NATO OTAN

2009 IM & EM Technology Symposium

IM Response Descriptors — An Update for Assessment Processes

Presenter:

Thomas Eich, BWB, Germany

Co-authors:

Bernie Halls, MSIAC

Serge Bordachar, DGA, France

Michael Sharp, DES/WPNS, UK

Thomas Swierk, NSWC, US

IM Response Descriptors

Overview

MSIAC sponsored technical meetings in Jun & Dec 2008 to review & update IM response descriptors.

Participants:

Herve Benard (FR)
Stuart Blashill (US)
Serge Bordachar (FR)
Felix Daguise (FR)
Eric Deschambault (US)
Thomas Eich (GE)
Brian Fuchs (US)
Yanick Garcia (FR)
Regis Guegan (FR)
Jean-Pierre Gueguen (FR)
Bernie Halls (MSIAC)
Klaus Kupzik (GE)
Gerhard Schaad (GE)
Michael Sharp (UK)
Steven Struck (US)
Tom Swierk (US) **
Julian Taylor (UK)
Ken Tomasello (US)

**** Meeting chairman**

IM Response Descriptors

Why this update? Rationale for change

* ***Current definitions can sometimes lead to confusion & subjectivity***

- ***Criteria application***: the munition behavior and particularly its fragmentation process can vary among different munition types, such as an artillery shell or a solid rocket motor. This complicates the use of a common behavioral criteria. Based on effects criteria, munition size, type and configuration all have a major effect on descriptor use for assessments.

- ***Difficulties in response type assignment***: Types I - III (for artillery shells), Types III - V (for SRM) are more influenced by the different nature and the combination of criteria based on munition behavior (chemical energy release, fragmentation) and pure environmental effects (thermal flux, overpressure, fragment projection).

- ***Lack of precision*** in some measurement requirements: How do we address the strongly directional effects for air blast overpressures ? Location in the Mach zone ? Position of radiative heat flux gages, and overpressure measurement uncertainties?

IM Response Descriptors

Additional Rationale

**** A need to better assess collateral damage and to provide data for platform vulnerability studies.***

- *1997-1998 NIMIC workshops* — Identified missing link between response descriptors and damage (weapon platforms, ships, etc.). Descriptors focused both on chemical reactions of energetic materials and hazards induced by the munitions reactions. They are used as an input for vulnerability, IM and hazard class assessments.

- *Hazard division assessments* traditionally address the concept of damage on systems and personnel but have their own inherent limitations for operational platform vulnerability assessments (hostile environment and THA not included in the UN classification scheme, SRM and gun propellant tests do not address detonability (exception: TB 700.2, US). No international harmonization.

IM Response Descriptors

Objective of Technical Meetings

Review, examine & offer recommendations to update the Response Descriptors listed in AOP-39 and other documents for relevance to IM & HC assessments. This should improve the robustness of assessing the IM signature of a munition.

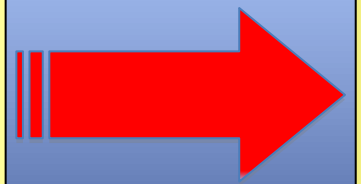
Examine current *IM Response Descriptors cited in*:

STANAG 4439

AOP-38 & 39

TB 700-2

MIL-STD-2105 (US)



Formulate new, standardized *IM Response Descriptors* for future IM & HC assessments

IM Response Descriptors

Background

1997 NIMIC Workshop topic: *IM Testing & Response Descriptors*

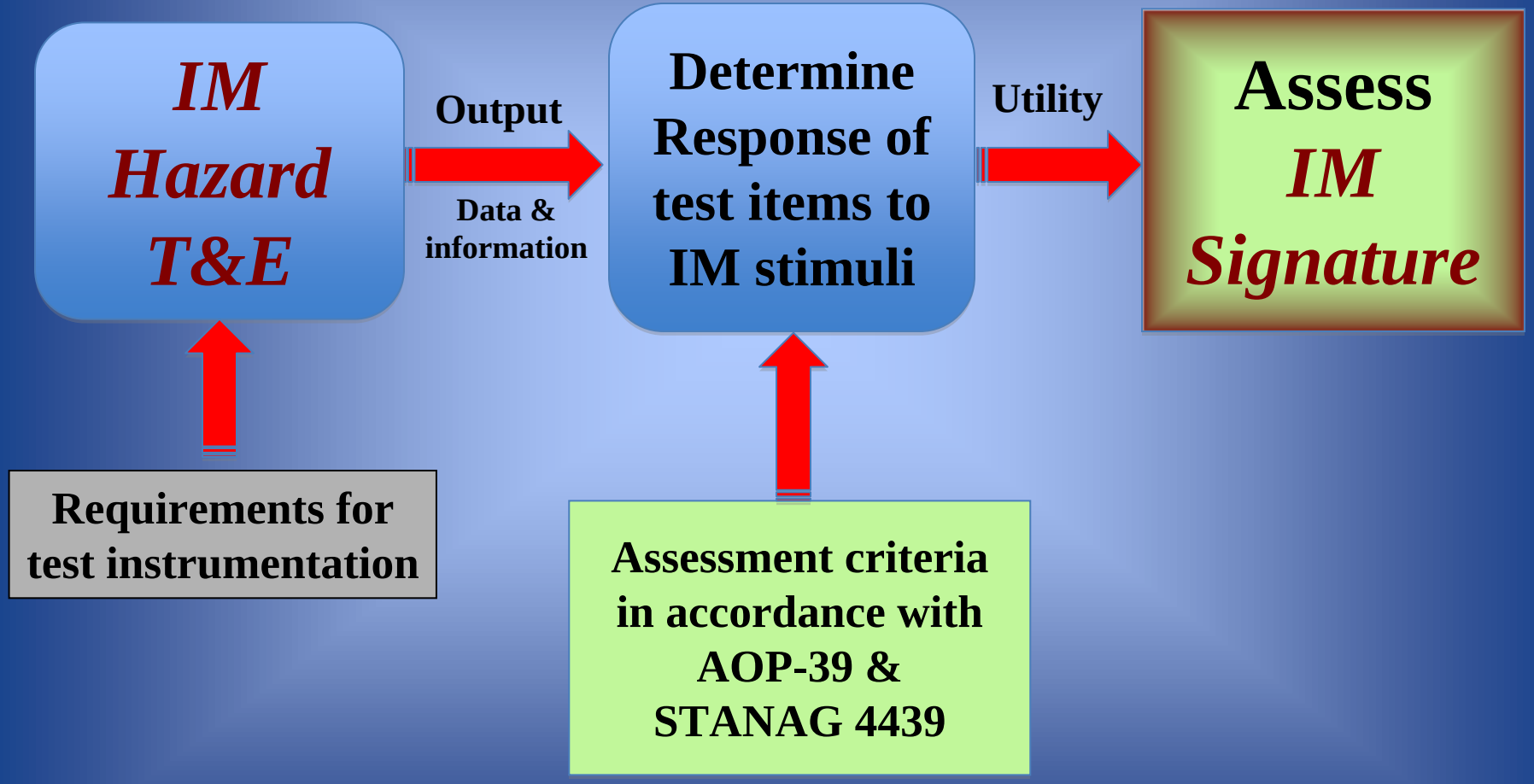
Summary of Recommendations

- **Identified threshold criteria for *qualitative* vs. *quantitative* descriptors:**
  - **Reaction type (current method) descriptors have limitations**
  - **Type descriptors concentrate only on chemical reaction of energetic materials and don't address energy release to surroundings (collateral damage).**
  - **This is not in concert with the IM goal of minimizing the probability of inadvertent initiation & the severity of subsequent collateral damage.**

- **Identified *Levels of Response* to move closer to user needs (safety authority, risk assessor, etc.) and to accommodate HC divisions.**

- **Levels of Response replace the Reaction types where munitions response is characterized by damage levels at various distances from point of origin.**

Response Descriptor Utility



IM Response Descriptors

Utility for IM Signature

Responce descriptors are initially used for authoratative assignment of reaction types to individual IM hazard and Hazard Classificaiton test results.

IM test results contribute to the IM assessment information & report (i.e., the total *Body of Evidence*) per AOP-39

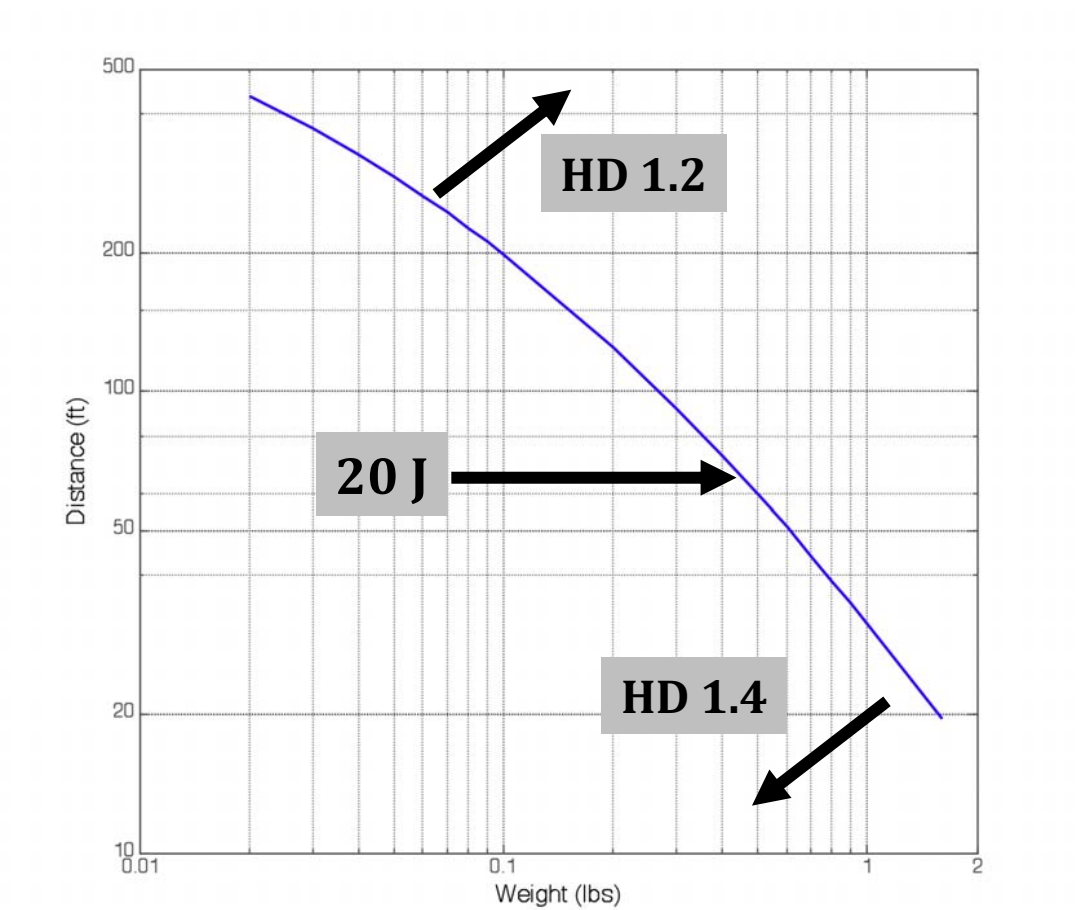
Response descriptors used to identify assigned reaction types are used in the IM Signature display per AOP-39.

IM Response Descriptors

Summary of Principal Recommendations from the Technical Meetings

- Identify Primary & Secondary evidence for each reaction type
  - Primary evidence must always be observed and would be definitive of the reaction type
  - Secondary evidence could be observed, but its lack would not preclude that reaction type
- Redefined a “hazardous fragment” for Type IV and TypeV reactions
  - Used 20J as energy threshold vice current 79J level.
  - This is consistent with the UN “Orange Book” that distinguishes HC 1.2 vs. 1.4
- Clarified the definition of a “propulsive reaction” as a subset of a Type IV reaction.
- Deleted blast pressure level of 50mbar at 15m for Types III, IV and V.
- Recommended calibration tests, when practical, as comparative (baseline) evidence.
- Ensured that a Type VI (no reaction) level is defined and included

IM Response Descriptors



Fragment energy relationship taken from Figure 5-17 of TB 700-2 (30 Aug 08)

IM Response Descriptors

Example :

Type I Detonation

- *Primary evidence* : Must include
  - Shock wave with magnitude and timescale = calculated or measured value
  - Rapid plastic deformation of the metal casing with extensive high shear rate fragmentation

- *Secondary evidence*: May include
  - prompt consumption of all energetic material
  - Perforation, fragmentation and/or plastic deformation of witness plates
  - Ground craters corresponding to the amount of energetic material in the munition

AOP –39 (edition 2), Annex I (current version)

Response Type	Munition Behaviour		Effects			
	Energetic Materials	Case	Blast	EM projection	Fragment projection	Other
I (detonation)	Supersonic decomposition	Very fast plastic deformation; Total fragmentation	Intense shock wave; Damage to neighboring structures	All the materials react	Perforation, plastic deformation or fragmentation of adjacent metal plates	Large craters in the ground
II (partial detonation)	Supersonic decomposition	Partial fragmentation with large fragments	Intense shock wave; Damage to neighboring structures	All the materials react	Perforation, plastic deformation or fragmentation of adjacent metal plates	Large craters in the ground (proportional to amount of detonating EM)
III (explosion)	Fast combustion of confined material; local pressure build-up	Violent breaking into large fragments	Blast effect < Type I; Damage to neighboring structures; P > 50 mbar at 15m	Scattering of burning EM; Risk of fire	Long range projection; damage to metal plates (breaks, rips, cuts)	Small craters in the ground
IV (combustion/deflagration)	Non-violent pressure release	Breaks but does not fragment into more than 3 parts; expulsion of end caps; gases release through opening	Blast effect limited to P < 50 mbar at 15m	Scattering of EM; Risk of fire	Expulsion of end caps and large structural parts; no significant damage	Damage caused by heat and smoke; propulsion of unattached sample
V (burn)	Combustion	Splits in a non-violent way; smooth release of gases; separation of ends	Blast effect limited to P < 50 mbar at 5m	EM remains nearby (<15m)	Debris remains in place except covers; no fragment of more than 79J or > 150g beyond 15m	Heat flow < 4 kw/m^2 at 15m

AOP –39 (edition 2), Annex I (revised version)

Response Level	Munition Behaviour		Observed or Measured Effects			
	Energetic Materials (EM)	Case	Blast	EM projection	Fragment projection	Other
Type I (detonation)	**(P) Shock wave with magnitude & timescale = to a calculated value or measured value from a calibration test**	**(P) Rapid plastic deformation of the metal casing contacting the EM with extensive high shear rate fragmentation**	Prompt consumption of all EM once the reaction starts	All of the EM reacts	Perforation, fragmentation and/or plastic deformation of witness plates	Ground craters of a size corresponding to the amount of EM in the munition
Type II (partial detonation)	**(P) Shock wave with magnitude & timescale < than that of a calculated value or measured value from a calibration test**	**(P) Rapid plastic deformation of some, but not all, of the metal casing contacting the EM with extensive high shear rate fragmentation**	Intense shock wave; Damage to neighboring structures	Scattered burned or unburned EM	Perforation, plastic deformation and/or fragmentation of adjacent metal plates	Large craters in the ground (proportional to amount of detonating EM)
Type III (explosion)	**(P) Rapid combustion of some or all of the EM once the munition reaction starts**	**(P) Extensive fracture of metal casings with no evidence of high shear rate fragmentation resulting in larger and fewer fragments than observed from purposely detonated calibration tests**	Observation or measurement of a pressure wave with peak magnitude << than and significantly longer duration that of a measured value from a calibration test	Significant long distance scattering of burning or unburned EM; risk of fire	Long range projection; damage to metal plates (breaks, rips, cuts)	Small craters in the ground
Type IV (deflagration)	**(P) Combustion of some or all of the EM**	**(P) Rupture of casings resulting in a few large pieces that might include enclosures or attachments.**	May include a longer reaction time than would be expected in a Type III reaction	Scattered burning or unburned EM; risk of fire	**(P) At least one piece (casing, enclosure or attachment) travels beyond 15m with an energy level > 20J based on the distance/mass relationship used for HC[1].**	**(P) There is no primary evidence of a more severe reaction and there is evidence of thrust capable of propelling the munition beyond 15m.** Damage caused by heat and smoke.
Type V (burn)	**(P) Low pressure burn of some or all of the EM**	**(P) The casing may rupture resulting in a few large pieces that might include enclosures or attachments.**	Some evidence of insignificant pressure in the test arena and for a rocket motor a significantly longer reaction time than if initiated in its design mode.	**(P) A small amount of burning or unburned EM relative to the total amount in the munition may be scattered, generally within 15m but no farther than 30m>**	**(P) No item (casing, enclosure or attachment) travels beyond 15m with an energy level > 20J based on the distance/mass relationship used for HC[1].**	**(P) No evidence of thrust capable of propelling the munition beyond 15m**
Type VI (no reaction)	**(P) No reaction of the EM without a continued external stimulus**	**(P) No fragmentation of the casing or packaging greater than that from a comparable inert test item.**	None	**(P) Recovery of all or most of the unreacted EM with no indication of a sustained ignition.**	None	None

IM Response Descriptors

Process to implement changes: