



## Review/ Przegląd

# Safe handling of explosives containers in seaports *Bezpieczeństwo przeladunku kontenerów z materiałami wybuchowymi w portach morskich*

Mirosław Franciszek Chmieliński

Polish Naval Academy, 69 eng. J. Śmidowicza Street, 81-127 Gdynia, Poland

E-mail: m.chmielinski@amw.gdynia.pl

**Abstract:** The article characterises the principles of handling explosives containers regarding maritime transport safety. The transport of explosives in containers involves not only transshipment and organisation of deliveries of this type of cargo, but most of all ensuring safety. Improper transshipment of containers can lead to dangerous situations during transport at seaports. Also, correct handling of explosives in containers impacts safety in seaports.

**Streszczenie:** W artykule dokonano charakterystyki zasad przeladunku materiałów wybuchowych w kontenerach w aspekcie bezpieczeństwa transportu morskiego. Transport kontenerowy materiałów wybuchowych to nie tylko przeladunek i organizacja dostaw tego typu ładunków, ale przede wszystkim kwestia zabezpieczenia zapewnienia bezpieczeństwa. Niewłaściwy przeladunek kontenerów może doprowadzić do niebezpiecznych sytuacji podczas przewozu na terenie portów morskich. Poprawne przeprowadzenie przeladunku materiałów wybuchowych w kontenerach ma wpływ na bezpieczeństwo w portach morskich.

**Keywords:** hazardous materials, transportation safety, explosives

**Słowa kluczowe:** materiały niebezpieczne, bezpieczeństwo transportowe, materiały wybuchowe

## 1. Introduction

The technology of transporting cargo in containers has dominated the current market of sea and land transport. The term «container» means a large, reusable container that serves as bulk packaging for the transport of smaller packages or other general, break bulk and bulk cargo. Safety standards for the container loading unit are set by the Convention on Safe Containers (CSC). CSC Safety Approval Plate, or the Convention on Safe Containers 1972, was developed by the International Maritime Organisation (IMO), which applies to all containers presently in international circulation, with the exception of air containers [1]. The regulations specify the durability requirements that the unit must meet and determine how to test and approve it prior to operation. They also specify the requirements for its monitoring and maintenance during operation. In most countries, classification organisations deal with testing, approval and supervision of the container unit. In accordance with the International Convention on Safe Containers, in a visible place on the container casing (Fig. 1), a plate identifying a container as secure should be attached [2].



**Figure 1.** Label recognising container as safe - CSC [Source: author's own photo archive]

The container unit type is selected by matching it with the transport conditions required for the cargo properties. In the case of hazardous materials, the selection of a unit is dictated by the relevant provisions of the following codes:

- maritime transport: IMDG Code (*International Maritime Dangerous Goods Code*),
- road transport: ADR (fr. *Accord européen relatif au transport international des marchandises Dangereuses par Route*),
- rail transport RID (fr. *Règlement concernant le transport international ferroviaire des marchandises dangereuses*),
- inland waterway transport: ADN (*European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways*), relating to the transport of dangerous goods by various modes of transport.

Similarly to ADR or RID, maritime regulations provide their own definitions of the most important terms. The most essential of these are:

- “operator” means the owner or manager of a ship,
- “agent” means any person obliged or authorised to supply information on behalf of the operator of the ship,
- “shipper” indicates any person by whom, in whose name or on whose behalf a contract of carriage of goods has been concluded with the carrier,
- “enterprise” means an enterprise within the meaning of Regulation 1 of the 2nd Chapter of the IX SOLAS Convention (*International Convention for the Safety of Life at Sea*),
- “ship” means any seagoing vessel or craft,
- “dangerous goods” indicate goods classified in the IMDG code.

In maritime transport, containerisation has embraced virtually all general cargoes, the mass and external parameters of which correspond to the load capacity and dimensions of a standard container. Containers and other loading units can be loaded onto a ship using several basic loading technologies. The traditional technology most commonly used for containers is the vertical *lift-on/lift-off* vessel.

The load is moved during loading and unloading operations utilising ship or shore cranes. The most popular and efficient in this respect is the shore based gantry crane. Ro-ro technology (*roll-on/roll-off*) means horizontal loading and unloading ‘on wheels’. Road sets, railway wagons, road semi-trailers roll in or are rolled onto a ship in the loading port and roll out or are rolled out in the unloading port. This solution allows for maximum reduction of port operation time, and thus the entire transport chain from the sender to the recipient [3]. During road transport, reloading is carried out only by means of vertical and horizontal technology, depending

on the terminal, possibilities on site *etc.*, using specialised stackers (forklifts and stackers equipped with an upper spreader). Railway wagons and semi-trailers, apart from a few exceptions, are not equipped with container hoisting equipment.

Control of trade of products of strategic importance, including explosives, is an important element of security policy, both nationally and globally. It concerns joint actions undertaken by entrepreneurs and government administration, which is related to the foreign trade of goods, technologies and services of strategic importance for national security, as well as for maintaining international peace and security. It forms the main pillar of foreign and security policy of NATO (*North Atlantic Treaty Organisation*) and the European Union as well as cooperation between the Member States in this field [4].

The rules for foreign trade in items of strategic importance are regulated by the Act of the 29th of November 2000, concerning the foreign trade of goods, technologies and services of strategic importance for national security as well as for maintaining international peace and security.

In order to ensure the security of trading explosives using maritime transport, determining the role and scope of responsibility of individual institutions and establishing the principles of international cooperation in detecting and counteracting threats to ships, the provisions of the International Convention for the Safety of Life at Sea and the International Ship and Port Facility Security Code, apply in ports. Moreover, specialised port fire brigades also ensure security.

## 2. Environmental conditions for the transport of explosives

The transport of explosives is subject to specific requirements in relation to classification, approval for transport, selection of packaging, marking and requirements related to the means of transport and realisation of the transport. The purpose of the legal provisions regulating the transport of explosives is to eliminate or at least minimise the risks associated with this kind of transport.

There are many definitions clarifying what explosive materials really are. In order to unambiguously define the concept of “dangerous goods”, the terms goods, object, material *etc.* are adopted, which based on the relevant legal regulations relating to individual modes of transport, may be classified in one of the identified classes of hazard. From the point of legal provisions, dangerous goods are the materials and objects, the transport of which on the basis of relevant provisions is either forbidden or allowed only under the conditions specified in these provisions [3].

According to the Act of 2002 on explosives used for civilian purposes, explosives should be understood as solid or liquid chemical substances or mixtures of substances capable of chemical reactions resulting in the production of gas at such temperature and pressure and at such speed that they can cause damage to the surrounding environment, as well as products containing explosive materials [5].

Based on the type of hazard, dangerous goods are divided into 9 classes. The division applies to all transport modes and is the basis for the classification of all dangerous goods. A given good is assigned to a specific hazard class based on the type of hazard that a particular load poses to the environment. The type of hazard that a given load poses is expressed by means of a classification code.

In addition to the major hazard, dangerous goods sometimes pose additional risks. In this situation, the basic criterion for the selection of packaging is to ensure protection due to the intensity of the fundamental hazard posed by the load [2, 6, 7]. An appropriate selection of packaging during the transport of dangerous goods is very important to ensure an adequate level of safety for the surrounding of the process of transporting goods.

Currently, in accordance with regulations, packaging of materials, bombs, missiles *etc.* must contain a so-called UN number, which is specifically used for packaging, *e.g.* cardboard boxes or cases, and does not apply to the UN number for the explosive that is inside these items. Therefore, such packaging must have a UN number (it is a four-digit identification mark of the material that is determined by the United Nations Central Committee to ensure international recognition and use). Using this number, the substances are added to the *List of Hazardous Materials in Transport*, prepared by the UN Committee of Experts on the Transport of Hazardous Materials. The UN number sometimes refers to a group of materials that exhibit the same hazardous properties.

Figure 2 illustrates a sticker placed on the container showing the UN number, *i.e.* 0209, which consists of four digits, and a sticker marking 1.1, D on a class 1 sticker. 0209 UN number refers to trinitrotoluene (TNT).



**Figure 2.** Sticker with a UN number placed on a container [7]

The hazard level is expressed by the assigned phrase “*packing group*”. On a ship carrying dangerous goods, on which there is a fire, a spill, chemical poisoning with dangerous goods or it is likely that dangerous goods will enter the sea, the ship’s crew must comply with EmS (*Emergency Procedures for Ships Carrying Dangerous Goods*), *i.e.* the regulations for emergency procedures for seagoing vessels carrying dangerous goods. These take into consideration the fact that the approach for dealing with emergency situations is dependent on the properties and location of the cargo on the ship (in hold or on deck).

The first aid procedures supplement these regulations. The maritime character, associated with the ship’s heel and wave pressure, requires compliance with additional standards in the scope of compatibility of CTU (*Cargo Transport Unit*), a basic transport unit, which can mean both a container and a vehicle, as well as stowage, *i.e.* placing individual CTUs on a ship. Stowage considers which dangerous goods can be safely transported, taking into account their compatibility with other types of cargo, thus preventing further damage in case of an accident. Furthermore, class 1 goods are transported in accordance with one of 5 stowage categories (on cargo ships). The type of packaging depends on the type of load, its volume and physical form [8].

Another very important element related to the transport of explosives is the appropriate marking on the packaging, in which a given load is transported. This marking contains information about the packaging, *e.g.* symbol, code, manufacturing year and warning information regarding the contents of the package and the course of action.

In road and rail transport, the same symbols are used, which are placed onto appropriate pieces of cargo. Appropriate documentation of these symbols is maintained to facilitate assistance of rescue services in case of a breakdown.

The transport of explosives by sea is carried out using various ships. On a ship that transports dangerous goods, passengers as well as other non-crew members or non-passengers should be prevented from accessing the holds or other rooms and places on board where such goods are located (Fig. 3). The ship should meet the requirements for additional medical equipment and medicines in accordance with the *Medical First Aid Guide for accidents involving chemical poisoning caused by transported dangerous goods*, which is an appendix to the IMDG Code. The ship should meet the requirements for additional fire-fighting and anti-spill equipment in cases involving fire or spillage of transported dangerous goods in accordance with the guide for acting in such cases (EmS Guide), which is an appendix to the IMDG Code.

Dangerous goods should be loaded, arranged and secured for the duration of the travel in accordance with the requirements determined in IMDG. Due to their proximity to other goods, dangerous goods in packaging or loading transport units should be arranged and segregated in accordance with the principles contained in Chapters 7.1 and 7.2 of the IMDG Code. Every ship carrying dangerous goods in packaging or in loading transport units should have an approved cargo securing manual referred to in the regulation in Chapter 5 of the VI SOLAS Convention.

Packaging intended for the transport of dangerous goods by sea should reduce the potential risks arising from the properties of these goods to humans or the marine environment, or meet the requirements of the IMDG Code or Regulation 2 of Enclosure III to MARPOL (*Maritime Pollution*), International Convention for the Prevention of Pollution from Ships. Marking dangerous goods intended for sea transport, placing stickers and information plates on them, should be done in accordance with the requirements set out in the IMDG Code or Regulation 3 of Enclosure III to the MARPOL Convention.



**Figure 3.** Ship at the port quay [Source: author's own photo archive]

The safety of transport of class 1 dangerous goods depends on the strict compliance with the requirements of the provisions related to the organisation of fire and environmental safety, alerting in case of danger, detailed rules for the organisation of rescue and fire-fighting operations as well as the evacuation of people from hazardous areas during the organisation of the transshipment of class 1 dangerous goods. The transport of dangerous goods, as experience shows, creates many problems even for experienced practitioners. It results from the necessity to apply many rules, which are designed to reduce risks. Thus, the issues raised herein have the character of the most accurate approximation of the existing problems, which serve to provoke a discussion on this topic in order to determine, among others, the necessary course of action to ensure the safety of transporting dangerous class 1 goods [7, 9].

Class 1 explosives should be transported in compliance with all the rules specified in the regulations. Following the entire transport procedure for this group of materials, one should start with the shipping procedure. The shipping procedure will not apply to the case of trained bomb squads transporting unexploded materials. This role is taken over by the bomb squad patrol responsible for appropriate packaging and transport of unexploded materials. The shipment procedure for explosive materials primarily includes an appropriate selection of packaging (Fig. 4), its labelling, generating appropriate transport documentation and shipment of an appropriate amount of material, specified in the provisions of the IMDG agreement based on the available means of transport.



**Figure 4.** Class 1 explosives during loading into a container [10]

### 3. Safety rules for the transport of class 1 dangerous goods

It is important to properly and in accordance with applicable requirements, classify hazardous products and goods, which are substances and objects classified in the IMDG code [5], that also apply to ADR and RID, in order to establish the basic principles of safe transshipment of class 1 dangerous goods in a sea port.

Class 1 includes explosives and objects with explosives (according to IMDG, ADR/RID). The basic criterion for classifying a material as Class 1 (explosive) is its sensitivity to mechanical (impact and friction) and thermal stimuli, characterising the possibility of converting the combustion of an explosive (deflagration), the linear burning speed of which is below 1 m/s, to detonation combustion.

After loading the container, the shipper should seal the container by putting on a bottle seal (Fig. 5) on the right door of the container. When loading the goods into the container, it is advisable to create photographic documentation of the container loading.

Explosives may pose danger to humans, animals and the natural environment. It is important that people involved in their transport are able to take effective initial rescue measures in the event of an accident or another adverse event. It is crucial that every person participating in their transport is thoroughly aware of the characteristics of the materials. In the event of a dangerous situation, the accident instructions should be followed, which may proceed according to the following steps:

- prevent unauthorised access to the place of the incident, mark the stopping place with warning signs,
- write down identification numbers of the packages,
- secure any leaks (if possible), taking appropriate precautions,
- if health or life hazards arise, move away from the danger area,
- notify the nearest Maritime Search and Rescue Service within the Polish maritime areas, and the port fire department in ports [11].

In order to maintain the basic safety rules while operating ships containing dangerous goods classified as class 1, the basic rule should be to provide a system for direct monitoring of the handling of dangerous goods carried out by employees, and an established and implemented system of procedures for securing fire safety and environmental protection, as well as established methods for informing nominated personnel and alerting the emergency services.



**Figure 5.** Securing the container closure with a bottle seal [7]

The required qualifications of employees handling class 1 dangerous goods include, among others, training for employees participating in the transport process and performing transshipment operations of class 1 dangerous goods.

Employees employed directly to operate and carry out the handling of class 1 dangerous goods (including operators of quay cranes, yard cranes and other transshipment and transport equipment) should have the following qualifications:

- basic employee training in the field of work safety and fire prevention,
- qualification certificates from the Transport Technical Supervision (TTS), required to operate lifting and handling equipment.

#### **4. Provisions regarding class 1 dangerous goods in maritime transport**

In the field of maritime transport, the following legal acts regulate the transport of dangerous goods:

1. Maritime Code of the 18<sup>th</sup> of September 2001 (Journal of Laws no. 138, item 1545, as amended).
2. Act of the 9<sup>th</sup> of November 2000 *on maritime safety* (Journal of Laws from 2006, no. 99, item 693, as amended).
3. Act of the 16<sup>th</sup> of March 1995 *on the prevention of sea pollution by ships* (Journal of Laws No. 99, item 692).
4. Ordinance of the Minister of Infrastructure of the 6<sup>th</sup> of August 2002 *on the principles and procedure for conducting inspections, tests and approval of containers and bodies authorised to carry out these activities and to control the condition of containers* (Journal of Laws No. 169, item 1388).
5. Regulation of the Minister of Infrastructure of the 30<sup>th</sup> of April 2004 *on the provision of information by a shipper providing dangerous or polluting goods for ship loading* (Journal Of Laws No. 103, item 1084).
6. Ordinance of the Minister of Infrastructure of the 12<sup>th</sup> of May 2003 *on the provision of information by the shipowner of a ship carrying hazardous or polluting goods* (Journal of Laws No 101, Item 938).
7. International conventions ratified by Poland in the field of transporting dangerous goods by sea (including MARPOL 73/78 Convention - International Convention for the prevention of pollution from ships, IMDG Code [5] annexed to the International Convention for the safety of life at sea (SOLAS), IBC Code – International code for the construction and equipment of ships carrying dangerous chemicals in bulk.

The IMDG Code [5] is always subject to cyclical changes in 2-year periods, conversely to ADR/RID, which occurs in even numbered years. The growing interest in the issues of maritime transport and related

container packing operations prompted a systematic development of this subject. Below, several legal acts and definitions that allow for efficient navigation in the maritime subjects are presented:

- SOLAS means the International Convention for the Safety of Life at Sea, together with the protocols and amendments,
- SAR Convention means the 1979 International Convention on Maritime Search and Rescue,
- ISM Code means the International Safety Management Code for the safe management and operation of ships at sea,
- IMDG Code [5],
- IGC Code means the International Gas Carrier Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk,
- BC Code means the IMO Code of Safe Practice for Solid Bulk Cargo. It is optional; however, it is used by nearly all operators,
- IMO Resolution A.851 (20) means the Resolution 851 (20) of the International Maritime Organisation entitled “*General principles for ship reporting systems and ship reporting requirements, including guidelines for reporting incidents involving dangerous goods, harmful substances and/or marine pollutants*”,
- Provisions regarding the conditions and the notification of dangerous and polluting goods carried on ships Journal of Laws L 208, 05/08/2002 P. 0010 - 0027 2002/59/EC Directive of the European Parliament and of the Council,
- MARPOL Convention on the protection of the marine environment of the Baltic Sea area adopted in the Polish law (Journal of Laws from 2000, No. 28, pos. 346),
- STCW Convention (*Standards of Training, Certification and Watchkeeping*) published in Poland (Journal of Laws from 1984, No. 39, item 201) as the International Convention on the requirements for the training of seafarers, issuing certificates and watchkeeping.

It should be added here that in addition to these conventions, it is very important to know the applicable rules at the destination ports.

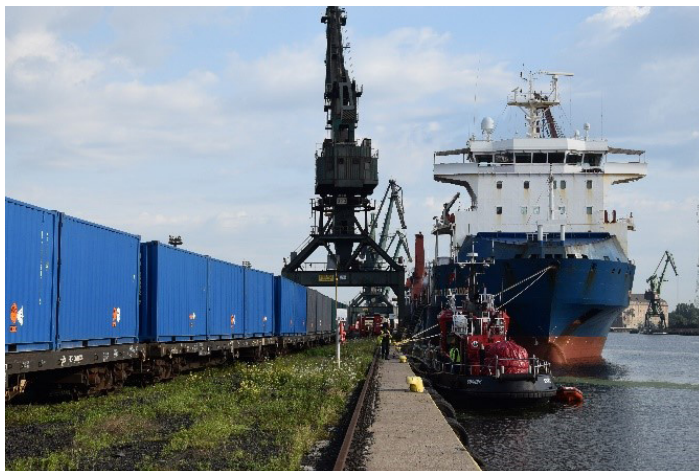
Stowage of containers should immobilise goods during transport. Without the proper stowing and securing of a hazardous load, serious damage to goods can occur during transport. In many cases, the freight forwarder has no control over the load formation and is unable to check the container contents during transport. If it is known that the container has not been stowed in a way that ensures safe transport, it should not be accepted for transport. Usually, simply filling the empty voids with wood or air cushions at the sides and by the front walls is sufficient. The goal is always the same – to immobilise the load. Therefore, the following general rules for stowing containers, which affect the transport safety should be followed:

- the mass of the stowed cargo in the container should not exceed the load capacity of the container,
- the stowed cargo in the container should be evenly distributed on the container floor surface. One half of the container should never contain more than 60% of the total mass of the load, as this may lead to axle overload,
- the stowage cargo in the container should be secured against all forces that can be expected during the journey,
- the stowage cargo in the container should not exceed the strength of the binding straps/lashing,
- special precautions must ensure that the door of the stowed container is under the least load.

When transhipping and handling hazardous materials classified as class 1 in areas within the territorial jurisdiction of the Director of the Maritime Office, the rules specified in the relevant ordinance are to be followed [8].

Transhipments of individual types of dangerous goods take place in different, distant parts of the port in separate port areas (Fig. 6). Even if several transhipment stations exist for a given commodity, they are located at an appropriate distance from each other in such a way as to create separate fire zones.





**Figure 6.** Harbour position during the transhipment of dangerous goods onto a ship [7]

When transhipping a cargo of dangerous goods classified as class 1 (Fig. 7), the greatest threat to the transhipped goods, the ship, people carrying out the transhipping as well as the surroundings in the danger zone is a fire, which, if not nipped in the bud, may lead to an explosion on the ship, in the land transport in front of the ship or at the place where these are located [12].



**Figure 7.** Containers with explosives on the ship at the port quay [Source: author's own photo archive]

For this reason, to secure the work associated with transhipment, stopping of land and sea means of transport containing hazardous materials classified as class 1 in the port area, fire assistance must be provided. The purpose is to ensure the correct process of transhipment, stopping the means of transport containing these goods, and in the event of any danger – its immediate removal.

## 5. Conclusions

Modern port infrastructure and efficient access infrastructure is a condition for further increases in the level of transhipments. Thus, it should be considered that the ports activity, aimed at intensive handling of large

amounts of materials, substances and equipment, creates risks requiring effective preventive measures. Particularly in the case of processes involving dangerous substances, we are dealing with a wide spectrum of hazards. The first are the fire hazards, which in the event of breakdowns and technical disasters in the port surrounding, result in significant losses concerning people as well as materials.

Containerisation is a factor that increases safety by providing a kind of isolation of the explosive material from external stimuli, which can initiate an uncontrolled explosion process, and the segregation of explosive materials specified in the IMDG Code as well as the requirements concerning safe handling, ensure a high degree of minimisation of such risks. Nevertheless, it should be considered that in the case of unfavourable technical and technological conditions, resulting from human error as well as intended human action, such threats may occur. Therefore, it is important to prepare procedures that should be followed by all people involved in the transshipping and handling of explosive materials in such circumstances.

In order to maintain basic safety rules while operating ships containing dangerous goods classified as class 1, the fundamental rule should be to provide a system for direct monitoring of such goods, carried out by employees, as well as an established and implemented system of procedures for securing fire safety and environmental protection. Moreover, establishment of methods informing nominated personnel and alerting the emergency services is crucial.

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