MEMS Implementation in the M213 Hand Grenade Fuze

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Abstract

C70 Detonator of M213 Fuze is not IM compliant to support M67 Hand Grenade. In addition C70 detonator contains of Lead Azide, Lead Styphnate and RDX. Lead materials are very hazardous to health and are not environmentally friendly. Because of the safety issue, environmental and health issues, ARDEC is actively working to replace this detonator.

To produce an IM compliant C70 detonator replacement, ARDEC is in process of developing a MEMS scale out-of-line detonator. Micro-Energetic Initiating technology will also improve the safety. A micro actuator will be utilized to slide the primary explosive in-line after the pin is pulled. The primary explosive will be a greatly reduced quantity of lead azide, or a heavy-metal free compound. This MEMS concept will be integrated into existing C70 detonator case.

Test results obtained during the design and evaluation of this concept will be presented at the IM Conference.

KEYWORDS: M213, C70 detonator, MEMS

Background

The M67 fragmentation hand grenade is widely used in the field by the US Army and US Marine Corps. RDECOM-ARDEC is designing a replacement fuze for this grenade because the current one fails to comply with the Insensitive Munitions (IM) requirements and a major component is only available from foreign sources. Both of these issues are related to the C70 Detonator used in the fuze. It contains large quantities of lead-based primary explosives that initiate the grenade under many of the IM test conditions. Safety issues, in combination with the environmental compliance requirements for use of lead compounds, make the manufacture of these detonators an unattractive investment for US-based manufacturers. With no in-country source, a disruption of C70 supply could cause the complete breakdown of M67 production, a situation known as a single point failure of the supply chain. The new fuze/detonator design must retain the lethality of the present design, while meeting the IM safety requirements. It also should reduce the item’s total life-cycle cost, and the soldiers’ and environment’s exposure to lead. The design approach described below makes use of MEMs technology to meet the goals of the fuze redesign effort.

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Approach

The M67 Hand Grenade is a traditional pull-pin grenade. Pulling the pin in the grenade's fuze, the M213, releases the spoon and the hammer, which hits the primer at the top of the fuze body (see Fig. 1), initiating the firing train. The delay mix is ignited by the primer, and burns several seconds before initiating the attached C70 detonator. This detonator is massive, containing approximately 10 times more lead styphnate, lead azide, and RDX than other detonators. This size is not simply a case of over engineering; the length is required to properly initiate the grenade's explosive fill for good fragmentation, while its diameter is dictated by the dimensions of the fuze body.

This fuze train is simple, and has functioned well and reliably in grenades for decades. Unfortunately it is also has major safety issues. Any unwanted stimulus that causes the primer to function, like fire, initiates the entire fuze train. The large quantities of primary explosive in the detonator can also be detonated by external stimulus with enough energy to function the entire grenade. These problems are exacerbated when many grenades are in the same location, through sympathetic detonation.

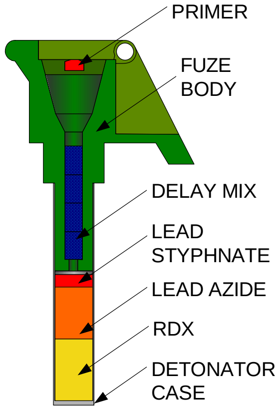

Figure 1: M213 Grenade Fuze
(spoon and hammer not pictured)

The new design will replace the contents of the C70 Detonator with an out-of-line detonator and a booster, and uses the detonator case to preserve the fragmentation pattern of the grenade. While the detonator case size is large compared to other detonators, it only has an approximate inner diameter of 0.3 inches, so a MEMs scale detonator is required. This detonator will only slide the explosives in line when the delay functions under normal conditions, and will have drastically smaller quantities of primary explosives (see Fig. 2). Not only will the fuzes IM performance be improved, but heavy metal-free primary explosives can be used, eliminating lead from the grenade.

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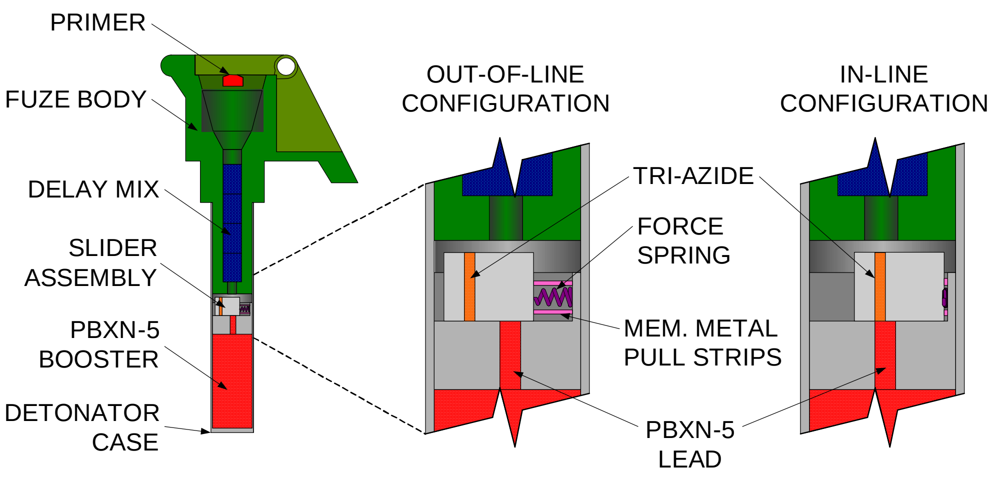

Figure 2: MEMS concept

Testing and Results

In developing the fuze concept pictured in Fig. 2, a series of tests were conducted with various energetic materials and configurations. These tests and their results are discussed below.

In order to eliminate lead from the fuze, a lead-free primary explosive must be used in place of the lead styphnate and lead azide. A promising material, cyanuric triazide (referred to as triazide), was identified. This heavy metal-free material contains three azide groups bonded to a ring of carbon and nitrogen. Previous tests had shown triazide to behave like a primary explosive, but had not demonstrated its ability to function as part of a fuze train.

The first test used parts fabricated from plastic. These disks had a small hole drilled in their centers. Two disks were glued together, one disk loaded with triazide and the other was loaded with RDX or CL-20 based formulations. The triazide was initiated with a hot wire. The triazide released enough energy to initiate both types of output charge, as well as fracture the disk (see Fig. 3). Based on the fracturing of the output disk, the CL-20 based formulation (EDF-11) functioned better than RDX, but the energy was directed into the fixture instead of outward.

Figure 3: Functioned first design of hardware parts

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Since plastic fixtures were not sufficiently confining, aluminum blocks were used for the second test. First, a small hole was drilled through a center of a block, and then a larger hole was drilled from bottom, about one-third distance through the block. The small hole was filled with 150-200 mg of cyanuric triazide and the larger hole was press loaded with the output charge of 100 mg of EDF-2c. Once loaded, this block was taped to another aluminum block acting as a witness plate. The triazide was initiated with the hot wire and it initiated the EDF-2, but the results were disappointing (see figure 4). Again the energy appeared to be directed outward instead of into the witness block.

Figure4: Functioned fixture loaded with EDF-2/Cyanuric Triazide.

The next step was to determine if the delay is capable of setting off the triazide. A simple test was performed where triazide was loaded into an aluminum cup. The cup was fitted over the end of the fuze stem (see figure 5), and the fuze was functioned normally. The triazide was initiated.

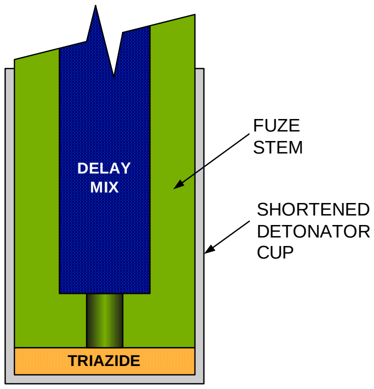

Figure 5: Delay-Triazide Test

Since the triazide was initiated properly by the delay column, next step was to see if the triazide can set off a PBXN-5 lead and a PBXN-5 booster, eliminating the output charge all together. Small aluminum rods were used as fixtures and were press loaded with triazide and PBXN-5. These were glued together in-line and dropped into the C70 detonator case along with a small booster pellet. The C70 cup was fitted over the end of the fuze stem (see figure 6). The whole train worked, with the delay setting off the triazide and the triazide setting off the PBXN-5 lead and booster. The aluminum sleeves (loaded with the triazide and PBXN-5 lead) expanded on the lead end, demonstrating the reaction was high order (see figure 7).

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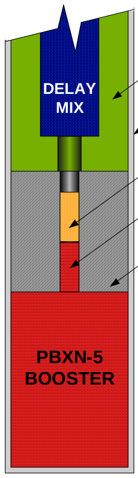

Figure 6: C70 cup loaded with primary and PBXN-5


Figure 7: Functioned Fuze with Triazide, PBXN-5 Lead and PBXN-5 booster

Testing continued with out-of-line experiments. These tests are necessary to establish that the fuze will not function while in out-of-line configuration. The set up was similar to in-line test, except that the triazide rod and the PBXN-5 lead rod were set out-of-line (see figure 8). When fired, the delay set off the triazide, but the PBXN-5 lead remained intact in the rod (see figure 9).

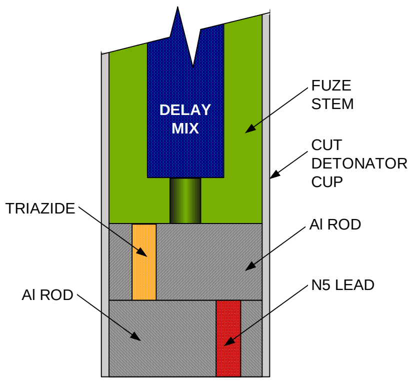

Figure 8: Out-of-line Testing

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Figure 9: Out-of-line Test

Conclusion

The test results show that an out-of-line detonator could allow the M67 Hand Grenade fuze to be IM compliant. This concept will improve safety and eliminate a single point failure issue. Use of cyanuric triazide will reduce lead exposure to soldiers and the environment.

The design has not been proven, but further testing is underway.

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