Logistics-Explosives-Safety

Cost, safety, and compliance with international regulations are among the most important factors with respect to shipping explosives. The following article gives detailed insight into the transport and storage of explosives necessary for destroying mines and UXO.

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Introduction

The humanitarian disaster caused by landmines and UXO littered throughout more than 60 countries has created an active and growing response from the international community that could eventually lead to the elimination of the use of landmines. As mines can be very dangerous or impossible to render safe, they often must be destroyed in-situ. Quality demolition products are essential for the safety of the mine clearance experts. Delivering materials for the demining teams can be solved with reasonable economic resources and within a relatively short time; however, problems associated with explosives must be solved first. For example:

- Can explosives suitable for demining be delivered locally?
- Can explosives be transported to the site and stored safely?
- Is it possible to get explosives from neighbouring countries?
- Can explosives be delivered from other countries?
- What type of explosives should be delivered?

Many traditional safety precautions and procedures for destroying mines and UXO are still being used. The following section includes a short discussion of the difficulties of transporting explosives and a proposal for simplifying procedures for destroying or rendering safe mines and UXO that can easily be delivered.

Transport of Explosives

To understand the transport of explosives, a few things must be clear. First, explosives are classified as dangerous goods. The dangerous goods covered by the heading of a class are defined on the basis of their properties. The assignment of Class 1 explosive substances and articles has been assigned to a division and a compatibility group. The division is based on the results of the tests described in UN regulations. Listed below are the various divisions and compatibility groups into which Class 1 explosive substances and articles are subdivided.

Compatibility Group	Definition of Compatibility Group
B	Article containing a primary explosive substance and not having two or more effective protective features. Some articles, such as detonators for blasting, detonator assemblies for blasting and cap-type primers, are included, even though they do not contain primary explosives.
D	Secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance. In each case, without means of initiation and without a propelling charge, or an article containing a primary explosive substance and having two or more effective protective features.
S	Substance or article so packed or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder or prevent fire-fighting or other emergency response efforts in the immediate vicinity of the package.

Table 1: Classification of compatibility groups.

Class 1: Explosive Substances and Articles

Division numbers give information on how the explosives can be transported. Explosives typical for demining can be put into one of the following divisions:

- **Division 1.1**: Substances and articles that have a mass explosion hazard (a mass explosion is an explosion that affects almost the entire load instantaneously).
- **Division 1.4**: Substances and articles that present only a slight risk of explosion in the event of ignition or initiation during carriage. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire shall not cause an instantaneous explosion of the entire contents of the package.

Compatibility Groups

Compatibility groups inform you about how to stuff a container and how it can be transported as well. Definitions of compatibility groups of substances and articles for demining are listed in Table 1 to the top right.

When stuffing a container with explosives, you are allowed to have normal goods in the container as well, but under no circumstances can it contain other dangerous goods. Table 2 shows what is possible to mix when stuffing a container.

By putting division number and compatibility group together, it is possible to stow and transport the explosives by sea or air in accordance with International Maritime Organization (IMO) regulations (transporting by ship) or in accordance with the International Air Transport Association (IATA) dangerous goods regulation (transporting by air) as in Table 3.

Table 3 is rather theoretically and can be difficult to understand. All explosives will be listed as Class 1. In addition, they will have a division number, a compatibility number, a UN number and a proper shipping name. Typical explosives for demining can be as Table 4 depicts.

	B	D	S
B	Possible	Forbidden	Possible
D	Forbidden	Possible	Possible
S	Possible	Possible	Possible

Table 2: Mixing of explosives when stuffing. (by compatibility groups)

Typical tender for explosives for demining is:

- Explosives (Classified 1.1 D, e.g., PE4 or similar) approximately 1–5 tons
- Detonating cord (Classified 1.1 D, e.g., 10 g/m) approx. 1,000–10,000 m
- Electric detonators (Classified1.1 B) approx. 5–10,000 p.c.
- Safety fuse (Classified 1.4 S) approx. 1–5,000 m
- Detonators non-electric for blasting (Classified 1.1 B, detonator to be crimped on a safety fuse) approx. 500–1,000 p.c.

The explosives shall be delivered as soon as possible.

A tender for explosives is very informative and for a limited project. Transportation must be by ship as explosives, detonating cords and non-electric detonators for blasting are classified 1.1 D and 1.1 B, and the goods must be stuffed in two containers. One of the containers will have explosives and the detonating cord (approximately six tons in total or 10 pallets). The second container will have the electric detonators, the safety fuse and the non-electric detonators (approximately 600 kg on one pallet). The only reason for having two containers is because of the non-electric detonators for blasting. These detonators have an extremely low value as well, but must be stuffed separately from the explosives.

Finding a ship that will carry explosives becomes more and more difficult because the liners and insurance companies classify them as high-risk goods. Also, the liner will have restrictions as to which harbours they can go into (a lot of harbours have very heavy restrictions as to what type of goods a ship must carry). When planning such a tender, a lot of money can be saved, but the tender must be changed to one of the two following alternatives.

Alternative 1

- Explosives (Classified 1.1 D, e.g., PE4 or similar) approx. 1–5 tons
- Detonating cord (Classified 1.1 D, e.g., 10 g/m) approx.1,000–10,000 m
- Electric detonators (Classified1.4 S) approx. 6–11,000 p.c.

The goods must be forwarded by ship, but only one container is needed. The deminers can do the same job as what the first tender asked for.

Alternative 2

- Charges, shaped (Classified1.4 S) approx. 6–11,000 p.c.
- Electric detonators (Classified1.4 S) approx. 6–11,000 p.c.

Passenger or cargo aircraft can ship the goods. Extremely quick delivery is possible and you only pay the freight cost for the goods that you transport by aircraft. The deminers can do the same job as what the first tender asked for.

	By ship	Passenger and Cargo Aircraft	Cargo Aircraft only
1.1 B	Possible	Forbidden	Forbidden
1.4 B	Possible	Forbidden	Possible
1.1 D	Possible	Forbidden	Forbidden
1.4 S	Possible	Possible	Possible

Table 3: Transportation of explosives.

Storage of Explosives

Many regulations for storage of explosives exist. If explosives are classified 1.1 D and 1.1 B, there are very heavy restrictions on storage of these explosives because of the potentially fatal consequences for the surrounding area if the explosives were to go off. Storage of explosives 1.4 S are not subjected to heavy restrictions but are subject to fire regulations because if the storage caught on fire, the material would burn out without going into detonation, or in the worst case, only a very limited quantity of fragment will come out without causing serious harm to the firemen.

Explosives for Demining

Procedures for use of explosives for demining and destruction of UXO have traditionally been made by the armed forces. Reliable procedures have been developed. Explosives to be used are normally:

- Explosives (Classified 1.1 D, e.g., PE4 or similar)
- Detonating cord (Classified1.1 D, e.g., 10 g/m)
- Electric detonators (Classified 1.1 B)
- Safety fuse (Classified 1.4 S)
- Non-electric detonators for blasting (Classified 1.1 B, detonator to be crimped on a safety fuse)

When blasting mines, the explosives are normally used as a small bulk charge of 100–200 g placed on the mine or even better, on the side of the mine without touching the mine. When blasting UXO, the explosives are used in bulk charge of 200–500 g placed on the shell or a minor explosives' charge is placed in the firing channel of the UXO. From time to time to conserve explosives, improvised shaped charge containers are used, and the demining teams fill in the plastic explosives themselves. The charge is placed a little bit away from the mine or the shell without touching the UXO. Ignition of the explosives is done with electrical detonators, which are extremely reliable. The intentional firing of the detonators ensures that interruption of the firing is possible if animals or people are entering the firing area. The use of electric firing demands shot firing cable and a proper blasting machine.

In some cases, the deminers use a safety fuse with a detonator crimped on. Only a match is needed—no firing cable and no blasting machine—but it is impossible to interrupt the firing if animals or people come into the firing area. The reliability of this kind of firing system is low compared to the electric detonators and because of poor reliability and no chance for interrupting the firing; therefore, this firing system should not be recommended for use in demining. As for explosives for demining, shaped charges should be recommended as the standard operating procedure (SOP) for destruction of mines and UXO because

the mines will not be touched and the shaped charges are more than sufficient for ignition of UXO as well.

Conclusion

When taking into consideration the problems in transportation and secure storage of explosives classified 1.1 D and 1.1 B, it should be highly recommended to demand use of shaped charges and electric detonators classified 1.4 S. The prices for the shaped charges classified 1.4 S are higher than for explosives 1.1 D, but this is not of interest. The most important thing is the price when fired on the demolitions site—what the cost has been for transportation of high explosives compared to the shaped charges, what the cost has been for storage and what the price is for improved safety for the shaped charges compared to high explosives. If the vendor includes all of those factors in the cost, the shaped charges will be competitive to high explosives.

The price for electric detonators classified 1.4 S is slightly higher compared to ordinary packed electric detonators, and adding the cost of transporting the electric detonators classified 1.4 S becomes much cheaper than the ordinary packed electric detonators. Giving up the detonating cord, the explosives 1.1 D, safety fuse and detonators for the safety fuse and demanding shaped charges and electric detonators 1.4 S, it will be easier to have the necessary explosives in a short time and with the highest possible safety for the users and during transport and storage. ■

■ Table 4: Classification of Typical Explosives for Demining

Classification	UN Number	*Proper Shipping Name/Description*
1.1 D	UN No. 0084	Explosives, blasting, Type D (e.g., PE4, C4 or similar high explosives)
1.1 D	UN No. 0027	Black powder granular, or as meal
1.1 D	UN No. 0059	Charges, shaped, without detonator
1.1 D	UN No. 0065	Cord, detonating flexible
1.4 S	UN No. 0105	Fuse, safety
1.1 B	UN No. 0029	Detonators, non-electric, for blasting (e.g., blasting cap to be crimped on a safety fuse)
1.1 B	UN No. 0030	Detonators, electric, for blasting
1.4 B	UN No. 0255	Detonators, electric, for blasting
1.4 S	UN No. 0456	Detonators, electric, for blasting
1.1 B	UN No. 0360	Detonator, assemblies, non-electric, for blasting
1.4 S	UN No. 0500	Detonator, assemblies, non-electric, for blasting
1.4 S	UN No. 0441	Charges, shaped, without detonator

**All graphs courtesy of the authors.*

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