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INSENSITIVE MUNITIONS (IM) TECHNOLOGIES AND IMPLEMENTATION OF NEW DESIGNS

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14. ABSTRACT

In order to meet arising threats, current munitions development goals are transitioning from providing safer munitions to providing higher performance. The improvement of insensitive munitions response does not necessarily mean a reduction in performance, and, in some cases, performance actually improves. This paper will review some of these technologies and the opportunities offered by the implementation of new designs.

15. SUBJECT TERMS
IM Insensitive munitions IM improvement methods Carbon composite rocket motor systems Package venting Improved fragmentation Integrated technologies

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CONTENTS

FIGURES

INTRODUCTION

The need for increased safety, through the development of insensitive munitions (IM), has been recognized under U.S. law:

> "The Secretary of Defense shall ensure, to the extent practicable, that Insensitive Munitions under development or procurement are safe throughout development and fielding when subject to unplanned stimuli" (ref. 1).

Internationally, the North Atlantic Treaty Organization (NATO) has also implemented IM improvements:

> "Technological advances in the design of explosive ordnance are making possible the development of a range of munitions termed Insensitive Munitions (IM) or Munitions à Risques Atténués (MURAT) which are less dangerous than previous weapons when subjected to accidental and com- bat stimuli. Such munitions remain effective in their intended application, and are less sensitive than their predecessors to extreme but credible environments such as heat, shock or impact.
>
> Introduction of IM into service is intended to enhance the survivability of logistic and tactical combat systems, minimise the risk of injury to personnel, and provide more cost effective and efficient transport, storage, and handling of munitions" (ref. 2).

In order to develop IM, it is necessary to either suppress the release of the chemical energy in munitions or release it in a less violent manner. Violent reactions can occur with any poorly designed munition, and the violence is not limited to systems containing energetics. Examples of violent reactions with poorly designed safety are easily found in the large number of steam explosions in the early industrial age, shown in figure 1 (ref. 3). Inert bombs loaded with concrete have been known to have more violent reactions in cook-off than properly designed munitions, due to a steam explosion from the water within the concrete. The challenge facing modern munitions engineers is to improve performance while maintaining or increasing safety. However, many legacy systems were designed prior to modern modeling and materials were available without as much emphasis on safety. Fielding new systems represents an opportunity to increase performance and safety.

Figure 1
Boiler explosion at Hays Manufacturing Co., Erie, Pa

INSENSITIVE MUNITIONS IMPROVEMENT METHODS

Decreasing the IM responses of a munition requires a systems approach. For a legacy system designed without IM consideration, replacing the energetic material to developing the IM improved munition is rarely sufficient. The violence of reaction is not determined by the intended use (propellant, detonating explosive) but rather the confinement and the detonation and burning properties of the energetics.

For many modern systems, many propellants are more detonable than some of the latest IM explosive fills. As a result, IM technologies are focused on two areas of improvement:

- Suppressing the release of the chemical energy:
    - Less shock sensitive
    - Larger critical diameter
    - Self-extinguishing (some materials require higher than atmospheric pressure to burn unaided barriers between munitions)
    - Armor
- Releasing the chemical energy in a less violent manner:
    - Venting
    - Select materials with lower burning rates at higher pressure
    - Less of the energetic materials

By considering the physics of the problem, improved performance and IM design can co-exist. The following subsections are examples of some techniques that can be used.

Carbon Composite Rocket Motor Systems

The performance advantages of carbon composite rocket motor cases have been recognized since the 1960s (ref. 4). The light weight and high strength of these materials can be used to improve performance. The technology has been demonstrated in the Terminal High Altitude Area Defense (THAAD) and Phased Array Tracking Radar to Intercept of Target (PATRIOT) Advanced Capability - 3 (PAC-3) large missile systems, shown in figures 2 and 3 (ref. 5).

Figure 2
THAAD missile

Figure 3
PAC-3 missile

Composite rocket motor cases have been shown to be an effective component of IM mitigation systems. Esslinger et al. demonstrated improvements in fast cook-off (FCO), slow cook-off (SCO), bullet impact (BI), and fragment impact (FI) testing by utilizing composite cases (ref. 6).

Composite cases are successful because of their high strength, yet the cases have large fractures and vent areas when they fail, which reduces internal pressures. Additionally, direct exposure to fire weakens the cases. With decreased weight when compared to older steel cases, composite rocket motor cases represent a “low hanging fruit” technology where safety and performance can both be improved with investments in manufacturing and inspection techniques (ref. 7).

Package Venting

The packaging of munitions has evolved far beyond putting an item in a box. Modern packaging requires the design for difficult handling, drop testing, electro-static protection, long shelf life, etc. Military packaging is an advanced technical specialty. Simple changes to the protective packaging used for munitions have been shown to have profound effects on munition responses. Panels and packages that melt away in the event of a fire have been shown to be effective without losses in performance or logistics and are undetected by the user. This technology has been applied to the Modular Artillery Charge System (MACS). Figure 4 shows the logistical configuration of the MACS charge during IM testing, and figure 5 shows the post-test results of the FCO test (ref. 8).

Figure 4
MACS charge staged for FCO test

Figure 5
MACS charge after FCO test

The IM success stories are not well reported because the lack of fatalities, injuries, and damage to equipment do not generate concern. The MACS charge is an exception. After development and fielding, there was a fire at the manufacturing plant. There was significant fire damage but no blast or fragmentation damage due to the improved IM packaging design, which is shown in figure 6 (ref. 9).

Figure 6
MACS charge after plant dire

Improved Fragmentation

Modern methods are being developed that eliminate the chaotic nature of natural fragmentation in order to improve both the lethality and fragment distribution from a warhead. Some of these methods improve the safety of the munitions. Baker et al. developed a melting plastic liner that provides both venting area and designed fragmentation, as shown in figure 7 (ref. 10).

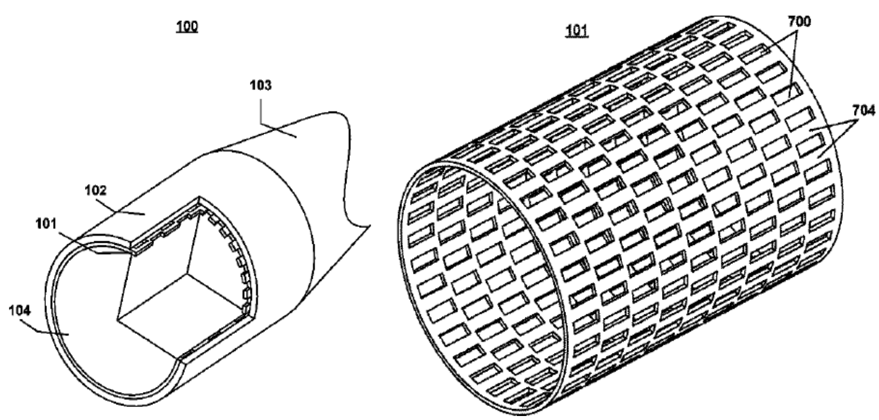


Figure 7
Melt liner for controlled fragmentation IM

Another method utilizes preformed fragments, where dense fragments of desired size are embedded in a matrix. If the matrix is a polymer, venting of the munition from unplanned stimuli is easily achieved. The lethality of embedded fragments has been demonstrated on the High Explosive-Preformed Fragmentation (HE-PFF) 105-mm M1130 artillery projectile (ref. 11). This can be seen in figures 8 and 9. Embedding fragments within a polymer matrix has been demonstrated by Widener et al. as shown in figure 10 (ref. 12).

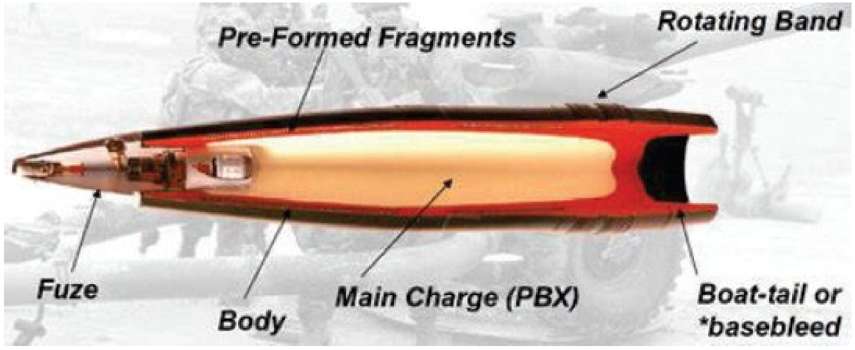


Figure 8
PFF warhead

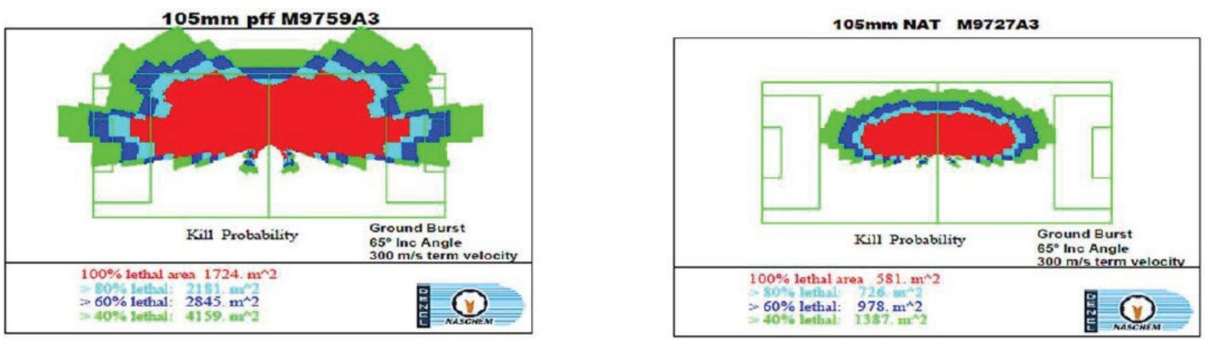


Figure 9
PFF lethality

Figure 10
Melt liner for controlled fragmentation

New Energetics

Many legacy systems are still utilizing trinitrotoluene (TNT) as a main explosive fill; although, at this time, an IM waiver is required. The U.S. Air Force has developed the explosive AFX-757 for main bomb fills with improved insensitivity and 39% performance increase over Composition (Comp) B and TNT/1,3,5-Trinitro-1,3,5-triazinane (RDX) melt-cast formulation (ref. 13).

Torpedo Explosives

Recent heavyweight torpedoes are achieving greatly improved IM responses, as well as improved performance. These include the F21 (ref. 14), SeaHake Mod 4 DM2A4, TP-2000, and the Black Shark. The F21 incorporates IM design features including thermal protection and controlled ignition for cook-off mitigation. Reduced sensitivity explosive formulations are incorporated to provide mitigation against impact threats, sympathetic reaction (SR), and even shaped charge jet (SCJ) attack. These newer explosive formulations [PBXN-105, B-2211D, and PBXN-111 (same formulation as B-2211D)] are proving to produce increased bubble energies over more traditional torpedo explosives (Tritonal, HBX-3, and Torpex 9). Figure 11 presents a relative comparison of bubble energies for the different explosives. Figure 12 presents F21 warhead and IM signature.

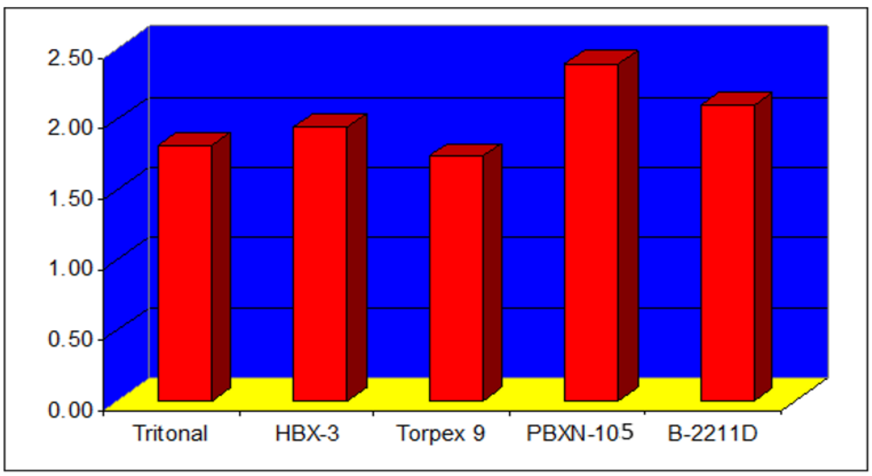
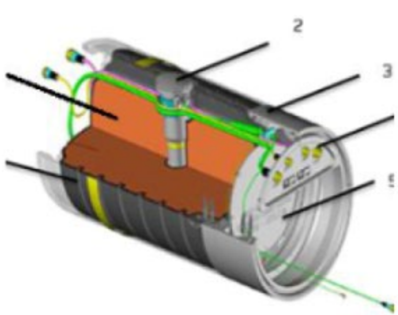


Figure 11
Relative bubble energies for different explosives (refs. 15 and 16)

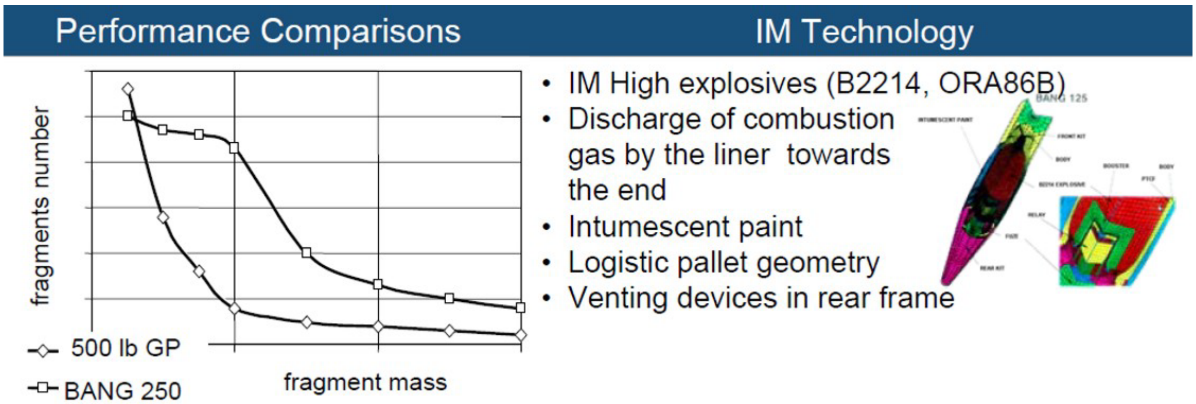


	FCO	SCO	BI	FI	SR	SCJ
HBX/Torpex					>III	
F21	V	IV	V	V	III	IV

Figure 12
F21 warhead (left) and IM signature (right) compared to HBX or Torpex-filled torpedo warheads

Integrated Technologies

The development of munitions systems with reduced violence to unplanned stimuli require multiple technologies to be successful. The French CBEMS 500-lb bomb is an example (fig. 13) (ref. 17). By utilizing a new energetic with improved venting and logistics, the munition was capable of passing five of the six standard IM tests. For improved safety, an intumescent paint was applied to increase the time to reaction in fires (ref. 18).



IM Signature

	FCO	SCO	BI	FI	SR
Mk82 mod 2 TP	I	I	I	I	I
CBEMS/BANG	V	V	V	V	III

4 palletized bombs without the fuze MURAT **

Figure 13
French CBEMS 500-lb bomb (ref. 18)

CONCLUSIONS

With a new emphasis on performance, it is anticipated that innovative and updated systems will be fielded. This should be viewed as an opportunity to implement the insensitive munitions (IM) technologies that have been developed and improve both safety and effectiveness of the munitions portfolio. However, despite the IM developments that address effectiveness, utility, and lethality, there is a desire to de-emphasize the importance of these technologies.

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