Summary of Newly Ratified NATO Standard AEP 2920, Ed. A, V1

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Abstract. The NATO Standard STANAG 2920 Ed.3 – AEP 2920 Edition A, Version 1 entitled 'Procedures for the Evaluation and Classification of Personal Armour, Bullet and Fragmentation threats', ratified autumn 2014 and published June 2015 on the NSO portal , replaces the STANAG 2920, Ed. 2, July 2003 'Ballistic Test Method for Personal Armour Materials and Combat Clothing'. While STANAG 2920 Ed. 2 was a guideline for the conduct of ballistic tests, the AEP 2920, Ed. A, V1 describes the procedure agreed within NATO for classification of personal armour for protection against bullets and fragments threat. The procedure includes standard techniques and reproducible test procedures for evaluating the level of protection of combinations of items, components or representative material samples used in personal armour systems and the method to designate the performance by use of a set of identifiers. Bullets and fragments are identified in classes to facilitate the designation following the ballistic tests. The standard applies to material samples, components such as flexible armour and helmet shells and personal armour items (helmet, face and eye protection and plates) and combination of flexible armour with hard armour. This paper summarizes the most significant modifications from STANAG 2920 Ed. 2 to AEP 2920 Ed. A, V1 and gives guidelines to understand the threat classes and personal equipment performance identification.

1. FROM GUIDELINES TOWARD A STANDARD FOR CLASSIFICATION OF PERSONAL ARMOUR

To ensure interoperability of personal armour equipment in multinational missions, it is essential for nations to use a common classification method which links protection levels against threats that from an operational perspective are considered to be of importance. This classification shall be based on reproducible ballistic tests from a recognised standard. STANAG 2920 Ed. 2 [1] is unable to achieve that goal considering that its aim was: '*to establish guidelines for the conduct of ballistic tests'*. It therefore did not include a classification method, while the lack of detail in Edition 2 lead to a degree of divergence in testing procedures considered to be too large for an internationally acceptable classification.

To fulfil these gaps, a Team of Experts from 10 nations shared their experience, practises and available data during the period of 2007 to 2012 to revise the STANAG 2920 Ed. 2. This has now resulted in the ratification of STANAG 2920 Edition 3 [2] stating: *For personal armour in their inventory participating nations agree:*

- *to use the method of classification (testing procedures, criteria and method of designation) described in the standard;*
- *to classify on the basis of ballistic tests performed according to the standard.*

The standard referred to, is the 1st edition of the AEP[1] 2920, Ed. A, V1 entitled 'Procedures for the Evaluation and Classification of Personal Armour – Bullet and Fragmentation Threats' [3]. This procedure includes the techniques and procedures for evaluating the level of protection of combinations of items, components or representative material samples used in personal armour systems and the method to designate the performance by use of a set of identifiers. STANAG 2920 Ed. 3 has currently been ratified by 19 NATO nation members.

This paper highlights the methodology, the most important changes from STANAG 2920 Ed. 2 to STANAG 2920 Ed. 3 – AEP 2920, Ed. A, V1 and focuses on the classification method introduced by this standard.

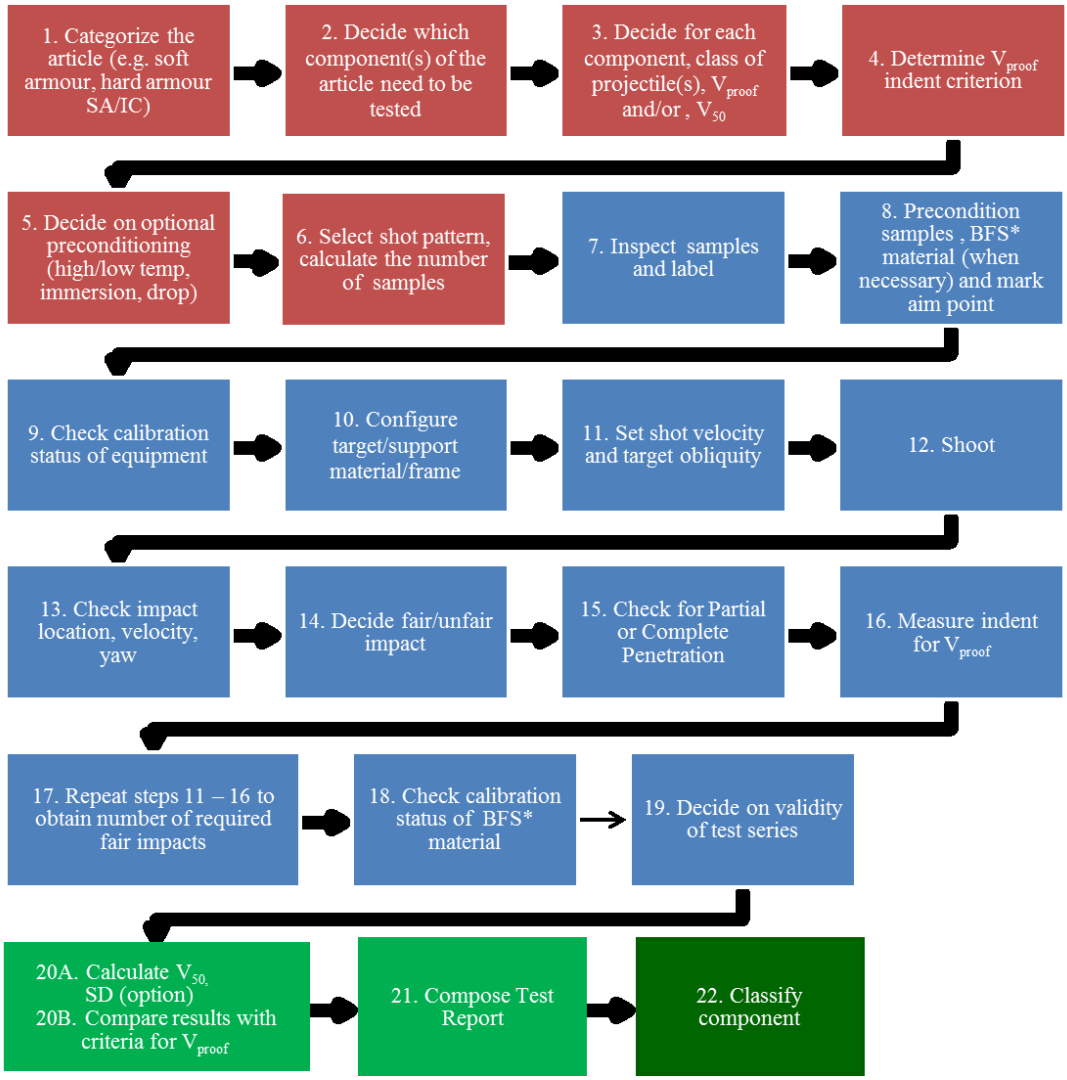
2. METHODOLOGY

The ballistic test procedures, criteria and method of designation described in the AEP 2920 Ed. A, V1 document apply to material samples, components (soft armour, helmet shells) and personal armour

[1] Allied Engineering Publication approved by NATO Army Armaments Group

items (hard armour, helmets, face and eye protection) and combinations of soft armour and hard armour.

The classification of personal armour is to be defined by the assignor of the testing. The assignor can be the representative of a Nation, i.e. the procurement agency or a manufacturer, etc. Figure 1 shows an overview of the phases and responsibilities involved in the process leading to classification. The classification process involves three main stages: 1) test plan definition (in red), 2) ballistic evaluation (in blue), 3) data analysis (light green) and classification (dark green).



*BFS material = Back Face Signature material

Figure 1. Methodology

Stage 1– Test Plan Definition (Step 1 to 6): The assignor of the testing decides the classification aimed at for a particular item. At this stage it is required to state for that item at least:

- the class (defining the type of projectile(s) to be used), see section 3.1 and 3.2;
- whether the purpose is to validate a V_{proof} or to assess a V_{50};
- if the purpose is to validate a V_{proof}, the V_{proof}.

Although not shown in Figure 1, the assignor has also to define for hard armour (stand alone and in conjunction):

- the width of the edge zone characterising the area of non-fair hit;
- the number of impacts per item (single hit or multi hit);
- whether the hard armour is to be used stand alone or in conjunction. In the latter case, the soft armour is to be tested in conjunction with the hard armour.

Preconditioning other than at standard room temperature is an option. After this stage, the scope of ballistic testing is defined and the samples can be tested by the Testing Facility.

Stage 2 – Ballistic evaluation (Step 7 to 19): is the actual ballistic testing by the Test Facility. Section 5 highlights the changes between the new edition and Edition 2. The assignor shall ensure that ballistic tests are conducted at test facilities known to be in compliance with the AEP. The test procedures described can equally be used for research and development, qualification of materials or designs and in the procurement of new equipment.

Stage 3 – Data analysis (Step 20 to 21) and Classification (Step 22): It is again the responsibility of the assignor, who shall decide on the basis of the test report what the classification of the item shall be. A nation/manufacturer can decide to mark the item accordingly or use the classification solely to inform others on request of the performance of its equipment when required.

3. CLASSES OF PROJECTILES AND VELOCITIES

To classify a personal armour item and ensure interoperability in multinational missions, the protection shall defeat the projectiles as defined by the Nation in Stage 1.

3.1. Bullets

Each Nation is to adhere to the classes of small calibre ballistic projectiles (bullets) defined in ANNEX B of the AEP and in Table 1 of this paper. On this aspect the AEP 2920 Ed. A, V1 differs in two respects from other standards:

1. It states classes of ammunition instead of levels and
2. It does not set a minimum impact velocity for a specific bullet.

The community involved in the definition of the STANAG 2920 Ed. 3/AEP 2920 Ed. A, V1 has decided to use classes of ammunition instead of level. Most standard uses a level gradation resulting in a general assumption that protection developed for a higher level adequately protects against lower level threats. Therefore, a protection level III should protect against all ammunition of level I and level II. Depending on the ammunition design, this assumption might not be always true, putting the wearer at risk. Also, each level generally includes multiple bullets that may not necessarily be equivalent in term of difficulty to be defeated. As an example, one standard includes in the same level the 5.56 x 45 SS109 and the 7.62 x 51 ball (M80). Due to the design of the penetrator, the SS109 is more difficult to defeat and requires a very different protection scheme. Therefore, in working with ammunition classes, the Team of Experts aimed to avoid that sort of association.

Table 1 presents the AEP 2920 reference bullets table. Bullets are categorised in 4 categories, designated A, B, C, D, on the basis of (core) hardness. In each category projectiles are ranked on calibre. From the table, it is seen that independent on the category a class number is always associated with the same calibre. As an example, the 5.56 x 45 is associated with class #3. Similarly, the 7.62 x 39 refers to class #4 and the 7.62 x 51 refers to class # 5 in all categories. To correctly identify the protection level against a specific type of ammunition, the category, the class and the V_{proof} will appear.

Current ballistic standards differ in the V_{proof} for the same type of projectile. In the AEP the Nation has the authority to choose the V_{proof} as appropriate for its operational requirements. This approach will allow a comparison between items of different nations without discarding specifications currently in circulation.

The V_{proof} shall ensure that at a confidence level of 90% the probability of a partial penetration (stop) for the specified projectile (s) at the velocity specified (V_{proof}) is higher than 90%. The minimum number of shots required in the evaluation of V_{proof} has been established using the statistical binomial law and equals 22 fair impacts.

Multiple designations of the same item are possible. As an example A5 [Vp 850] and B4 [Vp 720] for a hard armour indicates that it will protect against the 7.62 x 51 ball with a V_{proof} of 850 m/s (or higher) and the 7.62 x 39 (M43) that has a core hardness of no less than 40HRC and a V_{proof} of 720 m/s (or higher).

Table 1. List of acceptable bullets

Category	Calibre [mm]	Class	Projectile Mass [g]	Minimum Core Hardness	Core Mass [g]	Acceptable Projectile
A Lead core projectiles	9 x 19	A1	8.0 ± 0.1	-	-	According to STANAG 4090
	4.6 x 30	A2	2.6 ± 0.1	-	-	RUAG FMJ SX
	5.56 x 45	A3	3.6 ± 0.1	-	-	FN SS 92 / M 193
	7.62 x 51	A5	9.3 ± 0.1	-	-	According to STANAG 2310
	Emerging threats	A Special				NA specified
B Mild steel core projectiles	4.6 x 30	B2	2.0 ± 0.1	40 HRC	2.0 ± 0.1	RUAG AP SX
	5.56 x 45	B3	4.0 ± 0.1	40 HRC	0.4 ± 0.1	According to STANAG 4172
	7.62 x 39	B4	7.9 ± 0.2	40 HRC	3.6 ± 0.1	7,62 x 39 M 43 PS
	7.62 x 51	B5	9.6 ± 0.1	40 HRC		
	Emerging threats	B Special				NA specified
C Hardened steel core projectiles	7.62 x 39	C4	7.7 ± 0.3	60 HRC	4.0 ± 0.1	7,62 x 39 API BZ
	7.62 x 51	C5	9.5 ± 0.1	60 HRC	4.6 ± 0.1	FN P80
	7.62 x 54	C6	10.4 ± 0.5	60 HRC	5.3 ± 0.2	7,62 x 54R B32 API
	7.62 x 63	C7	10.7 ± 0.1	60 HRC	5.2 ± 0.1	M2 AP US Arsenal
	Emerging threats	C Special				NA specified
D Tungsten cobalt (WC) core projectiles	9 x 19 AP	D1	5.7 ± 0.1	70 HRC		MEN 9x19 AP
	5.56 x 45	D3	3.4 ± 0.1 4.0 ± 0.1	70 HRC	2.2	M995 MEN AP DM 31
	7.62 x 51	D5	8.2 ± 0.1	70 HRC	5.9	M 993 Nammo AP8
	Emerging threats	D Special				NA specified

3.2 Fragment Simulators

The classes of fragment simulators representing fragmentation are defined in ANNEX C of the AEP. Fragment simulating projectiles included in the classification are divided in 3 categories: F; G; R each subdivided in weight by a weight specific number. The character designates the shape of the fragment threat:

- F designating Chisel Nose Cylinders (FSP) launched with sabot;
- G designating Chisel Nose Cylinders (FSP) launched without a sabot;
- R designating Right Circular Cylinders (RCC).

The number (1….9) defines the weight of the fragment simulating projectile. Again the number is independent of the category, although minor differences in weight between categories are present. Details can be found in Table 2, 3, and 4 and Figure 2 and 3 of this paper. The exact dimensions, weights, and tolerances were taken from the most recent version of existing National Standards. Minor differences from Edition 2 of STANAG 2920 may exist due to changes in these underlying documents.

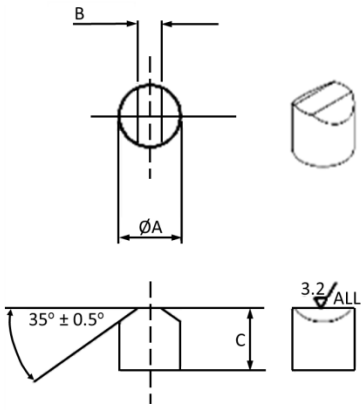
In favour of standardisation a number of less often used, types of fragment simulators have been abandoned in AEP 2920 Ed. A, V1. This is the case for the steel sphere, the steel cube, the steel parallelepiped and the flechette simulators.

The V_{50} classification of personal armour shall ensure that the probability of perforation for the specified projectile(s) at the velocity specified (V_{50}) is less than 50%. The up and down method is required when determining the V_{50}. To measure the degree of variability on the V_{50}, it is recommended to evaluate the standard deviation using the Probit method. The Probit method is detailed in the reference document.

To correctly identify the performance against specific fragments, the category, the number referring to a weight and the V_{50} are to be specified. As an example, F5 [V_{50} 850] and R6 [V_{50} 800], for a helmet indicates a minimum V_{50} of at least 850 m/s for a FSP of 1.1 grams and for the RCC of 2.84 grams a V_{50} of at least 800 m/s.

Table 2. Chisel Nose Cylinders (FSP), launched with a sabot available for classification of personal armour.

Class	**F1**	**F2**	**F3**	**F4**	**F5**	F6
Mass [g]	0.162	0.237	0.325	0.486	1.102	2.786
Drawing	C.1.1	C.1.1	C.1.1	C.1.1	C.1.1	C.1.1
Reference	DCTA/A3/6723 (launch with sabot)					



DCTA IDENTITY	WEIGHT (g)	DIM A ± 0.02 (mm)	DIM B + 0.0 - 0.5 (mm)	DIM C SEE NOTE 2 (mm)
A3/6723/1	1.102 ± 0.02	5.385	2.54	6.350
A3/6723/2	0.162 ± 0.01	2.642	1.27	3.175
A3/6723/3	0.237 ± 0.01	3.251	1.52	3.810
A3/6723/4	0.486 ± 0.02	4.064	2.03	4.572
A3/6723/5	2.786 ± 0.02	7.493	3.18	8.763
A3/6723/6	0.325 ± 0.01	3.600	1.75	4.313

Notes

1. After manufacture item shall have a hardness value of HRC 30 ± 2 (steel alloy)
2. Adjust dimension C to give correct weight

Figure 2. AEP2920 drawing reference C1.1 (launched with sabot DCTA/A3/6723).

Table 3. Chisel Nose Cylinders (FSP) launched without a sabot available for classification of personal armour.

Class		**G5**	**G6**		**G8**	**G9**
Mass [g]		1.10	2.84		13.39	52.73
Drawing		C.2.1	C.2.2		C.2.3	C.2.4
Reference		MIL DTL 46593 (launch without sabot)				

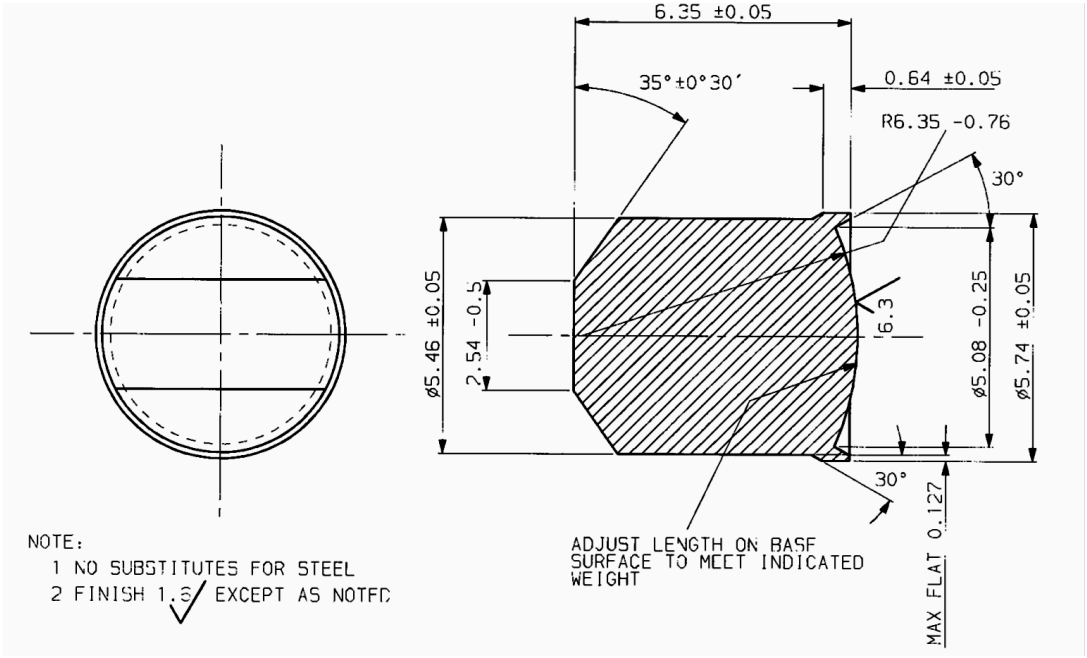


Figure 3. AEP2920 drawing reference C2.1 (launch unsaboted, MIL-DTL46593).

Table 4. Right Circular Cylinders (RCC) available for classification of personal armou**r.**

Class	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Mass [g]	0.16	0.24	0.33	0.49	1.04	2.84	4.15

Class	**MASS (g)**	**A (mm)**	**B (mm)**
R7	4.15 ± 0.03	8.74 ± 0.03	8.82
R6	2.84 ± 0.03	7.49 ± 0.04	8.19
R5	1.04 ± 0.03	5.39 ± 0.06	6.17
R4	0.49 ± 0.03	4.06 ± 0.14	4.78
R3	0.33 ± 0.03	3.60 ± 0.19	4.07
R2	0.24 ± 0.03	3.25 ± 0.22	3.64
R1	0.16 ± 0.03	2.64 ± 0.27	3.77

1 - Length B is approximate and must be adjusted to obtain indicated mass;
2 - All burrs are to be removed and all surfaces to be as smooth as possible;
3 - Projectiles are to have a hardness value of HRC 30 ± 2.

4. LIMITATIONS

The STANAG 2920 Ed. 3 / AEP 2920 Ed. A, V1 only covers the test methods and classification procedure to determine the level of ballistic protection of personal armour. Minimum criteria for the design of ballistic protective equipment are given in STANAG 2902 (helmets), STANAG 2911 (body armour) and STANAG 4296 (eye protection). It is expected that an effort to revise these STANAGs will start in the near future.

The classification is assigned on the basis of the performance after preconditioning and testing at normal ambient temperature. Testing after more severe preconditioning (extreme hot/cold temperature conditions, immersion, drop tests) is not mandatory but strongly recommended to establish/determine

the extent of performance degradation of personal armour after short time exposure to higher/lower temperatures, wet conditions or mechanical impact. Specific conditions and test methods are recommended and can be found in AEP 2920 Ed. 3 / AEP 2920 Ed. A, V1.

Aging and non-perforating projectile ricocheting are not considered in the classification of the protection. No guidance on these aspects is provided.

5. COMPARING STANAG 2920 ED. 2 WITH STANAG 2920 – AEP 2920 ED A, V1

On the fundamental aspect of the tests procedures, both standards show many similarities. However, in order to guarantee results would be repeatable, independently of the laboratory doing the tests AEP 2920 Ed. A, V1 provides many more details. Table 5 summarizes these changes.

Besides the details on projectiles, the AEP 2920 Ed. A, V1 includes details on facilities and equipment to be used, explains how to complete a ballistic evaluation, what retention system should be used for what item, how to condition samples or backing material, which shot pattern for every item, how to compile a V_{50} or a V_{proof}, describes a test method for shatter gap evaluation and defines partial or complete penetration for the categories of personal armour.

Table 5. Comparing STANAG 2920 Ed. 2 with STANAG 2920 Ed. 3 – AEP 2920 Ed A, V1

			STANAG 2920 Ed. 2	**STANAG 2920 Ed. 3 – AEP 2920 Ed A, V1**
Threats detail list	Bullets		none	list based on core material and hardness
	Fragments		FSP RCC sphere steel cube steel parallelepiped	FSP RCC
	Flechette		include	none
Assessment	V50		up and down min # shots: 6 within 40 m/s no max	up and down min # shots: 6 within 40 m/s max # shots:14 within 60 m/s
	Vproof		V_0 method min # shots 14	min # shots: 22
Standard deviation method			none	included: Probit
Target retention system and	V50:	Soft armour	rigid frame + witness plate (detail)	rigid frame + witness plate (no detail) strap + low density foam
		Hard armour	none	included
		Helmet	included	included
		Eye & Face	none	included
	Vproof:	Soft armour	no backing material specified	Roma Plastilina #1
		Hard armour	no backing material specified	Roma Plastilina #1
		Helmet	none	included
		Eye & Face	none	included
Shot pattern			none	soft armour hard armour small fabric pieces helmet face & eye protection
Criteria PP/CP			included	included (category specific)
Criteria for fair impact			included	included
Target conditioning			T: 20 ± 2°C, 24hrs H: 65% ± 5%	T: 20 ± 2°C, 6hrs 40% > H < 70%

Backing material conditioning & calibration	none	included
Extreme temperature conditioning (Recommended)	none	high T: 70 ± 2°C, 6hrs cold T: -40 ± 2°C, 6hrs
Immersion (recommended)	none	de-ionised distilled water, 24hrs surrogate sea water, 24hrs
Drop testing (recommended)	none	hard armour helmet
BABT instrumental measurement (recommended as an additional method)	none	included
Angle of impact measurement	included	included + method
Shatter gap (recommended)	none	included
Tests set up configuration	none	included
Velocity measurement	included	included + correction for air drag
Projectile spin	included	none

6. CONCLUDING REMARKS

The Team of Experts believes STANAG 2920 Ed. 3 – AEP 2920 Ed. A, V1 will improve the repeatability and reproducibility in ballistic testing of personal armour. As any standard the AEP 2920 Ed. A, V1 is a compromise, more detail would have limited the number of laboratories able to adhere to the AEP, too little detail would lead to classifications of armour difficult to compare.

Hopefully the STANAG 2920 Ed. 3 / AEP 2920 Ed. A, V1 like the STANAG 2920 Edition 2 will be widely used. All users are encouraged to report their experiences in working with the new document to their national representatives.

The reader of the AEP 2920 Ed. A, V1 will notice that the AEP in essence is similar to other standards. To the opinion of the Team of Experts new methods of testing like BABT rigs were not sufficiently validated to be used for classification. Existing methods have a long history and the data thereof is not easily discarded in favour of new practices. Moreover, these methods have resulted in field proven personal armour. New test methodologies tend to demonstrate a higher degree of biofidelity, opening new possibilities in providing the combat soldier with better personal armour.

In the meantime, work on the STANAG 2920 edition 4 has started. The main objectives are to review those aspects of STANAG 2920 Ed. 3 – AEP 2920 Ed. A, V1 that needs to be clarified, discuss possible additions that may have become necessary considering materials and armour systems are constantly evolving and evaluate new methods once more.

References

[1] STANAG 2920 PPS (EDITION 2) – BALLISTIC TEST METHOD FOR PERSONAL ARMOUR MATERIALS AND COMBAT CLOTHING, 31 July 2003, NATO Standardization Agency, Brussels

[2] STANAG 2920 – Classification of Personal Armour (EDITION 3), 22 June 2015, NATO Standardization Office, Brussels

[3] AEP 2920 – Procedures for the Evaluation and Classification of Personal Armour, Bullet and Fragmentation Threats, Edition A, Version 1, 22 June 2015, NATO Standardization Office, Brussels