

TEST GUIDELINE

“Specially protected vehicles”

Bullet resistance

VPAM-BRV

Edition 3

Version: Mar 15, 2021

Englische Übersetzung, es gilt immer die deutsche Originalfassung!
English translation, however the original German edition always prevails!

Editor:

VPAM – Vereinigung der Prüfstellen für Angriffshemmende Materialien
und Konstruktionen
(Association of Test Laboratories for Attack Resistant Materials and
Constructions)

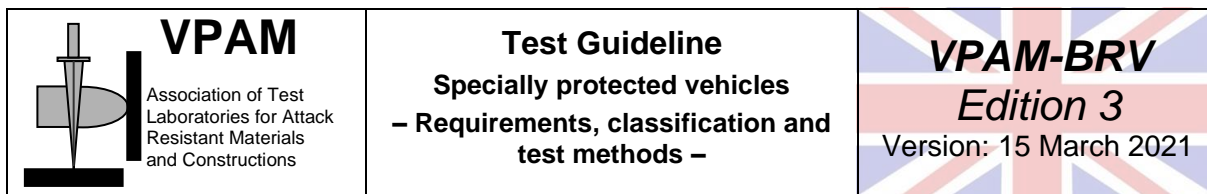
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Change Record

(When the edition changes, an amendments record is not maintained, the previous editions are, however, available at www.vpam.eu (guidelines archive)).

Amendments		Changes were implemented in the following paragraphs
No.	Date	
1	Mar 15, 2021	Adaptation to the new VPAM-APR Edition 3. “VPAM-BRV2009” becomes “VPAM-BRV”.
2	Mar 15, 2021	Section 1, Scope, last passage, addition of “with more than 48 V”. Resulting further adaptation in paragraph 4.2.4.2, Energy storage devices, “up to 48 V”.
3	Mar 15, 2021	Paragraph 3.5, the term “transitional areas” is replaced by “transparent materials”, resulting adaptation in paragraph 3.7. Insertion of paragraph 3.6, which changes the numbering up to paragraph 3.8. Paragraphs 6.2.2 and 6.2.3, adaptation of terms.
4	Mar 15, 2021	Insertion of paragraphs 3.9 and 3.10.
5	Mar 15, 2021	Addition of “upon request” in paragraph 4.2.3, passage 3.
6	Mar 15, 2021	Addition of “in accordance with VPAM-PM” in paragraph 6.2.3, passage 2.
7	Mar 15, 2021	Paragraph 6.3, change to the text.
8	Mar 15, 2021	Paragraph 6.4.3, change to the text and deletion of passage 5.

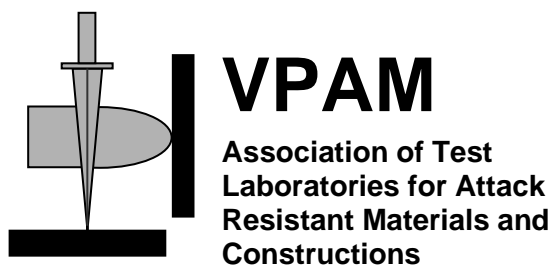


Foreword

This guideline was prepared by the Association of Test Laboratories for Attack Resistant Materials and Constructions (VPAM).

The latest edition of the binding guideline and further decisions are available at:
www.vpam.eu

VPAM-BRV may be obtained from:



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Introduction

This test guideline for specially protected vehicles describes the procedure that serves on the one hand to obtain reproducible results by standardizing tests and test expenditures. On the other hand, it provides bigger market transparency by allowing customers and users of these vehicles to objectively compare products from different manufacturers tested according to the same guidelines.

Explosive resistance requirements are defined in the VPAM-ERV test guideline.

1 Scope

This test guideline defines the product-specific requirements, classification and test methods for ballistic vehicles (BRV). Ballistic vehicles are intended to protect people and assets against impacts of bullets fired from small arms and rifles.

Specially protected vehicles must prevent penetration by bullets from all angles of attack.

Specially protected vehicles of the classes listed in paragraph 4.1 of this guideline shall be tested in the following areas:

- Side sections, including sills, A-/B-/C-/(/D-) pillars, and doors including glazed areas
- Front with windshield
- Rear end with rear window
- Roof area
- Floor area (upon request)

Bullet resistance testing of “specially protected vehicles” is carried out without taking interactions with active or passive protection systems, special equipment and energy storage devices with more than 48 V into account. This is why further hazards that may be posed by the above-mentioned systems to the vehicle occupants cannot be assessed.

Restrictive test conditions are described in paragraph 4.2.3.

2 Applicable documents

Specifications taken from the following documents are incorporated in this guideline by reference. Dated references do not cover later amendments or revisions to these publications. We recommend that contracting parties applying this guideline consider using the latest edition of these documents.

For undated references, the latest edition of the document referred to applies. Legal provisions shall always be applied as amended.

- VPAM decisions

- VPAM-APR “Allgemeine Prüfgrundlagen für ballistische Material-, Konstruktions- und Produktprüfungen“ (General basics for ballistic testing of materials, constructions and products)
- VPAM AND-SoM “Munitionsarten für Sonderprüfungen” (Ammunition Types for Special Tests)
- VPAM-PM “Durchschusshemmende plattenartige Materialien” (Bullet resistant plate materials)

3 Definitions

Basic definitions are laid down in VPAM-APR. The following definitions also apply to this guideline:

3.1 Specially protected vehicles

Specially protected vehicles are vehicles offering protection from attacks with firearms.

3.2 Angle of attack

The angle of attack is either the angle between the bullet line of flight and the surface area on which the vehicle stands (inclination of weapon from 0° to 90°) or the angle between the bullet line of flight and the vehicle direction (position of vehicle from 0° to 360°), see Annex 1.

3.3 Triangular impact (standard)

Triangular impact refers to three hits whose hit pattern forms an equilateral triangle in accordance with Annex 2.

3.4 Multi-hit impact (MH)

Multi-hit impact refers to three hits whose hit pattern forms an equilateral triangle in accordance with Annex 2.

3.5 Transparent materials (areas)

Transparent materials are glazing with a material structure that corresponds to the structure of the pre-certified type of glass. All glass areas whose individual layers no longer correspond to the pre-certified structure due to their design are considered as non-transparent materials.

3.6 Non-transparent materials (areas)

Non-transparent materials are all other materials (areas) that do not fit the description in paragraph 3.5.

3.7 Roof area

If a ballistic attack on the roof is requested to be performed at a limited angle of attack of 45° or 30°, respectively, the areas between roof and front window or roof and rear window are considered part of the roof area.

3.8 Floor area

The floor area is usually the underbody with armor on the inside and/or underbody armor.

3.9 Gap

A gap is an interstice or space for tolerance (e.g. door gap, overlaps, joints and similar body openings).

3.10 Glass in mounting position

For the classes VR8, VR9 and VR10, the transparent areas may be tested, upon request, in their mounting position with an angle of attack parallel to the surface area on which the vehicle stands. In this case, the glass area to be tested is restricted to the transparent materials defined in paragraph 3.5.

4 Division into classes, test conditions and classification

4.1 Division into classes

Bullet resistant vehicles in accordance with VPAM-BRV are divided into the classes specified in the following chart.

Chart 1: Division into classes

Test level according to VPAM-APR	Test class according to VPAM-BRV
1	VR1
2	VR2
3	VR3
4	VR4
5	VR5
6	VR6
7	VR7
8	VR8
9	VR9
10	VR10

4.2 Test conditions

4.2.1 General test conditions

Bullet resistant vehicles are to be tested with all angles of attack. This does not apply to the floor area. Upon request, testing of the floor area can be extended.

Only materials that have previously been tested in accordance with paragraph 6.2 shall be used as protective components in vehicles. The respective tests must have been conducted in compliance with the current requirements. The certificates must have been issued by a member of the VPAM test laboratories.

The test specimen presented for testing must be provided with all constructional elements showing the ballistic characteristics of a “specially protected vehicle”.

Testing with types of ammunition other than those mentioned in VPAM-APR shall be carried out with the ammunition types stated in the subsequent guideline AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests). In this case, no classes are assigned.

4.2.2 Additional testing

For the following test levels to be tested with armor-piercing or iron core ammunition, the gaps shall additionally be tested with the following soft-core ammunition.

Test level	Bullet				Test velocity [m/s]
	Caliber [mm]	Type	Nominal mass [g]	Manufacturer/Type	
VR6	7.62 x 39	FMJ/PB/SC*	8.0	-	720 ±10
VR8 VR9	7.62 x 51	FMJ/PB/SC (VR7)	9.55	VPAM-APR test level 7	830 ±10
VR10	7.62 x 54 R	FMJ/PB/SC*	11.8	-	810 ±10

* steel casing

4.2.3 Restrictive test conditions (optional)

The restrictive test conditions described in the following shall be indicated clearly in the test report and test certificate.

In the roof area, the upper limit of the angle of attack for the defined classes may be reduced to 45° or 30°. Depending on the request and the weak point analysis, it is possible to test all angles from 0° to 45° or from 0° to 30°, respectively. Door gaps are not subject to the restrictions of the angle of attack.

For the classes VR8, VR9 and VR10, the transparent areas may be tested, upon request, in their mounting position with an angle of attack parallel to the surface area on which the vehicle stands.

4.2.4 Extended test conditions (optional)

4.2.4.1 Floor area

Ballistic testing of the floor area is performed upon request only.

4.2.4.2 Energy storage devices

Ballistic testing of energy storage devices (up to 48 V), which are installed in the vehicle and have an increased risk potential, such as lithium-ion cells / batteries that are not inside the passenger compartment to be protected in accordance with paragraph 6.4.1, is performed upon request only. In this case, the test is usually performed on the

ballistic protection housing the storage device. The test is conducted in accordance with paragraphs 4.2, 5.2, 6.4.1 and 7.2. Such tests are to be coordinated with the testing facility.

4.3 Classification

Classification is only possible for vehicles in accordance with the requirements specified in paragraphs 4.2 and 6.4. Individual areas cannot be classified.

Test conditions for the roof and transparent areas must be indicated in the certificate if they are restricted in accordance with paragraph 4.2.3.

Classification examples:

Example 1:

Test level 4 i.a.w. VPAM-APR, chart 1, without restrictions.

VR4, without restriction

Example 2:

Test level 7 i.a.w. VPAM-APR, chart 1, roof tested with an angle of attack of $\leq 45^\circ$, transparent area without restriction.

VR7, roof area 45°, transparent area without restriction

Example 3:

Test level 8 i.a.w. VPAM-APR, chart 1, roof tested with an angle of attack of $\leq 30^\circ$, transparent area in mounting position.

VR8, roof area 30°, transparent area in mounting position

Example 4:

Test level 9 i.a.w. VPAM-APR, chart 1, roof and transparent area without restriction.

VR9, without restriction

5 Test installations and equipment

Test and measuring equipment as well as all parameters relevant for testing are defined in VPAM-APR. Guideline-specific requirements are specified in the following paragraphs.

5.1 Test setup

Test setup must comply with Annex 1 of VPAM-APR. Test velocity shall be determined for every shot fired.

If for technical reasons measuring the test velocity is not possible in exceptional cases (e.g. in the sill or roof area) or the measured test velocity is up to 10 m/s below the specified tolerance, the use of tested ammunition must be ensured with an average value out of a minimum of 10 shots remaining within the tolerance range for test velocity required according to APR, paragraph 4.1, chart 1. This shall be included in the test report together with the measured values.

5.2 Penetration witness plate

For the test in accordance with the BRV guideline, the penetration witness plate must consist of a 0.5 mm polycarbonate foil.

The polycarbonate used in the respective test laboratories must have been tested and approved in accordance with the procedure “Falltest zur Freigabe von Indikatoren“ (Drop test for the approval of indicators) of the Bayerisches Landesamt für Maß und Gewicht, Beschussamt München (Bavarian State Office of Weights and Measures, Munich Proof House).

The penetration witness plate shall be mounted inside the vehicle directly behind the area to be tested / the impact point. It should not be in direct contact with the area to be evaluated in order to demonstrate penetration.

6 Test procedures

6.1 General test procedure

Test procedures and parameters not defined herein are stated in VPAM-APR.

The test procedure for specially protected vehicles consists of the following test parts:

- Pre-testing of the materials of the essential protective areas
- Inspection of built-in protective components
- Test conduct

6.2 Pre-testing of materials

Only materials that have previously been tested in accordance with VPAM-PM shall be used as protective components in vehicles. These materials shall be pre-tested in finished condition (e.g. heat-treated, with cathodic dip coating etc.). They must correspond to the vehicle to be tested in accordance with the BRV guideline and to the materials in the vehicle. This test refers to the essential protective areas that constitute the vehicle.

Materials that cannot be previously tested shall be tested in built-in state during ballistic testing of the vehicle.

6.2.1 Non-transparent materials

For these materials, the multi-hit impact shall be demonstrated in addition.

6.2.2 Curved transparent materials

Curved glazing is delivered and tested with a standardized radius of $R = 1500$ mm. This glazing requires an appropriately bent support frame, which has clamping features as specified in the PM guideline and is aligned in accordance with BRV, Annex 3.

6.2.3 Class VR8, VR9 and VR10 transparent materials

In accordance with paragraph 4.2.3, such glass elements can also be pre-tested at the angle of their mounting position. The tested angle must at least correspond to the angle of the mounting position in the vehicle. The angle of the mounting position is determined by means of an upper and lower reference point at the glazing installed in the vehicle. The two reference points are at the upper and lower edge of the visible glass unit. Protruding cover glass at the edge of the window and covered glass areas are not taken into account.

Glazing with a mounting angle of less than 60° must be, in addition, pre-tested in accordance with VPAM-PM, class 7, 90°.

For curved glazing, the test conditions in accordance with paragraph 6.2.2 must also be met.

6.2.4 Materials for the roof area

In accordance with paragraph 4.2.3 “Restrictive test conditions“, these materials may be pre-tested with an angle of attack of 45° or 30°. The maximum permissible angle of attack of the requested restricted test is used for testing.

6.3 Inspection of built-in protective components

After installation, the protective components shall be inspected by the testing facility. At the time of inspection, all protected areas must be visible. The manufacturer shall provide the design and construction documents. If, despite these requirements, vehicle areas to be tested are not visible, the manufacturer shall be obliged to make them visible.

The inspection includes a weak point analysis of the vehicle protection. The inspection results shall determine the impact points and angle of attacks for the ballistic attack. The selection and arrangement of impact points depends on the overall construction of the area to be protected.

Impact points are in particular those vehicle areas where the bullet meets the least resistance.

The manufacturer shall ensure that no changes to the protective components affecting the test results are implemented between inspection and testing. Changes must be previously agreed upon by the testing facility and included in the test report.

6.4 Test conduct

6.4.1 Test specimen

For testing, the complete vehicle inspected in accordance with paragraph 6.3 shall be provided. Its protected area, usually the passenger compartment, must be finished.

It is permissible to provide the vehicle for testing without engine, chassis and seats. These deviations must be documented in the test report. If an engine is installed, the relevant variant must be indicated.

The requesting party is responsible for ensuring that there is no risk during testing arising from e.g. POL products and auxiliary materials, electrical operating systems, protection systems etc.

6.4.2 Positioning of weapon / weapon system in relation to test specimen

During ballistic attack on a vehicle, the weapon / weapon system and the test specimen shall be positioned in a way to meet the requirements regarding impact points and angles of attack defined during inspection, as well as the required spacing of the hits.

6.4.3 Number and spacing of hits

During testing of the classes VR4 and VR7, a balanced ratio of both types of ammunition should be used in each area. If a different ratio is considered necessary, the decision shall be justified and included in the test report. For both classes, the triangular impact on glazing using the low-energy bullets is, in exceptional cases, not necessarily required if so determined by the testing facility.

If the surface area is big enough (e.g. roof, doors, sides, windows), triangular impact shall be used in each case.

For the non-transparent surface areas, multi-hit impact in accordance with Annex 2 shall be used in addition. In this case, the spacing to any hit of the triangular impact must be at least 120 mm.

If possible, three shots shall be fired at all areas such as gaps, A-/B-/C-/D-pillars, mirror fixtures, door lock cutouts, servicing covers, protective structures changing within the overall construction, integration of active openings, connections to other construction areas, sills, roof connections, glazing edges, radiator tank, openings etc. where penetration by bullets is most likely. The distance between the hits should be at least 120 mm.

If a zone in a non-transparent area is not large enough, the hit-to-hit spacing may be reduced to four times the caliber taking the multi-hit impact tolerances into account. Alternatively, the test can be performed at several similar spots.

The hit-to-hit spacing and the number of hits depend on the design and construction.

6.5 Verification tests

After consulting with the testing facility, verification tests may also be performed on partial areas of the vehicle. The partial area's nature must correspond to the relevant area of the complete vehicle already tested. In this context, the requirements and test conditions specified in the BRV guideline in the edition applicable to the original test shall be used.

The following verification tests are distinguished:

6.5.1 Verification of a design change after penetration

If a penetration occurs, the manufacturer may, in consultation with the testing facility, improve the relevant weak point.

Concerned areas shall be verified in accordance with this guideline.

6.5.2 Verification of constructional extensions/changes

In consultation with the testing facility, such extensions/changes can only be implemented as supplement (including test report) to the certificate already issued.

7 Test documentation and evaluation

7.1 Documentation

Testing shall be documented and evaluated in accordance with VPAM-APR, section 7 (as amended). Guideline-specific requirements are specified in the following paragraphs.

Every hit shall be marked clearly on the vehicle and documented with photographs. The type of bullet including caliber, test velocity, hit positioning, vehicle direction and inclination shall be documented for every hit.

Any fragments or spalling found inside the vehicle area to be protected shall be documented, even if the penetration witness plate is not perforated.

The test report also includes plate materials previously tested in accordance with VPAM-PM. Compliance shall be demonstrated by means of certificates. Information on other materials must be comprehensible on the basis of the manufacturer's documentation (e.g. drawing status).

The vehicle weight shall be indicated in the test report. In this context, the vehicle's equipment state (e.g. without liquids, interactive systems, seats etc.) shall be mentioned.

7.2 Evaluation

The test is considered failed if penetration has occurred.

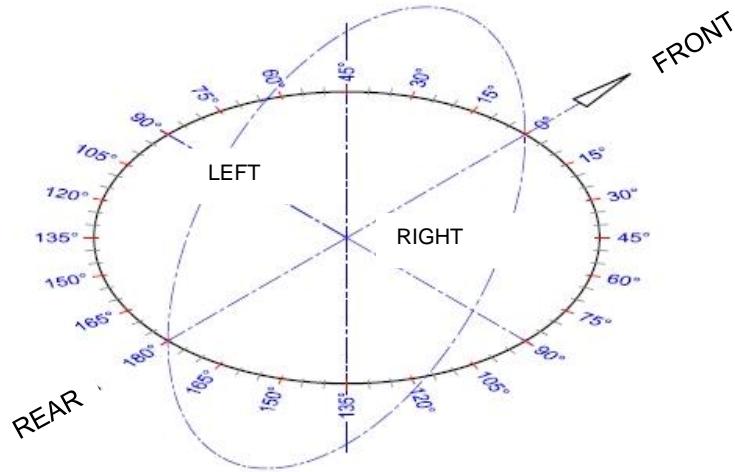
For every hit, the penetration witness plate shall be inspected and assessed for damage. As a rule, penetration is determined by the state of the penetration witness plate.

Penetration occurred whenever the penetration witness plate is perforated.

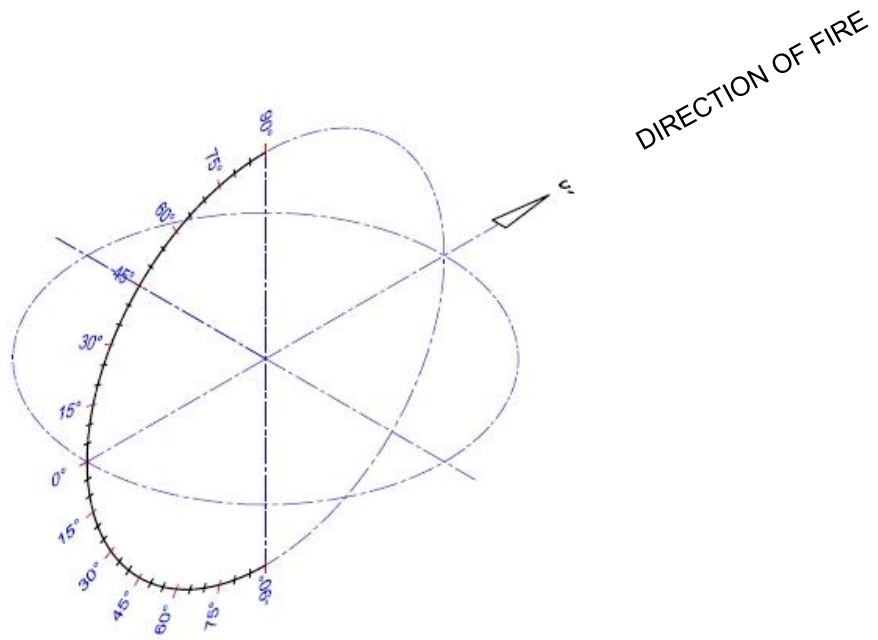
In special cases in which the penetration witness plate is not perforated, the testing facility will decide.

Annex 1: Angle of attack

(Example)



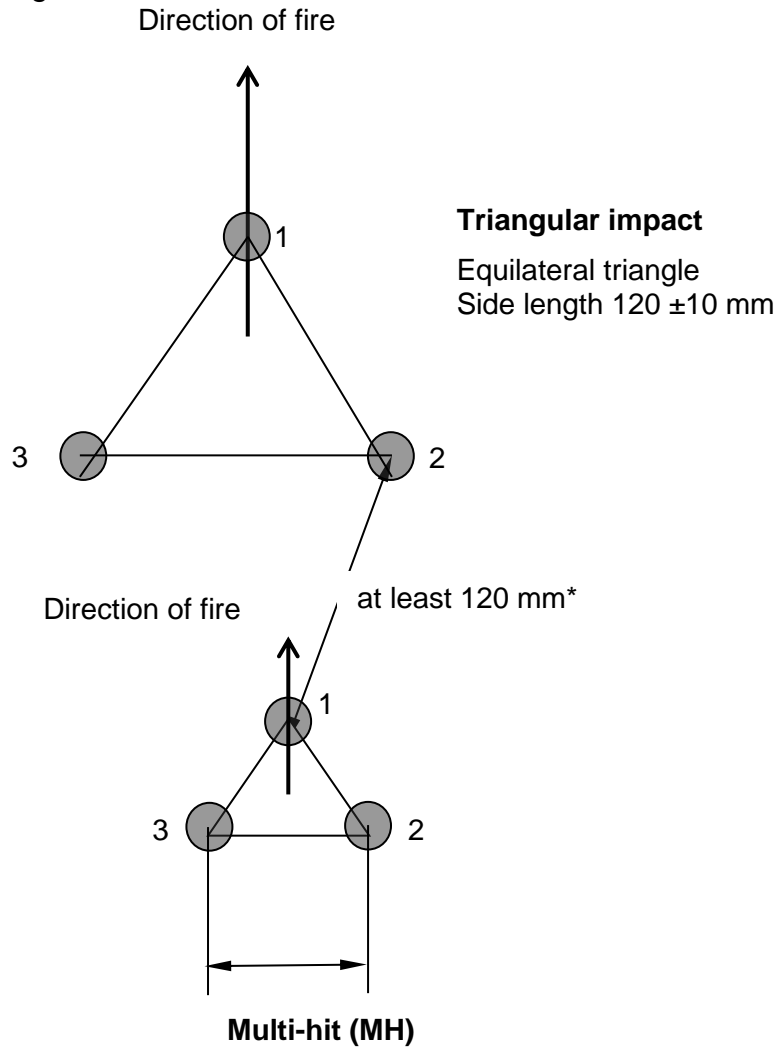
Vehicle direction



Inclination

Annex 2: Hit-to-hit spacing

(Positioning example)



<p>MH hit-to-hit spacing = $Kr \times 4 \pm 1Kr$</p> <p>Kr = Caliber in mm rounded up to whole numbers</p>
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* to any other impact point

Annex 3: Alignment of curved glass

(Example)

Triangular impact:

Equilateral triangle

Side length 120 ± 10 mm

Middle of triangle = middle of test specimen

