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Ammunition Exploitation System and Its Organisation in the Polish Army

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Abstract
Ammunition, as a product of particular importance to national defence, is subject to special supervision during its use and production. One of the fundamental conditions it must meet during operation is its safe operation. This also involves a number of logistical processes, such as transport, storage, record-keeping, etc. This article presents an overview of ammunition use in the national defence system.

Keywords: ammunition, diagnostic tests, transport, safety of use.

1. INTRODUCTION

The term "ammunition use" refers to all activities related to ammunition from the moment it is accepted into the military inventory. This includes use during combat missions and troop training, storage in various climatic conditions, transportation, as well as technical inspections, diagnostic tests, repairs, and disposal of components that may become unsafe after their technical useful life has expired. These activities, in addition to use, are also referred to as "maintenance." The "Instruction on the Quality Control and Safety of Munitions in the Operational Process at the Ministry of National Defence," introduced by a decision of the Minister of National Defence in 2010 for use in the Armed Forces (AF), regulates the testing of munitions (MW) during their operational process. The current technical condition of MW is directly influenced by natural aging processes, their operational method, and production quality. Ensuring the safety of soldiers during their use is a priority. Thanks to ongoing diagnostic tests, it is possible to use products with a known technical condition, as well as to use up specific, selected batches of products with a worse technical condition first.

In wartime, the use of ammunition predominates. However, the more important tasks of the operational system include organisational activities, such as planning deliveries and timely supply of troops, taking into account the appropriate calibres and types of ammunition, organising storage, and recovering reusable components (e.g., cartridge cases). In this type of operation, transportation, short-term storage, and rapid wear and tear of individual batches of ammunition predominate. Therefore, the scope of maintenance is limited to essential inspection, cleaning, and decontamination before release for combat use.

In peacetime, the characteristic features of ammunition operation include limited use, long-term storage, diagnostic testing, technical inspections, maintenance and repairs, and loading onto transport vehicles and combat vehicles. Combat wear is relatively low (primarily for military training) and greater need for disposal of components whose technical condition no longer allows for further use. Operational characteristics such as serviceability, i.e., ease of diagnosis and potential repair, durability, and service life are important.

Durability is defined as the time during which ammunition is fit for use and repair, while service life is the period during which it meets the requirements for safety and operational reliability.

During their long-term "life," warfare agents are subject to processes that affect their functional properties. These include chemical processes (e.g., corrosion, chemical decomposition of powders) and spontaneous mechanical processes (e.g., relaxation of tensioned springs), as well as damage occurring during loading and unloading, and during their movement. The course of chemical and spontaneous mechanical processes is largely dependent on the quality of the raw materials used in the production of the warfare agents. Other mechanical damage results from failure to comply with or ignorance of occupational health and safety regulations, the design, and operation of the warfare agents.

During long-term storage, qualitative changes occur in ammunition. These changes result from natural aging processes, which alter the ammunition's physicochemical, ballistic, and mechanical properties. The main factors influencing this are atmospheric conditions, particularly humidity, temperature fluctuations, and atmospheric pollution, as well as storage conditions and mechanical impacts during operation. Precision ammunition components, such as fuses and primers, as well as products containing pyrotechnic mixtures (e.g., tracers) and propellant charges (powder), are particularly susceptible to natural aging. Retaining only ammunition with full combat value in stockpiles and timely eliminating ammunition exhibiting excessive aging processes ensures safe operation.

Regional Logistics Bases, military units, material depots and bases, repair and disposal plants, range supply points, and research and development units (military institutes) cooperate in implementing the use and maintenance of ammunition in a peaceful operating system. Military units store ammunition in various states of readiness, ensure its proper transport, conduct technical inspections and maintenance repairs, and use it during exercises. Depots and bases organise the storage and transport, conduct technical inspections, and repairs of ammunition. Some, depending on their competence and capabilities, dispose of ammunition whose technical condition no longer allows for further use. Range supply points primarily store ammunition intended for use. Research and development units conduct diagnostic tests of ammunition to verify its technical condition. A logistics body (LO) – the Support Inspectorate of the Polish Armed Forces – is responsible for overall management of ammunition use, performing control, coordination, and dispatch functions.

2. ACCEPTING GUARDS FOR ARMING AND KEEPING THEIR RECORD

The Armaments Agency (AU), which purchases ammunition for the military, sources it from domestic industry and foreign producers. The main countries from which we currently source the largest quantities of ammunition include Germany, the United States, South Korea, Czechia, Bulgaria and Slovakia. Both industrial and imported ammunition are delivered as complete cartridges or in components. Small-calibre cartridges are delivered ready for immediate use, while large-calibre cartridges are most often delivered in components. Batches of propellant charges, fuses, primers, and tracers are stored in airtight packaging, while the remaining batches are stored in non-airtight packaging and, as needed, assembled into complete cartridges at ammunition bases. After production by a domestic plant, each batch of ammunition or its components undergoes acceptance testing—in the laboratory and on the field. After obtaining positive test results, the Regional Military Representative (RPW) approves it for use in the Polish Armed Forces and notifies the Military Office. This authority decides whether to send the ammunition to a specific material depot or military unit. After the transport from the ammunition arrives at the designated location (photo no. 1), is unloaded into warehouses, and is entered into the register, the ammunition is accepted into the armed forces.

Imported ammunition is directed to designated warehouses. There, it is unloaded and inspected. The commission accepting the shipment prepares a protocol, which serves as the basis for accepting the ammunition for military use. The purpose of the records is to present all activities related to ammunition circulation and current status—both quantitative and qualitative—in the IT accounting system and material documents. Recording of components, their parts, and combat assemblies, such as primers, boosters, etc., begins already during the production process, as well as recording batch numbers and quantities of components included in the manufactured batch (e.g., fuses). This information is included in the "Technical Acceptance Protocol," which contains source qualitative and quantitative data on the materials, semi-finished products, and assemblies used. It also contains information on the batch size, the results of laboratory and field acceptance tests, and the RPW decision on the suitability of the batch of components or cartridges for military use (Ministry of National Defence, 1985, p. 316).

Upon delivery to the base (depot, military unit), the ammunition is recorded in accordance with the receipt or acceptance protocol. The following information is recorded: calibre, type and grade of ammunition, cartridge (component) characteristics strictly defined by the uniform material index (JIM), batch, year of production, production plant number, number of pieces, and category defining the ammunition quality. In the database, the assembly of finished cartridges from components is documented in a "production report," which accounts for the expenditure of components used to assemble and the receipt of finished, complete cartridges. The same report is prepared for ammunition repairs. In such cases, cartridges and components submitted for repair are debited from the inventory, and repaired cartridges and components remaining after repair (defective, dangerous) are received. After production, cartridges are stored in depots (bases) or transferred to military units. The "order - receipt" registration document is used for transfer. This document serves as the basis for recording the ammunition from the supplying party's inventory and transferring it to the receiving party's inventory. A "requisition - consumption report" is used to document the consumption (disposal) of ammunition.

Photo No. 1 – transport with munitions (own source)

3. RESOURCE CONSUMPTION AND MANAGEMENT

Rational management is a process aimed at maintaining operational and safe ammunition stockpiles. At the same time, it is a method of using it that ensures the lowest possible operating costs. Ammunition for shooting should be used intensively and stockpiles replenished with new ammunition to meet the standard shelf life and avoid costs incurred for diagnostic testing, repairs, and disposal of obsolete components. Unfortunately, this is difficult to achieve in peacetime, as resources are typically accumulated over the years and often exceed the capacity for training. Therefore, proper management should be considered to minimise the amount of ammunition to be withdrawn, repaired, and disposed of, while ensuring its safety and operational reliability. Using ammunition for training and combat shooting is a fundamental, natural way to maintain the required quality of resources. In a quality-controlled operational system, training and practice firing primarily utilises ammunition batches that have already begun to deteriorate. Using ammunition from other batches for firing is inadvisable due to the disruption of rational operational processes and the potential for significant financial losses. Furthermore, acquiring practice ammunition when sufficient stocks of a given type of live ammunition have been stored for long periods may not be justified. Once a certain level of stockpile is reached and a specified storage period, shorter than the warranty expiration date, is reached, acquiring practice ammunition is often abandoned and practice ammunition prepared from live ammunition is used for firing. When ammunition of varying ages and used in varying conditions is stored, material compositions should be swapped out depending on the needs of combat equipment during training. The basis for proper management is the careful recording of ammunition by cartridge assembly batches and component production batches. Only such recording ensures complete control of the entire inventory and enables proper logistical management of resources and quality control. It is crucial to apply the following principles of ammunition consumption in practice:

1) send new ammunition and its components to material depots and store them in warehouses, trying to move them as little as possible during the manufacturer's warranty period,
2) supply the troops primarily with ammunition that, after exceeding the standard shelf life, has been classified into the appropriate group with worse technical condition and a forecasted shorter service life,
3) during exercises, use only the ammunition indicated by the armament service,
4) use the entire batch of ammunition and do not leave short batches for storage (so-called ends and bulk batches),
5) in the absence of indications from the armament service, use batches of ammunition from the oldest years of production.

Compliance with these principles significantly reduces the costs of operating ammunition in peacetime.

4. STORAGE AND TRANSPORT

During peacetime, ammunition storage is characterised by being in various states of readiness and being stored under varying conditions that affect its technical condition. In the most common state of readiness, ammunition is fully assembled into cartridges, packed in wooden boxes, and stored in typical unheated warehouses.

At a higher readiness level, ammunition is fully assembled, packaged in standard packaging, and stored on vehicles in garages and warehouses. At the highest readiness level, complete ammunition is stored unpackaged in combat vehicles, loaded into magazines and belts. Cartridges have the lowest readiness when stored in standard warehouses, in components factory-packed in airtight boxes and cans.

Changes in ammunition properties significantly depend on storage conditions, which is particularly noticeable in ammunition stored in heavily used combat vehicles. In addition to natural aging, this ammunition also exhibits physical aging symptoms, such as dents, dents, marking wear, chipping of protective coating, etc. These inconsistencies reduce operational safety, combat suitability, and the ability to store the ammunition. Therefore, ammunition in this state of readiness requires increased frequency of maintenance and repair.

Ammunition is stored in warehouses to facilitate quantitative and qualitative checks, as well as receipt and issue. Ammunition crates are stacked according to batch size. The stack height depends on the type of ammunition and the permissible floor load. Stacks are marked with fabric tags, and less-full crates are provided with tags indicating the number of ammunition items contained within. These tags are placed on the top layer of the stack. For safety reasons and to avoid mistakes during retrieval, training ammunition is stored in a separate warehouse.

In addition to storage, storage encompasses a range of maintenance procedures and the creation of conditions essential to ensuring the proper technical condition of ammunition from the moment it is accepted for storage until its release. One of the most important tasks of warehouse workers is maintaining a microclimate in warehouses that should effectively inhibit corrosion processes and the natural aging of materials used in ammunition (Ministry of National Defence, 1994, p. 17). Air humidity, temperature, and contamination have a decisive influence on the development of ammunition corrosion. Moisture is the most important factor accelerating corrosion and decomposition of pyrotechnic components during long-term storage and a factor promoting microbial activity. It also has a decisive influence on the aging process of powder primers, pyrotechnic retarders, powder fuses and boosters, tracers, etc. It causes a decrease in the activity of chemical components and the temperature of the generated flame jets, as well as a decrease in the mechanical strength of firecrackers and powder pellets, and an increase in the corrosive effect on casings and adjacent parts. Moisture also favours the growth of fungi on bags containing propellant and incendiary charges, cardboard components, and packaging. Therefore, preventive measures should be taken to ensure the minimum possible level of ammunition moisture under existing conditions. Warehouses should be dried by airing during the summer. Airing should be carried out when the absolute humidity of the outside air is lower than the absolute humidity of the air in the warehouse.

Temperature has a significant impact on the aging of ammunition components. While moisture determines the development of these processes, temperature accelerates or retards them. A 10°C temperature increase causes an average doubling of the speed of chemical reactions. A transition from negative to positive temperature values is accompanied by a rapid increase in corrosive aggressiveness, with temperature primarily influencing the aging of metal surfaces. The amplitude of temperature changes has a particular impact. The greater the fluctuations, the faster the surface aging. This phenomenon is one of the causes of fuse failure during firing, as the loss of smoothness of the surfaces of the mating parts in the safety mechanisms causes them to jam and fail to release in the projectile's path (Podbudny, 1953, p. 83).

Ammunition should be suitable for transport by any means of transport. It is transported in standard packaging, i.e., wooden crates, special containers, palletised, or in containers. The packaging should be in good condition, and the ammunition inside should be well secured and secured against movement (photo 2). Vehicles should be loaded so as not to exceed their permissible load capacity. Armed artillery rounds, rocket projectiles, and mortar rounds, due to the possibility of their fuses being deactivated or armed, should be placed with their axes of symmetry perpendicular to the direction of travel. Vehicles and trailers should be marked in accordance with applicable traffic regulations and military requirements. A responsible person – the convoy commander – is designated for each transport, who is in charge of the inventory of the transported property. This list contains data on the ammunition (name, index, number of pieces, weight) and the transport number, wagon or truck number, order number, date of shipment, seal characteristics, name and signature of the transferor and recipient.

When transporting ammunition, a specific driving speed must be observed, which is strictly defined for road transport. A safe distance between vehicles in a convoy must also be maintained. Neither a convoy nor a single vehicle carrying ammunition may stop in residential areas or near residential areas. Also, during a thunderstorm, do not stop near structures that may be struck by lightning. The permissible amount of ammunition that can be loaded onto a single vehicle is established by loading standards. Loading and unloading of ammunition is performed under the supervision of a representative designated by the sender or recipient, whose responsibility is to:

- organising work at the loading point,
- providing the loading point with fire-fighting equipment and training employees in the event of a fire,
- checking the qualifications of people assigned to work (whether they have the required authorisations),
- supervision over the proper placement of ammunition crates on means of transport,

– ensuring that employees comply with safety rules while working.

Photo No. 2 – method of packaging warfare agents (own source)

5. AMMUNITION DIAGNOSTIC TESTS

The quality of ammunition and its components is assessed based on technical inspections and diagnostic tests. Technical inspections of ammunition enable ongoing evaluation at the user's premises, i.e., in military units and at material depots. Their purpose is to determine the ammunition's suitability for combat use and long-term storage, detect and assess changes in its technical condition that occurred during storage, and determine the causes of these changes. For ammunition exhibiting qualitative changes, the scope of repair is determined.

In addition to determining the technical condition of the ammunition and its packaging, the technical inspection also includes a check of the ammunition inventory by batch and its compliance with the actual state, with particular attention paid to ensuring that the inventory and stored ammunition do not include batches designated for withdrawal or whose use has been suspended (photo 3). Storage conditions are also verified to ensure they comply with applicable regulations.

A technical inspection assesses the quality of ammunition based on external characteristics (e.g., correct assembly and marking, type and number of mechanical damages, condition of protective coatings). Therefore, its results only provide a limited indication of the safety and reliability of, for example, fuses and primers, and in particular their mechanisms and assemblies. It is almost impossible to determine the loss of service life of ammunition components due to natural aging processes based on technical inspection results, or to predict their service life. Diagnostic tests are used for this purpose.

Diagnostic testing consists of a set of tests and checks that allow for the development of a diagnosis of the qualitative condition of a specific set of components, and based on this, a set of complete cartridges. Assessing the quality of ammunition components in the diagnostic process involves determining whether the defects in a given set exceed established (permissible) limits (photo 4). In laboratory testing, a set of typical checks includes the assessment of the following characteristics:

– surface smoothness of assemblies and parts,
– strength properties of springs and safety catches,
– the ability to ignite and initiate explosions through primers,
– chemical stability of ashes,
– moisture and deformation of powder grains in propellant charges,
– the strength of the light and the burning time of the tracers,
– safety and reliability of operation of fuses and igniters.

Any deviations from the requirements specified in the technical documentation are classified into the appropriate nonconformity group, assigned a hierarchy of importance and taking into account the impact of each nonconformity on the product's fundamental performance. Negative laboratory test results do not always constitute grounds for disqualifying products from further use. If warranted, these products are subject to repeated laboratory testing or field tests are conducted to determine the impact of the nonconformities on product performance.

Field testing includes a set of typical tests to verify the ballistic parameters of powder charges, as well as the safety and reliability of fuses and igniters. Positive field test results indicate that these products have not yet lost their combat properties and can continue to be used. However, they should be designated for disposal first, as they have begun the aging process, which limits their long-term storage capabilities. If negative laboratory and field test results are obtained, the products are subject to withdrawal from service.

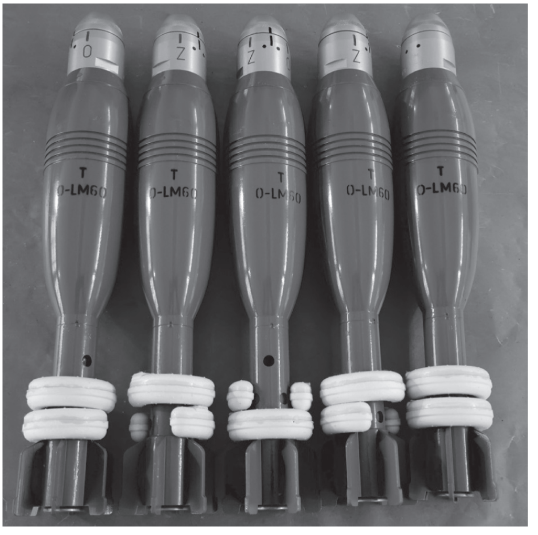

Photo No. 3 – technical inspection of mortar ammunition (own source)


Photo No. 4 – swollen and salt efflorescence on the pyrotechnic mixture of tracers from anti-aircraft ammunition (own source)

6. AMMUNITION DISPOSAL

Ammunition decommissioning is a deliberate act aimed at depriving live ammunition or its components of any signs of use and potentially recovering the materials for further use. The materials thus obtained constitute valuable secondary raw materials. Decommissioning involves the complete removal of all materials from all ammunition components: high-explosive, initiating, pyrotechnic, and propellant. Decommissioning primarily targets ammunition that has lost its original combat properties due to long-term storage and is no longer suitable for use or repair, as well as obsolete ammunition that no longer meets the requirements of the modern battlefield.

Small arms ammunition can be disposed of by mechanical disassembly, thermal disassembly, or by shooting. The mechanical disassembly method involves separating the projectile from the case, pouring it out, and

Gunpowder and igniting the primer contained in the shell. Lead is melted from projectiles and projectiles containing pyrotechnic explosives are disposed of in armoured furnaces. The thermal method involves heating the projectiles in special armoured furnaces, where, under the influence of high temperatures, they self-destruct. The gunpowder, primer initiation material, and other explosives and pyrotechnic materials contained in the projectiles are burned off. The thermal method can be used to dispose of all types of firearms. Furthermore, this method can be successfully used to burn off initiators and pyrotechnic materials contained in various components, assemblies, and parts of artillery ammunition intended for disposal.

The disposal of artillery ammunition is a more complex process. Due to their high destructive power, there are no methods for comprehensively disposing of entire artillery rounds. It should be emphasised that the need to dispose of complete rounds is very rare. These are cases where there is a concern that they are armed and could pose a real threat to the surrounding area. Most often, it is necessary to dispose of only individual ammunition components, such as projectiles, fuses, primers, powder charges, and tracers. Each of these components requires a different disposal method. This is performed after the component has been removed from the ammunition.

Destruction, however, applies to ammunition whose disassembly, disarming, and dismantling pose a safety risk. This is accomplished by detonating it using explosives. Destruction of ammunition is a particularly dangerous activity. Unexploded projectiles of all types, found on training grounds after military exercises, are detonated where they fall and are detected.

Unexploded wartime ammunition found in built-up areas is destroyed by special bomb disposal teams. Such ammunition is removed from built-up areas and destroyed in designated locations.

7. SAFETY WHEN WORKING WITH WAR MEASURES

Operational processes, like the production processes of ammunition and its components, pose numerous very serious threats to human life and health, as well as to military equipment, if improperly organised. This applies primarily to the operation of complete ammunition and its components, which contain explosives in various forms. Ensuring safety during all operations involving these components requires knowledge of the physicochemical and mechanical characteristics of explosives, as well as knowledge of the structure and operation of the mechanisms of ammunition components.

The accident rate in ammunition work is relatively low. After many years of experience, safety rules have been developed. A potential accident may result from failure to follow these rules. It should be noted, however, that such an accident is usually very serious.

There are general safety rules that must be followed in all cases. The most important of these is the prohibition of touching ammunition or any of its components of unknown origin, unidentifiable, or incapable of being detonated. This also applies to ammunition or its components lying on the firing range if they lack any distinguishable features or signs indicating the complete absence of explosives. It is also prohibited to tamper with any component of ammunition containing explosives or to use ammunition for purposes other than its intended purpose (Terenowski, 2016, p. 107).

In addition to these general safety rules, during the operation of ammunition, specific requirements related to the use, transport and storage of ammunition as well as its diagnosis, repair and disposal must be observed, and above all:
- do not place cartridges, cartridges in shells and mortar rounds vertically, as this may result in hitting the primer or igniter and igniting the propellant charge,
- do not hit cartridges against hard objects, especially fuses, as the impact may cause them to activate or arm, which may result in activation during transport, loading or when firing,

- do not allow loaded cartridges to fall from a height of one meter or more. Such a fall, under unfavourable circumstances (angle of fall, type of surface, etc.), may cause the fuse to arm, therefore only one cartridge or projectile should be carried in the hands without packaging, unpackaged loaded projectiles of calibre 152 mm and larger should not be carried without fall protection holders, and cartridges should not be carried on the shoulder or on the back.

Unpackaged ammunition is prohibited in vehicles, and ammunition crates should not be stacked above the edge of the cargo bed. Furthermore, it is prohibited to transport ammunition with liquid fuels, smoke on vehicles loaded with ammunition, and stop a convoy of ammunition in populated areas. Armed cartridges transported in railway wagons should be arranged with their axes of symmetry perpendicular to the direction of travel. This arrangement prevents the fuse's safety mechanisms from shifting under the inertial force generated by vigorous rolling of the wagons.

In a warehouse where powders and components containing explosives are stored, activities that could cause sparks should not be performed. Rocket projectiles should be stowed so that their warheads do not point at other ammunition warehouses or residential buildings.

BIBLIOGRAPHY

[1] Podbudny W. N., *Corrosion of weapons and ammunition*, Warsaw 1953.
[2] Terenowski H., *Occupational safety in diagnostic testing of warfare agents*, Greenery 2016.
[3] Tretiakow G., *Artillery ammunition*, Warsaw 1954.
[4] *Land Forces Ammunition - Manual*, Ministry of National Defence, Warsaw 1985.
[5] *Instructions for drying warehouses of technical combat agents, weapons and military equipment*, Ministry of National Defence, Warsaw 1994.

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