



INDIAN HEAD

***2006 NDIA-IMEMG Insensitive Munitions &  
Energetic Materials Technology Symposium***

**INSENSITIVE MUNITIONS (IM) TESTING OF THE  
M816 81MM INFRARED MORTAR CARTRIDGE**

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# OVERVIEW

- Introduction
- System Description
- System Function
- Cartridge Description
- Slow Cook-Off
- Fast Cook-Off
- Bullet Impact
- Fragment Impact
- Sympathetic Detonation
- Conclusions
- Acknowledgements

# INTRODUCTION

- NSWC Indian Head Division was tasked by the U.S. Marine Corps Systems Command to obtain a Navy Final (Type) Qualification (FTQ) (per NAVSEA Instruction 8020.5B) for the M816 81mm Infrared Illuminating Mortar cartridge
- Effort required Navy Qualification of several energetic materials contained within the cartridge
- System level testing requirements for FTQ include evaluating the response of the system to a wide range of external stimuli
  - Temperature, electrostatic discharge, movement type transportation hazards, aging, and Insensitive Munitions tests
- Presentation will focus on the IM testing that was performed on the M816 Mortar cartridge

# SYSTEM DESCRIPTION

- In use by the the US Army for many years
- Identical to the M853A1 Standard Illuminating Mortar cartridge except illuminant composition
- USMC uses Standard Illuminating cartridge with ground based and Light Armored Vehicle (LAV) mounted M252 Mortar System
  - M816 to be used in same scenarios
- Cartridge provides illumination in the infrared spectrum
- IR illumination allows battlefield observation with passive night vision equipment



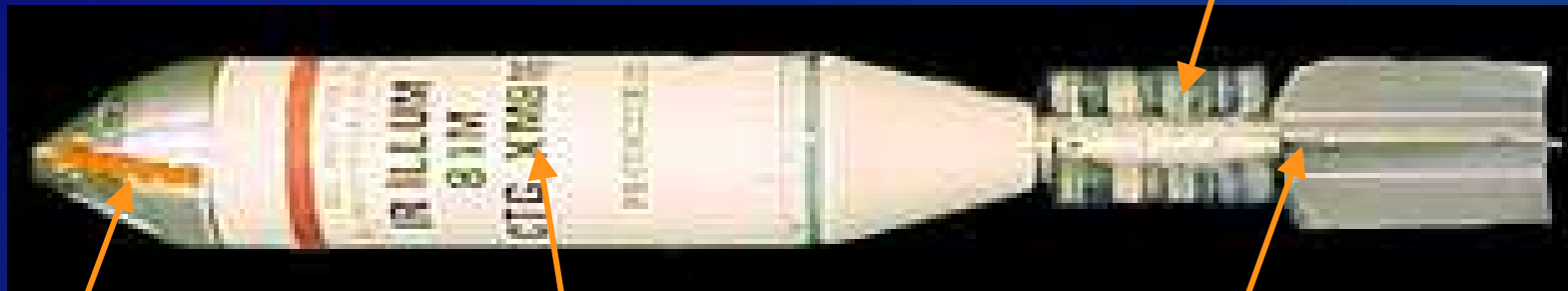
# SYSTEM FUNCTION

- Cartridge is removed from fiber container and allowed to fall into the 81mm mortar barrel
- Impact with the barrel bottom initiates primer, igniting the ignition charge and M38 ball powder propellant charge
- Propellant charge, with one to four additional incremental propellant charges, propels the cartridge out of the barrel
- At a prescribed altitude, the mechanical time delay fuze separates the candle assembly from the cartridge body, deploys a parachute, and ignites the IR illuminant material
- Candle provides illumination for 50-60 seconds

# CARTRIDGE DESCRIPTION

- Length: 25.49 Inches
- Weight: 8.90 lbs

Incremental  
Propellant  
Charges



M772  
Mechanical  
Time Fuze

Candle/Parachute  
Assembly  
Enclosure

Igniter/Fin  
Assembly

# SLOW COOK-OFF

- Four full-up rounds were tested
- Conditioning chamber was 16 inches larger than round in all directions
- Cartridge was supported by a saddle-type steel fixture
  - Provided 8 inches of floor clearance
  - Fixture insulated from cartridge
- Two variations of the test were conducted
  - Setup 1
    - Temperature ramped to 160°F in one hour and maintained for minimum 8 hours
    - Temperature was then increased 6°F ± 1°F per hour until the item reacted
  - Setup 2
    - Temperature ramped to 250°F in one hour and maintained for minimum 8 hours
    - Temperature was then increased 6°F ± 1°F per hour until the oven temperature reached 1000°F
    - Chamber was then allowed to return to ambient





# SLOW COOK-OFF

Test #	Setup	Chamber Temp at Reaction (°F)
1	1	274.9 (Primer / Propelling Charge)
2	1	274.8 (Primer / Propelling Charge)
3	2	271.9 (Primer / Propelling Charge) 591.7 (Expulsion Charge)
4	2	274.6 (Primer / Propelling Charge) 592.2 (Expulsion Charge)

- Cartridge stayed completely within the confines of the conditioning chamber for each test
  - Setup 1 result - top
  - Setup 2 result - bottom





# FAST COOK-OFF

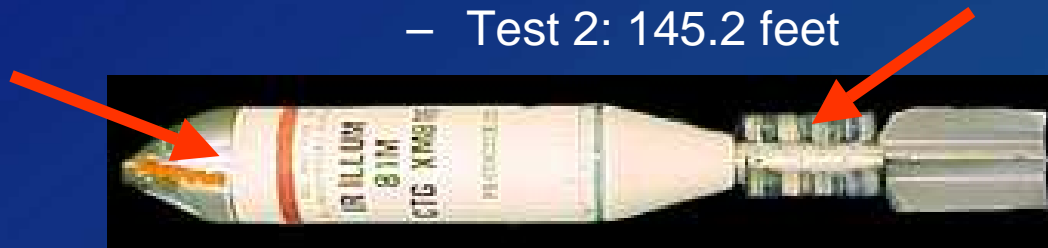


- Prior to this effort, a Final Hazard Classification for the M816 had been obtained from the Department of Defense Explosive Safety Board
  - Insensitive Munitions Office agreed to accept the use of the external fire test results for fast cook-off requirements
- Test arrangement had a metal grid elevated over a pool of fuel
- Several ammunition canisters containing M816 cartridges were strapped to the metal grid
- Fuel was ignited and allowed to burn until all energetic material had sufficient time to react
- Initial reaction occurred at time 3:23 after fuel ignition
- Final reaction was observed at time 1:08:23 after fuel ignition
- Multiple fragments traveled over 50 feet
  - Furthest found at 143 feet

# BULLET IMPACT



- Two full-up rounds were tested
- Each cartridge was impacted simultaneously by two .50 caliber type M2 armor-piercing projectiles at a velocity of  $2800 \pm 200$  ft/s
- Tests were conducted with the cartridge horizontally installed in a fixture
- Aim points for each test were the propelling charges and fuze expulsion charge
- No blast overpressures were detected
- Fuze assembly found to be the furthest fragment
  - Test 1: 44.7 feet
  - Test 2: 145.2 feet



# FRAGMENT IMPACT



- Four full-up M816 cartridges were tested
- Each cartridge was impacted by two 1/2-in. steel cubes launched from a fragment-projecting gun
- A fixture was used to support the test item
- Round was restrained to avoid undesired movement from the fragment impacts

# FRAGMENT IMPACT

Test #	Fragment #	Aim Point	Fragment Velocity (ft/s)	Maximum Fragment Distance (ft)
1	1	Fuze	8151	149.5 (Fuze)
	2	Candle Section	8164	
2	1	Aft End of Fuze	8439	58.6 (Tail Shaft)
	2	Expulsion Charge	8378	
3	1	Aft End of Fuze	8099	204.0 (Tail Shaft)
	2	Expulsion Charge	7898	
4	1	Fuze	9035	245.9 (Fuze)
	2	Candle Section	ND	

- No blast overpressures were detected



# SYMPATHETIC DETONATION

- Three tests were performed using four containers with three rounds per container
- One container was opened and one round removed
  - M70 detonators were placed on the primer of the ignition cartridge and on the lead in the fuze
  - The modified donor round was then replaced into the container
- Container holding the donor round was placed on a witness plate with three acceptor containers surrounding it
  - One acceptor container was placed on each side and one on top of the donor container
- Containers were covered with one meter of sand
- Similar results were observed for each test
  - Sand covering was moved but with no visible smoke
  - Donor container was bulged
  - No propagation to other rounds within donor container
  - Acceptor containers scorched on sides facing donor



# CONCLUSIONS

- Insensitive Munitions Review Board (IMRB) assessment of the M816 Infrared Mortar cartridge:

Slow Cook-Off	Type V (Burn)
Fast Cook-Off	Type IV (Deflagration)
Bullet Impact	Type IV (Deflagration)
Fragment Impact	Type III (Explosion)
Sympathetic Detonation	Pass

- It is believed that the primary contributors to the response of the system is the use of black powder in the fuze and ignition charge, and the double base M38 propellant in the ignition charge and propellant charges
- Failures in fast cook-off, bullet impact, and fragment impact dictated that an IM Waiver was required
  - A waiver request was submitted to the Joint Requirements Oversight Council (JROC) and was granted in February of 2005
- M816 Infrared Mortar cartridge was granted a Navy Final (Type) Qualification in June of 2005



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