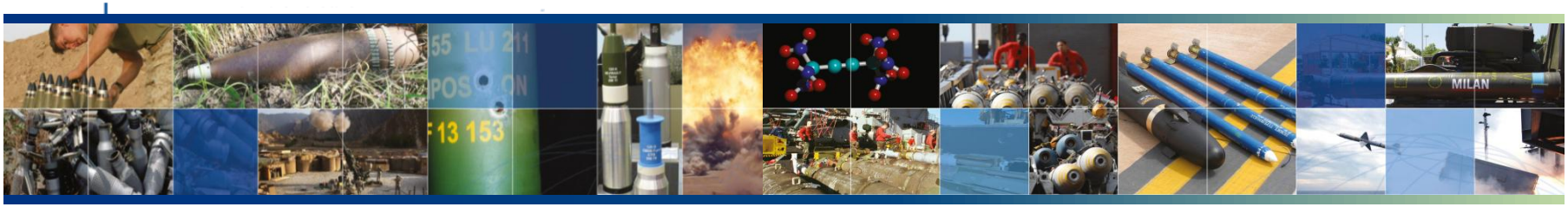
MSIAC

Munitions Safety Information Analysis Center

Supporting Member Nations in the Enhancement of their Munitions Life Cycle Safety



STANAG 4241 Review of the Bullet Impact Test

IMEMTS 2013 – San Diego, CA, USA

Emmanuel Schultz
TSO Propulsion Technology
+32.(0)2.707.54.47
e.schultz@msiac.nato.int

MSIAC Office
+32.(0)2.707.54.16
info@msiac.nato.int
http://www.msiac.nato.int

Agenda

- Background
- Questionnaire
- Standards
- Analysis
- Summary of recommendations
- Next steps

Background

- TTCP has recommended NATO to review the STANAG 4241 ed.2 for the following reasons (extract from [R1]) :
  - Current requirement has been very difficult to consistently obtain
  - Many BI tests ruled “no test” because velocity below lower limit
  - Would have been good test under old standard *
  - Why the Change?
  - What are the experiences of the other services and nations?
- NATO AC/326 SG B has tasked MSIAC to work on this topic.

* : It is important to note that this author refers to the MIL STD 2105 and NOT the STANAG. The tolerance of the velocity has changed between MIL-STD 2105 B and MIL-STD 2105 C from ± 60 m/s to ± 20 m/s. The tolerance has been constant in ed. 1 and ed. 2 of the STANAG 4241 (± 20 m/s).

[R1] “Lessons learned from the use of the new response descriptors”, Stuart Blashill, TTCP WPN TP-4, February 2012.

Procedure

- MSIAC has written a survey related to the Bullet Impact test (Broader scope than just the velocity)
- The survey was reviewed and amended by the custodian of STANAG 4241 (DEU)
- The survey was send to the following nations mid-January:
  - AUS, AUT, CAN, CZE, DEU, FIN, FRA, ITA, NLD, NOR, SVK, ZAF, ESP, SWE, CHE, TUR, GBR, USA
- After reception & analysis of the answers and other related documents, MSIAC has written the report O-152.

Contents of the survey

- Summary of the contents of the survey:
  - Do you have a test procedure?
  - What bullet do you use?
  - What weapon do you use?
  - Single or triple bullet test?
  - Firing distance?
  - Meteorological conditions?
  - Do you adjust the Muzzle Velocity (V_0) & how?
  - How do you measure the impact velocity (V_i)? Accuracy?
  - Have you encountered difficulties to achieve the V_i requirement? Frequency? Why? Do you solve it?
  - Do you thing the velocity is realistic?
  - Are there other points (except the velocity) that you would like to highlight / should be reviewed?

Test Standards

- The bullet impact test is defined with several documents.
  - In NATO:
    - STANAG 4439 ed.3 (Reaction level)
    - STANAG 4241 ed.2 (test requirements)
    - AOP-39 ed.3 (Guidance)
  - In UN, for HC 1.6:
    - Test 7 (j) of UN Recommendations on the transport of dangerous goods – Manual of tests and criteria, 5th revised edition, amendment 1

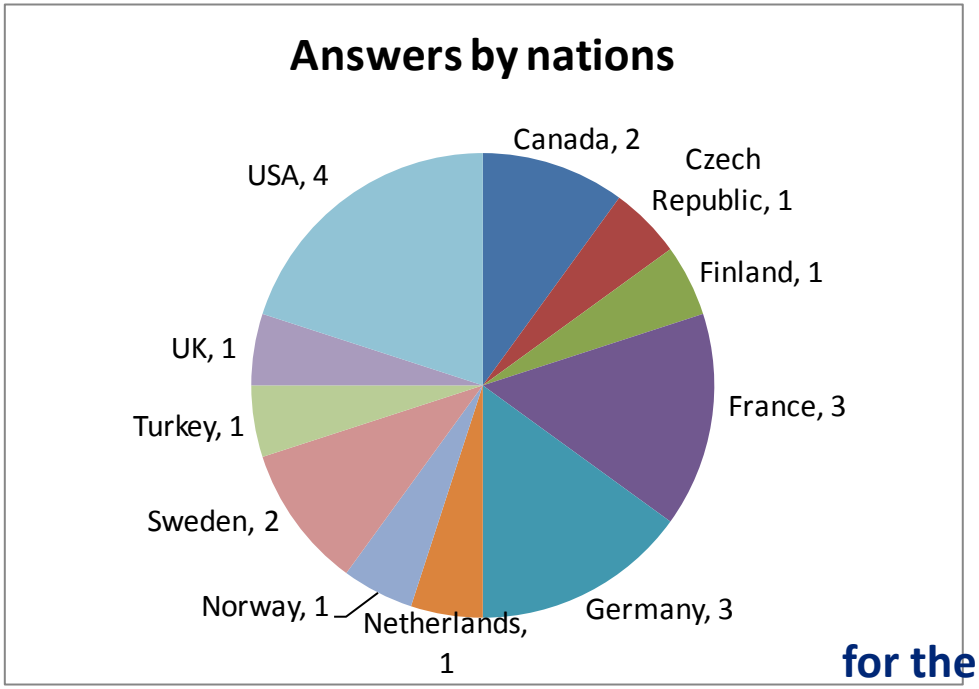
Comparison between NATO & UN

	STANAG 4241 ed.2	UN 7 (j) (5a1)
Alternative procedure	Yes	No
Number of tests	2	3
Type of bullet	*M2*, 0.5 cal, AP	0.5 cal, AP
Projectile mass	*Not specified (bullet is specified)*	*0.046 kg*
Aiming point	Main filling + most shock-sensitive *but the booster*	3 tests in 3 orientations, most vulnerable areas
Firing distance	*20* to 30 m	*10* to 30 m
Velocity	*Impact V = 850 ± 20 m/s*	*V (Muzzle?) = 840 ± 40 m/s*
Rate of fire	600 ± *50* rounds / minute	600 rounds / minute
Guns	A rigidly mounted gun	*Three* 12.7 mm guns
Size of the target	*5 cm circle*	*Not specified*
Reaction level acceptable	Burning or no reaction	Burning or no reaction

- Additional precision in UN:
  - Need of three guns remotely controlled
  - The propellant load may require adjustment
- Lack of clarity in UN:
  - M2 not specify
  - No tolerance on weight, firing rate
  - Which velocity (Impact, Muzzle)?
  - Aiming point? Does that mean the booster has to be hit in the three tests?

Answers

- 20 test centers from 11 nations have provided a full answer. And others have provided comments.
- 13 from governments and 7 from industries.



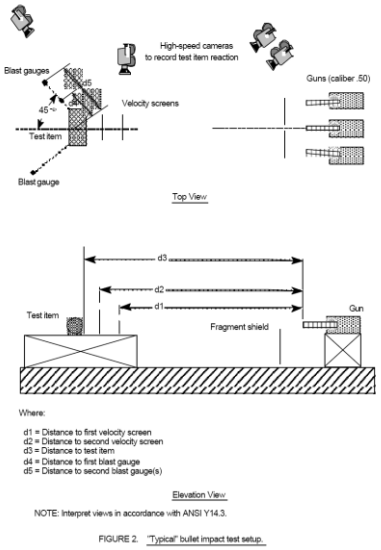
Nation	Organisation	Status
CAN	DRDC Valcartier	Gov
CAN	Canadian Explosives Research Laboratory (CERL)	Gov
CZ	Military Technical Institute	Gov
FIN	Test Firing Center	Gov
FRA	DGA-EM	Gov
FRA	DGA-TT	Gov
FRA	Herakles	Private
GER	Bayern-Chemie	Private
GER	TDW	Private
GER	WTD91	Gov
NLD	Centre of Excellence Weapons and Ammunition	Gov
NOR	Nammo	Private
SWE	Bofors Test Center	Private
SWE	FOI	Gov
TUR	several firms	Private
UK	QinetiQ	Private
USA	NAWC China Lake	Gov
USA	NSWC Dahlgren D	Gov
USA	Redstone (Army)	Gov
USA	Yuma (Army)	Gov

THANK YOU

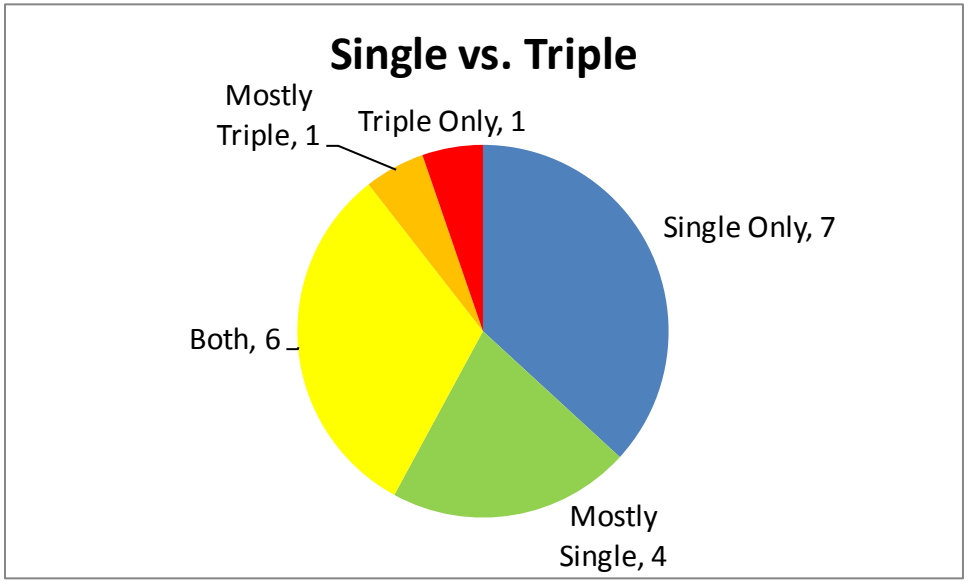
for the number and the quality of your answers

Test Procedure

- 50/50 between specific procedure and STANAG only. Specific procedures detail:
  - Type of test (single vs. triple)
  - Aiming point
  - Test setup
  - Safety procedure
  - ***=> add test setup (3 examples on the report)***
- Most of the nations fire on the booster. AOP39, Fragment Impact test and UN recommend to fire on the booster:
  - ***=>Not to exclude the booster if hit probability is sufficient (determined by THA and approved by National Authority)***
  - ***=>French translation of "booster" is "relais d'amorçage"***



Single vs. Triple



- The procedure 1 (standard) specifies a three-round burst.
- In reality, a majority of test centers apply the single BI (Procedure 2), even if we consider only the Governmental facilities.
  - ***=> The 2 procedures should be kept***

Type of Weapons

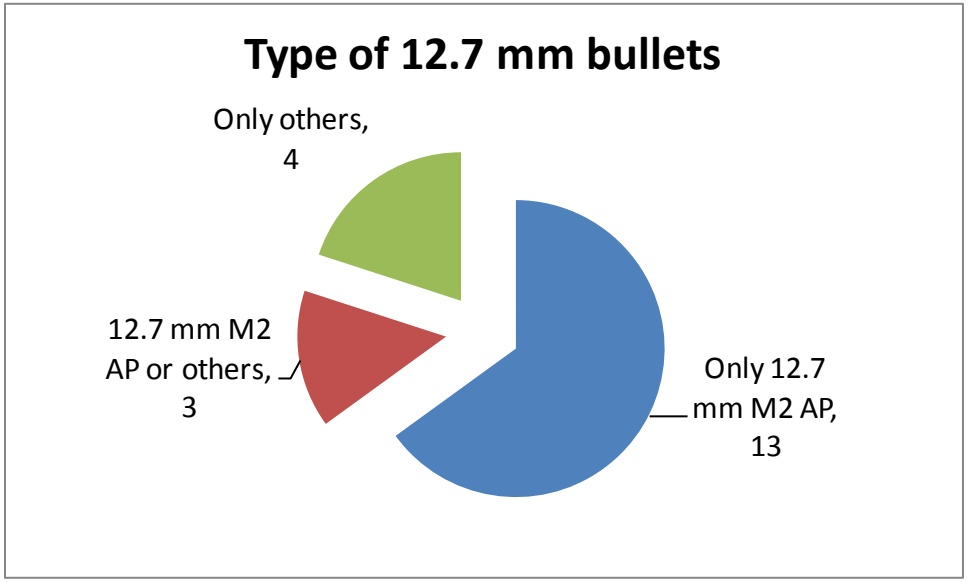
- Several weapons used:
  - Machine gun M2 HB (45” barrel)
  - Aircraft gun M2 (36” barrel)
  - AIMTEST
  - Custom made barrels

ANM2 .50 caliber aircraft, fixed.

.50 caliber HB (heavy barrel) ground, flexible.

- The rate of fire requirement (600 ± 50 rds/min) is compatible with the performance of this type of guns
  - M2 HB ~ 500 rds/minute
  - M2 Aircraft ~ 800 rds/minute
  - M3 Aircraft: up to 1200 rds/minute
- But, impossible to fire 3 bullets in a 5 cm circle at this firing rate with 1 gun:
  - ***=> explicitly mention the need of three guns remotely controlled***
- Booster unlikely to be hit by three bullets:
  - ***=> Triple-round burst in the main explosive filling***
  - ***=> Single shot in the most sensitive explosive component***

Type of Bullets



- A large majority of test centers use the 12.7mm M2 AP.
- Other bullets mentioned:
  - 12.7x99 PF1 (similar to M2 AP)
  - 12.7x99 AP-S, NM 185
  - 12.7x99 AP, DM51 (Similar to M8)
  - 12.7x99 API, M8

Firing Distance

- Current recommendation: 20 to 30 m.
- Firing distances range from 3 to 50 meters.
  - The really short distances reported are for small items (accuracy)
  - 15 m seems acceptable in term of stability
- ***=> A range of approximately 15 to 30 m to the target (sufficient to assure bullet stabilization) is acceptable. Exact range is determined by the test authority, depending on accuracy and safety aspects.***

Measuring equipments

- Several types of equipments to measure the impact velocity:
  - Radar (10)
  - Trigger screens (7)
  - High speed camera + reference board (6)
  - Optical screens (4)
- Non contact equipment is preferred
- ~Half of the facilities also measure the V_0 (radar, screens, chronograph)

Meteo

- AOP-39, 9-H:
  - Extreme external conditions (e.g. wind, rain, temperature) that might influence the test outcome should be avoided.
- The tests centers applying weather restrictions have mentioned:
  - Wind speed in excess
  - Thunder storm (lightning)
  - Relative humidity too low
  - Rain / snow
- => the recommendations of AOP seem sufficient

Velocity requirements

	Common	Rare	Total
Had issue with Vi	7	3	10/19
Still have issue with Vi	2	3	5/19

- Several facilities used to have difficulties in achieving the velocity requirements (V_i=850 ± 20 m/s):
  - Often too low
  - Or often too high
  - Or issue with the tolerance
- Most of them have solved this problem, by adapting the procedure:
  - Adjustment of propellant load / reloading with new propellant
  - Warming the tube (with pre-firing)
  - Selection of bullet with a tighter weight tolerance
  - Conditioning the propellant in temperature
- Methodologies used by several test facilities are described in the report.
- A large majority considers the requirement is achievable.
- ***=> Preliminary shots may be useful to warm the barrel, adjust the Vi and set the aiming point***
- ***=> the propellant loads may require adjustment.***

Velocity realistic?

- Vi considered realistic for most of the facilities (12 yes, 3 No, 4 w/o position)
- However, this question has brought up questions on the pertinence of the M2 AP and what the worst case is:
  - Firing close to the muzzle velocity (current position) or at a lower velocity
  - Firing with a smaller / higher caliber bullet (7.62 mm, 14.5 mm)
  - Firing with a multi purpose round (e.g. API M8)
- Difficult question:
  - The worst case is system dependant
  - Higher penetration doesn't always mean worst reaction.
  - The aim of the STANAG is not to represent the wide range of bullets (procedure 2 allows to test other bullets) but a standardized threat.
- For info, in the report O-152, MSIAC has gathered data on several bullets. A bullet is characterized by several parameters: weight, velocity, material of the jacket and of the core, dimension of the core, presence of incendiary or explosive compositions, presence of a tracer or not.

Other issues

- Availability of this bullet:
  - Some suppliers identified in the paper
- Impossible to fire 3 bullets in a 5 cm circle at this firing rate w/o restraining the test item:
  - **=> *Add guidance on the way to restrain the test item.*** (No example provided)
  - Should we keep this requirement, or decrease firing rate, or increase the target size, or replace triple by double burst?
- Small items inside packaging: STANAG is not clear on the procedure.

Summary of recommendations

- Add example(s) of test setup in the STANAG
- For Procedure 1 IM tests, two tests are required, one aiming at the largest explosive component (i.e. the main charge filling of the warhead or the propellant of the rocket motor), and the other aimed at the most sensitive explosive component (i.e. the rocket motor igniter or warhead booster). However, if the impact on the most sensitive area is of sufficient low probability, as defined by the THA and approved by the review board, the second test should be replaced by an additional one on the largest explosive component.
- Booster should be translated in the French version by “le relais d’amorcage”.
- Offering 2 different methods is representative of what the nations are doing. Therefore, the 2 procedures should be kept.
- Explicitly mention the need of three guns remotely controlled to perform the triple bullet test, in order to achieve the requested accuracy and firing rate.
- If the booster or rocket motor igniter is considered as an aiming point, then the test should consist only of a single shot. Therefore, the procedure 1 should become:
  - A three-round burst firing in the main explosive component
  - A single shot firing in the most shock-sensitive explosive component
- For bullet impacts, a range of approximately 15 to 30 m to the target (sufficient to assure bullet stabilization) is acceptable. The exact range from gun to target is to be determined by the test authorities, depending on accuracy and safety aspects.
- Preliminary shots may be useful to warm the barrel, adjust the impact velocity and set the aiming point.
- To achieve the impact velocity requirement, the propellant loads may require adjustment.
- Add guidance on the way to restrain the test item when performing the triple-burst test.
- Add a procedure for small items.

Open questions

- Is the 0.5 cal M2 AP still the good choice?
- What is best practice for small items inside a packaging?
- Competition between firing rate and size of the target for the triple-burst:
  - Should we keep the triple burst? (Consistency with UN orange book)
  - Should we decrease the firing rate?
  - Should we enlarge the size of the target?

Conclusion

- Creation of an expert working group:
  - to tackle the open questions
  - To discuss all the recommendations
- A transformation of the STANAG into an AOP (likewise the 4240 for Fast Cook-Off)

- This survey was an effective way to get feedback from the nations, to share information, and to prepare the working group.

Merci pour votre attention