NATIONAL STANDARD OF CANADA

CAN/BNQ 2910-510/2015

Explosives – Quantity Distances

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NATIONAL STANDARD OF CANADA

CAN/BNQ 2910-510/2015

Explosives – Quantity Distances

Explosifs – Distances par rapport à la quantité d'explosifs

ICS: 13.200; 13.220.40; 71.100.30

BNQ
BUREAU DE NORMALISATION DU QUÉBEC

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EXPLOSIVES — QUANTITY DISTANCES

Standard prepared by the Bureau de normalisation du Québec (BNQ)

and approved by the Standards Council of Canada (SCC)

Standards Council of Canada
Conseil canadien des normes

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FOREWORD

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CONTENTS

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EXPLOSIVES — QUANTITY DISTANCES

1 PURPOSE AND SCOPE

This standard is intended to establish the minimum separation distances to be used between potential explosion sites (PES) and exposed sites (ES), to reduce the risk to life and property.

This standard applies to all locations in which a quantity of stored or manufactured explosives has the potential, if its contents were to explode, to create a blast that could be associated with the projection of fragments or debris, or with a fire hazard.

This standard excludes transportation activities. This standard also excludes day boxes that are used on site for the temporary storage of explosives during blasting operations.

2 DEFINITIONS

For the purpose of this document, the following definitions shall apply:

aboveground storage, n. An aboveground building or structure for the storage of explosives, with or without earth cover, or in open stacks. French: ***entrepôt hors-sol***.

authority having jurisdiction, n. A body or agency that has been authorized by an empowering act or a regulation to enforce any requirement of this standard. French: ***autorité compétente***.

barricade, n. A natural ground feature, artificial earth mound or wall that is capable of intercepting high velocity low angle projections from a potential explosion site (PES). French: ***merlon***.

black powder, n. (syn.: gunpowder, n.) An intimate mixture of sodium nitrate or potassium nitrate with charcoal, with or without sulphur. {Reference: IATG 01.40 (adapted wording) [see Annex K].} French: ***poudre noire***.

blast, n. The wave of high pressure air resulting from a detonation, a deflagration, the rupture of a pressure vessel, or other similar sudden energy release. French: ***souffle***.

cartridge, n. A cased quantity of explosives (excluding rocket motors) complete with its own means of ignition. French: ***cartouche***.

containment barricade, n. A natural or man-made structure that limits the trajectory of hazardous projections. French: ***merlon de confinement.***

NOTE — Unlike a barricade, which is intended to arrest high velocity low trajectory projections to prevent propagation to other exposed sites (ESs), a containment barricade is intended to deal with all trajectories, including high trajectory lobbed fragments and secondary debris from sources such as magazine break-up.

curtain wall, n. A non-load bearing wall of glass, metal, or masonry attached to the exterior of a building's structural frame. French: ***mur rideau***.

debris, n. A portion of the natural ground or a portion of a structure or material (not part of the functioning explosive) that is propelled from the site of an explosion. {Reference: IATG 01.40 (adapted wording) [see Annex K].} French: ***débris***.

deflagration, n. A combustion reaction that moves through an explosive substance at subsonic velocity in the reacting material. {Reference: IATG 01.40 (adapted wording) [see Annex K].} French: ***déflagration***.

NOTE — Under certain circumstances, a deflagration could transition into a detonation.

detonation, n. A combustion reaction that moves through an explosive substance at supersonic velocity in the reacting material. {Reference: IATG 01.40 (adapted wording) [see Annex K].} French: ***détonation***.

dividing wall, n. A wall or structure designed to prevent a sympathetic detonation between explosives located on each side. French: ***mur de refend***.

explosion, n. A sudden release of energy producing a blast effect with the possible projection of fragments. (Reference: IATG 01.40 [see Annex K].) French: ***explosion***.

explosive, n. A substance or article manufactured to produce an explosion, a detonation, or a pyrotechnic or propulsive effect. French: ***explosif***.

NOTE — The definition encompasses the term "cartridge."

explosives area, n. An area used for the handling, processing, or storage of explosives that may contain within its boundaries a number of potential explosion sites (PESs) and exposed sites (ESs). French: ***zone d'explosifs***.

exposed site (abbrev.: **ES**), n. (syn.: susceptible site, n.) A building in which people live, work or assemble; a public road, railway or other transportation infrastructure; a pipeline, electrical facility or power line, or any place in which a substance that increases the likelihood of a fire or explosion is likely to be stored including, but not limited to, a site containing aboveground or underground storage of carbon fuels, or a site containing explosives (magazine, tanker loaded with explosives, factory or mobile process unit). French: ***site exposé*** (abbrev.: ***SE***); ***siège exposé***.

fragment, n. A solid material, part of the functioning of the explosive, propelled from the site of an explosion. French: ***fragment***; ***éclat***.

hazardous projection, n. A single piece of fragment or debris whose kinetic energy exceeds 80 J. French: ***projection dangereuse***.

heavy-walled building, n. A building of non-combustible construction without windows, with reinforced concrete walls at least 450 mm thick, with walls made of solid brick at least 700 mm thick, with unreinforced concrete walls at least 700 mm thick or with walls having an equivalent resistance to fragment penetration. French: ***bâtiment à parois épaisses***.

inhabited building, n. A building or site where members of the general public or personnel not involved in explosives-related operations work, live or congregate. French: ***bâtiment occupé***.

inhabited-building distance (abbrev.: **IBD**), n. The minimum separation distance between a potential explosion site (PES) and an inhabited building or an exposed site (ES) that requires the same level of protection as an inhabited building. French: ***distance avec un bâtiment occupé*** (abbrev.: ***DBO***).

inter-magazine distance (abbrev.: **IMD**), n. The minimum separation distance between a potential explosion site (PES) and a storage site containing explosives or an exposed site (ES) that requires the same level of protection as a storage site containing explosives. French: ***distance entre dépôts*** (abbrev.: ***DED***).

mass explosion, n. An explosion that affects, practically instantaneously, virtually the entire quantity of explosives under consideration. {Reference: IATG 01.40 (adapted wording) [see Annex K].} French: ***explosion en masse***.

> NOTE — This term usually relates to detonation but also applies to deflagration when the practical effects are similar (e.g. the mass deflagration of black powder or propellants under strong confinement so as to produce a bursting effect and a serious hazard from debris).

navigable waterway, n. Rivers, streams, channels or canals capable of being used in their ordinary or maintained conditions, as highways of commerce on which trade and travel are or may be conducted in the usual ways, including waterways used for the operation of pleasure boats. French: ***voie navigable***.

net effective explosive quantity (abbrev.: **NEEQ**), n. A concept used when tests have shown that the effective quantity of explosive substances in a container, cartridge or building is significantly different from the net explosive quantity (NEQ). French: ***quantité équivalente nette d'explosifs*** (abbrev.: ***QENE***).

> NOTE — There are two broad categories of explosives for which the NEEQ is used:
>
> - When the inherent properties of the explosives in question are such that the potential explosion site (PES) is classified as PE1, but their packaging, cartridge, or arrangement precludes the whole quantity from undergoing a mass explosion (e.g. shaped charges used in perforating guns, detonators or detonating cord so packaged); and
>
> - When the explosive does undergo a mass explosion, but the power of the explosive is other than what is implied in the quantity-distance (Q-D) tables of this document.

net explosive quantity (abbrev.: **NEQ**), n. The mass of an explosive excluding the mass of any packaging or container and, in the case of an explosive article, excluding any component that is not an explosive substance. {Reference: Canada, *Explosives Regulations, 2013* (adapted wording) [see Annex K].} French: ***quantité nette d'explosifs*** (abbrev.: ***QNE***).

non-explosives workshop, n. A building in which technical support operations directly related to the explosives area are carried out, but which does not contain explosives. French: ***atelier sans explosifs***.

perforating gun, n. A device used to perforate oil and gas wells in preparation for production, containing shaped explosive charges. French: ***perforateur***.

permanent workplace, n. The location in which one or more persons normally perform their employment duties. French: ***lieu de travail permanent***.

picking area, n. A designated location away from licensed magazines where the selection and re-packing of pyrotechnic articles takes place. French: ***zone de sélection***.

> NOTE — The location of a picking area relative to surrounding magazines will depend on the quantity of pyrotechnic articles being brought to the picking area for the selection and repacking process and will be based primarily on the Q/D Tables (see Annex E).

potential explosion site (abbrev.: **PES**), n. (syn.: donor site, n.) The location of a quantity of explosives that will create a blast that could be associated with the projection of fragments or debris or a fire hazard if its contents should explode. French: ***site potentiel d'explosion*** (abbrev.: ***SPE***); ***siège potentiel d'explosion***.

process-building distance (abbrev.: **PBD**), n. The minimum separation distance between a potential explosion site (PES) and an explosives process building or an exposed site (ES) that requires the same level of protection as an explosives process building. French: ***distance avec un bâtiment de fabrication*** (abbrev.: ***DBF***).

propellant, n. A deflagrating explosive often used for propulsion. {Reference: IATG 01.40 (adapted wording) [see Annex K].} French: ***poudre propulsive***.

protective roof, n. A roof with suitable support designed to prevent fragment penetration made of 150 mm or greater reinforced concrete or a material with an equivalent resistance to fragment penetration. French: ***toit protecteur***.

public traffic route (abbrev.: **PTR**), n. A road used for general public traffic, a road accessible to the general public (ex.: forest road), a railway outside the explosives area, or a navigable waterway. French: ***voie publique***.

public traffic route distance (abbrev.: **PTRD**), n. The minimum separation distance between a potential explosion site (PES) and a public traffic route or an exposed site (ES) that requires the same level of protection as a public traffic route. French: ***distance avec une voie publique*** (abbrev.: ***DVP***).

pyrotechnic, adj. Designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as a result of a non-detonating, self-sustaining exothermic chemical reaction. French: ***pyrotechnique***.

unmanned building, n. A building within the explosives area that is not a permanent workplace and that can be entered by only a few people at a time to perform a task of limited duration. French: ***bâtiment non habité.***

vulnerable building (abbrev.: VB), n. A building that requires a higher level of protection than an inhabited building by nature of its construction or function. French: ***bâtiment vulnérable*** (abbrev.: **BV**)**.**

NOTE — A non-exhaustive list of vulnerable buildings can be found in Table B.2 (see row 13).

vulnerable-building distance (abbrev.: **VBD**), n. The minimum separation distance between a potential explosion site (PES) and a vulnerable building or an exposed site (ES) that requires the same level of protection as a vulnerable building. French: ***distance avec un bâtiment vulnérable*** (abbrev.: ***DBV***).

3 CLASSIFICATION OF POTENTIAL EXPLOSION SITES (PESs) BY POTENTIAL EFFECT (PE)

3.1 GENERAL

PESs shall be classified into one of the following potential effect (PE) categories:

- PE1: Mass explosion hazard;
- PE2: Projection hazard, but not a mass explosion hazard;
- PE3: Fire hazard and a secondary blast or projection hazard (or both), but not a mass explosion hazard; or
- PE4: Local fire hazard.

3.2 DETERMINATION OF THE APPLICABLE PE CLASSIFICATION

3.2.1 General

The applicable PE classification of a PES shall be determined in consultation with the authority having jurisdiction and shall be approved by the authority having jurisdiction.

NOTE — In many cases, the classification of PESs by PE is based on the hazard classification of the UN Classification for the Transport of Dangerous Goods (see Annex H). However, when the manufacturing or storage conditions of an explosive represent a higher risk than the transportation conditions, the classification of PESs by PE takes into account the increased risks that are incurred as a result of process and storage conditions.

3.2.2 Aggregation of different types of explosives at a single potential explosion site (PES)

When a PES is used for the manufacture or storage of an aggregation of different types of explosives, the PES shall be assigned the PE classification of the explosives that represent the highest risk.

4 DETERMINATION OF THE MAXIMUM NET EXPLOSIVE QUANTITY (NEQ) ALLOWED AT A POTENTIAL EXPLOSION SITE (PES)

The maximum net explosive quantity (NEQ) allowed at a PES shall be determined in consultation with the authority having jurisdiction. It shall be derived from the NEQ of the explosives that are intended to be stored or manufactured at the PES or based on the distance separating the PES from the ESs, as set out in Annex A.

NOTE — To calculate the NEQ from the net effective explosive quantity (NEEQ), the authority having jurisdiction should be consulted.

5 DETERMINATION OF THE MINIMUM SEPARATION DISTANCES

5.1 GENERAL

Minimum separation distances shall be determined using the quantity-distance (Q-D) tables, as set out in Clause 5.2. Alternatively, the minimum separation distance may be calculated using the scale factor equations in the applicable Q-D table.

Any deviation from the Q-D tables shall be approved in writing by the authority having jurisdiction. This permission shall apply only to the specific facility for which it is given. In these cases, or when the authority having jurisdiction has a special need, additional information, such as specific elements related to risk assessment, shall be provided to support the request for deviation.

5.2 DETERMINATION OF THE MINIMUM SEPARATION DISTANCE USING QUANTITY-DISTANCE (Q-D) TABLES

5.2.1 Explosives areas with a single potential explosion site (PES)

5.2.1.1 General — To calculate the minimum separation distance between a PES and each ES located inside and outside an explosives area with a single PES, the PES and each ES shall be associated with a pictogram, as set out in Annex B.

The minimum separation distance between the PES and each ES shall then be determined from the Q-D table corresponding to the PE classification of the PES, as follows:

- PESs classified as PE1 shall meet the requirements specified in Annex C;
- PESs classified as PE2 shall meet the requirements specified in Annex D;

- PESs classified as PE3 shall meet the requirements specified in Annex E; and
- PESs classified as PE4 shall meet the requirements specified in Annex F.

5.2.1.2 Acceptance criteria — If the required separation distances between the PES and the ESs cannot be achieved, the following shall be considered:

- Using the means set out in Clause 5.2.3 to reduce the separation distances;
- Reducing the maximum NEQ allowed at the PES;
- Relocating either the PES or the ES; or
- Changing the types of explosives to be manufactured or stored at the PES so as to change the PE classification of the PES.

In no case shall the minimum separation distances fail to be met without the approval of the authority having jurisdiction.

5.2.2 Explosives areas with more than one potential explosion site (PES)

5.2.2.1 Calculation of minimum separation distances — For explosives areas with two or more PESs, the minimum separation distance shall be calculated between each PES and ES as set out in Clause 5.2.1.

The minimum separation distance between two PESs shall be established based on the PES that requires the larger separation distance.

If the minimum separation distances cannot be achieved, the provisions of Clause 5.2.1.2 or 5.2.2.2 shall be considered.

5.2.2.2 Aggregation of net explosive quantities (NEQ) for the purpose of establishing separation distances — When two or more PESs are not separated by the minimum separation distance set out in Clause 5.2.2.1, the PESs may be considered a single PES. In that case, the NEQ used to determine the separation distances from the Q-D tables shall be the sum of the maximum NEQ allowed at each PES. The PE classification shall then be based on the PES with the most stringent classification.

5.2.3 Means to reduce separation distances

5.2.3.1 Use of effective barricades to reduce separation distances — When two or more PESs are not separated by the minimum separation distance, effective barricades can be put in place to reduce the minimum separation distance as specified in the Q-D tables. A barricade shall be considered effective if it meets the requirements set out in Annex G.

5.2.3.2 Use of dividing walls in a potential explosion Site (PES) building — Alternatively, a PES building may be divided into individual compartments using dividing walls approved by the authority having jurisdiction. The specifications of the dividing walls shall take into account the design criteria set out in Annex G.

When dividing walls are used, the minimum separation distances shall be calculated from the Q-D tables on the basis of the maximum NEQ allowed in one compartment instead of the aggregate maximum NEQ allowed in the building. The PE classification of each compartment shall be the same as the PE established for the PES building, regardless of the types of explosives stored in each compartment.

6 MEASUREMENT OF THE SEPARATION DISTANCES

Separation distances shall be measured from the nearest point of the PES to the nearest point of the ESs along a straight line regardless of barricades or intervening buildings or structures.

When the total quantity of explosives in a PES is separated using dividing walls, the separation distances shall be measured from the outside of the dividing walls to the nearest point of the ESs.

Separation distances shall be measured with a measuring tape, range finder (laser), GPS, satellite or survey map. The method of measurement used shall be recorded.

-0-0-0-0-0-0-0-0-0-0-0-0-0-0-

ANNEX A
(normative)
[mandatory]

DETERMINATION OF THE MAXIMUM NET EXPLOSIVE QUANTITY (NEQ) ALLOWED AT A POTENTIAL EXPLOSION SITE (PES) BASED ON THE DISTANCES SEPARATING THE PES FROM THE EXPOSED SITES (ESs)

A.1 GENERAL

It is possible to determine the maximum NEQ allowed at a PES based on the distances separating the PES from the ESs located both inside and outside the explosives area.

A.2 DETERMINATION OF THE MAXIMUM NEQ ALLOWED AT A PES

To establish the maximum NEQ allowed at a PES, the PES classification shall be determined as set out in Clause 3.2.

Once the PE classification of the PES has been determined, the following procedure shall be used to determine the maximum NEQ allowed at an existing or future PES:

a) Measure the distances separating the PES from each ES as set out in Chapter 6;

b) Select the appropriate pictogram that represents the PES and each of the ESs from Tables B.1 and B.2, respectively;

c) Using the Q-D matrix and the Q-D table applicable to the PE classification of the PES (e.g. Tables C.1 and C.2 for a PES classified as PE1), determine the minimum separation distance between the PES and each ES;

d) If a fixed distance is specified in the Q-D matrix and if the measured distance between the PES and a given ES is equal to or greater than the fixed distance prescribed in the Q-D matrix, the NEQ associated with the ES shall be deemed to be 250 000 kg.

e) If a fixed distance is specified in the Q-D matrix and if the measured distance between the PES and the ES is less than the fixed distance prescribed in the Q-D matrix, the PES shall not be installed at that location.

f) If the minimum separation distance is expressed as D1, D2, D3 […] and depends on the NEQ, select the NEQ that corresponds to the measured distance between the PES and the ES for the specified Q-D scale (e.g. D7 in Table C.2)

g) If the distance between the PES and the ES falls between two distances specified in the Q-D table, the NEQ corresponding to the lesser distance shall be used.

h) The maximum NEQ allowed at the PES shall be equal to the most restrictive result obtained from this procedure.

If the maximum NEQ allowed that is obtained from this procedure does not meet the needs of the user or if the fixed distance requirements of the Q-D matrix cannot be met, the following measures shall be taken:

- Using the means set out in Clause 5.2.3 to reduce the separation distances; or
- Relocating the PES or the ES; or
- Changing the types of explosives to be manufactured or stored at the PES so as to change the PE classification of the PES.

ANNEX B
(normative)
[mandatory]

IDENTIFICATION OF THE POTENTIAL EXPLOSION SITE (PESs) AND EXPOSED SITES (ESs) WITH THEIR ASSOCIATED PROTECTION LEVEL

B.1 IDENTIFICATION OF THE PESs

To establish the minimum separation distances, each PES shall be associated with the applicable pictogram, which shall be selected from one of the categories set out in Table B.1.

NOTE — PESs are grouped into categories on the basis of the risk they present.

B.2 IDENTIFICATION OF THE ESs AND THEIR ASSOCIATED PROTECTION LEVEL

To establish the minimum separation distances, each ES shall be associated with the applicable pictogram, which shall be selected from one of the categories set out in Table B.2.

NOTE — Each pictogram indicates the protection level that is provided by the separation distance between the PES and ES. For example, the pictogram indicating the protection level "Public traffic route distance — Medium traffic (PTRD-MT)" is used for all the ESs requiring a PTRD-MT, including public parks.

TABLE B.1

POTENTIAL EXPLOSION SITES (PESs)

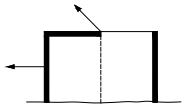
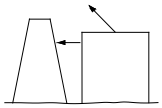
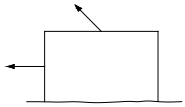
Potential Explosion Site (PES) Category	Pictogram	
Heavy-walled building with or without a protective roof		1
Barricaded site: Open air stack, light structure or unattended tanker, mobile process unit (MPU), trailer or railcar loaded with explosives, or blasting explosives stored at or near fixed-surface blast sites or mining sites located at a site protected by a barricade that meets the requirements set out in Annex G.		2
Unbarricaded site: Open-air stack, light structure, or unattended tanker, mobile process unit (MPU), trailer or railcar loaded with explosives, or blasting explosives stored at or near fixed-surface blast sites or mining sites located on a site not protected by a barricade.		3
Burning, destruction and test areas: The minimum separation distances shall be established on a case-by-case basis with the authority having jurisdiction and approved by the authority having jurisdiction.		4

TABLE B.2

EXPOSED SITES (ESs) AND ASSOCIATED PROTECTION LEVEL

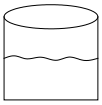
Exposed Site (ES) and Associated Protection Level		Pictogram	
Protection level: **No Q-D required.** Only fire considerations apply.	**Unmanned buildings providing direct explosives area support services with a minimal risk of loss of life or loss of critical material** A minimum separation distance of 25 metres from the PES shall be observed to prevent flashover from lightning strikes or the spread of fire from the ES to the PES. Examples include the following: • Material handling equipment (MHE) accommodation; • MHE charging facilities; • Motor control centre (MCC); • Stores for empty packages or other inert materials required at the explosives area.		0
	On-site aboveground storage of non-volatile carbon fuels On-site aboveground storage of non-volatile carbon fuel used for process purposes and for the transfer to mobile process units shall be 25 metres away and be located at a lower elevation than ammonium nitrate storage, explosives storage and explosives process buildings for fire consideration purposes. The only exemption is for on-site aboveground storage of non-volatile carbon fuels with a volume of 10 000 litres or less, which may be located 8 metres from an explosives storage or an explosives process building.		

TABLE B.2

EXPOSED SITES (ESs) AND ASSOCIATED PROTECTION LEVEL

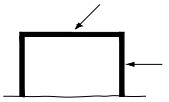
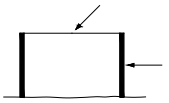
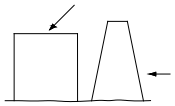
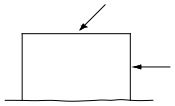
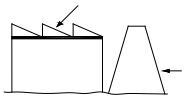
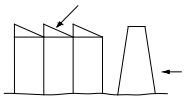
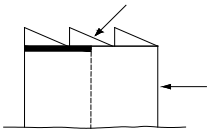
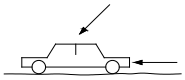
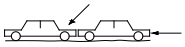
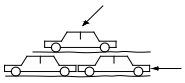
Exposed Site (ES) and Associated Protection Level		Pictogram	
Protection level: **Inter-magazine distance (IMD).** **ESs requiring an IMD:** Magazines used for the storage of explosives, including open-air stack, light structure or truck, trailer or railcar loaded with explosives.	Heavy-walled buildings with a protective roof. The door of the heavy-walled building shall be barricaded if it faces a PES.		1
	Heavy-walled buildings without a protective roof. The door of the heavy-walled building shall be barricaded if it faces a PES.		2
	ESs protected by a barricade that meets the requirements set out in Annex G.		3
	ESs located on a site not protected by a barricade.		4
Protection level: **Process-building distance (PBD).** **ESs requiring a PBD**: Explosives process buildings for the manufacturing of explosives and the following: • explosives laboratories; • ammunition assembly buildings; • guard shelters and guard rooms in which those directly responsible for the security of the explosives area are located when on duty; • buildings with explosives with an occupancy of no more than six persons with jobs essential to specific hazardous operations; and • packaging and shipping (transit) buildings in the explosives area.	Buildings with a protective roof and protected by a barricade that meets the requirements set out in Annex G. NOTE — A heavy-walled building is considered as being protected by a barricade.		5
	Buildings without a protective roof, but protected by a barricade that meets the requirements of Annex G. NOTE — A heavy-walled building is considered as being protected by a barricade.		6
	Buildings with or without a protective roof and not protected by a barricade.		7

TABLE B.2

EXPOSED SITES (ESs) AND ASSOCIATED PROTECTION LEVEL

Exposed Site (ES) and Associated Protection Level		Pictogram	
Protection level: **Public traffic route distance (PTRD).**	**Light traffic (PTRD-LT)** **ESs requiring a PTRD-LT:** Public traffic routes and mine haul roads that convey on average the equivalent of 20 vehicles to fewer than 500 vehicles* per day. Public traffic routes and mine haul roads that convey on average the equivalent of fewer than 20 vehicles per day as well as private roads are not considered as ESs requiring a PTRD-LT and are not subjected to minimum separation distance considerations.		8
	Medium traffic (PTRD-MT) **ESs requiring a PTRD-MD:** Public traffic routes that convey on average the equivalent of 500 vehicles to fewer than 5 000 vehicles* per day, as well as the following: • public parks; • recreational areas without structures; • parking areas; • non-explosives workshops with an occupancy of fewer than 20 persons with jobs essential to a specific hazardous operation.		9
	Heavy traffic (PTRD-HT) **ESs requiring a PTRD-HT:** Public traffic routes that convey on average the equivalent of 5 000 vehicles* or more per day.		10

* For the purpose of this standard, vehicles shall be assessed as follows:

Type of vehicle	Equivalent number of vehicles
1 car (2 persons)	1 vehicle
1 bus (20 persons)	10 vehicles
1 personal watercraft (1 person)	0.5 vehicles
1 vessel under 10 m (4 persons)	2 vehicles
1 vessel over 10 m (16 persons)	8 vehicles
Passenger train: 45 persons per car	22.5 vehicles per car
1 freight train (4 persons)	2 vehicles
Ferry and cruise ships	To be determined with the authority having jurisdiction

TABLE B.2

EXPOSED SITES (ESs) AND ASSOCIATED PROTECTION LEVEL

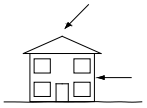
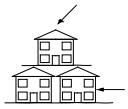
Exposed Site (ES) and Associated Protection Level		Pictogram	
Protection level: **Inhabited-building distance (IBD).**	**ESs requiring an IBD for fewer than 20 people:** Inhabited buildings with fewer than 20 people in total: • Single isolated dwellings; • Factory offices or administrative buildings associated with an explosives area that house fewer than 20 employees not directly involved with explosives, such as administrative staff; and • Non-explosives workshops that house fewer than 20 employees whose job is not essential to specific hazardous operations.		11
	ESs requiring an IBD for 20 people or more: Built-up areas of inhabited buildings with 20 people or more, as well as: • places of assembly; • sports stadiums; • warehouses and shops that shall not be placed at risk, because of their vital nature or high intrinsic value; • factory offices or administrative buildings associated with an explosives area that house 20 employees or more not directly involved with explosives, such as administrative staff; • canteens within the administrative area of an explosives area; • non-explosives workshops that house 20 employees or more; • structures and facilities associated with the explosives area that are important for the functioning of the explosives area, such as fire stations, central heating plants, vehicle pools, gasoline storage and dispensing facilities, and unprotected water supply and power facilities; and • remote airports as determined by the authority having jurisdiction.		12

TABLE B.2

EXPOSED SITES (ESs) AND ASSOCIATED PROTECTION LEVEL

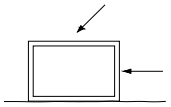
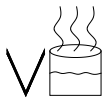
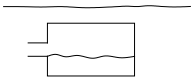
Exposed Site (ES) and Associated Protection Level		Pictogram	
Protection level: **Vulnerable-building distance (VBD)**.	**ESs requiring a VBD**: ESs that require a VBD are to be determined by the authority having jurisdiction. Examples include: — buildings of curtain-wall construction that have four storeys or more and are constructed with external non-load bearing panels on a separate sub-frame that is supported off the structural frame or floors; NOTE — Where these cladding panels are large and constructed of glass or similar lightweight frangible material, which is liable to shatter, producing dangerous debris, or be displaced under the effect of lateral explosive blast loads greater than the designed wind forces, the curtain wall is considered a hazard to personnel both inside and outside the building because of possible flying debris or falling panels. — buildings of four storeys or more in which more than 50 % of the wall area is glazed; — buildings of national and historic importance; — large factories. — multi-storey office or apartment buildings; — public buildings and edifices of major value; — large educational facilities; — large hospitals; — major traffic terminals (e.g. railway stations and airports); — major public utilities (e.g. gas, water and electricity); — major sports stadiums; — exhibition areas and assembly halls.		13
Aboveground non-critical volatile carbon fuel storage Aboveground non-critical storage of volatile carbon fuels (e.g. petroleum, liquid petroleum gas [LPG], natural gas, coal gas, methane, propane, butane and paraffin).			14

TABLE B.2

EXPOSED SITES (ESs) AND ASSOCIATED PROTECTION LEVEL

Exposed Site (ES) and Associated Protection Level	Pictogram	
Aboveground critical volatile carbon fuel storage Aboveground critical storage of volatile carbon fuels (petroleum, liquid petroleum gas [LPG], natural gas, coal gas, methane, propane, butane and paraffin).		15
Underground pipelines and underground storage of volatile carbon fuels Underground pipelines or underground storage of volatile carbon fuels (petroleum, liquid petroleum gas [LPG], natural gas, coal gas, methane, propane, butane and paraffin) with a minimum cover of 1.2 m of earth or 100 mm of concrete.		16
Electrical installations Electrical generators, unprotected substations and transformers.		17
Electrical power lines		18
Surface blasting or mining operations		19
Tankers and mobile process units (MPU) containing explosives: If mixing or gassing on the unit is going on, the unit shall be sited as a process building. Otherwise, it shall be sited as a magazine.		20

ANNEX C
(normative)
[mandatory]

MINIMUM SEPARATION DISTANCES FOR POTENTIAL EXPLOSION SITES (PESs) CLASSIFIED AS PE1

C.1 GENERAL

The minimum separation distance between a PES classified as PE1 and each exposed site (ES) shall be determined from the Q-D matrix (see Table C.1).

If the minimum separation distance between the PES and ES is expressed as D1, D2, D3 […], this separation distance depends on the maximum net explosive quantity (NEQ) allowed at the PES and shall be determined from the Q-D table (see Table C.2).

If the maximum NEQ allowed at the PES falls between two NEQs in the Q-D table, the separation distance applicable to the next greater NEQ shall be used. Alternatively, the minimum separation distance may be calculated from the scale factor equations provided in Table C.2.

C.2 SPECIAL CASE OF BULK AMMONIUM NITRATE STORAGE

When bulk ammonium nitrate storage is located in the same explosive area as a PES classified as PE1, the minimum separation distance between the bulk ammonium nitrate storage and the PES specified in Table C.3 shall be observed.

If the minimum separation distance specified in Table C.3 is observed, the bulk ammonium nitrate storage shall not be regarded as a PES for Q-D purposes.

If the minimum separation distance specified in Table C.3 cannot be achieved, 50 % of the maximum mass that is allocated by the license for the bulk ammonium nitrate storage shall be added to the maximum NEQ allowed at the PES before using the applicable Q-D table.

> EXAMPLE — A licensed 30 000 kg bulk ammonium nitrate silo is located near a 20 000 kg blasting explosive magazine classified as PE1. To determine whether or not the bulk ammonium nitrate silo is located far enough from the PES for Q-D purposes, Table C.3 states that the minimum separation distance is to be as follows:
>
> - 6.6 m if there is a barricade at least 0.87 m thick between the bulk ammonium nitrate silo and the 20 000 kg blasting explosive magazine;

- 40 m if there is no barricade between the bulk ammonium nitrate silo and the 20 000 kg blasting explosive magazine or if the barricade is not at least 0.87 m thick.

If the minimum separation distance specified above is observed, the bulk ammonium nitrate storage shall be ignored for Q-D purposes and the NEQ to be used for the Q-D tables shall correspond to the maximum NEQ allowed at the PES, namely 20 000 kg.

If the minimum separation distances are not achieved, then 50% of the maximum mass that is allocated by the licence for the bulk ammonium storage shall be added to the maximum NEQ allowed at the PES. This means that the NEQ to be used for the Q-D tables shall be 35 000 kg, which is the sum of 20 000 kg and 50% of 30 000 kg.

C.3 ALTERNATIVE PROVISIONS FOR SMALL QUANTITIES OF EXPLOSIVES

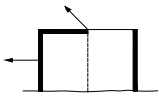
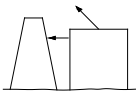
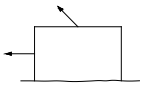
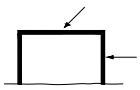
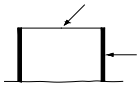
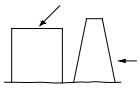
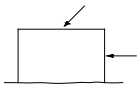
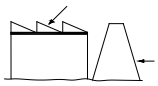
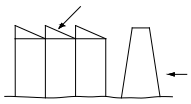
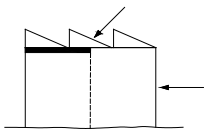
When the maximum NEQ allowed at a PES classified as PE1 is equal to or less than 1 800 kg, the minimum separation distance requirements set out in Table C.4 may be applied instead of the requirements set out in Chapter C.1.

C.4 ALTERNATE PROVISIONS FOR LARGE-CALIBRE PYROTECHNIC SHELLS AND SOUND SHELLS

A magazine used to store less than 100 kg gross mass of large-calibre pyrotechnic shells and sound shells (PES classified as PE1) may not have to comply with the requirements of Chapter C.1. The alternate provisions shall be determined in consultation with the authority having jurisdiction and approved by the authority having jurisdiction.

TABLE C.1

Q-D MATRIX FOR PE1 PESs

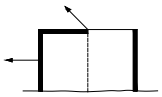
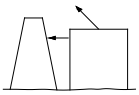
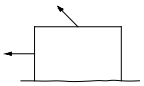
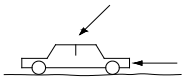
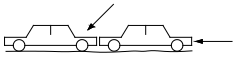
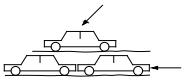
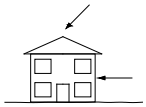
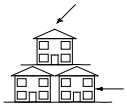
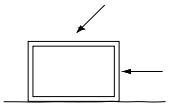
Exposed Site (ES)				Potential Explosion Site (PES) Classified as PE1		
				Heavy-Walled Building with or Without Protective Roof	Barricaded Site	Unbarricaded Site
						
1	Magazine	Heavy-walled building with protective roof		D2	D2	D2
2		Heavy-walled building without protective roof		D2	D2	D2
3		Barricaded site		D1 or D2	D1 or D2	D1 or D2
				D1 may be used only if the PES contains ANFO or other explosives classified as UN Division 1.5		
4		Unbarricaded site		D6	D1 or D2	D6
				D1 may be used only if the PES contains ANFO or other explosives classified as UN Division 1.5		
5	Explosives process building	Building with protective roof and barricade		D3* or D4	D3* or D4	D3* or D4
6		Building without protective roof, but with barricade		D3* or D4 (≥ 270 m)	D3* or D4	D3* or D4
7		Building with or without protective roof and without barricade		D7	D3* or D4	D7

* D3 may be used only when:

- the maximum NEQ allowed is less than 4 000 kg;
- the number of people in the explosives process building is equal to or less than 10; and
- the building has been designed to meet at least the "Low" level of protection specified in Standard CSA S850 (see Annex K).

TABLE C.1

Q-D MATRIX FOR PE1 PESs

Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE1		
		Heavy-Walled Building with or Without Protective Roof	Barricaded Site	Unbarricaded Site
				
8	Public traffic routes — light traffic 	D4	D4	D4
9	Public traffic routes — medium traffic 	D5	D5	D5
10	Public traffic routes — heavy traffic 	D7	D7	D7
11	Inhabited buildings with fewer than 20 people in total 	D7	D7	D7
12	Area of inhabited buildings with 20 people or more 	D7* (≥ 400 m)	D7* (≥ 400 m)	D7* (≥ 400 m)
13	Vulnerable buildings 	D8* (≥ 400 m)	D8* (≥ 400 m)	D8* (≥ 400 m)
14	Aboveground non-critical volatile carbon fuels 	D7 NOTE — Where aboveground storage of non-critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.		

* The minimum distance is 400 m. This provides for debris protection from the explosion. A minimum distance of 270 m may be used if there are 20 people or fewer between 270 m and 400 m.

TABLE C.1

Q-D MATRIX FOR PE1 PESs

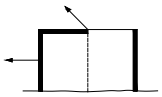
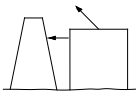
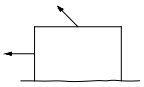
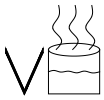
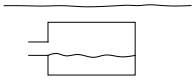
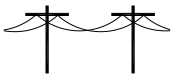
Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE1		
		Heavy-Walled Building with or Without Protective Roof	**Barricaded Site**	**Unbarricaded Site**
				
15	Aboveground critical volatile carbon fuels 	D7 ≥ 450 m NOTE — Where aboveground storage of critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.		
16	Underground pipelines/bulk storage 	0.5 × D2	0.5 × D2	0.5 × D2
17	Electrical facilities 	• 45 m from electrical generators and unprotected substations • 10 m from transformers at protected substations that are designed to withstand the effects of an internal explosion with provision to contain the cooling oil		
18	Power lines 	1. Power lines < 15 kV and private power lines: The greatest of the following distances from overhead cables *a*) 15 m *b*) $D = \frac{S}{2} - H$ where D : minimum separation distance, in metres S : span between the pylons or the power line supporting structures, in metres H : height of the insulators on the pylon or the power line supporting structure, in metres 2. Power lines ≥ 15 kV except private power lines shall use D5. 3. Critical power lines shall use D7.		
19	Surface blasting or mining operations 	D7 or D5, where an emergency plan is in effect.		

TABLE C.2

Q-D TABLE FOR PE1 PESs

NEQ, in kg	**Quantity Distance (Q-D)**, in m							
	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
50	5	10	18	30	180	45	270	400
60	5	10	19	32	180	45	270	400
70	5	10	20	33	180	46	270	400
80	5	11	21	35	180	48	270	400
90	5	11	22	36	180	50	270	400
100	5	12	23	38	180	53	270	400
120	5	12	24	40	180	55	270	400
140	5	13	25	42	180	60	270	400
160	5	14	27	44	180	63	270	400
180	5	14	28	46	180	65	270	400
200	5	15	29	47	180	65	270	400
250	6	16	31	51	180	70	270	400
300	6	17	33	54	180	75	270	400
350	6	17	34	57	180	80	270	400
400	6	18	36	59	180	83	270	400
450	7	19	38	62	180	88	270	400
500	7	20	39	64	180	90	270	400
600	7	21	42	68	180	95	270	400
700	8	22	45	72	180	100	270	400
800	8	23	48	75	180	105	270	415
900	8	24	50	78	180	108	270	430
1 000	8	24	53	80	180	113	270	445
1 200	9	26	58	86	180	120	270	475
1 400	9	27	63	90	180	125	270	500
1 600	10	29	68	94	180	130	270	520
1 800	10	30	73	98	180	135	270	540
2 000	11	31	78	105	180	140	270	560
2 500	11	33	90	110	185	153	275	610
3 000	12	35	105	120	205	163	305	640
3 500	13	37	115	125	220	170	330	680
4 000	13	39	130	130	235	178	350	710
5 000	14	42	140	140	255	190	380	760
6 000	15	44	150	150	270	203	405	810
7 000	16	46	155	155	285	213	425	850
8 000	16	48	160	160	300	223	445	890
9 000	17	50	170	170	310	235	465	930

TABLE C.2

Q-D TABLE FOR PE1 PESs

NEQ, in kg	**Quantity Distance (Q-D)**, in m							
	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
10 000	18	52	175	175	320	240	480	960
12 000	19	55	185	185	340	255	510	1 020
14 000	20	58	195	195	360	270	540	1 080
16 000	21	61	205	205	375	280	560	1 120
18 000	21	63	210	210	390	295	590	1 180
20 000	22	66	220	220	405	305	610	1 220
25 000	24	71	235	235	435	325	650	1 300
30 000	25	75	250	250	460	345	690	1 380
35 000	27	79	265	265	485	365	730	1 460
40 000	28	83	275	275	510	380	760	1 520
50 000	30	89	295	295	550	410	820	1 640
60 000	32	94	315	315	580	435	870	1 740
70 000	33	99	330	330	610	460	920	1 840
80 000	35	105	345	345	640	480	960	1 920
90 000	36	110	360	360	670	500	1 000	2 000
100 000	38	115	375	375	690	520	1 040	2 080
120 000	40	120	395	395	730	550	1 100	2 200
140 000	42	125	420	420	770	580	1 160	2 320
160 000	44	135	435	435	810	610	1 220	2 420
180 000	46	140	455	455	840	630	1 260	2 520
200 000	47	145	470	470	870	650	1 300	2 600
250 000	51	155	510	510	940	700	1 400	2 800

Q-Ds are based on the following:

- D1 is based on a scaled factor of 0.8
- D2 is based on a scaled factor of 2.4
- D3 is based on smaller distances for certain process buildings
- D4 is based on a scaled factor of 8.0
- D5 is based on a scaled factor of 14.8
- D6 is based on a scaled factor of 11.1
- D7 is based on a scaled factor of 22.2
- D8 is based on a scaled factor of 44.4

Annex I provides additional information on scaled factors.

TABLE C.3

MINIMUM SEPARATION DISTANCE BETWEEN BULK AMMONIUM NITRATE AND PESs CLASSIFIED AS PE1

NEQ, in kg	**Barricaded Facility***		**Facility Without a Barricade**
	Minimum Separation Distance, in m	**Minimum Thickness of Artificial Barricade**, in m	**Minimum Separation Distance**, in m
0 < NEQ ≤ 50	0.9	0.31	5
50 < NEQ ≤ 135	1.2	0.31	7
135 < NEQ ≤ 275	1.5	0.31	9
275 < NEQ ≤ 450	1.8	0.31	11
450 < NEQ ≤ 725	2.1	0.31	13
725 < NEQ ≤ 900	2.4	0.31	14
900 < NEQ ≤ 1 400	2.7	0.38	16
1 400 < NEQ ≤ 1 800	3.0	0.38	18
1 800 < NEQ ≤ 2 800	3.4	0.39	20
2 800 < NEQ ≤ 3 600	3.7	0.50	22
3 600 < NEQ ≤ 4 500	4.0	0.51	24
4 500 < NEQ ≤ 5 500	4.3	0.51	26
5 500 < NEQ ≤ 7 250	4.6	0.63	28
7 250 < NEQ ≤ 9 000	4.9	0.64	29
9 000 < NEQ ≤ 11 500	5.5	0.65	33
11 500 < NEQ ≤ 13 500	5.8	0.76	35
13 500 < NEQ ≤ 16 000	6.1	0.76	37
16 000 < NEQ ≤ 18 000	6.4	0.76	38
18 000 < NEQ ≤ 20 000	6.6	0.87	40
20 000< NEQ ≤ 23 000	7.0	0.89	42
23 000 < NEQ ≤ 25 000	7.3	0.89	44
25 000 < NEQ ≤ 28 000	7.6	0.89	46
28 000 < NEQ ≤ 32 000	7.9	1.02	47
32 000 < NEQ ≤ 36 000	8.5	1.02	51
36 000 < NEQ ≤ 40 000	9.0	1.02	54
40 000 < NEQ ≤ 45 000	9.7	1.02	58

TABLE C.3

MINIMUM SEPARATION DISTANCE BETWEEN BULK AMMONIUM NITRATE AND PESs CLASSIFIED AS PE1

NEQ, in kg	**Barricaded Facility***		**Facility Without a Barricade**
	Minimum Separation Distance, in m	**Minimum Thickness of Artificial Barricade**, in m	**Minimum Separation Distance**, in m
45 000 < NEQ ≤ 54 000	10.4	1.26	62
54 000 < NEQ ≤ 64 000	11.3	1.27	68
64 000 < NEQ ≤ 73 000	12.3	1.27	74
73 000 < NEQ ≤ 82 000	13.4	1.27	80
82 000 < NEQ ≤ 91 000	14.6	1.28	88
91 000 < NEQ ≤ 100 000	15.8	1.52	95
100 000 < NEQ ≤ 113 000	17.1	1.52	103
113 000 < NEQ ≤ 125 000	18.3	1.52	110
125 000 < NEQ ≤ 136 000	19.5	1.52	117

* The minimum separation distance for barricaded facilities applies only if the barricade between the bulk ammonium nitrate storage and the PES has the specified minimum thickness. If this minimum thickness is not observed, the minimum separation distance for facilities without a barricade shall be used.

If the ammonium nitrate cannot be located at least at the minimum separation distance, half the mass of the ammonium nitrate shall be considered for Q-D purposes as set out in Chapter C.2.

If the maximum NEQ allowed at the PES is not covered by this table, the minimum separation distances between the bulk ammonium nitrate storage and the PES shall be determined in consultation with the authority having jurisdiction.

TABLE C.4

Q-D TABLE FOR PE1 PESs WITH A MAXIMUM NEQ ALLOWED LESS THAN OR EQUAL TO 1 800 kg

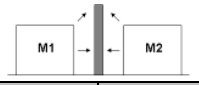
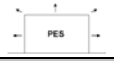
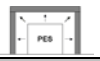
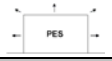
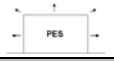
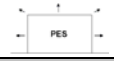
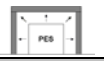
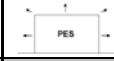
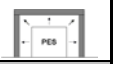
NEQ, in kg	 D1, in m	D2, in m	 D2OR, in m	 D4, in m	 D4CB, in m	 D5, in m	 D5CB, in m	 D6, in m	 D7, in m	 D7CB, in m	 D8, in m	 D8CB, in m
1	0.8	1.8	3.0	30	9	180	16	45	270	21	540	42
2	1.0	1.8	3.0	30	9	180	16	45	270	21	540	42
3	1.2	1.8	3.0	30	12	180	16	45	270	21	540	42
4	1.3	2.6	3.0	30	12	180	21	45	270	29	540	58
5	1.4	2.6	3.0	30	12	180	21	45	270	29	540	58
6	1.5	3.4	3.5	30	14	180	25	45	270	34	540	68
7	1.5	3.4	3.5	30	14	180	25	45	270	34	540	68
8	1.6	3.4	3.5	30	14	180	25	45	270	34	540	68
9	1.7	3.4	3.5	30	14	180	25	45	270	34	540	68
10	1.7	3.4	3.5	30	14	180	26	45	270	34	540	68
11	1.8	3.7	4.0	30	16	180	29	45	270	39	540	78
12	1.8	3.7	4.0	30	16	180	29	45	270	39	540	78
13	1.9	3.7	4.0	30	16	180	29	45	270	39	540	78
14	1.9	3.7	4.0	30	16	180	29	45	270	39	540	78
15	2.0	3.8	4.0	30	16	180	29	45	270	39	540	78
16	2.0	3.8	4.5	30	17	180	32	45	270	44	540	88
17	2.1	3.8	4.5	30	17	180	32	45	270	44	540	88
18	2.1	3.8	4.5	30	17	180	32	45	270	44	540	88
19	2.1	3.8	4.5	30	17	180	32	45	270	44	540	88
20	2.2	4.4	4.5	30	17	180	32	45	270	44	540	88
21	2.2	4.4	5.0	30	20	180	36	45	270	48	540	96
22	2.2	4.4	5.0	30	20	180	36	45	270	48	540	96

TABLE C.4

Q-D TABLE FOR PE1 PESs WITH A MAXIMUM NEQ ALLOWED LESS THAN OR EQUAL TO 1 800 kg

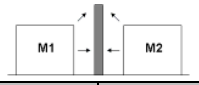
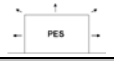
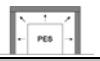
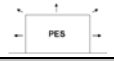
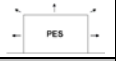
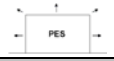
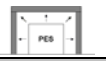
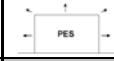
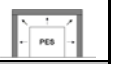
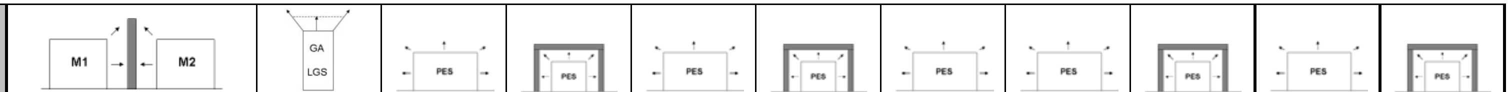
NEQ, in kg	 **D1,** in m	**D2,** in m	 **D2OR,** in m	 **D4,** in m	 **D4CB,** in m	 **D5,** in m	 **D5CB,** in m	 **D6,** in m	 **D7,** in m	 **D7CB,** in m	 **D8,** in m	 **D8CB,** in m
23	2.3	4.4	5.0	30	20	180	36	45	270	48	540	96
24	2.3	4.4	5.0	30	20	180	36	45	270	48	540	96
25	2.3	4.6	5.0	30	20	180	40	45	270	48	540	96
26	2.4	4.6	5.5	30	22	180	40	45	270	53	540	106
27	2.4	4.6	5.5	30	22	180	40	45	270	53	540	106
28	2.4	4.6	5.5	30	22	180	40	45	270	53	540	106
29	2.5	4.6	5.5	30	22	180	40	45	270	53	540	106
30	2.5	4.6	5.5	30	22	180	40	45	270	53	540	106
31	2.5	4.6	6.0	30	22	180	40	45	270	53	540	106
32	2.5	4.6	6.0	30	22	180	40	45	270	53	540	106
33	2.6	4.6	6.0	30	22	180	40	45	270	53	540	106
34	2.6	4.6	6.0	30	22	180	40	45	270	53	540	106
35	2.6	4.6	6.0	30	22	180	40	45	270	53	540	106
36	2.6	4.9	6.5	30	23	180	43	45	270	58	540	116
37	2.7	4.9	6.5	30	23	180	43	45	270	58	540	116
38	2.7	4.9	6.5	30	23	180	43	45	270	58	540	116
39	2.7	4.9	6.5	30	23	180	43	45	270	58	540	116
40	2.7	4.9	6.5	30	23	180	43	45	270	58	540	116
41	2.8	4.9	7.0	30	23	180	43	45	270	58	540	116
42	2.8	4.9	7.0	30	23	180	43	45	270	58	540	116
43	2.8	4.9	7.0	30	23	180	43	45	270	58	540	116
44	2.8	4.9	7.0	30	23	180	43	45	270	58	540	116

TABLE C.4

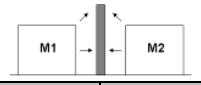
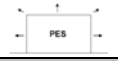
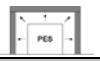
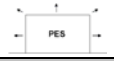
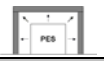
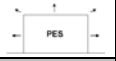
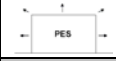
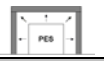
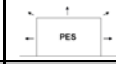
Q-D TABLE FOR PE1 PESs WITH A MAXIMUM NEQ ALLOWED LESS THAN OR EQUAL TO 1 800 kg



NEQ, in kg	D1, in m	D2, in m	D2OR, in m	D4, in m	D4CB, in m	D5, in m	D5CB, in m	D6, in m	D7, in m	D7CB, in m	D8, in m	D8CB, in m
45	2.8	4.9	7.0	30	23	180	43	45	270	58	540	116
46	2.9	4.9	10.0	30	23	180	43	45	270	58	540	116
47	2.9	4.9	10.0	30	23	180	43	45	270	58	540	116
48	2.9	4.9	10.0	30	23	180	43	45	270	58	540	116
49	2.9	4.9	10.0	30	23	180	43	45	270	58	540	116
50	5.0	10.0	10.0	30	30	180	43	45	270	58	540	116
60	5.0	10.0	15.0	32	32	180	43	45	270	63	540	126
70	5.0	10.0	15.0	33	33	180	46	46	270	70	540	140
80	5.0	11.0	15.0	35	35	180	49	48	270	70	540	140
90	5.0	11.0	15.0	36	36	180	52	50	270	75	540	150
100	5.0	12.0	15.0	38	38	180	55	53	270	75	540	150
120	5.0	12.0	20.0	40	40	180	60	55	270	80	540	160
140	5.0	13.0	20.0	42	42	180	65	60	270	85	540	170
160	5.0	14.0	20.0	44	44	180	70	63	270	85	540	170
180	5.0	14.0	20.0	46	46	180	74	65	270	92	540	184
200	5.0	15.0	20.0	47	47	180	78	65	270	92	540	184
250	6.0	16.0	25.0	51	51	180	87	70	270	100	540	200
300	6.0	17.0	25.0	54	54	180	95	75	270	106	540	212
350	6.0	17.0	30.0	57	57	180	103	80	270	112	540	224
400	6.0	18.0	30.0	59	59	180	110	83	270	118	540	236
450	7.0	19.0	35.0	62	62	180	117	88	270	121	540	242
500	7.0	20.0	35.0	64	64	180	123	90	270	129	540	258

TABLE C.4

Q-D TABLE FOR PE1 PESs WITH A MAXIMUM NEQ ALLOWED LESS THAN OR EQUAL TO 1 800 kg

NEQ, in kg	 D1, in m	D2, in m	 D2OR, in m	 D4, in m	 D4CB, in m	 D5, in m	 D5CB, in m	 D6, in m	 D7, in m	 D7CB, in m	 D8, in m	 D8CB, in m
600	7.0	21.0	40.0	68	68	180	135	95	270	141	540	282
700	8.0	22.0	45.0	72	72	180	135	100	270	146	540	292
800	8.0	23.0	50.0	75	75	180	135	105	270	156	540	312
900	8.0	24.0	55.0	78	78	180	143	108	270	165	540	330
1 000	8.0	24.0	60.0	80	80	180	148	113	270	174	540	348
1 200	9.0	26.0	65.0	86	86	180	157	120	270	191	540	382
1 400	9.0	27.0	70.0	90	90	180	166	125	270	206	540	412
1 600	10.0	29.0	75.0	94	94	180	173	130	270	220	540	440
1 800	10.0	30.0	80.0	96	96	180	180	135	270	233	540	466

D1: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and a magazine containing articles insensitive to impact, friction, shock and electrostatic energy that is protected by a barricade that meets the requirements set out in Annex G.

D2: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and a magazine protected by a barricade that meets the requirements of Annex G.

D4: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and an ES requiring a process-building distance (PBD) or a public traffic route distance for light traffic (PTRD-LT).

D5: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and an ES requiring a public traffic route distance for medium traffic (PTRD-MT).

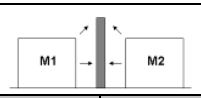
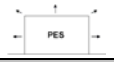
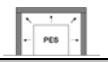
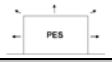
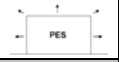
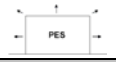
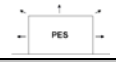
D6: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and an unbarricaded magazine.

D7: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and an ES requiring a public traffic route distance for heavy traffic (PTRD-HT) or an inhabited-building distance (IBD).

D8: Minimum separation distance between a PES with a maximum NEQ allowed less than or equal to 1 800 kg and an ES requiring a vulnerable-building distance (VBD).

TABLE C.4

Q-D TABLE FOR PE1 PESs WITH A MAXIMUM NEQ ALLOWED LESS THAN OR EQUAL TO 1 800 kg

NEQ, in kg	 **D1**, in m	**D2**, in m	 **D2OR**, in m	 **D4**, in m	 **D4CB**, in m	 **D5**, in m	 **D5CB**, in m	 **D6**, in m	 **D7**, in m	 **D7CB**, in m	 **D8**, in m	 **D8CB**, in m

Use of the orientation of perforating guns to reduce the minimum separation distances in a perforating gun assembly workshop (D2OR)

Where only those personnel associated with single gun assembly (GA) operation are accessing explosives storage areas (magazine or loaded-gun storage [LGS]) within a workshop, a reduced separation distance corresponding to D2OR may be used as shown in Figure C.1 if the perforating guns are placed so that their ends are directed toward the magazine or LGS.

The D2OR separation distance shall be used only with loaded perforating guns in workshops. The perforating gun assembly workshop shall still be considered a PES with respect to all other ESs, and the minimum separation distances of this standard shall apply to the PES and ESs.

NOTE — This practice aims to reduce the risk of a sympathetic detonation of the explosives in the magazines or in the LGS in the workshop by directing the potential field of fragments or jets exiting the sides of the perforating guns away from the nearby ESs.

Use of containment barricades (CB) to reduce the D4, D5, D7 and D8 distances

The D4, D5, D7 and D8 distances may be reduced by using containment barricades that are approved by the authority having jurisdiction. If a containment barricade is used, the minimum separation distances applicable to D4, D5, D7 and D8 can be reduced to D4CB, D5CB, D7CB and D8CB respectively.

NOTE — It is not possible to define the design requirements that apply to containment barricades since the ability to meet the specified criteria is based on a number of varying factors, including, but not limited to: the type of explosives, quantity of explosives, type and construction of magazines, position of explosives within magazines or structures, construction and volume of workshops or structures, and blast overpressure behaviour within structures.

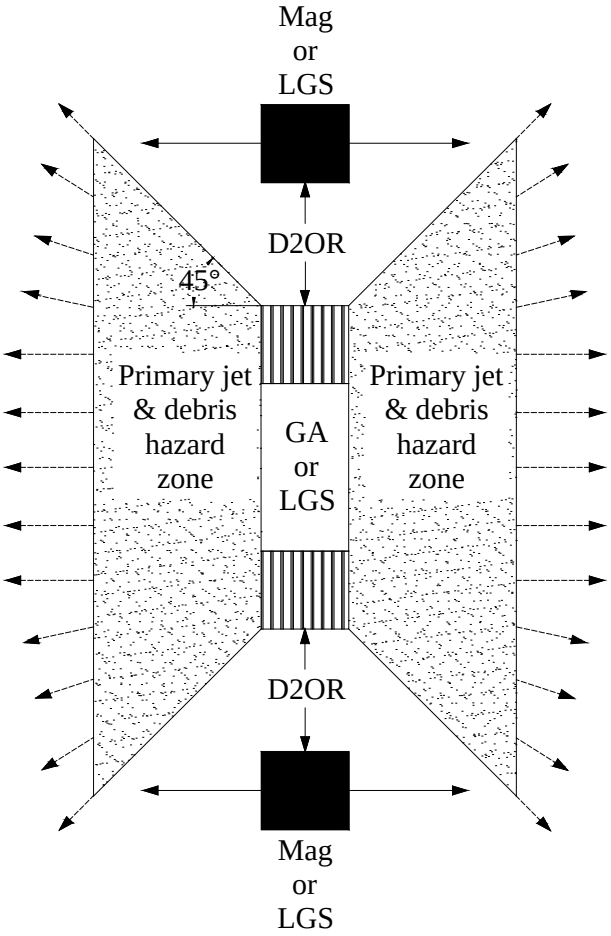


FIGURE C.1 — USE OF THE ORIENTATION OF PERFORATING GUNS TO REDUCE THE MINIMUM SEPARATION DISTANCES IN A PERFORATING GUN ASSEMBLY WORKSHOP (D2OR)

ANNEX D
(normative)
[mandatory]

MINIMUM SEPARATION DISTANCES FOR POTENTIAL EXPLOSION SITES (PESs) CLASSIFIED AS PE2

The minimum separation distance between a PES classified as PE2 and each exposed site (ES) shall be determined from the Q-D matrix (see Table D.1).

If the minimum separation distance between the PES and ES is expressed as D1 or D2, this separation distance depends on the maximum net explosive quantity (NEQ) allowed at the PES and shall be determined from the Q-D table (see Table D.2).

If the maximum NEQ allowed at the PES falls between two NEQs in the Q-D table, the separation distance applicable to the next greater NEQ shall be used. Alternatively, the minimum separation distance may be calculated from the scale factor equations provided in Table D.2.

TABLE D.1

Q-D MATRIX FOR PE2 PESs

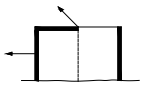
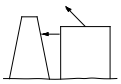
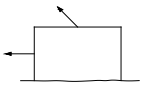
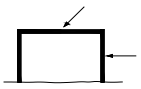
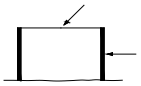
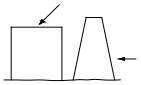
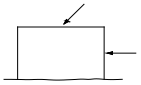
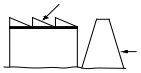
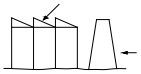
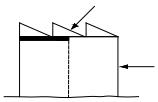
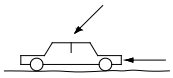
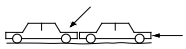
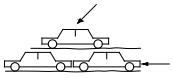
Exposed Site (ES)				Potential Explosion Site (PES) Classified as PE2		
				Heavy-Walled Building with or Without Protective Roof	Barricaded Site	Unbarricaded Site
						
1	**Magazine**	Heavy-walled building with protective roof		10 m		
2		Heavy-walled building without protective roof		90 m		
3		Barricaded site		90 m		
4		Unbarricaded site		90 m		
5	**Explosives Process Building**	Building with protective roof and barricade		25 m		
6		Building without protective roof, but with barricade		135 m for ammunition of storage subdivision (SsD) 1.2.1 90 m for ammunition of SsD 1.2.2		
7		Building with or without protective roof and without barricade		135 m for ammunition of storage subdivision (SsD) 1.2.1 90 m for ammunition of SsD 1.2.2		
8	Public traffic routes — light traffic 			135 m for ammunition of storage subdivision (SsD) 1.2.1 90 m for ammunition of SsD 1.2.2		
9	Public traffic routes — medium traffic 			135 m for ammunition of storage subdivision (SsD) 1.2.1 90 m for ammunition of SsD 1.2.2		
10	Public traffic routes — heavy traffic 			D2 for ammunition of storage subdivision (SsD) 1.2.1 D1 for ammunition of SsD 1.2.2		

TABLE D.1

Q-D MATRIX FOR PE2 PESs

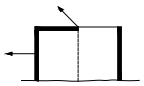
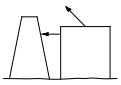
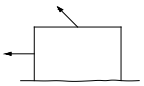
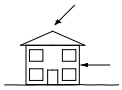
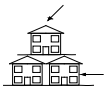
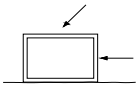
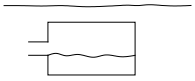
Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE2		
		Heavy-Walled Building with or Without Protective Roof	**Barricaded Site**	**Unbarricaded Site**
				
11	Inhabited buildings with fewer than 20 people in total 	270 m for ammunition of storage subdivision (SsD) 1.2.1 180 m for ammunition of SsD 1.2.2		
12	Area of inhabited buildings with 20 people or more 	D2 for ammunition of storage subdivision (SsD) 1.2.1 D1 for ammunition of SsD 1.2.2		
13	Vulnerable buildings 	D2 for ammunition of storage subdivision (SsD) 1.2.1 D1 for ammunition of SsD 1.2.2		
14	Aboveground non-critical volatile carbon fuels 	D2 for ammunition of storage subdivision (SsD) 1.2.1 D1 for ammunition of SsD 1.2.2 NOTE — Where aboveground storage of non-critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.		
15	Aboveground critical volatile carbon fuels 	D2 for ammunition of storage subdivision (SsD) 1.2.1 D1 for ammunition of SsD 1.2.2 (≥ 450 m) NOTE — Where aboveground storage of critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.		
16	Underground pipelines/bulk storage 	25 m		

TABLE D.1

Q-D MATRIX FOR PE2 PESs

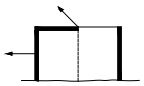
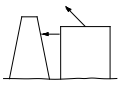
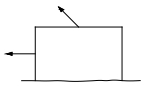
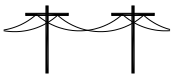
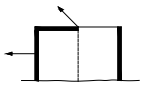
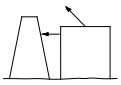
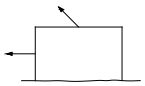
Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE2		
		Heavy-Walled Building with or Without Protective Roof	**Barricaded Site**	**Unbarricaded Site**
				
17	Electrical facilities 	• 45 m from electrical generators and unprotected substations • 10 m from transformers at protected substations that are designed to withstand the effects of an internal explosion with provision to contain the cooling oil		
18	Power lines 	1. Power lines < 15 kV and private power lines: The greatest of the following distances from overhead cables *a*) 15 m *b*) $D = \frac{S}{2} - H$ where D : minimum separation distance, in metres; S : span between the pylons or the power line supporting structures, in metres; H : height of the insulators on the pylon or the power line supporting structure, in metres. 2. Power lines ≥ 15 kV except private power lines shall be at a distance of: *a*) 135 m for ammunition of storage subdivision (SsD) 1.2.1 *b*) 90 m for ammunition of SsD 1.2.2 3. Critical Power Lines shall use: *a*) D2 for ammunition of storage subdivision (SsD) 1.2.1 *b*) D1 for ammunition of SsD 1.2.2		

TABLE D.1

Q-D MATRIX FOR PE2 PESs

Exposed Site (ES)	Potential Explosion Site (PES) Classified as PE2		
	Heavy-Walled Building with or Without Protective Roof	Barricaded Site	Unbarricaded Site
			

Articles of HD 1.2 are generally military in nature. For purposes of quantity distance, a distinction depending on the size and range of fragments is made between items that produce fragments with moderate range (classified as storage subdivision SsD 1.2.2) and items that produce fragments with considerable range (classified as SsD 1.2.1).

SsD 1.2.2 items include high explosive (HE) projectiles (with or without propelling charges) with an individual NEQ less than or equal to 0.73 kg and other items not containing HEs, such as cartridges, rounds with inert projectiles, pyrotechnic articles or rocket motors.

SsD 1.2.1 items are generally HE projectiles (with or without propelling charges) with an individual NEQ greater than 0.73 kg.

These storage subdivisions have no other role than for Q-D calculation and are not to be used for transport. The List of Authorized Explosives does not divide HD 1.2 into the storage subdivisions. For military-type ammunition, this information shall be obtained prior to applying these guidelines. Any commercial explosives in HD 1.2 shall be assessed on an individual basis by the authority having jurisdiction.

Q-Ds are based on the following:

D1 = 53 $NEQ^{0.18}$ where the ammunition items are of SsD 1.2.2

D2 = 68 $NEQ^{0.18}$ where the ammunition items are of SsD 1.2.1

where *NEQ*: maximum net explosive quantity allowed at the PES, in kilograms.

For NEQs less than 50 kg, the authority having jurisdiction shall determine the Q-D.

TABLE D.2

Q-D TABLE FOR PE2 PESs

NEQ, in kg	**Quantity Distances (Q-D)**, in m	
	D1	**D2**
50	180	270
60	180	270
70	180	270
80	180	270
90	180	270
100	180	270
120	180	270
140	180	270
160	180	270
180	180	270
200	180	270
250	180	270
300	180	270
350	180	270
400	180	270
450	180	270
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

TABLE D.2

Q-D TABLE FOR PE2 PESs

NEQ, in kg	**Quantity Distances (Q-D)**, in m	
	D1	**D2**
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

Q-Ds are based on the following:

- D1 = 53 $NEQ^{0.18}$
- D2 = 68 $NEQ^{0.18}$

where *NEQ*: maximum net explosive quantity allowed at the PES, in kilograms

ANNEX E
(normative)
[mandatory]

MINIMUM SEPARATION DISTANCES FOR POTENTIAL EXPLOSION SITES (PESs) CLASSIFIED AS PE3

The minimum separation distance between a PES classified as PE3 and each exposed site (ES) shall be determined from the Q-D matrix (see Table E.1).

If the minimum separation distance between the PES and ES is expressed as D1, D2, D3 […], this separation distances depends on the maximum net explosive quantity (NEQ) allowed at the PES and shall be determined from the Q-D table (see Table E.2).

If the maximum NEQ allowed at the PES falls between two NEQs in the Q-D table, the separation distance applicable to the next greater NEQ shall be used. Alternatively, the minimum separation distance may be calculated from the scale factor equations provided in Table E.2.

Table E.1 defines the requirements applicable to three types of explosives that are represented by the letters A, B and C as follows:

- A: These requirements shall be applied to bulk propellant and pyrotechnic substances, which, on ignition, are likely to produce a fire ball with intense radiant heat, firebrands and some fragments.

- B: These requirements shall be applied to pyrotechnic articles, which are less hazardous than those in A and which are likely to produce minor projections, including fragments and firebrands.

- C: These requirements shall be applied to pyrotechnic articles of Type B that are being stored in a picking area.

Table E.1 also defines two levels of protection that are represented by the following abbreviations:

- CP: Complete protection against propagation of fire caused by flame, radiant heat, firebrands, projections and lobbed ammunition.

- HDP: High degree of protection against propagation of fire caused by the following sources of ignition: flame, radiant heat, firebrands, projections or lobbed ammunition. The remaining risk is associated with the sources of ignition themselves, especially lobbed ammunition, and the ignition of combustible parts of a building they could cause, unless effective fire-fighting is able to prevent such an outcome.

TABLE E.1

Q-D MATRIX FOR PE3 PESs

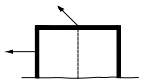
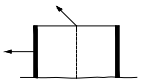
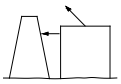
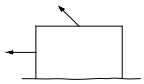
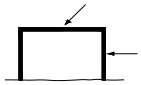
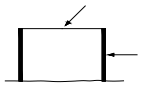
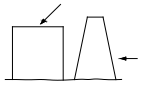
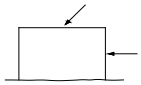
Exposed Site (ES)				Potential Explosion Site (PES) Classified as PE3			
				Heavy-Walled Building with a Protective Roof	**Heavy-Walled Building Without Protective Roof**	**Barricaded Site**	**Unbarricaded Site**
							
1	**Magazine**	Heavy-walled building with protective roof		A: 2 m (CP) B: 10 m (CP)	A: 2 m (CP) B: 10 m (CP)	A: 10 m (HDP) B: 10 m (CP)	A: 10 m (HDP) B: 10 m (CP)
2		Heavy-walled building without protective roof		A: D1 (CP) B: 25 m (HDP) B: D1 for NEQ ≤ 70 000 kg (CP) B: 60 m for NEQ > 70 000 kg (CP)	A: D1 (CP) B: 25 m (HDP) B: D1 for NEQ ≤ 70 000 kg (CP) B: 60 m for NEQ > 70 000 kg (CP)	A: D1 (HDP) B: D1 for NEQ ≤ 70 000 kg (HDP) B: 60 m for NEQ > 70 000 kg (HDP)	A: D1 (HDP) B: D1 for NEQ ≤ 70 000 kg (HDP) B: 60 m for NEQ > 70 000 kg (HDP)
3		Barricaded site		A: D1 (CP) B: 25 m (HDP) B: D1 for NEQ ≤ 70 000 kg (CP) B: 60 m for NEQ > 70 000 kg (CP)	A: D1 (CP) B: 25 m (HDP) B: D1 for NEQ ≤ 70 000 kg (CP) B: 60 m for NEQ > 70 000 kg (CP)	A: D1 (HDP): B: D1 for NEQ ≤ 70 000 kg (HDP) B: 60 m for NEQ > 70 000 kg (HDP)	A: D1 (HDP) B: D1 for NEQ ≤ 70 000 kg (HDP) B: 60 m for NEQ > 70 000 kg (HDP)
4		Unbarricaded site		A: D1 (CP) B: 25 m (HDP) B: D1 for NEQ ≤ 70 000 kg (CP) B: 60 m for NEQ > 70 000 kg (CP)	A: D1 (CP) B: 25 m (HDP) B: D1 for NEQ ≤ 70 000 kg (CP) B: 60 m for NEQ > 70 000 kg (CP)	A: D1 (HDP) B: D1 for NEQ ≤ 70 000 kg (HDP) B: 60 m for NEQ > 70 000 kg (HDP)	A: D1 (HDP) B: D1 for NEQ ≤ 70 000 kg (HDP) B: 60 m for NEQ > 70 000 kg (HDP)

TABLE E.1

Q-D MATRIX FOR PE3 PESs

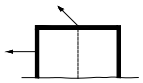
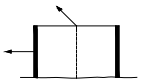
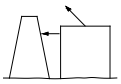
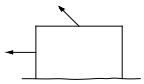
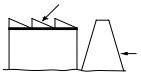
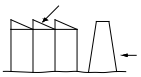
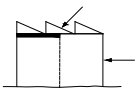
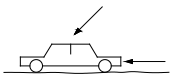
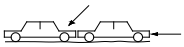
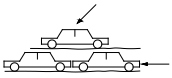
Exposed Site (ES)				Potential Explosion Site (PES) Classified as PE3			
				Heavy-Walled Building with a Protective Roof	Heavy-Walled Building Without Protective Roof	Barricaded Site	Unbarricaded Site
							
5	Explosive Process Building	Building with protective roof and barricade		A: D2 B: 25 m			
6	Explosive Process Building	Building without protective roof, but with barricade		A: D2 B: D2 for NEQ < 1 000 kg B: 60 m for NEQ ≥ 1 000 kg C: 25 m for NEQ < 2 000 kg C: D2 for NEQ ≥ 2 000 kg			
7	Explosive Process Building	Building with or without protective roof and without barricade		A: D2 B: D2 for NEQ < 1 000 kg B: 60 m for NEQ ≥ 1 000 kg C: 25 m for NEQ < 2 000 kg C: D2 for NEQ ≥ 2 000 kg			
8	Public traffic routes — light traffic 			A: D2 B: D2 for NEQ < 1 000 kg B: 60 m for NEQ ≥ 1 000 kg			
9	Public traffic routes — medium traffic 			A: D3 B: D3 for NEQ < 800 kg B: 60 m for NEQ ≥ 800 kg			
10	Public traffic routes — heavy traffic 			D4			

TABLE E.1

Q-D MATRIX FOR PE3 PESs

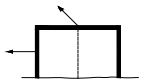
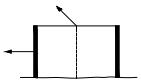
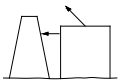
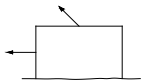
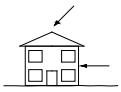
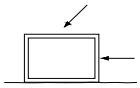
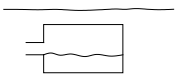
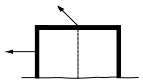
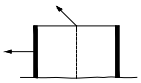
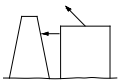
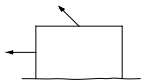
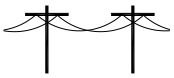
Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE3			
		Heavy-Walled Building with a Protective Roof	Heavy-Walled Building Without Protective Roof	Barricaded Site	Unbarricaded Site
					
11	Inhabited buildings with fewer than 20 people 	D4			
12	Area of inhabited buildings with 20 people or more 	D4			
13	Vulnerable buildings 	D4			
14	Aboveground non-critical volatile carbon fuels 	D3 NOTE — Where aboveground storage of non-critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.			
15	Aboveground critical volatile carbon fuels 	D4 NOTE — Where aboveground storage of critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.			
16	Underground pipelines/bulk storage 	25 m			
17	Electrical facilities 	• 45 m from electrical generators and unprotected substations • 10 m from transformers at protected substations that are designed to withstand the effects of an internal explosion with provision to contain the cooling oil			

TABLE E.1

Q-D MATRIX FOR PE3 PESs

Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE3			
		Heavy-Walled Building with a Protective Roof	**Heavy-Walled Building Without Protective Roof**	**Barricaded Site**	**Unbarricaded Site**
					
18	Power lines 	1. Power lines < 15 kV and private power lines: The greatest of the following distances from overhead cables *a*) 15 m *b*) $D = \frac{S}{2} - H$ where D : minimum separation distance, in metres S : span between the pylons or the power line supporting structures, in metres H : height of the insulators on the pylon or the power line supporting structure, in metres 2. Power lines ≥ 15 kV except private power lines shall be at the following minimum distance: *a*) A: D3 (≥ 60 m) *b*) B: 60 m 3. Critical power lines shall use D4 (≥ 60 m)			

A: These requirements shall be applied to bulk propellant and pyrotechnic substances, which, on ignition, are likely to produce a fire ball with intense radiant heat, firebrands and some fragments.

B: These requirements shall be applied to pyrotechnic articles, which are less hazardous than those in A and which are likely to produce minor projections, including fragments and firebrands.

C: These requirements shall be applied to pyrotechnic articles of Type B that are being stored in a picking area.

CP: Complete protection against propagation of fire caused by flame, radiant heat, firebrands, projections and lobbed ammunition.

HDP: High degree of protection against propagation of fire caused by the following sources of ignition: flame, radiant heat, firebrands, projections or lobbed ammunition. The remaining risk is associated with the sources of ignition themselves, especially lobbed ammunition, and the ignition of combustible parts of a building they could cause, unless effective fire-fighting is able to prevent such an outcome.

TABLE E.2

Q-D TABLE FOR PE3 PESs

NEQ, in kg	**Quantity Distance (Q-D)**, in m			
	D1	**D2**	**D3**	**D4**
75	25	25	28	30
100	25	25	30	35
125	25	30	35	40
250	25	30	40	40
300	25	35	40	45
350	25	40	45	50
400	25	45	45	55
500	25	45	50	60
600	25	50	50	60
700	25	55	55	60
800	25	55	60	60
900	25	55	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	69	92	140
12 000	25	74	98	150

TABLE E.2

Q-D TABLE FOR PE3 PESs

NEQ, in kg	**Quantity Distance (Q-D)**, in m			
	D1	**D2**	**D3**	**D4**
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

Q-Ds are based on the following:

- D1 = 0.22 $NEQ^{1/2}$
- D2 = 3.2 $NEQ^{1/3}$
- D3 = 4.3 $NEQ^{1/3}$
- D4 = 6.4 $NEQ^{1/3}$

where *NEQ*: maximum net explosive quantity allowed at the PES, in kilograms

ANNEX F
(normative)
[mandatory]

MINIMUM SEPARATION DISTANCES FOR POTENTIAL EXPLOSION SITES (PESs) CLASSIFIED AS PE4

The minimum separation distance between a PES classified as PE4 and each exposed site (ES) shall be determined from the Q-D matrix (see Table F.1).

If the minimum separation distance between the PES and ES is expressed as D1, D2, D3 […], this separation distance depends on the maximum net explosive quantity (NEQ) allowed at the PES and shall be determined from the Q-D table (see Table F.2).

If the maximum NEQ allowed at the PES falls between two NEQs in the Q-D table, the separation distance applicable to the next greater NEQ shall be used. Alternatively, the separation distance may be calculated from the scale factor equations provided in Table F.2.

TABLE F.1

Q-D MATRIX FOR PE4 PESs

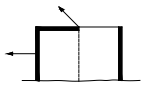
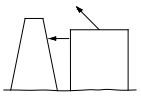
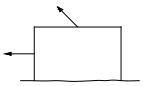
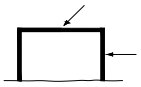
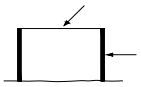
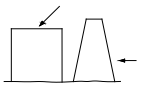
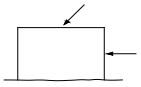
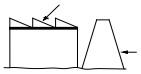
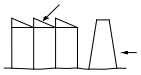
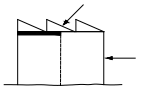
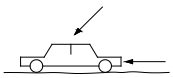
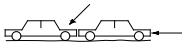
Exposed Site (ES)				Potential Explosion Site (PES) Classified as PE4		
				Heavy-Walled Building with or Without Protective Roof	**Barricaded Site**	**Unbarricaded Site**
						
1	**Magazine**	Heavy-walled building with protective roof		D1		
2		Heavy-walled building without protective roof		D1		
3		Barricaded site		D1		
4		Unbarricaded site		D1		
5	**Explosive Process Building**	Building with protective roof and with barricade		D2		
6		Building without protective roof, but with barricade		D2		
7		Building with or without protective roof and without barricade		D2		
8	Public traffic routes — light traffic 			D3		
9	Public traffic routes — medium traffic 			D3		

TABLE F.1

Q-D MATRIX FOR PE4 PESs

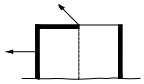
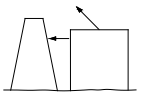
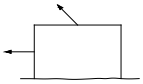
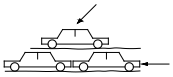
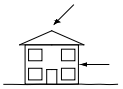
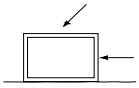
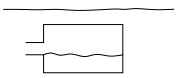
Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE4		
		Heavy-Walled Building with or Without Protective Roof	Barricaded Site	Unbarricaded Site
				
10	Public traffic routes — heavy traffic 	D3		
11	Inhabited buildings with fewer than 20 people 	D4		
12	Area of inhabited buildings with 20 people or more 	D4		
13	Vulnerable buildings 	D4		
14	Aboveground non-critical volatile carbon fuels 	D3 NOTE — Where aboveground storage of non-critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.		
15	Aboveground critical volatile carbon fuels 	D4 NOTE — Where aboveground storage of critical volatile carbon fuels is protected from blast and projection hazards, the distance may be reduced through a risk assessment, subject to the approval of the authority having jurisdiction.		
16	Underground pipelines/bulk storage 	25 m		

TABLE F.1

Q-D MATRIX FOR PE4 PESs

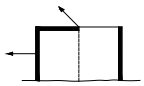
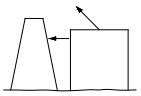
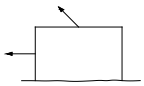
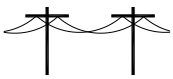
Exposed Site (ES)		Potential Explosion Site (PES) Classified as PE4		
		Heavy-Walled Building with or Without Protective Roof	**Barricaded Site**	**Unbarricaded Site**
				
17	Electrical facilities 	• 45 m from electrical generators and unprotected substations • 10 m from transformers at protected substations that are designed to withstand the effects of an internal explosion with provision to contain the cooling oil		
18	Power lines 	1. Power lines < 15 kV and private power lines: The greatest of the following distances from overhead cables *a*) 15 m *b*) $D = \frac{S}{2} - H$ where D : minimum separation distance, in metres S : span between the pylons or the power line supporting structures, in metres H : height of the insulators on the pylon or the power line supporting structure, in metres 2. Power lines ≥ 15 kV except private power lines shall be placed at a distance ≥ 60 m 3. Critical power lines shall use D4 (≥ 60 m)		

TABLE F.2

Q-D TABLE FOR PE4 PESs

NEQ, in kg	**Quantity Distance**, in m			
	D1	**D2**	**D3**	**D4**
Up to 50	9	12	9	16
100	9	12	10	16
200	9	12	11	19
300	9	12	13	22
400	9	12	14	25
500	9	12	15	29
750	9	12	17	31
1 000	9	12	18	33
1 250	10	15	18	36
2 500	13	21	21	37
5 000	17	25	23	42
10 000	21	27	25	46
12 500	23	27	26	50
15 000	24	27	27	52
20 000	25	27	28	54
25 000	26	27	29	55
30 000	27	27	30	59
40 000	27	27	30	60
50 000	27	27	30	60
75 000	27	27	32	65
100 000	27	27	33	70
125 000	27	27	38	77
150 000	27	27	39	80
175 000	27	27	40	82
200 000	27	27	41	84
250 000	27	27	43	88

ANNEX G
(normative)
[mandatory]

BARRICADES AND DIVIDING WALLS

G.1 GENERAL

To be considered effective, barricades and dividing walls shall meet the requirements of this annex.

G.2 EARTH BARRICADES

G.2.1 GENERAL

Proper barricade geometry and proper materials shall be used for earth barricades to be effective, as set out in Clauses G.2.2 to G.2.6.

NOTE — Annex J provides additional information on the effectiveness of barricades.

G.2.2 MINIMUM THICKNESS AND HEIGHT OF EARTH BARRICADES ABOVE STACKS OF EXPLOSIVES

To establish the minimum thickness and height of an earth barricade above two stacks of explosives, a 2-degree rule shall be applied as shown in Figures G.1 and G.2 and as described below:

- Point A shall be placed on the selected stack of explosives whose top face is at the lowest elevation above sea level.
- Point A shall be placed on top of the face of the selected stack of explosives that is farther from the other stack. If both stacks are covered by protective roofs, point A may be placed on top of the face of the selected stack of explosives that is nearer to the other stack.
- Point B shall be placed on the top face of the other stack that is nearer to the stack where point A was placed.
- Line AB shall be drawn by connecting points A and B.
- Line AC shall be drawn at an angle of 2 degrees above line AB.

The earth barricade shall be considered effective if it meets the following requirements:

- Line AB of Figure G.1 or G.2, as the case may be, shall pass through at least 2.4 m of barricade material or undisturbed natural earth (minimum thickness of the earth barricade at the top level of explosives).

- Line AC of Figures G.1 or G.2, as the case may be, shall pass through at least 1.0 m of barricade material or undisturbed natural earth (minimum height of the earth barricade).

  NOTE — For ease of application, the minimum 1.0 m of barricade material or undisturbed natural earth that is required to be passing through line AC may also be measured at the top of the barricade, as shown in Figures G.4, G.5, G.6 and G.7.

In the case of earth barricades that are provided with a support made of reinforcing material (see Figures G.5, G.6 and G.7), the following earth equivalents are provided to help determine the contribution of the reinforcing material to the overall effectiveness of the barricade in stopping high velocity, low angle fragments and debris:

- Brick: 4 times;

- Unreinforced concrete: 4 times;

- Reinforced concrete: 6 times;

- Steel: 24 times.

In these cases, the barricade thickness may be reduced accordingly, but the equivalent mass at the top level of explosives shall not be reduced below that of 2.4 m of earth.

The 2-degree rule shall be applied when stacks of explosives are separated from each other by a distance of less than 300 m and the slope between the two stacks of explosives is less than 10 degrees.

If the stacks of explosives are separated from each other by a distance greater than or equal to 300 m, or if the slope between the two stacks of explosives is greater than or equal to 10 degrees, the 2-degree rule does not apply. In these cases, the minimum height and thickness of the earth barricade shall be approved by the authority having jurisdiction.

In existing facilities where the 2-degree rule cannot be applied without a major reconstruction, the minimum height and thickness of the earth barricade shall be approved by the authority having jurisdiction.

G.2.3 MINIMUM LENGTH OF EARTH BARRICADE

To determine the required length of an earth barricade, the two stacks of explosives shall be connected by two lines as shown in Figure G.3. The minimum length of the earth barricade shall extend from a minimum of 1 m on each side of the lines connecting the two stacks of explosives at

a height at which a minimum of 2.4 m of barricade material or undisturbed natural earth is present (line AB of Figure G.1), as shown in Figure G.3.

G.2.4 MINIMUM DISTANCE FROM A STACK OF EXPLOSIVES OR BUILDING CONTAINING EXPLOSIVES TO THE FOOT OF AN EARTH BARRICADE

The minimum distance from a stack of explosives or building containing explosives to the foot of an earth barricade shall be determined on a case-by-case basis and approved by the authority having jurisdiction. In all cases, the minimum distance from a stack of explosives or building containing explosives to the foot of an earth barricade shall not be less than 2.4 m.

In the case of PESs classified as PE1, the earth barricade shall be sited so that the crater of an accidental explosion does not undermine the earth barricade by more than one third of its thickness at ground level. The crater radius of an accidental explosion shall be calculated as follows:

$$r_c = 0.5NEQ^{1/3}$$

where r_c : radius of the crater of the possible explosion measured from the centre of the stack of explosives, in metres;

NEQ : maximum net explosive quantity allowed at the PES, in kilograms.

In certain soil conditions, such as saturated soil or clay, the crater of a possible explosion may be larger than calculated by the above equation. In such conditions, the minimum distance from a stack of explosives or building containing explosives to the foot of an earth barricade shall be approved by the authority having jurisdiction, and consideration shall be given to increasing the distance between the PES and the exposed site (ES).

NOTE — The minimum distance from a stack of explosives or building containing explosives to the foot of an earth barricade is a compromise. Each case should be considered individually to achieve the optimum solution, taking into account the following factors:

- A barricade close to a stack results in smaller dimensions for the barricade to intercept high velocity projections. However, on a sloping terrain, the smallest barricade will not necessarily be located at the the minimum separation distance.
- A barricade further away from the stacks results in easier access for maintenance and for vehicles and the possibility to site the barricade outside the predicted crater for PESs classified as PE1.

G.2.5 FORMS OF EARTH BARRICADE

The forms of the earth barricade shall be one of the following:

- A double-slope barricade that meets the requirements of Figure G.4;
- A single-slope vertical-face barricade that meets the requirements of Figure G.5;

- A single-slope partial vertical-face barricade that meets the requirements of Figure G.6;

- A steep double-slope barricade that meets the requirements of Figure G.7.

G.2.6 MATERIAL FOR EARTH BARRICADES

The material used to construct an earth barricade shall be approved by the authority having jurisdiction.

To ensure the structural integrity of the earth barricade, the material used shall be cohesive and suitable for that purpose. Compaction and surface preparation shall be carried out as necessary to maintain structural integrity and avoid erosion. Where it is impossible to use a cohesive material (e.g. in a sandy area), the earth work shall be finished with either a layer of cohesive soil or an artificial skin.

Precautions shall also be taken to reduce the hazards to explosives and personnel at an ES should the material be dispersed by an accidental explosion. The selection of material and its use shall be governed by the following:

- Rubble from demolished buildings shall not be used.

- Stones larger than 0.3 m in diameter shall be removed during construction. Other harmful matter shall be removed.

- In climates where permafrost is present, consideration shall be given to providing an impermeable cover over the material or to ensuring drainage.

- Solid wet clay shall be avoided because it is too cohesive and would result in an excessive debris hazard.

G.3 OTHER TYPES OF BARRICADES

G.3.1 WALL BARRICADES

On the approval of the authority having jurisdiction, a 450 mm thick reinforced concrete wall, 700 mm thick unreinforced concrete wall or 700 mm brick wall may be used as a wall barricade. Wall barricades shall meet the requirements of Figure G.8.

G.3.2 NATURAL LAND FORMATION

Upon the approval of the authority having jurisdiction, a natural land formation may be used as a barricade.

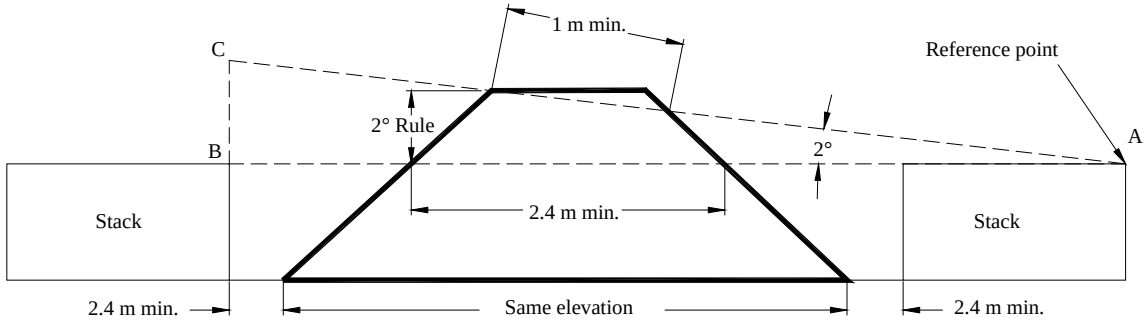
NOTE — Thick vegetation (e.g. dense trees) is normally not considered an effective barricade.

G.3.3 DIVIDING WALLS

As indicated in Clause 5.2.3.2, dividing walls may be used to divide a building into individual compartments.

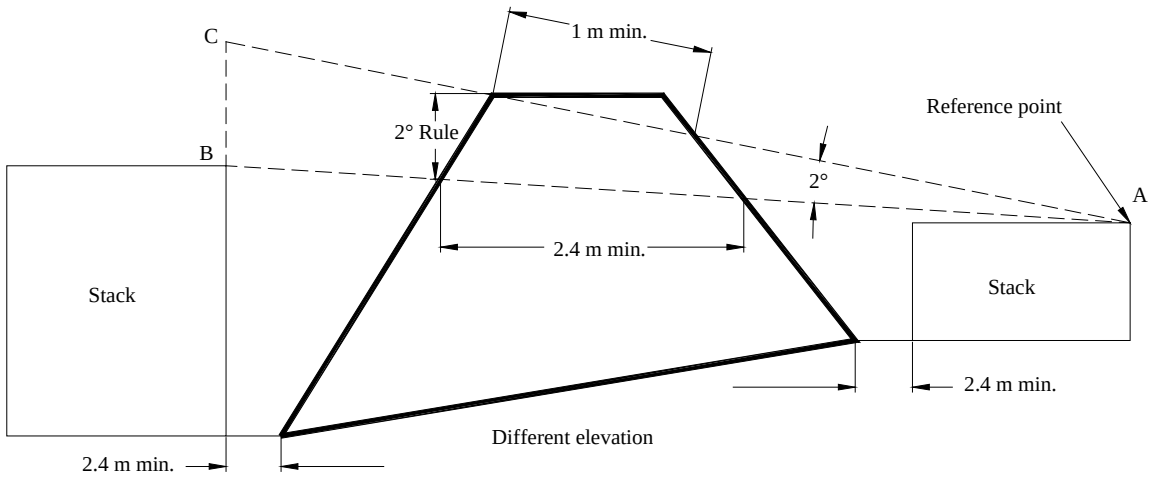
The specification of a dividing wall depends on the quantity, proximity and type of explosives located in each compartment. The design shall be approved by the authority having jurisdiction and shall take into account blast loading, including the effect of reflections, flame, ground shock, fragments and debris (spalling and scabbing from the remote face of the wall).

NOTE — Document UFC 3-340-02 of the US Department of Defense (see Annex K) provides additional information on the state of the art of designing dividing walls to resist the effects of accidental explosions.



A and B correspond to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

FIGURE G.1 — DETERMINATION OF BARRICADE HEIGHT WHEN STACKS ARE AT THE SAME ELEVATION



A and B correspond to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

FIGURE G.2 — DETERMINATION OF BARRICADE HEIGHT WHEN STACKS ARE NOT AT THE SAME ELEVATION

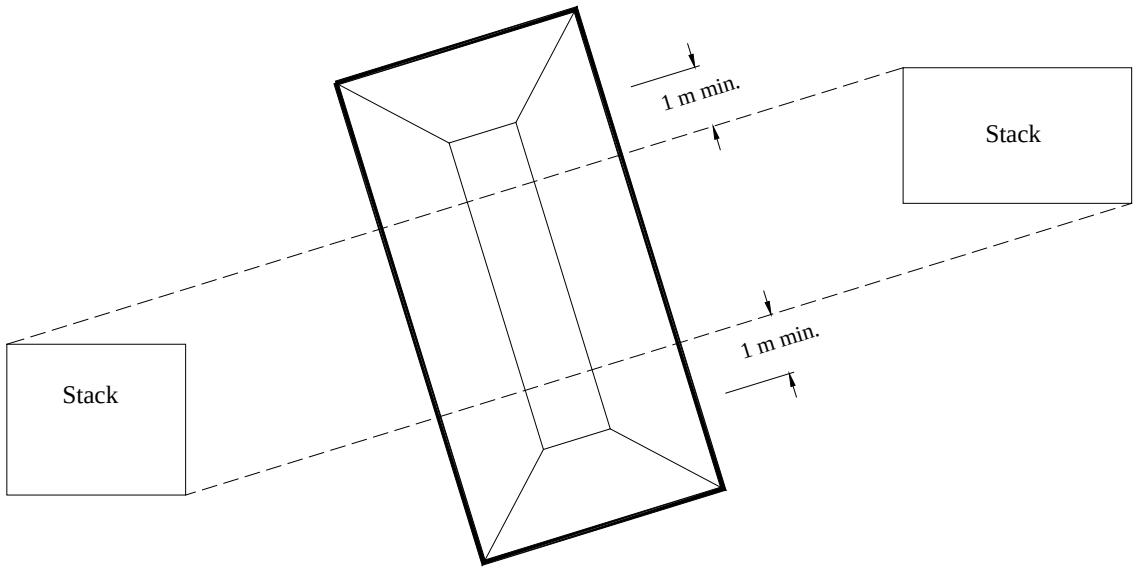
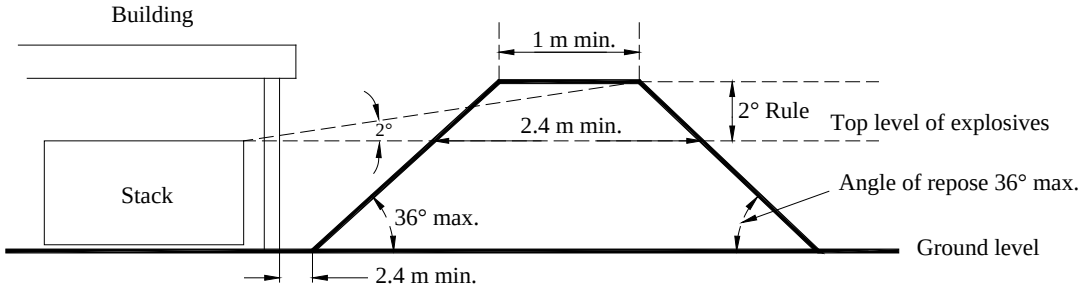
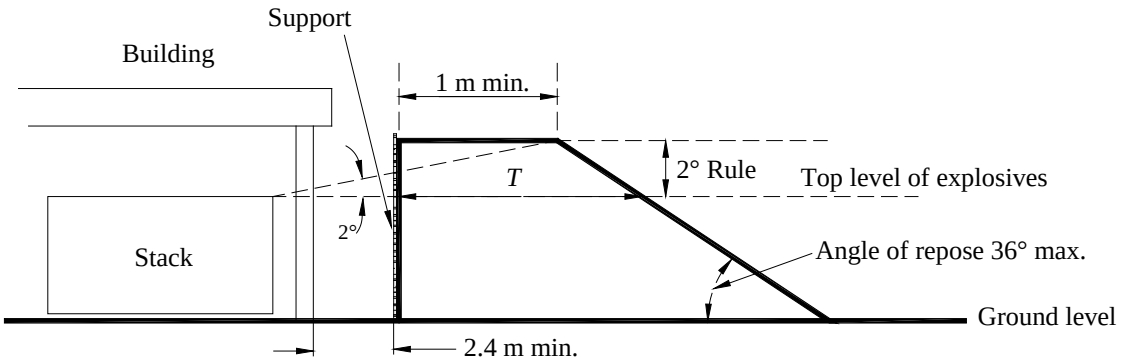


FIGURE G.3 — DETERMINATION OF BARRICADE LENGTH



The top level of explosives corresponds to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

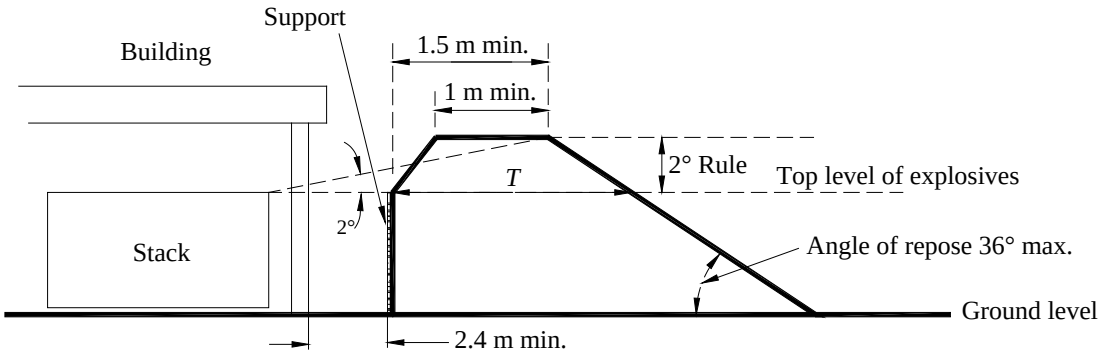
FIGURE G.4 — DOUBLE-SLOPE BARRICADE



T: The minimum thickness of the earth barricade (see Clause G.2.2).

The top level of explosives corresponds to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

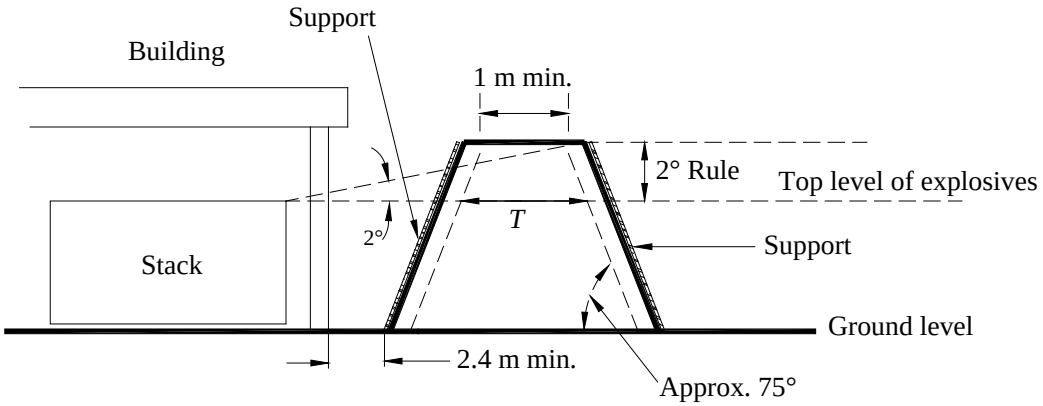
FIGURE G.5 — SINGLE-SLOPE VERTICAL-FACE BARRICADE



T: The minimum thickness of the earth barricade (see Clause G.2.2).

The top level of explosives corresponds to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

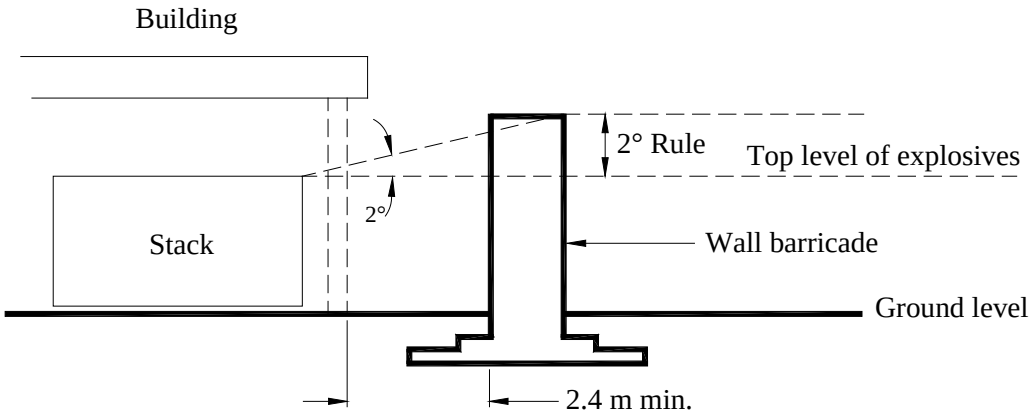
FIGURE G.6 — SINGLE-SLOPE PARTIAL VERTICAL-FACE BARRICADE



T: The minimum thickness of the earth barricade (see Clause G.2.2).

The top level of explosives corresponds to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

FIGURE G.7 — STEEP DOUBLE-SLOPE BARRICADE



The top level of explosives corresponds to the highest point of the stack in the case of an open stack, and to the stacking line in the case of a magazine.

FIGURE G.8 — WALL BARRICADE

ANNEX H
(informative)
[non-mandatory]

HAZARD CLASSIFICATION OF EXPLOSIVES AS PER THE UN CLASSIFICATION FOR THE TRANSPORT OF DANGEROUS GOODS

In the *UN Recommendations on the Transport of Dangerous Goods — Model Regulations* from the United Nations Economic Commission for Europe (see Annex K), explosives are assigned to one of the following divisions, depending on the type of hazard they present during transport:

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

The hazard classification of explosives for the transport of dangerous goods is determined in accordance with the requirements of Part 1 of the *UN Recommendations on the Transport of Dangerous Goods — Manual and Test Criteria* from the United Nations Economic Commission for Europe (see Annex K).

ANNEX I
(informative)
[non-mandatory]

BLAST DAMAGE ASSESSMENT

I.1 GENERAL

To obtain the expected effects from a detonation of a potential explosion site (PES) classified as PE1, it is important that the separation distance between the PES and exposed site (ES), as well as the maximum net explosive quantity (NEQ) allowed at the PES, be known. As barricades have no significant effect on blast overpressures, they are ignored.

The expected effects from a detonation of a PES classified as PE1 are classified by scaled factors as follows:

$$SF = \frac{d}{\sqrt[3]{NEQ}}$$

where SF : scaled factor;

d : separation distance between the PES and the ES, in metres;

NEQ : maximum net explosive quantity allowed at the PES, in kilograms.

It can be assumed that the blast overpressures from stocks in the open or aboveground magazines are as follows:

Scaled Factor	**Peak Incident (Side-On) Overpressure Expected**, in kPa
44.4	1.5
22.2	5.0
14.8	9.0
8.0	21.0
3.6	70.0
2.4	180.0

The expected outcomes associated with each scaled factor are described in Chapters I.2 to I.12. For scaled factors falling between those that are provided, the expected effects are to be estimated.

I.2 SCALED FACTOR 55.5

The expected outcomes are as follows:

a) The overpressures at this distance will cause little or no damage to an unstrengthened structure.

b) Vulnerable construction buildings or buildings with large areas of glass, especially if they face the PES, may suffer some glass breakage or cladding displacement.

c) Personnel are afforded a very high level of protection from death or injury. The primary hazard is from broken glass or cladding falling from a considerable height and striking people at high speed.

I.3 SCALED FACTOR 44.4 (D8)

The expected outcomes are as follows:

a) Unstrengthened structures are likely to suffer only superficial damage.

b) If large panes of exposed glass are facing the PES, breakage may be 50 % or greater.

c) Personnel are afforded a high level of protection from death or serious injury. Injuries that do occur will be caused primarily by broken glass.

This is the scaled factor used for calculating the separation distances between a PES and vulnerable buildings (twice the inhabited-building distances).

I.4 SCALED FACTOR 22.2 (D7)

The expected outcomes are as follows:

a) Unstrengthened buildings will suffer minor damage, especially 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.

b) Personnel are afforded a high level of protection against the direct effects of an explosion, but are likely to suffer injuries from broken glass and flying or falling debris.

c) Metal buildings will have corrugated aluminum or steel panelling moderately buckled with joints separated.

d) Roof rafters in wood frame structures will crack.

e) Large and small glass windows will shatter, and frames will occasionally fail.

This is the scaled factor used for calculating the separation distances between a PES and inhabited buildings and public traffic routes for heavy traffic.

I.5 SCALED FACTOR 17.6 (BETWEEN D5 AND D7)

The expected outcomes are as follows:

a) Unpressurized liquid storage tanks will be slightly damaged.

b) Aircraft will suffer minor damage to control surfaces and other areas.

I.6 SCALED FACTOR 14.8 (D5)

The expected outcomes are as follows:

a) Unstrengthened buildings will suffer average damage that will cost approximately 10 % of the total building replacement cost to repair.

b) Personnel under cover are afforded a high level of protection from death or serious injury. Injuries that do occur will be mainly caused by broken glass and building debris.

c) Personnel in the open are not likely to be seriously injured by the blast.

d) Corrugated asbestos siding will shatter.

e) Unreinforced concrete-block or brick walls will be severely damaged or shattered.

f) Metal buildings will suffer severe buckling, and some panels will be torn off.

g) Large and small glass windows will suffer severe frame failure; however, frame failure will not occur if the glass is thin and breaks easily.

h) Aircraft that are landing or taking off could lose control and crash.

i) Unsheltered aircraft will likely sustain minor damage due to blast, but should remain airworthy.

This is the scaled factor used for calculating the separation distances between a PES and public traffic routes for medium traffic.

I.7 SCALED FACTOR 9.6 (BETWEEN D4 AND D5)

The expected outcomes are as follows:

a) Unstrengthened buildings can be expected to suffer damage to main structural members that will require repair. Repairs may cost more than 20 % of the replacement cost of the building. Strengthening of buildings to prevent damage and secondary hazards is feasible and not excessively expensive.

b) Personnel could suffer temporary hearing loss; however, permanent ear damage is not likely. Other injuries from the direct effects of overpressure are unlikely.

c) There will be some personnel injuries caused by translation of the individual(s) involved.

d) Automobiles may suffer some damage from the blast to metal portions of the roof and body. Windows facing the blast may be broken; however, the glass should not cause serious injuries to the occupants.

e) Aircraft will suffer some damage to appendages and sheet metal skin; however, they should be operational with only minor repairs.

f) Cargo ships will suffer minor damage from the blast to deck houses and exposed electronic gear.

g) Wood frame structures will experience cracked studs and sheathing.

h) Injury from secondary blast effects, such as building debris and impact with hard surfaces, can be expected.

I.8 SCALED FACTOR 8.0 (D4)

The expected outcomes are as follows:

a) Unstrengthened buildings can be expected to suffer serious damage that is likely to cost more than 30 % of the total replacement cost to repair.

b) There is some possibility of delayed communication of the explosion as a result of fires or equipment failure at the ES. Direct propagation of the explosion is not likely.

c) Cargo ships will suffer damage to decks and superstructures. In particular, doors and bulkheads on the weather-deck are likely to be buckled by overpressure.

d) Aircraft are expected to sustain considerable structural damage.

e) Metal buildings will have the siding and interior completely destroyed. Frame failure may occur if the siding has been reinforced or strengthened.

This is the scaled factor used for calculating the separation distances between a PES and public traffic routes for light traffic as well as process buildings protected by a barricade.

I.9 SCALED FACTOR 7.2

The expected outcomes are as follows:

a) A high level of protection is provided against the direct propagation of an explosion.

b) There is some possibility of delayed communication of the explosion as a result of fires or equipment failure at the ES.

c) Damage to unstrengthened buildings will be serious. Repairs are likely to cost 50 % or more of the total replacement cost.

d) Cargo ships will suffer some damage to doors and bulkheads, and the weather-deck will be buckled by overpressure.

e) Aircraft can be expected to suffer considerable structural damage from the blast. In some cases, the aircraft may have to be salvaged.

f) Unpressurized liquid storage tanks will be severely damaged.

g) Reinforced concrete walls will exhibit moderate cracking.

h) Reinforced concrete blocks or brick walls built between rigid supports will shatter or experience severe damage.

i) There is a 10 % chance of eardrum damage to personnel.

j) Transport vehicles will incur extensive, but not severe, body and glass damage, consisting mainly of dented body panels and cracks in shatter resistant window glass.

This scaled factor is used by the US Department of Defense for the process-building distance called the *unbarricaded intraline distance*.

I.10 SCALED FACTOR 4.4

The expected outcomes are as follows:

a) Heavy machinery (e.g. generators and compressors) will be completely displaced with moderate damage.

b) Unpressurized liquid storage tanks will collapse.

c) Reinforced concrete walls will suffer severe spalling and wall displacement.

d) Unstrengthened concrete block or brick walls will collapse.

e) Wood frame structures will collapse.

f) Personnel will incur serious injury to eardrums and lungs or possible death due to the blast.

I.11 SCALED FACTOR 3.6

The expected outcomes are as follows:

a) A high level of protection is provided against the direct propagation of an explosion when barricades are placed between the two PESs.

b) Explosions may subsequently occur in adjacent sites from fire spread by lobbed debris from blast site.

c) Unstrengthened buildings will suffer severe structural damage approaching total demolition.

d) Severe injuries or death to occupants of the ES are to be expected from direct blast, building collapse or translation.

e) Aircraft will be damaged by the blast to the extent that they will be beyond economical repair.

f) Improperly designed barricades or protective structures may increase the hazard from flying debris and may collapse in such a manner as to increase the risk to personnel and equipment.

g) Heavy machinery (e.g. generators and compressors) will be destroyed.

h) Vehicles and trailers will be destroyed.

I.12 SCALED FACTOR 2.4

The expected outcomes are as follows:

a) Steel towers will be blown down.

b) Reinforced concrete walls will be completely destroyed.

c) Personnel will be killed by the direct action of the blast.

d) Vehicles will be overturned and crushed by the blast.

e) Aircraft will be destroyed.

I.13 FRAGMENTS/DEBRIS

An important consideration in analyzing the hazard associated with an accidental explosion is the effect of the projections generated by the explosion. These projections are known as primary or secondary projections depending on their origin.

Fragments are primary projections formed as a result of the shattering of the explosive container. The container may be the casing of conventional ammunition, the kettles, hoppers or other metal containers used in the manufacture of explosives, the metal housing of rocket engines or similar items. These projections are usually small and travel initially at velocities of thousands of metres per second.

Debris are secondary projections formed as a result of high blast pressures on structural components and items close to the explosion. These projections are somewhat larger in size than primary projections and travel initially at velocities of hundreds of metres per second.

The minimum separation distances for PESs classified as PE1 are a reflection of minimum separation distances for protection from fragments.

I.14 THERMAL RADIATION

Detonation of an explosive typically results in the production of a visible flash of flame. Normally, the thermal radiation from this short-lived flame is of negligible hazard in comparison with the blast and missile effects, and may be ignored.

Propellants and pyrotechnic substances and articles (PES classified as PE3) differ from detonating explosives (PES classified as PE1) in that, unless heavily confined, their reaction does not result in the generation of high-pressure gases. Their energy is released in the form of an intense flame and may cause a hazard by thermal radiation and additionally by direct impingement of the flame.

ANNEX J
(informative)
[non-mandatory]

EFFECTIVENESS OF BARRICADES

J.1 FUNCTIONS OF BARRICADES

An effective barricade stops high velocity, low trajectory projections from an explosion, which otherwise could cause the direct propagation of the explosion at the exposed sites (ES).

A barricade may also provide limited protection against the blast and flame arising from an external or internal explosion when the quantity of explosives is relatively small, as is usually the case in process buildings.

J.2 INFLUENCE OF BARRICADES ON THE SEPARATION DISTANCES FOR PESs CLASSIFIED AS PE1

J.2.1 SEPARATION DISTANCES BETWEEN A POTENTIAL EXPLOSION SITE (PES) CLASSIFIED AS PE1 AND A MAGAZINE

An effective barricade avoids the use of very large separation distances between a potential explosion site (PES) classified as PE1 and a magazine. This is a significant factor in the cost of a storage site. The reduced separation distances are provided in the quantity-distance (Q-D) tables (see Tables C.1 and C.2).

J.2.2 SEPARATION DISTANCES BETWEEN A PES CLASSIFIED AS PE1 AND A PROCESS BUILDING

An effective barricade avoids the use of very large separation distances between a PES classified as PE1 and a process building. A barricade or heavy wall around the process building that is considered an ES may provide some protection for personnel in the lee of the barricade.

J.2.3 SEPARATION DISTANCES BETWEEN A PES CLASSIFIED AS PE1 AND AN ES OUTSIDE THE EXPLOSIVES AREA

Investigation of damage caused by blasts in recorded accidents and trials shows that, in the case of a PES classified as PE1, barricades are not effective for ESs located outside the explosives area, such as inhabited buildings and public traffic routes. In such cases, the separation distance difference between an ES protected by a barricade and an ES not protected by a barricade is too small to be taken into account.

J.3 INFLUENCE OF BARRICADES ON SEPARATION DISTANCES FOR PESs CLASSIFIED AS PE2 OR PE3

A barricade other than a door barricade does not generally provide sufficient effective protection against flame, radiant heat, projections and lobbed ammunition to justify a reduction in separation distances. In such cases, the authority having jurisdiction should be consulted for guidance.

J.4 GEOMETRY OF EARTH BARRICADE

Proper barricade geometry is necessary to reduce the risk of high-velocity projections escaping above or around the ends of the barricade and producing an explosion in an adjacent ES. Since such projections do not move along perfectly linear trajectories, reasonable margins in barricade height, thickness and length are to be provided beyond minimum dimensions, which block lines of sight.

ANNEX K
(informative)
[non-mandatory]

INFORMATIVE REFERENCES

K.1 DOCUMENT FROM A STANDARDS BODY

CSA Group [www.csagroup.org/ca/en/services/codes-and-standards]

CSA S850 — *Design and assessment of buildings subjected to blast loads*.
(Calcul et évaluation des bâtiments soumis à des charges d'explosion.)

K.2 LAW, REGULATION OR SIMILAR DOCUMENT

CANADA. *Explosives Regulations, 2013*.

K.3 GOVERNMENT DOCUMENT

US DoD (US Department of Defense)

UFC 3-340-02 — *Structures to Resist the Effects of Accidental Explosions.*

K.4 OTHER DOCUMENTS

UNECE (United Nations Economic Commission for Europe)

UN Recommendations on the Transport of Dangerous Goods — Manual and Test Criteria.

UN Recommendations on the Transport of Dangerous Goods — Model Regulations.

UNODA (United Nations Office for Disarmament Affairs)

IATG 01.40 — *International Ammunition Technical Guidelines: Glossary of terms, definitions and abbreviations.*

ANNEX L
(informative)
[non-mandatory]

BIBLIOGRAPHY

L.1 DOCUMENT FROM A STANDARDS BODY

NFPA (National Fire Protection Association) [www.nfpa.org]

NFPA 495 — *Explosive Materials Code*.

L.2 LAW, REGULATION OR SIMILAR DOCUMENT

CANADA. *Explosives Act*.

L.3 GOVERNMENT DOCUMENTS

NRCAN (Natural Resources Canada)

Directive # 3 — *Amendments to the Quantity Distance Principles Manual*, February 2014, 6 pp.

G05-05 — *Potential Effect Classification*, June 2007, 10 pp.

Quantity Distance Principles — User's Manual, 1995, 79 pp.

US DoD (US Department of Defense)

6055.09-M Volume 3 — *DoD Ammunition and Explosives Safety Standards, Volume 3, General Quantity-Distances Criteria for Accidental Detonations.*

L.4 OTHER DOCUMENTS

NATO Standardization Office [www.nsa.nato.int]

AASTP-1 — *Manual of NATO Safety Principles for the Storage of Military Ammunition and Explosives*.

AOP-38	*Specialist Glossary of Terms and Definitions on Ammunition Safety.*

UNODA (United Nations Office for Disarmament Affairs)

IATG 02.20	*International Ammunition Technical Guidelines: Quantity and Separation Distances.*

COMMENTS

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CAN/BNQ 2910-510 *Explosives – Quantity Distances*.

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Bureau de normalisation du Québec

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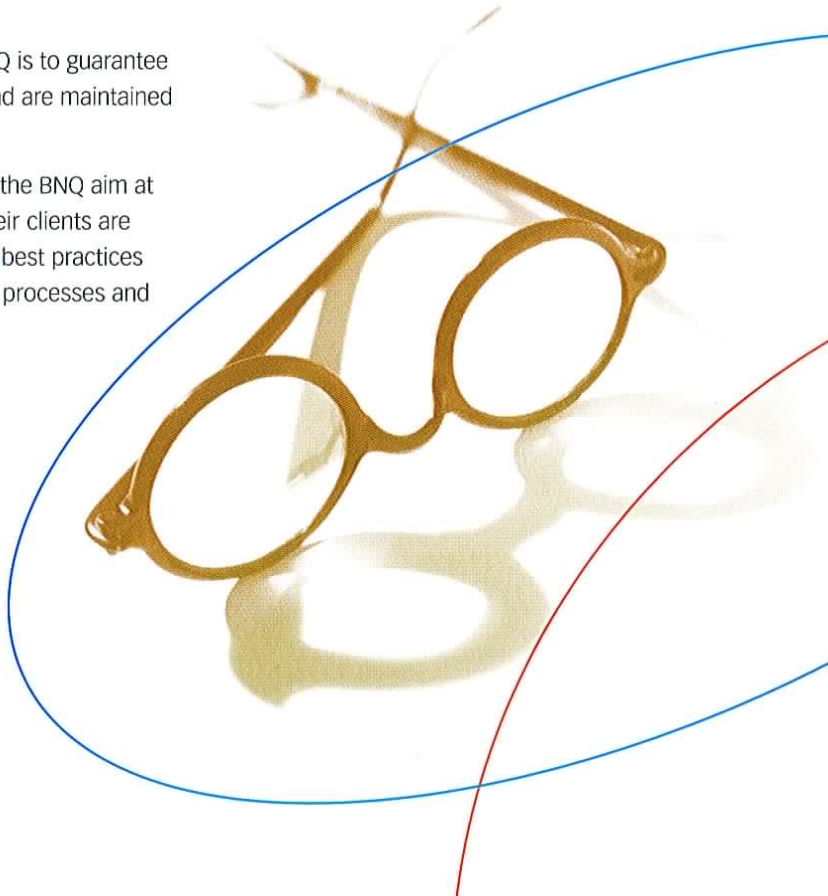

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