

TEST GUIDELINE

“Bullet resistant plate materials”

VPAM - PM

Edition 3

Version: Mar 15, 2021

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

Issued by:

VPAM

Vereinigung der Prüfstellen für angriffshemmende Materialien und
Konstruktionen

(Association of Test Laboratories for Attack Resistant Materials and
Constructions)

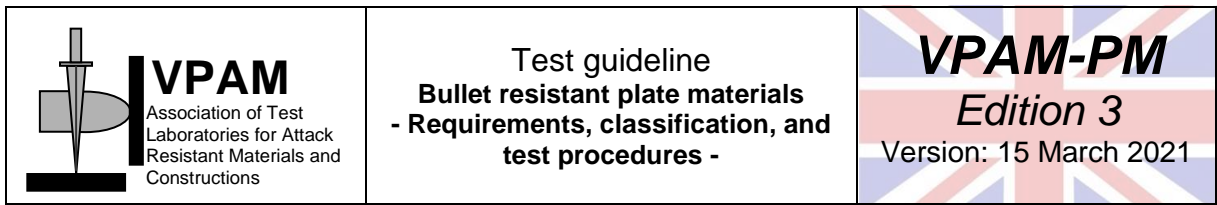
Initial issue of VPAM-PM 2007: October 25, 2007

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Change Record

(Amended editions do not contain a record of changes, but the homepage www.vpam.eu offers access to older edition in the guideline archive)

Amendment		Changes were implemented in the following paragraphs
No.	Date	
1	Mar 15, 2021	Alignment with new VPAM - APR Edition 3 changed from "VPAM - PM 2007" to "VPAM - PM".

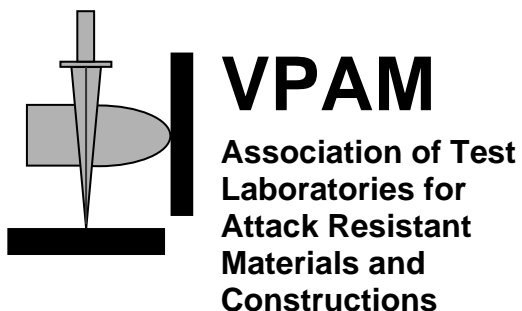


Introductory remarks

This guideline was prepared by VPAM.

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

VPAM - PM may be obtained from



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Introduction

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

1 Scope

This test guideline defines the product-specific requirements, classifications, and test procedures for plate materials (PM). Bullet resistant plate materials are intended to protect people and objects against effects from bullets fired from small arms and rifles. These materials are intended to prevent penetration by bullets and bullet fragments.

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. It is recommended, however, that contracting partners applying the present guideline check whether they may apply the latest editions of the documents listed below.

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 of Ballistic Material, Design, and Product Tests)
- VPAM AND-SoM “Munitionsarten für Sonderprüfungen” (Ammunition Types for Special Tests)

3 Definitions

Basic definitions are laid out in VPAM - APR. In addition, the following terms shall apply to the present guideline:

3.1 Plate materials

Plate materials usually are flat* items of production consisting of fabrics, organic, inorganic, transparent, or non-transparent materials with a single- or multi-layer design (see Annex 2 for examples). The individual layers may be connected to each other, amongst other things, by bonding, welding, soldering, weaving, screwing, or clamping.

3.1.1 Homogeneous materials

In homogeneous materials, every layer shows a continuously uniform cross section.

3.1.2 Inhomogeneous materials

In inhomogeneous materials, one or more layers show a distinctly uneven mass distribution or possess other weak points that may increase the probability of penetration, such as in ceramic plates consisting of several parts.

3.2 Penetration witness plate

The penetration witness plate shall be placed behind a test specimen during testing, depending on the material tested. The penetration witness plate shows the penetration of the test specimen by the bullet and/or bullet parts, and/or spalling from the test specimen.

3.3 Triangular impact (standard)

Triangular impact refers to three hits whose hit pattern forms an equilateral triangle, see Annex 1 Fig. 1.

3.4 Multi-hit impact (MH)

Multi-hit refers to three hits whose hit pattern forms an equilateral triangle, see Annex 1 Fig. 1.

*Exception: bent glass according to VPAM - BRV, Section 6.2.3 with a radius of $R = 1,500$ mm

3.5 Angle of attack (AOA)

The term angle of attack refers to the angle between the line of flight of the projectile and the rigid rear frame the test specimen is mounted on, see Section 6.5.1.

4 Categorization, test conditions and classification

4.1 Categorization

Bullet resistant plate materials in accordance with VPAM - PM are categorized in line with the following table.

Table 1: Categorization

Test level according to VPAM APR	Classification according to VPAM - PM
1	PM1
2	PM2
3	PM3
4	PM4
5	PM5
6	PM6
7	PM7
8	PM8
9	PM9
10	PM10

4.2 Test conditions

4.2.1 General test conditions

Bullet resistant plate materials are intended to prevent the penetration by bullets and bullet fragments at an angle of attack (AOA) of 90° and a storage temperature (T) of +20 °C ±3 °C. Different angles of attack and storage temperatures may be certified when testing for special requirements. Per test condition, one separate test report and, if applicable, one certificate will be issued.

Testing with types of ammunition other than those mentioned in VPAM APR may be carried out provided that the ammunition types stated in the related guideline VPAM - AND-SoM "Munitionsarten für Sonderprüfungen" (Ammunition Types for Special Tests) are used. In those cases, there is no categorization.

4.2.2 Optional multi-hit impact (MH)

For every test, there is the option of performing a multi-hit impact.

4.3 Classifications

Classifications must be stated in the following order:

Class / Angle of attack (AOA) / Storage temperature (T) / Optional multi-hit (MH)

Examples for classifications

Example 1:

Test level 9 in accordance with VPAM - APR, table 1, at T +20 °C, AOA 90°

PM9, 90°, +20 °C

Example 2:

Test level 6 in accordance with VPAM - APR, table 1, at T -20 °C, AOA 60°

PM6, 60°, -20 °C

Example 3:

Test level 8 in accordance with VPAM - APR, table 1, at T -30 °C, AOA 70°

PM8, 70°, -30 °C

Example 4:

Test level 9 in accordance with VPAM - APR, table 1, AOA 45°, at T +49 °C and MH

PM7, 45°, +49 °C, MH

5 Test facilities and measurement equipment

Test and measuring equipment and all parameters relevant for testing are defined in VPAM - APR. Requirements specific to the present guideline are set out in the following sections.

5.1 Test setup

The test setup shall conform to Annex 1 of the VPAM APR. Impact velocity shall be determined for every shot fired.

5.2 Penetration witness plate

A penetration witness plate shall be used to determine penetration and spalling of the test specimen.

The penetration witness plate is an aluminum sheet with a thickness of 0.5 mm (AlCuMg1 F40/F44). It shall be fixed 150 mm \pm 5 mm behind the test specimen. It shall be positioned in a way that allows for clear detection.

6 Test procedures

6.1 General

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

6.2 Number of test specimens

As a rule, three identical test specimens of each plate material shall be provided per test condition to be tested. More test specimens may be required for testing multi-hit impacts, inhomogeneous test specimens and/or test classes with two calibers. In these cases, the testing facility shall be consulted.

6.3 Size of test specimens

The size of the test specimens is 500 x 500 x 10 mm. Smaller test specimens are permitted for metal plates if the hit-to-hit spacing requirements are met and the hit-to-edge spacing is at least 75 mm.

Any deviation in size must be agreed upon by the testing institute. These deviations must be stated in the test report.

6.4 Conditioning of the test specimens

Test specimens shall be stored for a minimum of 16 hours at $+20 \pm 3$ °C before testing. In case the storage temperature of test specimens should differ, they shall be stored for a maximum of 32 hours.

The test specimen shall be taken out of the conditioning cabinet immediately before the testing. Testing shall take place within 15 minutes. In case testing cannot take place within this time frame, the test specimen must once again be stored according to the provisions.

6.5 Fixing of test specimens

6.5.1 General principles of fixing test specimens

Test specimens of all materials shall be fixed between a rigid rear frame and a front frame allowing for a minimum contact surface of 30 mm on all sides.

The fixture shall ensure secure fitting of the test specimen during the entire time of testing.

Differing regulations are discussed in Sections 6.5.2 to 6.5.4.
The fixing method shall be recorded in the test report.

6.5.2 Fragile materials

Test specimens made of fragile materials such as glass and ceramic compounds shall be fixed between a rigid rear frame and a front frame allowing for a minimum contact surface of 30 mm on all sides. A 4 mm thick neoprene rubber shall be mounted on the contact surface between the test specimen and both the rear and the front frame.

6.5.3 Metal materials

As an alternative to Section 6.5.1, the test specimen may be mounted symmetrically on the rear frame using a minimum of four clamps. The clamps shall be spaced evenly on the specimen's rim.

6.5.4 Other plate materials

In case none of the fixing methods described in Sections 6.5.1 - 6.5.3 offers a sufficiently secure fit of the test specimen, the fixing method chosen shall be optimized. It must be ensured that the test specimen is not pulled out of the front frame by more than 15 mm per side during testing. If this requirement is not met, the hit is deemed invalid (unless it is a complete penetration) and the test shall be repeated. If the requested minimum contact surface of 30 mm is not observed, the test specimen shall be fixed again.

6.6 Number and spacing of hits

6.6.1 Triangular impact

Three shots shall be fired at each test specimen with a hit-to-hit spacing of 120 ± 10 mm (Annex 1, Fig. 1).

For inhomogeneous test specimens, their structure shall be marked on the outside of the test specimens. In that case, seven shots shall be fired at the test specimen in accordance with the shot pattern in Annex 2, Fig. 4.2. The three shots of the triangular impact (standard) shall not hit the spaces between plates, if possible. If weak spots cannot be clearly identified and the manufacturer gives no further information on the structure of the test specimens, the number of hits shall be increased to six hits per test specimen (two triangular impacts) and the number of test specimens shall be five. The hit-to-hit spacing shall remain at 120 ± 10 mm.

6.6.2 Multi-hit impact

Three shots shall be fired at each test specimen with the hit-to-hit spacing specified in Annex 1, Fig. 1.

No single hit may be closer than 75 mm to the inner rim of the frame. This test may also be performed on a test specimen already tested according to Section 6.5. In that case, the distance between the hits of the triangular impact shall be at least 120 mm (Annex 1, Fig. 1). For inhomogeneous test specimens, e.g. ceramic plates consisting of several parts, the first shot shall hit the center of a ceramic plate if possible.

7 Test documentation and evaluation

7.1 Documentation

As a rule, testing shall be documented and evaluated according to VPAM - APR, Section 7. Requirements specific to the present guideline are set out in the following sections.

Every impact point shall be clearly marked on the test specimen. The type of bullet including caliber, bullet velocity, angle of attack, and storage temperature of the test specimen shall be documented for every hit.

The certificate includes the actual measurement of the thickness of the material.

7.2 Evaluation

The test is considered failed if penetration has occurred.

Penetration has occurred if

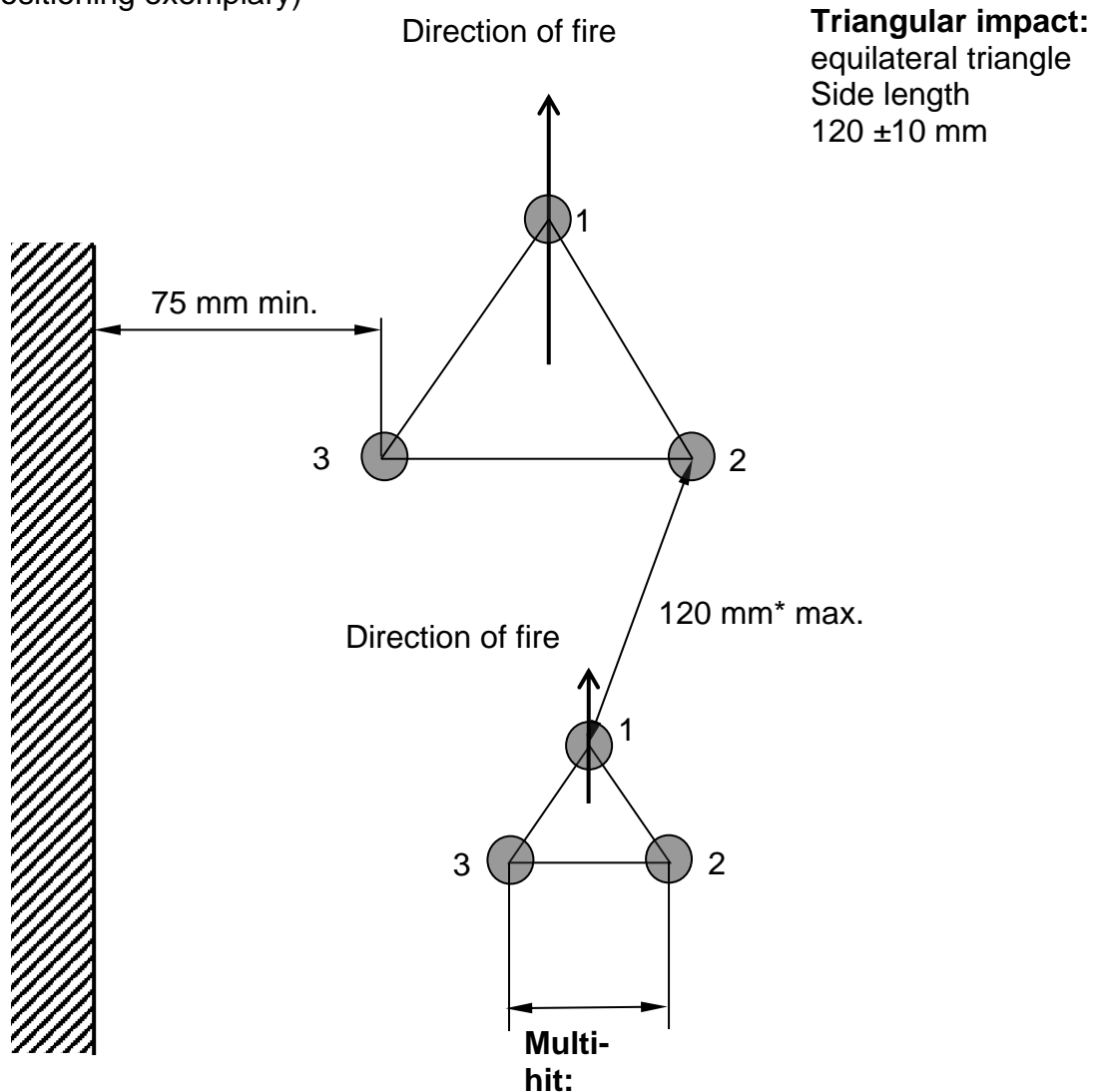
- the bullet or a bullet fragment passed through the test specimen
or
- the back of the test specimen was penetrated by a bullet or bullet fragments that remain stuck in the test specimen
or
- the test specimen shows a hole even though the aforementioned options cannot be proved
or
- the penetration witness plate is penetrated.

7.3 Spalling

Any fragments or spalling shall be documented, even if the penetration witness plate is not perforated.

Annex 1: Hit-to-hit spacing

Fig. 1 Hit-to-hit spacing
(Positioning exemplary)



MH hit-to-hit-spacing = Cal x 4 ± 1 Cal

Cal = caliber in mm, rounded up to whole values

* to the closest hit

Annex 2: Plate materials, directions of fire, and shot patterns

(Examples)

