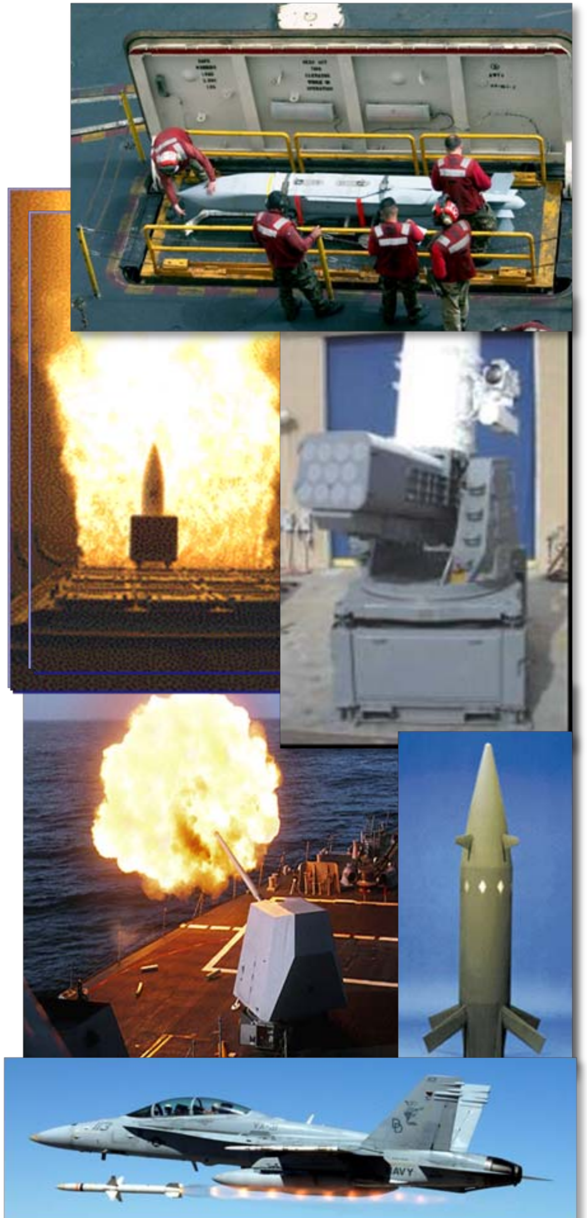

Rationalization of IM Test Requirements: The 6°F/hr SCO Test

Insensitive Munitions and Energetic Materials Symposium
Munich, Germany
11-14 October 2010

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Agenda

- Purpose
- Slow cook-off (SCO) background
- Testing criteria
- SCO heating rate discussion
- Mitigation of SCO
- Conclusions
- US Navy recommendations

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Purpose

- Introduce SCO
- SCO event: USS FORRESTAL and aftermath
- Implications of munition design to pass 6°F/hr SCO IM test
- Describe current IM processes
  - US Joint IM and HC Test Standards
  - Synchronization of IM testing criteria with a System Safety approach
  - US Navy path forward

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Ordnance Accidents

IM can save lives and resources.

Bomb explosion following the tractor-trailer collision in Checotah, OK (1985)

Failures Don't Forgive

Ammunition train explosion, Roseville, CA. (1973)

U.S. Army Camp Doha, Kuwait (1991)

Indian Head, MD (1994)

Bien-Hoa Air Base, Vietnam (1965)

USS Oriskany (1966)

USS Forrestal (1967)

USS Enterprise (1969)

USS Nimitz (1981)

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IM Background / SCO Event

USS FORRESTAL (CVA-59)- Debris and damage caused by the fire and munition explosions. U.S. Navy Photo.

➢ IM is …

- A CNO initiative to increase ship survivability
- Acquisition-driven to integrate energetic materials and munitions design technologies that reduce weapons' reaction violence and collateral damage to heat, shock and impact stimuli while maintaining performance

USS FORRESTAL (CVA-59)- Hole in the deck caused by a bomb detonation. U.S. Navy photo.

➢ IM compliance requires …

- Passing standardized test series per JROC guidance
  - Thermal (fast cook-off; slow cook-off)
  - Impact (bullet, fragment, shaped charge jet)
  - Shock (sympathetic detonation)
- Systems approach for comprehensive solution
  - Less sensitive energetic materials (explosives, propellants)
  - Novel materials (rocket motor cases; warhead materials)
  - Packaging

IM is important to the Fleet to protect platforms and personnel from reactions of our own weapons – whether through accident, combat or terrorist activities.

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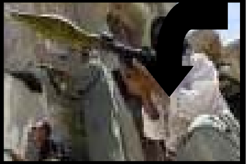
IM Technical Requirements

Providing Ordnance Safety For Our Warfighters

IM CLASSES OF THREATS ARE RELEVANT

Threats						
	FUEL FIRE Such as a truck or an aircraft on a flight deck	**NEARBY HEAT** Such as fire in adjacent magazine, store or vehicle.	**BULLETS** Such as small arms from terrorists or combat	**FRAGMENTS** Such as from bombs, artillery, or IEDs	**SYMPATHETIC REACTION** Such as detonation of adjacent stores	**SHAPED CHARGE JET** RPG, Bomblets, ATGMs: Combat or terrorists
						

STANDARDS ARE REPRESENTATIVE AND ONE METRIC OF MUNITION RESPONSE AND TECHNOLOGY MATURITY

Tests & Passing Reactions						
	Fast Cook-off	Slow Cook-off	Bullet Impact	Fragment Impact	Sympathetic Detonation	Shaped Charge Jet
	FCO	SCO	BI	FI	SD	SCJ
						
	Type V Burn	Type V Burn	Type V Burn	Type V Burn	Type III Explosion	Type III Explosion

REACTION CONSEQUENCE AFFECTS INVESTMENT STRATEGY FOR MUNITION INCREMENTAL IMPROVEMENTS & IM SCIENCE & TECHNOLOGY

Reactions					
	Detonation/ Partial Detonation	**Explosion**	**Deflagration/ Propulsion**	**Burn**	**No Sustained Reaction**
	Type I/II	**Type III**	**Type IV**	**Type V**	**Type VI**
					

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Standardized IM Tests/Passing Criteria

- *Approved by JROC on 6 Nov 06 (JROCM 235-06)*

		Threat	Passing Criteria	Comments	STANAG
FCO		Liquid Fuel Fire (e.g., truck or an aircraft on a flight deck)	Burning	**HC Relation** : Required for hazard classification **Stimulus** : Rapid heating response **Comments** : **None**	4240
SCO		Slow Heating 3.3 C/Hr (e.g., fire in adjacent magazine, store or vehicle)	Burning	**HC Relation** : Required for reduced hazard classification **Stimulus** : Slow heating response **Comments** : Additional technical studies appropriate	4382
BI		.50 Cal M2AP 3 round burst (e.g., small arms from terrorists or combat)	Burning	**HC Relation** : Required for reduced hazard classification **Stimulus** : Low level kinetic impact **Comments** : Relevant small arms threat More severe threats exist Additional studies appropriate	4241
FI		18.6 gram fragment 8300 +/- 300 fps (e.g., bombs, artillery, or IEDs)	Burning	**HC Relation** : Not required for hazard classification **Stimulus** : Combine shock, mechanical, thermal **Comments** : Artillery fragments slower Some KE and EFP threats more severe	4496
SD		Detonation of a single donor (detonation of adjacent stores)	Explosion	**HC Relation** : Required for hazard classification **Stimulus** : Output of a like munition **Comments** : Does not address mixed storage Does not address multiple donor	4396
SCJ		81-mm Precision shaped charge (e.g., RPG, Bomblets, ATGMs: Combat or terrorists)	Explosion	**HC Relation** : Not required for hazard classification **Stimulus** : Shock **Comments** : More severe threats exist Pragmatic threat considering technology potential	4526

Legend

I / II	III	IV	V	VI
Detonation/ Partial Detonation	**Explosion**	**Deflagration or propulsive reaction**	**Burning**	**No sustained reaction**

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Joint IM Standards - Test Configurations

IM Test	Number of Required Tests	Test Configuration	Test Procedure
FCO	2	1 Operational, 1 Logistical	STANAG 4240, Standard Procedure, Excluding Annex B
SCO	2	2 Logistical	STANAG 4382, Procedure 1
BI	2	1 Operational, 1 Logistical	STANAG 4241, Procedure 1
FI	2	1 Operational, 1 Logistical	STANAG 4496, Standard Procedure
SR/SD	2	2 Logistical	STANAG 4396, Procedure 1
SCJ	2	1 Operational, 1 Logistical	STANAG 4526, Procedure 2, PG-7V Surrogate (81mm precision Shaped Charge)**

•Additional testing may be required for additional threats per Threat Hazard Assessment (THA).

** PG-7V Surrogate configuration is identified by ARDEC Picatinny Arsenal DWG 7GP20078

Ref: OUSD Memo Feb 2010

NAVSEA
NAVAL SEA SYSTEMS COMMAND

Joint IM Test Standards

Providing Ordnance Safety For Our Warfighters

- Single set of IM Standard tests approved by JROC
  - JROCM 235-06 Nov 2006
- OUSD Memo Feb 2010
  - Test Standards Codified

THE UNDER SECRETARY OF DEFENSE
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ACQUISITION, TECHNOLOGY AND LOGISTICS

FEB 01 2010

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
CHAIRMAN OF THE JOINT CHIEFS OF STAFF
COMMANDER, U.S. SPECIAL OPERATIONS COMMAND
DIRECTORS OF THE DEFENSE AGENCIES

SUBJECT: Joint Insensitive Munitions Test Standards and Compliance Assessment

The November 6, 2006, Joint Requirements Oversight Council (JROC) memorandum recommended a standardized, single set of Insensitive Munitions (IM) tests and passing criteria for use by all Components for assessing IM compliance. I approve these standard protocols, which are attached, and I also endorse the JROC's activities in validating any unique variations thereto within the Joint Capabilities Integration Development System.

Although the IM standard tests and passing criteria have been implemented for all programs since their recommendation by the JROC, and this process has been overseen by my office through the Joint Services IM Technical Panel, they have not been officially documented. Through their issuance in this memorandum, I wish to clearly direct their use for making assessments of IM compliance for all conventional munitions.

Ashton B. Carter

Attachment:
As stated

Slow Cook-Off

Test Standard	Req.	Pass/Fail
WR-50 (1964)	6°F/hr	No Burn, Deflag, Det @ <300°F
OD 44811 (1972)	6°F/hr	No Burn, Deflag, Det @ <300°F
DOD-STD-2105 (Navy) (1982)	3.3°C/hr (~6°F/hr)	Per WSESRB review
MIL-STD-2105A (1991)	6°F/hr	≤ Type V (Burning)
MIL-STD-2105B (1994)	3.3°C/hr (6°F/hr)	≤ Type V (Burning)
MIL-STD-2105C (2003)	3.3°C/hr (~6°F/hr)	≤ Type V (Burning)
STANAG 4439 AOP-39 (2010)	3.3°C/hr (~6°F/hr)	No Burn, Deflag, Det @ <300°F

- Not documented
- WW II hot gun – most violent reaction
- Worst case lab test

IM Policy

Harmonize with TB 700-2 HC Slow Heating test

SCO Heating Rate Discussion

- US Navy conducted studies
  - Fontenot and Jacobson (1988)
    - Thermal soaking based on weapon size
    - 53°F/hr, 31°F/hr, and 13°F/hr for 500 lb, 1000 lb and 2000 lb class weapons respectively
    - Below deck fires in adjacent compartments to magazines
  - Gokee (1996)
    - 2.75 inch rocket
    - 40°F/hr was selected to represent below deck fires
- US Army had chosen to use 50°F/hr
  - Lower bound estimate of what may happen in a real event
- With the implementation of the codified and harmonized IM and HC standards (OUSD 2010), the US Joint Services are held to SCO testing at 6°F/hr unless a variation is authorized.
  - STANAG 4382 has Procedure 2: default rate is 45°F/hr (25°C/hr)

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Mitigation of SCO

NOSSA has a concern that programs are attempting to design their munition systems to pass the 6°F/hr SCO test, not addressing the effect to overarching System Safety.

- Shipboard fire threat
  - How long do sailors have to fight a fire?
  - What are the most vulnerable munitions in a shipboard fire?
  - Can the munitions be loaded in the magazine in such a manner as to reduce their vulnerability?
  - What are the consequences of a cook-off reaction?

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Mitigation of SCO

NOSSA has a concern that programs are attempting to design their munition systems to pass the 6°F/hr SCO test, not addressing the effect to overarching System Safety.

- Mitigation Devices
  - Active Mitigation Device (AMD)
  - Passive Mitigation Device (PMD)
- Usage of either an AMD or a PMD within a Navy munition system requires concurrence from the Weapon System Explosives Safety Review Board (WSESRB).
- Design guidelines for the development of an Active or Passive Mitigation Device (AMD or PMD)
  - Used to mitigate the expected reaction of a munition exposed to environments characterized by the IM testing criteria.
  - Ensure the System Safety within a munition system.

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Active or Passive Mitigation Design Guidelines

Draft guidelines

- Active Mitigation Devices (AMDs) or Passive Mitigation Devices (PMDs) are required to respond to a specific Insensitive Munitions (IM)-threat environment (usually fast and/or slow cook-off), and to remain safe when exposed to both normal and abnormal environments at all other times.
- AMD designs must comply with appropriate military specifications and standards to prevent inadvertent initiation of an energetic reaction in a rocket motor or warhead.
- Programs must be able to demonstrate that there is a tangible benefit to having an AMD or PMD, and this benefit must relate to a reduction of the hazard.
- Reaction temperatures of AMDs should be as high as the particular energetic material will allow without creating undesirable reactions (absolute temperature, not a rate-based temperature). The AMD must remain safe at all normal and abnormal thermal environments below this specific reaction temperature.
- AMDs or PMDs must be designed to survive the same logistic cycle as the munition to which it is mounted. The devices must be tested as part of the actual munition, and must not react at an undesired thermal or mechanical environment.
- Safety hazard analyses must consider the possibility of inadvertent activation of the AMD on a weapon loaded on a launch platform, and the safety risks to the platform, personnel, and adjacent weapons.
- Recommendations for fire-fighting must be developed and coordinated with Safety authorities.

Conclusion

- The SCO 6°F/hr heating rate is a characterization test; a test with use to identify a possible worst case scenario during a slow cook-off event.
- SCO heating range between 40°F/hr and 60°F/hr is a true representation of the credible shipboard slow cook-off event.
- Data from a 6°F/hr SCO characterization test only, does not account for the munition reaction from the most credible thermal threat (below deck fires in adjacent compartments to magazines).
- US Navy is recognizing this shortfall within the IM sanctioned SCO test protocol as providing an incomplete answer with respect to overarching System Safety.

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Recommendations

- SCO hearing rates of 40°F/hr - 60° F/hr could be used to represent below deck fire threats.
- The 6°F/hr should be maintained for the IM SCO characterization test.
- Need for program Threat Hazard Assessments (THAs) that address the most hazardous SCO threats for test environments using the most credible SCO temperature as well as flexibility to test to safety concerns as well as standard requirements.
- US Navy recommends not designing a munition system to push a point solution. In other words, do not design to only pass the 6°F/hr IM SCO characterization test; design to address the appropriate and credible below deck fire threats as well as a possible worst case scenario.
  - The WSESRB may require evidence, through an additional SCO test at 40°F/hr - 60°F/hr or by an engineering analysis, that the munition system will meet the expectation of System Safety requirements.
- US Navy recommends international discussions with Subject Matter Experts to address appropriate SCO testing protocols related to munition System Safety.
  - US Navy will voluntarily take the lead to coordinate.

NOSSA (N85) – IM and HC POCs

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