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**Specifics of fire damage to cotton clothing
while shooting point-blank
at a human torso simulator from a Fort-12RM pistol**

This Article Purpose is to determine specifics of damage to cotton jersey, arising from a point-blank shot from a nickel-plated "Fort-12RM" pistol, equipped with .45 Rubber cartridges into dressed simulator of a human torso made of ballistic gel. For achieving this goal, 12 human torso simulators were made, dressed in cotton T-shirts, with the subsequent firing of shots using a nickel-plated "Fort-12RM" pistol equipped with .45 Rubber cartridges. The shots were fired from a distance, closely followed by examination of damage to clothing using photographic and microscopic research methods. Obtained data and

their comparison with the previously obtained research results when the shots were fired at the clothing samples, fixed in the frame made it possible to identify important differences and for the first time describe the phenomenon of internal muzzle imprint mark and volumetric muzzle imprint mark; while describing the internal muzzle imprint mark, specific deposition of additional factors of the shot (namely, soot), reminiscent of a candle flame was found. In addition, a double marker phenomenon was observed around the input gunshot injury on the investigated human torso simulator. Most of additional factors of the shot (in form of soot and dust particles of unburned gunpowder) were determined in wound channel. While carrying out the contact-diffusion method of research, small particles of nickel were determined around input fire damage to the simulator. The revealed differences require revision of the classical method of experimental shooting, while test samples of clothing are fixed in a frame or fixed in a similar way. An important stage in research formulation is to recreate the conditions as close as possible to real ones. The search for the most appropriate, efficient and simple method for carrying out such experiments is promising for ballistics.

Keywords: “Fort-12RM”, ballistic gel, gunshot damage, point-blank shot, non-lethal weapon, muzzle imprint mark.

Formulation of Research Problem. Non-lethal weapons are becoming more common both in military formations and among the civilian population, as this type of weapon is not designed to destroy the enemy, but only to neutralize it with minimal damage to health. However, this does not prevent criminals from using this type of weapon to commit criminal acts. This is especially true of non-lethal weapons (mostly traumatic pistols) ¹.

According to the US Department of Justice in 2016 ², among those serving sentences for crimes committed in federal prisons, 8,300 people committed criminal offenses using firearms (700 murders, 600 rapes, 1,600 robberies, 700 armed attacks), out of these 43.2% received weapons illegally and only 10.1% bought it in gun shops. There has been a significant increase (from 33 to 112%) in the use of semi-automatic weapons in offenses ³.

¹ E.g., Alper M., Glaze L. Source and Use of Firearms Involved in Crimes: Survey of Prison Inmates, 2016. *U. S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics*. 2019. January ; Hiquet J., Gromb-Monnoyeur S. Severe craniocerebral trauma with sequelae caused by Flash-Ball® shot, a less-lethal weapon: Report of one case and review of the literature. *SAGE Journals*. 2015. June, 30 ; Koper C. S., Johnson W. D., Nichols J. L., Ayers A., Mullins N. Criminal Use of Assault Weapons and High-Capacity Semiautomatic Firearms: an Updated Examination of Local and National Sources. *Journal of Urban Health*. 2017. October, 02 ; Ribeiro A. P., Souza E. R. de, Sousa C. A. M. de. Injuries caused by firearms treated at Brazilian urgent and emergency healthcare services. *Ciênc. saúde coletiva*. Rio de Janeiro, 2017. Set. Vol. 22. No. 9.

² Alper M., Glaze L. *Ibid*.

³ Koper C. S., Johnson W. D., Nichols J. L., Ayers A., Mullins N. *Ibid*. Pp. 313—321.

During the 90 days in 2016, Indian law enforcement agencies in the Kashmir region, armed with traumatic pistols, inflicted nearly 10,000 injuries and killed 80 people. The same source said that the use of traumatic firearms by paramilitary groups in 2010 killed 120 people ¹.

B. Dumenčić and co-authors ² estimate that between 1998 and 2018, the use of gas weapons led to 69 deaths in Croatia.

In Brazil in 2014, the use of firearms caused 45,068 deaths. And 71.6% of all murders in the country: it is with the use of firearms ³.

As for Ukraine, after the beginning of the Russian aggression in 2014 the criminogenic situation worsened that is connected, in particular, with illegal input of firearms from the ATO zone ⁴. Prior to that, without significant practical experience, forensic medicine in Ukraine for the first time encountered the widespread use of various types of firearms (both non-lethal and lethal), which caused fatalities in the final stages of the Revolution of Dignity ⁵.

Because of all these factors, there is an urgent need for research to determine the specifics of the damage caused by firearms, including non-lethal action, which will help in identifying the weapon, determining the distance of the shot, and so on. Of particular interest are the damage from firearms in the case of shooting point-blank ⁶. Currently, most wound ballistics research is performed using ballistic gel cubes ⁷, and clothing damage research is performed by fixing

¹ David S. Use of pellet guns for crowd control in Kashmir: How lethal is “non-lethal”? *Indian journal of medical ethics*. 2016. December, 20.

² Dumenčić B., Rajc J., Pavoković D., Damjanović T. Fatal injury by air gun: a case report. *Egyptian Journal of Forensic Sciences*. 2020. July, 21.

³ Ribeiro A. P., Souza E. R. de, Sousa C. A. M. de. Ibid. Pp. 2851—2860.

⁴ Ленъ В. В., Олійников Г. В. Незаконний обіг вогнепальної зброї, бойових припасів, вибухових речовин та пристроїв, пов'язаний із проведенням антитерористичної операції: окремі питання запобігання. *Право і суспільство*. 2016. № 1. P. 204—208.

⁵ Mishalov V. D., Petroshak O. Y., Hoholyeva T. V., Gurina O. O., Gunas V. I. Forensic assessment of gunshot injuries in Maidan Nezalezhnosti protesters. *World of medicine and biology*. 2019. Vol. 3 (69). Pp. 118—122.

⁶ Pircher R., Bielefeld L., Geisenberger D., Perdekamp M. G., Pollak S., Thierauf-Emberger A. Muzzle imprint mark: a patterned injury which may be constituted of intradermal blood extravasations. *Forensic science international*. 2014. Vol. 244. Pp. 166—169.

⁷ Perdekamp M. G., Glardon M., Kneubuehl B. P., Bielefeld L., Nadjem H., Pollak S., Pircher R. Fatal contact shot to the chest caused by the gas jet from a muzzle-loading pistol discharging only black powder and no bullet: Case study and experimental simulation of the wounding effect. *International Journal of Legal Medicine*. 2015. Vol. 129 (1). Pp. 125—131.

the material in a frame ¹. However, it should be noted that the results of such experiments may be inaccurate, because they do not take into account the physiological shape of the human body and the presence of clothing, which is not only a common obstacle, but also a factor that (along with the human torso simulator) damage.

All this requires research using modern models of domestic firearms of non-lethal action on the human torso simulators and clothing together as one complex.

Analysis of Essential Researches and Publications. Once this issue was studied by P. Yu. Bobkov, M. F. Lebed, A. M. Perebetiuk, V. I. Hunas, O. M. Hurov, S. V. Kutsenko, V. V. Shcherbak, D. B. Hladkykh, V. V. Sapielkin and other scientists ².

The **Article Purpose** is to determine specifics of damage to cotton jersey, arising from a point-blank shot from a nickel-plated *Fort-12RM* pistol, equipped with .45 Rubber cartridges into dressed simulator of a human torso made of ballistic gel.

Main Content Presentation. For achieving this goal, 12 human torso simulators were made according to the generally accepted method of making gelatin blocks ³ with adaptation of the authors (10 % edible gelatin 270 Bloom, obtained from Scientific Research Center National Pirogov Memorial Medical University), dressed simulators in white, cotton T-shirts of the appropriate size and fired at them from *Fort-12RM* pistol equipped with .45 Rubber cartridges.

The shots were fired point-blank (hermetically), at right angles, with a preliminary fixation of the weapon in the vise in the shooting range of the Vinnytsia Scientific Research Forensic Center (within the framework of the cooperation agreement between National Pirogov Memorial Medical University and the Vinnytsia Scientific Research Forensic Center). Performed 4 shots at each

¹ Бобков П. Ю., Лебедь М. Ф., Перебетюк А. М., Гунас В. І. Судово-медична характеристика вогнепальних пошкоджень шкірозамінника при пострілах із пістолета «Форт-17Р» (Актуальні питання судово-медичної експертизи). *Буковинський медичний вісник*. 2019. Т. 23. № 2 (90). Р. 51—56 ; Bobkov P., Perebetiuk A., Gunas V. Peculiarities of gunshot injuries caused by shots Fort-12RM pistol using cartridges of calibre. 45 Rubber. *Folia Societatis Medicinae Legalis Slovacae*. 2019. Vol. 9. Nr. 1. Pp. 44—48 ; Щербак В. В. Морфологічні особливості вогнепальних пошкоджень при пострілах впритул із пістолета «Форт-12» в залежності від матеріалу одягу. Судово-медична експертиза : наук.-практ. журн. 2014. № 1. Р. 41—45.

² Бобков П. Ю., Лебедь М. Ф., Перебетюк А. М., Гунас В. І. Op.cit. Bobkov P., Perebetiuk A., Gunas V. Ibid ; Гуров О. М., Куценко С. В., Щербак В. В., Гладких Д. Б., Сапелкін В. В. Механізм утворення подвійної штанцмарки при пострілах із пістолетів модельного ряду Форт. *Судово-медична експертиза* : наук.-практ. журн. 2019. № 1. Р. 60—65.

³ Stevenson T., Carr D. J., Stapley S. A. The effect of military clothing on gunshot wounding patterns in gelatine. *International Journal of Legal Medicine*. 2019. Vol. 133. Pp. 1121—1131.

simulator on its anterior surface in the left and right thoracic areas, epigastrium and umbilical area. Subsequently, damage to clothing and the surface of the ballistic gel was examined under normal lighting using photographic and microscopic examination methods. In order to detect unburned gunpowder particles, Aidlin's, Vladymyrskiy's reactions and the microscopic method of examination were used. Microscopic examination was performed using the MBS — 10 microscope under a magnification of 4.8x to 56x. The metallization of the lesions was studied using the contact-diffusion method of the study.

As a result of a series of shots (4 shots in each simulator) there were 48 gunshot wounds, of which: 11 formed a defect of clothing round shape (average diameter of the defect — 1.35 cm), 37 — oval shape (average size 1.67 × 1), 38 cm, Fig. 1).

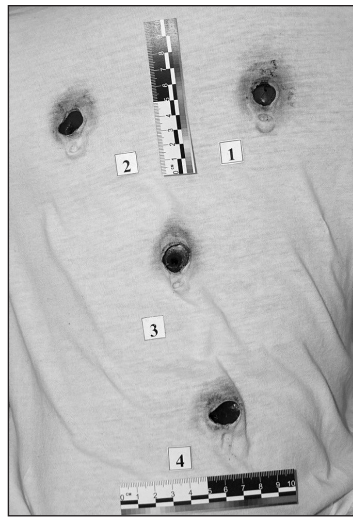


Fig. 1. General view of the mannequin after a series of shots

The edges of the damage are uneven, pointed, turned inward by about 0.10—0.15 cm in the direction of flight of the bullet, disheveled, thinned, slightly scorched, dark gray and black-gray. Externally around the damage, soot deposits of indefinite shape of light gray, gray and black-gray colors were found. The width in the upper part of the damage is approximately 2.31 cm, on the sides — 1.10 cm and down — 1.62 cm below the lower edge of the imprint of the return spring tip and the external dimensions of approximately 5.51 × 3.72 cm. The damage is located on the background of the inwardly imprinted muzzle end of the weapon (punch) with contour soot deposits of a more intense dark gray color. In the lower part, the existing soot deposition was observed in the form of a crescent-shaped strip about 0.01—0.15 cm wide, and a radius of about 0.61 cm, about 1.21 cm long. Soot deposition was clearer on the upper and lateral

edges, and less intense on the lower edges. The edges of all the damage formed a volcanic rise (three-dimensional stamp) above the level of undamaged material by 0.60—1.30 cm. The edges that protrude outwards are also pointed, with the formation of free single threads, sometimes burnt. In the area of the imprint of the front edge of the return spring, deformation of the material is noted: in the center — a recess, and behind the periphery — a roller-like increase (Fig. 2).



Fig. 2. Appearance of clothing damage from the outside

On the inside of clothing, soot deposition is more intense, especially in the upper and side areas in the form of a drop or flame of a candle measuring approximately 1.51—2.79 cm from the upper edge of the material defect and in side areas wide approximately 1.10—1.52 cm from the edge of the material defect. In all cases, the narrow part of the edge of the sediment is directed upwards and gradually disappears (Fig. 3).

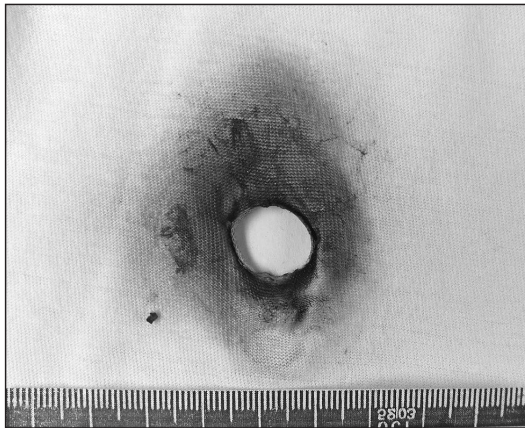


Fig. 3. Appearance of clothing damage from the inside

A superficial examination of the damage to the human torso simulator shows that most of the additional factors of the shot in the form of soot and unburned gunpowder are deposited in the wound canal. During the contact-diffusion method of research (the method of color prints) around the input fire damage of the simulator, small nickel particles were detected. In most cases (31 out of 48 injuries), specific soot deposition in the form of a double stamp was observed around the input gunshot wound of the human body simulator.

Comparison of these data with our previous study, in which we used similar weapons, ammunition and targets (but the target was fixed in a frame), revealed significant differences. First of all, the square shape of the defect attracts attention, while in the study with the torso simulator we observed a defect of oval, sometimes round shape. However, this difference, in our opinion, is due to the fact that in this experiment we used cotton knitwear, while in the previous one we used cotton fabric (calico). The size of the defect was approximately 1.0×1.0 cm, while using a torso simulator — 1.67×1.38 cm and a diameter of 1.35 cm (if the shape of the defect is oval and rounded, respectively). In addition, there were no deposition of additional factors of the shot on the inner surface and changes in the relief of the target (three-dimensional stamp). A slightly different configuration of the deposition of additional firing factors around the incoming gunshot damage was also noted ¹. All these data indicate that there are differences in the results obtained, so the question arises: which of the designs of the experimental study is more reliable and adequate?

V. V. Shcherbak ² also studied the features of damage to cotton fabric fixed in the frame in the case of point-blank shots, but using *Fort-12*. He described a star-shaped damage with a defect size of 1.5×1.4 – 1.9×1.8 cm. In this study, in particular, multilayer targets were used, however, in none of the cases the author did not describe such phenomena as *internal stamping* or *three-dimensional stamping*.

According to the authors, the detected deposition of additional factors of the shot on the inner surface of the garment (internal stamping) is probably an analogue of the same phenomenon as the Vynohradov phenomenon. However, the search for a reliable explanation of the phenomenon of internal stamping described by us, we believe, it should be the goal of further research. Regarding the shape of the deposition of additional shot factors in the form of a candle flame, this is probably due to the action of the return spring tip, which blocks the lower part of the fabric during the shot (as if creating an obstacle) and thus causes more additional factors to go up.

Regarding the discovered phenomenon of double stamping, this phenomenon has already been studied for pistols of the *Fort* model series by a group of Ukrainian scientists headed by O. M. Hurov ³, and R. Pircher with

¹ Бобков П. Ю., Лебедь М. Ф., Перебетюк А. М., Гунас В. І. *Op.cit.*

² Щербак В. В. *Op.cit.*

³ Гуров О. М., Куценко С. В., Щербак В. В., Гладких Д. Б., Сапелькін В. В. *Op.cit.*

co-authors ¹, in cases from practice, have described the effect of cartridges on stamp deformation.

For forensic medicine and criminalistics, the study of clothing is critical. Thus, according to 202 cases of gunshot wounds that occurred in Tehran from 2014 to 2017, in 70% of cases, the study of clothing allowed to determine the distance and type of firearms ($P = 0.0001$) ².

D. J. Carr and co-authors ³ have identified features of clothing damage previously contaminated with blood, which can be used to develop realistic scenarios for working out in combat zones.

A significant category of work is the study, in which scientists study microscopic features (e.g., the condition of the threads in the area of damage, the application of trace elements, etc.), to determine the distance of the shot and the type of firearm ⁴.

Studies of clothing damage from firearms are quite small both in Ukraine and abroad, and studies of the impact of clothing on injuries to the human body or its simulator are generally rare in the scientific literature.

¹ Pircher R., Glardon M., Perdekamp M. G., Pollak S., Geisenberger D. Rearward movement of the slide in semi-automatic pistols: a factor potentially influencing the configuration of muzzle imprint marks in contact shots. *International Journal of Legal Medicine*. 2019. № 133 (1). Pp. 169—176. DOI: 10.1007/s00414-018-1978-2 (date accessed: 05.02.2021).

² Najari F., Jafari H., Alimohammadi A. M., Najari D. The importance of victim's clothes in gunshot wounds. *Journal of Emergency Practice and Trauma*. 2020. № 6 (2). Pp. 73—76. DOI: 10.34172/jept.2020.13 (date accessed: 05.02.2021).

³ Carr D. J., Featherstone M., Malbon C., Miller D., Teagle, M. Preliminary development of a bleeding layer to assess the effect of a ballistic impact on textile damage. *Forensic science international*. 2018. № 288. Pp. 169—172. DOI: 10.1016/j.forsciint.2018.04.031 (date accessed: 05.02.2021).

⁴ Carr D., Kieser J., Mabbott A., Mott C., Champion S., Girvan E. Damage to apparel layers and underlying tissue due to hand-gun bullets. *International Journal of Legal Medicine*. 2014. № 128 (1). Pp. 83—93. DOI: 10.1007/s00414-013-0856-1 (date accessed: 05.02.2021) ; Giraud C., Fais P., Pelletti G., Viero A., Miotto D., Boscolo-Berto R., Viel G., Montisci M., Cecchetto G., Ferrara S. D. Micro-CT features of intermediate gunshot wounds covered by textiles. *Ibid*. 2016. № 130 (5). Pp. 1257—1264. DOI: 10.1007/s00414-016-1403-7 (date accessed: 05.02.2021) ; Hinrichs R., Frank P. R. O., Vasconcelos M. A. Z. Short range shooting distance estimation using variable pressure SEM images of the surroundings of bullet holes in textiles. *Forensic science international*. 2017. № 272. Pp. 28—36. DOI: 10.1016/j.forsciint.2016.12.033 (date accessed: 05.02.2021) ; Roberts K. A., Fischer G., Davis A. R. Identification of polygonal barrel rifling characteristics in bullet wipe residue deposited on textiles. *International Journal of Legal Medicine*. 2020. № 134 (2). Pp. 533—542. DOI: 10.1007/s00414-019-02009-0 (date accessed: 05.02.2021) ; Sahu K. I., Kennao P., Gupta A. K., Saran V., Waghmare N. P. Study of 9mm Improvised Pistol Pattern & Gunshot Residue with respect to Different Range. *Int. J. Comput. Sci. Eng.*, 6. 2018. Pp. 155—160.

In particular, T. Stevenson with co-authors¹ did an experiment with the use of combat firearms on gelatin blocks to identify the effect of military clothing on the features of firearms damage. At the same time, we have not found research in modern literature that would study the features of gunshot damage to clothing on the human body simulator.

Conclusions and prospects for further studies. The study provided completely new data on damage to clothing in the case of non-lethal firearms, namely the *Fort-12RM* pistol. Phenomena such as three-dimensional stamping and internal stamping were described for the first time, and during the description of the latter, a specific deposition of soot in the form of a candle flame was revealed. The phenomenon of double stamping was observed around the entrance gunshot wound on the studied human torso simulator. Most of the additional shot factors in the form of soot and unburned gunpowder were noted in the wound canal. During the contact-diffusion method of the study, small nickel particles were observed around the input fire damage of the simulator.

Given the data obtained and the experience of previous studies using the same pistol, ammunition and clothing material, there is a need to revise the classical method of experimental shooting, when the studied clothing samples are fixed in the frame.

In the future, we plan to conduct similar studies using simulators of other parts of the human body (head, upper and lower extremities), other types of weapons and clothing.

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¹ Stevenson T., Carr D. J., Stapley S. A. Ibid.

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**Особливості вогнепальних пошкоджень
бавовняного одягу в разі пострілу впритул
в імітатор людського торса з пістолета «Форт-12РМ»**

Зброя нелетальної дії набуває дедалі більшого поширення як у військових формуваннях, так і поміж цивільного населення, адже такий вид зброї створено не для знищення супротивника, а лише для його нейтралізації з мінімальною шкодою для здоров'я. Проте, це не заважає злочинцям застосовувати цей вид зброї для вчинення кримінальних дій. Особливо це стосується вогнепальної зброї нелетальної дії (здебільшого травматичних пістолетів).

Мета роботи — визначити особливості пошкоджень бавовняного трикотажу, які виникають у разі пострілу впритул з нікельованого пістолета «Форт-12РМ», спорядженого патронами .45 Rubber, в одягнутий імітатор людського торса, виготовлений із балістичного гелю.

Для досягнення поставленої мети 12 імітаторів людського торса вдягли в бавовняні футболки, по ним виконували постріли впритул з нікельованого пістолета «Форт-12РМ», спорядженого патронами .45 Rubber, із подальшим дослідженням пошкоджень одягу фотографічним і мікроскопічним методами. Порівняння здобутих результатів з більш ранніми, коли постріли виконували у зразки одягу, закріплені в рамці, дали змогу вперше описати феномен внутрішньої штаницьмарки й об'ємної штаницьмарки: під час опису внутрішньої штаницьмарки виявлено специфічне відкладання додаткових факторів пострілу (а саме — кіптяви), що нагадує полум'я свічки. Окрім того, спостерігали феномен подвійної штаницьмарки навколо

вхідного вогнепального пошкодження на досліджуваному імітаторі людського торса. Більшість додаткових факторів пострілу (у вигляді кінтяви та порошинок незгорілого пороху) виявлено в рановому каналі. Під час проведення контактнo-дифузійного методу дослідження навколо вхідного вогнепального пошкодження імітатора спостерігали дрібні частинки нікелю.

Виявлені відмінності вимагають перегляду класичної методики проведення експериментальних відстрілів, коли досліджувані зразки одягу закріплюють у рамі або фіксують у схожий спосіб. Важливим етапом постановки дослідження є відтворення умов, максимально наближених до реальних. Пошук найбільш доречного, ефективного та простого методу для здійснення таких експериментів є перспективним для балістики.

Ключові слова: «Форт-12РМ», балістичний гель, вогнепальні пошкодження, постріл упритул, зброя нелетальної дії, штанцмарка.

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Особенности огнестрельных повреждений хлопковой одежды при выстреле в упор в имитатор человеческого торса из пистолета «Форт-12РМ»

Цель работы — определить особенности повреждений хлопкового трикотажа, возникающих при выстреле в упор из никелированного пистолета «Форт-12РМ», снаряжённого патронами .45 Rubber, в одетый имитатор человеческого торса, выполненный из баллистического геля. Для достижения поставленной цели были изготовлены 12 имитаторов человеческого торса, одетых в хлопчатобумажные футболки, с последующей постановкой выстрелов с использованием никелированного пистолета «Форт-12РМ», снаряжённого патронами .45 Rubber. Выстрелы выполняли с дистанции вплотную с последующим исследованием повреждений одежды, используя фотографический и микроскопический методы исследования. Полученные данные и сравнение их с ранее полученными результатами исследований, когда выстрелы выполняли в образцы одежды, закреплённые в рамке, позволили выявить важные различия и впервые описать феномен внутренней штанцмарки и объёмной штанцмарки; при описании внутренней штанцмарки обнаружено специфическое отложение дополнительных факторов выстрела (а именно копоти), напоминающих пламя свечи. Кроме того, наблюдался феномен двойной штанцмарки вокруг входного огнестрельного повреждения на исследуемом имитаторе человеческого торса. Большинство дополнительных факторов выстрела (в виде копоти и пылинок несгоревшего пороха) определяли в раневом канале. При проведении контактнo-диффузионного метода исследования вокруг входного огнестрельного повреждения имитатора определяли мелкие частицы никеля. Выявленные различия нуждаются в пересмотре классической методики проведения экспериментальных отстрелов, когда исследуемые

образцы одежды закрепляют в раме или фиксируют похожим образом. Важным этапом постановки исследования является воссоздание условий, максимально приближённых к реальным. Поиск наиболее уместного, эффективного и простого метода для осуществления таких экспериментов является перспективным для баллистики.

Ключевые слова: «Форт-12РМ», баллистический гель, огнестрельные повреждения, выстрел в упор, оружие нелетального действия, штанцмарка.

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Contributors

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