IM in the Field – Experience of Reduced Sensitivity Mortar Cartridges to Actual Combat Threat Stimuli

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Abstract

Between 1998 and 2001, the US Army Armaments Research, Development and Engineering Center, supported by the Office of the Product Manager, Mortar Systems, developed a reduced sensitivity version of the standard M720 60mm mortar cartridge. The M720, approved for service use in 1979, is a conventional high explosive cartridge filled with Composition B. The round is highly vulnerable to external threat stimuli, reacting violently to most threats. The new cartridge, designated, M720A1, is a reduced sensitivity munition, specifically designed to match combat performance of the M720 with several Insensitive Munitions mitigation features added. Also developed in conjunction with the M720A1, was the M768 cartridge, identical to the M720A1 except for the use of a lower cost fuze. Both rounds were placed in service in 2005 and 2006. In 2009, during operations in Southwest Asia, a convoy was attacked by insurgents using improvised explosive devices. A vehicle carrying mortar ammunition was hit and set on fire. The M768 cartridges in the vehicle successfully resisted the threat stimuli and merely burned with the vehicle. This event is a validation of the IM features applied to the round and serves as an example of the utility of insensitive munitions programs worldwide.

As a result of several disastrous incidents involving accidental initiation of munitions exposed to external threat stimuli, the Insensitive Munitions (IM) Program was initiated by the US Navy in the early 1980's. The program was eventually adopted by the US Department of Defense and codified in law and regulation. Initial work by the Navy, was the development of reduced sensitivity plastic bonded explosives (PBX's), typically with inert binders. A large variety of these "IM" explosives were developed and approved for service use, including cast cure and pressed types. During the late 1980's, the US Army began development of reduced sensitivity explosives, focusing on pressed, energetic binder PBX's, leading with PAX-2.

In 1997, the Product Manager Mortar Systems, initiated a program to reduce the sensitivity of 60mm high explosive (HE) mortar ammunition to external threat stimuli. The management of the program was later transferred to the Project Manager Conventional Ammunition Systems (PM CAS). An integrated product team (IPT) based at the US Army Armaments, Research, Development and Engineering Center (RDECOM-ARDEC) at Picatinny Arsenal was formed to execute this program. The focus of this effort was

the M720 cartridge, the standard 60mm HE round at the time. The round is a typical high rate/high volume production item. The IPT quickly recognized that existing reduced sensitivity PBX's were not highly suited to this application. Specifically, pressed PBX's would be too expensive to use, requiring the design of a two piece projectile as well as significantly increasing fill costs. Furthermore, cast cure PBX's could also significantly raise fill costs due to buffer storage requirements during curing, as well as the limited availability of mass production fill facilities. In addition, the non-energetic binder typical of most PBX's, require the addition of more energetic solids, increasing vulnerability to some IM threat stimuli. As a result, the IPT chose to develop a reduced sensitivity melt pour explosive. Other changes to the munition were also required to optimize the reduced sensitivity characteristics of the explosive.

The IPT began the effort by examining the design of the existing M720. The team choose to limit the extent of modifications to the cartridge and packaging to reduce cost and logistics impacts in service use. The ammunition proponent, the US Army Infantry Center was consulted during this process. The team subsequently contracted with the energetics development group at ATK Thiokol Corporation to assist in the development of a reduced sensitivity melt pour explosive. Other cartridge modifications were designed at RDECOM-ARDEC. The primary non-energetic modification was the design, development, and testing of a fuze well vent, making use of a meltable, plastic fuze adapter to allow explosive gases to leave the cartridge after exposure to slow and fast cookoff threat stimuli. This required the modification of the existing fuze well. Another change was the addition of an intumescent coating on the munition container to reduce the rate of heat input to the cartridges. In addition, the fuze booster and lead was changed from the highly vulnerable Composition A-5 to a much reduced sensitivity PBXN-5 PBX material.

The explosive development effort focused on finding a low cost energetic binder, suitable for use in the existing, large melt pour industrial base in North America. Requirements included reduced sensitivity, ease of filling, and compatibility with existing, low cost nitramines and other typical explosive solids. After extensive development, the binder 2-4, dinitroanisole was identified as meeting the requirements. It exhibited superior filling characteristics, including far less shrinkage and much greater adherance to the projectile wall when compared to TNT, and was not vulnerable to deflagration/detonation behavior when subjected to thermal stress when properly vented. Another major effort in this development was a full toxicological study to determine lifecycle risks associated with the new binder system and its energetic end products. As a result, the first US qualified reduced sensitivity melt pour explosive was

qualified and designated PAX-21.
The end item, the M720A1 and a low cost alternate munition with a different fuze, the M768, was type classified in 2003. Both rounds exhibited significantly reduced violence of reaction when subjected to external threat stimuli, but did not meet all of the standard "IM" threat requirements, including shaped charge jet impact. Subsequent initial production testing also revealed an issue with the intumescent coating when subject to temperature extremes (-50 F). The coating tended to de-bond during drop testing and was eventually removed from the production configuration. The M720A1 and M783 entered full scale production in 2006 and was issued to the ammunition inventory in 2007.

During October 2009 US Army Specialist (SPC) Ng, the son of an ARDEC engineer Yam "Peter" Ng, was home on mid-tour leave from duty in Afghanistan. SPC Ng was a mortarman in the 10th Mountain Division's C Company, 2nd Battalion, 87th Infantry. While here, he spoke with engineers from PM CAS and ARDEC and the M720A1 IPT about his experiences with Picatinny-developed munitions and weapons.

SPC Ng was on convoy duty in Afghanistan on 12 September 2009, traveling in a Mine Resistant Ambush Protected (MRAP) vehicle. During the operation an ambush was encountered. SPC Ng's vehicle was destroyed by a very powerful Improvised Explosive Device (IED). The IED ruptured the vehicle's hull and fuel tank, engulfing the vehicle interior in flames. In the vehicle were sixteen M768 60mm mortar cartridges in fiber tubes (unloaded from the metal overpack) carried inside the cabin with the seven-man crew.

Interior view of the MRAP after the fire. An unexploded shell body from a M768 cartridge *can be seen at the lower left.*

The M768 incorporates the IM features detailed above, including the new main charge fill and the fuze well vent. The plastic fuze adaptor melted in the fire, allowing the fuze to separate from the cartridge. This relieved internal pressure from the heating melt pour explosive and prevented a violent reaction of the PAX-21. After the MRAP had stopped burning, SPC Ng examined the wreckage and was amazed to find all of the rounds' shell bodies intact, demonstrating the non-violent reaction. He also found the remains of the fuzes that had separated from the cartridges as designed, providing the venting to limit the PAX-21 explosive fill to a burn reaction. The IPT thanked SPC Ng for his service during his visit to Picatinny and were gratified to learn that their efforts were paying off for US and Allied soldiers in such a dramatic way.

Shell bodies and separated M783 fuzes from M768 cartridges recovered from the vehicle after the fire.

The Insensitive Munitions Program typically uses an approach using iterative improvements to gradually eliminate the vulnerability of munitions to external threat stimuli. While the M720A1/M768 ammunition did not pass all of the IM requirements, in an actual combat situation, the munition performed in an "IM" manner as designed, limiting response to a Type V, burn only reaction. Further improvements are being developed to increase IM performance. However, in this actual case, the IM mitigation

techniques applied to the munition performed as designed, minimizing combat losses.