EXPERIMENTAL DETERMINATION OF TARGET AREA LIMITS AT SHOOTING WITH SMALL ARMS WITH FITTED SILENCER

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Abstract: *Currently terrorism is one of the biggest threats for the security on national and international level. The increase of the terrorist activities led to the expansion of tasks performed by the Armed Forces. In a significant part of cases due to the specificity of the anti-terrorist activity the sound of the shots should be hidden. This can be achieved by using special devices called suppressors. That require determine of target area limits which is the purpose of that report.*

Keywords: SMALL ARMS, SILENCER, TARGET AREA LIMITS.

1. Introduction

Global acts of terrorism points out new threats to international peace and security through intentional acts of violence against the civilian population in order to achieve certain political and economic ideas.

Struggling with terrorist organizations demands an alteration in traditional perceptions of military activity and tactical usage of small arms. There by the use of special small arms equipment for anti-terrorist units is required. Parts of this special equipment are the suppressor, which allows the sound of the shot to be reduced by lowering the temperature and velocity of the effluent gases.

On the other hand, the use of special equipment for individual ballistic protection demands high efficiency for small arms. High efficiency is achieved by increased precision and shots grouping, which represents impact area at shooting with small arms.

In military units of the Republic of Bulgaria, main type of small arm is the automatic rifle AK-47. The suppressor designed for AK-47 is PBS-1, a chamber type suppressor with a rubber chopper wheel.

The survey of available literature in the Republic of Bulgaria reveals that the wear of the rubber chopper wheel has an impact on the shots grouping, but there cannot be found any results about experimental determination of target area limits at shooting with small arms with a fitted suppressor.

Based on the facts above and to determine the target area limits in semi-automatic fire mode using a fitted chamber type suppressor with rubber chopper wheel, in this report several researches have been conducted.

2. Experimental determination of the target area limits

2.1. **Purpose:** experimentally to determine the dimensions of the target area limits in semi-automatic fire mode with small arms using fitted chamber type suppressor with a rubber chopper wheel.

2.2. Objectives:

- to determine the mathematical expectation and the standard deviation of the impact points;

- to determine the vertical and horizontal target area limits where 100% of the impacts are on target.

In order to achieve the purpose of this report, data obtained from the experimental investigation will be used, described in [1]. Deviations of the hits from the control point in the horizontal and vertical plane are to be determined.

Deviations of the hits from the control point are shown horizontally in Table 1 and vertically in Table 2.

Table1: *Deviations of hits from control point horizontally*

Deviation of hits from control point horizontally in centimetres	Series № 1	2	3	4	5	6	7	8	9	10
1	0,00	-8,30	-18,90	-19,70	-9,50	-16,40	2,20	-1,20	-7,00	-27,30
2	-7,00	-8,40	-20,80	-20,60	-17,20	-18,20	2,20	-1,50	-8,30	-28,40
3	-7,70	-9,50	-21,80	-25,00	-20,60	-19,80	6,40	-3,50	-10,00	-31,20
4	-10,00	-10,20	-22,00	-25,80	-20,90	-20,00	7,50	-3,80	-11,30	-32,50
5	-10,20	-11,00	-23,70	-26,50	-22,40	-20,50	-1,00	-4,00	-12,60	-35,80
6	-12,50	-12,00	-24,90	-26,60	-22,50	-22,80	-1,20	-8,50	-12,80	-35,80
7	-12,70	-14,00	-25,00	-26,60	-22,70	-23,50	-1,40	-10,00	-13,70	-36,00
8	-13,20	-16,00	-26,00	-26,80	-23,50	-23,50	-2,00	-10,30	-13,80	-36,60
9	-14,40	-17,30	-26,60	-27,20	-23,60	-23,70	-2,80	-11,40	-13,90	-36,70
10	-15,20	-18,00	-26,80	-27,80	-27,40	-24,10	-2,80	-12,00	-14,00	-37,00
11	-15,60	-18,20	-27,20	-28,90	-27,70	-25,00	-3,40	-12,30	-15,40	-39,50
12	-16,30	-19,60	-27,80	-29,50	-27,60	-26,00	-4,00	-13,00	-15,70	-40,20
13	-17,40	-20,70	-27,30	-29,80	-27,80	-26,30	-5,40	-15,00	-16,10	-40,40
14	-18,90	-21,10	-25,80	-30,60	-28,60	-26,40	-6,00	-18,00	-17,40	-40,60
15	-19,30	-22,10	-29,30	-31,20	-29,10	-27,80	-7,40	-18,60	-17,50	-40,70
16	-19,40	-24,00	-29,70	-31,80	-29,60	-28,80	-9,60	-20,70	-18,00	-41,20
17	-20,00	-24,20	-30,40	-33,90	-29,40	-29,50	-9,90	-21,50	-18,10	-41,50
18	-22,60	-25,30	-29,50	-34,90	-32,30	-31,80	-10,00	-22,80	-19,50	-43,20
19	-25,50	-26,30	-32,50	-35,60	-33,40	-32,00	-14,00	-23,60	-22,50	-46,40
20	-28,50	-31,00	-34,30	-41,40	-35,80	-38,00	-19,70	-23,60	-23,00	-48,50

Table2: *Deviations of hits from control point vertically*

Deviation of hits from control point vertically in centimetres	Series № 1	2	3	4	5	6	7	8	9	10
1	13,50	33,00	18,80	8,30	-8,40	-5,20	0,80	15,60	5,80	35,60
2	6,80	32,30	9,50	1,50	-6,00	-4,50	-7,00	-3,10	6,40	29,30
3	18,00	31,90	10,10	11,00	-8,50	-3,40	-7,20	12,90	3,80	39,00
4	15,00	34,40	6,50	4,30	3,60	-2,60	0,80	11,90	5,50	29,00
5	22,00	29,70	12,80	1,00	6,30	-4,20	-0,50	7,80	3,30	-4,00
6	11,80	31,50	14,40	3,40	-5,20	-2,00	-1,70	17,80	1,80	26,80
7	13,00	27,40	14,00	3,20	12,00	-3,70	4,40	16,50	-4,70	26,40
8	22,90	26,80	15,10	10,70	1,90	-6,80	0,80	13,50	2,80	31,40
9	14,20	30,90	3,80	-0,60	7,40	-2,20	-2,10	13,50	-5,60	18,80
10	27,80	32,30	14,60	-0,80	4,20	-3,70	8,50	19,80	-14,70	28,20
11	15,50	28,00	14,50	2,80	3,20	-8,50	0,40	18,60	5,80	33,80
12	15,50	30,00	8,70	0,90	10,50	-7,50	3,70	6,20	4,70	30,60
13	13,00	26,20	10,00	12,60	6,80	-6,40	-0,60	-1,70	3,60	26,20
14	17,10	32,50	21,00	10,00	18,60	-5,00	12,20	2,00	-6,20	34,40
15	18,80	17,90	13,50	12,10	6,50	-2,20	4,20	9,60	-2,30	24,30
16	17,00	30,60	17,00	12,50	9,60	-5,90	-0,20	2,80	4,60	20,80
17	15,80	32,00	17,70	9,10	11,30	-9,20	-0,60	1,80	-0,90	34,50
18	16,10	29,20	21,80	7,20	13,30	-8,30	0,60	-7,70	0,80	17,50
19	25,40	24,00	16,00	12,50	9,20	-3,20	0,50	-1,40	4,50	24,40
20	17,10	5,60	5,50	10,20	7,00	-7,60	4,80	-4,50	3,60	19,20

The position of hits' deviation from control point is represented graphically on Fig. 1.

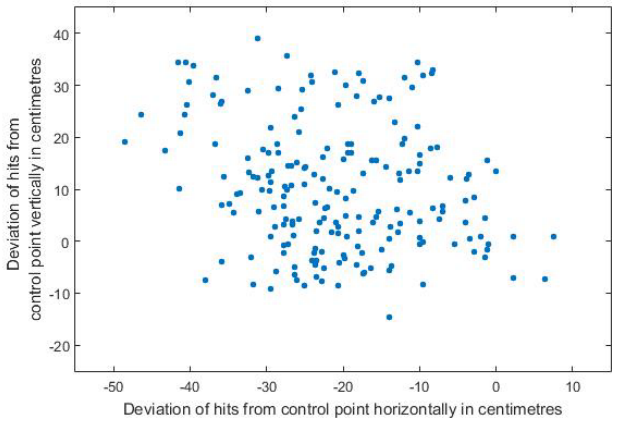

Fig. 1 *Graphics of hits' deviation from control point.*

The results are recorded in the following matrix:

$$m = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

The quantities are defined as:

n = 10 –number of series;

m = 20 –number of shots per series.

To define the mathematical expectation and the standard deviation of the hits by using mathematical software Math Lab, following equations would be used:

- for mathematical expectation:

$$\chi = \frac{1}{n}\sum_{i=1}^{n} x_i,$$

- for the standard deviation:

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \chi)^2}$$

In these equations, the quantities are defined as:

n- number of series on the basis of which the arithmetic mean value is determined;

x_i –value of i^{th} *(i=1..n)* examined deviation.

On Fig. 2 and 3 are presented the deviations on the series and histograms for each series.

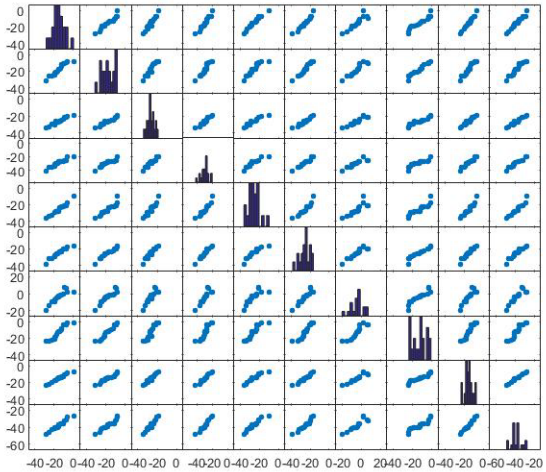

Fig. 2 *Deviations and histograms - horizontally.*

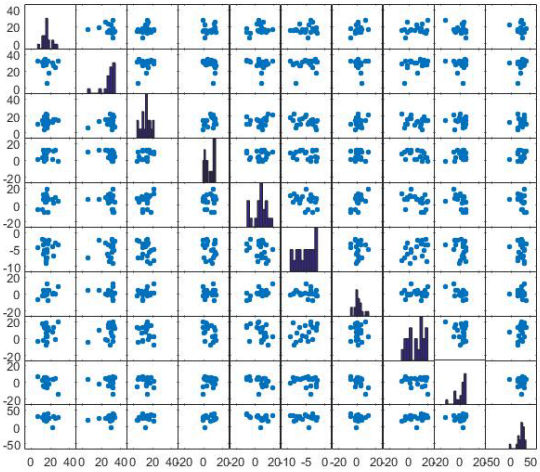

Fig. 3 *Deviations and histograms - vertically.*

In table 3 the mathematical expectation and the standard deviation of the hits in horizontal and vertical plane are presented.

Table3: *Mathematical expectation and standard deviation of series hits*

	Series №									
	1	2	3	4	5	6	7	8	9	10
χ horizontally in centimetres	-15,32	-17,86	-26,52	-29,01	-25,58	-25,21	-4,12	-12,77	-15,03	-37,98
χ vertically in centimetres	16,82	28,31	13,27	6,60	5,17	-5,11	1,09	7,60	1,13	26,31
σ horizontally in centimetres	6,48	6,43	3,79	4,91	5,88	5,07	6,38	7,35	4,10	5,29
σ vertically in centimetres	4,71	6,38	4,82	4,71	7,18	2,24	4,38	8,34	5,26	9,06

Table 4 presents the calculated mean values of the mathematical expectation and the standard deviation from the conducted experimental investigation with a chamber type suppressor with a rubber chopper wheel in semi-automatic fire mode.

Table4: *Mean values of mathematical expectation and standard deviation*

	mean value of **χ** in centimetres	mean value of **σ** in centimetres
horizontally	-20,938	5,568
vertically	10,117	5,707

Experimental data analysis shows that the deviation of hits horizontally is approximately 210 mm to the left and deviation of hits vertically is approximately 101 mm upwards, which leads to necessity to adjust sights of small arms before shooting with fitted chamber type suppressor with a rubber chopper wheel.

The analysis shows that the wear of the rubber chopper wheel has a significant impact on the deviation of the hits from the control point by constantly shifting them in different directions along the horizontal and vertical planes, but the hits grouping is influenced in a significantly lower level.

From the analysis made, using the mean values of σ and the rule of the three σ – are determined the dimensions of the target area limits on the vertical and the horizontal planes in which the 100% of the bullet hits.

The rule of the three σ sets a range in which all values of normal distributed random variable fall within, with confidence level not less than 99.7%. This range represents $\pm 3\sigma$ about mathematical expectation as shown in Figure 4.

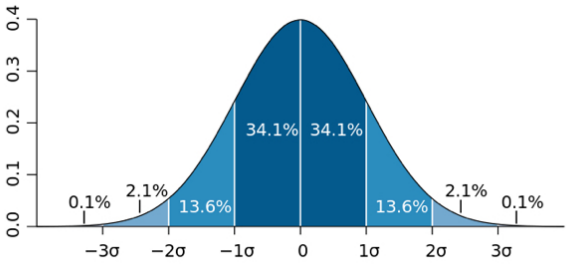

Fig. 5 *Graph of normal distribution probability of hits in standard deviation range.*

On Fig. 5 according to the rule of the three σ's with outer ellipse is graphically represented the probable dispersion and with the inner circle - the limits of the allowed deviation of the hits from the control point, which coincides with a deviation ± σ.

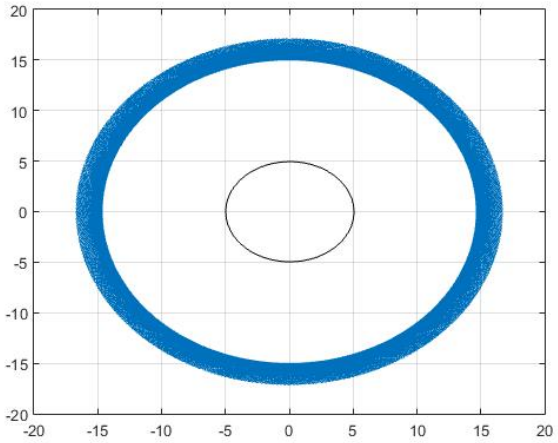

Fig. 5 *Graphic depiction of the target area limits.*

The research shows that the target area limits in which with 99.7% probability the hits fall into, within the approximate range of:

- horizontally

$$x = 3\sigma .2 = 3.55{,}68 .2 = 334{,}08 \text{ mm}$$

- vertically:

$$y = 3\sigma .2 = 3.57{,}07 .2 = 342{,}42 \text{ mm}$$

Within the permissible deviation of the hits from the control point, which almost coincides with a deviation ± σ, the probability of a hit is 68%.

3. Conclusion

From the conducted research, it is clear that in order to ensure reliable target damage, it is necessary to shoot at least two rounds on target, larger than 350 X 350 millimeters and the weapon needs to have its sight adjusted when using fitted suppressor.

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