795 HE	M739A1	MACS at Increment 5
5-8	M795 HE	M739A1	M203A1
9-12	M107 HE	M739A1	M4A2 White Bag - Charge 7

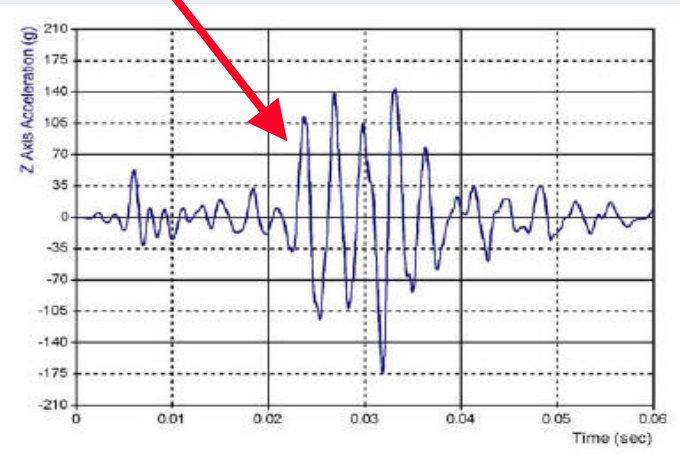
Data Reduction/Signals Analysis

Raw Accel Data – Z Axis



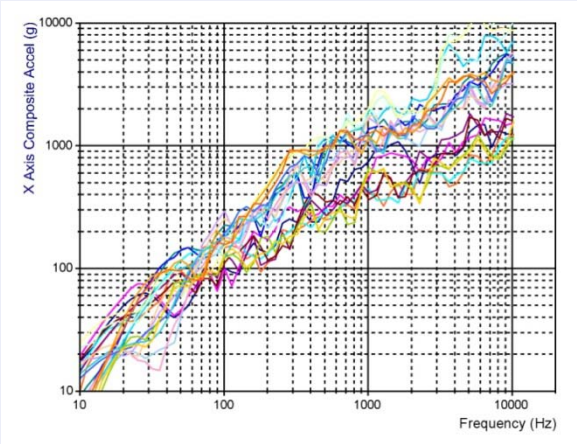


Smoothed

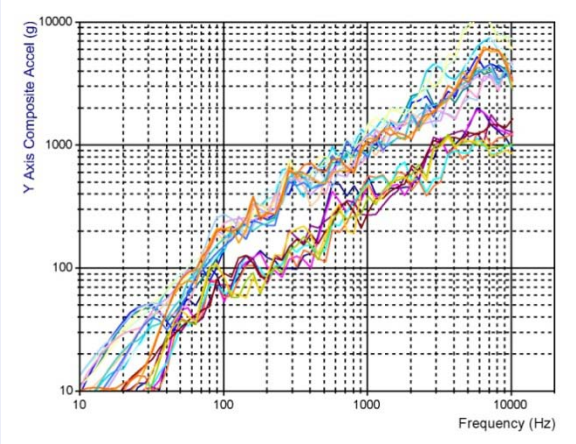


Band Pass Filter

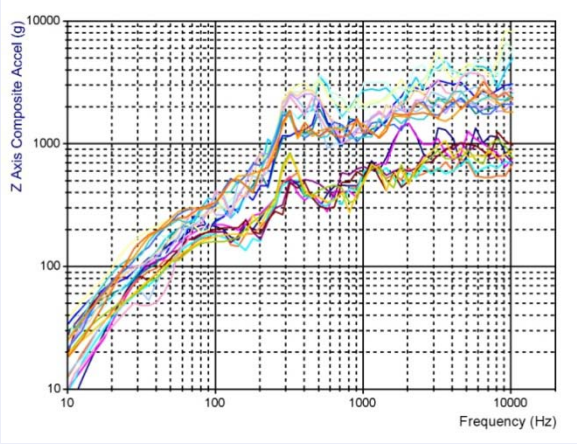
Composite Acceleration Shock Response Spectra



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

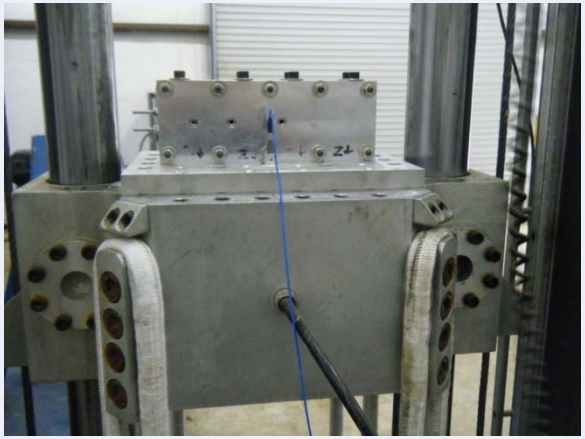
- Laboratory simulation requires three techniques
  - Pyrotechnic Shock
    - Simultaneous in all 3 axes
    - Based on Composite SRS
  - Electro-Dynamic Shaker
    - 250 Hz, 200 g Sine Burst in Z axis
  - Drop Test
    - 200 g, 10 msec Half Sine Pulse in Z axis

Simulation of Operational Loads – Test Methodology

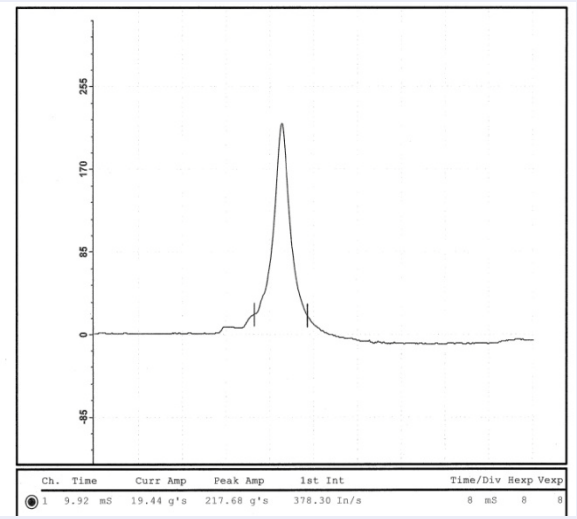
- **Sensitivity Testing**
  - **Establish Baseline M82 Percussion Primer Lot Sensitivity**
  - **Evaluate Impact of Sequential Shock Testing on Sensitivity**
- **Shock Testing w/Test Fixtures to Replicate Tactical Magazine Interfaces**
  - **100 Primers Total**
  - **Replica Magazine Test Fixture Holds 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

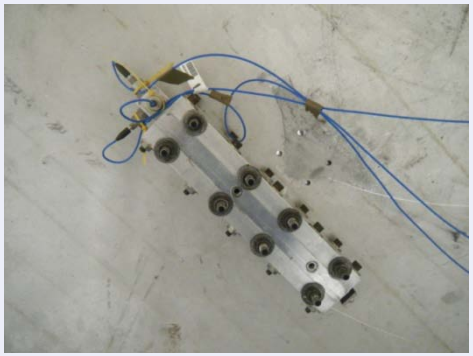


Drop Shock Test Setup

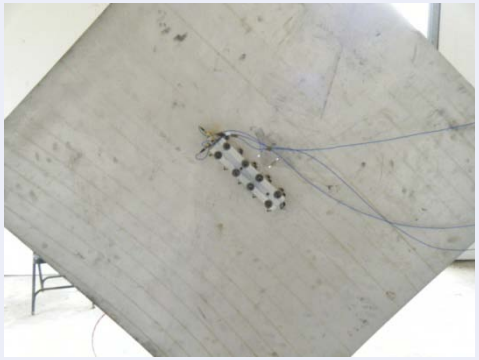


Accel Data – Z Axis

Pyrotechnic Shock Testing

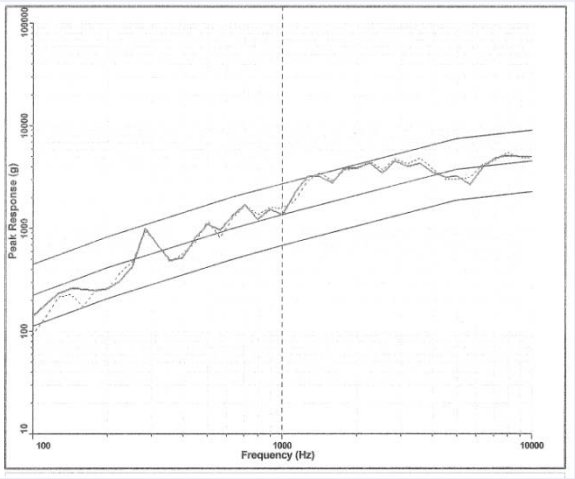


Magazine Fixture w/Accels



Magazine Fixture Mounted to Resonating Plate

Det Cord Patters for Pyroshock



Example +/- SRS Response Curve

Pyrotechnic Shock Testing
Premature Function of M82 Primer

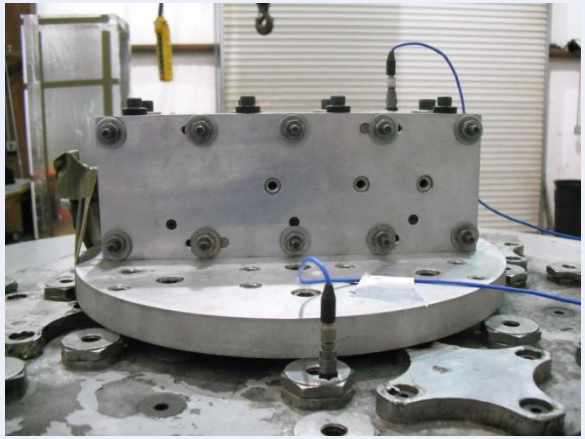
Group 5 Pre-Test

Group 5 Post-Test

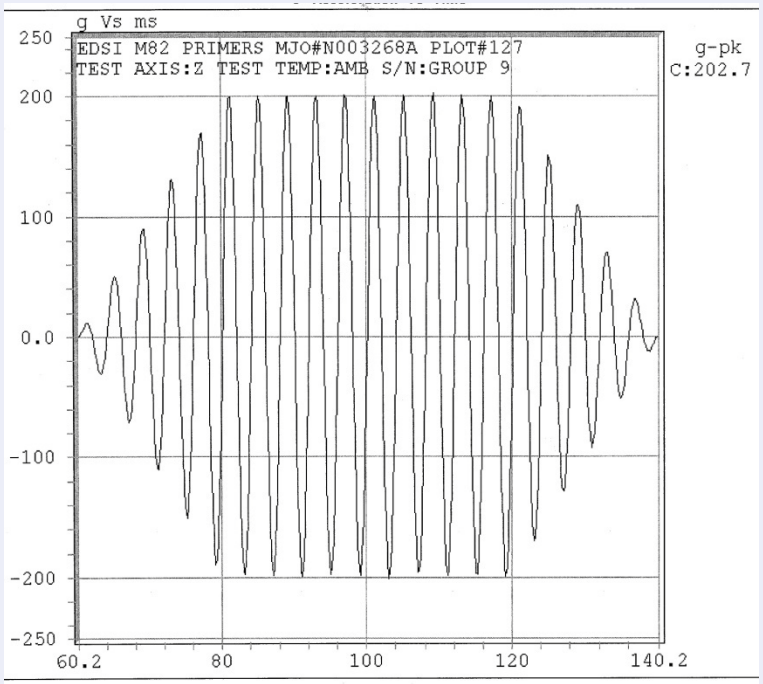
Group 5 SN 1 Premature Function
(overstress of force)

Sine Burst Shock Testing

Group 10 Pre-Test

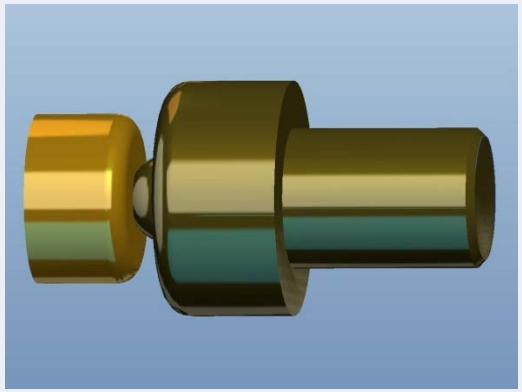


Electro-Dynamic Shaker Test Setup

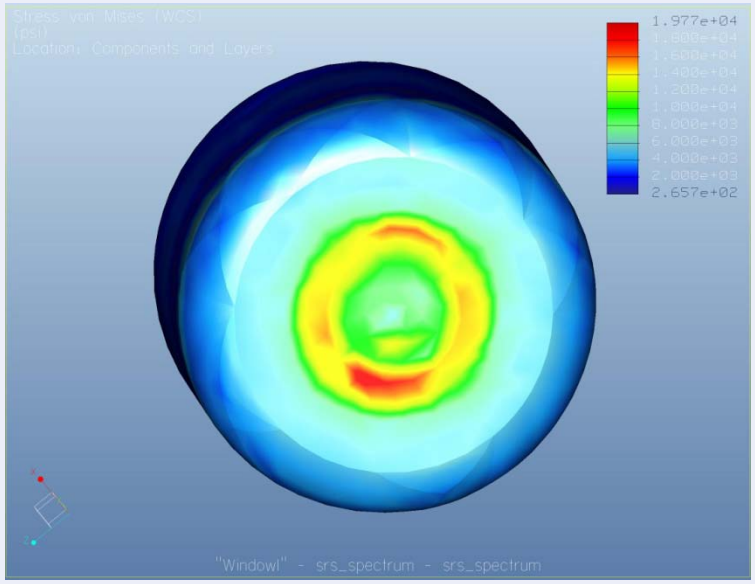


Example Response Accel Output

Dynamic FEA Analysis Results



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



Dynamic Shock Load	Max Von Mises Stress in Primer Cup (ksi)
Z Axis Pyroshock SRS	19.8
Z Axis Drop Shock	0.136
Z Axis Sine Burst	0.235

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