Research Article
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Experimental study on exclusively the size and morphology of the gas dispersion cone in 5.56 mm and 7.62 mm rifles – used by core (special resources coordination) / pcerj (civil police of the state of Rio de Janeiro)

Abstract

This experimental study aimed to observe, record, and document the dimensions of the gas and residue dispersion cone produced at the moment of firing rifles chambered in 5.56 × 45 mm NATO and 7.62 × 51 mm NATO, which are operationally used by CORE/PCERJ personnel. The investigation focused exclusively on the geometric characterization of the dispersion cone, analyzing its shape, amplitude, and visible boundaries at different distances between the muzzle and the target, specifically 15 cm, 30 cm, 50 cm, and 1.0 meter. The experiment was conducted in a closed, non-ventilated environment in order to minimize external environmental interference and ensure greater control of the variables involved. The results allowed for the objective documentation of the dispersion cone configuration and its progressive reduction as distance increased, providing relevant technical support for forensic ballistic interpretation, reconstruction of firearm-related events, and the improvement of police training activities.

Keywords: Dispersion con,; muzzle gases, long guns, firearm forensics, ballistic analysis.

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Introduction

This document presents an experimental study developed to observe, record, and document the dimensions of the gas dispersion cone produced at the moment of firing of rifles[1,2] used operationally by the Special Resources Coordination Unit of the Civil Police of the State of Rio de Janeiro. The investigation adopted a strictly geometric approach, restricting itself to the analysis of the aperture, shape, and visible amplitude of the dispersion cone at distances classified as short, according to parameters established in the specialized ballistic literature. The central objective was the objective documentation of the spatial behavior of gases, without the intention of establishing inferences of a physicochemical or dynamic nature. It is deliberately emphasized that the scope of this study did not include the evaluation of the number of ejected particles, their chemical composition, the velocity or pressure of the gases, the presence of metallic residues, nor the analysis of grouping or dispersion patterns of the projectiles. These methodological limitations aim to ensure the accuracy of the experimental design, as well as to avoid interpretative extrapolations incompatible with the data actually observed.

Objective

To evaluate exclusively the size and morphology of the gas dispersion cone produced at the moment of firing weapons in calibers 5.56 × 45 mm NATO and 7.62 × 51 mm NATO, at previously standardized distances between the muzzle and the target, namely: 15 cm, 30 cm, 50 cm and 1.0 meter.[3,4]

Experiment location

The experimental tests were conducted at the Shooting Range of the City of Police, belonging to the Civil Police of the State of Rio de Janeiro. The location is characterized as an enclosed environment devoid of artificial or natural ventilation, a condition that allowed the elimination of external interferences, such as wind or air currents.

This environmental setup ensured greater control over the experimental variables, providing uniformity and reproducibility in the observations, especially with regard to the shape and dispersion of the gases resulting from the firing.

Theoretical framework (summary)

Specialized literature classifies shooting distances into three main categories: short, medium, and long range.[5–8]

Short distance

There is gaseous action, partially burned particles, and thermal influence. In long guns, the gaseous action can extend over 1 meter.

Average distance

Thermal action disappears; projectile remains and possibly scattered particles with no interpretative value. Typically between 1.0 m and 1.5–2.0 m.

Long distance

No significant gas action. Generally above 1.5–2.0 m, depending on the caliber and weapon.

Methodology

I. **Weapons used:**rifles in calibers 5.56 × 45 mm NATO and 7.62 × 51 mm NATO.

II. Rifle, caliber 7.62x51mm NATO, American made (ARMALITE), model AR10, 16-inch barrel, with original flash suppressor fixed to the muzzle.

For the reader's better understanding, in the photograph provided above, on the left, we present the 7.62x51mm NATO caliber rifle, manufactured in the United States (ARMALITE), model AR10, with a 16-inch barrel, and on the reader's right, we present the original flash suppressor fixed to the muzzle.

I. Next, we present the ammunition used: CBC (Company) Brazilian Cartridge Company.

For the reader's better understanding, in the photograph provided above, on the left, we present the ammunition box used in the 7.62x51mm NATO caliber rifle and, on the right, the ammunition already properly displayed.

I. 5.56× 45 mm NATO caliber rifle, American made (SIG SAUER), model SIGM 400 Pro, 14.5-inch barrel, with original flash suppressor fixed to the muzzle.

For the reader's better understanding, in the photograph provided above, on the left, we present the 5.56 × 45 mm NATO caliber rifle, of American manufacture (SIG SAUER), model SIGM 400 Pro, 14.5-inch barrel, and on the right, we present the original flash suppressor fixed to the muzzle.

For the reader's better understanding, in the photograph provided below, on the left, we present the ammunition box used in the 5.56 × 45 mm NATO caliber rifle and, on the right, the ammunition already properly displayed.

I. TARGET - Mannequin: TPE (thermoplastic elastomer) model, "painted" with white Decor Multi-Use Spray paint for standardization and contrast, facilitating the visualization of the cone, while being fixed to a flat surface.

I. TARGET - Mannequin: TPE (thermoplastic elastomer) model, "dressed" in white shirts, for better visualization of the cone, composed mainly of cotton fabric.

I. Distances measured: 15 cm, 30 cm, 50 cm, 1.0 m.

II. Two shots were fired for each stipulated distance, for a total of 8 shots for each caliber studied, half at the mannequin "painted" with paint and the other half at the mannequin "dressed" in a shirt.[9,5]

III. All shots were fired with the weapons firmly supported on a tripod, at a fixed height of 110 cm from the ground, which ensured the stability of the assembly and prevented any variation

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in positioning between shots. The only variables controlled during the tests were the distance to the target and the nature of the target, which could consist of a painted surface or a target covered by clothing.

IV. It was not deemed necessary to continue the tests with an increased distance of the gun barrel from the target, since no significant changes were observed in the morphology or dimensions of the dispersion cone when comparing the results obtained at distances of 50 cm and 1.0 m.

V. Variables analyzed:

The behavior of the scattering cone was analyzed exclusively as a function of the distance between the gun barrel and the target. No particle collection or physicochemical measurements were performed, since the study is strictly descriptive and based on visual analysis.

Results achieved

High-definition visual documentation was obtained, allowing for detailed observation of the dispersion cone's shape at the different sizes and distances analyzed. From this analysis, it was possible to identify:

I. The type of characteristic dispersion cone produced by the weaponry employed by CORE;

II. The progressive reduction in the density of the scattering cone as the distance between the gun barrel and the target increases;

III. The almost complete attenuation of the visible scattering cone from a distance of 1.0 m from the target.

Next, we will present the results obtained with the targets and distances described; initially, the results obtained when studying the 7.62x51mm NATO caliber rifle.

Initially, photographs are presented that show the scattering cones observed at a distance of 15 cm from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted


With the shirt


I. When comparing the targets, it was found that the one fired against the shirt fabric presented a large tear, predominantly horizontal, with a significantly greater extent than the vertical axis, and its edges were charred.

II. Regarding the dispersion cone, no relevant differences were observed between the targets analyzed, both presenting approximately similar diameters.

III. The barrier formed by the shirt, despite the tear caused by the gunshot, was not sufficient to alter the morphology of the dispersion cone, with a concentration of the cone's constituent elements observed in both cases.

Next, photographs are presented that show the scattering cones observed at a distance of 30 cm from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted


With the shirt


I. At a distance of 30 cm from the target, the presence of the shirt proved relevant in terms of the concentration observed in the dispersion cone. The tears identified in the fabric were smaller, with a roughly oval morphological pattern, and no areas of charring were observed.

Next, photographs are presented that show the scattering cones observed at a distance of 50 cm from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted


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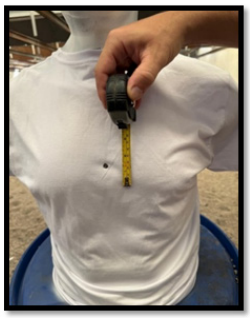
With the shirt

I. At a distance of 50 cm from the target, macroscopic evaluation showed that the dispersion cone becomes practically imperceptible, both with and without the shirt. The observed pattern is sparse, so that, for a safe and unequivocal affirmation of the occurrence of a shot at close range, complementary examinations are necessary, at the expert's discretion.

Next, photographs are presented that show the scattering cones observed at a distance of 1.0 m from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted

With the shirt



At a distance of 1.0 m from the target, macroscopic evaluation did not allow for the identification of the dispersion cone, both with and without the shirt. The observed pattern appeared sparse, so that, in our view, further examinations are necessary to confirm with certainty that a shot was fired at close range.

I. The following presents the results obtained with the targets and distances previously described, relating to the study carried out with the 5.56 × 45 mm NATO caliber rifle.

II. Initially, photographs are provided showing the cones found when placed 15 cm from the target; starting with the target only painted and then dressed with the shirt.

Painted

With the shit

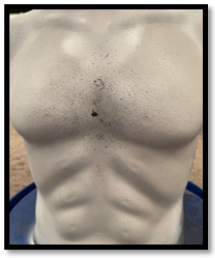
I. When comparing the targets, it was found that the one hit by a shot against the shirt fabric presented a large tear, distinct from the pattern observed in the 7.62 mm caliber, in which the shape tends to be roughly rounded. However, similarly to what was observed with the 7.62 mm caliber, the edges of the tear produced by the 5.56 mm caliber were charred.

II. Regarding the dispersion cone, no relevant differences were identified between the targets analyzed, both presenting approximately similar diameters.

III. The barrier represented by the shirt, despite the tear produced by the gunshot, was not sufficient to alter the morphology of the dispersion cone, with a concentration of the constituent elements of the cone being observed in both cases.

Next, photographs are presented that show the scattering cones observed at a distance of 30 cm from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted



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With the shirt

I. At a distance of 30 cm from the target, the presence of the shirt proved relevant in terms of the concentration of the dispersion cone observed on the mannequin. The tears identified in the fabric were smaller, with an irregular morphological pattern, and no areas of charring were observed.

II. On the other hand, in the shirtless mannequin, the dispersion cone showed a larger diameter when compared to that observed with the 7.62 mm caliber rifle, although with a lower degree of concentration of its constituent elements.

Next, photographs are presented that show the scattering cones observed at a distance of 50 cm from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted

With the shirt

I. At a distance of 50 cm from the target, similarly to what was observed in the study concerning the 7.62 mm caliber, the macroscopic evaluation practically did not allow the identification of the dispersion cone, both in the presence and absence of the jacket. The observed pattern was sparse, so that, in our view, complementary examinations are necessary for a safe and unequivocal affirmation of the occurrence of a shot at close range.[7,10]

Next, photographs are presented that show the scattering cones observed at a distance of 1.0 m from the target, beginning with the documentation obtained with the target only painted and, subsequently, with the target covered by a shirt.

Painted

With the shirt

At a distance of 1.0 m from the target, macroscopic evaluation did not allow for the identification of the dispersion cone, both with and without the shirt. The observed pattern appeared sparse, so that, in our view, further examinations are necessary to confirm with certainty that a shot was fired at close range.

Final considerations (revised and expanded version)

This study provides an objective, experimental, and applied basis for understanding the behavior of the gas and gunfire residue (GSR) cone on the target,[7,11] at distances classified by the specialized literature as short range, using weapons routinely employed by CORE components.

The results obtained demonstrated that, at distances of 50 cm and 1.0 meter, it was not possible to macroscopically identify a typical dispersion cone, both in targets without clothing and in those covered by a shirt, regardless of the caliber analyzed (5.56 mm or 7.62 mm).[7,12] Under these experimental conditions, the deposition pattern of the residues proved to be sparse and uncharacteristic, not allowing, based solely on macroscopic evaluation, the categorical statement that the shot occurred at close range.

This finding reinforces the need for caution in forensic interpretation, especially in contexts where the analysis is limited to visual examination of the target or clothing. In light of the observed results, it is understood that, for the unequivocal confirmation of a shot fired at close range, it is essential to carry out complementary examinations, such as microscopic, chemical, or instrumental analyses specifically for the detection of gunshot residue.

Although this is a simple experimental record, the study has practical and scientific relevance, as it complements existing literature with direct documentation obtained in a controlled environment, using real weapons and conditions compatible with everyday operational and forensic situations. Therefore, the data presented here contribute to improving forensic ballistic interpretation, assisting both

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in technical training and in decision-making in forensic examinations related to events involving firearm discharges.

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Conflicts of interest

The authors report no conflict of interest.

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