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

Nicholas M. McGregor, Robert S. Hutcheson, and Mathew J. Domoradzki

NSWC Indian Head Division
101 Strauss Avenue
Indian Head, MD 20640

ABSTRACT

As part of an effort aimed at acquiring a Navy qualification for the M816 81mm Infrared Mortar Cartridge, Insensitive Munitions tests were performed. The system was originally designed for the U.S. Army for infrared illumination of combat areas and is identical to the M853A1 Standard Illuminating Mortar cartridge except for the pyrotechnic found within the candle assembly. The motivation for this effort was a desire by the United States Marine Corps (USMC) to adopt the M816 for ground as well as Light Armored Vehicle (LAV) mounted deployment. Testing of the system included fast and slow cook-off, bullet impact, fragment impact, and sympathetic detonation. Slow cook-off results were rated a Type V (burning) reaction. Sympathetic detonation testing was carried out in a confined (earthen covered) configuration. Results from these tests were scored as pass responses. Fast cook-off results were taken from Final Hazard Classification external fire testing by the Department of Defense Explosive Safety Board (DDESB) and were scored as a Type IV (deflagration) reaction based on fragmentation flight distances. Bullet impact testing, with aim points at the ignition cartridge and black powder fuze expulsion charge resulted in a Type IV (deflagration) reaction. Fragment impact targets were either the fuze and candle assembly or the propellant charge and ignition cartridge. A Type III (explosion) reaction was given for these tests. Based on the overall performance of the M816 in the suite of IM tests, a waiver of non-compliance was required and granted. 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 powder in the ignition charge and propellant charges.

INTRODUCTION

The Naval Surface Warfare Center, Indian Head Division (NSWCIHD) was tasked by the Marine Corps Systems Command (MCSC) to obtain a U.S. Navy Final (Type) Qualification (FTQ) for the M816 81mm Infrared (IR) Illuminating Mortar cartridge (Figure 1). This effort required that several energetic materials contained within the

cartridge to undergo Navy Qualification testing as dictated by NAVSEA Instruction 8020.5B (Qualification and Final (Type) Qualification forof Navy Explosives). System level testing for FTQ prescribed by the same instruction includes evaluating the response of the system to a wide range of external stimuli. These include such things as temperature, electrostatic discharge, various movement type transportation hazards, aging, and Insensitive Munitions (IM) testing. This paper will focus on the IM testing that was performed on the M816 Mortar cartridge, including fast cook-off, slow cook-off, fragment impact, bullet impact, and sympathetic detonation.

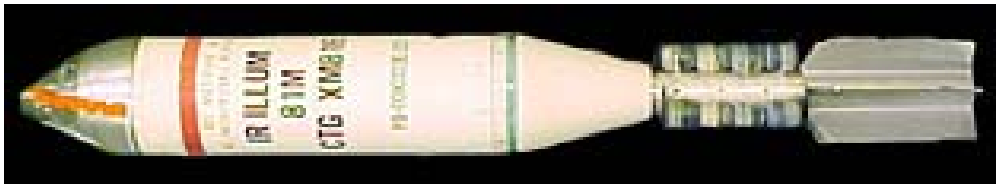

Figure 1. M816 81mm Infrared Mortar Cartridge

BACKGROUND

System Description

The M816 IR Illuminating Mortar cartridge was designed by the U.S. Army for use with the M252 81mm Mortar System (Figure 2). Its purpose is to illuminate target areas to facilitate adjustment of fire and observation of troop location and movement. The M816 cartridge carries an illuminant candle assembly and parachute assembly. It is identical to the M853A1 Standard Illuminating Mortar cartridge with the exception of the illuminant candle composition. The M853A1 contains a standard illuminant mix that provides illumination in the visible spectrum. The M816 cartridge contains an infrared illuminant mix that provides illumination in the infrared bandwidth for use with standard night vision devices. The M816 is equipped with the M772 Mechanical Time Fuze that functions at a user-specified time after launch. When the fuze functions, it initiates the candle assembly and separates the front and rear projectile segments. Following the parachute deployment, the candle burns for 50 to 60 seconds, providing the required illumination over the target area.

The USMC currently uses the M853A1 Standard Illuminating cartridge with the ground based and Light Armored Vehicle - Mortar (LAV-M) (Figure 3) mounted M252 Mortar System. The USMC will use the M816 IR Illumination cartridge with both scenarios.

Nicholas McGregor
NSWC Indian Head Division
101 Strauss Avenue, Indian Head, Maryland 20640

Figure 2. M252 Mortar System

Figure 3. Light Armored Vehicle - Mortar

System Function

The M816 cartridge is removed from its fiber container and allowed to fall into an 81mm mortar barrel. Following impact at the bottom of the mortar, a primer initiates an ignition cartridge, which initiates an M38 Ball Powder Propellant charge. The M38 Ball Powder Propellant charge, either by itself, or together with one to four additional incremental propellant charges, propels the cartridge out of the mortar barrel and over the area to be illuminated. At a prescribed altitude, the mechanical time delay fuze separates the IR candle assembly from the cartridge body, deploys a parachute, and initiates burning of the IR illuminating material. The burning material in the candle illuminates the ground below as it descends. The IR illumination allows passive night vision equipment to observe enemy troop movements, fortifications, and equipment, allowing military capability and damage assessment. The M816 cartridge is launched from the same mortars, using the same basic procedures, as the M853A1 cartridge.

Nicholas McGregor
NSWC Indian Head Division
101 Strauss Avenue, Indian Head, Maryland 20640

INSENSITIVE MUNITIONS TESTING

Slow Cook-Off

Slow cook-off (SCO) testing of the M816 was conducted at National Technical Systems (NTS) in East Camden, Arkansas. Testing was conducted in accordance with the methodology of MIL-STD-2105B (Hazard Assessment Tests for Non-Nuclear Munitions). Four full-up rounds were tested. Live items were installed in an oven with a conditioning chamber that was at least 16 inches larger than the item in all directions (Figure 4). The round was centered within the oven and supported by a saddle-type steel fixture that provided a minimum of eight inches of clearance between the bottom of the item and the oven floor (Figure 5). The item was insulated from direct contact with the test fixture using strips of ceramic insulating cloth.

Figure 4. Slow Cook-Off Test Setup

Figure 5. Slow Cook-Off Test Fixture

Two setups were used during this testing. For setup one, the oven containing the round was ramped from site ambient temperature to 160°F in one hour. The live item was then conditioned at 160°F for a minimum of 8 hours prior to starting the continuous increase in oven air temperature. Following this temperature soak, the oven temperature was increased 6°F ± 1°F per hour until the item reacted. This procedure was repeated using the second item. For setup two, the oven containing the rounds was ramped from site ambient temperature to 250°F in one hour. The item was then conditioned at 250°F for a minimum of 8 hours prior to starting the continuous increase in oven air temperature. The oven temperature was then increased 6°F ± 1°F per hour until the oven temperature reached 1000°F. At that point, the oven was turned off and allowed to return to the ambient temperature of the test site. This procedure was repeated using a second round.

For each of the four slow cook-off tests performed, the temperature at which reactions occurred is given in Table 1. The typical results from setup one and setup two

Nicholas McGregor
NSWC Indian Head Division
101 Strauss Avenue, Indian Head, Maryland 20640

are shown in Figure 6. For each test, the cartridge was found to remain entirely within the confines of the oven. No external fragments were detected.

Table 1. SCO Reaction Temperatures

Test #	Setup	Average Oven Temperature at Reaction (deg. 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)

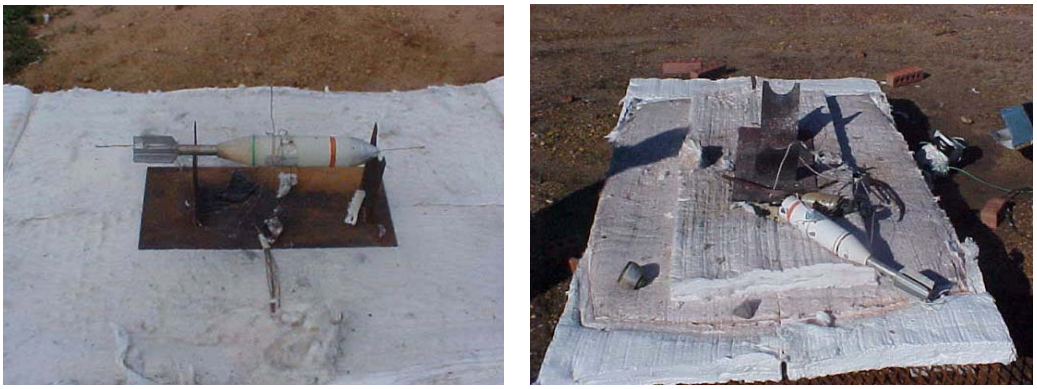

Figure 6. Results for SCO Setup 1 (left) and Setup 2 (right)

Fast Cook-Off

Prior to FTQ evaluation of the M816 cartridge, a Final Hazard Classification (FHC) for the system had been obtained from the Department of Defense Explosive Safety Board (DDESB). The Insensitive Munitions Office (IMO) agreed to accept the use of the external fire test results from the FHC to meet the fast cook-off (FCO) test requirements.

The ammunition containers containing the mortar cartridges were supported with steel straps during the test. The metal grid was elevated to ensure adequate heating from below. A liquid hydrocarbon pool fire was used and the grid was placed above the fuel. Fuel was placed beneath the grid so that the fire engulfed the test item. The fire was burned until all the energetic material was given sufficient time to react to the fire. The test setup is shown in Figure 7.

Nicholas McGregor
NSWC Indian Head Division
101 Strauss Avenue, Indian Head, Maryland 20640

Figure 7. External Fire/Fast Cook-Off Test Setup

The initial reaction was observed at 3 minutes and 23 seconds after the ignition of the fire. The final reaction was observed at 1 hour, 8 minutes and 23 seconds. The test resulted in multiple fragments traveling distances greater than 50 feet, with the furthest fragment reaching 143 feet.

Bullet Impact

Two M816 rounds were subjected to bullet impact (BI) testing at NTS in accordance with the methodology of MIL-STD-2105B. The test setup is shown in Figure 8. Each cartridge was impacted simultaneously by two .50 caliber type M2 armor-piercing projectiles at a velocity of 2800 ± 200 ft/s. The striking points of the two projectiles for each test were the propelling charges and into the fuze expulsion charge. The tests were conducted with the test cartridge horizontally installed in a fixture. This fixture supported the cartridge and restrained it from any undesired motion due to the bullet impacts. The reaction of the cartridge to the impacts was recorded on video equipment, and photographs were taken to document the test setup and the condition of the cartridge before and after each test. Blast pressure, and the weight and throw distance of any fragments were recorded.

Figure 8. Bullet Impact Test Setup

Nicholas McGregor
NSWC Indian Head Division
101 Strauss Avenue, Indian Head, Maryland 20640

For both tests, no blast overpressures were detected. The furthest distance traveled by a fragment for test one was 44.7 feet. For test two, the greatest fragment distance was 145.2 feet. In each case, the fuze was thrown the greatest distance from the initial test position.

Fragment Impact

Four M816 rounds were subjected to fragment impact (FI) testing at NTS in accordance with the methodology of MIL-STD-2105B. The rounds were held in the fixture shown in Figure 9. Each live 81mm M816 cartridge was impacted by two 1/2-in. steel cubes launched from a fragment-projecting gun. The fixture supported the test item and restrained it from any undesired motion due to the fragment impacts. Audio, video, and air blast data was collected for each test.

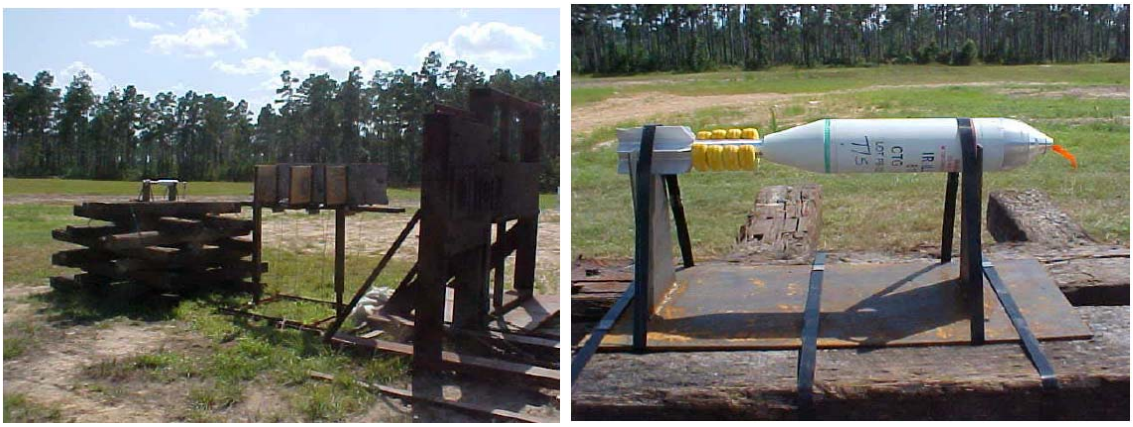

Figure 9. Fragment Impact Test Fixture

The results found from the fragment impact testing are given in Table 2. No blast overpressures were detected for any of the four tests conducted.

Table 2. Fragment Impact Results

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	

Nicholas McGregor
NSWC Indian Head Division
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Sympathetic Detonation

Sympathetic detonation (SD) tests were conducted by U.S. Army TACOM-ARDEC, Picatinny Arsenal, NJ in accordance with the methodology of MIL-STD-2105B. Three tests were performed using four containers with three rounds per container. One container was opened and one round removed. The fiber packaging tube was then opened. An M70 detonator was placed on the primer of the ignition cartridge and on the lead in the fuze, as shown in Figure 10. The fiber tube was then sealed and placed back in the ammunition container. The ammunition canister that contains the donor round was placed on a witness plate with three acceptor containers surrounding it. One acceptor was placed on each side and one on top of the ammunition canister containing the donor round. The four ammunition canisters were then covered with one meter of sand as shown in Figure 11.

Figure 10. Donor Initiation Setup

Figure 11. Sympathetic Detonation Test Setup

For each of the three sympathetic detonation tests, a similar result was observed. The sand covering was moved, however no visible smoke was detected from the sand mound. The ammunition canister containing the donor cartridge was bulged. No

propagation to other cartridges in the same canister as the donor occurred. The acceptor canisters were scorched on the side facing the donor canister.

CONCLUSIONS

Based on the Insensitive Munitions testing performed on the M816 Infrared Mortar cartridge, the Insensitive Munitions Review Board (IMRB) assessment is summarized in Table 3. 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 powder in the ignition charge and propellant charges. The failures in fast cook-off, bullet impact, and fragment impact dictated that an IM Waiver would be required. A waiver request was submitted to the Joint Requirements Oversight Council (JROC) and was granted in February of 2005. The M816 Infrared Mortar cartridge was granted a Navy Final (Type) Qualification in June of 2005.

Table 3. Summary of IM Responses

FCO	Type IV (Deflagration)
SCO	Type V (Burn)
BI	Type IV (Deflagration)
FI	Type III (Explosion)
SD	Pass

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Nicholas McGregor
NSWC Indian Head Division
101 Strauss Avenue, Indian Head, Maryland 20640