HIGH-G TESTING FOR FUZE RESEARCH

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SEPTEMBER 2005

Symposium Presentation

This presentation was made at the 74th Shock & Vibration Symposium, San Diego, California, October 28, 2003. One or more of the authors is a U.S. Government employee working within the scope of his/her position; therefore, the U.S. Government is joint owner of the work. If published copyright may be asserted. If so, the U.S. Government has for itself and others acting on its behalf, the right to copy, distribute, and use the work by or on behalf of the U.S. Government.
# High-G Testing for Fuze Research

**1. REPORT DATE**  
30-09-2005

**2. REPORT TYPE**  
Symposium Presentation

**3. DATES COVERED**  
01-10-2002 – 30-09-2003

**4. TITLE AND SUBTITLE**  
High-G Testing for Fuze Research

**5. AUTHOR(S)**  
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**6. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**  
Air Force Research Laboratory  
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AFRL/MNMF  
Eglin AFB, FL 32542-5430

**7. PERFORMING ORGANIZATION REPORT NUMBER**

**8. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**  
Air Force Research Laboratory  
Munitions Directorate  
AFRL/MNMF  
Eglin AFB, FL 32542-5430

**9. SPONSOR/MONITOR’S ACRONYM(S)**  
AFRL-MN-EG

**10. SPONSOR/MONITOR’S REPORT NUMBER(S)**  
AFRL-MN-EG-TP-2005-7412

**11. DISTRIBUTION / AVAILABILITY STATEMENT**  
APPROVED FOR PUBLIC RELEASE; Distribution Unlimited

**12. ABSTRACT**  
The Fuzes Branch of the Air Force Research Laboratory, Munitions Directorate, has performed/instrumented numerous experiments in support of fuze development. These experiments include a wide shock spectrum ranging from relatively benign bench level experiments up to high velocity impact into multi-layered hardened structures. In this presentation we will discuss the Air Force requirements for high-g shock testing for fuze research and our testing and instrumentation capabilities.

**13. SUPPLEMENTARY NOTES**  
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**14. SECURITY CLASSIFICATION OF:**

<table>
<thead>
<tr>
<th>a. REPORT</th>
<th>b. ABSTRACT</th>
<th>c. THIS PAGE</th>
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<tr>
<td>Unclassified</td>
<td>Unclassified</td>
<td>Unclassified</td>
</tr>
</tbody>
</table>

**15. SUBJECT TERMS**  
Fuzes, Ordnance, Shock Testing, High-g Shock, Dynamic Fuze Testing, VHG, Drop Tower, Hopkinson Bar

**16. NUMBER OF PAGES**  
21

**17. LIMITATION OF ABSTRACT**  
SAR

**18. NAME OF RESPONSIBLE PERSON**  
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**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std. Z39.18
High-G Testing for Fuze Research

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74th Shock & Vibration Symposium
San Diego, California
October 28, 2003
Outline

• What’s a Fuze
• Requirements
• Testing Capabilities
• Challenges
A fuze ensures that munitions:

- Do not explode prematurely
- Determines when and where to detonate
- Initiates the detonation
Penetrating Weapon
Penetration Fuzing

Electronic Bomb Fuze
FMU-143 B/B
Fixed Pyrotechnic Delay

Joint Programmable Fuze
FMU-152 /B
Proximity Fire, Electronic Select,
Impact Delay

Hard Target Smart Fuze
FMU-159 /B
“Smart” Void, Layer, Time…
The Future of Penetration Fuzing

- More robust
- More reliable
- Smaller
- Smarter
  - Different sensors
  - Focused initiation
- Communication
  - Between munitions
  - During impact
Guidelines

• Safety Rules (MIL-STD 1316)
  – Explosives
  – Environmental Sensors
  – Arming
  – Safe Separation
  – Launch

• Safety rules evaluated in context of each Munition System
  – e.g. safe separation for AMRAAM different than Mk-82 bomb

• Rules applied depending on explosive train design
The Problem At Hand

• Understand the acceleration environment
  
  – Lower frequencies to determine rigid body response for development of burst point control fuzing
  
  – Higher frequencies to define the environment the fuze must survive

• Create realistic environments; known and repeatable

• No Mil Std for shock survivability, outside of transportation
Testing Capabilities for Shock

- Dynamic Shock Facility
  - Hopkinson Bar
  - Drop Tower
  - Very High G (VHG) Machine
  - Centrifuge
- Field Testing
  - Cannon
  - Sled Track
  - Air-Delivered
Hopkinson Bar

• Attributes:
  – Air driven impactor
  – 1 in. diameter titanium bar
  – Programmers used to shape leading edge of pulse

• Used for:
  – Instrumentation Studies
  – Material Properties Testing
    • Shock-isolation materials & techniques
Drop Tower

• Attributes:
  – Drop heights up to 10 ft.
  – Free fall or driven with a bungee cord
  – Programmers used to shape pulse
  – Payload – 25 lbs

• Used for:
  – Component Testing
  – Full-up Fuze
Very High G (VHG) Machine

- **Attributes:**
  - Air driven 10 lbs impactor
  - Payload – 10 lbs
  - Pulse shaped using:
    - Different anvil materials
    - Programmers

- **Used for:**
  - Instrumentation Studies
  - Component Testing
  - Full-up Fuze
Centrifuge

- Attributes:
  - 20-30 kg
  - Payload – 5 lbs
  - Long-duration high-g testing
  - RF data transmission

- Used for:
  - Instrumentation Studies
  - Component Testing
Cannon Testing

• Attributes:
  – Howitzer Cannons
    • various barrel sizes
    • Smooth bore and rifled
  – Projectiles
    • OD 3.6 - 8 in.
    • Weight between 25 – 250 lbs
  – Targets
    • 4 in. thick to 4 ft thick
    • 30 in. dia. to 7 ft x 9 ft
    • Single or multi-layer configurations

• Used for:
  – Full-up Fuze
  – Component Testing
  – Instrumentation Studies
Sled Track

• Attributes:
  – 2000 ft long
  – Velocities > 2000 fps for a 2000 lb item
  – Unlimited target size

• Used for:
  – Full-up Fuze
  – Full-scale weapon (integration) testing
Air-Delivered

• Attributes:
  – Realistic missions
  – Realistic environment

• Used for:
  – Full-up fuze
  – Full-scale weapon system (integration) testing
Objective vs. Capabilities

![Graph showing comparison between Hopkinson Bar, VHGC, Drop Tower, Field Data, and Requirement over time and g-level.](image-url)
Challenges

• Can’t afford to conduct just field tests (nor is it appropriate)

• Currently limited to 1-D environments in the lab

• Experience has shown that to survive a sled test an entire suite of tests must be conducted in the lab, e.g.,
  – Normal
  – Reverse
  – Lateral at varying angles (0, 45, 90, etc.)
Summary

• Changing requirements
  – More severe environments
  – Perform additional functions

• Combination of lab/field tests required

• Interesting testing and instrumentation challenges remain
  – Realistic environments
  – Testing techniques
  – Accurate, robust instrumentation