Best Practice Guide on Physical Security of Stockpiles of Conventional Ammunition

The aim of this Best Practice Guide (BPG) is to provide guidance on the following safety and security requirement for the management of conventional ammunition stockpiles:

PHYSICAL SECURITY OF STOCKPILES OF CONVENTIONAL AMMUNITION IN MILITARY AMMUNITION DEPOTS
IMPLEMENTATION OF THE STOCKHOLDERS DUTY OF CARE

Every holder of ammunition has a legal and moral duty of care to those it employs in the management of the ammunition and the general public that may be affected by the theft and potential use of ammunition stolen from ammunition storage facilities and from an explosive event within an ammunition storage site. It is anticipated that this guide will contribute to and facilitate the development and application of high common standards to provide the required levels of public safety and stock protection.

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I. PHYSICAL SECURITY OF STOCKPILES OF CONVENTIONAL AMMUNITION IN MILITARY AMMUNITION DEPOTS

1. Aim

The aim of this Best Practice Guide (BPG) is to provide guidance for the effective management and security of national conventional ammunition stockpiles in military ammunition depots. It is anticipated that this guide will contribute to and facilitate the development and application of high common standards in this field.

2. Scope

This BPG deals with conventional ammunition except those specifically excluded by the OSCE Document on Stockpiles of Conventional Ammunition (OSCE, 2003). The scope of the guide is to elaborate a methodology for the development of policy and general operational guidelines and procedures on all aspects of conventional ammunition security. It outlines the various requirements to ensure that the responsible ammunition stockpile managers provide the appropriate duty of care.

3. Introduction

Every holder of ammunition has a legal and moral duty of care to those it employs in the management of the ammunition and the general public that may be affected by the theft and potential use of ammunition stolen from ammunition storage facilities.

Where these practices cannot all be implemented, participating States should implement those practices for which they have the capability, and work on implementing further practices with the aim of creating a comprehensive stockpile management program.

RESPONSIBILITIES with regard to CONVENTIONAL AMMUNITION

Responsible ministries and governmental agencies possessing conventional ammunition should:

- Plan, program, and budget resources to ensure that ammunition in their custody is secure;
- Establish procedures to review all military ammunition storage construction and installation modification projects prior to contract award to ensure that they meet the required security criteria;
- Consolidate ammunition stocks within operational, safety, and mission requirements to reduce security costs.

If required, the security of existing facilities should be upgraded. Such facilities shall be prioritized for security upgrade[1] as follows:

- Facilities storing Category I items;
- Facilities storing Category II items;
- Facilities storing Category III and IV items.

4. Security categories

On the basis of their use, attractiveness, and availability to subversive and criminal elements, ammunition is categorized according to the risks involved. As a general rule, only arms, missiles, rockets, explosives rounds,

1 See paragraph V.

mines, and projectiles that have an unpacked unit weight of 45 kilograms or less shall be categorized as sensitive for purposes of this BPG. Any single container that contains a sufficient amount of components that, when assembled, will perform the basic function of the end item shall be categorized the same as the end item. The following provides guidance based on commonly accepted security applicability:

Category I

- Man portable missiles and rockets in a ready-to-fire configuration.

Category II

- Missiles and rockets requiring a crew-served platform mounted launcher or other equipment to function.

Category III

- Missiles and rockets requiring a crew-served platform mounted launcher or other equipment to function and complex hardware and software equipment to function;
- Launch tube and grip stock for the Man Portable Air Defence Systems missile;
- Ammunition, .50 calibre and larger, with explosive filled projectile with an unpacked weight of 45 kilograms or less;
- Incendiary grenades and fuses for high explosive grenades;
- Blasting caps;
- Supplementary charges;
- Bulk explosives;
- Detonating cord.

Category IV

- Hand or rifle grenades (high explosive and white phosphorous);
- Antitank or antipersonnel mines with an unpacked weight of 22 kilograms or less;
- Explosives used in demolition operations, C-4, military dynamite, and TNT with an unpacked weight of 45 kilograms or less;
- Ammunition with non-explosive projectile (unpacked weight of 45 kilograms or less);
- Fuses (other than those for high explosive grenades);
- Illumination, smoke, and CS grenades;
- Incendiary destroyers;
- Riot control agents with an unpacked weight of 45 kilograms or less;
- Explosive compounds of sensitive missiles and rockets (except warheads);
- Warheads for precision-guided munitions with an unpacked weight of more than 45 kilograms.

5. Protection modes – ingress/egress

Modes of operation

An integrated real-time security system can be designed to operate in the following modes of operation:

- Ingress Prevention.
  Unauthorized persons (or weapons effects) are prevented from entering (or destroying) the denial zone containing the assets at risk.
- Egress Prevention.
  Unauthorized persons are prevented from exiting with the assets.

Depending upon the assets and the threat, one or both of the above security modes may be used. For example, security for arms, ammunition, and explosives-type assets may require ingress prevention to assure that an intruder never gains access to the weapons because of

potential engagement advantages against the guards offered by the weapons, or because of political embarrassment, or other considerations. On the other hand, egress prevention may be more appropriate for property assets when the objective is theft and not sabotage. In this case allowance can be made in the timeline calculations and design for intruder ingress and egress from the installation. When both of the above operating modes are combined into one integrated system, it can be considered to be in-depth security capability.

6. Integrated security systems

The security elements associated with the installation to ensure the effectiveness of an integrated security system design are:

- Barrier layout and construction to delay the intruder;
- Access control at points of entry to protect against covert entry threats;
- Intrusion detection sensors and alarms to detect an attack on or within the installation, and/or unauthorized insiders after hours;
- Closed Circuit Television (CCTV) to assess whether an alarm is actually a threat;
- Guards to respond to the location of a real threat.

All these elements are important. None of them can be eliminated or compromised if an effective security system is to be achieved but an optimal combination of them should be strived for. Also, without detection, the response force would not be alerted. In addition, the delay offered by the physical protection must provide sufficient time after detection for threat assessment and guard force response.

7. Intrusion Detection Systems (IDS)

Applicability

Ammunition storehouses storing Categories I and II missiles and rockets, Category I and II explosives should be protected by an IDS unless the areas where they are located are continuously manned or under constant surveillance in such a manner that unauthorized entry into and around the structures can be detected.

IDS Suitability

The detection of an intruder can be accomplished using on-site guards, IDS, or combinations of both. Locating guards in towers or deploying sensors along extended fence lines adds to the intruder‘s ingress/egress time to cover the distance from the fence to the stockpiles. This option involves operating costs for guards or, if sensors are used, initial purchase, installation, and maintenance costs. The cost effectiveness of using exterior detection along extended perimeters to gain added intruder ingress/egress time must be weighed against the cost of physical protection and installing IDS in a smaller area or on building(s). The time to penetrate or climb over a perimeter fence is often only a few seconds and that the ingress time for an intruder carrying cutting tools and covering a hundred metres between the fence and stockpile is less than a minute. Given the nominal amount of time gained relative to the expense involved, the use of guards or IDS on extended fence perimeter may not be mandatory unless specified by the appropriate national security and explosive safety regulators. For security guards to respond to an intrusion, threat detection either by security personnel or remote systems IDS is required. The function of an exterior perimeter IDS is to detect a threat and initiate the security system response timeline at the exterior perimeter of the site. IDS performance parameters of concern include:

- Completeness of coverage;

- False and nuisance alarm rates;
- Probability of detection;
- Zone at which the alarm occurred;
- Detection at the installation perimeter.

Guards or sensors may be located to ensure deployment before the physical protection is penetrated by intruders. For a barrier to be effective in delaying an intruder, detection must occur before penetration of the barrier has occurred. Surface sensor systems, such as vibration sensors, are usually more cost-effective than stationing guards.

Contractual Service Agreements

An IDS should be installed by reputable security suppliers with proven relevant experience. The contract should include a robust service agreement to ensure the continuous effectiveness of the system. Service/maintenance must be provided as required by the specifics for the installation.

Interior IDS systems

Amongst the many available IDSs the following are most common:

- Fence-mounted strain-sensitive cable on the fence fabric in combination with a „Y“ taut wire on the fence outriggers;
- Ported coaxial cable clear zone sensor;
- Microwave fence sensor.

Closed circuit television (CCTV)

A properly designed CCTV assessment system provides a rapid and cost-effective supplement to guards for determining the cause of intrusion alarms and assessing a potential threat. CCTV enables evaluations to be made from remote locations. Using video event recorders, events can also be viewed later when multiple alarms or delayed guard force attention occurs. In general, CCTVs increase the efficiency and effectiveness of security personnel and security response timelines. They can be a cost-effective alternative to human on-the-spot assessment, which typically involves extended time delays for guards to respond, or the use of costly on-site guards.

IDS Integrity

To ensure the integrity, reliability and serviceability of IDS the responsible authority must ensure that:

- All IDSs must be approved by the responsible security authority;
- All alarm signals will enunciate at a central control or monitoring station from which a response force can be dispatched. The reaction time of the response force must allow action before the physical protection is penetrated;
- Where an IDS is installed in a installation outside a military installation, arrangements shall be made to connect to local police or commercial monitoring companies from which immediate response to activated alarms can be directed.

A daily log shall be maintained of all alarms received. Logs shall be maintained for a minimum of 90 days and shall be reviewed to identify and correct IDS reliability problems. The log shall reflect the following:

- Nature of the alarm (nuisance, system failure, illegal entry);
- Date, time, and location of alarm;
- Action taken in response to the alarm.

IDS transmission lines shall have line security electronically monitored to detect evidence of tampering or attempted compromise. Upon loss of either communication path, the system shall immediately initiate notification to the monitoring installation via the other communication link. Additionally, a protected backup independent power source of four-hour minimum dura-

tion shall be provided. Systems shall be tested quarterly to ensure the proper functioning of the alarm sensors.

8. Restricted area posting

An installation containing explosives shall be designated as a military „RESTRICTED AREA“ and be managed according to national requirements as applicable.

9. Explosive store house physical security

Security fences

In general, security fences are made of either taut wire or standard chain link metal fabric with various enhancements. Fence enhancements include different configurations of barbed wire outriggers. In general, fences (both with and without enhancements) offer delays of less than 1 minute against low-level threats to as little as 3 to 8 seconds against trained and dedicated high-level intruder teams. The height of the fence or the degree of enhancements used makes little difference on this time. In general, fence material can be easily cut, or climbed over. This includes barbed wire which can easily be climbed over with the aid of blankets, etc. However, fences do offer some advantage in limiting the amount of tools and equipment that an intruder can readily carry into the site. In general the delay time offered is not a significant factor in selecting a fence. A simple fence without enhancements will be adequate in most cases to define the installation boundary, deter the casual intruder, or support an exterior IDS system. The use of fence enhancements offers the increased appearance of impregnability, but this should be weighted in terms of the increased material and maintenance costs.

10. Drainage culverts and utility openings under fences

Special protective measures must be designed for culverts, storm drains, sewers, air intakes, exhaust tunnels and utility openings that pass through cleared areas, traverse under or through security fences.

11. Security lighting

Security lighting aids threat detection, assessment, and interdiction. Lighting may also have value as a deterrent. Security lighting increases the effectiveness of guards and CCTV by increasing the visual range during periods of darkness or by illuminating an area where natural light is insufficient. Exterior security lighting is typically located along exterior perimeters and entry points to the installation. Each installation presents its particular deployment problems based on physical layout, terrain, weather conditions, and security requirements.

Lighting may operate continuously or on a standby basis. Continuous lighting is the most common security lighting system. It consists of a series of fixed luminaries arranged to flood a given area continuously during the hours of darkness with overlapping cones of light. The two primary methods of using continuous lighting are glare projection and controlled lighting:

- Glare lighting uses luminaries slightly inside a security perimeter and directed outward. It is considered a deterrent to a potential intruder because it makes it difficult for him to see inside the area being protected. It also facilitates for a guard inside the installation to observe intruders by keeping him in comparative darkness.
- Controlled lighting is used when it is necessary to limit the width of the lighted strip outside the perimeter because of adjoining property or nearby highways, railroads, navigable waters, airports and like facilities.

Switches for exterior lights shall be installed in such a manner that they are accessible only to authorized personnel.

12. Door locks and padlocks

Each explosives storehouse door should have either:

- A single mortise lock requiring two separate unique keys;
- Two mortise locks each requiring its own unique key;
- Two padlocks and hasps to the required national security standard each with its own unique key.

The padlock is commonly used as it is applicable on all door assemblies. Preferably the padlock body has an extension shielding over the shackle of at least 9,5 millimetres above the top and on three sides that will allow close onto the associated hasps the hasps. These padlocks and special hasps are highly resistant to forced and surreptitious entry and should meet the following resistance criteria:

- Defeat the use of devices, equipment and methods such as picking, shimming, bypassing, impressioning, and other methods used by locksmiths to open padlocks without harm to the padlock or clearly visible evidence of attempts to open, for not less than 15 minutes.
- Defeat the use of saws and drills (manual or batter powered), hammers, chisels, punches, jimmies, wrecking bars, torque levers, common hand tools chemicals (excluding explosives) for not less than five minutes accumulated work time.

Key control

The following control requirements are an imperative part of the overall security strategy:

- Keys to explosives storage areas, buildings, rooms, racks, containers, and IDS shall be maintained separately from other keys;
- They shall be accessible only to personnel whose official duties require access to them;
- A current roster of personnel authorized key access shall be maintained and kept from public view;
- The number of keys shall be held to the absolute minimum;
- Master keying of locks and the use of a master key system is prohibited for explosives exterior access doors;
- Keys shall not be left unsecured or unattended at any time;
- In the event of lost, stolen, or misplaced keys, the affected locks or lock cores shall be replaced immediately;
- When not attended or in use, operational keys to Category I and II explosives shall be secured in approved high security containers;
- Keys to Category III and IV explosives may be stored in secure containers with an-approved built-in three position changeable combination lock;
- Reserve or replacement locks, cores, and keys shall also be secured as prescribed above;
- Keys shall not be removed from the explosives site except for operational necessity;
- installation Commanders, or their designees, shall appoint in writing explosives lock and key custodians;
- Key custodians shall not be unit armourers or other persons responsible for the explosives storage facilities;
- Key control registers shall be maintained to reflect continuous key accountability;
- Key registers shall contain the following information:
- Name and signature of individuals receiving keys;
- Date and hour of issuance;
- Key serial numbers or other identifying information;
- Signature of individuals issuing keys;
- Keys return date and hour;
- Name and signature of individual receiving returned keys.

Key Rotation

"In-use" keys should be rotated on a regular basis with reserve and replacement keys to ensure even wear and tear.

13. Security breaches

Documented and practiced procedures should be in place to undertake a suitable and timely response to incidents involving the loss or theft of ammunition, and any other breaches of security, which can be considered to result in an ammunition security threat. This process should include coordination with other police and national security organisations. Effective lines of communication should be in place to ensure that any incident can be immediately reported to the appropriate senior staff.

Any such incidents should be fully investigated to determine any failings in existing procedures and identify practicable and reasonable remediation. Whilst the specific mechanisms will be determined by internal national organisations and structures the reporting procedure should follow the following general process:

- Depot level investigation to verify the facts and subsequent Command level reporting;
- Command level assessment and coordination with other responsible authorities;
- If appropriate Ministerial response and action;
- Initial remediation response;
- Formal enquiry, report and implementation of recommendations;
- Continued related oversight.

II. IMPLEMENTATION OF THE STOCKHOLDERS DUTY OF CARE

1. Introduction

The handling, maintenance, transport and storage of munition are an inherently hazardous and risky process. Whilst ammunition is designed and manufactured to be safe in storage and transport, the significant number of recent catastrophic ammunition storage accidents starkly confirms that these are not the result of "credible accidents", but the result of stockpile management failings. Every holder of ammunition has a legal and moral duty of care to those it employs in the management of the ammunition and the general public that may be affected by an explosive event within the explosive area.

The correct compliance with agreed norms of ammunition stockpile management will ensure, as far as is reasonable and practical, that adequate protection will be provided; the management of ammunition cannot, nor seeks to, provide absolute protection. Where these practices cannot all be implemented, participating States should implement those practices for which they have the capability, and work on implementing further practices with the aim of creating a comprehensive stockpile management program.

2. Scope

This best practice guide covers the various requirements for ammunition stockpile managers to follow. It is based on the requirement for above ground storage, although certain sections are relevant to all ammunition storage modes.

These requirements are designed to manage risks and hazards associated with the storage and handling of ammunition and explosives by providing protection criteria to minimize loss of life, serious injury and damage to property, both military and civilian. They are not intended to be so rigid as to prevent the Services from accomplishing their assigned missions.

The steps required to ensure the duty of care will afford a high degree stock protection.

This Guide covers the following general requirements:

- UN Classification of Dangerous Goods;
- Explosion Effects;
- Hazard and Risk Analysis;
- Hazard Mitigation;
- Explosives Quantity Distances;
- Safe Guarding of Explosive Sites;
- Waivers and Exemptions.

3. Definition

Aboveground Storage

Storage in magazines with or without earth-cover or in open stacks at surface level. An accidental explosion at the storage site may result in blast, fire and projections.

Ammunition[2]

General: An item which, in order to perform its function, requires to contain energetic materials.

Specific: A complete device charged with explosives, propellants, pyrotechnics, initiating compositions, or nuclear, biological or chemical material for use in military operations.

Note 1: In logistic configuration, the logistic packaging of the munition is included.

Assembly Place

A building or place where it is customary for people to assemble (e.g. church, school, sports stadium).

Barricade

A natural ground feature, artificial mound, traverse or wall which for storage purposes is capable of preventing the direct communication of explosion from one quantity of explosives to another although it may be destroyed in the process.

Buried Storage

Storage in chambers or magazines below surface level. In case of an accidental explosion at the storage site, the hazard of low-angle, high velocity projections is reduced significantly. The other hazardous effects are similar to those in aboveground storage, but are gradually reduced as the cover is increased.

Classification Code

The alpha-numeric symbol which denotes the complete hazard classification for a particular type of ammunition. The code comprises two digits, indicating the hazard division, followed by a letter corresponding to the compatibility group.

Compatibility Classification

Ammunition and explosives are considered to be compatible if they may be stored or carried together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

2 The term „ammunition“ in its restricted meaning is used throughout this Manual in the same sense as „explosive article“ is used by UN and IMO in the Orange Book and IMDG Code respectively to mean an article containing one or more explosive substances.

Debris
Any portion of the natural ground or of a structure (rocks, structural materials, fittings, equipment, barricade materials etc.) which is propelled from the site of an explosion.

Deflagration
Chemical explosion in which the zone of chemical reaction propagates through the initial medium at a subsonic velocity, mainly by thermal conduction.

Deflagrating Explosive
A secondary explosive which reacts by deflagration rather than detonation when used in its intended role.

Detonation
Decomposition reaction in which the zone of chemical reaction propagates through the initial medium at a supersonic velocity behind a shock front.

Detonating Explosive
An explosive which reacts by detonation rather than deflagration when used in its intended role.

Explosion
A nuclear, chemical or physical process leading to the sudden release of energy.

Explosive[3] Material
A substance (or a mixture of substances), which is capable by chemical reaction of producing gas at such a temperature and pressure as to cause damage to the surroundings.

Note 1: The term explosive material includes solid and liquid high explosives, propellants and pyrotechnics.

Note 2: It also includes pyrotechnic substances even when they do not evolve gases.

Note 3: The term explosive is often used in short for explosive material.

Explosives Area
An area used for the handling, processing and storing of ammunition and explosives. Where there is no fence it is taken as being the area within a radius of 50 m from any building or stack containing explosives.

Explosives Workshop
Any structure used for the inspection, maintenance and renovation of ammunition and explosives.

Exposed Site
A magazine, cell, stack, truck or trailer loaded with ammunition, explosives workshop, inhabited building, assembly place or public traffic route, which is exposed to the effects of an explosion (or fire) at the Potential Explosion Site under consideration.

Exterior Quantity-Distance
The minimum permissible distance between a PES and an ES outside the explosives area.

Fragment
Any metal portion of the ammunition or its package which is propelled from the site of an explosion.

3 The term „explosive“ is used throughout this Manual in the same sense as „explosive substance“ is used by UN and IMO in the Orange Book and IMDG Code.

Hazard Classification or Classification

The assignment of a type of ammunition to the correct hazard division, according to tests or other assessment, and the appropriate compatibility group. Thus there are two components in the complete classification.

Heavy-Walled Building

A building of non-combustible construction used for explosives storage with walls of at least 45 cm reinforced concrete (70 cm brick) or equivalent penetration resistance of other materials, with or without a protective roof. The door is barricaded if it faces a PES.

High Velocity Projections

Debris or fragments at high velocity as the result of an explosion and with sufficient remaining energy to propagate an explosion to another stack.

Inhabited Building Distance

The separation between potential explosive sites and non-associated exposed sites requiring a high degree of protection from an accidental explosion.

Igloo

A magazine - normally built at ground level - earth-covered, and constructed in corrugated steel or reinforced concrete, provided with a strong headwall and door(s). The earth covers the roof, the sides and the rear. The magazine and its earth-cover are designed to stringent criteria for resistance to external blast loading and attack by high velocity projections. The cross-section of the igloo may be semi-circular, elliptical, rectangular or a combination of these.

Initiation

Action by means of a suitable pyrotechnic device leading to a detonation, deflagration or combustion.

Initiation system

System to initiate an explosive train or component in a munition.

Interior Quantity-Distance

The minimum permissible distance between a PES and an ES inside the explosives area.

Light Structure

A structure erected to protect a stack against weather.

Lobbed Ammunition

Unexploded ammunition projected from an exploding stack. It may explode on impact.

Mass Explosion

An explosion which affects virtually the entire quantity of explosives under consideration practically instantaneously. The term usually relates to detonation but also applies to deflagration when the practical effects are similar, for example the mass deflagration of propellants under very strong confinement so as to produce a bursting effect and a serious hazard from debris.

Mass Fire

A deflagration of the entire quantity of explosives under consideration in circumstances that avoid a bursting effect and a serious hazard from debris. A typical mass fire occurs in a few seconds at most and produces extensive flame, intense radiant heat and minor projection effects.

Means of Initiation

Any device used to cause a detonation of an explosive.

Moderate Fire

A fire comparable with that involving an ordinary commercial warehouse which burns comparatively slowly

and with a moderate flame radius. Some items may be thrown out of such a fire for a short distance.

Net Explosives Quantity

The total explosives contents of an ammunition item.

Potential Explosion Site

The location of a quantity of explosives that will create a blast, fragment, thermal or debris hazard in the event of an accidental explosion of its content.

Primary Explosive

Substance, or mixture of substances, used to initiate a detonation or a burning reaction.

Note 1 : In their intended role, these materials are sensitive to a range of thermal, mechanical and electrical stimuli, like for instance heat, impact, friction, electricity, and undergo a rapid reaction upon initiation.

Note 2 : Primary explosives are used in initial or intermediary charges in devices such as primers, detonators, caps, relays, electric matches, etc.

Projections

Overarching term for debris, fragments, non-metallic portions of the ammunition or its package, and lobbed ammunition.

Protective Roof

A 15 cm reinforced concrete roof or its equivalent designed to protect the contents of a building from debris, fragments and lobbed ammunition. The roof should not collapse if the walls are damaged, except in the case of earth-covered structures.

Public Traffic Route

A road used for general public traffic; a railway outside the explosives area which is used for public passenger traffic; a waterway, such as a river having tidal water and a canal, used by passenger vessels.

Pyrotechnic Composition

Substance or mixture of substances which when ignited, undergoes an energetic chemical reaction at a controlled rate intended to produce on demand and in various combinations, specific time delays or quantities of heat, noise, smoke, light, or infrared radiation.

Note 1 : Pyrotechnic compositions may be used to initiate burning reactions such as in igniters.

Note 2 : Pyrotechnics, in most of their applications, are required not to undergo a deflagration-to-detonation transition.

Note 3 : The term excludes propellants and (high) explosives.

Secondary Explosive

A substance or mixture of substances which will detonate when initiated by a shock wave but which normally does not detonate when heated or ignited.

Note 1 : As opposed to primary explosive.

Serious Structural Damage

Damage that renders buildings uninhabitable and is not readily repairable. For example: serious weakening or displacement of foundation, supporting walls, interior supports, side walls, floors or ceiling structures, breaking numerous rafters or other important supporting members of roofs or floors.

Spall

Material, especially small pieces of rock, detached from a surface by passage of a shock.

Static Pressure

The pressure due to the increased mass and temperature of gases inside a structure aftershock effects from an explosion have ceased.

Vulnerable Buildings

Large building constructed with external non loadbearing panels or with more than 50% of its wall area glazed.

Note : These buildings are sited at two times inhabited building distance because they are expected to be heavily damaged from an explosion at inhabited building distance (i.e., 22.2 $Q^{1/3}$).

With a Propelling Charge

The propelling charge is assembled to the projectile or packed with the projectile in the same package or palletized with the projectile on the same pallet.

4. UN Classification of Dangerous Goods

UN Dangerous Goods Class 1

In order to promote the safe transport of dangerous goods, an International System for Classification has been devised[4].

The system consists of 9 classes of which Class 1 comprises ammunition and explosives. Class 1 is divided into divisions. The Hazard Division indicates the type of hazard to be expected primarily in the event of an accident involving a stack of ammunition. Class 1 ammunition is further divided into 14 Compatibility Groups designed to minimise the risk of storing items together that will either increase the significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident. Whilst initially produced for the transport of dangerous goods the principles have been applied by many nations as the basis for a simplified consequential hazard and risk assessment for the storage of ammunition. This process does not take into account the probability of an incident. It assumes that if it can happen it will, and when it does, it identifies the extent of the hazards. The associated UN Hazard Divisions and Compatibility Groups for ammunition definitions are at Annexes A and B respectively.

UN Hazard Divisions

The UN Recommendations for the Transport of Dangerous Goods sub-divides dangerous goods into separates groups according to their Hazard Class. Explosive substances and articles are Hazard Class 1. The 6 HDs are fully defined at Annex A. The following is a simplified description for the purposes of this Section:

- Division 1.1. Ammunition that has a mass explosion hazard.
- Division 1.2. Ammunition that has a projection hazard but not a mass explosion hazard.
- Division 1.3. Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.
- Division 1.4. Ammunition that presents no significant hazard.
- Division 1.5. Very insensitive substances which have a mass explosion hazard.
- Division 1.6. Extremely insensitive articles which do not have a mass explosion hazard.

4 The UN Recommendations on the Transport of Dangerous Goods (ISBN: 92-1-139057-5).

HDs can be mixed within the guidance provided in Annex A of the OSCE Best Practice Guides on Procedures for Management of Stockpiles of Conventional Ammunition. In general such combinations are aggregated and assessed as the worst case. A combination of HD 1.1 and HD 1.2 will be considered to be HD 1.1.

UN Classification Code

The UN Classification Code is an integral part of ammunition management for both transport[5] and storage; for many OSCE participating States it is a mandatory package marking[6] requirement. The classification code is composed of the number of the Hazard Division and the letter of the Compatibility Group, for example "1.1 B".

Mixing of UN Compatibility Groups for Ammunition Storage

It must be noted that due to the differing risks associated with ammunition storage and transport many national competent authorities apply modified mixing rules for the storage of ammunition. The following table is based on storage mixing rules that have been adopted by many OSCE participating States:

Effect of Package on Classification

As the packaging may have a decisive effect on the classification, particular care must be taken to ensure that the correct classification is determined for each configuration in which ammunition and explosives are stored or transported. Therefore, every significant change in the packaging (e.g. degradation) may well affect the classification awarded.

Compatibility Group	A	C	D	G	L	S
A	X					
C		X[1)]	X[1)]	X[3)]		X
D		X[1)]	X[1)]	X[3)]		X
G		X[3)]	X[3)]	X		X
L					X[2)]	

1) Mixing permitted provided substances have all passed UN Test Series 3.
2) Compatibility Group L substances must always be stored separately from all substances of other compatibility groups as well from all other substances of Compatibillity Group L.
3) The mixing of Compatibility Group G substances with other compatibility groups is at the discretion of the National Competent Authority.

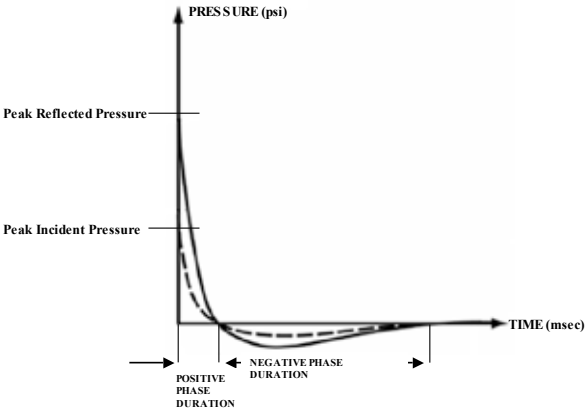
5 OSCE Best Practice Guide on the Transportation of Ammunition (FSC.DEL/554/85/Rev 2).
6 OSCE Best Practice Guide on Ammunition Package Markings and Record Keeping (FSC.DEL/73/07/Rev 1).

5. Explosion Effects

Hazard Division 1.1 Explosion Effects

In an incident involving the mass detonation of explosives (HD 1.1), the violent release of energy creates a sudden and intense pressure disturbance termed the „blast wave". The blast wave is characterized by an almost instantaneous rise from ambient pressure to a peak incident pressure. This pressure increase, or „shock front", travels radially outward from the detonation point. Gas molecules making up the front move at lower velocities. This velocity, which is called the „particle velocity", is associated with the „dynamic pressure", or the pressure formed by the winds produced by the shock front. As the shock front expands into increasingly larger volumes of the medium the incident pressure decreases whilst the duration of the pressure-pulse increases. If the shock wave impinges on a rigid surface (e.g., a building) at an angle to the direction of the wave's propagation, a reflected pressure is instantly developed on the surface and this pressure rises to a value that exceeds the incident pressure. This reflected pressure has the propensity to inflict considerable damage.

When an explosion occurs within a structure, the peak pressure associated with the initial shock front will both be high and amplified by reflections within the structure. In addition, the accumulation of gases from the explosion will exert additional pressure and increase the load duration within the structure. This effect may damage or destroy the structure unless the structure is designed to either withstand or vent the gas and shock pressures. Structures that have one or more strengthened walls may be vented for relief of excessive gas by either frangible construction of the remaining walls or roof or through the use of openings.



PRESSURE TIME CURVE

An important consideration in the analysis of the hazards associated with an explosion is the effect of any fragments produced. Depending on their origin, fragments are referred to as „primary" or „secondary" fragments. Primary fragments result from the shattering of the ammunition in direct contact with the explosive. These fragments usually are small, initially travel at thousands of metres per second and may be lethal at long distances from an explosion. Secondary fragments are debris from structures and other items in close proximity to the explosion. These fragments, which are somewhat larger in size than primary fragments and initially travel at hundreds of metres per second, do not normally travel as far as primary fragments.

Hazard Division 1.2 Explosion Effects

In an incident involving ammunition that has a projection hazard but not a mass explosion hazard (HD 1.2) can be expected to both explode sporadically and burn. Fire will propagate through the mass of the ammunition over time. Some ammunition may neither explode nor burn. Blast effects from the incident are limited to the immediate vicinity and are not considered to be a significant hazard.

HD 1.2 events may occur over a prolonged period of time. Generally, the first reactions are relatively non-violent and, typically, begin a few minutes after flames engulf the ammunition. Later reactions tend to be more violent. Reactions can continue for some time, even after a fire is effectively out. Generally, smaller ammunition tends to react earlier in an incident than larger ammunition.

The primary hazard from a HD 1.2 event is fragmentation. Fragmentation may include primary fragments from ammunition casings or secondary fragments from containers and structures. At longer ranges, primary fragments are the major contributors to fragment hazards. During a HD 1.2 event, fragmentation may extensively damage exposed facilities. However, less fragmentation damage can be expected from a given quantity of HD 1.2 than would be expected from the corresponding quantity of HD 1.1 because not all the HD 1.2 will react.

Hazard Division 1.3 Explosive Effects

In an incident involving ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard (HD 1.3) the heat flux presents the greatest hazard to personnel and assets. Internal gas pressures may produce fragments from the bursting of containers or the rupture of containment facilities. In general, such fragments will be large and of low velocity. These fragments are considerably less hazardous than those produced by HD 1.1 and HD 1.2 events.

Hazard Division 1.4 Explosive Effects

As the products of this ammunition are contained within the package it does not present a significant hazard.

Hazard Division 1.5 and 1.6 Explosive Effects

These two division comprise of very insensitive substances (HD 1.5) and extremely insensitive articles (HD 1.6) which will require special consideration if held within the inventory.

6. Hazard and Risk Analysis

Objectives

Any explosives safety management system must care for risks associated with the activities. The storage of ammunition aims to provide a reasonable and practical level of protection; it does not guarantee absolute protection.

Hazard and Risk Assessment

In the event that the prescriptive ammunition storage regulations are unable to meet the required levels of stockpile and personnel safety the explosives safety authority may consider the application of a Risk and Explosive Safety Hazard assessment. This may require expert guidance from suitably qualified Hazard and Risk Assessors, or suitable publications. The following guidance outlines the processes and procedures.

Hazard

A hazard can be defined as any real or potential condition that can cause mission degradation, injury, illness, death to personnel or damage to or loss equipment or property.

Risk

An expression of the impact and possibility of a mishap in terms of severity and the likelihood of occurrence. The relationship between the two can be shown by the following graphic:

HAZARD PROBABILITY					
	frequent	likley	occasional	seldom	unlikely
catastrophic					
critical					
moderate					
negligible					

extremely high
high
medium
low

The combinations of probability and consequence in red in the picture, "extremely high", must be dealt with first hand.

Risk Analysis

Risk analysis is the application of quantitative or qualitative measures to determine the level of risk associated with a specific hazard. The process defines the probability and severity of a mishap that could result from the exposure of personnel or assets to that hazard. The associated steps are:

- Identify the hazards;
- Analyze risk control measures;
- Make control decisions;
- Implement risk controls;
- Implementation requires commitment of time and resources;
- Supervise and review.

7. Hazard Mitigation

Definition

Explosive hazard mitigation can be defined as:
"Any cost-effective action taken to eliminate or reduce the long-term risk to life and property from an explosive event".

Hazard Principles and Objectives

The effect of explosive hazards and the problems related to inter-magazine propagation can be mitigated by the construction of the explosive storehouse and associated barricades. It is the lack of effective hazard mitigation that invariably results in the catastrophic loss of ammunition facilities due to a single explosive event.

Protective Construction

Construction features and location are important safety considerations in planning facilities. The effects of potential explosions may be significantly modified by construction features that limit the amount of explosives involved, attenuate blast overpressure or thermal radiation, and reduce the quantity and range of hazardous fragments and debris. The location of Exposed Sites (ES) in relation to Potential Explosion Sites (PES) also helps to minimize unacceptable damage and injuries in the event of an incident. The major objectives in installation planning are to:

- Protect against explosion propagation between adjacent bays or buildings.
- Protect personnel, within and outside the Explosives Area, against death or serious injury from incidents in adjacent bays or buildings.
- The construction of separate buildings to limit explosion propagation, rather than the use of either protective construction or separation of explosives within a single building should be considered when safety would be greatly enhanced.

Reduced Distances

Hardening an ES or constructing a PES to suppress explosion effects to provide an appropriate degree of protection, or the use of effective container traverses, may allow a reduction of the separation distances required by Quantity Distance (QD) tables.

Barricades

Properly constructed and sited barricades and undisturbed natural earth have explosives safety applications for both protecting against low-angle fragments and reducing shock overpressure loads very near the barricade. Barricades provide no protection against high angle fragments or lobbed ammunition. If the traverse is destroyed in the process of providing protection, then secondary fragments from the destroyed barricade must also be considered as part of any hazards analysis.

To reduce hazards from high-velocity, low-angle fragments, the barricade must be placed between the PES and the ES so that the fragments of concern impact the barricade before the ES. The barricade must both be thick enough so that it reduces fragment velocities to acceptable levels and high enough to intercept high velocity, low trajectory fragments. The recommended norm is 0.3 metres.

EXPLOSIVES QUANTITY DISTANCES.

Application of Quantity Distance Criteria

To ensure that an explosive event within an ammunition storage location does not result in the propagation of other locations, potentially resulting in a catastrophic event, and at the same time ensure reasonable protection to facilities outside the explosives area, ammunition locations are suitably separated from each other and external at-risk facilities. The resulting separation distances, referred to as Quantity Distances (QD) are based on a matrix of the following criteria:

- The associated United Nations (UN) Hazard Division (HD).
- The net explosive quantity of the storage location.
- The building design and construction.
- The aspect of the building relative to other storage locations.

Quantity-distances are generated by distance functions subject, in certain cases, to fixed minimum or maximum distances.

Degree of Protection

There are varying levels of inter-magazine protection based on the QD separation. They are:

- Virtually complete protection against instantaneous propagation.
- High degree of protection against instantaneous propagation.
- Moderate degree of protection against instantaneous propagation.

Application of Storage Criteria

The application of storage principles, as accepted by many OSCE participating States, will provide the following levels of personal protection at the Inhabited Building distance:

- The peak incident (side-on) overpressure will not exceed 5 kPa; the accepted threshold level of pressure for ear damage is 35 kPa.
- Un-strengthened buildings will suffer minor damage, particularly to parts such as windows, door frames and chimneys. In general, damage is unlikely to exceed approximately 5% of the replacement cost but some buildings may suffer serious damage. The debris will not exceed one lethal fragment (energy > 80 J) per 56 m^2 at the Inhabited Building Distance. They are not sufficiently large enough to prevent breakage of glass and other frangible materials.
- Injuries and fatalities are very unlikely as a direct result of the blast effects. Injuries that do occur will be caused principally by glass breakage and flying/falling debris.

UN Hazard Divisions

See Section IV and Annex A.

Net Explosive Quantity

The Net Explosives Quantity (NEQ) is the total explosives contents of ammunition unless it has been determined that the effective quantity is significantly different from the actual quantity. It does not include such substances as white phosphorus, war gases or smoke and incendiary compositions unless these substances contribute significantly to the dominant hazard of the hazard division concerned.

Building Design and Construction

The effects of an event within an ESH for any HD, and the resulting damage to other ESHs, can be mitigated by design features (Section. VII - Hazard Mitigation).

Scaled Distances

The propagation relationship between a Potential Explosion Site (PES) and the Exposed Site (ES) can be expressed as a mathematical relationship between the NEQ and a derived function (f). This relationship is

based on known blast wave and fragmentation throw data. The blast overpressure effects at a given scaled distance can be predicted with a high degree of confidence. For example the inhabited distance is derived using the formula $D=22.2Q^{1/3}$. Thus the distance at which the blast over pressure will be 5 kPa the Inhabited Building Distance, (IBD) is $D = 22.2 \times 1.000^{1/3} = 222$ metres.

The following scaled distances are generally accepted to predict HD 1.1 effects for any given NEQ:

Scaled Distance (Q in kg, distance in m)	Peak Incident (Side-on) Overpressure Expected (kPa)	Exposed Site
$44.4\ Q^{1/3}$ to $33.3\ Q^{1/3}$	2 to 3	Vulnerable Building distance
$22.2\ Q^{1/3}$	5	Inhabited Building Distance
$14.8\ Q^{1/3}$	9	Inter-magazine Distance
$9.6\ Q^{1/3}$	16	Inter-magazine Distance
$8.0\ Q^{1/3}$	21	Ammunition Process Building Distance[7] (APB)
$7.2\ Q^{1/3}$	24	Inter-magazine Distance
$3.6\ Q^{1/3}$	70	Inter-magazine Distance
$2.4\ Q^{1/3}$	180	Inter-magazine Distance

This methodology is well developed and the effects of blast may be treated deterministically, however, the techniques for determining the hazards from projections are considerably less developed and the effects require a probabilistic approach.

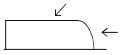
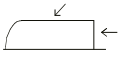
The following scaled distances are generally accepted to predict the distance at which HD 1.2 effects are acceptable for any given NEQ to meet a required degree of protection:

- D1 =0 53 $Q^{0.18}$ (high degree of protection).
- D2 =0 68 $Q^{0.18}$ (limited degree of protection).

HD 1.3 utilises a fixed separation distance of 2 metres between protected buildings and scaled distances for inhabited buildings and public traffic routes.

Structural Relationship between ES and PES

The construction of an ammunition store may result in relatively weaker sections, for example the access end of an earth covered bunker and therefore not provide the same degree of all-round containment and protection. Such buildings with the doors facing each other will require a larger QD that a back to front configuration. The following is an example of separation distances for standard earth covered bunker where the roof and face wall are not designed to withstand the same side-on and rear over pressure.

PES (Potential Exposed Site)			
ES (Exposed Site)			
	30 metres	30 metres	30 metres
	30 metres	30 metres	67 metres
	30 metres	30 metres	180 metres

REQUIRED QUANTITY DISTANCES FOR 50.000 KILOGRAMS OF HD 1.1 AMMUNITION

7 APBs are used for the inspection and repair of ammunition. They are therefore continuously manned and are required to provide increased protection to the process workers. They also represent a greater PES risk.

Explosives Storehouse Licence

In order to provide documentary evidence that an explosive hazard assessment of explosives in an explosive storehouse has been undertaken, an Explosive Limit Licence (ELL) is prepared and approved by the appropriate explosive licensing authority. An example of a licence for an earth covered 700 kPa Igloo[8] containing 10.000 kilograms of HD 1.1 ammunition, based on the factors outlined above, is at Annex C. It is a visual matrix of the explosives NEQ, the associated HDs, the structural relationships between PES and ES and the associated scaled functions.

The required data can either be derived from known scaled distance functions or by the use of available tables based on the functions.

A licence should be prepared for each explosives storehouse and ammunition process building in an explosive site. This process will require appropriately trained practitioners; this guide does not provide sufficient information to effectively complete an ELL. Further advice can be sought from the OSCE or other member nations who have the required expertise.

8. Safe Guarding of Explosive Sites

The Yellow Line

Any effective explosive licensing methodology will determine the Outside Quantity Distances (OQD) between the explosives storehouses and the limit of the explosive hazard. The OQD defines the distance at which the public and inhabited buildings are ensured reasonable protection from an explosive event within the explosive site. The OQD may extend beyond the secure explosives area. The demarcation between the hazard zone and the safe zone is commonly known as the Yellow Line[9].

If unrestricted development is subsequently permitted within the Yellow Line the explosives capacity of the area may be seriously prejudiced or any development unduly hazarded.

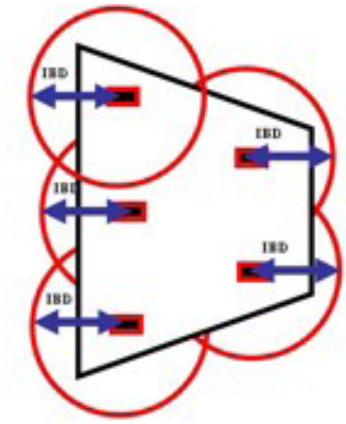
It is therefore necessary to have a consultative procedure agreed by central and local government, preferably enforceable by law, whereby all development within the OQD of an explosive area, known as the safeguard area, are referred through the local planning authority and the appropriate Central Government Ministries for consideration.

Preparing the Yellow Line

The following example is base on an explosive site with 5 ESHs.

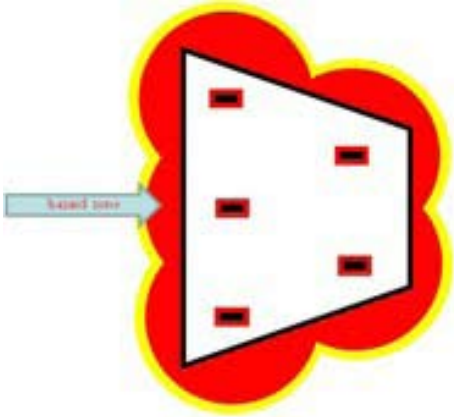
8 An earth covered building with at least 0,6 m depth of earth cover. The head-walls and the doors (single sliding door) are designed to resist an external blast loading of 7 bar and an impulse of 14 kPas.

9 The Yellow Line takes its name from the common practice of marking the separation zone with a yellow marker on associated plans and maps.



A circle radius the IBD is drawn around each ESH IBD

A yellow line is drawn on all external arcs of the circles



The red area inside the yellow line defines the hazardous area and the yellow line the limit of the risk to the public.

Existing Explosive Sites

The Yellow Line will identify the hazard area for the PESs within the explosives site and delineate the consolidated Inhabited Building Distances. Any encroachment within the Yellow line will require either:

- The remediation of the hazard.
- The reduction of explosives held in the offending explosive stores.
- The improvement of the store houses to remediate the hazard.
- The issuance of a Waiver or Exemption.

New Developments

New developments will need to be planned within the limitations of the Yellow line.

Purple Line

The Purple Line is a continuous line encircling the explosives area delineating a distance twice the IBD to buildings of vulnerable construction[10].

9. Waivers and Exemption

Compelling Justification

Ammunition and explosives safety standards are designed to protect against serious injury, loss of life, and damage to property, but are not intended to be so rigid as to prevent the Services from accomplishing its assigned mission. When deviating from the accepted national ammunition storage regulations there must be compelling strategic or operational reasons to justify the added risk to personnel and property. Formal approval of any deviation is the issue of an authorized waiver or exemption. It must acknowledge and accept the added risk to personnel or property.

10 Buildings that are of curtain wall construction with four storeys or more, of largely glass construction or employs non load-bearing cladding panels. For a fuller explanation see Section III. Definitions.

Waiver

A waiver is written authority that permits temporary deviation from accepted national ammunition storage regulations for strategic or other compelling reasons. Waivers are generally granted for a short period of time pending the remediation of the cause of the waiver requirement. Waivers should:

- Only be granted for periods not exceeding 5 years. Exceptional situations may require time for completing corrective action or actions that exceed 5 years, in which case the waived conditions must be reviewed and approved by the next higher approval authority.
- Only be granted by officials assigned responsibilities consistent with the level of risk identified, the authority to control the resources required to accomplish corrective actions, and the type of deviation.
- Be reviewed at least annually for relevancy and applicability of control measures.

Exemptions

An exemption is written authority that permits long-term non-compliance with these standards for strategic or other compelling reasons. Exemptions require statutory approval. Exemptions should be reviewed for applicability at intervals not to exceed 5 years. Exemptions must meet all the following conditions:

- Be required by a strategic or compelling need.
- Required for a long-term (exceeding 5 years) or permanent departure from the accepted National ammunition storage regulations.

Risk Analysis

Any exemption request should be supported by a Hazard Risk Analysis.

References:
On safety principles for the storage of ammunition NATO AASTP-1.
On Risk Analysis NATO AASTP-4.

10. Fire Prevention and Firefighting

Fire prevention

The spread of fire is the most common cause of catastrophic ammunition events. The following outline requirements are included to provide guidance on the preparation of specific fire fighting response.

- Responsible fire officer
  The installation Commanding Officer will nominate a suitably trained member of the installation staff as the responsible Depot Fire Officer.
- Fire orders.
  Fire orders are to be published in accordance with national MOD regulations.
- Fires and naked lights.
  Ideally, the use of fires and naked lights within an explosives area should be completely prohibited; however such an absolute ban is not practical. Fire and naked lights may be authorized subject to the conditions laid down in the following paragraphs.
- Hot water heating.
  Boiler houses are to be located outside any building used for the storage, processing or handling of ammunition. The use of open fires, including slow combustion stoves, for heating or cooking anywhere in the explosives area is totally prohibited. When practicable, fires in boiler houses are to be extinguished before close of work each day. When this is not possible, arrangements are to be made for a competent boiler attendant to visit the boiler house during silent hours.
- Chimneys.
  Installation chimneys, within and without the explosives area, are to be cleaned on a regular basis. Those which could be a potential hazard are to be fitted with spark arresters.
- Incinerators.
  Domestic incinerators for the disposal of non-salvageable material, rubbish, classified waste paper etc

are to be sited outside the explosives area. Incinerators for the disposal of explosive items and waste will be constructed and operated in accordance with the national MOD rules.

- Smoking.
  Smoking is to be strictly prohibited within the explosives area except in places and at the times specially authorized by the Commanding Officer in consultation with the depot fire officer. Control measures are to be laid down in depot standing orders.
- Conveyance of controlled articles.
  All smoking materials and means of producing a flame are regarded as controlled articles. Where smoking areas or fires are authorized, special arrangements are to be made for the conveyance of the required articles through the explosives area. Lockable containers are to be used for the conveyance and the keys are to be held by a responsible person.
- Dangerous articles and spontaneously combustible materials.
  The introduction into an explosives area of any article, which is likely to increase the risk of an explosion or fire, is to be strictly controlled. Bulk stocks of oils, paints and solvents are not to be stored within the explosives area. Quantities of oils, paints and solvents sufficient and essential for the normal day to day maintenance of ammunition, not exceeding a five day supply, may be held in a non-combustible store. Each item is to be held in a secure metal container. Only limited quantities sufficient for one day use are to be taken into buildings containing ammunition or explosives. All oils, paints and solvents are to be removed before close of work each day and returned to the store. Articles liable to spontaneous combustion, such as oily rags, are only to be taken into buildings when required for immediate use. They are to be removed from buildings containing ammunition and held in closed metal or other non-combustible containers every time the building is vacated and disposed of daily in a designated place outside the explosives area.
- Temporary use of flame producing equipment.
  All flame and spark producing equipment, fires and naked lights required to be used in the explosives area on a temporary basis by depot personnel or contractors are to be considered as prohibited articles and controlled in accordance with national regulations.
- Grass and undergrowth.
  All undergrowth and flammable vegetation is to be cleared or kept short for at least 15 m around open stacks and buildings containing ammunition. This does not apply to ground ivy or similar vegetation used to bind traverses, although excessive growth should be cleared as necessary.
- Cut vegetation.
  Cut vegetation is to be removed immediately and stacked beyond a distance of 50 m from any building containing ammunition. It is to be removed from the explosives area for burning, but where this is impracticable burning within the explosives area may be permitted provided that:
  - Burning is carried out in the open at a safe distance from any building on a site approved by the Commanding Officer on the advice of the Depot Fire Officer.
  - The fire is kept under close supervision and attended by trained fire-fighting personnel with adequate equipment and supply of water ready for immediate use to prevent any spread of fire.
  - The fire is extinguished and thoroughly wetted at least one hour before close of work and at least one hour before sunset.
- Refuelling of grass cutting equipment.
  Petrol driven grass cutters, strimmers and similar vegetation control machinery may be used within an explosives area. Refuelling may be carried out within the explosives area. However the refuelling point must be 25 m from any explosives and fire extin-

guishers are to be readily available.

- Use of weed killers.
  Only chlorate-free approved weed killers are to be used in explosives areas and in fire breaks established at the explosives area perimeter.
- Fire breaks.
  Fire breaks are to be maintained in the explosives area and at the perimeter of the areas as advised by the local fire adviser. The following minimum widths of fire breaks are to be observed in areas which are heavily wooded with coniferous trees:
  - o Perimeter. 30 m.
  - o Internal Roads. 5 m clearance either side.
  - o Internal Sections. 30 to 50 m clearance.
- Fire extinguishers on vehicles.
  No mechanically propelled vehicle is to be allowed to enter the explosives area unless it is equipped with a fire extinguisher of a suitable size and type to extinguish any fire originating in a vehicle when not containing explosives. Types and sizes of extinguishers are to be approved by the Depot Fire Officer.

FIRE-FIGHTING MEASURES

Effective fire-fighting is achieved by a combination of the following:

- First aid fire-fighting.
- Additional fire-fighting measures.
- Liaison with civil authorities.
- Speed.

Speed

Speed is the essence of successful first aid fire-fighting. Attack the fire before it can develop. When persons are present at the actual outbreak of a fire, provided that the outbreak is not already overwhelming, much can be done by immediately dousing the fire with large quantities of water, except where this is specifically forbidden. Where practicable the burning object should be removed or isolated by the removal of other inflammable objects nearby.

Fire Divisions

The fire divisions are synonymous with the storage and transport Hazard Divisions 1.1 through 1.4 for ammunition and explosives. They are serially numbered by Arabic figures from 1 to 4. The four fire divisions correspond to the UN and NATO hazard divisions as follows:

Fire Division	Hazard Division
1	1.1
2	1.2
3	1.3
4	1.4

Fire Division 1 indicates the greatest hazard. The hazard decreases with ascending fire division numbers as follows:

Fire Division	Hazard involved
1	Mass explosion
2	Successive explosions with projections
3	Mass fire, or fire with minor blast or projections
4	No significant hazard

For details of hazards, see Annex A.

The four fire divisions have been assigned distinctive symbols for easy recognition by fire-fighting personnel approaching the scene of fire.

Fire Division 1

Fire Division 2

Fire Division 3

Fire Division 4

Training

A proportion of the depot personnel are to be trained in fire-fighting duties. All personnel working within the explosives area are to be instructed in first aid fire-fighting. All personnel employed on ammunition duties are to be trained in the action to be taken with the different divisions and to be able to judge whether or not the fire can be controlled. The following general requirements apply to all fire divisions:

- Hand Held Fire Extinguishers
  In the outbreak of fire, the prompt application of fire-fighting first aid measures to prevent the development of a serious fire. This will normally be affected by the use of hand held fire extinguishers.
- Fire Alarm
  The fire alarm is to be sounded immediately and the appropriate first aid measures vigorously applied. All non-essential personnel are to be evacuated to a safe predetermined position.
- Prevent Spread
  When ammunition is not involved, action should be directed to preventing the extension of the fire to adjacent buildings containing ammunition or other inflammable material.
- Substantial Cover
  The fire-fighting of ammunition should be fought from behind substantial cover.
- Water supply
  Provision is to be made for adequate water supplies to be available throughout the explosives area. The number, size and siting of the static water tanks and the number of hydrants and volume of water to be provided will be advised by the appropriate Defence Fire Service.
- Water supply maps
  Water Supply Maps showing details are to be maintained in each depot.
- Fire alarm system
  An efficient fire alarm system including adequate telephonic communication is to be maintained. Telephone test calls are to be made frequently. At least one test call in three should be made outside normal working hours.

11. Environmental Impact on Ammunition

General Requirements

Ammunition may deteriorate or become damaged unless it is correctly stored, handled and transported, with the resultant effect that it may fail to function as designed and may become dangerous in storage, handling, transport and use. The factors which cause deterioration or damage are:

- Damp.
- Heat.
- Careless and rough handling.

Good storage, handling and the use of ammunition requires that the above factors are kept constantly in mind. It is essential that ammunition be:

- Kept dry and well ventilated.
- Kept as cool as possible and free from excessive or frequent changes of temperature.
- Protected from the direct rays of the sun.
- Handled with care.

Protection from Moisture

Rain, snow and damp quickly cause irremediable damage to ammunition. Exceptional efforts are often necessary to ensure dry conditions during storage and in transportation. Providing an ammunition store is given adequate protection against the access of moisture, good ventilation of the ammunition will not only keep it cool but prevent condensation in and around the containers and the ammunition therein. The effects of moisture on various types of ammunition and associated materials are as follows:

- Unboxed ammunition
  The most harmful effect is corrosion. In the early stages basic cover and stencil markings (essential for identification) are obliterated. Later, pitting of the ammunition may occur to such an extent as to make it unserviceable.
- Steel containers
  Steel containers not only lose their basic colour and markings, but eventually become perforated with rapid deterioration of the contents following. Substances particularly subject to decay under damp conditions in steel containers are components made from certain alloys and paper cylinders.
- Explosive compositions
  Some substances used in explosive compositions attract and hold moisture with the consequent falling off or even total loss of the explosive properties. They can also become unserviceable and sometimes dangerous after short periods in damp conditions.
- Non-explosive materials
  The decay of soft woods through moisture is not a common source of trouble with ammunition containers. However, fabrics, felt and paper materials, by absorbing moisture, create conditions favourable to corrosion and decay in other materials in the same container.

All sites are inspected periodically to ascertain if the conditions of storage are having a deleterious effect on the contents. These inspections are to be carried out at least once every four months and at the times when the storage conditions are likely to be most adverse, for example, at times of excessive damp or heat. Dampness on surfaces within buildings is generally due to one or both of the following causes:

- Condensation of moisture on the comparatively cold surfaces of walls, ammunition and ammunition containers from the warm, damp air admitted, when buildings are opened.
- Free moisture may penetrate inadequately drained or badly constructed roofs, or walls having unsatisfactory damp courses. Ground moisture may penetrate walls which abut on to native rock/soil or earth traverses.

Temperature Considerations

Extremes of temperature may affect the performance of solid propellants such as rocket motors. They also can cause rapid deterioration in explosives, whether the explosives are the fillings of rounds and components or are held in bulk. Very low temperatures are not as objectionable as high ones, but it must be borne in mind that explosives containing Nitroglycerine can become dangerous at very low temperatures.

Careless Handling

Careless or rough handling may not only cause visual damage to ammunition but can also affect the internal mechanisms of components which cannot be detected. Such damage may render the ammunition unserviceable or unsafe to use. Ammunition containers are specifically designed to protect ammunition during storage and transportation. Damage to a container through careless handling may directly affect the contents. It may also reduce the effectiveness of the protection provided to the contents which could consequently deteriorate. Identification markings may also become obliterated or difficult to decipher.

12. Ammunition Surveillance

Methods

Ammunition surveillance can be carried out in any of the following ways:

- In-Service Proof.
- Component Proof.
- Surveillance of Ammunition Performance at Training (SOAPAT).

- Performance Failure, Accident and Defect Reporting (PAD).
- Inspection.
- Repair.

Inspection

An Inspection is a type of surveillance which involves the physical examination of the ammunition and or its container in order to assess its condition. Types of inspection tasks may include:

- Initial Acceptance.
- Preparation of ammunition for ISP.
- Pre-issue, including fractioning.
- Ex-unit Inspection, Returned Ammunition Group (RAG).
- Special Inspection, e.g. confirmation of condition or quantity.

Repair

Repair is defined as the maintenance or modification of ammunition in order to maintain or improve its condition. Types of repair tasks include:

- Modification of ammunition.
- Maintenance of ammunition.
- Special, e.g. de-fuze or re-fuze.

Ammunition Defects

During inspection or repair, ammunition may be found, which is defective in some way. All defects will fall into one of the following categories:

- Critical
  Defects affecting safety in storage, handling, transportation or use.
- Major
  Defects that affect the performance of the ammunition and that require remedial action to be taken.
- Minor
  Defects that do not affect the safety or performance of the ammunition, but are of such a nature that the ammunition should not be issued prior to remedial action having been taken.
- Insignificant
  Any defect that does not fall into any of these categories, but which could conceivably deteriorate into one of them if no remedial action is taken.
- Technical
  Any defect that requires further technical investigation.

Ammunition Conditions

Based on the identified serviceability of the ammunition is given an Ammunition Condition. The Ammunition Condition is used to define the degree of serviceability of the ammunition and the degree of any constraints imposed.

In general these conditions designate the ammunition as:

- Serviceable stocks available for use.
- Stocks banned from use pending technical investigation.
- Stocks in suspension pending technical inspection, repair, modification or test.
- Stocks for disposal.

Annex A

UN Hazard Divisions

These HDs are used commonly for the process for determining safe separation distances (Quantity Distances) between storage locations and other facilities outside the explosive perimeter. The 6 UN Hazard Divisions are:

Hazard Division 1.1:

There is a mass explosion hazard; a mass explosion is one which affects the entire load virtually instantaneously.

The major hazards of this division are blast, high velocity projections and other projections of relatively low velocity. The explosion results in severe structural damage, the severity and range being determined by the amount of high explosives involved. There may be a risk from heavy debris propelled from the structure in which the explosion occurs or from the crater.

Hazard Division 1.2:

Substances and articles which have a projection hazard but not a mass explosion hazard.[11]

The explosion results in items burning and exploding progressively, a few at a time. Furthermore fragments, firebrands and unexploded items may be projected in considerable numbers; some of these may explode on impact and cause fires or explosions. Blast effects are limited to the immediate vicinity.

For the purpose of determining quantity-distances a distinction, depending on the size and range of fragments, is made between those items which give small fragments of moderate range (for instance, projectiles and cartridges from 20 to 60 mm) and those which give large fragments with a considerable range (for instance projectiles and cartridges exceeding 60 mm, rockets and rocket motors in a propulsive state which do not have a mass explosion hazard).

Hazard Division 1.3:

Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard[12].

This division comprises substances and articles:

- which give rise to considerable radiant heat;
- which burn one after another, producing minor blast or projection effects or both.

This division includes some items which burn with great violence and intense heat emitting considerable thermal radiation (mass fire hazard) and others which burn sporadically. Items in this division may explode but do not usually form dangerous fragments. Firebrands and burning containers may be projected.

Hazard Division 1.4:

This division includes items which have primarily a moderate fire hazard. They do not contribute exces-

11 In order to differentiate between the two associated hazards some nations apply the following sub-divisions that are not part of the UN system:
HD 1.21 - the more hazardous part of Hazard Division 1.2
HD 1.22 - the less hazardous part of Hazard Division 1.2

12 In order to differentiate between the two associated hazards some nations apply the following sub-divisions that are not part of the UN system:
HD 1.33 - propellants
HD 1.34 - other than propellants

sively to a fire. The effects are largely confined to the package. No fragments of appreciable size or range are to be expected. An external fire does not cause the simultaneous explosion of the total contents of a package of such items.

Some but not all of the above items are assigned to Compatibility Group S. These items are so packed or designed that any explosive effect during storage and transportation is confined within the package unless the package has been degraded by fire.

Hazard Division 1.5:

Very insensitive substances which have a mass explosion hazard.

This division comprises substances which have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions.

The probability of transition from burning to detonation is greater when large bulk quantities are transported or stored.

For storage purposes, such substances are treated as Hazard Division 1.1 since, if an explosion should occur, the hazard is the same as for items formally assigned to Hazard Division 1.1 (i.e. blast).

Hazard Division 1.6:

Extremely insensitive articles without a mass explosion hazard.

This division comprises articles which contain only extremely insensitive detonating substances and which demonstrate a negligible probability of accidental initiation or propagation.

The risk from articles of Hazard Division 1.6 is limited to the explosion of a single article.

Annex B

Compatibility Groups

The 14 UN Compatibility Groups are:[13]

Group A

Primary explosive substance.

Group B

Article containing a primary explosive substance and not containing two or more effective protective features.

Group C

Propellant explosive substance.

Group D

Secondary detonating article containing a secondary detonating explosive substance without means of initiation and without a propelling charge.

13 The CG definitions have been simplified. The full definitions can be found in the UN Orange Book.

Group E

Article containing a secondary detonating explosive substance without means of initiation, with propelling charge.

Group F

Article containing a secondary detonating explosive substance with its own means of initiation, with a propelling charge.

Group G

Pyrotechnic substance, or article containing a pyrotechnic substance, or article.

Group H

Article containing both explosive substance and white phosphorus.

Group J

Article containing both an explosive substance and a flammable liquid or gel.

Group K

Article containing both an explosive substance and a toxic chemical agent.

Group L

An explosive substance or item containing an explosive substance and presenting a special risk (e.g. due to water-activation or presence of hypergolic liquids, phosphides or a pyrophoric substance) requiring isolation of each type.

Group N

Articles which contain only extremely insensitive detonating substances.

Group S

Substances or articles so packed or designed that any hazardous effects arising from accidental functioning are confined within the package.

Annex C

EXPLOSIVE LIMIT LICENCE

The following is an example of an Explosive Limit Licence between a 7-bar earth covered ESH (the PES) and 2 Exposed Sites; a second 7-bar earth covered ESH and an Inhabited Building (the ES). The separation distance between the ESHs is <11 metres and 480 metres to the Inhabited Building. Based on the appropriated QD tables the fixed separation distance will allow an NEQ of up to 10.000 kilograms of HD 1.1 and unlimited NEQs for HDs 1.2, 1.3 and 1.4.

EXPLOSIVE LIMIT LICENCE

Site	Munitions Disposal Facility	For use as	EXPLOSIVE STORE

Construction details - EARTH COVERED IGLOO WITH FRONT FACING EFFECTIVE TRAVERSE

location															
	>11														480
	>11														480

assessed net explosive quantities (units of 100 kilograms)

HD 1.1	10000														10000
	D2														D13
HD 1.21	unlimited														
	D2														
HD 1.22	unlimited														
	D2														
HD 1.33	unlimited														
	D2														
HD 1.34	unlimited														
	D2														

maximum permitted NEQ (kilograms) permitted by quantity distance

HD 1.1	10000	or	HD 1.21	unlimited	or	HD 1.33	unlimited	or	any combination of HDs not exceeding one of these quantities when mixed in accordance with National regulations
			HD 1.22	unlimited		HD 1.34	unlimited		

Licencing Authority	

Annex D

QUANTITY DISTANCE TABLE FOR HD 1.1 AMMUNITION

The following tables are provided as an example of the methodology used by NATO to determine storage quantity distances. The various HD 1.1, 1.2 and 1.3 reflect the differing hazards and protective requirements. HD 1.4 ammunition has fixed separation distances.

Each HD table comprises of 2 parts. The first provides a matrix in which each cell represents a combination of a PES and an ES and refers to one or more D-distances or constant values of distance. The second provides columns of tabulated values of D-distances generated from the distance function shown at the foot of each column, subject to any overriding minimum or maximum fixed distances. Where a cell in the matrix shows more than one option the selection is made on the basis of special conditions and the desired level of protection.

It must be emphasised that the application of these tables should only be undertaken by a suitably trained practitioner. They are provided to enable ammunition stockholders to undertake an initial hazard assessment.

TABLE 1	Q-D TABLE FOR HAZARD DIVISION 1.1					
PES / ES	(a)	(b)	(c)	(d)	(e)	(f)
1	D3[ag]	D3[ag]	D5[a]	D5[a]	D5[a]	D4[ag]
2	D3[ag]	D3[ag]	D5[b]	D5[b]	D5[b]	D4[ag]
3	D4[agh] or D5[ag]	D4[agh] or D5[ag]	D6[be]	D6[be]	D6[be]	D4[bghe] or D6[ae]
4	D3[ag]	D3[ag]	D5[b]	D5[b]	D5[b]	D5[ag]
5	D3[ag]	D3[ag]	D6[b]	D6[b]	D6[b]	D5[bg]
6	D4[bgh] or D6[a]	D4[bgh] or D6[a]	D6[ce]	D6[ce]	D6[ce]	D6[ce]
7	D4[ag]	D4[b] or D5[a]	D8[bde], D9[bje] or D12[ae]	D8[be]	D8[bde]	D8[bde]
8	D6[a]	D6[a]	D9[bde], D9[bje] or D12[ae]	D8[be]	D8[bde]	D8[bde]
9	D4[bgh] or D7[b]	D4[bgh] or D7[b]	D9[ce]	D4[cghe] or D9[ce]	D9[ce]	D9[ce]
10	D4[bgh] or D7[b]	D4[bgh] or D7[b]	D9[b]	D9[b]	D9[b]	D9[b]
11	D4[bgh] or D7[b]	D4[bgh] or D7[b]	D9[cje]	D4[cghe] or D9[ce]	D9[cje]	D9[cje]
12	D4[cgh] or D7[b]	D4[cgh] or D7[b]	D4[cghe] or D7[be]	D4[cghe] or D7[be]	D4[cghe] or D7[be]	D5[cghe] or D7[be]
13	D4[cgh] or D7[b]	D4[cgh] or D7[b]	D4[cghe] or D7[be]	D4[cghe] or D7[be]	D4[cghe] or D7[be]	D5[cghe] or D7[be]
14	D4[bgh] or D7[b]	D4[bgh] or D7[b]	D4[bghe] or D7[be]	D1[bie], D2[bie] D4[bghe] or D7[be]	D1[bie], D2[bie] D4[bghe] or D7[be]	D4[bghe] or D7[be]
15	D4[bgh] or D7[b]	D4[bgh] or D7[b]	D9[cje] or D12[fe]	D1[bie], D2[bie] D4[bghe] or D7[be]	D9[cje] or D12[fe]	D9[cje] or D12[fe]
16	D10	D10	D10	D10	D10	D10
17	D10 (∃270m)	D10 (∃270m)	D10 (∃270m)	D10[o]	D10[o]	D10 (∃270m)
18	D10 (∃270m)	D10 (∃270m)	D13	D10[o]	D13	D13
19	D11 (∃270m)[k] D16 (∃270m)[kn] D13 (∃400m) D14 (∃400m)[n]	D11 (∃270m)[k] D17 (∃270m)[kn] D13 (∃400m) D15 (∃400m)[n]	D11 (∃270m)[k] D13 (∃400m)	D11[k] D13	D11[k] D13	D11 (∃270m)[k] D13 (∃400m)
20	D13 (∃400m)[l] D14 (∃400m)[ln]	D13 (∃400m)[l] D14 (∃400m)[ln]	D13 (∃400m)[l]	D13[l] D13 (∃400m)	D13[l] D13 (∃400m)	D13 (∃400m)[l]

Table 1 (Page 2) - Q-D Table for Hazard Division 1.1

Net Explosives Quantity in kg	Quantity-Distances in metres											
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
500	3		4	7	9	15	20	29	39	64	180	180
600	3		5	7	10	16	21	31	41	68	180	190
700	4		5	8	10	16	22	32	43	72	180	200
800	4		5	8	11	17	23	34	45	75	180	210
900	4		5	8	11	18	24	35	47	78	180	215
1 000	4		5	8	11	18	24	36	48	80	180	225
1 200	4		6	9	12	20	26	39	52	86	180	240
1 400	4		6	9	13	21	27	41	54	90	180	250
1 600	5		6	10	13	22	29	43	57	94	180	260
1 800	5		7	10	14	22	30	44	59	98	180	270
2 000	5		7	11	14	23	31	46	61	105	180	280
2 500	5		7	11	15	25	33	49	66	110	185	305
3 000	6		8	12	16	26	35	52	70	120	205	325
3 500	6		8	13	17	28	37	55	73	125	220	340
4 000	6		8	13	18	29	39	58	77	130	235	355
5 000	6		9	14	19	31	42	62	83	140	255	380
6 000	7		10	15	20	33	44	66	88	150	270	405
7 000	7		10	16	22	35	46	69	92	155	285	425
8 000	7		10	16	22	36	48	72	96	160	300	445
9 000	8		11	17	23	38	50	75	100	170	310	465
10 000	8		11	18	24	39	52	78	105	175	320	480
12 000	9		12	19	26	42	55	83	110	185	340	510
14 000	9		13	20	27	44	58	87	120	195	360	540
16 000	9		13	21	28	46	61	91	125	205	375	560
18 000	10		14	21	29	48	63	95	130	210	390	590
20 000	10		14	22	30	49	66	98	135	220	405	610
25 000	11		15	24	33	53	71	110	145	235	435	650
30 000	11		16	25	35	56	75	115	150	250	460	690
35 000		15	17	27	36	59	79	120	160	265	485	730
40 000		16	18	28	38	62	83	125	165	275	510	760
50 000		17	19	30	41	67	89	135	180	295	550	820
60 000		18	20	32	44	71	94	145	190	315	580	870
70 000		19	21	33	46	75	99	150	200	330	610	920
80 000		19	22	35	48	78	105	160	210	345	640	960
90 000		20	23	36	50	81	110	165	220	360	670	1000
100 000		21	24	38	52	84	115	170	225	375	690	1040
120 000		22	25	40	55	89	120	180	240	395	730	1100
140 000			26	42	58	94	125	190	250	420	770	1160
160 000			28	44	60	98	135	200	265	435	810	1220
180 000			29	46	63	105	140	205	275	455	840	1260
200 000			30	47	65	110	145	215	285	470	870	1300
250 000			32	51	70	115	155	230	305	510	940	1400
Distance Functions	D1= 0.35 $Q^{1/3}$	D2=0. 44$Q^{1/3}$	D3=0. 5$Q^{1/3}$	D4= 0,8$Q^{1/3}$	D5=1. 1$Q^{1/3}$	D6=1 .8$Q^{1/3}$	D7=2. 4$Q^{1/3}$	D8=3 .6$Q^{1/3}$	D9=4. 8$Q^{1/3}$	D10=8 .0$Q^{1/3}$	D11=3.6$Q^{1/2}$ for Q<4500 D11=14.8 $Q^{1/3}$ for Q 4500	D12=22.2 $Q^{1/3}$

a. see 1.4.1.9.a)&1.4.1.9.b)1)	- virtually complete protection against instan-ta-neous propagation	h. see 1.4.5.3.	- excluding items at the ES vulnerable to attack by heavy spalling
b. see 1.4.1.9.a)&1.4.1.9.b)2)	- high degree of protection against instan- taneous propagation	i. see 1.4.3.1.	- modular storage of bombs in open stacks
c. see 1.4.1.9.a)&1.4.1.9.b)3)	- moderate degree of protection against in-stantaneous propagation	j. see 1.4.3.3.	- untraversed stacks of robust shell
d. see 1.4.5.6.a)1)	- effect of high velocity projections	k. see 1.4.1.14.b)	- reaction of drivers on busy roads
e. see 1.4.5.6.a)2)	- effect of lobbed ammunition	l. see 1.4.1.15.b)	- flying and falling glass, etc.
f. see 1.4.1.8.c)	- degree of protection depends on structure at ES and sensitiveness of its contents	m. see 1.4.1.15.c)	- 400 m minimum to built up areas
g. see 1.4.3.6.	- excluding very sensitive explosive substances	n. see 1.4.6.7.b)	- reduced Q-D for large earth-covered buildings containing NEQ<45 000kg
		o. see 1.4.1.13.	- serious fragment hazard

TABLE 2	Q-D TABLE FOR HAZARD DIVISION 1.2					
PES / ES	(a)	(b)	(c)	(d)	(e)	(f)
1	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]
2	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]
3	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]
4	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]
5	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]
6	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]	2m[ai]
7	2m[ai]	2m[ai]	10m[bd], 25[ad] or 90m[a]	10m[ad] or 25m[a]	25m[bd] or 90m[a]	25m[bd] or 90m[a]
8	2m[ai]	2m[ai]	10m[bd], 25[ad] or 90m[a]	10m[ad] or 25m[a]	25m[bd] or 90m[a]	25m[bd] or 90m[a]
9	2m[ai]	2m[ai]	10m[b] or 25m[a]	10m[a]	25m[b] or 90m[a]	25m[b] or 90m[a]
10	2m[ai]	2m[ai]	10m[b] or 25m[a]	10m[b] or 25m[a]	25m[b] or 90m[a]	25m[b] or 90m[a]
11	90m[a]	90m[a]	90m[a]	90m[a]	90m[b]	90m[b]
12	2m[ai]	2m[ai]	10m[a]	10m[a]	10m[a]	10m[a]
13	90m[b]	90m[b]	90m[b]	90m[b]	90m[b]	90m[c]
14	90m[b]	90m[b]	90m[b]	90m[b]	90m[b]	90m[c]
15	90m[b]	90m[b]	90m[b]	90m[b]	90m[c]	90m[c]
16	25m	25m	25m	25m	25m	25m
17	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]
18	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]	90m[h] or 135m[g]
19	90m[hk], 135m[gk], D1[h] or D2[g]	90m[hk], 135m[gk], D1[h] or D2[g]	90m[hk], 135m[gk], D1[h] or D2[g]	90m[hk], 135m[gk], D1[h] or D2[g]	90m[hk], 135m[gk], D1[h] or D2[g]	90m[hk], 135m[gk] D1[h] or D2[g]
20	180m[hj], 270m[gj] D1[h] or D2[g]	180m[hj], 270m[gj] D1[h] or D2[g]	180m[hj], 270m[gj] D1[h] or D2[g]	180m[hj], 270m[gj] D1[h] or D2[g]	180m[hj], 270m[gj] D1[h] or D2[g]	180m[hj],270m[gj] D1[h] or D2[g]

TABLE 2 - Q-D TABLE FOR HAZARD DIVISION 1.2

Net Explosives Quantity Q in kg	Quantity-Distances in metres	
	D1	D2
500	180	270
600	180	270
700	180	270
800	180	270
900	185	270
1 000	185	270
1 200	190	270
1 400	195	270
1 600	200	270
1 800	205	270
2 000	210	270
2 500	220	280
3 000	225	290
3 500	230	300
4 000	235	310
5 000	245	320
6 000	255	330
7 000	260	340
8 000	270	345
9 000	275	355
10 000	280	360
12 000	290	370
14 000	300	385
16 000	305	390
18 000	310	400
20 000	320	410
25 000	330	425
30 000	345	440
35 000	350	450
40 000	360	460
50 000	375	480
60 000	390	500
70 000	400	520
80 000	410	530
90 000	410	540
100 000	410	560
120 000	410	560
140 000	410	560
160 000	410	560
180 000	410	560
200 000	410	560
250 000	410	560
Distance Functions	$D1 = 53\ Q^{0.18}$	$D2 = 68\ Q^{0.18}$

a. see 1.4.1.10.1)	- virtually complete protection	g. see 1.4.1.5.b)	- PES contains rounds above 60 mm, etc.
b. see 1.4.1.10.2)	- high degree of protection	h. see 1.4.1.5.c)	- PES contains rounds up to 60 mm, etc.
c. see 1.4.1.10.3)	- limited degree of protection	i. see 1.4.5.1.c)	- practical considerations may require a greater distance
d. see 1.4.5.6.b)	- resistance of headwalls and doors at ES	j. see 1.4.1.15.d)	- buildings are isolated and are evacuated promptly
e.	- (reserved)	k. see 1.4.1.14.c)	- traffic is stopped promptly to avoid worst attack
f.	- (reserved)		

TABLE 3A	Q-D TABLE FOR HAZARD DIVISION 1.3					
PES / ES	(a)	(b)	(c)	(d)	(e)	(f)
1	2m[ag]	2m[ag]	2m[ag]	10m[ad] or 25m[a]	10m[ad] or 25m[a]	10m[ad] or 25m[a]
2	2m[ag]	2m[ag]	2m[ag]	10m[ad] or 25m[a]	10m[ad] or 25m[a]	10m[ad] or 25m[a]
3	2mag	2m[ag]	2m[ag]	10m[ad] or 25m[a]	10m[ad] or 25m[a]	D1[a]
4	2m[ag]	2m[ag]	2m[ag]	10m[ad] or 25m[a]	10m[ad] or 25m[a]	10m[ad] or 25m[a]
5	2m[ag]	2m[ag]	2m[ag]	10m[ad] or 25m[a]	10m[ad] or 25m[a]	10m[ad] or 25m[a]
6	10m[b] or 25m[a]	10m[b] or 25m[a]	10m[b] or 25m[a]	D1[b]	D1[b]	D1[b]
7	2m[adg] or 25m[a]	2m[adg] or 25m[a]	2m[adg] or 25m[a]	25m[ad] or D1[a]	25m[ad] or D1[a]	D1[ad], D1[bf] or 240m[b]
8	2m[adg] or 25m[a]	2m[adg] or 25m[a]	2m[adg] or 25m[a]	25m[ad] or D1[a]	25m[ad] or D1[a]	D1[ad], D1[bf] or 240m[b]
9	2m[ag]	2m[ag]	2m[ag]	25m[a]	25m[a]	D1[a]
10	10m[b] or 25m[a]	10m[b] or 25m[a]	10m[b] or 25m[a]	D1[a]	D1[a]	D1[bf] or 240m[a]
11	25m[a]	D1[a]	D1[a]	D1[b]	D1[b]	240m[b]
12	2m[ag]	2m[ag]	2m[ag]	10m[b] or 25m[a]	10m[b] or 25m[a]	D1[a]
13	25m[a]	D1[a]	D1[a]	D1[b]	D1[b]	240m[a]
14	25m[a]	D1[a]	D1[a]	D1[b]	D1[b]	240m[a]
15	25m[a]	D1[a]	D1[a]	D1[b]	D1[b]	240m[a]
16	D2	D2	D2	D2	D2	D2
17	D2	D2	D2	D2	D2	D2[f] or 240m
18	D2	D2	D2	D2	D2	240m[f] or D4 (∃240m)
19	D3[h] or D4	D3[h] or D4	D3[h] or D4	D3[h] or D4	D3[h] or D4	D3 (∃160m)[h] or D4 (∃240m)
20	D4	D4	D4	D4	D4	D4 (∃240m)

TABLE 3A - Q-D TABLE FOR HAZARD DIVISION 1.3

Net Explosives Quantity Q in kg	Quantity-Distances in metres			
	D1	D2	D3	D4
500	25	60	60	60
600	25	60	60	60
700	25	60	60	60
800	25	60	60	60
900	25	60	60	62
1 000	25	60	60	64
1 200	25	60	60	69
1 400	25	60	60	72
1 600	25	60	60	75
1 800	25	60	60	78
2 000	25	60	60	81
2 500	25	60	60	87
3 000	25	60	62	93
3 500	25	60	65	98
4 000	25	60	68	105
5 000	25	60	73	110
6 000	25	60	78	120
7 000	25	62	82	125
8 000	25	64	86	130
9 000	25	67	89	135
10 000	25	68	92	140
12 000	25	74	98	150
14 000	27	78	105	155
16 000	28	81	110	165
18 000	30	84	115	170
20 000	32	87	120	175
25 000	35	94	125	190
30 000	39	100	135	200
35 000	42	105	140	210
40 000	44	110	150	220
50 000	50	120	160	240
60 000	54	130	170	255
70 000	59	135	180	265
80 000	63	140	185	280
90 000	66	145	195	290
100 000	70	150	200	300
120 000	77	160	215	320
140 000	83	170	225	335
160 000	88	175	235	350
180 000	94	185	245	365
200 000	99	190	250	375
250 000	110	205	270	405
Distance Functions	$D1 = 0.22\ Q^{1/3}$	$D2 = 3.2\ Q^{1/3}$	$D3 = 4.3\ Q^{1/3}$	$D4 = 6.4\ Q^{1/3}$

a. see 1.4.1.11.1)	- virtually complete protection	e.	- (reserved)
b. see 1.4.1.11.2)	- high/limited degree of protection	f. see 1.4.6.6.a)	- door barricade at PES
c.	- (reserved)	g. see 1.4.5.1.c)	- practical considerations may require a greater distance
d. see 1.4.5.6.b)	- resistance of headwall and door(s) at ES	h. see 1.4.1.14.b)	- reaction of drivers on busy roads