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)

Foreword

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

Reference source of VPAM - APR 2006:

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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.

- **EN 10204**, metallic products – types of test certificates
- **EN 1063**, glass in construction engineering – special safety glazing – test methods and classification for the resistance against proof firing
- **STANAG 2920**, ballistic test method for personal armour materials and combat clothing
- **STANAG 4569**, protection levels for occupants of logistic and light armoured vehicles
- **VPAM guidelines**
- **TDCC**, dimension sheet of the permanent international commission for the test of small arms (C.I.P.)

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

3 Terms

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

3.1 General terms

3.1.1 Bullet/ballistic resistance

The resistance a material or a construction offers against the penetration of a projectile under defined conditions.

A material or a construction is bullet-resistant if it offers a defined resistance against attacks with specific types of arms and munitions.

3.1.2 Test level

Name for the classification of a resistance against a defined attack potential

3.1.3 Classification

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

3.1.4 Model name/identifier or model number

A unique name or code which is only assigned once and which identifies the model, the type and the materials used of a tested product.

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.

3.2.2 Sample

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

3.2.3 Test specimen

An item provided for testing which is implemented according to the test guidelines.

Note: model, type and materials used of the samples must coincide with the information provided by the manufacturers or the clients and must be representative for the product. The test specimen should be accompanied by inspection certificates (e.g. batch number) or a precise description of its structure (in particular the material composition) and the manufacturing process.

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 Impact point

A fixed point on the test specimen which should be striked by the projectile. It will be marked in the appropriate place prior to firing.

3.3.3 Impact angle

The angle between the direction of the projectile and the line which is perpendicular (90° equals 0° NATO) to the tangent plane to the impact point on the impact side of the test specimen.

3.3.4 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.

3.3.5 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.

3.3.6 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.

3.3.7 Backing material

Depending on the product specific requirements it is arranged behind a test specimen for the test duration. The material shows the deformation of the backside of the test specimen due to the projectile.

3.3.8 Indentation diameter

The greatest diameter of the indentation in the backing material after the projectile striked the test specimen.

3.3.9 Indentation depth

The greatest depth of the indentation in the backing material after the projectile striked the test specimen. The depth is measured in relation to the original surface of the backing material which is shown in the area of the surrounding non-affected materials.

3.3.10 Shot distance

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

3.3.11 Hit distance

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

3.3.12 Hit distance to the edge

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

3.4 Terms for bullets

3.4.1 Solid bullets

Solid bullets consist of a homogeneous material such as lead, brass or tombac without a jacket.

3.4.1.1 L/RN = Lead / Round Nose

3.4.1.2 FMs/CB = Full Ms / Coned Bullet

3.4.2 Soft core bullets

Soft core ***bullets*** consist of a deformable core such as a lead or Fe-core and a jacket.

3.4.2.1 FMJ/RN/SC = Full Metal Jacket / Round Nose / Soft Core

3.4.2.2 FMJ/PB/SC = Full Metal Jacket / Pointed Bullet / Soft Core

3.4.2.3 FMJ/CB/SC = Full Metal Jacket / Coned Bullet / Soft Core

3.4.2.4 FMJ/FN/SC = Full Metal Jacket / Flat Nose / Soft Core

3.4.2.5 FMJ/FeC = Full Metal Jacket / Fe-Core (non hardened)

3.4.2.6 FMJ/SCP = Full Metal Jacket / Soft Core Penetrator

3.4.3 Full Metal Jacket/Hard core

Full Metal Jacket/Hard Core consists of a non deformable core or core component and a jacket.
Note: These bullets are also known as Armour Piercing (AP)

3.4.3.1 FMJ/HC = Full Metal Jacket / Hard Core (steel core)

3.4.3.2 FMJ/PB/HCI = Full Metal Jacket / Pointed Bullet / Hard Core / Incendiary

3.4.3.3 FMJ/WC = Full Metal Jacket with tungsten carbide core

4 Test conditions

4.1 Tests with standardized 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 ± 0,1	Winchester	10 + 0.5	360 ± 10
2	K	9 mm Luger[5)]	FMJ/RN/SC, tinned	8,0 ± 0,1	DAG, DM 41	5 + 0.5	360 ± 10
3	K	9 mm Luger[5)]	FMJ/RN/SC, tinned	8,0 ± 0,1	DAG, DM 41	5 + 0.5	415 ± 10
4[1)]	K	357 Magnum	FMJ/CB/SC	10,2 ± 0,1	Geco	5 + 0.5	430 ± 10
		44 Rem. Mag.	FMJ[*)]/FN/SC	15,6 ± 0,1	Speer	5 + 0.5	440 ± 10
5	K	357 Magnum	FMs/CB	7,1 ± 0,1	DAG special	5 + 0.5	580 ± 10
6	L	7,62 x 39	FMJ/PB/FeC	8,0 ± 0,1 core 3,6	PS cold hardened	10 + 0.5	720 ± 10
7[1)]	L	223 Rem.[2)]	FMJ/PB/SCP	4,0 ± 0,1	MEN, SS 109	10 + 0.5	950 ± 10
		308 Win.	FMJ/PB/SC	9,55 ± 0,1	MEN, DM 111	10 + 0.5	830 ± 10
8	L	7,62 x 39	FMJ/PB/HCI	7,7 ± 0,1 core 4,1 hardness 65 HRC	BZ	10 + 0.5	740 ± 10
9	L	308 Win.[3)]	FMJ/PB/HC	9,70 ± 0,2 core 4,0 ± 0,1 hardness 62 ± 2 HRC	MEN/CBC, FNB, P 80	10 + 0.5	820 ± 10
10	L	7,62 x 54 R	FMJ/PB/HCI	10,4 ± 0,1 core 5,3 hardness 63 HRC	B32	10 + 0.5	860 ± 10
11	L	308 Win. [3)]	FMJ/PB/WC	8,4 ± 0,1 core 5,9	Nammo, AP 8	10 + 0.5	930 ± 10
12	L	308 Win.[3)]	FMJ/PB/WC	12,7 ± 0,1 core 5,58 hardness 1330 HV 10	SWISS P AP	10 + 0.5	810 ± 10
13	L	50 Browning	FMJ/PB/HC	43,0 ± 0,5 core 35,0 hardness 55 ± 2 HRC	SWISS P penetrator	[6)]	930 ± 20
14	L	14,5 x 114[4)]	FMJ/PB/HCI	63,4 ± 0,5	B32	[6)]	911 ± 20
The rates of twist can be gathered from the dimension sheets (TDCC) of the C.I.P.							

Legend for the abbreviations used in table 1

FMJ	full metal jacket (steel)
FMJ *)	full metal jacket (copper)
CB	coned bullet
RN	round nose
PB	pointed bullet
FN	flat nose
L	full lead
SC	lead-soft core
FeC	mild-steel core
SCP	lead-soft core steel penetrator
HC	hard core
WC	wolfram-carbide
FMs	full brass
I	Incendiary

C.I.P.	Permanent international commission for the testing of small arms
TDCC	Dimension sheets of the C.I.P.
DAG	RUAG Ammotec, Germany
Geco	RUAG Ammotec, Germany
MEN	Metallwerk Elisenhuette Nassau, Germany
Nammo	Nammo AS, Norway
FNB	FN Herstal, Belgium
Speer	Federal Cartridge Company, USA
1)	In theses steps both calibres are to use.
2)	twist rates 178 mm ± 5%
3)	twist rates 254 mm ± 5%
4)	twist rates arbitrary
5)	test barrel with a transition of 7,5 mm
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.

For constructions and vehicles to be tested with a hard core or mild-steel core ammunition, splits, joints and overlaps will be additionally tested with soft core ammuniton.

Step 6 and 8 are to be additionally tested with projectile FMJ/PB/SC calibre 7,62 x 39.

Step 9 is to be additionally tested with the projectile in test step 7 calibre 308 Win.

Step 10 is to be additionally tested with projectile type D (FMJ/PB/SC), 11,8 ± 0,1 g, v_0: 810 ± 10 m/s calibre 7,62 x 54R.

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 %
- Thermometer: ± 0.5 °C
- Hygrometer: ± 1% 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.

5.6 Backing material

The backing material - if existent - is described in the respective product specific guidelines.

6 Test procedures

6.1 General facts

If the test procedures and parameters are not defined here refer to the product specific test guidelines.

6.2 Test relevant parameters

- Impact velocity: according to table 1, no 4.1
- The ballistic velocity 2.5 m in front of the point of impact corresponds to the velocity of impact. Measuring systems which are capable of determining the factual velocity of impact are permitted.
- Ambient temperature: +20 ± 3 °C
- Relative humidity: 65 ± 10 %
- Test specimen temperature: +20 ± 3°C
- Tolerance of location of point of impact and hit distances: ± 10 mm
- Shot distance: 5 + 0.5 m alternatively 10 + 0.5 m
- Angle of impact: 90° (0° NATO) and, if indicated, other angles defined in the product specific guidelines
- Configuration and size of specimen as well as construction and manufacturing methods.
- Material specifications have to be submitted by the applicant and, if required in the product specific guidelines, also demonstrated; e.g. with steels corresponding to the melt analysis according EN 10204 - 3.1B as well as the corresponding identification

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 STANAG 2920 Method

If the STANAG 2920 method is requested for the determination of $V_{50,}$ the latest issue of this standard has to be used.

This method however is not able to determine a variance for the determination of any penetration probabilities.

6.4.3 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 f_k and the mid-value of class interval v_k^* 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 F_K be the relative penetration):

- *Area 1*: only stopped shots ($F_k = 0$)
- *Area 2*: penetrations as well as stopped shots ($0 \le F_k \le 1$)
- *Area 3*: only penetrations ($F_k = 1$).

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:

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

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

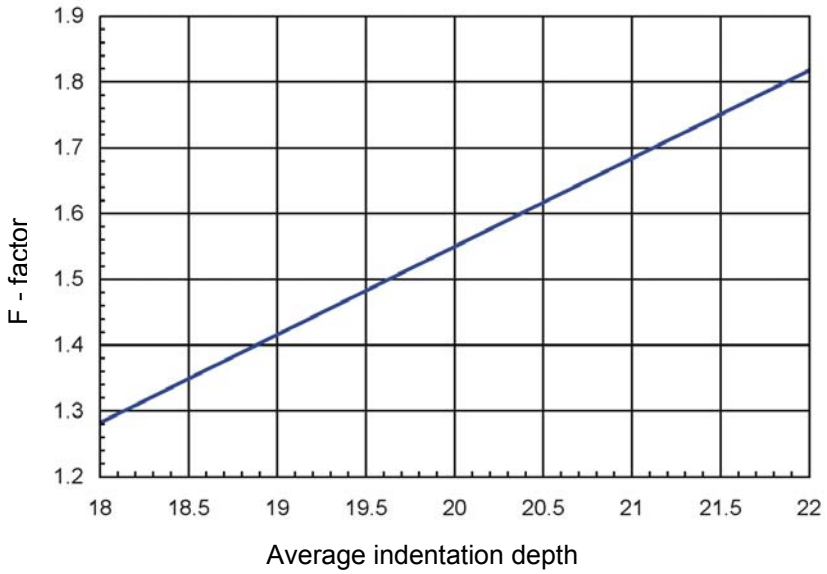
For the calibration of the plasticine, the indentation depths of five falling weight tests are averaged. With this average value d_m, which amounts 20 ± 2 mm, the maximum permitted volume V_{zul} of the indentation can be determined with the help of the following formula:

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

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 this guideline is considered as successful if the requirements of paragraph 4.1 are fullfilled.

The test of the ballistic resistance is considered as failed if there is a penetration in accordance with definition paragraph 3.3.5.

Depending on the recorded result, the following definitions and/or the following abbreviations have 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

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:

- Name and address of the test centre
- Name and address of the submitter
- Manufacturer and place of manufacture of the test specimen
- Brand name and/or type designation of the test specimen
- Number and date of the test report
- Date of test specimen receipt
- Test date
- Construction, -size and –number of test specimen as well as further relevant details (e.g. weight per unit area, thickness of test specimen)
- Details of the material, processing and batch number
- Details of the test requirements
- Details of the test specifications

- Deviations and restrictions as compared to the test requirements/test specifications
- Details about measuring inaccuracies (if required) as well as detected faults
- Measurements, analyses, derived results, tables, graphics, outlines and/or pictures
- Detection about penetration and/or other damages
- Remarks about special observations and detections during the test
- Statement that the test results refer exclusively to the test specimen
- Remarks about an eventually issued test certificate respectively test report
- Statement, that without approval of the test centre extracts of the test report in extracts may not be duplicated
- Name and signature of the responsible test officer

7.3 Test certificate/test confirmation

If the result of the test is positive, then a test certificate is issued. Only the members of the VPAM are entitled to issue a test certificate according to this guideline.

In the test certificate the test steps according to this guideline and requirements which are other and going beyond the guideline must be documented. If the test was not passed, then no test certificate is issued. The customer receives a test report.

If the required test according to the customer´s needs is carried out with a type of ammunition that is not classified according to table 1 (paragraph 4.1) of this guideline, he receives, provided that the test is positive, a test report and a written confirmation.
From the test certificate/written confirmation it must be recognizable that it only applies to the tested sample. It includes at least the following details.

- Name and address of the test centre
- Name and address of the customer
- Manufacturer and place of manufacture of the test specimen
- Object and model number of the test specimen
- Details of the test requirements
- Classification according to table 1 (paragraph 4.1)
- Number and publication of the test certificate/written confirmation
- Number of the test report
- Date and place of the test
- Details about validity and distribution of the test certificate/written confirmation

7.4 Validity test certificate/test confirmation

The test certificate/test confirmation is only valid as far as products manufactured consecutively are identical with the tested sample.

The validity expires, if

- changes or modifications of the production process, the materials or the quality management system, which can lead to an influence of the product conformity, are made or
- a following test yields a negative result.

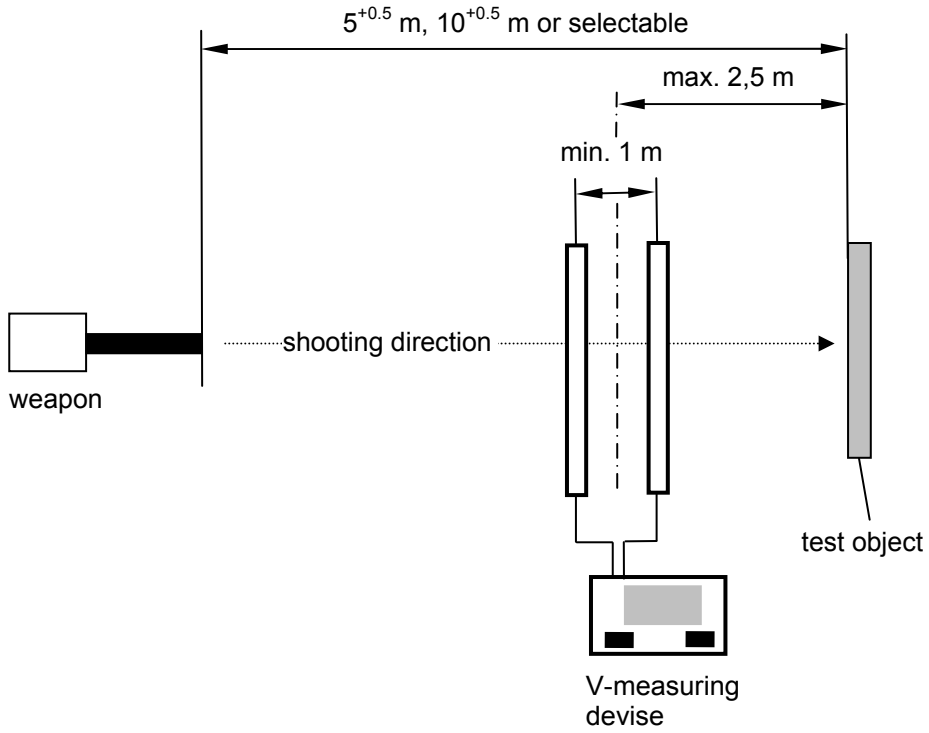
7.5 Traceability of the results

The customer has to ensure the storage of the test samples to establish of the traceability of the test results.

7.6 Details on material and material processing

Details on material, construction, manufacturing method and the melt analysis for metals in accordance with EN 10204 have to be deposited at the testing institute.

Attachment 1: Test set-up



Attachment 2: 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