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Review / Przegląd

Automation of a lowering transportation platform used for the safe transportation of explosive and dangerous items
Automatyka opuszczania platformy transportowej wykorzystywanej do przewożenia przedmiotów wybuchowych i niebezpiecznych

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Abstract. *The explosion-proof container described in the article is designed for the safe transport of medium-sized explosive and dangerous items containing the equivalent of up to 10 kg of TNT, taken by land clearing military patrols or other engineering subunits. Explosive and dangerous items are a specific type of goods, and due to the risks associated with them, are subject to separate legal regulations. Their handling is more restrictive than that of normal dangerous goods. The solution, presented in the article in the area of improving the processes of transporting explosive and dangerous items, is recognised as an example of good practice. This is supported by the above-average results obtained by the entities implementing the presented process solutions.*

Streszczenie: *Przedstawiony w artykule pojemnik przeciwwybuchowy przeznaczony jest do bezpiecznego przewożenia średniej wielkości przedmiotów wybuchowych i niebezpiecznych zawierających równoważnik do 10 kg trotylu, podejmowanych przez wojskowe patrole oczyszczania terenu lub inne pododdziały inżynieryjne. Przedmioty wybuchowe i niebezpieczne są specyficznym rodzajem towaru, a z powodu zagrożeń, które wiążą się z nimi, podlegają odrębnym przepisom prawa. Sposoby obchodzenia się z nimi są bardziej restrykcyjne niż w przypadku zwykłego towaru niebezpiecznego. Przedstawione w artykule rozwiązanie w obszarze doskonalenia procesów przewozu przedmiotów wybuchowych i niebezpiecznych uznano za przykład dobrych praktyk. Przemawiają za tym osiągane ponadprzeciętne wyniki przez podmioty, które wdrożyły zaprezentowane rozwiązania procesowe.*

Keywords: *safety, good transport practices, explosive and dangerous items*
Słowa kluczowe: *bezpieczeństwo, dobre praktyki przewozu, przedmioty wybuchowe i niebezpieczne*

1. Introduction

Even though several decades have passed since the end of World War II, n remnants of the war can still be encountered in daily life. People find many items, which are sometimes hard to recognize or even resemble military equipment. Many accidents are caused by the careless lifting, digging up, carrying, and throwing onto bonfires found unexploded ordnance [1]. Also, the transport of explosive and dangerous items always carries the risk of an accident or an unexpected event which poses a risk to the health and life of the persons directly involved in the process. Risks can also rapidly spread to the outside environment, causing damage to infrastructure and the natural environment. Therefore, it is important to put in place all proactive measures and implement a high-quality prevention system to minimise the level of risk. This goal can be achieved by ensuring safety in long-term operations and eliminating accidents. This is possible if one identifies safety factors which counter risk factors.

Failure to take proper safety precautions on finding an unexploded or unfired ordnance, and its improper handling due to lack of awareness of the inherent danger, can lead to many unnecessary accidents and even death. Therefore, when such items are found, one should immediately notify the police, who: will check whether the found item is explosive and dangerous, will notify a military unit, and will secure the place until the arrival of a sapper patrol or mine clearance patrol [2].

Those involved in the transportation of explosive and dangerous items are mandated to take effective safety measures appropriate to the nature and extent of the foreseeable risks, in order to prevent damage and injury and, if appropriate, to minimize their effects. In any case, in the event of an immediate threat to safety, people involved in the transport immediately notify the emergency services and provide them with the information required to carry out their operations. A corrective action is an action taken to eliminate the cause of an existing nonconformity, defect or other undesirable situation in order to prevent it from recurring, while a preventive action is an action taken to prevent potential nonconformities from occurring [3].

2. Rules for handling explosive and dangerous items

Despite the rapid development of knowledge and technology, it is difficult to predict the place, time and dimensions of the occurrence of explosive and dangerous items of military origin which are remains of previous wars. In Poland, there are still large quantities of mines, shells, bombs, and other explosive items buried in the ground at various depths, as a result of warfare. The problem of the mine threat in Poland has not been completely solved and explosive and dangerous items are still being regularly removed from various areas. The Armed Forces of the Republic of Poland have a duty to remove explosive and dangerous items of military origin from such areas and dispose of them.

Explosive items encompass all items of military origin which are dangerous when handled improperly, for example, detonators, shells, aerial bombs, artillery and rifle cartridges, bazookas, grenades, mines of all types, explosive charges, and metal scrap containing remains of explosive materials [4]. Explosive items also include items with explosive properties, both unfired and unexploded items – *Unexploded Explosive Ordnance* (UXO), and abandoned ammunition and weapons, including those found in shipwrecks and crashed aircraft – *Abandoned Explosive Ordnance* (AXO).

Explosive items of military origin which lie in the ground can be divided into:

- unexploded ordnance: bombs and fired shells which failed to detonate on impact,
- unfired ordnance: shells which could not be fired due to a defect,
- artillery munitions and aerial bombs abandoned at the end of hostilities (buried in craters, trenches, etc.),
- anti-tank and anti-personnel mines sown in minefields and individually,
- remains of artillery munitions damaged in the post-war years,
- unexploded ordnance and abandoned munitions in marine areas (naval mines, torpedoes, depth bombs, and artillery and rocket munitions).

Any unexploded ordnance found (Figure 1) must not be touched under any circumstances. It must not be thrown, hit, smashed, or handled. Therefore, under no circumstances may they be touched by unauthorized persons without the proper skills, training, and technical equipment [5]. It is strictly forbidden to lift them, dig them up, carry them, and throw them into a bonfire or into places such as ponds or deep ditches. It should be borne in mind that explosive materials used in military technology are, in practice, completely resistant to the effects of weather and, regardless of the date of manufacture and the length of time underground, still retain their explosive properties [6]. Many of these items are unexploded and unfired ordnance of large caliber and size, such as artillery ammunition, mines, aerial bombs, torpedoes, rockets and grenades. Due to their physical condition caused by the weather acting on them for several decades, they are unpredictable. Hitting, moving, handling, shaking, or other factors e.g. high temperature, can cause them to explode unexpectedly.

Figure 1. Explosive items of military origin found in forests [7]

On the other hand, all kinds of devices (materials) of military, industrial or other origin which having flammable, corrosive or poisonous properties or which, being in a state of compression (liquefied), pose a risk when manipulated (thrown, unscrewed) or coming into contact with air or high temperature, are also considered dangerous items. This includes, in particular, flammable, corrosive and poisonous liquids or their residues, in drums and containers, the contents of steel cylinders and fire extinguishers, the residues of various substances in laboratory devices, as well as other materials with harmful and dangerous properties. The technical organization tasked with the clearance of explosive and dangerous items is regulated by the Defense Standard *Detection, mine clearance, and clearance of explosive and dangerous items from areas* (NO-02-A043, 2009); based on this, internal documents are developed which govern the operation of units of the Polish Armed Forces in the clearance of explosive and dangerous items from land domain [8].

Clearance is defined as the undertakings carried out by designated specialized subdivisions of the Armed Forces of the Republic of Poland involving the detection, securing, neutralization and removal, as well as the final disposal of explosive and dangerous items of military origin which have been found.

In order to ensure the safety of people and property during planned neutralization, county and even provincial Emergency Staffs are set up for items whose impact covers several neighboring districts. Sapper patrols cooperate with government officials on the basis of the emergency management Act and the state of natural disaster Act. The task of removing dangerous materials and their disposal by the Polish Armed Forces is also one of the main undertakings included in the Provincial Emergency Management Plans.

Sapper patrols, mine clearance teams of Miner-Divers' Groups (MDG), and area mine clearance groups of military training field commands are responsible for the removal of explosive and dangerous items on the territory of the Republic of Poland. Any reported explosive and dangerous items must be cleared within 24 h in the event of hazard to life and health, property of high value, the environment and historical monuments or within 72 h in ordinary cases. Removing sea mines and aerial bombs with a high explosive content from bodies of water, is a particularly big problem [2].

3. Safety in the process of transporting unexploded and non-fired ordnance by road

As part of the emergency response in terms of the removal of explosive and dangerous items, the engineering branch of the Armed Forces of the Republic of Poland deploys mine clearance patrols and detection and mine clearance units to remove mines and clear the area of these items. The tasks carried out by the mine clearance patrols have remained the same over the years and involve eliminating dangerous and explosive materials which pose risks to the population. However, what varies are the circumstances under which the sappers operate: legal procedures, organization of units and facilities, chain of command, equipment, cooperation with local government and law enforcement units, capabilities and technical solutions. It should be emphasized that the listed relationships are subject to dynamic transformation in accordance with the state of current knowledge [8].

The provision of sec. 9 (2 and 3) of the Regulation of the Ministers of National Defense and the Minister of Interior and Administration of June 9, 2005 on the technical conditions applicable to special vehicles and vehicles used for special purposes of the Armed Forces of the Republic of Poland (Journal of Laws, no. 116, item 974) specifies the method for transporting unexploded and unfired ordnance, based on the installation of special containers or other devices which limit the possibility of destructive impacts of transported dangerous items on the vehicle (Figure 2) and the environment [2].

Figure 2. A sapper vehicle with the Wiktoria ventilated container for transporting explosives mounted on a trailer [9]

The process of transporting unexploded and unfired military ordnance by road differs from the standard transportation of dangerous materials in accordance with the ADR (despite the same technical requirements for the vehicles and the necessary qualifications of their users). The difference is that due to the physical condition of the unexploded and unfired military ordnance which constitutes the dangerous cargo, these items are transported in a state of high activity of their detonators (mainly due to the inability to separate or disarm the detonators). This activity is mostly the result of processes initiated and, for various reasons interrupted, which are intended to cause the detonation of the crushing material contained in these items (unexploded ordnance). As a result, the safety of the vehicles carrying unexploded and unfired military ordnance required the research processes discussed in publications on the subject [8, 10] to take a multifaceted view of the issue, which can be determined:

– by analyzing the effectiveness of the reduction of the possible impact of external factors on the dangerous cargo,
– on the basis of reducing the impact of the dangerous cargo on the environment.

The impact of external factors such as shock, vibration, temperature, fire, and electric discharges, can cause the interrupted processes (in particular, the detonation of unexploded ordnance) to resume.

Such a situation can occur as a result of accidental random events (in particular, involvement in a road accident) or as a result of the user's actions (most often during the handling of an item). Moreover, a precise quantitative and qualitative determination of the external factor which can cause detonation of the transported item is impossible and unnecessary, since the items may be characterized by completely different sensitivity to the efects of external factors.

4. Wiktoria anti-shrapnel, ventilated container

Explosion-proof containers guarantee full protection against air shock waves and shrapnel. During the XXI International Defense Industry Exhibition, the company Jakusz from Kościerzyna presented a trailer (Figure 3) with the Wiktoria anti-shrapnel container for transporting unexploded and unfired ordnance.

Figure 3. The Wiktoria ventilated container for transporting explosives on a trailer [11]

The Wiktoria ventilated anti-shrapnel container is designed for the safe transportation of medium-sized unexploded and unfired ordnance with an equivalent of up to 10 kg of TNT, carried out by military clearance patrols or other engineering units. It can also be used at airports, ferry terminals, and automated parcel sorting facilities to quickly isolate suspicious packages, letters or luggage which may contain explosives [3]. The ventilated anti-shrapnel trailer-mounted container can be used in a variety of weather and climate conditions and is capable of traveling on dirt roads. It protects people and the surrounding area effectively from being hit by shrapnel in the event of an uncontrolled explosion of unexploded or unfired ordnance and explosives carried within it.

Vehicles equipped with explosion-proof containers (Figure 4) manufactured by Jakusz, have special approvals, technical certificates and ADR transport certificates issued by the Łukasiewicz Research Network – Institute of Organic Industry, the Military Institute of Armament Technology, and the Military Institute of Armoured and Automotive Technology.

Figure 4. A vehicle and the Wiktoria ventilated container for transporting explosives mounted on a trailer [9]

The Wiktoria explosion-proof container is used for the safe transportation of medium-sized UXO ammunition, unexploded ordnance, and other explosives with an equivalent mass of up to 10 kg of TNT, carried out by military patrols or other land clearing units, in accordance with applicable regulations.

5. Automation of the transport platform for the Wiktoria trailer

The Wiktoria trailer-mounted container can be used in a variety of weather and climate conditions and is capable of travelling on unmade roads. The lowering transport platform (Figure 5) allows easy access to the loading bay for persons picking up unexploded and unfired ordnance, as well as other suspicious items which may contain explosive material and enables the use of a sapper robot to perform these activities without human intervention.

Figure 5. The Wiktoria ventilated container for transporting explosives on a trailer [9]

Electromechanical devices provide for the safe control of changing the position of the actuators. In addition, the system is equipped with a manual drive. The electromechanical devices (Figure 6) for a trailer with an anti-shrapnel container for the transport of unexploded and unfired ordnance, is designed to control the position of the lid and drawer and for signalling the end positions of the lid and drawer, i.e.:

- switching on and off the power supply to the electromechanical devices,
- distributing power to the individual electromechanical devices,
- switching off the electromechanical devices in emergencies,
- controlling the electric drives of the lid and drawer,
- transmitting signals from proximity sensors to the control panel,
- indicating (visualizing) the positions of the lid and drawer in the end positions,
- transmitting control signals from the control panel to the microprocessor circuits of the drive motors of the lid and drawer,
- opening and closing the lid of the container and extending and retracting the drawer from and into the container, using the control panel.

Figure 6. A view of the PSV-01 control panel and the RZ-1 control unit (Source: Arex archive)

The electromechanical devices consist of the following:
– a control panel,
– a control unit,
– a cover motor assembly,
– a drawer motor assembly,
– a drum cabinet with cable harness,
– a box for the limit switches and cable harness assembly.

The Wiktoria explosion-proof container (Figure 7) is mounted on a two-axle trailer and can withstand a detonation of a 10 kg of TNT-equivalent explosive and a 152 mm (NATO 155 mm) artillery shell with the maximum weight of the transported item being 150 kg. The loading window closes automatically, with the option of manual closing. The maximum cargo dimensions are (L×W×H) 800×460×200 mm.

Figure 7. The Wiktoria ventilated container for transporting explosives [11]

The inner insert consists of a bed, transport drawer and cargo box. The components move on guide rails, the bed moving inside the body of the anti-shrapnel container, and the cargo box sliding outwards with the transport drawer, beyond the flange of the loading bay.

6. Conclusions

- The adopted structure of the article meant that the presented solution to the problem presents a high degree of generality. There is no doubt that the issue of, presented in the article in the area of improving the processes of transporting explosive and dangerous items, is recognised as an example of good practice.
- It is undisputed that unexploded munitions and other dangerous items remnant of warfare and military training activities will be a real threat to security in our country for many years to come.
- There are many challenges associated with the proper application of good safety practices for the transportation of explosive and dangerous items because explosive and dangerous items are a specific type of goods, and due to the risks associated with them, are subject to separate legal regulations. Their handling is more restrictive than that of normal dangerous goods.

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