Development of guidelines for field storage of ammunition and explosives during military missions out of area

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1 Introduction

The Royal Netherlands Army (RNLA) and Royal Netherlands Air Force (RNLAF) are frequently called upon to participate in peace-keeping and contingency missions out of area. Since safety of the troops is paramount, strict directives for field storage of ammunition and explosives have to be observed. However, the organization in charge of the operations, like the UN or NATO, prescribe for instance interior and exterior safety distances, which are often in conflict with the desired operational flexibility of the troops. Furthermore, some directives on field storage of ammunition and explosives are inconsistent and insufficient to some extent, introducing an unnecessary additional risk. Commissioned by order of the RNLA and RNLAF, TNO Prins Maurits Laboratory has started a research programme to develop consistent, more user-friendly guidelines for field storage of ammunition and explosives to be used by commanders in the field. The work is supported by the NATO AC/258 Group with the aim of complying with general safety principles as stated in the NATO publication AASTP-1. This paper presents an overview of the results of the first phase of the research programme [1], in which all major aspects involved in field storage are inventoried, existing guidelines on field storage are evaluated and the principles of future guidelines for the RNLA and RNLAF are described.

2 Problem definition

One of the potential hazards during military missions out of area is formed by the ammunition and explosives of one's own troops during transport and storage in the field. In case the ammunition and explosives mass detonates for whatever reason (i.e. enemy attack, snipers, sabotage, fire, inattention of own personnel, etcetera), the explosion effects can be disastrous for the environment. Therefore, well-considered and consistent guidelines are vital. It is obvious that field storage principles differ from those for permanent storage during peacetime. While permanent storage in the interior zone emphasises explosion safety principles and the conditioning of the stored goods, field storage emphasises aspects like optimal accessibility of the stored goods, the need for storage facilities which are easy to construct and demolish, the use of logistics-friendly materials and the possibility to secure and defend the field storage site. These additional requirements can easily degrade explosion safety, if strict procedures are not available or not observed. Therefore, guidelines for field storage should prescribe a well-considered compromise between explosion safety principles and military applicability. Besides this consideration, a major problem in formulating guidelines for field storage is the large variety of parameters involved.
Firstly, the mandate of the operation (i.e. peace-keeping, peace-enforcing) determines the risk that is accepted. During peace-keeping missions, the survival of one's own troops and civilians in the direct

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surroundings is paramount, which means that safety principles take priority. For peace-enforcing missions or war, the military equipment, including ammunition and explosives, must remain operational and therefore takes priority. In these situations, the accepted risk for own troops is higher. Although essential in the development of guidelines for field storage, the total level of risk is hard to define and quantify, because it requires the specification of the probability of a mass explosion of a storage facility. In practice, only explosion effects corresponding to scaled distances and type of storage facilities with or without extra protective measures (barricades) can be quantified including the damage and injuries to be expected. Secondly, each mission out of area will meet various circumstances in the field. The quartermaster of the Corps of Engineers must be able to set up a site plan for all kinds of geotechnical and climatologic conditions. The guidelines should include alternative site planning options if the existing infrastructure does not permit observation of standard safety distances. Also, special attention has to be paid to the conditioning of the stored goods in extreme climatic environments, since the quality of the ammunition and explosives must remain good, not only during the mission but also when it is returned to the home country.

It is obvious that there are situations in which a field commander has to deviate from standard guidelines in order to fulfil a mission. Therefore, a very important part of future guidelines should be the inclusion of sufficient information about the consequences regarding explosion safety and consequences when standard safety precautions (i.e. safety distances) cannot be observed. In practice, this means the presentation of structural damage and personnel injuries for several sets of safety distances. With this kind of additional information, the field commander is sufficiently informed to take well-considered decisions. Another important aspect of the guidelines is that they should be user-friendly. The information to plan a storage site should be simple and straightforward.

Summarising, there are a number of aspects on which guidelines for field storage of ammunition and explosives should be based:

1. site-planning procedures;
2. storage facilities which meet the specific military demands for out of area operations;
3. explosion safety principles including corresponding consequences;
4. inclusion of alternative safety distances;
5. principles for proper storage conditioning;
6. user-friendliness of guidelines.

It is obvious that it is almost impossible to formulate guidelines which include all the variables as mentioned above. A selection or a more specific definition of the variables has to be made. Firstly, existing field storage guidelines are evaluated to inventory their principles, given solutions and shortcomings.

3 Evaluation of existing standards

World-wide, there are a number of standards presenting explosion safety principles for storage of ammunition and explosives. Only a few of them include specific information about field storage. Because these standards are generally much too detailed for use in the field, field regulations are derived from them. The main standards and field regulations which were available to TNO-PML at the time of the literature survey, were respectively:

1. NATO AC/258 Manual AASTP-1 [2];
2. U.S. Standards: DoD 6055.9-STD, DAP 385-64 and TM 9-1300-206 [3, 4 and 5];
3. UN Logistics Directive 100, 101 and 312 (two versions) [6,7, 8 and 9];

NATO AC/258 Manual AASTP-1

The NATO "Allied Ammunition Storage and Transport Publication", AASTP-1, was established by a forum of NATO members. Parts I to III of the AASTP-1 manual prescribe quantity-distances (Q-Ds) for all kinds of permanent storage facilities during peacetime. The international system of classification devised by the UN is adopted. The definitions of hazard classifications and compatibility groups are presented as well as quantity-distance functions and corresponding expected levels of damage and injuries. In 1981, it was decided to publish a new part (part IV) dealing with quantity-distance criteria for airfields. From that date on, regulations for field storage in general, missile installations and basic load ammunition holding areas were also published in this part of the manual. The general regulations for field storage are based on units of quantities. The smallest unit defined is a field stack module containing a maximum of 10 tons gross weight. Examples of these small units are loaded vehicles or containers. With these field stack modules, a field storage site can be planned, storing a maximum of 200 tons gross weight of ammunition and explosives. The positioning of modules in a field storage site is rather strict and based on explosion safety principles (i.e. to prevent sympathic detonation) and rapid access to the articles stored. Combinations of field storage sites are called a field storage area. They store between 200 and 5000 tons and consists of maximally 25 field storage sites. Interior and exterior distances are presented only for field storage sites. Although the guidelines in this chapter of the AASTP-1 are straightforward and thus easy to apply by commanders in the field, they are less suitable for the RNLA and RNLAF. The defined storage sites are often too large by RNLA and RNLAF measures, and the quantity-distances are based on gross weights instead of the preferable net explosives quantities (NEQs). Furthermore, the explosion effects and damage to the environment corresponding with the prescribed minimum exterior distances in case one of the storage facilities detonates, are not quantified. Thus, the commander has no information about consequences at all. Because a field commander has no such information, he might be tempted to reduce safety distances in order to increase the military applicability on aspects as mentioned earlier. For combat units, who have to keep their basic load ammunition in readiness within the boundaries of their barracks, the AASTP-1 publication prescribes separate Q-Ds. For basic load ammunition holding areas (BLAHAs), a number of Q-D functions are defined in an NEQ range from 50 kg to 4000 kg. These functions calculate minimum required interior and exterior safety distances. Although small NEQs are also included, they do not reduce the minimum required safety distances. This is caused by the fact that the throw out of fragmentation and debris is hardly affected by the amount of ammunition or explosives involved. The basic idea behind the guidelines for BLAHAs is very useful for the RNLA and RNLAF. Further improvements can be made by including the consequences when standard safety distances cannot be observed.

U.S. Standards: DoD 6055.9-STD, DAP 385-64 and TM 9-1300-206

The U.S. Department of Defense Explosives Safety Board (DDESB) established safety standards for ammunition and explosives. In 1983, the first edition of the DoD 6055.9-STD standard was published, which applies to all DoD components, such as the Military Departments, the Unified and Specified Commands and the Defense Agencies. These general safety standards were implemented in the technical manual TM 9-1300-206 entitled "Ammunition and explosives standards" and the Army Regulation AR

385-64 entitled “U.S. Army explosives safety program”, which includes the Department of the Army Pamphlet DAP 385-64 entitled “Ammunition and explosives standards”.

The DoD 6055.9-STD standard uses the hazard classification system for dangerous goods as devised by the UN and it presents quantity-distances for both permanent storage in the interior zone (i.e. U.S.A.) and non-permanent storage in the theatre of operations. The contents of the chapter on storage in the theatre of operations are basically the same as the chapter on basic load ammunition holding areas of the NATO publication AASTP-1. However, a chapter for larger ammunition supply points is not included.

Because the DAP 385-64 pamphlet is an implementation of the DoD 6055.9-STD standard, many of the numbers are identical. However, the pamphlet is a more practical handbook for the military in the field. Separate chapters for peacetime overseas operations and wartime operations are included. For wartime and contingency operations, additional options are provided to the commander faced with various and changing battlefield hazards, based on the acceptance of ever increasing degrees of risk. The major options mentioned are:

- where Q-D considerations must be relaxed, prevention of propagation and the preservation of military equipment, personnel, and ammunition should be paramount;
- the third (unwritten) factor in Q-D explosives safety calculations is time. The degree to which standards are relaxed should be directly related to the duration of the exposure. Relaxation of standards for 24 hours involves less risk than relaxation for 48 hours;
- the acceptance of a high degree of explosion risk is dependent upon the competing hazards of the battlefield. The risk of an accidental explosion is higher as ammunition approaches the forward line of troops;
- Hazard Division 1.2 (HD1.2) ammunition should be treated as HD1.1. When it becomes impractical to manage ammunition by HD, all ammunition, except identifiable HD1.4, should be treated as HD1.1. All captured ammunition, mixed ammunition, and unserviceable/unknown ammunition will be treated as HD1.1.

Although the TM 9-1300-206 is no longer in use, it includes some alternative approaches in field storage principles. A separate section is reserved for the storage of ammunition and explosives in the theatre of operations. It introduces a diffzerent hazard classification system for the ammunition and explosives. Field storage categories are defined based on the desirability of storing components of complete rounds in adjacent stacks and on consideration of the hazards of a propagating explosion, range of fragments, spread of fires and chemical contamination. It is likely that these categories are introduced specifically for use in the field for situations where it is not known what the hazard divisions and compatibility groups of the ammunition and explosives are as defined by the UN classification system.

UN Logistics Directives 100, 101 and 312

Military units operating under the flag of the UN use Logistics Directives for all kinds of military activities. Some of them include explosion safety principles for the storage of ammunition and explosives. During the literature survey, the following Logistics Directives, used by UNPROFOR and UNTAC units, were available at the TNO Prins Maurits Laboratory:

- Log Dir 312, entitled “Ammunition and explosives“;
- Log Dir 101, entitled “Ammunition and weapons recovery plan“;
- Log Dir 100, entitled “Ammunition and explosives“.

The following main conclusions were drawn from these field regulations:

1. in contrast with the above-mentioned standards, the procedures prescribed in the Logistics Directives are very straightforward but inadequate;
2. Logistics Directive 312 (dated 20 March 1993) is incomplete, since it does not relate the prescribed safety distances to maximum quantities. This can introduce hazardous situations;
3. the UN classification system is simplified to two hazard classes. These are “small arms ammunition and pyrotechnics” and “high explosives”. Safety distances are given for these two ammunition and explosives descriptions. This simplification is welcome. However, exact definitions of both hazard classes are not included;
4. all prescribed safety distances of storage areas to exposed sites are significantly smaller than prescribed by the NATO publication AASTP-1. The references of the procedures and the policy regarding the accepted level of risk are not mentioned;
5. Logistics Directive 101 repeats some advice from the NATO AASTP-1. However, some data is copied incorrectly, which can result in dangerous situations.

The basic shortcomings of the standards on explosive safety principles and the field regulations supplied by the UN are that the former ones are too detailed and therefore impractical for field commanders, and the latter ones give inadequate information, which can result in hazardous situations.

4 Principles of proposed future guidelines

As confirmed by the results of the evaluation of existing guidelines, it is almost impossible to set up consistent, clear and easily applicable field regulations for safe field storage of ammunition and explosives and still include all the important information. Therefore, a number of practical simplifications and definitions are proposed by the RNLA, RNLAF and TNO-PML.

- in order to make the future guidelines applicable for a wide range of users, ranging from small (mobile) basic load ammunition holding areas for first line troops up to larger semi-permanent ammunition supply points, a modular based storage concept is proposed. A 20 ft ISO-container is defined as one module, containing a maximum of 5000 kg NEQ of ammunition and explosives. Since such containers are already often in use for transportation, unnecessary transfers of the dangerous goods can be avoided or reduced to a minimum as well;
- the criteria on permissible explosion effects and resulting damage and injuries will be similar to those stated in the NATO publication AASTP-1 for permanent storage during peacetime;
- the standard interior and exterior safety distances are based on the maximum content of 5000 kg NEQ. Because, in practice, the containers are often not completely filled, explosion effects and resulting damage and injuries can be considered as worst case scenarios;
- the expected damage and injuries, corresponding to the standard safety distances in case a mass detonation occurs, will be included. Only then, a field commander is sufficiently informed to take well-considered decisions. Also, the consequences when standard measures cannot be met will be included as far as possible;
- the international system of hazard classification as devised by the UN will be adopted;
- the guidelines will include the option of using barricades surrounding a storage module, which will reduce the interior and exterior safety distances. Examples of effective barricades are earth walls or containers filled with small arms ammunition of Hazard Division 1.4S.

5 Conclusions

On behalf of the RNLA and RNLAF guidelines for safe field storage of ammunition and explosives for military operations out of area are being developed at TNO Prins Maurits Laboratory. In the first project

phase, shortcomings of current (international) directives are inventoried and specific demands and wishes of the RNLA and RNLAF are listed. The acquired knowledge and information will be used in the second phase of the project in which preliminary guidelines will be formulated. The current directives for field storage do not correspond to the basic demands of the RNLA and RNLAF. The NATO publication AASTP-1 prescribe well-founded regulations, but is not very accessible and therefore not applicable by commanders in the field. The logistic directives of the UN handling field storage of ammunition and explosives are inconsistent and inadequate. The offered level of protection for personnel and infrastructure is significantly lower compared with the NATO standard. The RNLA and RNLAF adopted the level of permissible damage and injuries as described in the NATO publication AASTP-1 for permanent storage during peacetime. However, it is expected that the implementation of this level of risk in future guidelines will affect the military applicability. Therefore, alternative sets of smaller safety distances and the consequences regarding the increase of hazards will be included as well. Then, the quartermaster or field commander will be informed as good as possible to take well-considered decisions.

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