



*High Speed Digital Infrared Imaging
of the
M201A1 Grenade Fuze Initiation Train
Presented to the
NDIA Fuze Conference
May 2010*

Co-Authors

- **Dr. Ryan Olsen, T&E Board Chairman, NSWC Crane, Detachment Fallbrook, ESED**
- **Ms. Christine Grasiniski, Mechanical Engineer, NSWC Crane, Detachment Fallbrook, ESED**
- **Mr. Jon Conner, Senior Scientist, National Technical Systems, Dana Point, CA**
- **Ms. Kathryn Hunt, Chemical Engineer, USMC MARCORSSCOM, PM Ammo**

Presentation Outline

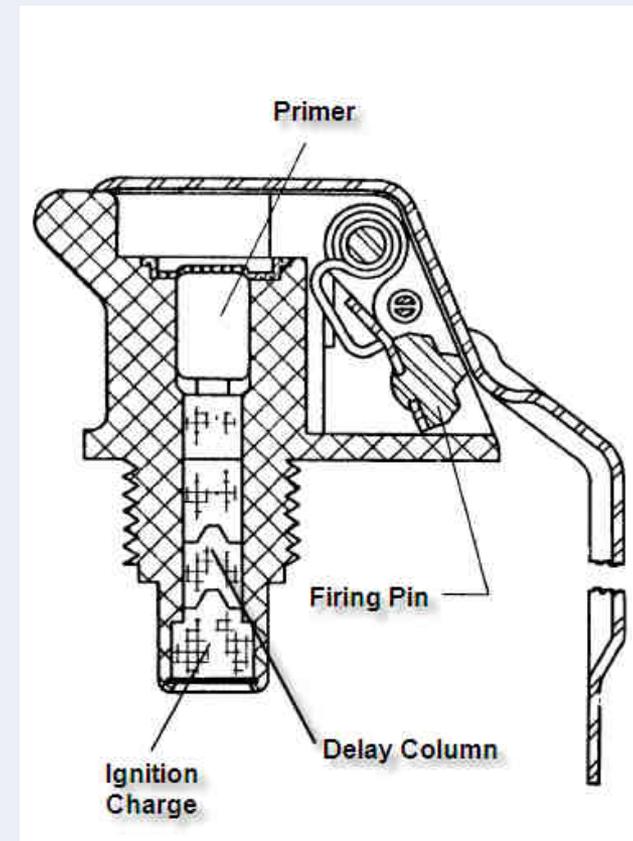
- **Background**
 - M201A1 Pyrotechnic Delay Hand Grenade Fuze Description
- **Approach**
 - Digital IR Camera Description
 - Test Setup
- **Test Results**
 - Data Reduction Methodology
- **Summary and Conclusions**

M201A1 Fuze Description

- The M201A1 Fuze is used on a number of hand grenades including:
 - M18 Colored Smoke
 - AN-M14 Incendiary Thermite (TH-3)
 - AN-M8 HC (Hexachloroethane) Smoke
 - M73A CS Riot Control
 - M83 TA Practice (Teraphthalic Acid) Smoke
- Failures of these grenades to function are often attributed to M201A1 Fuze misfire

M201A1 Fuze Description

- Contains three stage initiation train:
 - Primer
 - Delay Column
 - Ignition Charge
- Functional Sequence
 - Remove of Safety Pin
 - Release of Safety Lever
 - Spring loaded striker impacts Percussion Primer
 - Delay Column initiated (2 sec delay)
 - Ignition Charge fires



Approach

- **Typical thermal output assessment tools**
 - Disassembly and dissection of energetics
 - Bomb Calorimetry
 - DSC (Differential Scanning Calorimetry)
 - TGA (Thermal Gravimetric Analysis)
- **Approach**
 - Measure thermal output of fuze initiation train without disassembly
 - Perform high speed IR imaging of surface of fuze body
 - Quantify surface temperature profile during function

Digital IR Camera Description

- **FLIR Systems Thermovision SC4000 InSb Camera System**
 - Wavelength: 3.0-5.0 μm
 - Resolution: 320 x 256 Pixels
 - Full Frame Rate: 420 Hz
 - Sensor Cooling: Stirling Closed Cycle
 - Lens: 100 mm InSb lens, f/2.3
 - Sensitivity: 0.018 $^{\circ}\text{C}$
 - Thermovision ExaminIR MAX Software
- **Sub-Windowing allowed higher effective frame rate**
 - Max frame rate used in test: 160 x 128 pixel frame @ 1324 fps



Test Setup

- **Test Fixture Design**

- Rigid mount allowed viewing of the fuze body during function
- Pneumatic actuator to remove safety pin



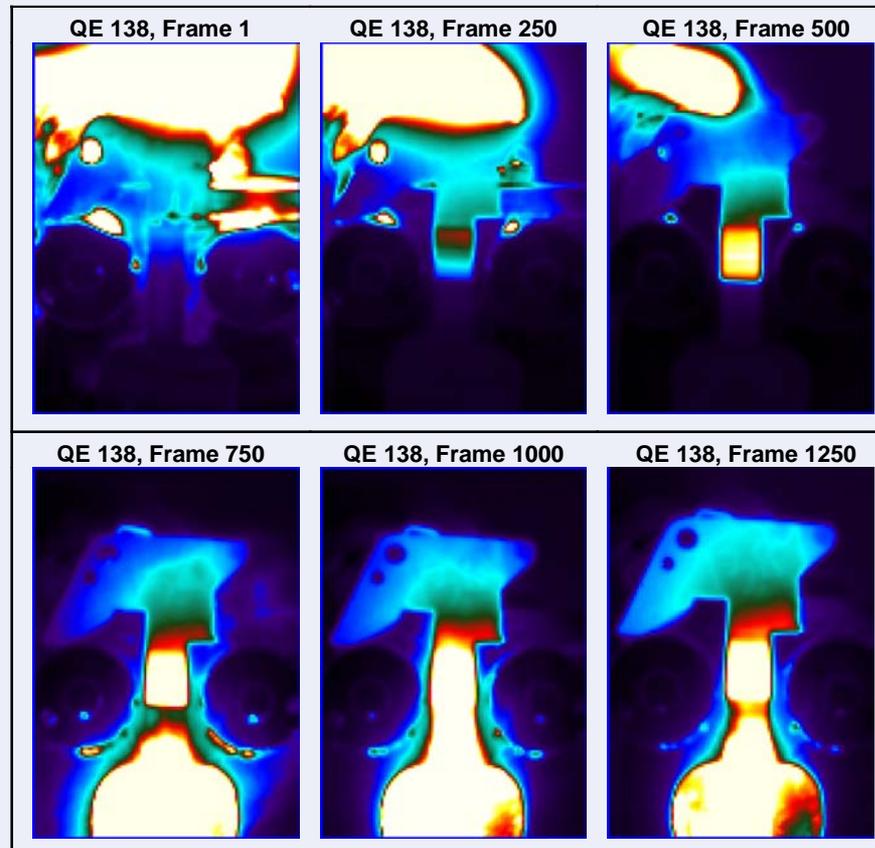
Test Setup

- **Test Layout**
 - High speed digital IR Camera System Positioned to allow fuze body to fill the field of view



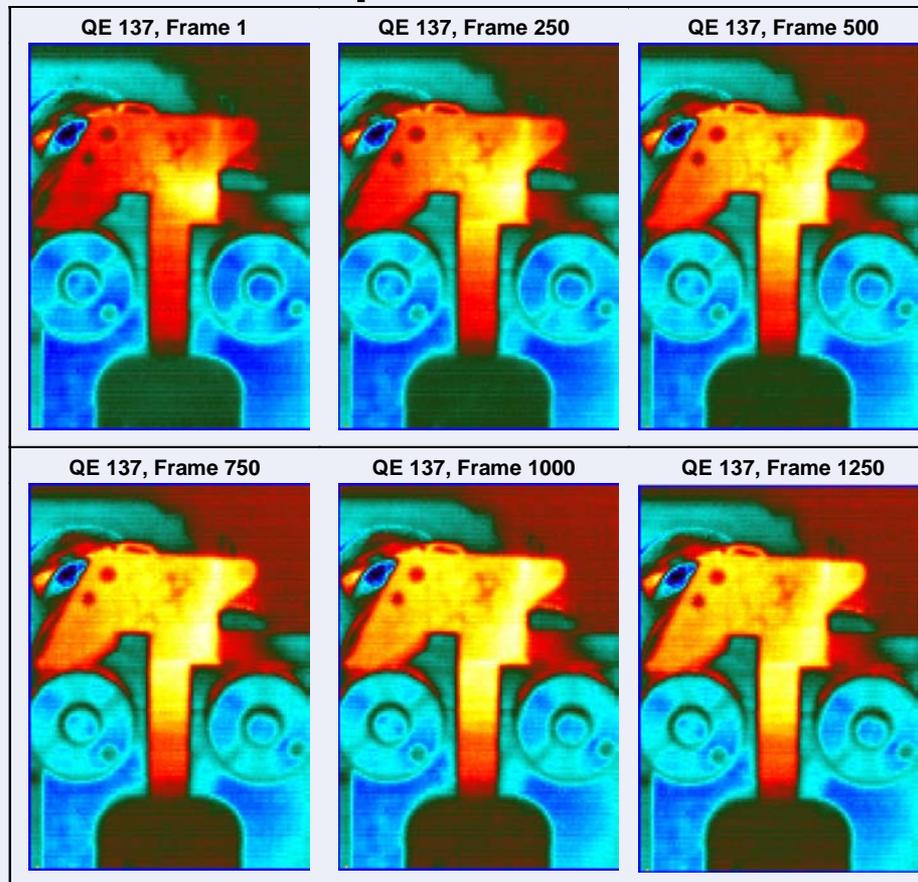
Test Results

- Pyrotechnic Reaction Sequence – “Good Fuze”



Test Results

- Pyrotechnic Reaction Sequence – Misfire



Comparative High Speed Video Images

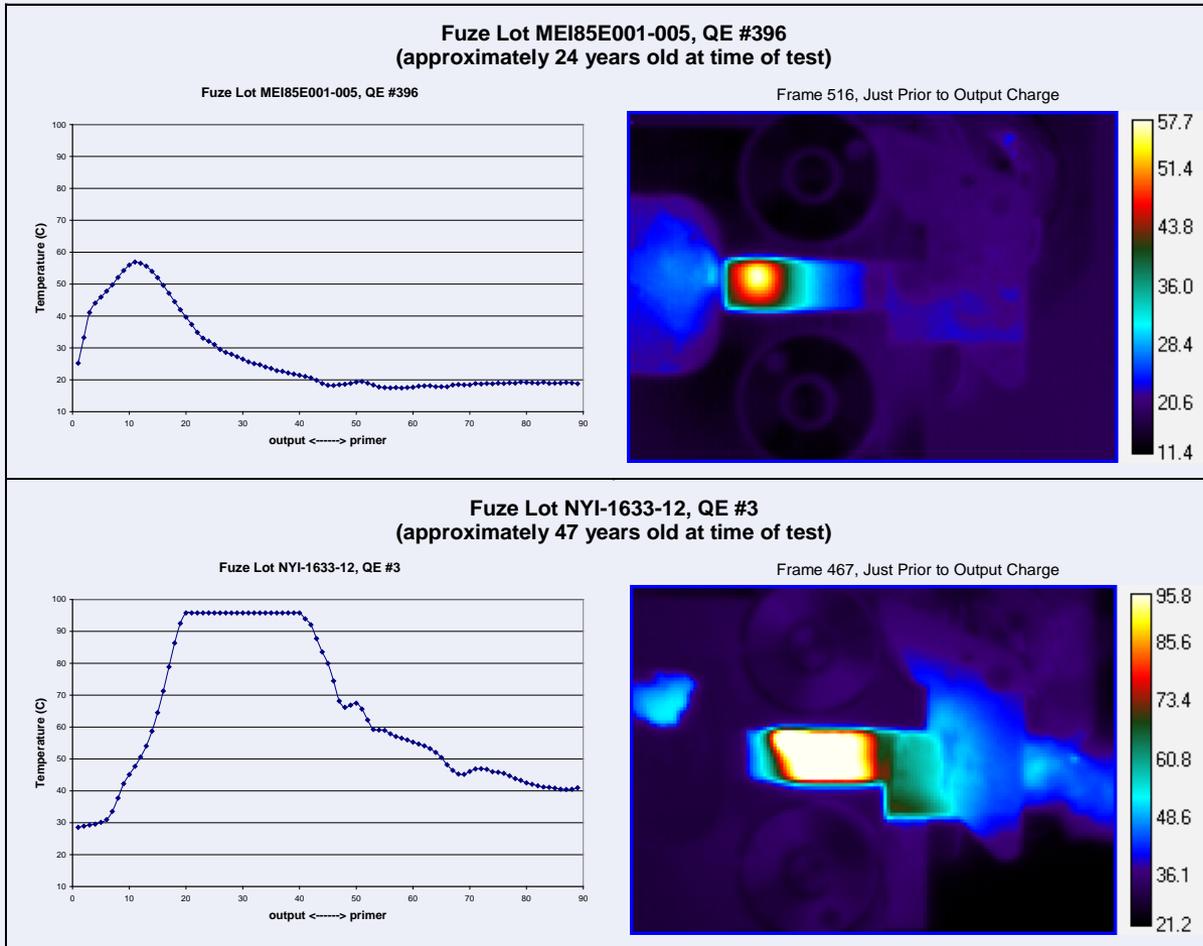
QE 365, Manufactured in 2000



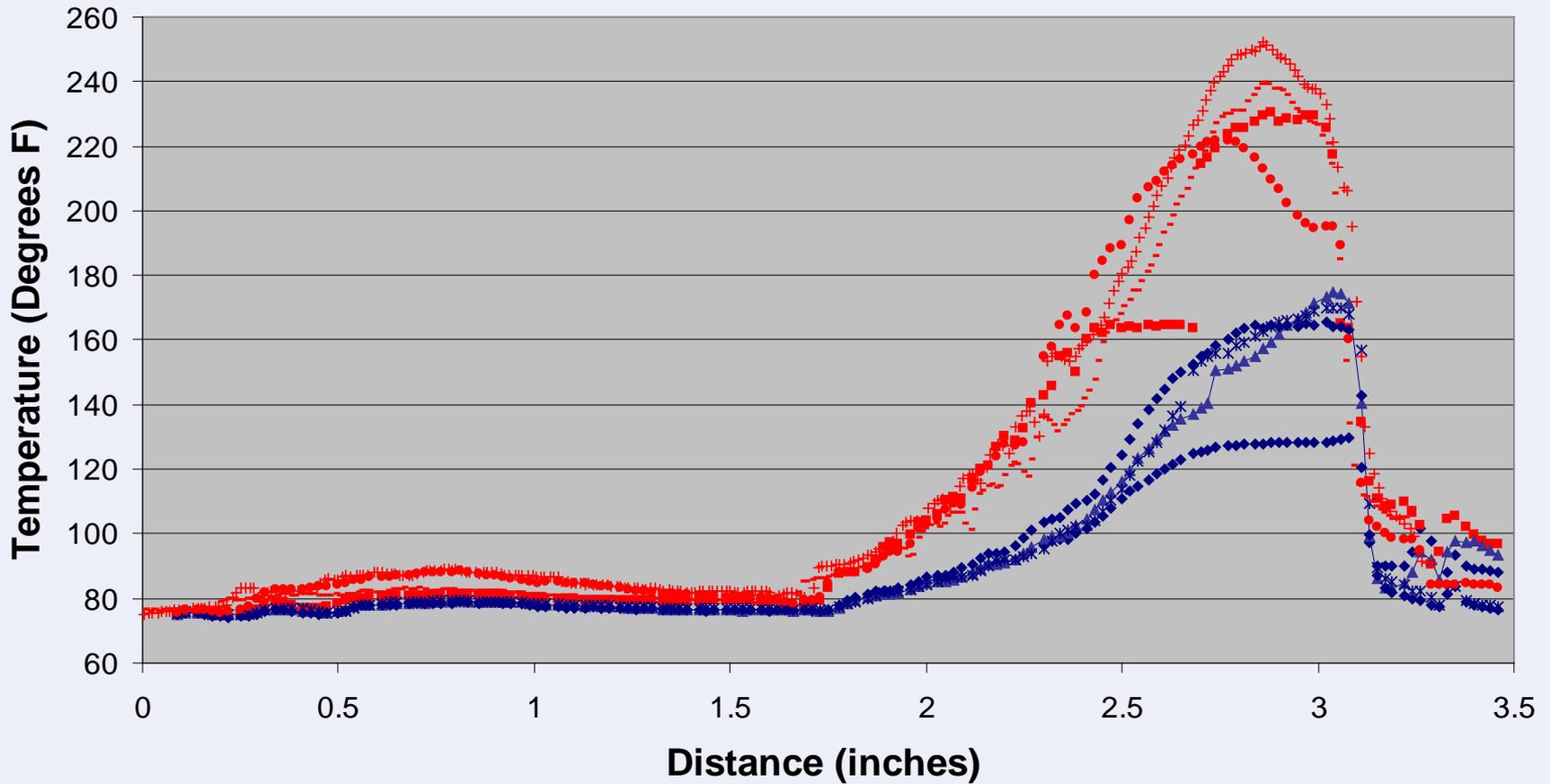
QE 429, Manufactured in 1968



Data Reduction Methodology



Example Temperature Profiles



Summary and Conclusions

- **High Speed Digital IR Camera Systems are effective in quantifying thermal output of pyrotechnic initiation trains**
- **Technique may be utilized on other pyrotechnic type items**