Explosive Remnants of War (ERW)

Undesired Explosive Events in Ammunition Storage Areas

Geneva International Centre for Humanitarian Demining
Centre International de Déminage Humanitaire - Genève

Explosive Remnants of War (ERW)

Undesired Explosive Events in Ammunition Storage Areas

Geneva International Centre for Humanitarian Demining
Centre International de Déminage Humanitaire - Genève

The **Geneva International Centre for Humanitarian Demining** (GICHD) supports the efforts of the international community in reducing the impact of mines and unexploded ordnance (UXO). The Centre is active in research, provides operational assistance and supports the implementation of the Anti-Personnel Mine Ban Convention.

For further information please contact:

Geneva International Centre for Humanitarian Demining
7bis, avenue de la Paix
P.O. Box 1300
CH-1211 Geneva 1
Switzerland
Tel. (41 22) 906 16 60
Fax (41 22) 906 16 90
www.gichd.ch
info@gichd.ch

Explosive Remnants of War (ERW) - Undesired Explosive Events in Ammunition Storage Areas, GICHD, Geneva, November 2002.

ISBN 2-88487-006-7

Contents

Skodra, Albania, March 1997. Seat of explosion of one of the explosive storehouses.

Acknowledgements

This report was researched and written by Adrian Wilkinson, Head of Technology and Standards, GICHD, and Bob Scott, BARIC Consultants. Additional research was conducted by Paul Ellis, GICHD. The report was edited by Jack Glattbach and laid out for publication by Françoise Jaffré.

Cover photo: Results of ammunition storage area explosion in Lagos, Nigeria, 27 January 2002, © Major A. Welch RLC, British Army.

Foreword

Unexploded ordnance and other remnants of war continue to have a detrimental effect on communities long after conflicts have ended. The mandate of the Geneva International Centre for Humanitarian Demining (GICHD) is to support the international community in reducing the impact of mines and unexploded ordnance. This report, *Explosive Remnants of War (ERW) — Undesired Explosive Events in Ammunition Storage Areas,* is a contribution to the efforts of the international community to address this important issue. It complements the previous report in the series, *Explosive Remnants of War (ERW) — A Threat Analysis*.

The present report identifies the risks and hazards to the local community in the post-conflict environment from undesired explosive events in ammunition storage areas. Unfortunately, only very limited quantitative evidence can be currently obtained from the post-conflict environment, therefore quantitative evidence from stockpiles of ammunition under national control in other situations is also used to illustrate the risks. The risks are broadly similar whether the stockpile is abandoned or under some form of national or international control.

The report makes no attempt to allocate responsibility for these explosive events, it uses them purely to highlight the risks to the local community. It makes specific recommendations for consideration by the international community, particularly with regard to the need to develop international standards or guidelines for the safe storage of ammunition and explosives.

This report has been prepared thanks to funding from the United Kingdom Department for International Development, which is gratefully acknowledged. The GICHD remains committed to providing technical expertise to the discussions held under the 1980 Convention on Certain Conventional Weapons whenever States Parties require it.

Ambassador Martin Dahinden
Director
Geneva International Centre for
Humanitarian Demining

Burrel, Albania, March 1997. UXO contamination inside perimeter of ammunition storage area.

1. Introduction

In almost all post-conflict situations, a hazard to the population exists in the form of abandoned or damaged stockpiles of ammunition. The age of conventional ammunition stockpiles, when combined with inadequate storage conditions and limited danger areas, poses a significant threat during post-conflict operations. The effects of an explosion within an ammunition storage area (ASA) are devastating, resulting in a requirement for major explosive ordnance disposal (EOD) operations. The severity of the threat to human life from blast and fragmentation depends on the proximity of the local population to the potential explosion site. Unlike unexploded ordnance (UXO), which normally affects one or more individuals, an undesired explosive event within an ASA may have an impact on the whole community; it will also result in the scattering of UXO over the surrounding areas, denying the use of that land to the local community.

ASAs constitute a major risk in a post-conflict scenario. The risk comes in three forms: (1) the inherent danger posed by ammunition and explosives; (2) deterioration in the ammunition or the conditions under which it is being stored; and (3) the security of the site. Unsecured ammunition sites are subjected to theft of metal (i.e. brass and copper), of packing materials for fuel, and of explosives for use in fishing or hunting. This in turn leads to the ammunition being mishandled or damaged in such a way as to make it dangerous. There is evidence from the Gulf War that individuals deliberately attacked ammunition sites with explosives after the cessation of hostilities purely out of curiosity. Until appropriately-qualified personnel have assessed an ASA, it must be considered a danger to people in the vicinity.

On numerous occasions, not only in post-conflict environments, explosions in ammunition storage areas have caused significant casualties, in both developing and developed countries.[1] This study attempts to highlight and illustrate the dangers that result from an undesired explosive event within an ASA or abandoned/damaged stockpiles. Although the study covers some of the basic principles of safe ammunition storage and risk management (see Appendixes 1 and 2), it is not intended to be a definitive statement of safe ammunition and explosives storage practices in post-

1. Albania 1997 (115 casualties), Nigeria 2002 (1,500 or more casualties).

conflict environments. These issues are discussed purely to illustrate the risks and possible solutions.

The GICHD was mandated[2] to examine the issue of undesired explosions within ammunition storage areas in order to provide background information to the Convention on Certain Conventional Weapons (CCW) process.[3] The study was financed by the United Kingdom Department for International Development.

The terms of reference developed for the study were to:

(a) research the cause and effects of undesired explosive events within ASAs over the last 20 years;[4]

(b) attempt to identify any common factors; and

(c) propose recommendations to improve future safety of ASAs in post-conflict environments.

Despite extensive literature and Internet searches it soon became apparent to the study team that limited information is available publicly. Therefore, the Netherlands Delegation to the Conference on Disarmament in Geneva requested information from delegates of the States Parties to the CCW in order to try and improve the statistical data on which the study recommendations are based.[5] A copy of the request is in Appendix 3.

The study discusses the factors that can lead to undesired explosions within ASAs and, where there is sufficient evidence, attempts to identify the cause of known explosions.[6] In order to try to identify common factors for undesired explosive events within ASAs it was necessary to expand the search for information to include explosions occurring in non-conflict environments. Although, strictly, these events fall outside the definition of ERW, their lessons are equally valid and have been included for this reason. It can be argued that if undesired explosions occur in ASAs in non-conflict environments, the possibility of an explosion occurring in an abandoned or damaged site in a post-conflict environment, where the standards of explosive safety are likely to be very much lower, must surely be greatly increased.

2. Meeting on 19 July 2002 at the Netherlands Mission to the Conference on Disarmament as Chair of the Explosive Remnants of War Group in the context of the Convention on Certain Conventional Weapons.
3. The formal name of the international treaty is the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects.
4. The 20-year period was chosen: (1) to try and ensure statistical validity, and (2) to try and identify if any patterns had emerged as a result of the changing international stage since the end of the Cold War.
5. This report was drafted in early November 2002 in preparation for the CCW meeting in December 2002. As at 5 November 2002, responses had been received from the following States Parties: Bulgaria, Brazil, Costa Rica, Denmark, Germany, Holy See, Japan, Latvia, Liechtenstein, the Netherlands, Norway, and Romania.
6. There is absolutely no intention on the part of the GICHD study team to allocate or imply blame for any of the undesired explosive events referred to in this study.

2. The explosive threat in post-conflict environments

The term "explosive remnants of war" (ERW) could be used to describe the explosive threat to the community in a region at the end of a conflict, or at the beginning of a period of stability. ERW are generated in many ways and present a variety of hazards due to the diverse types of ammunition used. The explosive threat in post-conflict environments can be divided into four major threat areas:

(a) mine[7] and UXO[8] contamination of the ground;

(b) abandoned armoured fighting vehicles (AFV);

(c) small arms and light weapons (SALW),[9] including limited ammunition and explosives in the possession of civilians and non-State actors; and/or

(d) abandoned and/or damaged/disrupted[10] stockpiles of ammunition[11] and explosives.[12]

Each of the above groups will have an impact on a population seeking to return to a normal lifestyle depending upon factors such as density of the ERW, civilian awareness of the dangers presented by the ERW, and the willingness of a proportion of the population to tamper with or even merely to live within an area affected by ERW. Although a formal definition of ERW has still to be agreed, it has the potential to cut across all four threat areas, therefore consistency of definitions is essential to enable progress to be made towards the reduction of the threat. The terms and definitions

7. A munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or a vehicle. [Anti-Personnel Mine Ban Convention].

8. Explosive ordnance that has been primed, fuzed, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other reason.

9. A variety of definitions for SALW have been proposed but international consensus on a "correct" definition has yet to be achieved. For the purposes of this paper the following definition is used, "***All lethal conventional munitions that can be carried by an individual combatant or a light vehicle, that also do not require a substantial logistic and maintenance capability***".

10. Stockpiles under national control may also pose an explosive threat to the community if not managed correctly, but this threat will not be considered under the ERW process.

11. A complete device charged with explosives, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including demolitions.

12. A substance or mixture of substances, which, under external influences, is capable of rapidly releasing energy in the form of gases and heat.

used within this study are included in Appendix 4. This paper concentrates primarily on the ammunition stockpiles threat, but acknowledges the presence of other generic threat areas, which are covered in more detail in the GICHD publication *Explosive Remnants of War (ERW) —A Threat Analysis*.

Effect of unconfined propellant ignition: only 50 kg of propellant is burning.

3. Causes of explosions in ammunition storage areas

The causes of ASA explosions can be broken down into the following generic categories:

(a) unstable ammunition;

(b) unsafe storage practices;

(c) unsafe handling practices; or

d) deliberate sabotage or acts of war.

Regrettably, the dramatic effects of an ammunition explosion normally make the key witnesses to the event its first victims. Therefore, any investigation after the event tends, by virtue of the fact that there are no direct witnesses, to concentrate on what was known of the practices and the regulations in force at the time, and may eschew imputing responsibility to the organisation involved in ensuring safety. This can lead to a conclusion that the explosion occurred as a result of factors beyond the control of that organisation. However, with the exception of deliberate sabotage/acts of war, the risk of undesired explosion for stable ammunition stored correctly and handled in a safe manner is very low indeed.

Additionally, in non-conflict environments there may well be numerous cases of "near misses", where an undesired explosive event has been prevented or contained due to sound ammunition management and storage practices. In the post-conflict environment, however, such controls are often absent, resulting in undesired explosive events, which are unlikely to be thoroughly investigated and thus for which the cause is never known.

© Major A. Welch RLC, British Army.

Results of ammunition storage area explosion in Lagos, Nigeria, 27 January 2002.

4. Effects of explosions in ammunition storage areas

The immediate effect on the community of an undesired explosive event within an ASA is primarily dependent upon its location; the closer the population to the point of explosion, the greater the likelihood that they will come to harm.

An undesired explosion within an ASA will result, in varying degrees, in all of the following physical effects:

(a) ***Blast.*** This is the "power" of the explosive and is directly related to the useful chemical energy contained within the explosive. It will exert significant pressure on the surrounding environment and will cause structural damage. The degree of damage is dependent on the size of explosion and the resistance to damage of surrounding structures.

(b) ***Shock.*** The shockwave is more powerful than the blast wave, but is of a much shorter duration and effective distance. Its only impact on the local environment will be damage caused to structures with which the explosive comes into direct contact, including the creation of fragmentation.

(c) ***Fragmentation.*** Fragmentation from the building containing the ammunition, and from the ammunition itself, has the potential to travel great distances. As an example, the safety distance for a single 155mm artillery shell is over 700 metres.

(d) ***Noise/sound.*** As an example, 34.5 kilopascals of pressure is required to cause permanent hearing damage. For ten tonnes of TNT, permanent hearing damage can be expected for any humans within 100 metres of the explosion.[13]

(e) ***Heat.*** The heat produced can ignite flammable materials in the local vicinity. Evidence is provided in this study of fire caused by one explosion then causing secondary explosions. (See page 12).

(f) ***Vibration.*** This is in the form of "ground shock" and the effective distance will be dependent on ground conditions; the effect will be felt further through rock than sand.

13. Kingerey and Bulmash, *Airblast Parameters from TNT Spherical Air Burst & Hemispherical Surface Burst*, Technical Report ARBRL-TR-02555, April 1984.

(g) ***Environmental contamination.*** This is least damaging to humans during the explosion itself, but there may be environmental impacts in the form of air, ground and water pollution in the longer term.

(h) ***UXO contamination.*** A medium-term impact is that it is very unlikely that all of the ammunition will detonate or burn during the initial or secondary explosions. A significant percentage will be projected into the surrounding area. This ammunition will have been subjected to forces very similar to the design forces required for arming: it will become "live". In effect it is now UXO, potentially unstable, and will require a planned EOD clearance operation. (The ammunition depot explosions in Albania in 1997 produced heavy UXO contamination[14] to a 100-metre radius, moderate UXO contamination[15] to a 300-metre radius, and light UXO contamination[16] to a 500-metre radius.)

(i) ***Explosive contamination.*** The effects of the explosion have the potential to break open munitions without initiating the explosive or propellant content. This could then be accidentally ignited at a later date resulting in secondary explosions. Apocryphal evidence suggests that a number of the ammunition depot secondary explosions in Albania during 1997 were caused by the local population walking on propellant, thereby igniting it through friction.

There is little doubt that "cleaning up" after an explosion in an ASA is complex, expensive, and time-consuming. Specialist skills, such as EOD, ammunition inspection and repair, environmental impact assessment, and civil engineering are all required to make the area safe. The explosion in Lagos, Nigeria, in January 2002 fully employed an international team of EOD technicians for over three months, whereas the Albanian Army EOD Unit of 20 staff needed three years to ensure the safety of their exploded ammunition depots.

Appendix 5 contains data on known or reported explosions within ammunition storage areas. It should not be regarded as definitive as it is based on information available from limited open sources, and the reports used to obtain the data have generally been written in the immediate aftermath of the explosion. No formal accident investigation reports have been made available to the study team. The list will be updated as more information is received as a result of the Netherlands' initiative. The data on undesired explosive events has been presented in three separate areas:

(a) ammunition storage areas in post-conflict environments;

(b) ammunition storage areas in non-conflict environments; and

(c) civilian firework production facilities (for comparative purposes only).

14. >5 UXO per square metre.
15. 2-5 UXO per square metre.
16. <2 UXO per square metre.

5. Analysis of data

The lack of detailed information on many of the known explosions and the lack of any information on other explosive events means that any analysis of the data is, by necessity, subjective. Yet it is possible to identify trends and draw certain conclusions from them.

Casualties

The following table compares the known casualties from reported[17] undesired explosive events in ASAs over the past 20 years:

Serial storage area	Type of ammunition	Casualties(1) Killed	Casualties(1) Injured	Ratio fatality to injury
(a)	(b)	(c)	(d)	(e)
1	Post-conflict environment	159+	595+	1 to 3.7
2	Non-conflict environment	1,675(2)	128+	1.4 to 1(2)
3	**TOTAL**	**1,854+**	**723+**	**2.6 to 1**
4	Civilian fireworks facilities	386	2,273+	1 to 5.8
5	**GRAND TOTAL**	**2,240**	**2,996**	**1 to 1.3**

(1) For many incidents no figures are currently available, but it can be reasonably assumed that the real casualty figures are higher than those reported here.

(2) This figure is heavily influenced by the explosion in 2002 in Lagos, Nigeria. The incident was the only one in the study that resulted in the deployment of a United Nations Disaster Assessment Cell (UNDAC) team, and must be considered a humanitarian emergency rather than an ammunition depot explosion. Evidence suggests that the casualties due to the initial explosion were low, and that the majority of the casualties were caused by panic and drowning as people tried to avoid the fire and heat. For the analysis of trends within this study it must be regarded as a statistical anomaly, and therefore the Lagos figures have not been included in the ratio calculation.

17. Reported by States Parties in response to the Netherlands' request for further information or from national and international media.

Causes of explosions

The following table analyses the causes of the explosions (where reported or confirmed):

Serial	Cause	Post-conflict	Non-conflict	Total	Civilian firework facilities	Total
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	Auto-ignition of propellant(1)		12	**12**		**12**
2	Cause unknown	10	1	**11**	20	**31**
3	Fire	1	3	**4**	2	**6**
4	High ambient temperature	1	1	**2**		**2**
5	Human error/security	16		**16**	1	**17**
6	Lightning strike		3	**3**		**3**
7	Movement/handling	2	1	**3**		**3**
8	Shelf life expired	1	1	**2**		**2**
9	Ammunition instability		1	**1**		**1**

(1) The high incidence of auto-ignition of propellant in this table is because one of the major source documents for the study was an evaluation of the risks of auto-ignition. Therefore this source of explosion will not be explored further, other than to suggest that it is a major risk in the post-conflict environment, when ammunition surveillance is often non-existent.

Comment

There is insufficient information available at the moment to determine objectively whether any factors are more prevalent than others as a cause of undesired explosions. The fact that so many incidents are reported as "cause unknown" suggests that accident investigation procedures and standards need examination.

What can be determined on the available evidence is that where explosions have occurred, and more than one storehouse destroyed, the basic principles of safe ammunition storage have been ignored. For example, at least one incident was exacerbated by the fact that the undergrowth within and surrounding the ammunition storage area had been allowed to grow; whatever the cause of the initial explosion, all subsequent explosions were initiated by the fire spreading uncontrollably through the undergrowth.

"The grass surrounding the depot ought to have been trimmed on a regular basis"

Major-General (Retired) Ashok K. Mehta, Indian Army

(In the aftermath of the Bharatpur ammunition storage area explosion on 28 April 2000, there were five fatalities, 10,000 people were evacuated and US$90 million worth of stock was destroyed. The grass had not been cut for two years as a cost-saving measure!)
Source: *Bharatnet News and Current Affairs*, 6 July 2000.

6. Safety of ammunition storage areas

There are basic principles for the safe storage and maintenance of ammunition stockpiles. If these principles are followed, in general the risk of an undesired explosion occurring is greatly reduced. An exception is the risks from sabotage or war although, even in this case, adherence to basic principles will reduce the resultant damage. A discussion of the safe storage of ammunition stockpiles is included for information as Appendix 1.

Knowledge of the basic principles of storage will enable the reader to better understand the contributing factors to undesired explosive events and what can go wrong during the storage of ammunition. Many of the factors are fixed; it is the relationship between these factors, the importance placed on the factors by the responsible authority and the available finance for storage that will determine whether or not an ammunition storage area is more, or less, likely to be at risk from an undesired explosive event.

"Ammunition is designed to kill. If you don't look after it properly, it may well end up killing you by accident!"

Brigadier (Retired) Paddy Blagden, British Army, Technical Consultant to the International Committee of the Red Cross

Source: ICRC Regional Conference on Landmines and ERW, Moscow, 4 November 2002.

©A.E.A. Wilkinson, 1998.

Burrel, Albania, March 1997. Large UXO outside perimeter of ammunition storage area.

7. Conclusions and recommendations

The scarcity of available detailed information at the moment makes any form of quantitative, objective analysis inappropriate. Yet there is sufficient evidence to identify trends from the available information.

There is a significant risk to communities in the close presence of abandoned or damaged stockpiles of ammunition in the post-conflict environment. Initial analysis, based on the statistical data in this report, suggests that the ratio of fatality to injury in the post-conflict environment is in the order of 1 to 3.7. This compares favourably with the ratio of 1.4 to 1 in the non-conflict environment; it is assessed that the difference could be due to lower population densities near military establishments in post-conflict environments, combined with the scarcity of statistical evidence to date. Unfortunately, insufficient evidence is currently available for an analysis or estimation of the actual risks of explosion, or the risks of an individual being affected.[18]

Over 30 per cent of undesired explosions in the post-conflict environment are "cause unknown", and this figure would be significantly higher were it not for the impact of the 15 explosions in Albania during 1997. Such a high percentage suggests that:

(a) national authorities are reluctant to release full details of incidents to the national and international media; or that

(b) accident investigations have not been effectively conducted.

Many of the known accidents could probably have been prevented if simple, inexpensive safety precautions and management processes had been implemented. For example, meeting NATO's extremely high safety standards for the storage of explosives in permanent ammunition depots is expensive, but acceptable explosive safety can be achieved at a fraction of that cost. Field storage is often used and, when done properly, accidents are rare. Explosive safety is largely influenced by training and the successful introduction of an ethos of safety. The concept of international

18. Theoretically the ratio between fatalities and the total population of a country for each year there has been an explosion would provide some data. The usefulness of such data is, however, limited and there is a risk that false lessons may be learnt.

guidelines for ammunition and explosive storage based on best practices should be examined.

The ideal conditions for safe storage are discussed in Appendix 1. Yet in the post-conflict operational environment it is extremely likely that formal static ammunition depots will have been subjected to some form of warlike operations, with consequent loss of some or all of the original integrity of the depot. Some field ammunition storage areas may also have suffered from military operations, have been sited and operated with regard to operational commitments and not necessarily sound storage principles, but probably will lack proper storage conditions. Some stocks may also be booby-trapped. It is therefore vitally important that these stockpiles are secured and an assessment of the technical threat is made.

Accordingly, it is recommended:

- **that further monitoring of explosive events in ammunition storage areas continue** in order to provide more visibility for any future identification and analysis of trends. States Parties may wish to discuss a suitable mechanism to implement this recommendation.
- **that an appropriate international organisation should consider the development of international standards and guidelines for the safe storage of ammunition and explosives** in order to reduce the risk to the community in the post-conflict environment. Such standards and guidelines should be based on current United Nations classification of ammunition, and should be based on easily-achieved methodology and technology.
- **that an operational methodology should be developed for military and police forces deployed on peace-support operations** to ensure security and safe technical management for abandoned or damaged ammunition storage areas discovered during operations. Such standards would also improve safety at other ammunition depots in environments where sound storage principles have not been implemented.

Appendix 1

An approach to safe ammunition storage

1. Introduction

There are no internationally-recognised standards for the safe storage of ammunition and explosives in either military or civilian ammunition storage areas. Regional organisations, such as NATO, do have agreed standards,[1] but the safe storage of ammunition and explosives is a national responsibility.[2] The following description and recommendations, which are offered as a possible approach to safe ammunition storage, have been developed from the NATO standard.

2. Ammunition

Ammunition is designed to be as lethal as possible when used and as safe as possible in storage; by its nature it contains very reactive compounds. In order to ensure the safety of that ammunition up to the point of its final use it should undergo the following:

- have been manufactured under controlled conditions and subject to quality control standards,
- subjected to handling and storage tests,
- be assigned a shelf life,[3]
- be the subject of periodic inspection,
- be stored with other ammunition that will not add additional effects should an undesired explosion occur.

2.1. Factors affecting ammunition

Additionally ammunition is susceptible to the following:

- extremes of temperature,
- rapid changes of temperature,
- impact,
- high levels of electro-magnetic radiation,

1. NATO AASPT-1.
2. In areas such as Kosovo or East Timor, where there are no national authorities, the lead organisation should assume responsibility.
3. See the glossary of terms and definitions in Appendix 4.

- ingress of moisture,
- (some components are) susceptible to attack by vermin,
- tampering by inquisitive unqualified personnel.

2.2. Ammunition packaging

Ammunition packaging is a crucial factor in maintaining the integrity of the ammunition. It protects ammunition in the following ways:

- helps to mitigate the extremes of temperature,
- acts as a shock absorber for impact,
- forms an electro-magnetic shield,
- prevents the ingress of moisture, and
- excludes vermin.

In some groups of ammunition it may contain the explosive effects of the functioning of the contents of that individual package spreading to adjacent packages or even alter the explosive effects. It therefore follows that ammunition that is not packaged, is in incorrect packaging or in packaging that has been allowed to degrade due to storage conditions is far more likely to cause or unduly contribute to undesired explosions.

Only ammunition that fulfils the following criteria should be considered suitable for general storage. All ammunition that does not achieve this standard should be subject to special storage conditions/remedial action or destruction:

- have undergone storage and handling tests,
- be undamaged,
- be within its shelf life,
- be correctly packaged in serviceable packaging.

3. The ammunition storehouse

The purpose of the ammunition storehouse is to continue and expand upon the protective cocoon formed by the ammunition packaging. An ammunition storehouse is defined in this paper as being any single storage site where ammunition is stored. It could be anything from a purpose-built igloo in an ammunition storage area to an open stack of ammunition in a field storage site. The principles to be observed in order to safely store the ammunition are the same; it is only the degree of emphasis placed upon those factors that will determine if a storage site is at risk. An ammunition storehouse should provide the following:

- protection from weather conditions including electrical storms,[4]
- physical security from intruders,
- fire protection,
- protection from explosions in adjacent storehouses.

4. This should include the use of lightning conductors.

3.1. Protection from weather conditions

The structure should be capable of withstanding the weather conditions prevailing in the area in which it is sited. It should maintain a stable temperature within the design parameters of the ammunition it stores; depending upon the prevailing conditions this may mean that heating or cooling appliances are required. Lightning protection should be provided and earthing tests carried out to reflect the nature of the sub-soil.

3.2. Physical security from intruders

The building should be capable of being secured from intruders either accidental or deliberate; these precautions will probably mean that the building should not have windows. Where possible the building should be enclosed in a compound that physically excludes all approach, except through the entrance gate. Alarm systems may be employed to detect intruders. Any ventilation openings should be constructed in such a manner as to prevent not only the entry of human intruders but also of animals. Dark, dry locations with stable temperatures are sought after by animals as nesting sites, the bedding material introduced in this manner is a fire risk. The animals themselves may damage wooden packaging and thin-skinned ammunition.

3.3. Provide fire protection

The building should be constructed of non-combustible materials and capable of withstanding an external fire. Internally the building may be fitted with a sprinkler system and fire detection equipment. Fire fighting equipment such as fire extinguishers should be provided to enable first-aid fire fighting. None of the internal fittings, fixtures or surfaces should be spark-producing either from friction or electrically.

3.4. Provide protection from explosions in adjacent storehouses

The structure of the building, or its surrounding traverse, should be robust enough to withstand an explosion in an adjacent storehouse: this is only possible if the whole ammunition storage site is carefully controlled and each storehouse is viewed firstly as a potential explosion site and then viewed as a receiver site.

4. Ammunition storehouse management

The parameters of what constitutes safe ammunition and what constitutes a safe storehouse have been explained, however in order for the two factors to combine to produce safe ammunition storage, the management of the ammunition and the associated storage must be considered.

4.1. Ammunition stacks

All ammunition stored in the same storehouse should be compatible; if this is not possible because of limited space then internal traversing must be erected. Each stack should be stable and consist of the same ammunition nature preferably of the same lot or batch. The ammunition should be stored on wooden dunnage and have an air gap of at least 150mm from walls to allow for the circulation of air and to prevent condensation. All boxes should be closed and preferably sealed; no ammunition should be removed from its packaging in the storehouse. All stacks should have a tally card recording the receipt and issue of ammunition, as an aid to accounting and a deterrent of theft.

4.2. Electrical standards

All electrical appliances should be dust-tight and be of a standard that does not produce sparking when in use. All wiring should be sheathed and fire retardant.

4.3. Prohibited articles

Nothing should be introduced into the storehouse that could endanger the ammunition or the integrity of its packaging. It should be normal practice to place a large sign listing all the articles that are prohibited at the point of entry to the compound containing the storehouse and to have a box into which any such items can be temporarily placed while the owner is in the compound. Nothing other than ammunition should be stored in the storehouse.

4.4. White phosphorus

Storehouses containing ammunition that incorporates white phosphorus should have additional equipment available; this includes a water-filled vessel large enough to completely hold the largest box of ammunition, banding cutters if the ammunition is palletised and eye-wash first aid packs. If the storehouse is not fitted with a smoke detector then the storehouse should be visited at least once a day. In countries where the temperature rises above 45ºC, care needs to be taken as white phosphorus becomes a liquid above this temperature and is then susceptible to leakage and spontaneous combustion.

4.5. Cleanliness

The walls and floor of the explosive storehouse should be kept clean and tidy; this will assist in identifying any degradation in the fabric of the building or the condition of the packaging. All extraneous material such as pallet furniture that is not associated with complete pallets should be removed.

4.6. Accounting

All the ammunition in the explosive storehouse should be accounted for and a record of the account kept in a location that would not be destroyed in the event of the storehouse being destroyed. Regular stock checks should be undertaken as a deterrent to and an identifier of theft.

4.7. Person limits

The number of people allowed into the explosive storehouse or process building should be kept to the minimum required to undertake a task and when that task is complete they should be removed.

4.8. Explosive limits

Every building that stores ammunition should be licensed to hold ammunition, the purpose being to consider what the effects on the surrounding area are likely to be should an explosion occur. The license will examine the storehouse both as a potential explosion site and also as a potential receiver site should an adjacent site explode. A limit will be placed on the amount of explosive that can be stored in the storehouse; it is important that as part of the accounting procedure and inspection routine that this upper limit is checked against the stock present to ensure the limit is not exceeded. Should ammunition of more than one hazard division (with the exception of 1.4S) be present then the total amount of explosive should be calculated as if the entire explosive was of the most restrictive group.

4.9. Vehicles

No vehicle that is not modified to work in an explosive area should be allowed into the explosive storehouse; loading and unloading of vehicles that do not conform should be undertaken outside the building.

4.10. Surrounding area

The area surrounding the explosive storehouse should be kept clear of all combustible material, including trees and undergrowth. Grass should be cut regularly and the trimmings immediately removed.

4.11. Fire fighting

Adequate fire fighting equipment should be available, even if there is a mains supply of water that produces enough pressure to be used in fire hoses; static water tanks should be present as it cannot be presumed that in the immediate aftermath of an explosion the water main will remain intact.

5. The ammunition storage area

Where there is more than one ammunition storehouse on a site the potential interaction between the storehouses becomes a major consideration in the overall storage plan. A major depot may also have a variety of facilities attached to it such as:

(a) ammunition process buildings for the repair and surveillance of ammunition;

(b) road/rail/air interchanges to facilitate in-loading and out-loading; and

(c) demolition areas for the destruction of unsafe or outdated ammunition.

As all these areas handle ammunition they must also be licensed to ensure that an undesired explosion at any of the locations does not adversely affect other sites. Additionally there will be support facilities that do not contain explosives but that could affect the storage of ammunition in other sites. These include:

(a) motor transport and associated refuelling facilities;

(b) administration areas;

(c) radio masts; and

(d) electrical power lines.

Outside the depot there may be buildings and structures that would be affected in the event of an explosion within the depot; these must be taken into consideration when determining the net explosive quantity (NEQ) to be allocated to the various storehouses.

5.1 Depot storage plan

This paper will ignore considerations of stock dispersal and camouflage as these are strategic or tactical decisions to be made by individual nations, however neither of these considerations should be promoted to the detriment of the safety of the storehouses. The amount and type of ammunition to be stored should be determined by a process of licensing which considers each site as a potential explosion site and then as a receiving site. If this process is done correctly and there are command and control procedures in place to ensure the limits are observed, then in the event of an explosion there should be no chain reaction.

5.2 Traverses

Traversing sites can be used to increase the amount of ammunition stored in a site and/or to protect facilities that would otherwise be vulnerable. These traverses fall into three main groups: donor traverses, interceptor or receiver traverses, and container traverses.

A donor traverse would be placed around a storehouse that is being considered as a potential explosion site. Its height is determined by drawing an imaginary line at $+2^0$ from the top of the ammunition stack furthest away from the traverse where this line intercepts the traverse. It should pass through at least one metre of the traversing material. The traverse should be constructed of a material that does not contain any large solid material. In the event of an explosion the traverse will direct blast upwards and arrest low-angle high-velocity fragments that represent the major cause of propagation in depot explosions. This traverse also acts as a receiver traverse in the event of an adjacent site exploding.

An interceptor or receiver traverse is placed around an exposed site that does not contain explosives but is judged to be at risk should an adjacent site explode. The traverse may be constructed of substantial material such as concrete, its height being determined by the degree of protection that is being offered to the exposed site. This type of traverse will offer protection from low-angle high-velocity fragments, some protection from blast and no protection from high-angle lobbed fragments.

Finally there are container traverses: normally these are substantially built following the 2^0 rule described above. The purpose of these traverses is to contain in conjunction with the building they surround almost all of the effects of an explosion. This type of traversing is only a viable proposition when small amounts of explosive are within the area and are normally associated with ammunition process buildings. Additionally, a degree of traversing can be obtained by the use of topographical features and the planting of trees. The trees should of course be at a sufficient distance from the storehouses so as not to constitute a fire risk.

5.3 Fire fighting

As with single buildings, reliance should not be placed upon water mains alone, static water tanks should be provided and climatic conditions taken into account to prevent either undue evaporation or freezing. Larger facilities should have a dedicated fire-fighting force.

Appendix 2

Risk management

1. The concept of safety

Safety is achieved by reducing risk to a tolerable level, which is defined in this paper as **tolerable risk**. There can be no absolute safety; some risk will remain and this is the **residual risk**. [ISO Guide 51: 1999(E)].

Therefore, in the context of safety within ASAs, such areas can never be absolutely safe; they can only be relatively safe. This is an inevitable fact of life, which does not mean that the responsibilities of international organisations (in post-conflict environments), or of national authorities (in non-conflict environments), to ensure safety for the civilian population are in any way diminished. They have a moral imperative to ensure that such areas are made as safe as possible within available resources, or to relocate the local population to an area of safety. Risk management systems should be developed to as close a 100 per cent ideal confidence level as is realistically possible, while allowing international organisations or national authorities to determine what is the **tolerable risk** they are prepared to accept in their particular environments.

2. Risk management

2.1. Determining tolerable risk

Tolerable risk is determined by the search for absolute **safety** contrasted against factors such as:

(a) available resources,

(b) the conventions of society,

(c) cost-effectiveness, and

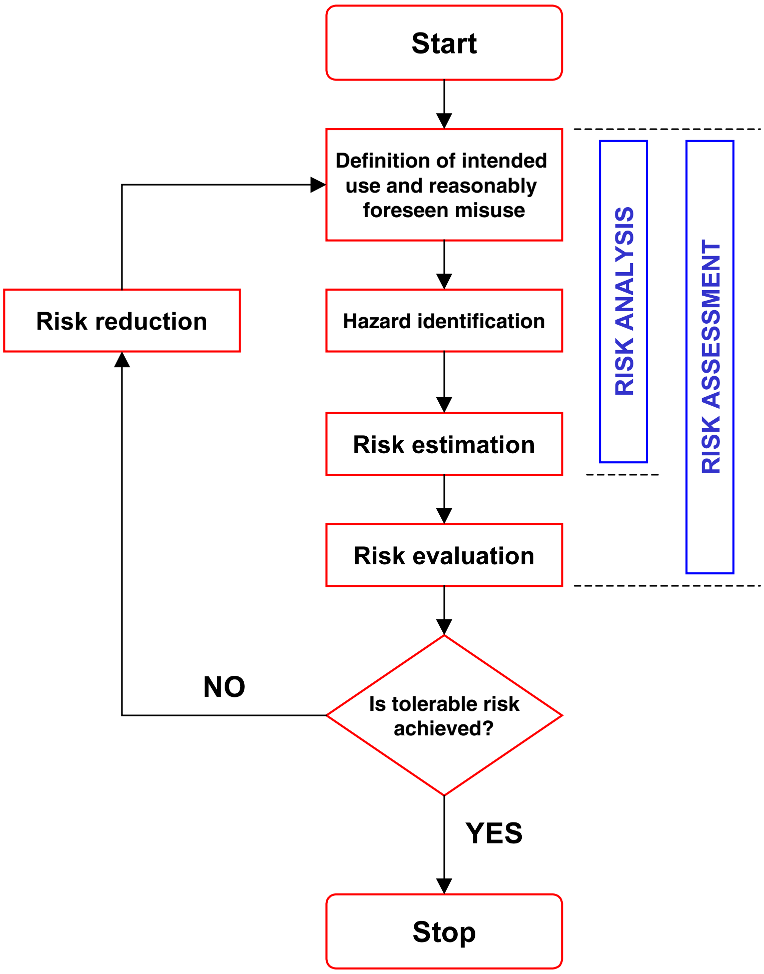
(d) the technical threat (a combination of hazard and risk).

It follows that there is therefore a need to continually review the tolerable risk that underpins the concept behind explosive safety in a particular environment.

2.2. Risk assessment and reduction

Tolerable risk is achieved by the iterative process of **risk assessment (risk analysis** and **risk evaluation)** and **risk reduction**.

2.3 Achieving tolerable risk



The following procedure should be used, in conjunction with any relevant standards, to reduce risks to a tolerable level:

(a) identify the likely group at risk in the vicinity of the ammunition storage area;

(b) identify the **intended use** and assess the **reasonably foreseeable misuse** of the procedures to implement explosive safety;

(c) identify each **hazard** (including any **hazardous situation** and **harmful event**) arising in all stages of the process;

(d) estimate and evaluate the **risk** to each identified user or group;

(e) judge if that **risk** is **tolerable** (e.g. by comparison with other risks to the user and with what is acceptable to society); and

(f) if the **risk** is not **tolerable** then reduce the risk until it becomes tolerable.

When conducting the risk-reduction process, the order of priority should be as follows:

(a) the historical frequency of undesired events in similar facilities;

(b) adequate explosive danger areas;
(c) an effective fire fighting and fire prevention capability;
(d) effective stock segregation in accordance with UN hazard divisions and compatibility groups;
(e) effective operating procedures;
(f) information for those at risk; and
(g) conduct an explosion consequence analysis and reassess (a) through (f) if necessary.

3. Conclusion

It must be emphasised that quality is **NOT** a synonym for safety, and consequently the respective roles of quality management and risk management should not be confused. The safety of ammunition and explosive storage is dependent on the integrated application of both quality management and risk management principles and procedures.

The civilian population in the vicinity of ammunition storage areas must be confident that they are safe. This requires site design and layout, management systems and operating procedures that are appropriate, effective, efficient and safe. Using best practice in risk and quality management will result in significant improvements. These benefits will be felt on the ground by communities and individuals potentially affected by undesired explosive events in ammunition storage areas.

Appendix 3

Netherlands request for information

To: Delegations of States Parties to the CCW

Netherlands Delegation to the
Conference on Disarmament
at Geneva
31-33, Av. Giuseppe Motta/C.P. 196
1211 Geneva CIC

Date: 27 September 2002
Our ref. Geo-137/02
Page 12/2
Encl.

Contact: Renate Reurink
Tel.: 00 41 22 748 18 53
Fax: 00 41 22 748 18 38
Email : renate.reurink@minbuza.nl

Re: Study on Undesired Explosions in Ammunition Depots; from the CCW Co-ordinator on Explosive Remnants of War

Dear Colleagues,

As a follow-up on discussions at the July meeting of the Government Group of Experts (GoGE) meeting under the Convention on Certain Conventional Weapons (CCW), the Geneva International Centre for Humanitarian Demining (GICHD) plans to undertake a short study on Undesired Explosions in Ammunition Depots. I believe that this work could provide us with a background on this subject to facilitate the future discussions within the GoGE. I would therefore kindly draw your attention to the following questions, which were put to me by the GICHD for circulation to States Parties to the CCW.

Questions on Undesired Explosions in Ammunition Depots.

1. Have you had any undesired explosions in ammunition stores in the past 20 years? (If the answer is yes, please answer as fully as possible the following questions).
2. What was the date and time of the explosion?
3. What was the location and purpose of the site where the explosion took place?
4. What was the area of damage from the undesired explosion?
5. Where there any casualties from the explosion and what were they, both wounded and fatalities?

6. What was the cause of the undesired explosion? If the cause is not known, what was the assumed cause?
7. Any other information of relevance, for example type and cost of material damage.

Answers from States Parties to the CCW would greatly facilitate the work of the GICHD. They can be addressed to *p.ellis@gichd.ch*, preferably by early November 2002.

The GICHD will endeavour to finalise the study and make it available to States Parties in time for the GoGE meeting in December.

In the meantime I remain,

Yours sincerely,

Chris Sanders
CCW Co-ordinator for ERW.

Appendix 4

Terms and definitions[1]

Amended Protocol II (APII)
Amended Protocol II (APII) to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to have Indiscriminate Effects (CCW).
It prohibits the use of all undetectable **anti-personnel mines** and regulates the use of wider categories of **mines**, **booby-traps** and other devices. For the purposes of the IMAS, Article 5 lays down requirements for the **marking** and **monitoring** of **mined areas**. Article 9 provides for the recording and use of information on **minefields** and **mined areas**. The Technical Appendix provides guidelines on, inter alia, the recording of information and international signs for **minefields** and **mined areas**.

ammunition
See **munition**

ammunition process building (APB)
A building where ammunition and explosives may be unpacked and inspected, or repaired.

ammunition storage area (ASA)
An area or installation devoted primarily to the receipt, storage, issue and maintenance of ammunition. It need not necessarily be a purpose built site, but could also be the storage of large quantities of ammunition and explosives under field conditions, or a mix of both.

explosives
A substance or mixture of substances which, under external influences, is capable of rapidly releasing energy in the form of gases and heat. [AAP-6]

explosive ordnance (EO)
All munitions containing **explosives**, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket and small arms **ammunition**; all **mines**, torpedoes and depth charges; pyrotechnics; clusters and dispensers; cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components explosive in nature. [AAP-6]

explosive ordnance disposal (EOD)
The **detection**, identification, evaluation, **render safe**, recovery and **disposal** of **UXO**. EOD may be undertaken:

(a) as a routine part of mine clearance operations, upon discovery of the UXO;

---

1. Wherever possible, all terms and definitions reflect those contained within the International Mine Action Standard (IMAS) 04.10 *Glossary of Terms*.

(b) to dispose of UXO discovered outside mined areas (this may be a single UXO, or a larger number inside a specific area);

(c) to dispose of explosive **ordnance** which has become **hazardous** by damage or attempted destruction.

explosive storehouse
An authorised building primarily designed to store ammunition and explosives.

harmful event
Occurrence in which a **hazardous situation** results in harm. [ISO Guide 51: 1999(E)]

hazard
Potential source of **harm.** [ISO Guide 51: 1999(E)]

hazardous situation
Circumstance in which people, property or the environment are exposed to one or more **hazards**. [ISO Guide 51: 1999(E)]

International Mine Action Standards (IMAS)
Documents developed by the UN on behalf of the international community, which aim to improve safety and efficiency in **mine action** by providing guidance, by establishing principles and, in some cases, by defining international requirements and specifications.

Notes: They provide a frame of reference which encourages, and in some cases requires, the sponsors and managers of mine action programmes and projects to achieve and demonstrate agreed levels of effectiveness and **safety**.

They provide a common language, and recommend the formats and rules for handling data which enable the free exchange of important information; this information exchange benefits other programmes and projects, and assists the mobilisation, prioritisation and management of resources.

munition
A complete device charged with **explosives**, propellants, pyrotechnics, initiating composition, or nuclear, biological or chemical material for use in military operations, including **demolitions**. [AAP-6].

Note: In common usage, "munitions" (plural) can be military weapons, ammunition and equipment.

render safe procedure (RSP)
The application of special **EOD** methods and tools to provide for the interruption of functions or separation of essential components to prevent an unacceptable **detonation**.

residual risk
In the context of safety in ammunition storage areas, the term refers to….. the risk remaining following the application of all reasonable efforts to reduce or remove all hazards from the ammunition storage area. [Modified from ISO Guide 51:1999]

risk
Combination of the probability of occurrence of **harm** and the severity of that **harm** [ISO Guide 51:1999(E)]

risk analysis
Systematic use of available information to identify **hazards** and to estimate the **risk.** [ISO Guide 51: 1999(E)]

risk assessment
Overall process comprising a **risk analysis** and a **risk evaluation.** [ISO Guide 51: 1999(E)]

risk evaluation
Process based on **risk analysis** to determine whether the **tolerable risk** has been achieved. [ISO Guide 51: 1999(E)]

risk reduction
Actions taken to lessen the probability, negative consequences or both, associated with a particular **risk**.

tolerable risk
Risk which is accepted in a given context based on the current values of society. [ISO Guide 51: 1999 (E)]

traverse
A mound of earth, or a brick or concrete wall, built around an explosive storehouse to protect the contents of the storehouse from high-velocity missiles emanating from an explosion in another storehouse and to contain the effects of an explosion within the traversed ammunition.

safety
Freedom from unacceptable **risk**. [ISO Guide 51: 1999(E)]

shelf life
The length of time an item of ammunition can be stored before the performance of that ammunition degrades. In the context of this study it is the time before the ammunition degrades to the point at which it becomes unstable.

undesired explosive event
Any explosion withia an ammunition storage area under your control or administration caused by accident, unknown deterioration of stocks or by external hostile intent.

unexploded ordnance (UXO)
Explosive ordnance that has been primed, fuzed, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other reason.

Appendix 5

Data on undesired explosions at ASA

Introduction

The data in the table on next page was either kindly provided by State Parties or compiled from information downloaded from the Internet. It covers the last 20 years and is almost certainly not a definitive listing of all explosions. The column headed BSD refers to the BARIC Source Document from which the information was gathered.

Notes:

- Causes have been allocated where there has been official recognition of the cause.
- Columns (e) and (f) with no figures means that information is not available. Where a zero (0) is shown, it means that sources suggest no casualties.

1. Ammunition storage areas (post-conflict environments)

Serial	Date	Country	Location	Casualties Fatal	Casualties Injury	NEQ[1]	Population evacuated	Cause	BSD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1	1990	Ethiopia	Addis Ababa					Cause not confirmed	042
2	24 Jun 91	Kuwait						Cause not confirmed	042
3	00 Jun 91	Saudi Arabia	UK Army	0	0	2		**High temperature**	
4	00 Jul 91	Kuwait	Camp Doha	3	52			**Human error**	010
5	1995	Yemen	Aden					Cause not confirmed	007
6	19 Mar 97	Afghanistan	Jalalabad	30	200	200		Cause not confirmed	010/22
7	00 Mar 97	Albania	Gjegjan	0	3	10		**Human error /security**	
8	00 Mar 97	Albania	Gjeroven	3	0	915		**Human error /security**	
9	00 Mar 97	Albania	Klos	1	1	154		**Human error /security**	
10	00 Mar 97	Albania	Kordhoc	0	2	322		**Human error /security**	
11	00 Mar 97	Albania	Laci	3	9	80		**Human error /security**	
12	00 Mar 97	Albania	Malesia Lezhe	7	0	52		**Human error /security**	
13	00 Mar 97	Albania	Mbreshtan	2	1	367		**Human error /security**	
14	00 Mar 97	Albania	Palikesht	0	14	316		**Human error /security**	
15	00 Mar 97	Albania	Peshkopi	0	3	70		**Human error /security**	
16	00 Mar 97	Albania	Picar	5	19	232		**Human error /security**	
17	00 Mar 97	Albania	Pilur-Vlore	2	0	38		**Human error /security**	
18	00 Mar 97	Albania	Qafe Shtame / Selixe	23	3	2000		**Human error /security**	
19	00 Mar 97	Albania	Shen Vasil / Sasaj	3	0	9		**Human error /security**	
20	00 Mar 97	Albania	Suc	1	2	200		**Human error /security**	
21	00 Mar 97	Albania	Ura Gjadrit	6	2	900		**Human error /security**	
22	09 Oct 99	Afghanistan	Mazar-e-Sharif	7	12			**Movement/handling**	022/043
23	15 Apr 00	Congo	Kinshasa	40	216			**Movement/handling**	003/4
24	03 Mar 01	Guinea	Conakry	10	0+			Cause not confirmed	015/43
25	20 May 01	Yemen	Al-Bayda	14	50			Cause not confirmed	026
26	08 Jun 01	Viet Nam	Hoa They	0	4	3.5		Cause not confirmed	043/046
27	11 Jul 01	Afghanistan	Darulaman					Cause not confirmed	025
28	08 Mar 02	Sri Lanka	Kankesanturai	0	0			**Ammunition past shelf life**	
29	05 May 02	Guinea	Conakry					Cause not confirmed	015
30	27 Jun 02	Afghanistan	Spin Boldak	19	2			Cause not confirmed	011/21
31	**TOTALS**			**123+**	**536**				

(1) Reported Net Explosive Quantity (Tonnes)

2. Ammunition storage areas (non -conflict environments)

Serial	Date	Country	Location	Casualties Fatal	Casualties Injury	NEQ[1]	Population evacuated	Cause	BSD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1	6 Nov 82	Australia	Mulwala					**Auto-ignition of propellant**	041
2	1983	U.S.	Arkansas	2	19			Cause not confirmed	016
3	11 Nov 84	U.S.	Montana					**Auto-ignition of propellant**	041
4	1985	U.S.	Arkansas	2	7			Cause not confirmed	016
5	6 Jun 85	U.S.	Kentucky					**Auto-ignition of propellant**	041
6	21 Jun 85	U.S.	Sangwan					**Auto-ignition of propellant**	041
7	1986	U.S.	Arkansas	0	0			Cause not confirmed	016
8	27 Jan 86	U.K.	Foulness					**Auto-ignition of propellant**	041
9	1987	U.S.	Arkansas	0	0			Cause not confirmed	016
10	25 Nov 88	Denmark	Jaegerspris	1	0			Cause not confirmed	
11	9 Aug 89	U.S.	Nevada					**Auto-ignition of propellant**	041
12	Oct 81	Brazil	Paracambi					Cause not confirmed	
13	1992	Russia	Vladivostok					Cause not confirmed	014
14	28 Jun 92	U.S.	Maryland					**Auto-ignition of propellant**	041
15	1993	India	Srinagar					Cause not confirmed	017
16	1 Aug 94	U.S.	Maryland					**Auto-ignition of propellant**	041
17	31 Jan 95	Brazil	Paracambi					Cause not confirmed	
18	16 Jul 95	Brazil	Rio de Janeiro		4			**Black powder instability**	
19	25 Jun 96	Saudi Arabia	Dhahran	19	0+			Cause not confirmed	036
20	21 Aug 96	U.S.	Maryland					**Auto-ignition of propellant**	041
21	16 Nov 96	Russia	Dagestan	68	0+			Cause not confirmed	036
22	5 Jul 97	Turkey	Kirikkale	2	10		50,000	Cause not confirmed	005/12
23	9 Jul 97	Romania		16	0+			Cause not confirmed	036
24	21 Feb 98	Russia	Engels	0	0			Cause not confirmed	006
25	21 Feb 98	Russia	Volgograd	0	0			Cause not confirmed	006
26	18 Jun 98	Russia	Ural Mountains	14	17	240	1,000+	**Lightning strike**	019/043
27	28 Apr 00	India	Bharatpur	5	0	10,000		**Fire**	009/10
28	Mar 01	Thailand	Bangkok	0	0	4		**High temperature**	001
29	Apr 01	India	Pathanot			427		**Fire or auto-ignition of propellant**	010/24
30	29 Apr 01	U.S.	Arkansas			60		Cause not confirmed	013
31	May 01	India	Suratgarh	1	2			**Fire or auto-ignition of propellant**	010/30
32	23 Jun 01	Russia	Nerchinsk	5	1		10,000+	**Lightning strike**	002
33	21 Jul 01	Russia	Ulan Ude	3	4		3,000	**Lightning strike**	010/43
34	9 Aug 01	Kazakhstan	Balkhash					Cause not confirmed	020/55
35	16 Aug 01	India	Tamil Nadu	25	3			Cause not confirmed	043/048
36	2 Oct 01	Brazil	Rio Grande do Sul					**Recovered fireworks**	
37	26 Oct 01	Thailand	Pak Chong	12	61		10,000	**Movement/handling ammunition past shelf life,auto-ignition of propellant**	001/8
38	27 Jan 02	Nigeria	Lagos	1,500	0+			**Fire**	029/040
39	**TOTALS**			**1,674**	**128**				

(1) Reported Net Explosive Quantity (Tonnes).

4. Civilian firework production facilities (for comparative purposes only)[1]

Serial	Date	Country	Location	Casualties		NEQ[(1)]	Population evacuated	Cause	BSD
				Fatal	Injury				
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1	TBC	China	Guangdong	40	45			Cause not confirmed	049/052
2	1991	Spain	Rafelcofer	1	0+			Cause not confirmed	044
3	27 Jul 97	U.S.	Michigan	1	17			Cause not confirmed	054
4	14 Oct 97	Japan	Anjo	0	3			Cause not confirmed	050
5	13 Feb 98	China	Beijing	47	0+			**Human error**	043
6	21 Feb 98	Russia	Engels	0	0			Cause not confirmed	006
7	13 Oct 98	Mexico	Tultepec	10	30			Cause not confirmed	043
8	11 Dec 98	U.S.	Michigan	7	0+			Cause not confirmed	043
9	12 Dec 98	Brazil	San Antonio	24	50			Cause not confirmed	043
10	28 Dec 98	Peru	Lima	7	8			Cause not confirmed	043
11	26 Sep 99	Mexico	Celaya	56	0+			Cause not confirmed	036
12	00 Dec 99	China	Chaoyang	11	40			Cause not confirmed	051
13	13 Jan 00	China	Anhui	22	0+			Cause not confirmed	043
14	12 Mar 00	China	Jiangxi	33	0+			Cause not confirmed	045
15	14 Mar 00	Mexico	Santa Ana	3	17			**Fire**	043
16	13 May 00	Netherlands	Enschede	22	2,000			**Fire**	042/043
17	15 May 00	Spain	Rafelcofer	5	18			Cause not confirmed	043/044
18	05 Aug 00	China	Jiangxi	21	25	2		Cause not confirmed	043/045
19	09 Dec 00	China	Mianyang	11	7			Cause not confirmed	053
20	07 Mar 01	China	Jiangxi	41	0+			Cause not confirmed	043
21	01 Jun 01	Pakistan	Lahore	9	4			Cause not confirmed	043
22	10 Aug 01	Portugal	Caldelas	5	1			Cause not confirmed	043/047
23	22 Oct 02	India	Velupuram	10	8			Cause not confirmed	034
24	**TOTALS**			**386**	**2,273+**				

(1) Incidents at firework production facilities have been included for comparative purposes. Fireworks are particularly dangerous and are much easier to initiate in an accident than the vast majority of military ordnance. The difference is in the effect if there is a major incident. (See Conclusions).
(2) Reported Net Explosive Quantity (Tonnes)

Geneva International Centre for Humanitarian Demining
Centre International de Déminage Humanitaire - Genève

Geneva International Centre for Humanitarian Demining
7bis, avenue de la Paix
P.O. Box 1300
CH - 1211 Geneva 1
Switzerland
Tel. (41 22) 906 16 60, Fax (41 22) 906 16 90
www.gichd.ch