

# SHAPED CHARGE JET ATTACKS

WHAT SHAPED CHARGE ?

WHICH TEST SET-UP ?

IMEMG's Expert Working Group on  
Hazard Assessment & Classification

*Presented by Yves GUENGANT*

*[www.imemg.org](http://www.imemg.org)*



# INTRODUCTION

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- European Organisation assembling twenty leading armament groups working with Insensitive Munitions technologies



# INTRODUCTION

Express the armament industry's viewpoint with regards to relevant transnational regulations and requirements.

## Expert Working Groups

- **Computer Models for IM Performance,**
- **Cost & Benefit Analysis,**
- **Fast Cook-off Test Procedure,**
- **Effects of Ageing,**
- **Hazard Assessment & Classification.**

*Hazard Assessment & Classification Expert Working Group  
to present this analysis*



# CONTEXT

## STANAG 4526 (Ed2)

### SHAPED CHARGE JET – MUNITIONS TEST PROCEDURE

» **not a real standardized reference:**

- not ratified by all Nations,
- 50 mm Rockeye Shaped Charge not readily available,
- Performance not correctly defined for determination of an equivalent Shaped Charge,
- test set-up not clearly defined (conditioning plate, target nose, ...),
- each test center to use own Shaped Charge and test procedure.

## **Recent feedback from Afghanistan and Iraq**

### **→ Threat Hazard Analysis review :**

Standard Shaped Charges design which would be representative of numerous RPG7 types:

- **USA** MIL-STD-2105(D) specifies a standardised LX-14 81mm Shaped Charge.
- **France** has selected CCEB 62,
- **Germany** is developing PG-7 replica;

» ***Presentation to introduce industrial experts points-of-view to the IM community.***



# CURRENT SITUATION



## CURRENT SITUATION

- STANAG 4439 & AOP 39
- TEST PROCEDURE STANAG
- IMPLEMENTATION DIFFICULTIES
- FEED-BACK FROM FRANCE
- FEED-BACK FROM GERMANY
- FEED-BACK FROM UNITED KINGDOM
- COMPARISON OF IM SIGNATURES

## STANAG 4439 & AOP 39

- **STANAG 4439 ed3**

- **Threat** : Shaped Charge weapon attack → Requirement: **Type III**,
- Shaped Charge Jet, Munitions Test Procedure → **STANAG 4526 ed2.**

## STANAG 4439 & AOP 39

- **AOP 39 ed3**

- The **Baseline Threat Range**

- » shaped charge caliber up to 85 mm diameter (AOP39 table 1).

- For the purpose of **IM**:

- » shaped charge to be "**broadly representative of Rocket Propelled Grenades and top attacks bomblets**" (AOP39 annex F)

- **Test conditions** (AOP39 annex H):

- » 50 mm Rockeye or equivalent V<sup>2</sup>d charge,

- » Use of conditioning plate not defined.

## TEST PROCEDURE STANAG

- **STANAG 4526 (Ed2)**

### SHAPED CHARGE JET – MUNITIONS TEST PROCEDURE

➔ designed for "*determining the degree of reaction of a munition when hit by typical top attack bomblet shaped charge jet*"

» **not ratified** by all NATO nations

» specified charge (50mm Rockeye) not readily available in many countries, therefore **not used** in IMEMG's Nations

## TEST PROCEDURE STANAG

- **STANAG 4526 (Ed2)**

### SHAPED CHARGE JET – MUNITION TEST PROCEDURES (cont'd)

- » test set-up **not precisely defined** (potential use of conditioning plate)
- » **inconsistent values** about 50mm Rockeye (confirmed during MSIAC IM Technology Gaps Workshop - June 2011)

Paper: "*Rocket Propelled Grenade Shaped Charge Initiation Test Configuration for IM Threat Testing*" by Ernest L. Baker and al.

## IMPLEMENTATION DIFFICULTIES

- The  $V^2d$  values is the link between different shaped charges:
  - Various shaped charges allowed, ... if same  $V^2d$
  - But values noted in STANAG 4526 Table 1 (to come) **much too high** by at least a factor of **> 2**

STANAG  
4526 ed2

Threat	Representative $V^2D$ ( $\text{mm}^3/\mu\text{s}^2$ )
Top Attack Bomblet	200
SCJ with characteristics of 50mm Rockeye	360
Rocket Propelled Grenade	430
Anti-Tank Guided Missile	800

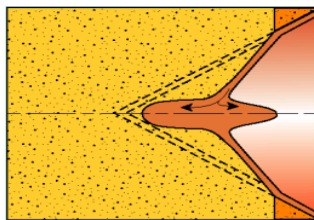
## IMPLEMENTATION DIFFICULTIES

- For example RPG-7
  - typical measured values for the Shaped Charge Jet tip:  
 **$V \sim 7.5 \text{ mm}/\mu\text{s}$  and  $d \sim 3 \text{ mm}$  gives a  $V^2d$  value of  $\sim 170 \text{ mm}^3/\mu\text{s}^2$**
  - **different from**  $430 \text{ mm}^3/\mu\text{s}^2$  as noted in previous table
  - i.e. a factor of  $430/170 = 2.5$  too large.

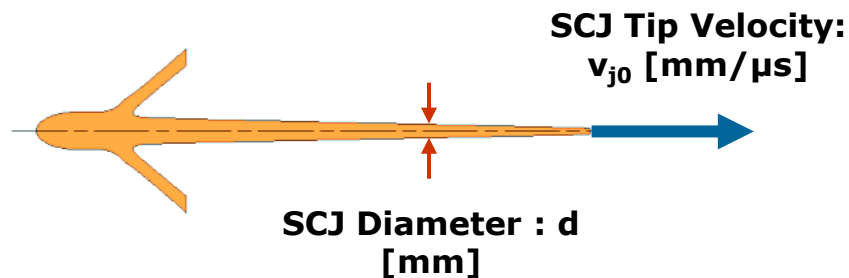
## IMPLEMENTATION DIFFICULTIES

- As  $V^2d$  is the link between different shaped charges
  - » very important to **define exactly** how **V** and **d** should be measured as below;
  - » Both numbers **V** and **d** are **not constant but variably** over the Shaped Charge Jet length;
  - » the **scattering** within the measurements should be taken into account.

Shaped Charge



Shaped Charge Jet Formation





## FEED-BACK FRANCE

- French test centers to use different Shaped Charges:
  - MILAN K115, MILAN 2, ACL 89 (mm), RPG-7, CCEB 62 (mm),...
  - Test conditions vary: target nose, stand-off, conditioning plate...



**ACL 89**  
with target nose



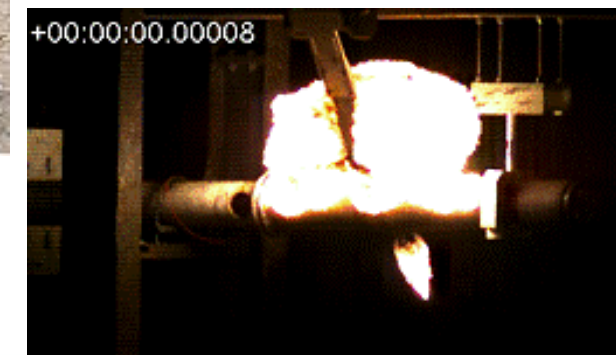
**45 mm**  
**Bomblet**



**CCEB 62**  
with conditioning plate



**RPG-7**

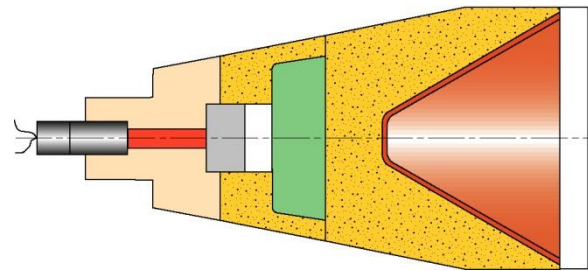
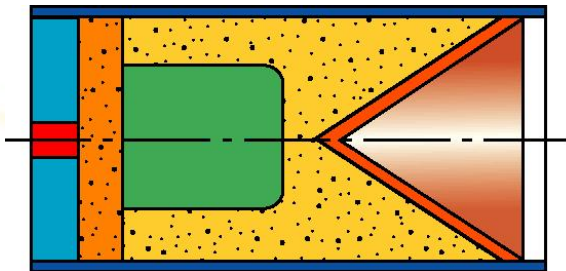


**RPG-7**

## FEED-BACK GERMANY

- Various Shaped Charges:
  - DM1244 (44 mm diameter)
  - PG-7 replica (75 mm)

**Bomblet**  
**Caliber 44 mm**



**PG-7 Replica**  
**Caliber 75 mm**



## FEED-BACK UNITED KINGDOM

- Shaped Charges used:
  - IBL 755 (50 mm diameter),
  - MLRS Bomblet : M42 (34 mm diameter),
  - Standard DERA Fort Halstead K4 (63.5 mm diameter).
- EMTAP test method define K4 Shaped Charge:
  - Conditioning plate can be used.

## FEED-BACK UK

- The SCJ test is only carried out
  - » when required by Threat Hazard Assessment of the relevant environments for the munition,
  - » However frequently used for assessing the IM response for Large Calibre Gun Propellant Charges,
  - » Validity considered by IMAP (IM Assessment Panel),  
IMAP also review the testing conducted.

## COMPARISON OF IM SIGNATURES

- Conditioning plate often use to :
  - adjust  $V^2d$  value according to specific Threat Hazard Analysis,
  - avoid the rear slug effect discrepancies.
- » a munition to pass the STANAG 4526 but which is the **real stimulus** ?
- In-service Shaped Charge are equipped with target nose
  - » i.e. for RPG7, target nose can **reduce significantly** the  $V^2d$  with the "same" charge

## COMPARISON OF IM SIGNATURES

- ***Main parameters to be known***

-  – **Shaped Charges**

- » Diameter from 45 mm to 120 mm,
- » In-service charge: with or without target nose,
- » High performance (tapered & fast) jet /// un-optimized and cheap serial charge,

-  – **Conditioning plate use**

-  – **Stand-off value**

- **Break-up time**

- **Penetration capability**

# COMPARISON OF IM SIGNATURES

- Difficult to understand when listed in a table with colors-coded boxes (AOP39 ed3)

	FH	SH	BI	FI	SR	SCJI
Configuration 1	V		NR	IV	N/A	III

Colour Coding	IM Compliance				
Green	IM requirement fulfilled.		Pass (P)	N/A	I
Yellow	IM requirement not fulfilled. One response level difference between the assessed response level and the IM requirement		Fail (F)	V Main Charge	P
Red	IM requirement not fulfilled. Two and plus response levels difference between the assessed response level and the IM requirement			III Booster	F
White	Not Assessed (N/A)		Not Assessed	N/A	(P)

			7.62 Ball			
	Full-up Round	(I)	V	IV	III	P



## COMPARISON OF IM SIGNATURES

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Colour Coding	
Green	IM r
Yellow	IM rec One response level differenc th
Red	IM rec Two and plus response level level a
White	Nc

		FH	SH	BI	FI	SR	SCJI
Configuration 1		V		NR	IV	N/A	III
Configuration 2		III		IV	N/A	N/A	I
Configu- ration 3	Warhead	(I)	N/A	NR	V Main Charge III Booster	P	F
	Propulsion Unit	IV	V	V 0.50 AP	N/A	N/A	(P)
				IV 7.62 Ball			
Full-up Round	(I)	V	IV	III	P	F	





# **FUTURE CHANGES**

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### **COMMENTS...**

- NEW TRENDS IN THREAT DEFINITION
- FRANCE
- GERMANY
- USA

## NEW TRENDS IN THREAT DEFINITION

- Recent feedback from Afghanistan and Iraq led to a Threat Hazard Analysis review
  - » RPG-7 is now the sole considered Shaped Charge Threat, RPG7-V has been measured at  $140 \text{ mm}^3/\mu\text{s}^2$
  - » Due to lack of RPG-7 reliability across various manufacturers, it is necessary to develop RPG-7 surrogate,

.../...

## NEW TRENDS IN THREAT DEFINITION

- Recent feedback from Afghanistan and Iraq led to a Threat Hazard Analysis review
  - » Many nations are designing their own RPG-7 surrogate and/or Standardised Shaped Charge
    - **USA** : LX-14 81mm (MIL-STD-2105(D))
    - **France** : CCEB 62 (mm)
    - **Germany** : 75 mm Shaped Charge "PG-7 German replica"

- **CCEB 62 = the French Standardized Shaped Charge for IM Signature assessment**
  - MoD Instruction N°211893/DEF/DGA/INSP/IPE **July 21, 2011**
  - **STANAG 4526 implemented** with CCEB62
  - **Test Procedure defined** in French Standard: NF T70-511
  - CCEB62 performances characteristics (i.e.  $V^2d$ ) **are available** and will be confirm in next future.
- Conditioning mild steel plates can be used
  - Critical  $V^2d$  determination: detonation/no detonation for EM characterization
  - Adjust  $V^2d$  to specified value (customer requirements)

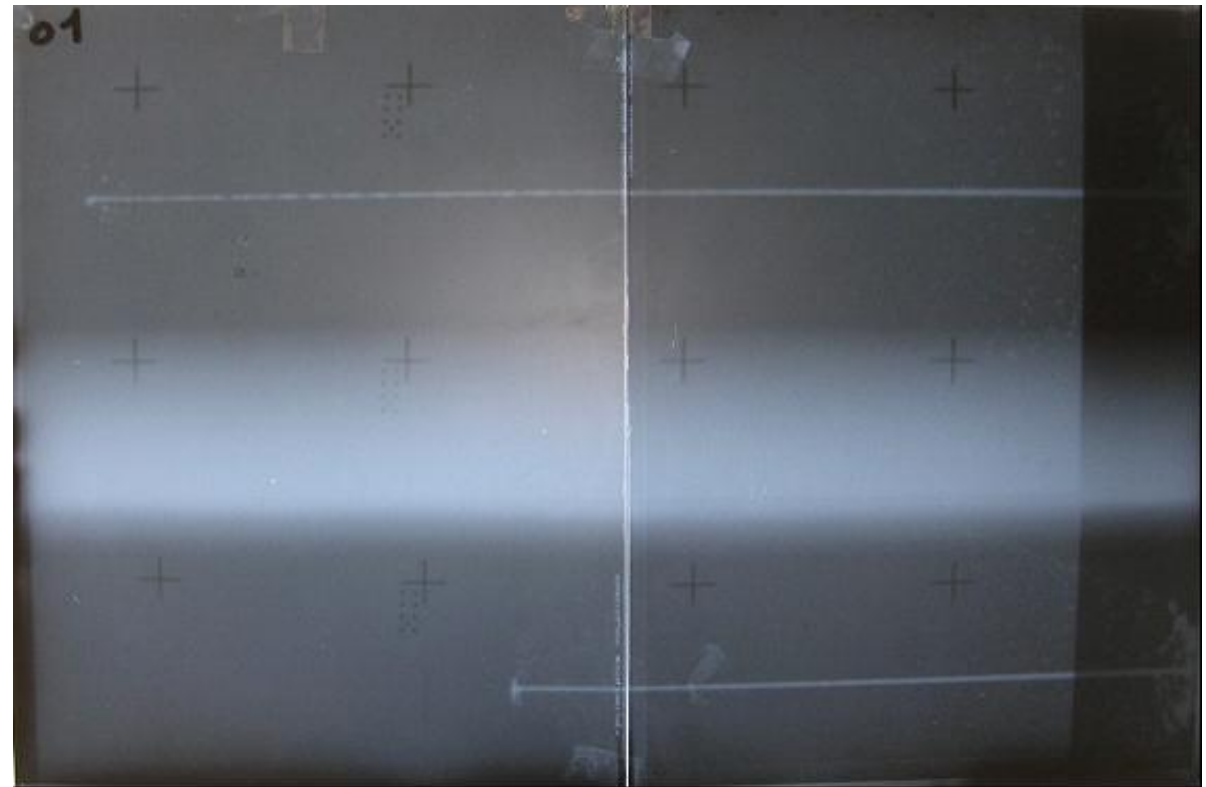
$V^2d$ (mm <sup>3</sup> /μs <sup>2</sup> )	203	103	93	82.5	72	62	41.5	52	31	21
Steel Plate thickness (mm)	0	20	25	40	60	80	110	150	200	280

## FRANCE

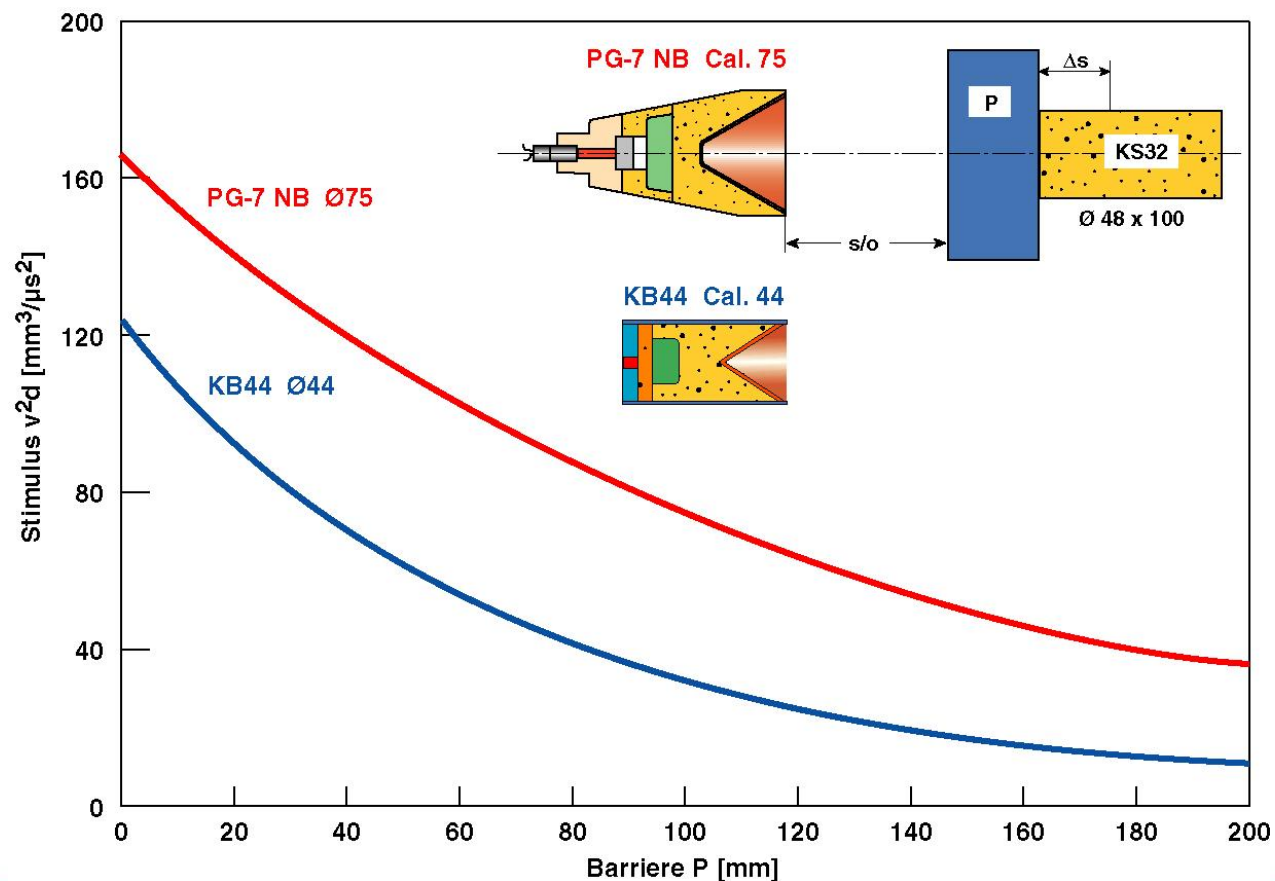
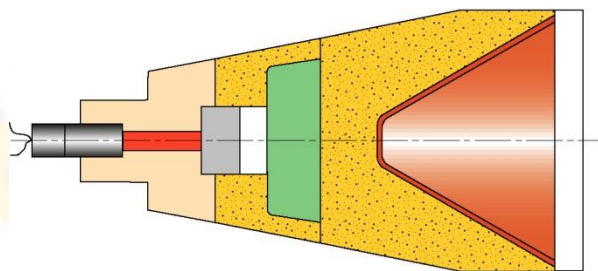
- CCEB 62 : Example of Free Jet X-Ray pictures (at two successive times)  
→ Note straightness diameter



**CCEB62 manufactured  
by NEXTER Munitions**



- **PG-7 replica would become German standard**
  - PG-7 replica (75 mm) manufactured by Dynamit Nobel.



- **LX-14 81mm appears as US Standard Shaped Charge**
  - **MIL-STD-2105(D)** requirement
  - Charge design and performance **are available** (E. L. Baker's Paper)
  - Tests seem to be **always carried out** with a 4" aluminum conditioning block, in that situation
    - » the  $V^2d = 141 \text{ mm}^3/\mu\text{s}^2$ ,
    - » tolerance about this value **not given**



- **LX-14 81mm appears as US Standard Shaped Charge (cont'd)**
  - the LX14 explosive loading characteristics are not precisely defined:
    - » **no real guarantee** that various LX14 batches manufactured by different producers will have the same performance,
    - » real performance with its tolerance would be re-checked.



# **IMEMG CONCERNS & COMMENTS**

## IMEMG CONCERNS & COMMENTS

- **Concerned** by the lack of consistency in various test procedures.
- **Difficult** to compare munitions responses to Shaped Charge Jet attack.
- NATO standards **should be agreed** and practicable with reproducibility by all member countries.

## IMEMG CONCERNS & COMMENTS

- **Shaped charge jet harmonization** has really begun, even if charges are different for each nation:
  - LX-14 81 mm, CCEB 62, PG-7 Replica
  - with  $V^2d$  that would be closed to  $141 \text{ mm}^3/\mu\text{s}^2$
- Each Shaped Charge referred to should have an **available and comprehensive technical data pack.**

## **IMEMG CONCERNS & COMMENTS**

**B U T ...**

## IMEMG CONCERNS & COMMENTS

- $V^2d$  is **not** the sole parameter for munition response:
  - same stimulus of  $V^2d$  can outcome Type I and Type V on the same tested item,
    - » future standard STANAG Shaped Charges **should not vary** too much in caliber,
- $V^2d$  level **tolerance** should be specified
  - » that means +/- 10 % or +/- 14 mm<sup>3</sup>/μs<sup>2</sup>  
(for the standard value 141 mm<sup>3</sup>/μs<sup>2</sup>)

## IMEMG CONCERNS & COMMENTS

- $V^2d$  stimulus of  $141 \text{ mm}^3/\mu\text{s}^2$  would be much too high:
    - » most charges (including some insensitive EM) can detonate, **only few EIS should survive** (Extremely Insensitive Substance in accordance with UN HD 1.6).
    - » STANAG to **define different stimuli** according to Life Cycle and Threat Hazard Assessment
- If **the standard procedure** is defined with the stimulus:  
 $V^2d$  is  $141 \text{ mm}^3/\mu\text{s}^2$  then,  
**an alternative procedure** should consider stimulus around  
 $60$  to  $70 \text{ mm}^3/\mu\text{s}^2$ , this value has to be discussed.*

## Authors

- CEA – DAM **FRANCE**  
Frank DAVID-QUILLOT
- EURENCO  
Yves GUENGANT
- MBDA-F  
Michel VIVES
- NEXTER Munitions  
Jérôme SOMAINI
- ROXEL  
Raymond COLENO
- TDA Armements  
Carole FOURNIER

- RWM Italia SpA **ITALY**  
Massimo CASTIGLIA

- MBDA TDW **GERMANY**  
Dr Werner ARNOLD
- RHEINMETALL WM GmbH  
Dr Gerhard HUBRICHT

- AWE Plc. **UK**  
Helen FLOWER
- BAE Systems GCSM  
Charles MARSHALL
- CHEMRING ENERGETICS  
John HAND
- MBDA-UK  
Sean RANDALL











