General basis for ballistic material, construction and product testing

Englische Übersetzung, es gilt immer die deutsche Originalfassung!

English translation, howewer the original German version always prevails!

Editor:

Association of test laboratories for bullet resistant materials and constructions (VPAM)

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List of Amendments

Amendments		Modifications were made and numbered as follows
No.	**Date**	
1	2007-10-25	4.1 (Upgrading to 14 levels, thus modifications for the levels 12 to 14)
2	2008-05-08	Front page (Modification of terms, thus modification for 3.1.2, 4.1, 6.4.1 and 7.3), Introduction, 6.4.3, 6.5.1, 6.5.2, 6.6, attachment 2 (calculation method) and attachment 3
3	2009-05-14	Introduction, 4.1 (testing level 9 and completion of the legend for table 1), 6.2 (5. enumeration), 6.6 (energy value in the example) and attachment 3 (dropped)
4	2010-05.12	Attachment 1 (Footnote)
5	2014-09-25	2 Normative references *change* 3.1 General terminology 3.1.4 Sample/type reference *change* 3.1.5 Conformity evaluation *record* 3.2 Terms for test sample 3.2.3 Test sample *change* 3.3 Terms for test procedure 3.3.4 Angle of attack and 3.3.12 point of impact *record* 3.3.7 Background material, 3.3.8 indent diameter and 3.3.9 indent depth *not applicable* 4.1 Test with standardised ammunition types Table 1 test level classification *change* Table 1 *revision* and *compiling* of an adjoining document AND#01.

		5.3 Precision of the measuring means *adjustment of the tolerances* 6.1 General *extension* 6.2 Test-relevant parameters *revision and adaptation of the list* 6.4 Determination of the ballistic limit value v50 6.4.2 method according to STANAG 2920 *not applicable* 7.1 Evaluation and documentation of the test 7.2 Test report *revision* 7.3 Test certificate *revision* terminology of test certification *not applicable* tests according to adjoining document *record* 7.4 Validity of test certificate *revision* 7.5 Traceability of results *change* 7.6 Specifications for material/processing *not applicable* Attachment 1 Test procedure shooting distance according to Table 1, figure 4.1, *adaptation* Attachment 2 Sketch “angle definition” *record* Attachment 2 becomes Attachment 3, *change*

Foreword

This guideline was developed by the Association of test laboratories for bullet resistant materials and constructions (VPAM).

The binding actual directive can be viewed at: www.vpam.eu

Reference source of VPAM - APR 2006:

VPAM
Association of test laboratories for bullet resistant materials and constructions

Office

Deutsche Hochschule der Polizei

Polizeitechnisches Institut
Postfach 48 03 53
48080 Muenster
Germany

Tel.: +49 (0) 25 01 806-259
Fax: +49 (0) 25 01 806-239

E-Mail: pti@dhpol.de
Internet: www.dhpol.de or www.vpam.eu

Objectives of VPAM

VPAM was founded in 1999 by the executive members with the aim to promote experience exchange and mutual assistance with possible questions regarding bullet resistant materials and constructions.

The co-operation is supported by a common statement regarding engineering standards, guidelines and other regulations.

The publishing of own test guidelines ensures reproducible results on the one hand and more market transparency for customers and users on the other hand. This is due to the objective evaluation other suppliers´ products and test reproducibility.

The members of VPAM are independent and committed to neutrality. The test centres, which are members of VPAM, operate exclusively according to appropriate quality specifications EN ISO/IEC 17025 (general requirements on the expertise of testing laboratories) and EN 45011 (general requirements on institutions which do product certification systems).

The contact details of all VPAM-members are listed online: www.vpam.eu

Table of contents

1 Fields of application

This guideline describes the basis for ballistic tests and/or conformity assessment [1] of materials, constructions and products, which offer protection against attacks by firearms.

The technical bases includes:

- Definitions
- Test conditions
- Test- and measuring equipment
- Test procedure(s)
- Evaluation and documentation of the test

This guideline is completed with product-specific guidelines of VPAM in which the deviant test conditions, test- and measuring equipment and test methods can be mentioned.

2 Normative Reference

The following standardised documents contain modalities that have to be considered as part of this test guideline as they are referred to.

Standards, references and legal regulations must always be applied according to their latest versions.

- **VPAM guidelines**
- **TDCC**, dimension sheet of the permanent international commission for the test of small arms (C.I.P.)

3 Terms

For the use of this general guideline the following terms are valid:

[1] To simplify this text the term test will be used in the following.

3.1 General terms

3.1.1 Bullet/ballistic resistance

Materialien, Konstruktionen und deren Produkte sind durchschusshemmend, wenn es/sie einen definierten Widerstand gegen Angriffe mit bestimmten Waffen- und Munitionsarten bietet.

3.1.2 Test level

Name for the classification of a resistance against a defined attack potential (According to clause 4.1 table 1).

3.1.3 Classification

Allocation to a particular class according to the tested bullet-resistant behaviour under defined conditions

3.1.4 Sample/type reference

The reference (name or code) for the model, the structure and the used materials of a tested product.

3.1.5 Conformity evaluation

The conformity evaluation is the determination of the compliance of a directive with the actual Model (target-actual comparison).

3.2 Terms for test specimen

3.2.1 Impact side

The side of the test specimen which is facing the impact and which has to be marked by the manufacturer/client (see AS in Appendix 2).

3.2.2 Sample

One or more test specimen, which are necessary for the test.

3.2.3 Test specimen

An object designated for testing that corresponds to a product-related test guideline (see PR in Appendix 2).

The model, structure and used materials of the sample must conform to the specifications of the manufacturer or the client and be representative of the product.

page 12 of 28

3.3 Terms for the test procedure

3.3.1 Impact velocity

The velocity of the projectile in m/s at a distance of max. 2.5 m in front of the impact point.

3.3.2 Point of impact

A set point on the test sample where the bullet should make impact (see ATP in Appendix 2). It is marked before issuing the shot at the corresponding point.

3.3.3 Angle of impact

Angle between the flight direction of the bullet focus and the test surface at the point of impact (see ATW in Appendix 2).

3.3.4 Angle of attack

Angle between the flight direction of the bullet's centre of gravity and the bullet axis (see ASW in Appendix 2).

3.3.5 Ballistic limit V_{50}

The velocity of the projectile corresponding to a probability of 0.5 (50%) that the defined projectile penetrates the test specimen.

3.3.6 Penetration

Is stated if

1. a projectile or projectile fragment completely penetrates the test specimen
2. the rear surface of the test specimen is penetrated by the stuck projectile or the stuck projectile fragment
3. the test specimen provides an opening on its backside with a light passage without evidence of no.1 and/or no.2
4. a specified penetration indicator is penetrated.

3.3.7 Penetration/fragment indicator

Is positioned behind the test specimen for the test duration depending on the product specific requirements. It shows the penetration of the specimen by the projectile and/or projectile fragments respectively splinter of the test specimen.

3.3.8 Shot distance

The distance between the muzzle of a weapon and the impact point of the projectile on the test specimen.

3.3.9 Hit distance

The distance between the centres of two hits on the test specimen.

3.3.10 Hit distance to the edge

The distance between the impact point and the nearest line which marks the edge of the protection area.

3.3.11 Point of impact

The actual point where the bullet impacts the test sample. Accordingly, this may deviate from the marked point of impact.

4 Test conditions

4.1 Testing with standardised types of ammunition

Table 1: Classification of the test levels

Test level	Type of weapon	Calibre	Ammunition and projectile			Test conditions	
			Type	Mass [g]	Manufacturer Type	shot distance [m]	Bullet velocity [m/s]
1	K/L	22 Long Rifle	L/RN	2,6	Winchester	10 + 0.5	360 ± 10
2	K	9 mm Luger[4)]	FMJ/RN/SC,	8,0	DAG, DM 41	5 + 0.5	360 ± 10
3	K	9 mm Luger[4)]	FMJ/RN/SC,	8,0	DAG, DM 41	5 + 0.5	415 ± 10
4[1)]	K	357 Magnum	FMJ/CB/SC	10,2	Geco	5 + 0.5	430 ± 10
		44 Rem. Mag.	FMJ[*)]/FN/SC	15,6	Speer Nr. 4459	5 + 0.5	440 ± 10
5	K	357 Magnum	FMs/CB	7,1	DAG special	5 + 0.5	580 ± 10
6	L	7,62 x 39	FMJ/PB/FeC	8,0	PS [5)]	10 + 0.5	720 ± 10
7[1)]	L	223 Rem.[2)]	FMJ/PB/SCP	4,0	MEN, SS 109	10 + 0.5	950 ± 10
		308 Win.	FMJ/PB/SC	9,55	MEN, DM 111	10 + 0.5	830 ± 10
8	L	7,62 x 39	FMJ/PB/HCI	7,7	BZ[5)]	10 + 0.5	740 ± 10
9	L	308 Win.[3)]	FMJ/PB/HC	9,6	FNB, P 80	10 + 0.5	820 ± 10
10	L	7,62 x 54 R	FMJ/PB/HCI	10,4	B32 [5)]	10 + 0.5	860 ± 10

The rates of twist can be gathered from the dimension sheets (TDCC) of the C.I.P.
Further types of ammunition are contained in the adjoining document AND#01.

Legend for the abbreviations used in table 1

FMJ	full metal jacket (steel)	C.I.P.	Permanent international commission for the testing of small arms
FMJ *)	full metal jacket (copper)	TDCC	Dimension sheets of the C.I.P.
CB	coned bullet	DAG	RUAG Ammotec, Germany
RN	round nose	Geco	RUAG Ammotec, Germany
PB	pointed bullet	MEN	Metallwerk Elisenhuette Nassau, Germany
FN	flat nose	Nammo	Nammo AS, Norway
L	full lead	FNB	FN Herstal, Belgium
SC	lead-soft core	Speer	Federal Cartridge Company, USA
FeC	mild-steel core	1)	In theses steps both calibres are to use.
SCP	lead-soft core steel penetrator	2)	twist rates 178 mm ± 5%
HC	hard core	3)	twist rates 254 mm ± 5%
WC	wolfram-carbide	4)	twist rates arbitrary
FMs	full brass	5)	test barrel with a transition of 7,5 mm
I	Incendiary	6)	arbitrary shot distance. Appropriate hits have to be ensured in terms of velocity, oscillation and impact point
		K	handgun
		L	rifle

The test steps 1 to 14 mentioned in table 1 are listed in increasing order according to their ballistic resistance. Test step 1 offers the lowest, step 14 the highest resistance against penetration. If a test specimen meets a particular level of resistance all underlying levels are also met.

In principle, the shooting distances according to table 1 should be adhered to. If necessary regarding the required speed, angle of attack and point of impact of the bullet, or there is another technical necessity, the shot distance can be adjusted.

The test is carried out exclusively with ammunition of the test level applied for.

5 Measuring and test equipment

5.1 Test set-up

The test set-up is shown in attachment 1. The shot distances are to be taken from table 1 paragraph 4.1. Additional and different requirements are described in the product specific test guidelines and/or standards.

5.2 Weapon system

It is necessary to ensure that the parameters defined in table 1 paragraph 4.1 are to be met with the used weapon and ammunition. The compliance to the defined demands (e.g. impact point, bullet velocities) can require the use of particular tools and barrels as well as specially loaded ammunition.

5.3 Accuracy of the measuring equipment

The determination of relevant measured quantities must comply to the following accuracies:

- Velocity - measuring system: ≤ 1 % of the measured value
- Thermometer: ± 0.5 °C
- Hygrometer: ± 3% relative humidity
- Length measuring equipment: ≤ 1% of the measured value.
- Protractor: ± 0.5°
- Scale: 1‰ of the measured value.

5.4 Fragment indicator

If no rules are laid down in the product specific guidelines, an aluminium foil with a thickness of 0.02 mm and an area-weight of 54 g/m² according to no. 7.1.3 of EN 1063 has to be used as the fragment indicator. It has to be fixed 500 mm ± 10 mm behind the test specimen so that an area of minimum 440 x 440 mm remains free.

5.5 Penetration indicator

If there no rules are laid down in the product specific guidelines, an aluminium sheet with a thickness of 0.5 mm (AlCuMg1, F 40) has to be used as the penetration indicator. It has to be fixed in a distance of 150 mm ± 5 mm behind the test specimen.

If the fragment indicator has to be used in connection with the penetration indicator, the penetration indicator has to be set at a distance of 150 mm ± 5 mm behind the fragment indicator.

6 Test procedures

6.1 General facts

If test procedures and parameters are not described here, they can be found in the productrelated test guidelines.

Before the shot test, the narrowest possible angle of attack at the point of impact must be ensured through suitable measures.

6.2 Test-relevant parameters

- Shot speed: according to table 1 under figure 4.1
- The shot speed, max. 2.5m in front of the point of impact, corresponds to the speed of impact. Measuring devices that can establish the actual impact speed are permissible.
- Temperature tolerance when conditioning: ± 3°C
- Relative humidity tolerance when conditioning: ± 5 %
- Point of impact and shot distance tolerance: ± 10 mm
- Angle of attack tolerance: ± 2°

6.3 Repetition of the test

If the results don't lead to an explicit assessment, the test may be repeated at an analogue point. This position mustn't be influenced by the previous hit.

If in individual cases the bullet speed is outside the range, the shot shall be repeated only in the following cases:

- if at a speed below the lower speed limit no penetration occurred
- if at a speed above the upper limit penetration occurred

6.4 Calculation of the ballistic limit V_{50}

6.4.1 Test procedures

The bullet velocity has to be determined as impact velocity according to paragraph 3.3.1.

The hits on the test specimen have to be chosen in a way that there are no prior damages of previous shots around the point of impact, which could influence the result.

If the damage of the test specimen is too severe because of too many hits, the test has to be continued using a further test specimen.

The tests have to be carried out with an angle of impact of 90 ± 2° (0° ± 2° NATO) as well as with the test arrangement according to attachment 1.

If plasticine is used as backing material, it has to be planed after every shot and drawn off with a blade, the clamped test specimen has to be planed as well.

The standards for the bullets, shooting distances and twist lengths must be applied according to table 1, paragraph 4.1.

If the bullet velocities can't be achieved with the determined test barrel for the test level, larger firing chambers with defined sizes (cone and length) can be used. Attention has to be paid to avoid as much as possible deformation of the bullets through the use of progressive powder.

6.4.2 Method VPAM-KNB

The advantage of the method VPAM-KNB is that every test proof firing can be analysed independently of the range of velocity and that in addition to V_{50} (mean value) an estimate for the standard deviation can be calculated. Thereby, it is assumed that the probability of penetration is a continuous, normal function of the impact velocity. Along with the V_{50} other safety levels (e.g. V_{95}) can be indicated.

As sampling always only includes a finite number of events, the probability function has to be replaced by the relative frequency. Relative frequencies of continuous random variables can, however, only be estimated if a classification of velocities in specific class ranges is carried out (e.g. 5 or 10 m/s). The change of the relative class frequency fk and the mid-value of class interval vk* of a specific class k results in:

$V_{50} = \sum v_k \cdot f_k$ mean value V_{50}

$s^2 = \sum (v_k - V_{50})^2 \cdot f_k$ standard deviation

$f_k = \Delta F_k = F_{k+1} - F_k$ change of the relative class frequency

$v_k = \frac{1}{2} \cdot (v^*_{k+1} + v^*_k)$ corresponding class velocity

From the results of a test firing, three areas can be identified (let FK be the relative penetration):

- *Area 1*: only stopped shots (Fk = 0)
- *Area 2:* penetrations as well as stopped shots (0 ≤ Fk ≤ 1)
- *Area 3:* only penetrations (Fk = 1).

In order to get a correct analysis, the following conditions have to be fulfilled:

- The minimal number of shots should be 16 (better 20 to 30)
- Every area must include at least 2 shots.

  This means that the shot with the lowest velocity may not be a penetration and the shot with the highest velocity must be a penetration. This condition is connected to the elementary form of the function of penetration probability, which tends to 0 for low values and to 1 for high values.

  If the central section is empty no determination of the variance is possible, because in this case s = 0.
- Between two neighbouring partitions there can't be more than one empty class of velocity.

The use of the above given formulas results systematically in a standard deviation for low shot numbers (< 100) which is too small; therefore a correction depending on the number of shots is necessary:

$$s_{corr} = s \cdot \left[1.71 - 0.151 \cdot \ln(n)\right]$$

Where n refers to the number of shots and ln to the natural logarithm. A form for the calculation of V_{50} and of the standard deviation s_{corr} can be found in attachment 2. The results (penetration "DS" or non-penetration "KD") have to be registered in the corresponding columns.

The analysis is done according to the above formulas.

Other safety levels than 50% can also be determined. This is done with the following relation (k_p according to table 2):

$$v_p = V_{50} + k_p \cdot s_{corr}$$

table 2: coefficients for safety levels

p [%]	k_p
75	0.674
90	1.282
95	1.645
99	2.326
99.5	2.576
99.9	

6.5 Statistical risk analysis

If for a ballistic protection the average penetration velocity (V_{50}) and the corresponding standard deviation s according to point 6.4.3 is determined, risk analysis can be carried out via statistical methods.

6.5.1 Determination of critical velocity for a given penetration probability

At a given penetration probability p the corresponding critical velocity v_p of the ballistic protection is calculated with the following relation. This enables the direct comparison of this critical velocity to the maximum combat velocity given by the user:

$$v_p = V_{50} + \alpha_p \cdot s_{corr} \quad \text{[m/s]}$$

Values for the number α_p are compiled in table 3, according to the penetration probability. They originate from the standardised normal distribution.

table 3: Numbers for the calculation of the critical velocity at a given penetration probability

p	10^{-6}	10^{-5}	10^{-4}	10^{-3}	0.01	0.02	0.05	0.1
α_p	-4.753	-4.265	-3.719	-3.090	-2.326	-2.054	-1.645	-1.282

Example:

V_{50} = 465 m/s

S_{corr} = 12.5 m/s

The formula $v_p = v_{50} + \alpha_p \cdot s_{corr}$ provides as critical velocity for the penetration probability p = 10^{-3} (1 penetration per 1000 shots):

$v_p = 465 - 3.090 \cdot 12.5 = 426.4$ m/s

6.5.2 Determination of the penetration probability at given impact velocity

Determination of the penetration probability p_v at a given maximum impact velocity v_p enables to estimate the remaining risk.
At known V_{50} and known standard deviation s_{corr} the penetration probability at the impact velocity v_p can be calculated as follows:

Determination of α_p with:

$$\alpha_p = \frac{v_p - V_{50}}{s_{korr}} \qquad [-]$$

Having α_p the probability p_v can be calculated according to the following formula:

$$p_v = P(\alpha_p) = \frac{1}{\sqrt{2 \cdot \pi}} \int_{\infty}^{\alpha_p} e^{-\frac{x^2}{2}} \, dx \qquad [-]$$

or with the following table:

Table 4: Penetration probability $p_v = P(v_p)$ as a function of α_p

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
-5	2.87e-07	1.70e-07	9.98e-08	5.80e-08	3.34e-08	1.90e-08	1.07e-08	6.01e-09	3.33e-09	1.82e-09
-4	3.17e-05	2.07e-05	1.34e-05	8.55e-06	5.42e-06	3.40e-06	2.11e-06	1.30e-06	7.94e-07	4.80e-07
-3	1.35e-03	9.68e-04	6.87e-04	4.83e-04	3.37e-04	2.33e-04	1.59e-04	1.08e-04	7.24e-05	4.81e-05
-2	2.28e-02	1.79e-02	1.39e-02	1.07e-02	8.20e-03	6.21e-03	4.66e-03	3.47e-03	2.56e-03	1.87e-03
-1	1.59e-01	1.36e-01	1.15e-01	9.68e-02	8.08e-02	6.68e-02	5.48e-02	4.46e-02	3.59e-02	2.87e-02
-0	5.00e-01	4.60e-01	4.21e-01	3.82e-01	3.45e-01	3.09e-01	2.74e-01	2.42e-01	2.12e-01	1.84e-01
0	5.00e-01	5.40e-01	5.79e-01	6.18e-01	6.55e-01	6.91e-01	7.26e-01	7.58e-01	7.88e-01	8.16e-01
1	8.41e-01	8.64e-01	8.85e-01	9.03e-01	9.19e-01	9.33e-01	9.45e-01	9.55e-01	9.64e-01	9.71e-01
2	9.77e-01	9.82e-01	9.86e-01	9.89e-01	9.92e-01	9.94e-01	9.95e-01	9.97e-01	9.97e-01	9.98e-01
3	9.99e-01	9.99e-01	9.99e-01	1.00e+00	1.00e+00	1.00e+00	1.00e+00	1.00e+00	1.00e+00	1.00e+00

Example:

V_{50} = 465 m/s

s_{korr} = 12.5 m/s

The formula $\alpha_p = \frac{v_p - v_{50}}{s_{korr}}$ provides for an impact velocity 420 m/s:

α_p = - 3.6

According to table 4 the penetration probability at 420 m/s is:

1.59×10^{-4}

One has to expect an average of about 1.6 penetrations per 10.000 shots.

6.6 Reference materials (Residual energy measurement)

For the determination of the remaining energy transferred to the body behind a ballistic protection in case of a non-penetration, plastically malleable materials (plasticine), in which the volume of the indentation formed at the impact is proportional to the transmitted energy, are used.

The residual energy behind a ballistic protection can be approximated by the determination of that volume. The proportionality factor between volume and energy is determined simultaneously with the determination of the plasticity of the plasticine by the ball drop method.

Procedure

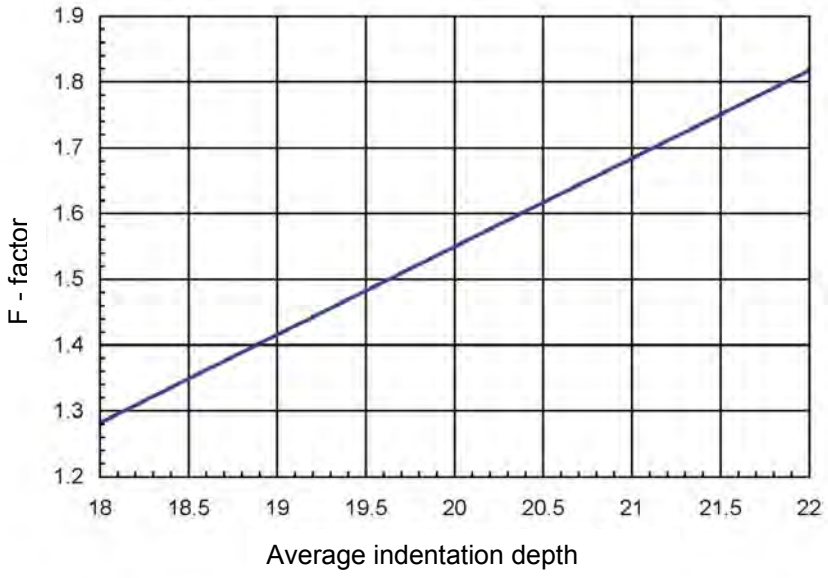
For the calibration of the plasticine, the indentation depths of five falling weight tests are averaged. With this average value d_m, which amounts 20 ± 2 mm, the maximum permitted volume V_{zul} of the indentation can be determined with the help of the following formula:

$$V_{zul} = F \cdot E_{zul} = (0.134 \cdot d_m - 1.13) \cdot E_{zul} \qquad (d_m \text{ in mm}) \qquad [cm^3]$$

Example: If 70 J apply for the permitted energy transferred to the body and an average indentation depth of 20.5 mm was measured in terms of the plasticity measurement, the maximum permitted volume of the formed indentation behind the ballistic protection is as follows (rounding up to the next cm^3):

$$V_{zul} = (0.134 \cdot 20.5 - 1.13) \cdot 70 = 1.62 \cdot 70 = 113.4 \text{ cm}^3$$

Instead of the formula the following graphic chart can also be used for the determination of the factor F:



After the impact the beads arisen around the dent have to be removed flatly. Thereupon the dent is filled with water, the filled volume measured and compared with the permitted value determined above.

7 Evaluation and documentation of the test

7.1 Evaluation of the test

A test according to a product-related guideline is evaluated as successfully if the requirements according to a test level of figure 4.1 or stated in the adjoining document Munition Types for Special Ammunition VPAM AND #01.

The bullet resistance test is considered failed if there is penetration according to the definition in the product-related guideline.

Depending on the established result, the following definitions and/or the following abbreviations are to be used in the test report:

oM	=	Without marks
BmRmL	=	Bulge with crack letting the light through (Penetration, if splinter in the plasticine)
BmRoL	=	Bulge with crack not letting the light through (no penetration)
BoR	=	Bulge without crack (no penetration)
Ds	=	Penetration
Ss	=	Bullet stopped inside specimen
Apr	=	Ricochet
GaO	=	Bullet left specimen on the impact side
GaS	=	Bullet left specimen at the side
NS	=	No-Splinters
S	=	Splinter
KP	=	No Penetration

Further abbreviations are permissible, to be described in the test report.

7.2 Test report

The test and the test result must be documented in the test report. This report must at least include the following details and statements:

General specifications:

- Name and address of the test institute
- Name and address of the client
- Name and address of the manufacturer
- Number and date of the test report
- Name and signature of the person responsible for the test
- Date of the test
- Specification of test conditions including permissible deviations
- Specification of ambient temperature and relative air humidity
- Specification of storage temperature and relative air humidity

- Notification of individual test results
- Notification of special observations and findings during the testing
- Notification that the test results refer exclusively to the test sample
- Notification of any compiled test certificate and test result
- Notification that the test report may not be copied nor extracts thereof without the permission of the test institute
- Additional measurements, examinations, derived results, tables, graphs, sketches and/or photos if available

Sample specifications

- Brand name and/or type reference of the test sample
- Test sample structure, size and number, as well as further relevant specifications
- Specifications regarding the material or a clear labelling that enables tracing of the used materials and the manufacturing/processing procedure.

7.3 Test certificate

In case of a positive test result according to Table 1 (figure 4,1) or AND'01, a test certificate is issued. Only members of VPAM are entitled to issue a test certificate according to this guideline. The test document must document the classification according to the product-related guideline and other requirements beyond the guideline. In case of a failed test, no test certificate is issued. If the test is carried out with a type of ammunition stated in the adjoining document AND#01, a test certificate without class attribution is issued. In this case, the test certificate must contain in addition the calibre, type of ammunition, bullet weight, manufacturer, type and the bullet speed. The test certificate must indicate that it only applies to the tested sample. It contains at least the following specifications:

- Name and address of testing institute
- Name and address of the client
- Name and address of the manufacturer
- Brand name and/or type reference of the test sample
- Specification of test requirements
- Classification according to table 1 (figure 4.1) and specification of type of ammunition according to adjoining document AND #01.
- Number of test certificate
- Date of test certificate
- Number of test report
- Name and signature of the person responsible for issuing the test certificate
- Date of the test
- Notifications that the test certificate or extracts thereof may not be copied without the permission of the test institute.

7.4 Validity of test certificate

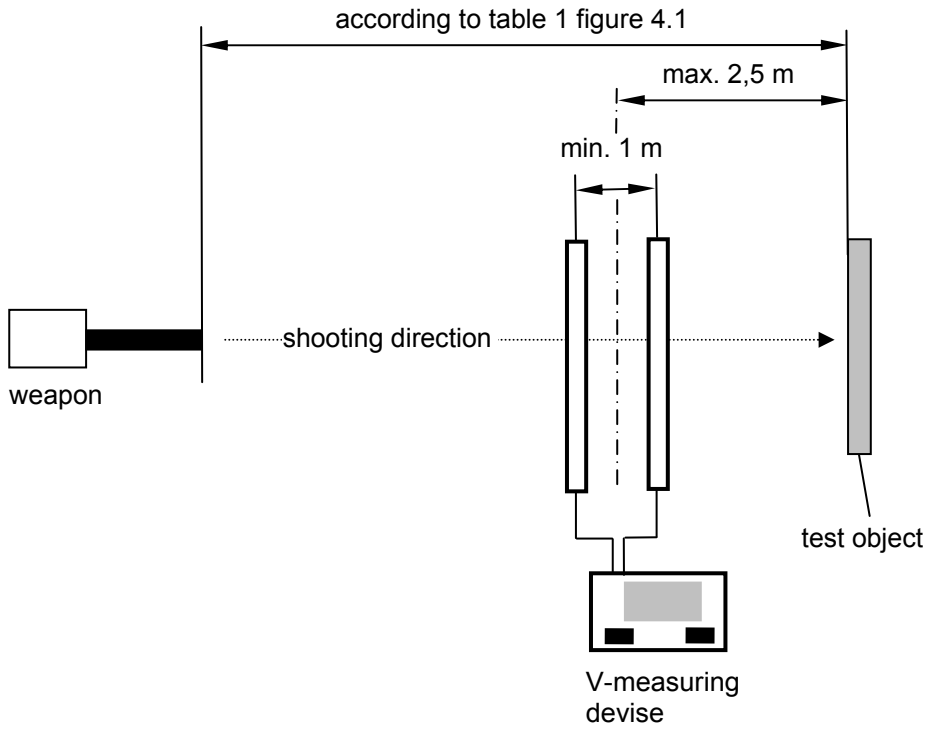
The test certificate is only valid if the following manufactured products conform to the teste sample.

The validity of the test certificate expires if changes or modifications are made to the manufacturing process of the materials or the quality management system which can lead to influencing of product conformity.

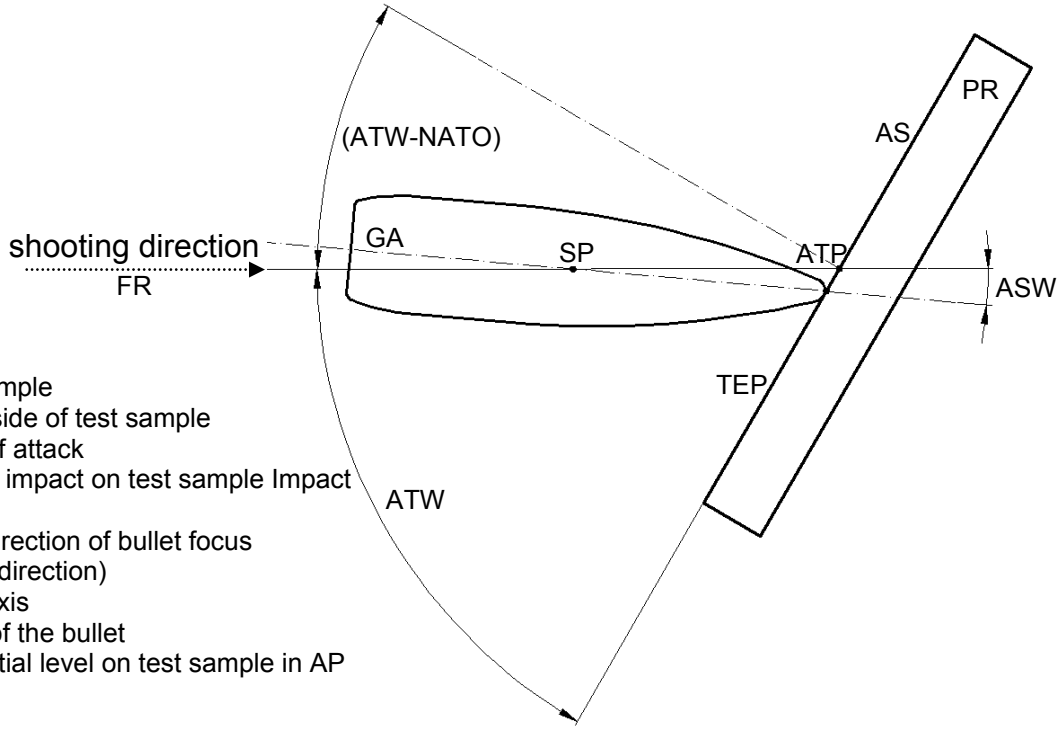
7.5 Traceability of the results

The client must ensure the traceability of the test results themselves.

Attachment 1: Test set-up



Attachment 2: sketch “angle definition”



PR	Test sample
AS	Attack side of test sample
ASW	Angle of attack
ATP	Point of impact on test sample Impact
ATW	angle
FR	Flight direction of bullet focus (= shot direction)
GA	Bullet axis
SP	Focus of the bullet
TEP	Tangential level on test sample in AP

Attachment 3: Form for the determination of V_{50} and standard deviation s

Penetration velocity of protective materials

Determination of average value and standard deviation

Test object: Date:

Test threshold: 0,01%
Class limit: 450 m/s
Class width: 5 m/s

V_u [m/s]	V_o [m/s]	KD	DS	F_k	$f_k = \Delta F_k$	V_k [m/s]	V_{50} [m/s]	S [m/s]
450	455	0	0	0,00	0,00	0,0	0,0	0,00
455	460	0	0	0,00	0,00	0,0	0,0	0,00
460	465	0	0	0,00	0,00	0,0	0,0	0,00
465	470	0	0	0,00	0,00	0,0	0,0	0,00
470	475	0	0	0,00	0,00	0,0	0,0	0,00
475	480	0	0	0,00	0,00	0,0	0,0	0,00
480	485	0	0	0,00	0,00	0,0	0,0	0,00
485	490	0	0	0,00	0,00	0,0	0,0	0,00
490	495	0	0	0,00	0,00	0,0	0,0	0,00
495	500	0	0	0,00	0,00	0,0	0,0	0,00
500	505	0	0	0,00	0,00	0,0	0,0	0,00
505	510	0	0	0,00	0,00	0,0	0,0	0,00
510	515	0	0	0,00	0,00	0,0	0,0	0,00
515	520	0	0	0,00	0,00	0,0	0,0	0,00
520	525	0	0	0,00	0,00	0,0	0,0	0,00
525	530	0	0	0,00	0,00	0,0	0,0	0,00
530	535	0	0	0,00	0,00	0,0	0,0	0,00
535	540	0	0	0,00	0,00	0,0	0,0	0,00
540	545	0	0	0,00	0,00	0,0	0,0	0,00
545	550	0	0	0,00	0,00	0,0	0,0	0,00
550	555	0	0	0,00	0,00	0,0	0,0	0,00
555	560	0	0	0,00	0,00	0,0	0,0	0,00
560	565	0	0	0,00	0,00	0,0	0,0	0,00
565	570	0	0	0,00	0,00	0,0	0,0	0,00
570	575	0	0	0,00	0,00	0,0	0,0	0,00
575	580	0	0	0,00	0,00	0,0	0,0	0,00
580	585	0	0	0,00	0,00	0,0	0,0	0,00
585	590	0	0	0,00	0,00	0,0	0,0	0,00
590	595	0	0	0,00	0,00	0,0	0,0	0,00
595	600	0	0	0,00	0,00	0,0	0,0	0,00
	Total	0	0				0,0	0,00

Average penetration velocity (v_{50}) : 0,0 m/s

Standard deviation (s_{korr}) : 0,0 m/s

0.0100% - critical velocity : 0,0 m/s

Penetration probability between 0 0 m/s 0,0E+00