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DO-IT-YOURSELF BODY ARMOR: MYTH OR TRUTH?

Vladimir Statev, Daniel Totev

Summary: *The global security environment changes. Violence levels are rising. A large number of individuals search for cost effective solutions for personal protection. The article presents the crafting process, mathematical expectations for penetration depth and the results of field testing of non-manufactured ballistic plates made using widely available materials. The research indicates that creating a functioning body armor is possible, but the protection level of such Do-It-Yourself (DIY) ballistic plates is limited.*

Keywords: *Ballistic Plate, Body Armor, Do-It-Yourself, Personal Protection, Projectile Penetration*

INTRODUCTION

The global security environment undergoes dynamic changes. According to the Global Conflict Tracker of the Council on Foreign Relations there are 28 ongoing armed conflicts of various scales around the world (Council on Foreign Relations). Using data from the Department of Peace and Conflict Research of Uppsala University makes it easy to visualize the steep rise of state-based violence spreading across five continents (Uppsala Conflict Data Program).

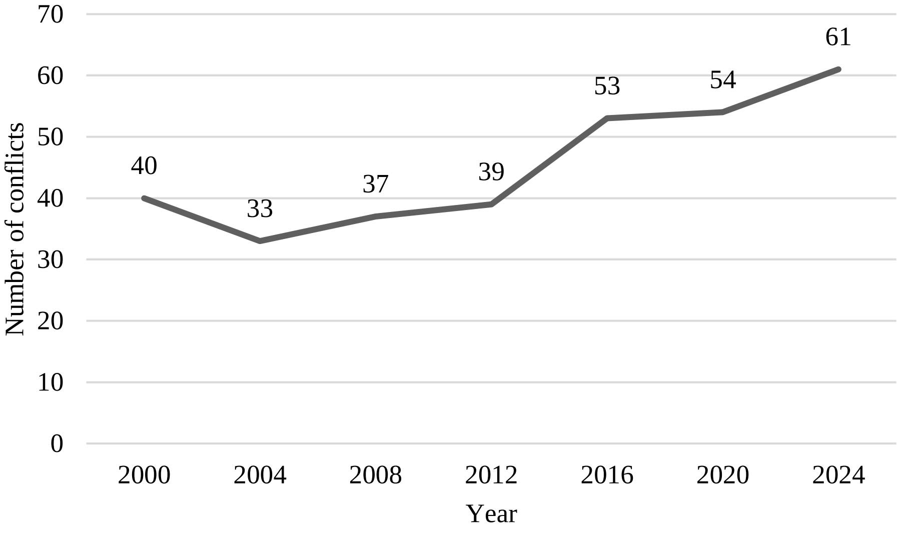

Figure 1. State-Based Violence in the period 2000-2024

The chart clearly demonstrates that the number of conflicts has almost doubled in the twenty-year period from 2004 to 2024. Research done by the Armed Conflict Location & Event Data shows that 1 in 8 people are estimated to have been exposed to conflict in 2024 (Conflict Index).

Examining the statistics from the perspective of regular citizens, it is not difficult to conclude that there is a serious problem with personal security worldwide. The reasons for the expansion of conflicts might vary, but in many cases, they are related to the failure of countries' politics or interstate diplomacy.

The number of people not content with the level and quality of the security guarantees provided by the government of the country they live in is rising. Such individuals seek ways to take matters into their own hands and increase their autonomy and survivability in a crisis scenario where state security and civil protection structures would be overloaded or not functioning.

Personal ballistic protection is among the top priorities of private citizens in an armed conflict scenario. However, military-grade ballistic protection gear like helmets and body armor is costly and not generally available to civilians in many countries. Typing the phrase "how to make body armor" in the Google search engine gives more than 220 000 000 search results (Google). That shows significant public interest in the topic. The World Wide Web is full of information on how an individual can make functional body armor with materials available in almost every hardware store. There are many claims that this Do-It-Yourself (DIY) body armor is cheaper and as effective as the one manufactured by major companies. On the Internet there are plenty of videos of such home-made body armor being tested, with mixed results. What most of those tests lack is a pre-established methodology and a clear representation of the results.

In order to generate verifiable results, it is necessary to conduct a well-documented practical experiment. Such an experiment needs to answer two questions:

1) Is it possible to create body armor using widely available and inexpensive materials?
2) Would DIY body armor actually stop firearm projectiles?

The purpose of the current article is to present the findings of such a practical experiment. The tested DIY body armor is crafted within a predetermined budget, sourcing materials from easily accessible stores and vendors. The testing itself is conducted following a test protocol, based on an international standard. The results are documented, analyzed and presented for future discussions.

1. CRAFTING

Body armor could be categorized into three types, based on the materials used in its production – soft, hard or composite armor. The different types of body armor provide different levels of comfort and protection. Soft body armor typically has a lower weight and grants greater comfort to the user in comparison to hard body armor but often scores lower protection levels. Common body armor materials used in the manufacturing of soft body armor include Kevlar, Aramid, Dyneema, Ultra-high-molecular-weight polyethylene, and Polyethylene. Hard body armor usually incorporates materials like Steel, Ceramic, Boron carbide, Aluminium oxide, and Silicone carbide. Composite armor consists of a combination of ballistic protection materials and normally yields the highest level of protection.

1.1 Materials

Creating a test DIY ballistic plate is essential to conducting the beforementioned practical experiment. That plate should meet a set of requirements in regard to its dimensions, weight, and cost. A standard plate carrier can fit plates size 300-330x250-260x30 mm (HxWxD). That means that the test plate should have similar dimensions.

On the Bulgarian on-line market there are seven types of ballistic plates that fit in the size requirements. Those are shown in Table 1 below:

Table 1. Ballistic plates available for purchase

№	**Brand**	**Protection level (NIJ[*])**	**Weight (kg)**	**Price (EUR)**
1	Mars (Brannik.bg)	III	2.5	226.77
2	Mars (Brannik.bg)	III++	3.2	279.47
3	Mars (Mars Armor)	IV	N/D[**]	342.05
4	N/D (Eldomremont LTD)	IV	2.7	255.64
5	Engarde TUFF PRO HD HARD ARMOR (Magazin Shturm)	III+	1.25	416.16
6	Engarde TUFF PRO HD HARD ARMOR (Magazin Shturm)	IV	2.8	428.40
7	SBA (Sabibarb.com)	III+	N/D	394.28
Average:			**2.49**	**334.68**

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[*] NIJ stands for *NATIONAL INSTITUTE OF JUSTICE*

[**] Not Disclosed

Based on the values of weight and price of the ballistic plates available on the market, it is reasonable that the test DIY plate should weigh no more than the heaviest plate (3.2 kg) and should be significantly cheaper to produce than the plate with the lowest price tag (226.77 EUR).

The materials available in online and physical hardware stores purchased for the crafting of the test DIY ballistic plate are listed in Table 2 below:

Table 2. Materials pricing

№	**Material**	**Size, Weight or Volume**	**Quantity**	**Price per unit, EUR**	**Delivery price, EUR**	**Price, EUR**
1	aluminium oxide	1000 g	1	7.13	1.43	8.56
2	fiberglass	3000x1000 mm	1	11.93	1.15	13.08
3	HDPE[*]	1000x300 mm	1	7.16	4.09	11.25
4	epoxy resin	390 ml	2	8.18	-	16.36
5	epoxy hardener	180 ml	2	3.78	-	7.56
6	cyanoacrylate glue + activator	200 + 50 ml	2	2.81	-	5.62
7	duct tape	200 g	1	5.22	-	5.22
TOTAL:						**67.65**

Their total cost is ~ 30% of the price of the cheapest ballistic plate sold online. In addition, the materials were enough to create two DIY ballistic plates.

1.2 Crafting process

A decommissioned ballistic plate rated to resist a 7.62x54mm R rifle rounds was used for modeling the DIY plates. The model plate measured 300x250x25 mm (HxWxD) and weighed 3200 g.

The steps of crafting the DIY plates were as follows:

1) Measuring, outlining, and cutting out the fiberglass sheet into forty 300x250 mm rectangles.

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[*] High-Density Polyethylene

2) Measuring, outlining, and cutting out the HDPE plate into four 300x250x3 mm rectangles.

3) Casting a 300x250x10 mm plate out of 86.2% aluminium oxide and 13.8% epoxy mixture (AEM) in a flat mold (the 86.2:13.8 ratio allows even distribution of Al_2O_3 when casting).

4) Laminating two batches of twenty fiberglass rectangles by applying a thin layer of epoxy resin + hardener between each sheet.

5) Putting the fiberglass sheets in a weighted press for 12 hours in order to expel excess epoxy resin and mold them into shape.

6) Gluing together two HDPE plates using a weighted press, a heat gun, and cyanoacrylate glue + activator.

7) Cutting the aluminium oxide epoxy tile into eight smaller tiles to compensate the plates curve.

8) Gluing the aluminium oxide epoxy tiles to the front of one of the plates using a layer of epoxy resin + hardener.

9) Cutting and grinding the edges of the two plates to the shape of the model plate.

10) Covering both sides of the plates with duct tape to protect the edges and give them a uniform look.

The result of the crafting process was two DIY ballistic plates. **Plate 1** was comprised of two layers of 3 mm HDPE on the back (wear face) and 20 layers of laminated epoxy fiberglass (EFG) on the front (strike face). Plate 1 weighed 1427 g and was 300x250x17 mm (HxWxD). The strike face of Plate 1 is shown on the left side of Figure 2, and the wear face is depicted on the right side.

Figure 2. Plate 1 – Strike and wear faces

Plate 2 has the same composition as Plate 1 with the addition of the 10 mm thick aluminium oxide epoxy tiles to its strike face. Plate 2 weighed 2725 g and was 300x250x26 mm (HxWxD).

Due to imperfect crafting technology and usage of binding agents there is a ~1 mm difference between the thickness of the materials and the overall thickness of the finished plates. The composition of Plate 1 is shown on the left side of Figure 3 and that of Plate 2 is depicted on the right side.

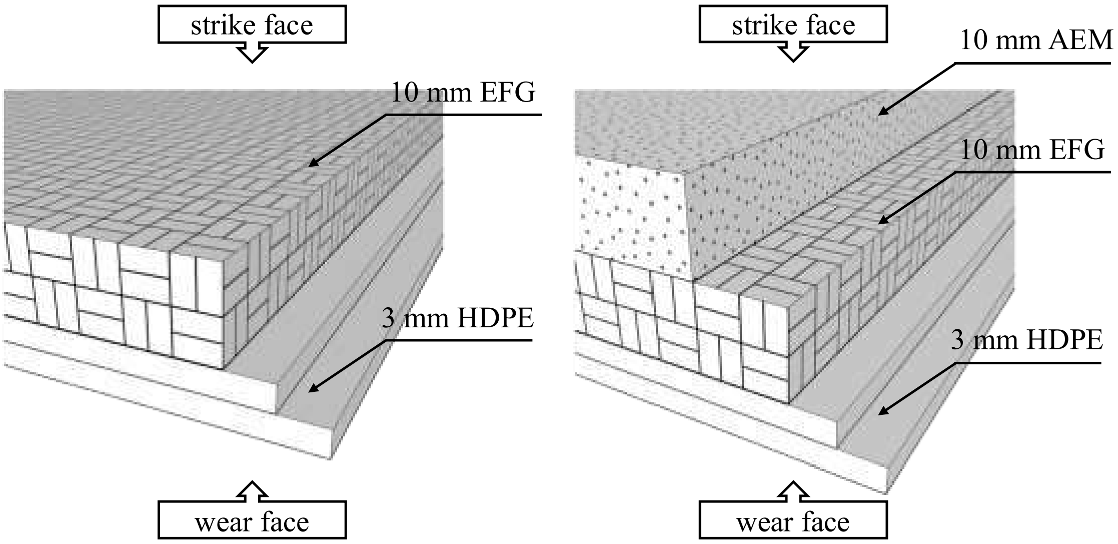

Figure 3. Plate 1 and Plate 2 composition

The crafted DIY ballistic plates meet the preset criteria for fitting into a standard plate carrier, weighing less than 3200 g and having overall cost of less than half the price of the cheapest ballistic plate on the market.

2. TESTING

2.1 Design of testing protocol

Crafting a plate using materials found in commercially produced ballistic plates does not mean it would have the same or even similar properties. Ballistic plates used by law enforcement agencies and the military undergo a certification process which must guarantee that those plates meet certain requirements and protection standards. The two most recognized standards for armor evaluation are NIJ and VPAM[*]. The NIJ standard is a national standard in the USA that is focused on specifying the minimum performance requirements and test methods for the ballistic resistance of body armor. VPAM is a European standard that is used primarily for

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[*] VPAM stands for *Vereinigung der Prüfstellen für angriffshemmende Materialien und Konstruktionen*

material-level testing of armor plates, transparent armor and vehicle components.

The NIJ standard serves as the basis for developing the testing protocol for the DIY ballistic plates due to its suitable test methods. The standard has five protection levels equivalent to resistance of different threats (U.S. Department of Justice, 2025) – two for handgun threats (HG) and three for rifle threats (RF). The protection levels are shown in Table 3 below:

Table 3. NIJ protection levels

NIJ Ballistic Protection Level	**Test Ammunition**	**Bullet type**	**Bullet weight, g**	**Reference Velocity, m/s**
NIJ HG1	9mm Luger (9x19mm)	Full Metal Jacket (FMJ) Round Nose	8	398
	.357 MAG (9.1x33mm)	Jacketed Soft Point	10.24	436
NIJ HG2	9mm Luger (9x19mm)	Full Metal Jacket Round Nose	8	448
	.44 MAG (10.9x32,6mm)	Jacketed Hollow Point	15.55	436
NIJ RF1	7.62x51mm M80	FMJ Steel Jacket	9.52	847
	7.62x39mm	Mild Steel Core (MSC) Ball Ammunition	7.9	732
	5.56mm M193 (5.56x45mm)	Lead core	3.62	990
NIJ RF2	7.62x51mm M80	FMJ Steel Jacket	9.65	847
	7.62x39mm Type 56	MSC Ball Ammunition	7.9	732
	5.56mm M193 (5.56x45mm)	Lead core	3.62	990
	5.56mm M855 (5.56x45mm)	Hardened steel front core and a lead rear core	4	950
NIJ RF3	30.06 M2 AP (7.62×63mm)	Hardened steel core	10.73	878

In order to be certified each test panel or plate must be able to withstand six fair hits without experiencing complete penetration at or below the reference velocity (±9.1 m/s). Complete penetration is the result of a projectile's impact where the projectile or a fragment of the projectile passes through the wear face of the plate, is visible from the wear face of the test plate or creates a hole in the test plate. For a hit to be qualified as "fair", it needs to meet the **minimum shot-to-edge** distance requirement of 51 mm for armor subjected to a single threat or 76 mm for armor subjected to heavier threat round when two threats are specified, and the **minimum shot-to-shot** distance requirement of 51 mm. For handgun rounds, the armor panel or plate that would be tested needs to be mounted 5.0 m ± 1.0 m from the muzzle of the test barrel, and for rifle rounds, the armor panels are mounted 15.0 m ± 1.0 m from the muzzle of the test barrel (U.S. Department of Justice, 2008). In addition, the backface deformation needs to measure at $\leq$ 44.0 mm Backface deformation (BFD) or backface signature is the indentation in the backing material caused by a projectile impact on the test item during testing (U.S. Department of Justice, 2025). BFD is measured using a **backing material** placed in a **backing material fixture** (BMF). A homogenous block of nonhardening, oil-based modeling clay placed in contact with the back of the armor panel or plate during ballistic testing is used as backing material. The backing material fixture is a rigid box frame, which contains the backing material (U.S. Department of Justice, 2008).

The protocol devised for testing of the DIY ballistic plates follows the requirements of the NIJ standard with few notable exceptions caused by the limitations and safety restrictions of field testing. The differences from the NIJ standard testing methodology include:

1) usage of firearms instead of test barrels;

2) increasing the armor plates mounting distance from 15.0 to 50.0 m for rifle threats testing;

3) usage of available in inventory ammunition that have minor deviations from the prescribed by the NIJ standard bullet weight and reference velocity.

The firearms used in the field testing of the ballistic plates include one pistols (a 9mm Sig Sauer SP2022), and one sniper rifle (a 7.62mm Heckler & Koch MSG90A1).

The ammunitions used in testing are listed in Table 4 below:

Table 4. Test ammunitions

№	**Make/Model**	**Type**	**Bullet weight, g**	**Bullet diameter, mm**	**Average bullet velocity, m/s**
1	**Arsenal (**Arsenal JSCo**)** 9x19mm	FMJ Round Nose	7.45	9.03	380
2	**Remington (**Remington**)** Premier Match 308/ 7.62x51mm	Open Tip Match	10.88	7.82	816

The decision to increase the distance for testing rifle threats is based on safety concerns. It could be argued that due to gravity and drag forces experienced by the bullet while traveling the extra 35.0 m will result in loss of velocity. However, this loss is relatively small over that distance and would have no significant effects on the bullet's penetration capacity.

The design of the testing protocol accounts for the limitations posed by the lack of multiple test samples and the limitations of field-testing conditions.

2.2 Mathematical expectations of test results

The different types of ammunitions used in the testing each have specific characteristics leading to difference in their performance. That assertion also applies to the materials used in the crafting of the ballistic plate (Carlucci, D. E., & Jacobson, S. S., 2025). In order to build reasonable expectations of the test result it is necessary to calculate the potential penetration of each test ammunition against each of the materials the DIY plate is comprised of.

Projectile penetration is governed predominantly by sectional density (Kneubuehl, B. P., & Rawcliffe, S., 2024), defined as the ratio of **mass** (m) to **frontal cross-sectional area** (A), and by impact velocity (V). At low velocities, penetration depth exhibits an approximate quadratic dependence on speed. However, as velocity increases, this dependence progressively diminishes, eventually becoming negligible at extreme velocities, where penetration can be treated as effectively constant.

At sub-ballistic velocities, penetration is governed predominantly by the mechanical strength of the target material. A certain amount of pressure (stress) must be applied to initiate plastic flow, as stresses below the elastic limit result only in reversible deformation with no residual damage. Permanent deformation commences once the applied pressure exceeds the elastic limit, and further loading beyond the yield strength induces progressive plasticity, material softening, and eventual fracture. For sufficiently thick targets, the projectile must also displace or compress the surrounding material to advance, a process characterized by the **cavity strength** (Y_c), which is typically about three times the material's **yield strength**[*]. The change in energy of the projectile (dE) equals the resistive force (F) exerted on the projectile times the incremental displacement into the target (d_x), as shown in Formula 1:

$$dE = -Fd_x \tag{1}$$

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[*] Yield strength is a material property that represents the stress level at which a material begins to deform plastically, meaning it will not return to its original shape after the stress is removed.

The minus sign indicates the force is in the opposite direction of the projectile motion, so that its energy is being reduced. For the projectile to penetrate a thick target, the pressure (P) it exerts on the target needs to be equal to the cavity strength:

$$P = Y_c \tag{2}$$

Combining the relations in Formula 1 and 2, results in:

$$dE = Y_c A d_x \tag{3}$$

Since this is a linear relation, in order to calculate the penetration (x_p) of the target, the value of the projectile's initial energy (E) in the moment of contact with the target must be known. In that case:

$$x_p = \frac{E}{Y_c \times A} \tag{4}$$

Considering only the projectile's kinetic energy, which equals:

$$E = \frac{1}{2} m V^2 \tag{5}$$

The penetration would be equal to:

$$x_p = \frac{mV^2}{A2Y_c} \tag{6}$$

This method of calculation applies only to slow moving projectiles, where the penetration is linear in sectional density and quadratic in velocity. The formula is consistent with the basic cavity expansion approximation used for rigid projectile penetration at low to moderate velocities, where material strength dominates.

At high velocity impact conditions, the projectile interacts with the target primarily through the inertial displacement of material along its trajectory, resulting in the transfer of kinetic energy from the projectile to the target material. As impact velocity increases, the rate at which target material must be accelerated to vacate the projectile path rises correspondingly, leading to significantly greater energy expenditure. Beyond a critical velocity regime, the inertial forces required for material displacement vastly exceed the intrinsic strength properties of the target. Consequently, the penetration process transitions from a strength-dominated regime to one governed by hydrodynamics, wherein the target can be effectively modeled as a fluid (Kneubuehl, B. P., & Rawcliffe, S., 2024). In such conditions, the projectile will experience a drag force (F_d) equal to:

$$F_d = \frac{1}{2} p_t V^2 A C_d \tag{7}$$

where:
p_t – density of target, kg/m^3
V – projectile's velocity, m/s
A – frontal area, m^2
C_d – drag coefficient (geometry-dependent, usually ≈ 1)

The **drag coefficient** ≈ 1 in rigid targets such as ballistic plates.

Characteristic length (x_c) is the distance traveled by the projectile after which its kinetic energy would have dropped to a factor of 1/e (≈1/2.71828) of its starting value.

$$x_c = \frac{m}{A} \times \frac{1}{C_d \times p_t} \tag{8}$$

Under this approximation, the calculated penetration depth is infinite, however, after the projectile has traversed several times the characteristic length (x_c), its velocity decreases to levels of negligible practical significance. Thus, the characteristic length is setting how quickly the inertial drag can decelerate the projectile.

Defining a threshold velocity (V_{thr}) at which strength and inertial (dynamic) resistances are comparable, enables estimation of the distance over which the projectile exhibits predominantly hydrodynamic behavior.

Threshold condition occurs when dynamic pressure = material resistance adjusted by drag factor (C_d):

$$\frac{1}{2} p_t V_{thr}^2 C_d = Y_c \tag{9}$$

Solving for V_{thr}:

$$V_{thr} = \sqrt{\frac{2 \times Y_c}{C_d \times p_t}} \tag{10}$$

For projectiles impacting at intermediate velocities, such as small-arms bullets striking a rigid target, both material strength and dynamic forces must be considered. When a projectile initially operates within the hydrodynamic regime but decelerates to velocities at which material strength becomes significant, the combined effects of hydrodynamic and strength-dependent forces are used to evaluate the differential energy loss during penetration.

In this scenario, two outcomes are possible. The first occurs when the pressure exerted by the projectile is below the yield strength of the target material, resulting in bullet deformation or scattering of the projectile without penetration. For instance, a jacketed lead pistol-caliber bullet impacting a thick, hardened steel plate will result in no penetration of the target.

The second possible outcome occurs when the pressure exerted by the projectile exceeds the yield strength of the target. In this case, the projectile induces deformation of the target, and penetration becomes significant. The extent of penetration is determined by both the target thickness and the characteristics of the projectile.

For sufficiently thin targets, the pressure required for penetration slightly exceeds the material's yield strength. However, that usually is not the case with ballistic plates, which makes it necessary to incorporate the characteristic length and threshold velocity into the analysis to determine the maximum penetration depth (x_m):

$$x_m = x_c ln(1 + \frac{V_0^2}{V_{thr}^2}) \tag{11}$$

The maximum penetration depth, x_m, is attained when the projectile's kinetic energy is fully dissipated. In estimating the penetration of test ammunition into DIY ballistic plates, the projectiles are to be considered as rigid, non-deforming bodies. This simplifying assumption eliminates the need to account for the material properties of the projectile and provides a conservative, worst-case estimate, since penetration is not reduced by an increase in frontal area due to deformation. In practice, however, most pistol and rifle projectiles undergo significant deformation upon impact, leading to an increase in their frontal cross-sectional area by approximately 1.5–2 times the original diameter, thereby reducing their penetration capacity.

The material properties of the components of the DIY ballistic plates are listed in Table 5 below:

Table 5. Material properties

№	**Material**	**Average density (p_t), kg/m^3**	**Average yield strength,** MPa
1	Aluminium oxide epoxy mixture (0.862:0.138 by weight)	3641.49	410.96
2	Laminated epoxy fiberglass	1500	300
3	HDPE	960	28.45
4	Aluminium oxide	4025	465
5	Epoxy cast resin	1255	74.7

Using Formula 8, 10 and 11 to estimate the penetration of a 9x19mm FMJ Round Nose fired from a 9mm Sig Sauer SP2022 in an aluminium oxide epoxy mixture gives the following results:

$$x_c = \frac{m}{A} \times \frac{1}{C_d \times p_t} = \frac{0.00750}{0.6407 \times 10^{-6}} \times \frac{1}{1 \times 3639.96795}$$
$$= 117.0633945 \times 0.000274728 = 0.032160556 \approx 0.0322$$

- characteristic length of 32.2 mm

$$V_{thr} = \sqrt{\frac{2 \times Y_c}{C_d \times p_t}} = \sqrt{\frac{2 \times 1232887800}{1 \times 3641.49}} = \sqrt{\frac{2465775601}{3641.49}} =$$
$$= \sqrt{677133.5317} = 822.8812379 \approx 822.88$$

- threshold speed of 822.88 m/s

$$x_m = x_c ln\left(1 + \frac{V_0^2}{V_{thr}^2}\right) = 0.032160556 \ln\left(1 + \frac{340^2}{822.8812379^2}\right) =$$
$$= 0.032160556 \ln\left(1 + \frac{115600}{677133.5317}\right) = 0.005069103 \approx 0.0051$$

- maximum penetration of 5,1 mm.

The calculations show that the 9mm ammunition would potentially penetrate 5.1 mm of AEM. The results for the other materials and test ammunition are shown in Table 6 below:

Table 6. Ammunition penetration in tested materials (x_m)

№	Material	Ammunition penetration, mm	
		9x19mm	7.62x51mm
1	Aluminium oxide epoxy mixture (0.862:0.138)	5.1	40.83
2	Laminated epoxy fiberglass	7.22	64.20
3	HDPE	54.26	322.41

The calculations show that theoretically Plate 1 and Plate 2 could resist a 9x19mm ammunition and that both plates would be penetrated by a 7.62x51 round even if stacked together (10 mm of AEM + 20 mm of EFG + 12 mm of HDPE).

2.3 Field testing

The field testing of the DIY ballistic Plate 1 took place in the following order:

1) The backing material fixture filled with the backing material was set at a distance of 5.0 m (measured using a laser range finder) and leveled using a laser leveler to ensure the angle of the shots.

2) Plate 1 was strapped to the BMF using elastic bands ensuring its wear face was in firm contact with the backing material.

3) One shot of 9x19mm FMJ Round Nose from a 9mm Sig Sauer SP2022 was fired at the plate resulting in complete penetration.

4) Testing was discontinued.

The backing material fixture with ballistic Plate 1 strapped is shown on the left side of Figure 4, and the indentation in the backing material resulting from the penetration is depicted on the right.

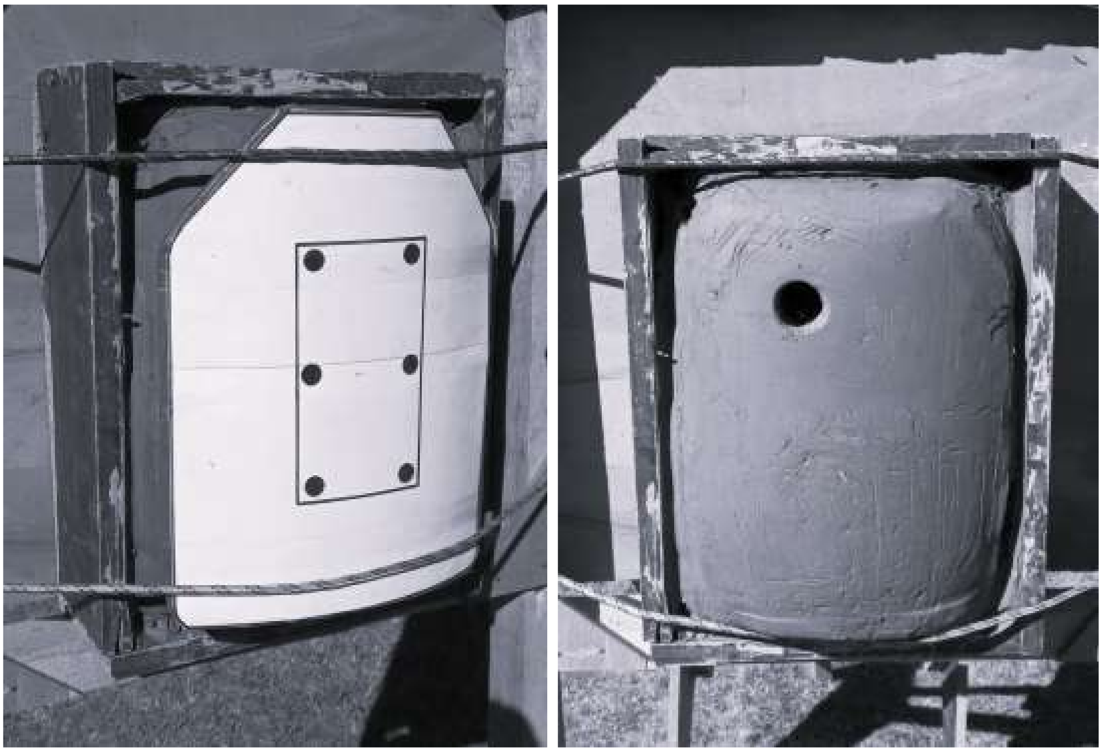

Figure 4. Plate 1 – Backing material fixture and its indentation

The field testing of the DIY ballistic Plate 2 was conducted following the established methodology:

1) The backing material fixture filled with the backing material was set at a distance of 5.0 m (measured using a laser range finder) and leveled using a laser leveler to ensure the angle of the shots.

2) Plate 2 was strapped to the BMF using elastic bands ensuring its wear face was in firm contact with the backing material.

3) One shot of 9x19mm FMJ Round Nose from a 9mm Sig Sauer SP2022 was fired at the plate resulting in no penetration. BFD was measured, backing material redistributed to ensure contact and the plate was restrapped.

4) Step 3) was repeated for 5 additional shots resulting in no penetration.

5) The backing material fixture filled with the backing material was set at a distance of 50.0 m (measured using a laser range finder) and leveled using a laser leveler to ensure the angle of the shots.

6) One shot of 7.62x51mm Open Tip Match from a 7.62mm Heckler & Koch MSG90A1 sniper rifle was fired at the plate resulting in complete penetration and partial disintegration of the BMF.

7) Testing was discontinued.

The strike face of Plate 2 post testing is shown on the left side of Figure 5 and the wear face with the complete penetration which was the result of the single rifle round fired is visible on the right.

Figure 5. Plate 2 – Post testing strike and wear faces

3. RESULTS AND ANALYSIS

Plate 1 could not resist the lowest level threat listed in the NIJ standard. The one shot fired on the plate resulted in complete penetration, making the plate unsuitable for ballistic protection from firearm projectiles. The bullet that penetrated Plate 1 was not deformed by the impact. However, it has lost its velocity and was found in the clay on the bottom of the BMF. This outcome highlights the limitations of the mathematical model, which is an idealization, and emphasizes the importance of material construction quality. The likely causes of failure include the fiberglass laminate not behaving as a solid, unified block, or the model's inability to account for all real-world factors influencing penetration.

Plate 2 resisted six hits by 9x19mm FMJ Round Nose ammunition without penetration to occur. However, it failed at stopping a single

7.62x51mm rifle round which was expected. Four of the hits on the plate would qualify as "fair", meeting the requirements for shot placement of the NIJ standard. The other three shots would either not meet the minimum shot-to-shot or shot-to-edge requirements. The shots that do not meet the criteria for "fair" hits that did not manage to penetrate the plate are to be considered a testament to its ballistic resistance qualities. The area which depicts the minimum edge-to-shot distance is designated as "Zone A" on the left side of Figure 6 and the positions of the hits are depicted on the right side. The shot locations numbered 1 to 6 are the pistol level threat hits and the one numbered 0 is the rifle level threat hit.

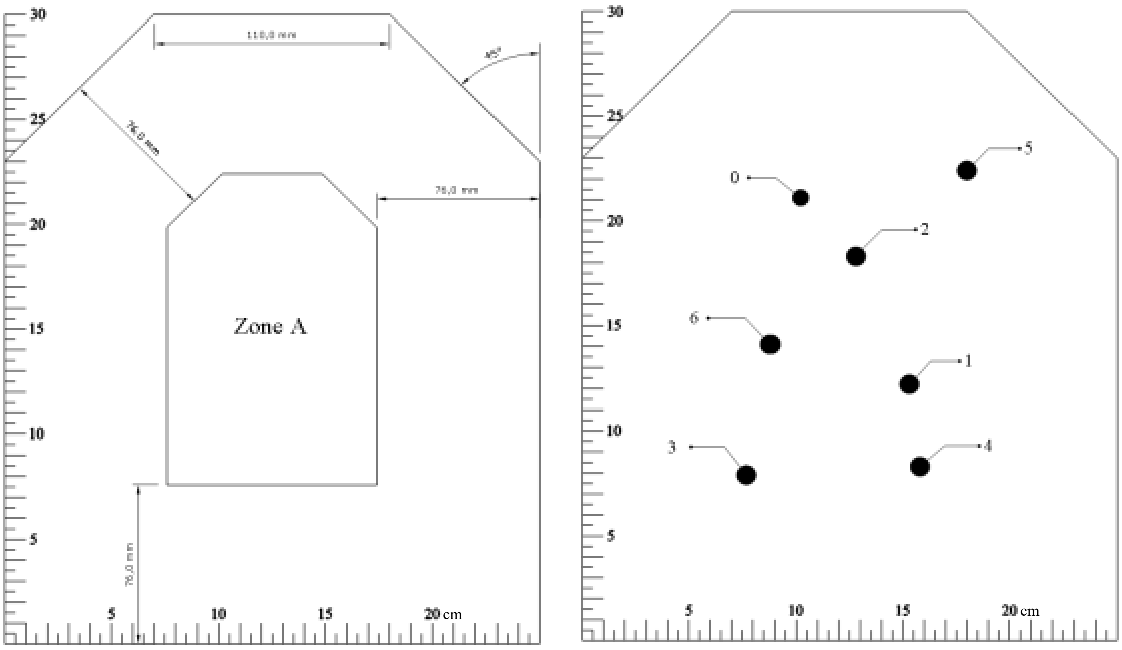

Figure 6. Hits on Plate 2

The average BFD is 13.33 mm which does not exceed the NIJ standard requirement for BFD of ≤ 44.0 mm. The results of the field testing of Plate 2 indicate that it might qualify for a NIJ rating of HG1 or higher, but it could not resist the lowest rifle level threat required for NIJ RF1.

The bullets and bullet fragments retrieved after the field testing are shown in Figure 7. On the left side are the 9mm bullets fired on Plate 1 and Plate 2. The bullet of shot № 2 fired on Plate 2 could not be dislodged from the plate for examination. On the right side of Figure 7 are the bullet fragments of the one 7.62mm bullet fired on Plate 2. It is clearly visible that the lead core (top) and its jacket (bottom) have separated after the impact with the plate.

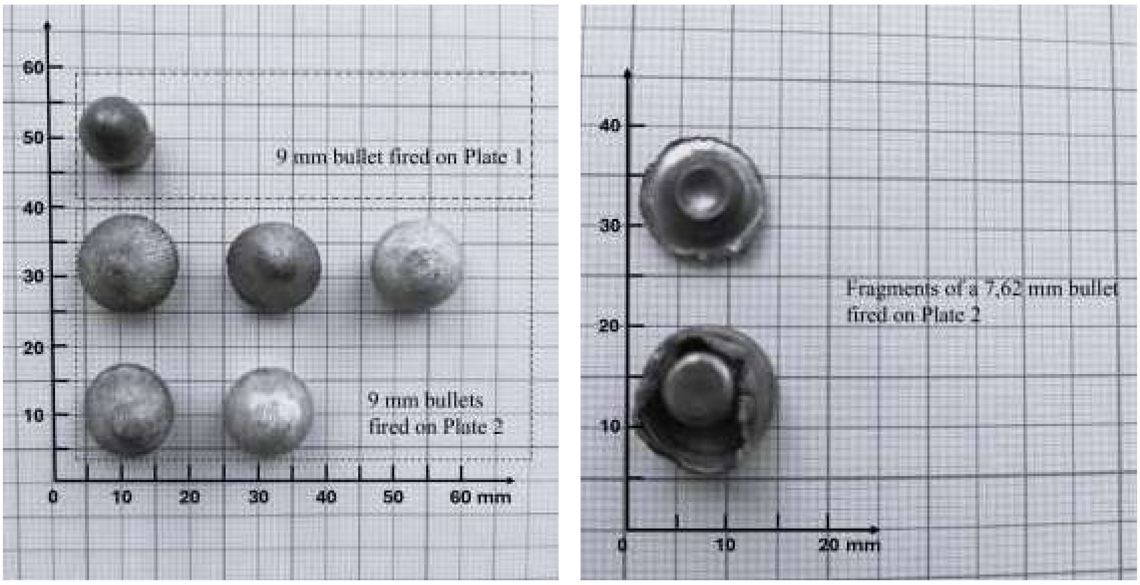

Figure 7. Bullets and bullet fragments retrieved after the field test

The measurements of the backface deformation resulting from hits on Plate 2 are shown in Table 7 below:

Table 7. Backface Signature

№	**Position of hits**		**Backface indentation**	
	X (mm)	Y (mm)	**Diameter** (D, mm)	**Depth** (H, mm)
0	102	211	—	—
1	153	122	32	19
2	128	183	35	17
3	77	79	34	14
4	158	83	32	14
5	180	224	15	4
6	88	141	36	12
AVERAGE:			30.66	**13.33**

The measurements of the deformation of the bullets after hitting Plate 2 are shown in Table 8:

Table 8. Deformation of bullets fired on plate 2

№	**Average diameter of the 9 mm bullets after impact**, mm
1	13.675
2	13.05
3	13.075
4	13.10
5	12.55
AVERAGE:	**13.09**
№	**Average diameter of the 7.62 mm bullet after impact**, mm
0	11.2

The deformation of the bullets increases their frontal area which reduces their penetration potential. The average increase in diameter for the 9 mm bullets is ~ 45.44% and the increase of the single 7.62 mm bullet is ~ 43.22%. The proximity of the values of the increases in the diameter that result from the deformation of the different types of bullets indicates a relation. However, the sample size is insufficient to support such claims.

CONCLUSION

The crafting of the DIY plates demonstrates that it is possible to make a ballistic plate that is significantly cheaper than the body armor panels manufactured by companies in that sector. Working with materials available in a hardware store that are not designed for use in ballistic protection makes the crafting process imperfect and the quality of the product questionable. However, the results of the field testing of the DIY ballistic plates show that some ballistic resistance could be achieved. Plate 2 would most likely qualify for NIJ HG1 protection level and even potentially cover the NIJ HG2 standard requirements, but that is not confirmed by test results.

The mathematical model for calculating penetration and the results of the field testing indicate that the current design of the DIY ballistic plates has room for improvement without increasing expenses. It is possible that using a different ratio in making the aluminium oxide epoxy mixture, removing the laminated epoxy fiberglass layer and replacing it with thicker AEM tiles could result in greater ballistic resistance.

Creating DIY body armor that can stop firearm projectiles is possible within the set parameters. Homemade ballistic plates can provide legitimate handgun protection in a difficult situation, but they do not match the rifle protection of certified plates. Nonetheless, the concept is not pure myth – effective low-level ballistic protection can indeed be crafted, as demonstrated. However, testing such ballistic plates outside a laboratory could be an extremely dangerous endeavor. The research presented in the article is driven purely by scientific interest, and the results are not to be used by individuals in attempts to create functional body armor.

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