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Muzzle Blast Cartridges:
Identification of Malfunctions and Solutions for Successful Application

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Abstract

Through observation, there have been a number of occurrences where the payload inside the 37mm Muzzle Blast cartridge does not disperse correctly. The purpose of this study was to examine the causes of 37mm Muzzle Blast cartridge malfunctions by evaluating them under the worst possible conditions that the product may face while stored in an officer's patrol vehicle and their functioning under adverse weather conditions. However, it was not possible to artificially create malfunctions that had been observed in the past. It was hypothesized that the mechanism affecting the performance of these munitions took place over a considerable period of time. It was also suggested that it was possible to mitigate the extent of contamination by early identification of the warning signs of chemical munitions malfunctions.

Introduction

Muzzle Blast cartridges have a variety of applications in law enforcement and corrections, and they can be fired from either the 37mm or 40 mm grenade launchers. Muzzle Blast cartridges are intended for uses in crowds, as a tool for riot control, and to overcome barricaded subjects. Cartridges can be filled with several chemical agent formulations, including: *Oleoresin Capsicum* (OC), *Chlorobenzylidene Malonitrile* (CS), *Chloracerophenone* (CN), or an inert powder, which is used for training purposes. When fired these munitions produce a loud report and an instantaneous cloud of agent. These munitions can be used both indoors and outdoors and have an effective range of 10-30 feet. *Figure 1* shows a typical muzzle blast cartridge being fired.

Figure 1: Muzzle Blast Functioning

Cartridge malfunctions have been reported, however, regardless of the manufacturer or brand name. Muzzle blast cartridges may fail to disperse the entire payload, leaving chemical agent inside the cartridge and weapon when fired. Cartridges may also project clumps of agent, rather than producing a fine cloud of powder. These malfunctions can cause contamination to the scene, and the shooter. The purpose of this pilot study was to determine the possible causes of the malfunctions in these types of munitions. During this study, inert muzzle blast cartridges were used to eliminate contamination of chemical agent.

Research Problem

Malfunctions in muzzle blast cartridges, where the payload inside the 37mm Muzzle Blast cartridge does not disperse correctly, have been reported anecdotally in practice. Reports include of a large amount of payload falling from the barrel when the breach is opened. This can potentially contaminate the scene and shooter and even create a serious weapon malfunction. This current study attempts to determine how these malfunctions occur.

Figure 2: Malfunctioning Muzzle Blast Deployment

Figure 2 illustrates the sequence of events in a malfunctioning muzzle blast cartridge deployment. The discharge of the cartridge is shown in the first photograph. As the launcher is lowered, a substantial amount of payload is seen falling from the barrel (second photo). The last two photos show the final amount of payload that was released as the breach of the launcher was opened.

Literature Review

Environmental Factors Affecting Use

Meteorological conditions such as temperature, wind and humidity may affect how the agent in a muzzle blast may behave. According to Combined Tactical Systems (CTS), "humidity and heat are the two most important damaging factors that can destroy chemical munitions and cause misfires or munitions malfunctions" (n.d., p. 38). The cloud of agent can cause reduced visibility, making it harder for the operator of the device to see or locate the subject(s) or suspect(s).

Wind speed and direction influence the agent payload's direction and speed, while temperatures affect the dispersion of the payload in height and density, and also influences the duration the agent remains airborne (Army, 1990). Smoke or powder can be used to predict wind speed or wind patterns (Lynch & Hack, 1984), therefore, powder and smoke behave in a similar fashion.

Wind

There are different types of wind patterns and speeds that can affect the deployment of chemical weapons in the field. The *head wind* is unfavorable as it blows the smoke in the direction of the target toward the weapon. *Quartering winds* blow between other winds in the direction of the smoke target. *Flanking winds* are useful for smoke operations as they blow across the smoke target. However, the best wind is a *tail wind* as it blows the smoke in the intended direction. Wind speeds play a part in how long the smoke will linger around an area. In low or calm winds, smoke may remain in the area for a long period of time (Army, 1990). The greater the wind speed, the further the chemicals may travel off target (Wolf & Hipkins, 2004) and blowbacks can occur when the agent is deployed into the wind (Jones, 2000).

Figure 3: Effects of Wind

Figure 3 illustrates the different effects that wind has on the performance of the agent payload. This is important, as smoke/powder will not perform the same every time it is used. The top two photos show the cloud dropping immediately. The second two photos illustrate show the smoke rising. The bottom two photos demonstrate the muzzleblast after being fired and maintaining a correct path to the intended target. The different wind patterns play a role in how the muzzleblast performs. This is important as wind patterns will determine where a shooter should aim.

Temperature

Temperature has an indirect relationship with smoke behavior. The temperature gradient is the direction and rate at which temperature changes most rapidly around a location. There are three types of gradients. Having an *unstable condition* is when the air temperature decreases in altitude, causing smoke to break up and diffuse. A *neutral condition* is when there is little or no change in the air temperature with an increase in altitude and in this condition, air currents are limited. *Stable conditions* occur when the air temperature increases as the altitude increases and causes the smoke to lie low to the ground (Army, 1990).

Humidity

Humidity also plays a role in how smoke behaves. Smoke particles absorb the moisture from the air, while the moisture increases the particle size and density. When humidity is high, the smoke tends to be denser or thicker. When there is precipitation, smoke generally lies low to the ground and spreads out (Army, 1990).

Storage of chemical munitions in a vehicle is discouraged as the conditions can vary and exceed the manufacturer's limitations. Proper storage is said to be at a controlled temperature of 60°F to 75°F with the relative humidity of less than 60%. Utilizing proper storage containers such as steel shipping drums, as well as maintaining proper rotation and inspections of the munitions can help decrease malfunctions (CTS, n.d.).

Methodology

This current study utilized a research design that was created to measure the performance of the muzzle blast cartridge under controlled conditions. The primary objective was to identify a variable that would explain why payload may not deploy properly. Inert muzzle blast cartridges were utilized for the majority of tests, but live agents were also used to confirm findings. According to CTS (n.d), CN agent weight is 49.2 grams per cartridge, CS agent weight is 18 grams per cartridge, and OC agent weight is 4 grams per cartridge. However, the manufacturer did not provide a weight for the payload of the inert cartridge. To determine this, one cartridge was selected at random and was disassembled by first removing the wadding, then cutting through the cardboard. The contents of the inert cartridge were then dumped into a container and weighed (36.828 grams of the agent).

The muzzle blast cartridges were testing by utilizing different techniques to produce the worst possible conditions that an officer may face while storing the cartridges in their patrol vehicle. The extant literature identified temperature and humidity as significant factors that were both controlled and used as variables in this study.

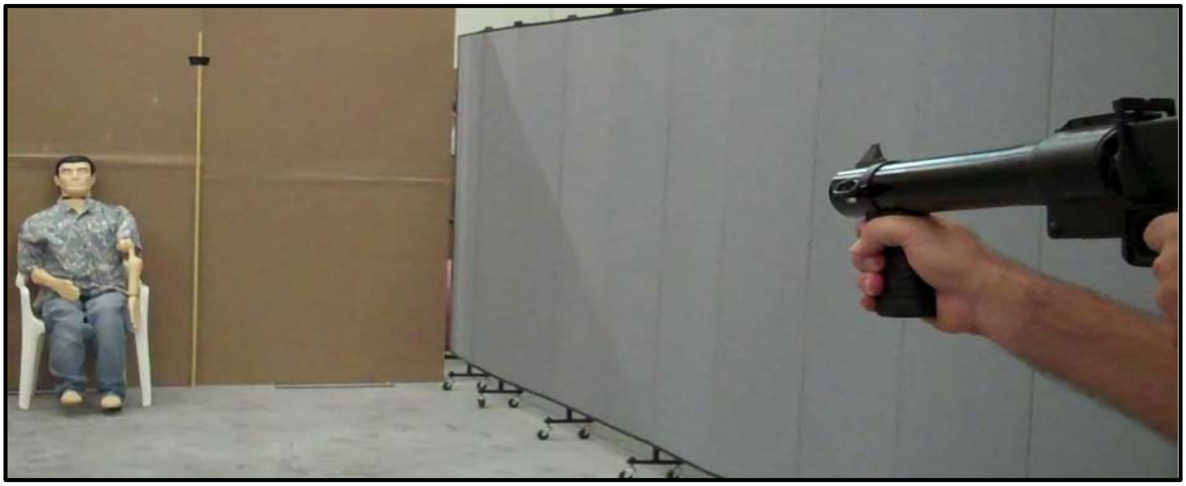
Figure 4: Test Chamber Solar Still

Moisture can come from rain, mildew, mold, humidity, extreme temperatures, even just the smallest amount of liquid contact (Lavoie, Cartilier, & Thibert, 2002). A test chamber was created to expose the cartridges to extreme heat and humidity at the same time. This was done by suspending the test cartridges over water within a sealed container, creating a solar still (left photo in *Figure 4*). The chamber was exposed to the sunlight, where both the temperature and humidity rose rapidly. During this time, the temperature exceeded 120°F on some occasions. The humidity stayed constant at 98% and condensation and mold were visible inside the test chamber (right photo).

To measure the effect of cold temperatures on muzzle blast cartridges, additional cartridges were frozen in the freezer for twenty three days. This time frame was used to allow ample opportunity for the cartridges to be affected by the introduced variables. The temperature inside the freezer was maintained at 28°F. Additional cartridges were left at outdoor humidity and temperatures for extended periods of time. Control cartridges were stored within a temperature and humidity controlled armory inside their proper storage containers. Cartridges were fired from each of these sample groups on weekly intervals to test for possible malfunctions.

A test area was created to conduct the testing of the muzzle blast cartridges. The results of each test were recorded on video and photographed for later analysis.

Figure 5: Test Area



Findings

Cartridges that were stored in the solar still produced no malfunctions, despite mold and green slime coating each shell. There were also no malfunctions from the cartridges that were frozen, or the cartridges that were left in the warehouse.

The control group contained both new and older munitions. The new cartridges within the control group performed to standards. However, the older cartridges consistently had failures. The fact that there were older munitions was unknown when the study began, as they we purchased through a regional distributor. Consequently, it is impossible to know how they were stored prior to our custody. Illustrated in *Figure 6* are clumps of the payload that fired from the launcher (left photo). After each malfunction, any excess powder was dumped from the launcher (right photo).

Figure 6: Payload Failure to Deploy

After malfunctioning shots were fired, the powder covered the gun, the cartridge and the shooter's hand, arm and fingers. *Figure 7* (left photo) illustrates how the shooter's hand was covered in the inert powder after cartridge malfunctions. The center photo illustrates the cartridge and the gun covered in the powder due to a malfunction. The photo on the right shows more powder covering the gun and the shooter's hand.

Figure 7: Muzzle Blast Cartridge Malfunction

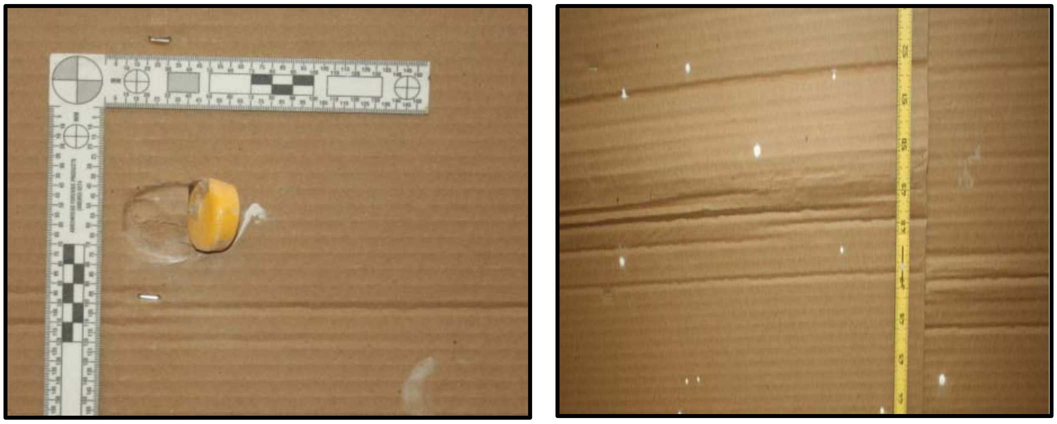
After a test shot that produced the visible clumps and large amounts of excess powder, a sample was collected and weighed. In this single instance, 13.04 grams was dumped from the gun (representing approximately 36% of the payload) and is equivalent to approximately five PepperBall® projectiles (see WERI report "PepperBall® SA-4 Launcher™ Accuracy Study" for more information on PepperBall®).

Figure 8: Foot Print Cross Contamination

In *Figure 8,* the shooter's footprints are clearly visible in the powder. This creates a serious concern for cross contamination particularly in closed environments such as corrections where the chemical agent could be tracked from one area of a facility to another.

According to Sanow (1989), in a live-fire situation, the muzzle blast cartridge must be aimed at the ground to prevent crowd injury from the cartridge wadding. This information has disappeared from factory and scientific literature as well as training in this munition. *Figure 9* illustrates the wadding that stuck in the target (left photo) and the clumps of agent that was dispersed, imbedded in the target (right photo).

Figure 9: Wadding and Clumping Malfunction



Conclusions

Munitions in this study were subjected to extremes that were possible if cartridges were stored within the patrol vehicle. However, the ability to artificially create muzzle blast malfunctions was not possible in this study, and may be indicative of the relatively short period of time that the cartridges were stored against the manufacturer's recommendations. However, proper storage of the muzzle blast cartridges may help reduce the possibility of malfunctions. This is only true if ammunition is purchased new from the manufacturer, and the consumer agency knows the history of the storage of the cartridges prior to receiving them. For this current study, many of the malfunctioning cartridges were purchased from distributors that had taken them in as trade and had resold them. It was hypothesized that the mechanism affecting the performance of these munitions took place over a considerable period of time.

This study was able to identify a key precursor of a major chemical agent contamination event. Each time "clumps" of powder were observed directly in front of the shooter, a large amount of payload remained in the barrel of the launcher. When this phenomenon is observed, the breach should not be opened and the barrel elevated to prevent accidental release of chemical agent. A simple stopgap measure might include the use of Saran Wrap and a rubber band to create a temporary seal until the weapon can be removed from the area and properly cleaned. As little to no research available has been conducted on this munition, further testing is warranted beyond this initial pilot study.

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