Humanitarian Demining Flare Against Cluster Munitions And Hard Cased Land Mines

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ABSTRACT

Unexploded cluster bombs often fail to explode, remaining live and dangerous. These unexploded cluster munitions complicate the clearing of minefields. Generally, EOD personnel or deminers destroy mines and other unexploded ordnance (UXO) in place using conventional demolition charges. This can result in a huge number of additional widely scattered metallic fragments, complicating mine detection. Recent conflicts in Kosovo and Afghanistan highlight the UXO threat. Individual BLU-97 bomblets from the CBU-87 and the British BL755 are a significant UXO problem. It is difficult to bring the explosive charges required to destroy the dud cluster munitions and mines into Kosovo because of the political situation. In the last few years, the Humanitarian Demining R&D Program has developed non-explosive and explosive mine neutralization technologies to make land mine and UXO clearance faster, safer and easier. A non-explosive method is needed to destroy these and other UXO. In response to this need, the Humanitarian Demining R&D Program and the NAVEODTECHDIV developed the Thiokol or Humanitarian Demining (HD) Flare. The Government tested the HD Flare against dud UXO (represented by the BLU-97 and Mk 118 Rockeye), two hard case AP mines and one metallic case AT mine. The HD Flares destroyed all munitions either by burning or by high order detonation. This investigation made it clear the two most important parameters to neutralize BLU-97s with burning are the location of flame on target, and separation distance from the target area. It took more than one flare to completely neutralize the explosive in the Rockeye by burning.

BACKGROUND

The Cluster Bomb Unit (CBU) was a frequently used munition in Operation Allied Force, the aerial bombing campaign to stop the Serbian “ethnic cleansing” against the Albanian population in Kosovo. A typical air-delivered CBU consists of a bomb-shaped cylindrical casing / dispenser containing a large number of sub-munitions or bomblets. Individual bomblets often fail to explode, remaining live and dangerous until cleared. The most important factor in the failure of CBUs to detonate is the environment into which they are dropped. The bomblets are designed to explode on impact but a soft surface such as mud, sand or snow, or the presence of trees or overgrowth can lead to failures. It is believed that as many as 34,744 live bomblets on the ground in Kosovo. These highly lethal sub-munitions may explode at the slightest touch, frequently killing more than one person because of their wide fragmentation pattern. Just like AP mines, the unexploded bomblets have killed or maimed over 200 people in Kosovo since the end of hostilities. Like land mines, cluster munitions must be located and destroyed one by one, a costly and time-consuming process.

INTRODUCTION

Recent conflicts in Kosovo and Afghanistan highlight the UXO threat. The orange-yellow-stripped “soda cans” are distinct remnants of the BLU-97 bomblets from the CBU-87 and British BL755. The most

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common in-situ UXO or mine neutralization procedure used by EOD or deminers is demolition, using explosives charges such as a C-4 or TNT blocks. However, this method is not suitable against UXO and mines found on or near important structures such as bridges, public building, railroads, water or oil wells, and power lines. In addition, detonation of UXO and metal case mines increases the amount of metal contamination in the area, making post-clearance quality control much more difficult and time consuming. Other serious drawbacks with removal for detonation include safety, cost, effective destruction, time constraints, storage, transportation, training, and the potential for the explosive to be stolen. In addition, the political situation in Kosovo makes it difficult to bring the explosive charges into Kosovo. The US Army Communications Electronics Command (CECOM) Night Vision and Electronic Sensors Directorate (NVESD), under the DoD Humanitarian Demining Research and Development (R&D) Program has developed non-explosive and explosive mine neutralization technologies to make land mine and UXO clearance faster, safer and easier. The non-explosive technologies for clearing mines and UXO are Bullet with Chemical Capsule (BCC), Bullet carries chemical [1], Reactive Mine Clearance (REMIC and REMIC-II) [2,3], Thermites [4], Mine Incinerator [5], Pyrotechnic Torch [6] and Thiokol or Humanitarian Demining Flare. These technologies neutralize mines and UXOs by deflagration (burning). The Humanitarian Demining Flare was developed with joint partnership with NAVEODTECHDIV. The Government tested the Humanitarian Demining Flares against BLU-97 and Mk 118 Rockeye sub-munitions, two hard case AP mines (PROM-1 and POMZ-2), and the TM-46 AT metallic case mine. These are commonly found in Kosovo. The next section describes the Humanitarian Demining (Thiokol) Flare.

HUMANITARIAN DEMINING (HD) FLARE

The HD Flare offers a highly efficient and versatile alternative to currently used conventional high explosive (C-4 or TNT) for neutralizing thin cases land mines and UXO. The flare neutralizes mines and UXOs by quickly burning through the casing and igniting the explosive fill without detonation. The flares are made from excess production Space Shuttle solid propellant fuel. The propellant in the flare configuration produces a low-thrust flame with an average temperature in excess of 3,500^0 F (1,927^0 C). The burning time of the flare is adjusted by varying the diameter and length of the flare. The tested (prototype) flare design is 5 inches long, one inch in diameter, and burns for approximately 60 seconds. Drilling a small blind hole (0.19” or 0.48cm in diameter and 1.1” or 2.79cm length) along the axis of the flare can increase the dynamic effects of the plume during the first 20 seconds of burning. Remote ignition is by an electric match or by a time fuse inserted in the hole. The tested prototype flares were inserted or cast in high temperature phenolic tubes. The re-designed commercially available flare is cast in cardboard tubes and comes with a metal rod or metal plate stand. The flare can be used with or without the stand. The Department of Transportation (DoT) classification is 1.4C. To operate, the flare is placed 1.5 to 3 cm above or to the side of the UXO or mine case, aimed at where the explosive fill is known to be. The Humanitarian Demining Program tested the prototype HD Flare against the BLU-97 and Mk 118 Rockeye sub-munitions, followed by three land mines.

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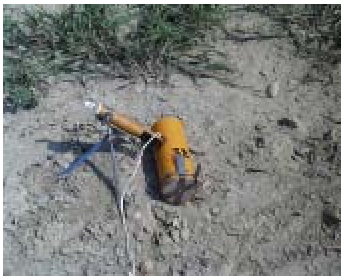
BLU-97: DESCRIPTION, FLARE SETUP, TEST RESULTS AND DISCUSSION

The BLU-97 is a small, aerially dispensed, decelerator stabilized, shaped charge, antimaterial/antitank bomblet. It consists of a standoff probe, fragmenting case, support collar, fuse, and an air-inflated decelerator (AID). The body is a formed piece of carbon steel rolled into a tube. The standoff probe is steel, the shaped charge linear is copper, the cup assembly and wind tabs are stainless steel and the AID canopy is nylon fabric. A copper cone is attached to the forward end of the bomb body to form the shaped charge liner. The booster is housed in a sealed aluminum cup at the bottom of the fuse well and surrounded by a zirconium ring to provide an incendiary capability.

The first test used 4 flares to neutralize four BLU-97s. Three flares were used from stands (one is shown in Figure 1a) and one placed on the ground with a rock at the end. The separation distance between the flares and the BLU-97s was 0.5”. An electric match ignited each flare. The flame location on the three of the BLU97s was 2.5” from the end of cone (main explosive charge). For the fourth sample, the flame was 0.75” from the end of the cone. In four seconds all four BLU-97s went high order and detonators were recovered for the first three tests. Figure 1b shows a broken flare and stand following high order detonation of a BLU-97.



1a

1b

Figure 1a: Flare on stand with an electric match, set up to destroy a BLU-97. 1b: Broken flare and stand following high-order detonation of the BLU-97.

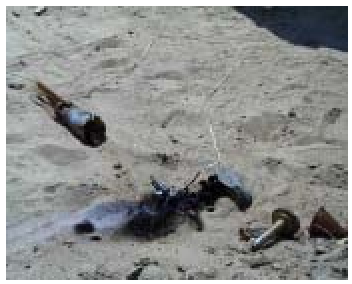
Four additional neutralization tests were conducted placing the flares and BLU-97s on the ground. The flame location was 4” from the back end (cup assembly) on all four BLU-97s. The separation distance between the flare and BLU-97s was 0.5” for two samples, 2” for the third and 2.5” for the fourth bomblet. An electric match ignited the first two flares (with 0.5” separation) and a time fuse ignited the other two flares. The first two BLU-97s went high order within three seconds. The BLU-97 with 2” separation exploded while the example with 2.5” separation exploded during burning. The high order detonations were due to the high temperature ($3{,}500^0$ F) produced by the flare, and the metal case of the BLU-97, which is a good conductor of the heat. For the example with the separation distance at 2.5”, the slightly higher separation distance meant that heat was transmitted less. As a result this sample did not detonate but burned and its case cracked. From this investigation it is clear that location of flame on target and separation distance from target are the two most important parameters to neutralize BLU-97s with deflagration (burning).

Mk 118: DESCRIPTION, FLARE SETUP, TEST RESULTS AND DISCUSSION

The Mk 7 Mod 6 dispenser houses 247 Mk 118 shaped charge bomblets. The Mk 118 bomblets come in three main parts: the conical shaped charge warhead, the fusing system and the tail assembly. The shaped charge contains 170 grams of octol (HMX + TNT) explosive. The standoff probe, bomb body, and base fuse element cover are anodized gold. The bomblet body is steel and the fin assembly is white. The shaped charge upon detonation produces a super heated jet and pressurized gas to penetrate 10 inches of steel. They fall free and arm themselves on their way to the targets. If they hit a hard target such as a tank, bunker, etc a piezo electric crystal in the tip of the probe crushes, which causes the crystal to produce electricity thus detonating the warhead. When bomblets hit a soft target, the impact is not sufficient to crush the crystal and they become live UXO. The Humanitarian Demining Program conducted 13 tests using Rockeyes and flares at varying separation distances from the Rockeyes and varying flame locations on Rockeyes.

Three Rockeyes were placed on the ground. Testers placed the flares on the ground with the flame aimed near the center of each sample as shown in Figure 2a. The separation distance between the flare and Rockeye was 0.5 inch for each test. All three flares were ignited remotely and electrically. As the flame penetrated into each Rockeye, it blew the cap and copper cone off and the explosive partially burned as shown in Figure 2b. We then selected two of these partially burned Rockeyes for continued testing. One flare was placed against each, pointing at the partially burned explosive with a separation distance of 0.5". An electric match ignited the flares. The partially burned explosive samples were completely burned with the second flare as shown in Figure 2c.

2a



2b

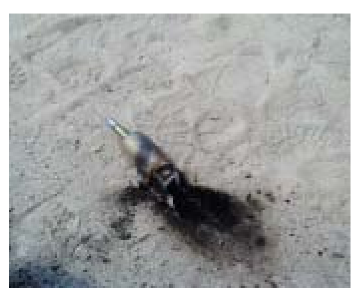
2c

Figure 2a: The flare aimed at the center of the Rockeye. 2b - Disrupted Rockeye following activation of the flare. The copper and the cone blew off, explosive partially burned. 2c - A second flare ignited against disrupted Rockeye and burned the rest of the explosive.

Two more Rockeyes were placed on the ground. A flare was placed against each with a 0.5" separation distance. Both Rockeyes burned 1.5" from the end. An electric match remotely ignited both flares. As the flares burned, the cap and copper cone blew off, the high explosive charge popped out and the booster separated on both Rockeyes.

A third test involved four additional Rockeyes. Each flare was separated by 0.5" from the Rockeyes. The flame location on two samples was near the base as shown in Figure 3a. The flame locations on the other two bomblets were 1.5" from the end and 0.25" from the front end. Three flares were electrically ignited, and the fourth flare (the one with 0.25" separation) was ignited with a time fuse. One of the two samples at 0.5" burned aggressively with two pops as shown in Figure 3b. The other 0.5" sample burned

3a



3b

Figure 3a: Placement of flare near base of Rockeye. 3b - Aggressively burned Rockeye.

out with a large pop, but the main explosive did not burn. The sample at 1.5" burned neatly leaving a hole in the surface of the munition, but leaving an intact case. Five seconds after the time fuse ignited the flare at 0.25", the standoff probe was separated with a pop. This last bomblet was reused with a flare placed on the ground, pointed at the Rockeye cone and separated by 0.5”. Following ignition by a time fuse, the explosive in the sample burned completely with use of the second flare.

Finally, five more Rockeyes were selected for further testing. The location of the flame on each sample was 0.5” from the front end. However, this time we varied the separation distance from the flare to the sample. The distance used was 0.5” for one sample, 1” for two samples, and 2” for the final two samples. The flares pointed at the first three samples were ignited remotely by electric match, while flares pointed at the 2” samples were ignited by time fuse. The sample ignited by the flare at 0.5” burned with a high flame after a few seconds. Within the first five seconds a series of pops was heard. One of the 1” samples burned completely but the flare was blown away. For the other 1” sample, within two minutes after the flare began burning the sample popped out and the Rockeye burned completely. Once the flare ignited the first 2” sample, it popped out in two minutes and separated completely and was burned completely. As the flare ignited the second 2” sample, the fuse popped out and the Rockeye was burned.

To summarize, three separation distance (0.5”,1” and 2”) were selected, while location of the flame on Rockeyes were near center of body, 1.5” from the end, near the base fuse, or 0.25” or 0.5” from front end. Nine tests were performed, keeping a separation distance of 0.5” between flares and Rockeyes and varying the flame location on the Rockeyes at five different locations. During most tests, the cap and copper cone were blown off and the explosive was partially burned from the Rockeyes. In some cases however, the main charge did not burn while in some cases the explosive was neatly burned with the case intact. From the test results four tests were selected that kept the flame position at 0.5” from the front end of the target, two each using flare separation distances of 1 and 2 inches respectively. In all cases the Rockeyes burned completely. To destroy a Rockeye completely one should consider two important parameters: separation distance of the flare and location of flame on the target. Partially burned explosive in munitions can be destroyed using a second flare. At present, Rockeyes are generally destroyed by demolition (use of high explosives).

LAND MINES

Three mines, two anti-personnel (AP) PROM-1, and PMOZ-2 and one anti-tank (AT) TM-46 were selected for this investigation. These mines are constructed from cast iron and heavy steel and proved very difficult to neutralize with HD Flares.

PROM-1: The PROM-1 is a bounding fragmentation, steel cased, bottle-shaped AP mine. The center of the mine is a tube filled with propellant. It contains 425 g of an equal mixture of TNT and RDX or TNT. It can be activated by a trip wire or pressure, and jumps into the air about 60 to 80 cm before detonating.

4a

4b

Figure 4a: PROM-1, flare with time fuse aimed at the shoulder of the mine from a stand. 4b - After neutralization, the main charge burned.

During the test the PROM-1 was buried and only the top portion was exposed as shown in Figure 4a. The flare was held on a stand and aimed at the shoulder of the PROM-1. The shoulder is the thinnest section of the steel casing. The separation distance was 0.5” between the flare and shoulder portion of the mine. The flare was ignited by a time fuse. During flare burning the top of mine was ejected and the main explosive charge burned. The empty mine casing was recovered and it is shown in Figure 4b.

POMZ-2: The POMZ-2 is an AP fragmentation stake mine consisting of a serrated cylindrical cast-iron fragment sleeve. It contains a 75g TNT charge, a MUV-type tripwire fuse, and a wooden stake. It is normally laid amidst concealing vegetation with the top of the mine approximately 30 cm above ground and the tripwire attached to a fixed object.

5a.

5b

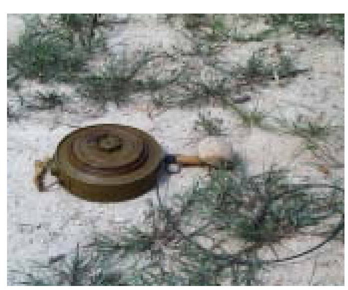
5c

Figure 5a: Unfused live POMZ-2, flare positioned from stand at side of mine. 5b: POMZ-2 after flare burned, TNT melted and flowed at bottom. 5c: Burned POMZ-2 after slug removed.

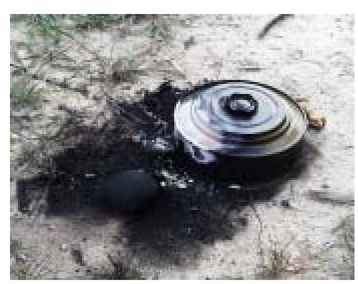
During the test, the POMZ-2 top was kept approximately 30 cm above ground with no trip-wire attachment. The flare was held horizontally on a stand pointing at the middle portion of the mine case as shown in Figure 5a. The separation distance was 0.5” between the mine case and flare. The flare was initiated by time fuse. As the flare burned, it penetrated halfway to mine’s case; due to the high temperature of the case, the TNT melted and flowed through the bottom as shown in Figure 5b and 5c. The mine did not initiate.

TM-46: The TM-46 is a metallic cylindrical shape with a 30 cm diameter AT mine. It contains 5.3 kg of TNT or Amatol (NH_4NO_3(ammonium nitrate) + TNT) as the main charge.

The mine was surface buried. The flare was placed on the ground with a stone at its back as shown in Figure 6a. The flare was separated by 0.5” from the mine case and pointed at the side of the mine case. The flare was ignited by a time fuse. The burning flare created a hole in the mine case as shown in Figure 6b and the explosive started burning. The mine burned more than 10 minutes but only half of the explosive was burned before burning ceased.



6a



6b

Figure 6a: TM-46 AT mine. Flare placed on the ground aimed at the side of the mine case. 6b: Mine after flare burned.

To neutralize the mine completely by deflagration, we left the mine in the same place. This time we placed two flares 0.5” from the mine case and at 180 degree apart. Both flares were ignited by time fuses. The burning flares created holes in the side of the mine case and ignited the remaining explosive in the mine. This time all the explosive in the mine was burned and the mine was completely neutralized, leaving an empty mine case.

The HD Flare successfully neutralized the PROM-1. The explosive in the POMZ-2 (TNT) melted and flowed from the bottom, and the case was only half penetrated. A single flare neutralized half of the explosive in the TM-46. Generally once an explosive starts burning, it does not stop until it is all consumed. We therefore assumed the TM-46 mine contains some non-explosive chemical. However, placing two flares at 180 degrees apart from the side of the TM-46 completely neutralized it.

Colin King tested the HD Flare in Kosovo on live, fused AT mines such as the TMM-1 metallic, and the TMA-3 and TMA-5 plastic case mines. He also tested the flare against the PMA-2 plastic AP mine. Temperatures ranged from 32^0 to 39^0 F. The TMA-3 and TMA-5 mines burned more than two minutes, then went high order. The TMM-1 casing burst open with the fuse being lost after it burned for about 25 seconds. The PMA-2, which contains 100gm of TNT, went very small low order after 25 sec [7].

High order detonation of AT mines can be avoided with the use of two flares opposite each other, pointed away from the detonators or fuses and aimed at the explosive portion of mines. This also reduces burning time by nearly one half. Burning time depends on the amount and type of explosive, and type of mine case.

CONCLUSIONS

The HD Flare is a non-explosive, safe, simple to use and train, and low cost device, which neutralizes munitions and mines by deflagration (burning) and detonation depending on the location of the flare’s flame on munitions and mines, and separation distance between the flare and munitions or mines. In some cases it took more than one flare to completely neutralize munitions and mines. However, placement of two flares away from the detonator and opposite to each other, pointed at the explosive portion of AT mines reduces the chance of high order and burning time. Hard cases munitions and mines are difficult to neutralize by burning. The ignition methods (electric match, time fuse or igniter cord) do not influence the performance of flares. However, use of a time fuse will eliminate requirements for long electrical wires and demolition devices, thus reducing logistical requirements. The flare is only applicable to surface exposed mines and munitions. The flare can be used with or without stand. If it is used without the stand, place a one half-pound stone at the back of the flare. The US army can take advantage of clearing mines on roads, on and under bridges, near power lines, public buildings and oil wells if the flare passes all safety tests. The HD Flare offers the capability to neutralize land mines in-situ while greatly improving the quality control process in humanitarian demining situations.

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