U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

Insensitive Munitions, Important Now More than Ever

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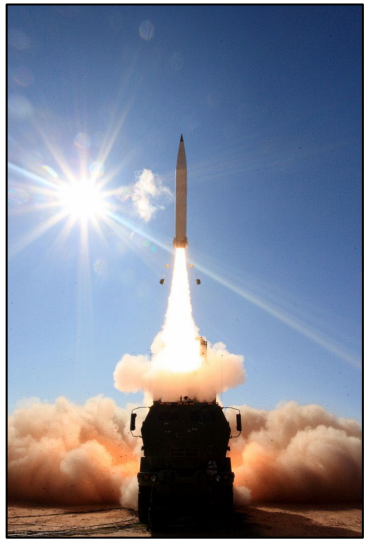
Introduction

In order to meet the ever changing requirements of the warfighter and national defense munitions, development must continue to evolve. This is true for all areas of armament technology, including Insensitive Munitions. This talk will highlight some of the changes and technical challenges as well as the community's responses. Additionally, the need for further IM development will be discussed in relation to world events.



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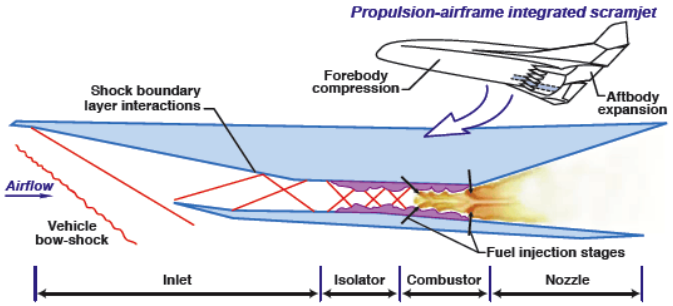
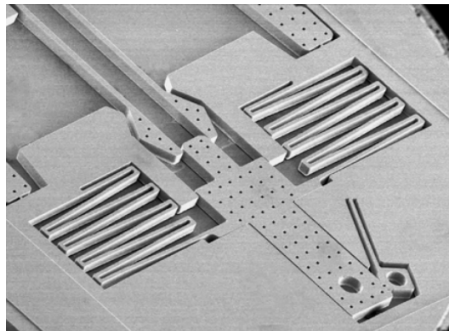
Technology is Changing Rapidly

- Artificial Intelligence
- Data Mining
- Additive Manufacturing
- Non-Carbon Based Fuels
- Autonomous Robots
- Unmanned Aircraft Systems and Swarms
- Electronic Warfare
- High Power Lasers
- Hypersonics
- Ramjets and Scramjets
- Smart Munitions
- MEMS





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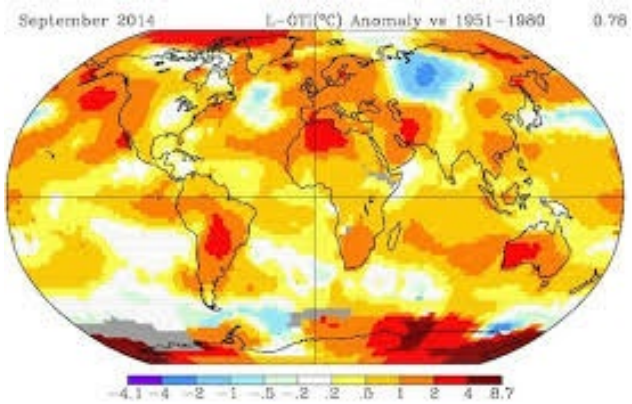
The World is Changing Rapidly

- Changing Economic Powers
- Chinese Belt and Road Initiative
- Rapid Development of Some Countries
- Changes in Eastern Europe
- A Larger NATO
- Increased Importance of Artic Regions
- New International Alliances
- Changes in International Trade
- Climate Changes



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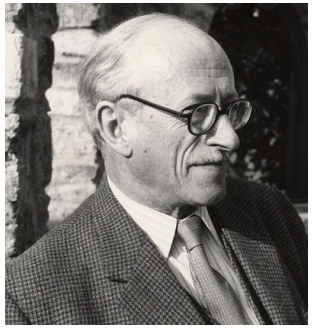
The Philosophy of Warfare Continues to Evolve

Sun Tzu

Victorious warriors win first and then go to war, while defeated warriors go to war first and then seek to win.

Carl von Clausewitz

War is nothing but a continuation of politics with the admixture of other means.



B. H. Liddell Hart

The only thing harder than getting a new idea into the military mind is to get an old one out.

- Mosaic Warfare
  - So many weapon and sensor platforms directed at the enemy, that its forces are overwhelmed
- Kill Chain
  - Structure of an attack
- Russian Hybrid Warfare
  - a blend of conventional, irregular and cyber warfare
- Chinese “Informatized Local Wars” and fully modernized military
- Unconventional warfare and asymmetric capabilities

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The Internationalization of Munitions Development

Boeing and Nammo's Ramjet 155. Photo: Boeing.

Boeing [BA] and the **Norwegian** defense firm **Nammo** have announced a successful test of its Ramjet 155 projectile weapon, which the companies developed for the **U.S. Army** to find new long-range artillery solutions.

The F-35 is developed, produced, and supported by a team of **eight international program partners** — the U.S., United Kingdom, Italy, Netherlands, Australia, Norway, Denmark and Canada.

https://www.lockheedmartin.com/en-us/products/f-35/f-35-global-partnership.html

January 18, 2022, the **Israel** Missile Defense Organization (IMDO) of the Directorate of the Defense Research and Development (DDR&D) at Israel's Ministry of Defense, together with the **U.S. Missile Defense Agency (MDA**) and Israeli Defense Forces, conducted a successful flight test of the Arrow Weapon System (AWS) and the Arrow 3 interceptor at a test site in central Israel.

As development costs increase for newer, sophisticated munitions, cost sharing through international collaboration is growing. All nations are becoming more interdependent upon foreign buys of munitions.

IM Threats

IM tests and evaluations are threat based. Each munition project / program shall develop a Threat Hazard Assessment (THA), which analyzes threats and probabilities. A series of standardized tests has been developed. The THA is used to modify these tests or introduce new tests as needed.

Threats						
	FUEL FIRE Truck or aircraft fire on a flight deck	**NEARBY HEAT** Fire in adjacent magazine, stores or vehicle	**BULLETS** Small arms from terrorists or combat	**FRAGMENTS** Bombs, artillery, or IEDs	**SYMPATHETIC REACTION** Detonation of adjacent stores	**SHAPED CHARGE JET** RPG, Bomblets, ATGMs
						

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A World without Insensitive Munitions
The War in the Ukraine

Ammunition depot explosions at Nova Kakhovka

Russian Tank

Russian Ship Moskva *source India Today*

Dr. Baker states that because none of the munitions "incorporated IM technology features and are filled with relatively sensitive explosives, it is no surprise that these incidents occurred and were to the severity observed."

THURSDAY, OCTOBER 20	
10:30 - 10:50 am	RECENT VULNERABILITY EVENTS DUE TO NON-IM MUNITIONS COSMPOLOTIAN AB Dr. Ernest Baker Warheads TSO, NATO MSIAC

“You must learn from the mistakes of others as you will never live long enough to make them all yourself.”
–Multiple Sources

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Missed Benefits of IM: Russia

- Improved Survivability for the Warfighter X
- Improved Survivability of Assets X
- Improved Logistics: X
  - Munitions can be stored closer to where they are needed
  - Minimize loss of munitions due to enemy action
- Improved Hazard Classification X
- Reduce likelihood of accidents in explosives factories X


Newsweek

WORLD

Multiple Dead After Mysterious Explosion at Russian Ammunition Plant

BY THOMAS KIKA ON 5/2/22 AT 12:05 PM EDT


BBC Sign in Home News Sport Reel Worklife Travel Future

NEWS

Home | Queen Elizabeth II | War in Ukraine | Coronavirus | Climate | Video | World | US & Canada | UK | Business | Tech

World | Africa | Asia | Australia | Europe | Latin America | Middle East

Dzerzhinsk explosion: Blast at Russian explosives factory injures 79

1 June 2019

It is not clear which individual incidents are related to a weak Insensitive Munitions program, but the shear number indicates that many are. It should be noted that rigorous safety and storage protocols were also nonexistent.

“Amateurs talk strategy, professionals discuss logistics.”- General Omar Bradley

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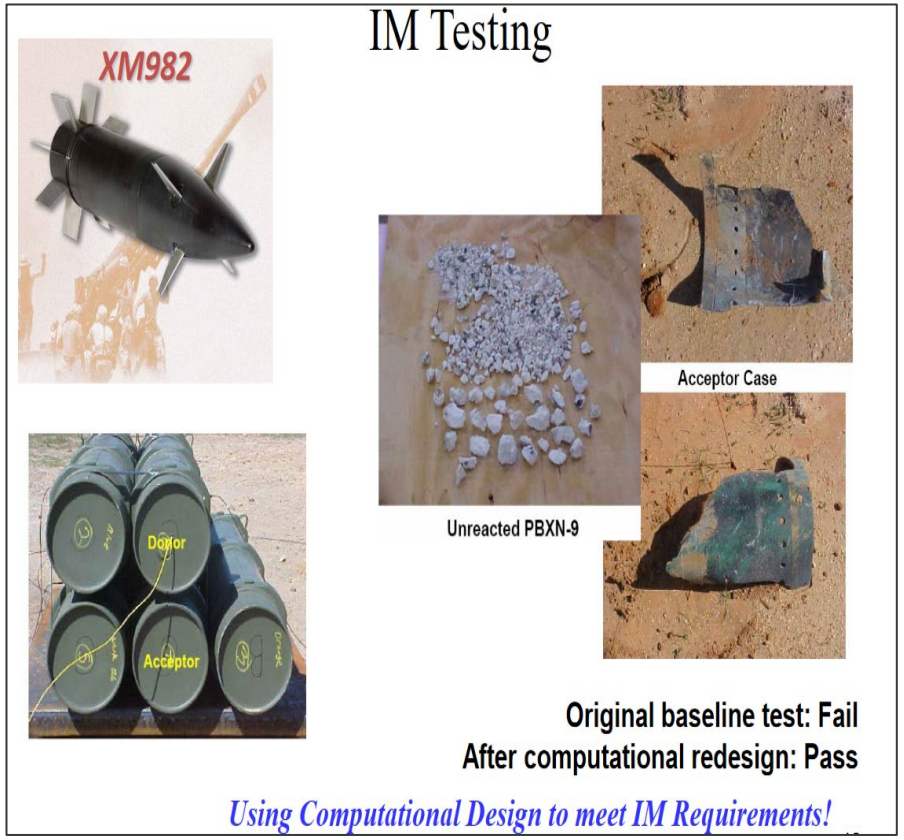
There is a Better Way: NATO/ MSIAC

- The U.S. Army's Explosive IMX-101, developed by BAE Systems, has been named one of "The 50 Best Inventions of 2010" by TIME Magazine. The Army team at Picatinny Arsenal earlier this year approved IMX-101 as an effective replacement to TNT in artillery. This decision revolutionized the way military ordnance is stored and transported; therefore, saving lives on and off the battlefield.

IMX-104 Fast Cook-off Test Results



- Most accurate US artillery shell was added to Ukraine's arsenal. The Pentagon is spending $92 million to replenish its stock- *Bloomberg, US Edition, 2022*

https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2017/armament/BakerTutorialA.pdf

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Magnitude of IM Events

The Bad News:

Catastrophic losses from incidents involving the inadvertent initiation and detonation of our munitions resulting in severe property damage, serious injury and loss of life.

USS Forrestal (1967)
134 killed, 161 injured,
$1.63B (2022 Dollars)

Doha, Kuwait (1991)
3 killed, 49 injured,
102 vehicles destroyed

The Good News:

- **Operational efficiencies gained from reduced hazard classification**
- **Economic efficiencies reduced storage and transportation requirements**

MRAP vehicle destroyed by an IED that ruptured the hull and fuel tank, engulfing the vehicle in flames, including (16) M768 60mm IM mortar rounds.

All 7 crew members survived

Modular Artillery Charge plant after a fire. There was significant fire damage but no blast or fragmentation damage.

No Injuries

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Changes in US IM Development

- Joint Insensitive Munitions Technology Program (JIMTP) was established in 2007 to develop IM technologies:
  - Served as a bridging mechanism to fund efforts to "jump start" the development of IM technologies for PEO/PM implementation
  - Program results are being used by the PMs to obtain IM solutions for multiple systems

- JIMTP's emphasis was changed to meet the DoD's need for speed, range and lethality; and has been rebranded as the Joint Enhanced Munitions Technology Program (JEMTP)

- Per a memorandum dated 5 March 2019, signed by Jih Fen Lei, Deputy Director, Research, Technology, and Laboratories:

"IM compliance requirements remain an important aspect of munitions reliably and readiness and thus will remain a critical characteristic of the program."

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IM Remains a Legal Requirement

USC, Title 10, Chapter 141, Section 2389 December 2001:

- " § 2389. Ensuring safety regarding insensitive munitions. 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."

DoDD 5000.01, September 9, 2020:

- The acquisition and procurement of DoD weapons and information systems **must be consistent with all applicable domestic law**, and the resulting systems must comply with applicable treaties and international agreements (for arms control agreements, see DoD Directive (DoDD) 2060.01), customary international law, and the law of armed conflict (also known as the laws and customs of war).

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Changes in the Insensitive Munitions Community and Processes

TUESDAY, OCTOBER 18

10:35 – 10:55 am

COMPARISON OF IM THREATS VERSUS THE REAL WORLD
COSMOPOLITAN AB

Christelle Collet
Technical Specialist Officer, MSIAC

TUESDAY, OCTOBER 18

10:55 – 11:15 am

NATO INSENSITIVE MUNITIONS PORTFOLIO PROGRESSION LEADING TO INSENSITIVE MUNITIONS - HAZARD CLASSIFICATION (IM-HC) HARMONIZATION
COSMOPOLITAN AB

Daniel Pudlak
CCDC-AC, U.S. Army

TUESDAY, OCTOBER 18

1:00 – 1:20 pm

24847 – The Status of International and National IM Policies Across the Nations
LOCATION

Christelle Collet
Technical Specialist Officer, MSIAC

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Evolution of Insensitive Munitions

2018	Shaped Charge Jet Impact changed to match the predominant threat of an RPG-7
2018	Fast Cook-off propane procedures clarified to allow and promote its greater use
2019	Slow Cook-off heating rate increased from 3.3˚C/hr to 15 ˚C/hr to better reflect real world events
2020	IM AOPs reorganized for uniformity and clarity
Current	Harmonization of Hazard Class and IM to streamline testing and development
Current	Moving towards a “whole body of evidence approach” (technical evaluations based on a rigorous review of science)

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NATO IM Portfolio Progression to IM-HC Harmonization

2010

- **<u>NATO IM Portfolio Structural Revision</u>**
  - Created new AOPs (Requirements Document)
  - Revised STANAGs (Policy Document)
  - Created SRD (Guidance Document)

- **<u>Creation of AOPs from STANAGs</u>**
  - 8 new documents (6 Test AOPs, Overarching AOP-39 & associated SRD):
    - AOP-39, AOP-39.1, AOP-4240, AOP-4241, AOP-4382, AOP-4396, AOP-4496, AOP-4526
  - Created Annex M (Document Modification History)

2019

- **<u>Revision of NATO IM Portfolio</u>**
  - 8 new AOPs promulgated in 2021-2022
    - Improved: consistency, accuracy, relevancy, readability and clarity compared to first iterations of AOPs and old STANAGs
    - Created new tool/matrix that simplified revision of portfolio with multiple documents

2021

2022

- **<u>Harmonization of IM-HC-S3</u>**
  - Currently revising AOP-39
    - Incorporate latest changes to portfolio, ensure relevancy and reduce redundancy
  - New overarching AOP-4864 under development
    - Harmonize IM, HC, S3, etc.
    - Reduces cost, schedule, test assets required
    - Incorporate risk assessment

2025

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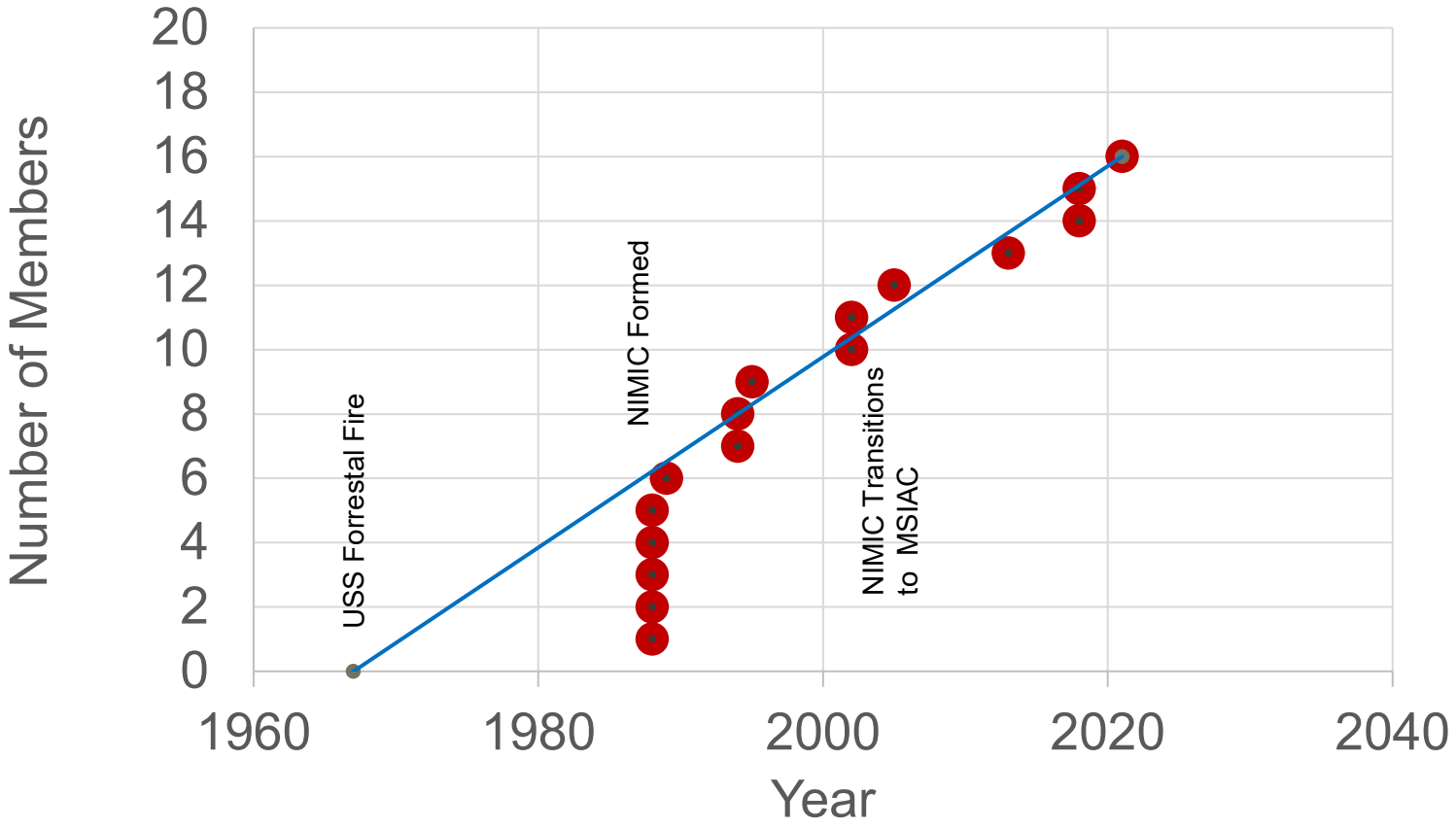
International Participation in MSIAC



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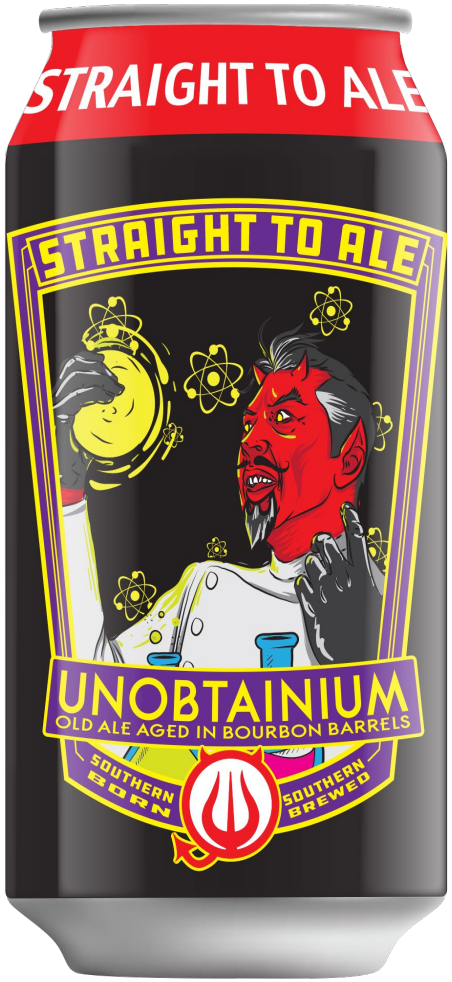
A Word of Caution, the Hunt for Unobtainium



Just changing the propellant or explosive does not guarantee a less violent reaction. Almost any material can fail IM tests (e.g. improper designs; confinement, packaging, shielding, etc.). No magic material exists that will solve all sensitivity and performance problems.

Burning C-4

Steam Explosion
Dana Corporation plant in Paris, Tennessee

http://www.dli.mn.gov/workers/boiler-engineer/fire-tube-steam-boiler-explosions

"For every complex problem there is an answer that is clear, simple and **wrong**" -H.L. Mencken

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Expanding Threats

The 2018 National Defense Strategy identified the problem:

It is now undeniable that the homeland is no longer a sanctuary. America is a target, whether from terrorists seeking to attack our citizens; malicious cyber activity against personal, commercial, or government infrastructure, or political and information subversion. New threats to commercial and military uses of space are emerging, while increasing digital connectivity of all aspects of life, business, government, and military creates significant vulnerabilities. During conflict, attacks against our critical defense, government, and economic infrastructure must be anticipated.

NATO/MSIAC members have little tolerance for avoidable accidents.
We must expand our consideration of potential threats.

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Near Peer IM Programs are Accelerating

Study on a novel high energetic and insensitive munitions formulation: TKX-50 based melt cast high explosive

Yuehai Yu,[a] Shusen Chen,[a] Tujuan Li,[a] Shaohua Jin,[a] Guangyuan Zhang,[b] Minglei Chen[b] and Lijie Li*[a]

Study of the sympathetic detonation reaction behavior of a fuze explosive train under the impact of blast fragments

Youcai Xiao, Xiangdong Xiao, Chenyang Fan, Yanyi Xiong, Zhijun Wang & Yi Sun

Journal of Mechanical Science and Technology **35**, 2575–2584 (2021)

135 Accesses | **2** Citations | Metrics

Numerical simulation of fragment impacting solid rocket motors

Cite as: AIP Advances 12, 055204 (2022); doi: 10.1063/5.0088412
Submitted: 16 February 2022 • Accepted: 11 April 2022 •
Published Online: 3 May 2022

View Online Export Citation CrossMark

Zhejun Wang,[a] Hongfu Qiang, Biao Geng, and Tingjing Geng

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materials MDPI

Materials (Basel). 2022 Apr; 15(7): 2438.
Published online 2022 Mar 25. doi: 10.3390/ma15072438

PMCID: PMC8999548
PMID: 35407769

Slow Cook-Off Experiment and Numerical Simulation of Spherical NQ-Based Melt-Cast Explosive

Yongshen Li,[1] Xue Zhao,[1,*] Jiuhou Rui,[1] Sen Xu,[2] Shengguan Chang,[3] Lizhe Zhai,[1] Siqi Qiu,[1] and Yuanyuan Li[1]

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Next Steps

- Improve IM mitigation technologies
- Ensure the developed technologies are used in new systems to the greatest extent possible
- Continually review evolving threats
  - Improve standard tests to reflect current threats as our understanding improves
  - Develop new tests as required
    - The spall impact test was dropped when no longer applicable
    - Will we need a laser impact test in the future?
- Educate program managers and developers on the advantages of Insensitive Munitions programs
- Apply our knowledge of munitions systems to fulfill the needs of the warfighter
- Streamline processes to promote rapid fielding of needed munitions
- Promote the continuous adoption of international standards and collaboration

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