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## NATO AMMUNITION SAFETY MANAGEMENT ADOPTION TO STRENGTHEN HUMAN SAFETY IN UKRAINE

**Abstract.** The Ukrainian ammunition safety management system is based on the former Soviet Union's regulatory basis and safety culture. Although the system is operated by professional and educated experts, it has not been updated since the 1990s. The large ammunition stockpiles left after the Soviet Army's withdrawal from Eastern Europe have resulted in a series of explosions causing deaths, casualties, and material losses. In 2017, NATO proposed assistance in reforming the ammunition safety management system in the Ukrainian Armed Forces to reach the minimum acceptable risk level of safety for the population. This paper aims to study the differences between the Ukrainian and NATO approaches to ammunition safety management and regulations. Through the analysis of their ammunition safety regulations, this study seeks to demonstrate the advantages of the NATO approach in providing an acceptable level of risk to people and property. The data for the study was collected from NATO standards and Ukrainian regulations in the ammunition safety field. The results indicate that the NATO approach is superior to the Ukrainian approach, providing a higher level of safety for the population.

**Key words:** ammunition safety management, NATO, Ukraine, regulatory basis, human safety, risk level, national security.

## ЗАПРОВАДЖЕННЯ УПРАВЛІННЯ БЕЗПЕКОЮ БОЄПРИПАСІВ НАТО ДЛЯ ПОСИЛЕННЯ БЕЗПЕКИ ЛЮДЕЙ В УКРАЇНІ

**Анотація.** Система управління безпекою боєприпасів в Україні базується на нормативно-правовій базі та культурі безпеки боєприпасів колишнього Радянського Союзу. Хоча цією системою керують підготовлені фахівці, вона не оновлювалася з 1990-х років. Великі запаси боєприпасів, що залишилися після виведення Радянської армії зі Східної Європи, призвели до вибухів, які спричинили загибель і поранення людей та пошкодження майна. У 2017 році НАТО запропонувала допомогу в реформуванні системи управління безпекою боєприпасів у Збройних Силах України, щоб вона забезпечувала мінімально прийнятний рівень ризику для населення. НАТО профінансувала проект з трансформації управління безпекою боєприпасів відповідно до стандартів безпеки боєприпасів НАТО у Збройних Силах України. У 2020 році Міністерство оборони України створило орган управління безпекою боєприпасів для забезпечення трансформації управління безпекою боєприпасів за підтримки радників НАТО шляхом формування політики, розвитку та нормативного врегулювання системи управління безпекою боєприпасів. Відтоді Україна разом з партнерами по НАТО створила фундамент для впровадження стандартів НАТО у сфері безпеки боєприпасів. Після повномасштабного вторгнення Росії 24 лютого 2022 року НАТО припинила проект, що негативно вплинуло на подальшу реалізацію трансформації управління безпекою боєприпасів в Україні. Метою цієї статті є дослідження відмінностей між підходами України та НАТО до управління безпекою боєприпасів та нормативно-правового регулювання. Шляхом аналізу нормативно-правових актів з безпеки боєприпасів, це дослідження прагне продемонструвати переваги підходу НАТО у забезпеченні прийнятного рівня ризику для людей і майна. Дослідження спирається на дані стандартів НАТО і українських нормативно-правових актів у сфері безпеки боєприпасів.

Результати свідчать про те, що підхід НАТО перевершує нинішній український підхід з точки зору забезпечення більш високого рівня безпеки і захисту цивільного населення, військовослужбовців та інфраструктури.

**Ключові слова:** управління безпекою боєприпасів, НАТО, Україна, нормативна база, безпека людини, рівень ризику, національна безпека.

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## INTRODUCTION

After the collapse of the Soviet Union in 1991, Ukraine gained its long-awaited independence. As Ukraine was on the front line of the USSR, vast military capabilities were left on its territory, including large ammunition stockpiles. Following the hurried withdrawal of the Soviet troops from Eastern Europe in 1989-1991, a significant amount of ammunition was stockpiled in Ukraine, with the plan to move it to the Russian territory after building proper storage facilities. However, most of the ammunition was put on the open ground at arsenals, which significantly violated safety rules for explosive storage and created unprecedented threats to the public and property.

Recognizing the situation, the Ukrainian government took steps to reduce the risks associated with improper ammunition storage. In June 1995, the government introduced Decree № 472, which approved the Program for providing survivability, explosion and fire safety of arsenals, bases, storage facilities, missiles, and ammunition of the Armed Forces of Ukraine for 1995–2015 (The Government of Ukraine, 1995). After 2015, the program was extended with changes until 2025. Despite these efforts, there were 36 total Unplanned Explosions at Munitions Sites (UEMS) in Ukraine between 1998 and 2018 (United States European Command, 2019).

According to the United States European Command (2019), sabotage was the most common cause, accounting for 15 (42%) of the 36 UEMS events. In addition, 10 events (28%) were classified as accidents, 8 events (22%) were classified as a result of improper fire safety, and 3 events (8%) were classified as due to improper storage. Although improper storage accounted for only 8%, for the biggest UEMS with the largest number of evacuations, deaths, wounded, and material losses, such as those in Kalynivka on September 26, 2017, Balakliya on March 23, 2017, and Ichnia on October 9, 2018, the improper ammunition storage was the second underlying cause. This led to mass explosions in adjacent storages over blast wave propagation and created devastating consequences for the local population.

Several causes of improper storage management were identified, including chronic underfunding to construct new magazines and a lack of political will

to apply international best practices in ammunition safety management to reduce threats. Ukraine inherited safety storage rules based on the Quantity Distances approach from the Soviet Ground Forces guidance (Ground Forces of Soviet Union [GFSU], 1972), which was developed in the 1960s. However, in the 1970s and 1980s, NATO countries made significant progress in developing a more sophisticated and flexible ammunition safety management system that could provide the most optimal solution to reach maximum operational capability for military commanders and provide an acceptable level of human safety. The adoption and implementation of NATO standards in ammunition storage could increase human safety in Ukraine during wartime.

## REGULATION REVIEW

### NATO ammunition safety standards

NATO is a political and military alliance of 30 countries. NATO's purpose is to guarantee the freedom and security of its members through political and military means. When member countries take decisions on security issues, it is a consensus of all 30 member countries (NATO, 2023). This approach applies in various fields during decision making including in the standardization area as well. Standardization helps to set common standards – rules or guidelines to ensure mutual understanding and practical functionality. It allows different countries to work with each other using well-established and familiar tools (NATO Standardization, 2023). NATO defines a standard as a “document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context” (NATO Standardization, 2023).

The Conference of National Armaments Directors (CNAD) Ammunition Safety Group (CASG) was established by NATO members to encourage and coordinate common approaches to ensure proper ammunition through-life management and benefit from sharing knowledge and experience in ammunition life cycle safety. In 2012, the NATO Standardization Agency established the Explosives Safety Munitions Risk Management (ESMRM) Panel, taking into account recommendations from countries such as the United Kingdom,

Canada, and the United States, among others. This panel aimed to develop and integrate explosives safety risk management into NATO planning and operations (Chiapello, 2015). Both groups coordinate and guide the development of ammunition safety standards, supporting NATO operations and its positive posture as a humane international actor. Currently, there are over 140 NATO standards related to ammunition safety, around 120 of which are supported and developed by these two groups. These standards cover various areas of ammunition through-life management, such as storage, handling and transportation, safety and suitability for service, in-service surveillance, energetic material, hazard classification, initiation system, and explosive safety risk management. Five most used NATO standards set safety rules for ammunition storage management to provide an acceptable level of safety in ammunition storage areas.

One of the oldest and most well-known NATO standards among ammunition safety experts is the Allied Ammunition Storage and Transport Publication AASTP-1 NATO Guidelines for the Storage of Military Ammunition and Explosives which was first introduced on September 1, 1963 (Allied Ammunition Storage and Transport Publication AASTP-1 NATO Guidelines for the Storage of Military Ammunition and Explosives [AASTP-1], 2015). The AASTP-1 provides guidelines between host countries and NATO forces for managing munitions storage areas on mutually agreeable regulations and forms the basis of national regulations as far as possible (AASTP-1, 2015). It defines Quantity Distance (QD) for above-ground storage, technical details for the design of explosives storage magazines, operational guidelines for explosives facilities, explosives storage management in underground facilities, ammunition and explosive storage in special situations (e.g., airfields, naval ports, destruction), and other fields.

The most commonly used part of AASTP-1 is the storage criteria which are based upon Hazard Classification of munitions and QDs. The QDs are recommended distances between potential explosive sites (PES) and exposed sites (ES), judged to be minimum acceptable levels of safety, although they “do not provide absolute safety in terms of immunity from propagation, damage, or injury/death in the case of an undesired explosive event” (AASTP-1, 2015, p. 28). The QDs are based on a series of trials and an analysis of available data on accidental explosions in different countries and are presented in tables in AASTP-1, depending on the types of PES and ES and the relations between them. The PES classification defines seven types

of PES and ten relation PES-ES types (spreading impact from PES) with the most commonly used PES being the earth-covered magazine (ECM). The ES classification defines 16 types of ES (ranging from facilities like ECM to public infrastructure) and 28 relation types (receiving impact by ES). The most recommended ES type for ammunition storage is a 7-bar Standard NATO Igloo designed to withstand the 7-bar blast pressure impact (AASTP-1, 2015). The QDs also depend on the Net Explosive Quantity (NEQ) and Hazard Classification, which are defined in NATO standard AASTP-03 Manual of NATO safety principles for the Hazard Classification of military ammunition and explosives.

The AASTP-03 provides definitions and rules for the classification of ammunition and explosives that comply with the United Nations’ recommendations on the transport of dangerous goods. Its purpose is to establish a common basis for nations to assess the risks generated by ammunition and explosives during transport and storage (NATO Manual of Safety Principles for the Hazard Classification of Military Ammunition and Explosives [AASTP-3], 1995). The AASTP-3 (1995) classifies Class 1 dangerous goods (ammunition and explosives) into six Hazard Divisions (HD1.1 – HD1.6) and 13 compatibility groups: A through H, J, K, L, N, and S (excluding I). Compatibility groups are used during storage and transportation to decrease “either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident” (AASTP-3, 1995, p. 12). To assess hazards induced by a single munition or a set of them, the AASTP-03 (1995) provides specific definition of the Net Explosives Quantity (NEQ).

Since the 2000s, NATO has engaged in several deployed operations leading to the development of two new NATO standards in the areas of safety on operations and risk management: the NATO guidelines for the storage, maintenance and transport of ammunition on deployed missions or operations; and Explosives safety risk analysis Part I: guidelines for risk-based decisions and Part II: technical background. The NATO standard regarding safety on operations aims to provide “guidance for the planning, transport, reconnaissance, establishment, and management of ammunition in the deployed environment” (NATO guidelines for the storage, maintenance and transport of ammunition on deployed missions or operations [AASTP-5], 2016, p. 1-1). AASTP-5 (2016) serves as an awareness guideline for Operational Commanders and their Specialists on

how to manage ammunition storage in missions. Additionally, it establishes minimum Field Distances (FD) for the Net Explosive Quantity (NEQ) not exceeding 4,000 kg, beyond which AASTP-1 Quantity Distances (QD) should apply (AASTP-5, 2016). The FDs were introduced to distinguish between the distances used in AASTP-1 and AASTP-5. Like the QDs in AASTP-1, the FDs depend on the potential explosive site (PES), exposed site (ES), NEQ, Hazard Division (HD), and type of ammunition. To calculate the total NEQ of PES when using FDs, all ammunition should be considered as HD 1.1, except HD 1.4 – 1.6, which must not be included (AASTP-5, 2016). The NATO on risk management standard establishes the terminology, principles, and mechanisms of risk-based methodology application in ammunition safety when the requirements of AASTP-1 and AASTP-5 QDs cannot be met (Explosives safety risk analysis Part I: guidelines for risk-based decisions [AASTP-4], 2016).

Following research on explosiveness safety challenges encountered during high-tempo operational environments in Afghanistan by Chiapello (2015), a standard related document was developed to support the effective integration of Explosives Safety and Munitions Risk Management (ESMRM) into NATO defense planning, training, and operations. Consequently, NATO adopted it as a standard ALP-16 which stands for Allied Logistics Publications for Explosive Safety and Munitions Risk Management (ESMRM) in NATO planning, training, and operations. Its purpose is “to establish requirements for the NATO ESMRM process and identify roles and responsibilities applicable to the NATO Operational Planning Process, the Operational Stages, and the Consumer Logistics Process across the full range of NATO military operations, including munitions-related contracted support” (Allied Logistics Publications for Explosive Safety and Munitions Risk Management (ESMRM) in NATO planning, training, and operations [ALP-16], 2014, p. 1-1).

Over the last 60 years, NATO member countries have recognized the significance of ammunition safety in the successful completion of joint missions. Consequently, they have developed a comprehensive set of ammunition safety standards that promote interoperability and effectiveness in ensuring the safety of personnel and property during joint military operations. The success of these standards has resulted in their recognition as a core component by the United Nations community which subsequently developed the International Ammunition Technical Guidelines (IATG) in 2011

to be used as a global ammunition management best practice in providing an acceptable level of safety for humans and property.

#### **Ukrainian regulations in ammunition safety**

After the collapse of the Soviet Union, Ukraine began to establish its own Armed Forces. With vast ammunition stockpiles remaining on Ukrainian territory, regulations for ammunition safety were needed to manage these stockpiles. The major regulations for ammunition safety were taken from the Soviet Army's ammunition safety regulations, with the GFSU (1972) establishing Hazard Classification, Quantity Distances, Compatibility Groups, and TNT equivalents for explosive mass calculations. Ukrainian ammunition experts utilized these regulations for about 20 years. However, to update these regulations, the General Staff of the Armed Forces of Ukraine approved a new document in 2017, called the Provisions on arsenals, bases and warehouses for the storage of missiles and ammunition of the Armed Forces of Ukraine which established provisions on arsenals, bases, and warehouses for missile and ammunition storage.

The Provisions (2017) adopted major principles, terminology, classifications, and approaches from the Soviet Guidelines for arsenals, bases, and stores of missiles and ammunition. Later amendments were made from ASSTP-1 (2015) that included the QDs calculation approach, which should be applied for new magazine construction (Provisions, 2017), and an updating of the compatibility ammunition storage table. Based on Provisions (2017), the Logistics Forces of the Armed Forces of Ukraine issued Guidelines on arsenal (base, warehouse) storage of missiles and ammunition of the Armed Forces of Ukraine in 2020. For further ASSTP-1 implementation, the Logistics Forces introduced their own interpretation of AASTP-1 Hazard Classification that was supposed to be in compliance with the Provisions (2017) Hazard Classification in Annex A (Guidelines on arsenal (base, warehouse) storage of missiles and ammunition of the Armed Forces of Ukraine [Guidelines], 2020).

Due to Ukraine's active warfare with Russian Federation troops since 2014, the Logistics Forces of the Armed Forces of Ukraine developed the provisions on field artillery depots of the Armed Forces of Ukraine which established principles and approaches to manage ammunition stockpiles in the field. Based on this, the Guidelines on field artillery depots were introduced to provide an integrated approach in field artillery depots management based on NATO standards and principles. Both the provisions and the guidelines only provide

recommendations for AASTP-5 regarding FDs (FDs table) for NEQ up to 4000 kg.

In 2021, the Ministry of Defense of Ukraine, together with NATO advisers, launched an ammunition safety management transformation in the Armed Forces of Ukraine. Since then the Military Standardization Body of Ukraine has adopted 16 NATO standards as military standards in the field of ammunition safety. These standards include AASTP-1, AASTP-3, AASTP-4, AASTP-5, ALP-16, and others. According to the Law of Ukraine on Standardization (2014, art. 13, p. 2), «standards adopted by enterprises, institutions and organizations are applied on a voluntary basis in Ukraine.» Therefore, currently, these military standards are voluntary for implementation by the Armed Forces of Ukraine, and they need to be introduced through other national imperative regulations to become obligatory for fulfillment.

### **Ammunition Safety Systems comparison analysis**

When comparing the ammunition safety management systems developed by NATO and the Ukrainian Armed Forces, there are notable similarities and differences. While both systems use similar concepts such as Quantity Distance (QDs), weight of explosions, Hazard Divisions, Compatibilities Groups, and types of magazines, the implementation and approaches to defining Hazard Classification, calculating weight of explosions, QDs, and facility classification differ significantly.

NATO employs six Hazard Divisions (HD1.1 – HD1.6) in Annex A, whereas Ukrainian regulations use Cyrillic letters (A-D). The Guidelines (2020) in Annex B attempted to combine the two, however, there are discrepancies in the classification of certain ammunition. For example, the 152 mm HE cartridge is classified as HD1.3 according to Ukrainian regulations, whereas NATO experts classify it as HD1.1, which requires a larger QD. Currently, the Ministry of Defense of Ukraine has issued the Military catalog “Hazard Classification of ammunition and explosives” ЖБИ 4-00(228).01 which contains the hazard classification of former Soviet Engineer and around 60% Ground Forces ammunition, as well as some foreign ammunition provided by partners. However, there is a lack of hazard classification for the Air Force and the Navy ammunition. Additionally, the Compatibilities Groups (CGs) in both systems differ – with NATO using 13 CGs (A through H, J, K, L, N, and S (except I)) and the inherited Soviet Union’s classification using 12 CGs (1-12).

Another significant difference between the two systems is the approach to calculating explosive

weight to identify QDs between facilities. NATO uses the Net Explosive Quantity (NEQ), which is calculated as “the total explosives content of the ammunition, unless it has been determined that the effective quantity is significantly different from the actual quantity” (AASTP-3, 1995, p. 33). The Ukrainian regulations use the TNT equivalent, which involves summing up the explosives multiplied by a coefficient depending on the explosive type (e.g., 1.25 for RDX) and half the weight of propellant (Guidelines, 2020). To ensure an acceptable level of safety, NATO experts base QDs on Hazard Classification, PES-ES relations, and NEQ. These QDs are flexible and vary (for HD1.1, they range from 3 m to 1400 m, depending on PES-ES relations and NEQ). In contrast, Ukrainian regulations only specify distances of 200 m, 100 m, and 50 m for magazines, and 25 m to 200 m for other facilities. NATO standards allow for greater flexibility and adjustability in ammunition storage management to optimize safety and operational military needs.

Over the past decade, NATO countries have increasingly adopted a risk-based approach in ammunition safety management field. This approach provides a deeper understanding of the risks and their causal factors aiding in decision-making and risk reduction (AASTP-4, 2016, p. 1). It is implemented when NATO explosives safety requirements, established in AASTP-1 or AASTP-5, cannot be met (ALP-16, 2014).

In Ukraine, both AASTP-4 Part 1 and ALP-16 have been adopted as military standards. However, the main factor in ammunition safety management decision-making lies in the national level of risk acceptance. The Concept of Risk Management of Technogenic and Natural Emergency Situations (2014) establishes a maximum permissible risk of  $1 \times 10^{-5}$  and a minimum risk that is less than or equal to  $1 \times 10^{-8}$ . Risks, whose values are greater than the maximum permissible limit, are considered absolutely unacceptable. These limits are similar to those of major developed countries, but there is no distinction between the risk level of acceptance for related personnel and non-related personnel in Ukrainian regulations. There is a practice used in many countries that typically results in a significant decrease in risk levels for related personnel. For example, in the US Department of Defense regulations, the Annual Maximum Individual risk for a related person is limited to  $1 \times 10^{-4}$ , whereas for the public, it is limited to  $1 \times 10^{-6}$  (AASTP-4, 2016).

Although both NATO and Ukrainian ammunition safety management systems are based on common principles, they differ in their classification approaches and criteria for major

input data used for managing ammunition safety such as Hazard Classification, the weight of explosives calculation, PES-ES relations, and types of facilities.

### CONCLUSION

The NATO ammunition safety management system offers several advantages over the inherited Soviet system used in Ukraine. The NATO system is research-based, flexible and evolved to meet the latest scientific advancements. Its implementation can ensure acceptable safety levels in ammunition storage, transportation and handling with fewer resources. With the ongoing war conflict in Ukraine,

adopting the NATO approach can reduce risks to the population living in conflict zones and provide the military leadership with necessary advice to avoid potential war crimes. However, future considerations must include separating permissible risk for personnel directly involved in ammunition operations from those who are not and determining the responsibility of military-political leadership in taking risks related to ammunition safety in both peacetime and wartime. By addressing these issues, the NATO ammunition safety management system can further enhance safety for both military personnel and civilians.

Annex A

### NATO Hazard classification

Hazard Division	Description
HD 1.1	Substances and articles which have a mass explosion hazard
HD 1.2	Substances and articles which have a projection hazard but not a mass explosion hazard
HD 1.3	Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard
HD 1.4	Substances and articles which present no significant hazard
HD 1.5	Very insensitive substances which have a mass explosion hazard
HD 1.6	Extremely insensitive articles which do not have a mass explosion hazard

Annex B

### NATO Hazard Classification adaptation in Ukrainian regulation

Hazard Division	Munition type
1.1	Explosive substance without shells Smoke powder and products from it Hand grenades Cartridges (projectiles) with a caliber greater than 200 mm Rocket projectiles (RP) of a caliber greater than 200 mm Cartridges of caliber 23, 30 mm
1.2	Smokeless loose powder Charges in cartridges Shots (charges) with cartridges with a combustible case Grenade shots Rockets Rocket projectiles with a caliber of up to 200 mm Incendiary shells (mines)
1.3	Artillery cartridges, projectiles, mines, main parts of 90–200-mm caliber
1.4	Final equipped artillery cartridges, projectiles, mines of 70–90 mm caliber Charges in cartridges and separate charging shots Pyrotechnic means
1.5	Incompletely equipped artillery shots, shells of 70–90-mm caliber Final equipped armor-piercing and armor-piercing incendiary shots up to 90 mm, projectiles caliber up to 70 mm
1.6	Smoke and lighting projectiles Subcaliber shots and projectiles Detonators, explosive devices and tubes Fired up hand grenades Capsule sleeves, pyro cartridges, ignition tubes Cartridges for small arms

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